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An Eventful Month

Photo: author

March 2023 has been a highly eventful month in the world of defence, seeing a number of important announcements and events take place.

On 13 March, the leaders of the US, UK and Australia met in San Diego to announce their nuclear submarine-building plans under the AUKUS defence pact. The leaders announced that Australia would first acquire three US-built Virginia class SSNs to serve through the 2030s, while at the same time procuring the UK-designed 'SSN-AUKUS' class of submarines, which are due to be domestically produced in Australia, to meet its requirements for the 2040s onward.

Also on 13 March, the UK announced a GBP 5 Bn spending boost to defence over the next two years, as part of its 'Integrated Review Refresh 2023'. Although the boost will no doubt be welcomed by the UK's armed forces, it is understood that with inflation running high at 10.1%, the boost will not lead to a real-term increase, but rather will be used to offset the effects of inflation. The review is due to be followed by an update to the 2021 Defence Command Paper, expected to be published in June 2023, which will set out the changes to defence spending plans in more detail.

In Ukraine, Russian forces have made incremental progress around the town of Bakhmut over the course of March, and at the time of writing, this has resulted in the near-complete encirclement of the town, as well as the capture of the Eastern half of the town, located across the Bakhmuta river. The capture of Bakhmut would open up a path for Russian forces to move on Sloviansk and Kramatorsk.

Despite this unenviable position, Ukrainian forces in Bakhmut have continued to hold out against the Russian advance. Numerous news outlets have reported that Ukraine is planning a counteroffensive in the Donbas at some point in the Spring, likely taking advantage of some of the newer donated equipment such as MBTs and other heavy equipment which has been pledged or already delivered by various countries.

Regional tensions were raised further following Russia's downing of a US MQ-9 Reaper Unmanned Aerial Vehicle (UAV) on 14 March. The UAV was downed by a Su-27 fighter which was stated to have collided with the Reaper, causing damage to its propeller and resulting in its eventual crash in the Black Sea southwest of Crimea.

With regards to new equipment in Ukrainian service, on 20 March, footage emerged on social media showing Ukrainian forces operating a French Crotale NG short-range air defence (SHORAD) system, successfully downing a target purported to be a Russian cruise missile. While such deliveries are broadly positive, providing a boost to Ukraine's air defence capabilities, their presence is also a possible indicator that Ukraine's domestic supply of air defence missiles has started to dry up. While this is of course not easy to confirm, seeing increasing instances of reliance on imported air defence equipment is an indicator that domestic supplies may have run fairly low.

Elsewhere on the ammunition front there is more hope in sight, as on 19 March, defence ministers of 17 EU states plus Norway signed an agreement on the joint procurement of ammunition for Ukraine. The procurement effort is due to take place under the leadership of the European Defence Agency (EDA), and seeks to provide a long-term sustainable supply chain for the manufacture and delivery of ammunition. Under the three-phase programme, the signatories would provide ammunition worth EUR 1 Bn from their own stocks, and jointly procure a further EUR 1 Bn worth of 155 mm artillery rounds.

On 20 March, President Xi Jinping paid a state visit to Moscow, at the invitation of Vladimir Putin, marking the President Xi's first visit to Russia since the country launched its invasion of Ukraine on 24 February 2022. It also followed on the heels of the International Criminal Court (ICC) in the Hague issuing an arrest warrant for Putin on 17 March, over the issue of alleged deportation and transport of Ukrainian children from Russian-occupied territories, classed as war crimes. During President Xi's state visit, the Chinese and Russian leaders stressed the close ties of their two countries.

China has previously offered to play the role of mediator in the Ukraine war, yet its ties to Russia have caused concern at this proposal in the West. Moreover, in late-February 2023, CNN reported citing unnamed sources that US intelligence suggested China was considering the provision of military aid to Russia. If this were to occur, it could mark a shift in the strategic situation, given China's impressive defence-industrial manufacturing capabilities.

As the year rolls on, both sides in the War in Ukraine appear to be settling in for the long haul, with no resolution yet in sight. All told, March has been an eventful month.

Mark Cazalet

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Cover Photo: An Arrow 3 interceptor missile is launches during tests carried out by the Israel Missile Defense Organization (IMDO) of the Directorate of Defense Research and Development (DDR&D) and the US Missile Defense Agency (MDA). These tests were conducted at Pacific Spaceport Complex-Alaska (PSCA) in Kodiak, Alaska. (Photo: MDA)

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Slovakia Becomes Second NATO Nation to Donate MiG-29s to Ukraine

(pf) Slovakia became the second NATO country to donate fighter aircraft to Ukraine on 17 March 2023, with the Slovakian government approving a plan to send the country's fleet of MiG-29 'Fulcrums' to support Ukraine's operations against its Russian invaders.

The move follows Poland's announcement the previous day that it would send a dozen or so MiG-29s to Ukraine.

Photo: USAF

These offers are significant because the Ukrainian Air Force (Povitryani Syly Ukrayiny – PSU) is already an operator of the Soviet-designed MiG-29, meaning that there will be few training or logistical issues in assimilating the Polish and Slovakian MiGs into the PSU inventory.

Slovakian Prime Minister Eduard Heger said during a news conference on 17 March that his government was "on the right side of history" and was "closely co-ordinated with the Polish side, Ukraine and other allies".

He added in a Tweet, "Promises must be kept and when [Ukrainian President Volodymyr Zelenskyy] asked for more weapons including fighter jets I said we'll do our best. Glad others are doing the same."

Although Heger's Tweet indicated Slovakia would send 13 MiG-29s to Ukraine, the Slovak Air Force's most recently operational combat fleet consisted of just 11 MiG-29s (nine single-seat MiG-29ASs and two MiG-29UBS twin-seat conversion trainers) originally delivered to the Czechoslovak Air Force in 1989 but upgraded by RAC MiG under contracts signed in 2004 and 2013. A further 12 MiG-29ASs and one MiG-29UBS have been in storage for some time.

On 31 August 2022 the Slovak Air Force grounded its MiG-29 fleet due to a lack of spares and expertise to maintain them after Russian technicians returned home.

The MiGs are due to replaced by 12 single-seat and two twin-seat F-16V Block 70/72s ordered from the United States in December 2018. These were initially supposed to be delivered from this year, but in March 2022 the Slovak Ministry of Defence said they had been delayed by 12 to 14 months.

According to an AP report on 17 March, Slovakia will receive EUR 200 M from the European Union as compensation and unspecified arms from the United States worth EUR 700 M in exchange for giving its MiG-29 fleet to Ukraine.

Before the Russian invasion of Ukraine on 24 February 2022 the PSU operated a fast jet combat air fleet of about 132 aircraft that included three or four dozen operational MiG-29s of around 100 of the type in its inventory. As of mid-March the Oryx website that tracks visually verifiable equipment destroyed in the Ukraine conflict was listing the PSU as having lost 18 MiG-29s, suggesting it possibly has around 20 operational 'Fulcrums' left.

The Slovak and Polish donations mean that the PSU could soon have at least two dozen additional 32 MiG-29s at its disposal.

The PSU will have to be careful how it uses the Polish and Slovakian MiG-29s once they are received. Unlike land systems, which can be dispersed and hidden relatively easily, the fact that fighters can only operate from aerodromes, be they military air bases or civilian airports, means the Russians are likely to target them with missiles or armed unmanned aerial vehicles.

US DoD's FY24 Defense Budget Request Marks 3.2% Increase Over FY23

(pf) The US Department of Defense (DoD) released the Biden Administration's Fiscal Year 2024 (FY24) Defense Budget request on 13 March 2023, having submitted it to the US Congress on 9 March. The request totals USD 842 Bn (EUR 793.58 Bn): an increase of USD 26 Bn, or 3.18%, over 2023 levels and USD 100 Bn more than FY 2022.

However, the US inflation rate is currently running at 6.04%, suggesting there will be no real-term increase in US defence spending.

Under the US National Defense Authorization Act process the defence budget must now be sent to the House and Senate armed services committees (HASC and SASC) for amendment, after which their mark-ups are reconciled. The defence budget is then presented for final approval by the president.

Commenting on the FY 2024 budget request, US Defense Secretary Lloyd J Austin was quoted as stating in a US DoD press release, "The FY 2024 budget is the most strategy-driven request we've ever produced from the Department of Defense. And as our National Defense Strategy makes clear, the People's Republic of China (PRC) is our pacing challenge. This budget seeks to meet this critical challenge today, tomorrow, and into the future by providing the resources today to continue to implement our National Defense Strategy and keep our nation safe while delivering a combat credible Joint Force that is the most lethal, resilient, agile, and responsive in the world.

"As the PRC races to modernize its military, this budget will sharpen our edge by making critical investments across all timeframes, theaters, and domains," said Austin. "Among numerous important actions that bolster our combat credibility in the short term, this budget makes the Department's largest-ever investments in readiness and procurement – and our largest investment in research and development."

Austin said the budget "makes major investments in integrated air and missile defenses and operational energy efficiency, as well as in our air dominance, our maritime dominance, and in munitions, including hypersonics". He noted that the budget includes the largest ever request for the Pacific Deterrence Initiative, focusing on "advanced capabilities, new operational concepts, and [a] more resilient force posture in the Indo-Pacific region" as well as "ground-breaking posture initiatives" in Guam, the Mariana Islands, the Philippines, Japan, and Australia.

The budget also "increases funding to continue modernizing all three legs of our nuclear triad to maintain a safe, secure, and effective strategic deterrent against advanced and persistent threats around the world", said Austin.

Key investments within the budget across all domains include:

- USD 61.1 Bn for air power to continue developing, modernising, and procuring lethal air forces, including a focus on the F-22, F-35, and F-15EX fighters; the B-21 bomber; mobility aircraft such as the KC-46A tanker; specialised support aircraft; and unmanned aircraft systems.
- USD 48.1 Bn for sea power, including new construction of nine battle force fleet ships and continued funding for the incremental construction of Ford-class nuclear-powered aircraft carriers and Columbia-class nuclear-powered ballistic missile submarines (SSBNs).
- USD 13.9 Bn for land power, supporting modernisation of US Army and US Marine Corps combat equipment, including the Armored Multi-Purpose Vehicle, Amphibious Combat Vehicle, and Optionally Manned Fighting Vehicle.

Photo: US Navy

- USD 37.7 Bn for Nuclear Enterprise Modernization, including: continued development and procurement of the B-21 bomber; production of the second Columbia-class SSBN; first-year advanced procurement funding for the LGM-35A Sentinel intercontinental ballistic missile programme; and development efforts supporting nuclear command, control, and communications systems.
- USD 29.8 Bn to enhance US missile defences, including: development of the Next Generation Interceptor for Ground-Based Midcourse Defense and extending the service life of the current interceptor fleet; increased investments in regional missile defences with Patriot missiles, a Lower Tier Air and Missile Defense Sensor, additional short-range air defence battalions, and hypersonic weaponry and defences; development of a resilient overhead persistent infrared capability in low and medium Earth orbit plus continued fielding of the Next Generation Polar programme; integration of the Terminal High Altitude Area Defense (THAAD) system into the US Army's Integrated Air and Missile Defense Battle Command System planning process, and continuing development of an eighth THAAD battery; advanced innovation technologies and demonstrations, including those involving cyber operations and hypersonic strike capabilities; and efforts to defence the Pacific island of Guam against the missile threat from China.
- USD 11.0 Bn to deliver a mix of highly lethal precision weapons, including hypersonic missiles and other long-range fires such as the Joint Air-to-Surface Standoff Missile, Long-Range Anti-Ship Missile, and Standard Missile 6.
- USD 33.3 Bn in vital space capabilities, resilient architectures, and enhanced space command and control.

The budget request focuses USD 146 Bn on readiness across all services, including USD 9.1 Bn in support of the Pacific Deterrence Initiative: a 40% increase from FY 2023.

In relation to countering Russian aggression, the FY 2024 budget includes USD 3.6 Bn for the European Deterrence Initiative, USD 601 M in contributions to NATO, USD 293 M on the NATO Security Investment Program, and USD 300 M on the Ukraine Security Assistance Initiative.

For research, development, test and evaluation initiatives the budget assigns USD 145 Bn: a 40% increase over the FY 2023 enacted level.

For munitions the budget requests USD 30.6 Bn: an increase of USD 5.8 Bn above last year's request. This is an area where the conflict in Ukraine has led to a revision in DoD thinking. On 15 March Michael J McCord, Undersecretary of Defense (Comptroller) and Chief Financial Officer, stated, "Ukraine has certainly informed us of the lack of flexibility in our industrial base. … We are going to up our game." He added that the DoD and US defence-industrial base need to be more agile in fulfilling any surge in demand for munitions. One solution being put into place, he noted, is multi-year procurements for munitions – similar to those for major defence platforms – that keep assembly lines running and workforces employed.

Tensions raised in Black Sea Region After Downing of US MQ-9

(pf) Tensions have been raised in the Black Sea region following an incident on the morning of 14 March 2023 in which one of two Russian Su-27 fighters operating in the area brought down a US MQ-9 Reaper unmanned aerial vehicle (UAV).

According to a statement released later that day by the US Department of Defense (DoD), the Su-27 struck the MQ-9's propeller, causing its US operator to bring the UAV down into international waters of the Black Sea.

Credits: US EUCOM

"Several times before the collision, the Su-27s dumped fuel on and flew in front of the MQ-9 in a reckless, environmentally unsound and unprofessional manner," said US Air Force General James B Hecker, commander of US Air Forces Europe and Air Forces Africa. "This incident demonstrates a lack of competence in addition to being unsafe and unprofessional."

According to the US DoD, the MQ-9 aircraft was conducting routine operations in international airspace when it was intercepted.

"This incident follows a pattern of dangerous actions by Russian pilots while interacting with US and allied aircraft over international airspace, including over the Black Sea," Gen Hecker added. "These aggressive actions by Russian aircrew are dangerous and could lead to miscalculation and unintended escalation."

By 15 March footage had emerged on Twitter apparently showing a Russian fighter passing in front of an MQ-9, taken from the cockpit of the Russian aircraft, although it has not been confirmed whether this was footage from 14 March. Then, on 16 March, US European Command (EUCOM) released declassified footage from the MQ-9's video feed and a storyboard outlining the sequence of events during the incident. The footage was edited for length, given that it depicts 42 minutes that cover the MQ-9's encounter with the Su-27s.

At the beginning of the footage a Russian Su-27 can be seen approaching the rear of the MQ-9. Then, at five minutes in, according to EUCOM, an Su-27 is seen dumping fuel as it passes the Reaper. At nine minutes in an Su-27 again passes over the MQ-9 while releasing fuel, which disrupts the video transmission. The fateful pass that produced the collision is stated by EUCOM to have occurred 29 minutes into the original footage. The edited video clearly shows an Su-27 approaching very close over the top of the MQ-9 as it dumps fuel and then the Reaper video feed is temporarily lost for about 60 seconds, according to EUCOM. As it is regained, the video footage clearly shows that the MQ-9's pusher propeller has been damaged, although the UAV continues to remain under controlled flight.

As per previous DoD statements, it is known that the Reaper was guided in a controlled descent and ultimately ditched in international waters southwest of Crimea.

Since the MQ-9 is not a small tactical system but a medium-altitude long-endurance UAV with a wingspan of more than 20 m, any contact with it would have also endangered the Russian fighter. Pentagon Press Secretary USAF Brigadier General Pat Ryder noted in a briefing to media after the incident that the collision "most likely caused damage to the Russian aircraft, although it was able to land".

With the UAV now at the bottom of the Black Sea, a race is on to recover the wreckage. Speaking on state TV, Russian Security Council Secretary Nikolai Patrushev confirmed that Moscow was attempting to find the aircraft.

Meanwhile, John Kirby, the US National Security Council's Coordinator for Strategic Communications, stated that the US Navy would also try to recover the wreckage, but added that if the Russians managed to find it first "their ability to exploit useful intelligence will be highly minimised".

CNN reported two US officials as saying that the Reaper's operators were able to remotely

wipe its sensitive software as it descended, mitigating any exposure of secret materials should the Russians find it first.

Ukrainian Foreign Minister Dmytro Kuleba told the BBC on 15 March that such incidents were bound to occur. "As long as Russia controls Crimea, these kinds of incidents will be inevitable and the Black Sea will not be a safe place," he said. "So the only way to prevent such incidents is actually to kick Russia out of Crimea."

The US military is very unlikely to curtail its operations over and around the Black Sea, so further confrontations with Russian fighters operating out of Crimea are certainly a possibility.

UK Commits to GBP 5 Bn Spending 'Boost' Amid Revamp of Security Strategy

(pf) The UK government has committed to a GBP 5 Bn (EUR 5.65 Bn) uplift in defence spending amid a revamping of the country's defence strategy "to meet the challenges of an increasingly volatile and complex world", a government press release indicated on 13 March 2023.

The 'Integrated Review Refresh 2023: Responding to a More Contested and Volatile World' (IR23) was published on 13 March and confirms that an additional GBP 5 Bn will be provided to the UK Ministry of Defence over the next two years.

Inflation, however, will inevitably take its toll in this uplift. According to UK Treasury accounting UK defence spending was GBP 71.4 Bn in 2021/22, so, with UK inflation currently running at 10.1% (January 2023), the UK defence budget would need to be GBP 78.6 Bn for the year just to keep pace with it – and a GBP5 Bn rise over two years does not reach that figure. UK Defence Secretary Ben Wallace had argued for a GBP 10 Bn spending boost. Thus, unless inflation can be tamed, the announced additional GBP 5 Bn will see no increase in defence spending in real terms.

Photo: Crown Copyright

As UK Prime Minister Rishi Sunak prepared to meet US President Joe Biden and Australian Prime Minister Anthony Albanese in San Diego on 13 March to discuss the next stage of the countries' 2021 AUKUS pact, it was announced that Sunak would set out an ambition to increase UK defence spending to 2.5% of GDP over the longer term. The UK government also stated that it "will lead a conversation with Allies on future posture and burden sharing at the NATO Summit in Lithuania this summer" and would review defence spending after 2025 in light of that ambition.

The BBC reported Downing Street as stating that, from the GBP 5 Bn defence spending uplift, GBP 3 Bn would be earmarked to support the AUKUS pact, along with boosting defence-industrial infrastructure and maintaining the UK's nuclear submarines, while the rest of the funds would be used to replace weapons and equipment sent to Ukraine and to improve the UK's munitions infrastructure. The latter has become important after donations of weapons and ammunition to Ukraine exposed the fact that the UK – along with a number of other countries in Western Europe – did not have the supply chain or production capacity to support their armed forces' munitions requirements over a prolonged period of conflict.

IR23 was commissioned to respond to emerging geopolitical threats, from Russia's illegal invasion of Ukraine to Chinese coercion and increased competition between states, a government press release explained, noting that these trends were identified in the original 2021 Integrated Review but have intensified over the last two years, "with far-reaching consequences for the security and prosperity of the British people".

Under IR23, the press release stated, the first and foremost priority "is dealing with the fundamental risk posed to European security by Russia, and denying Moscow any benefit from their illegal invasion of Ukraine".

Regarding the "Chinese Communist Party's increasingly concerning military, financial and diplomatic activity", IR23 "contains new measures to bolster the UK's economic security, technology capabilities and international development offer in the face of that threat", the government stated, adding that the "Prime Minister has set the direction across government for a consistent, coherent and robust approach to China, rooted in the national interest and aligned with our allies".

Sunak himself was quoted as saying, "As the world becomes more volatile and competition between states becomes more intense, the UK must be ready to stand our ground.

"By investing in our armed forces for the long term, we will be ready for the challenges of today and of the future. As I will discuss with our American and Australian allies in the US today, the UK will remain a leading contributor to NATO and a reliable international partner, standing up for our values from Ukraine to the South China Seas."

Notably, Sunak added, "We have seen all too clearly in the last year how global crises impact us at home, with Russia's appalling invasion of Ukraine driving up energy and food prices. We will fortify our national defences, from economic security to technology supply chains and intelligence expertise, to ensure we are never again vulnerable to the actions of a hostile power."

That statement effectively reveals the political reality in the UK that a rise in defence spending requires something close to an existential threat to the country before it can be effected. Polls continually show how highly the British public value their armed forces, but that hardly ever translates to sanctioning stronger defence spending.

Also subject to some debate in the UK is the extent to which the British armed forces are still able to – and should be required to – project power across the globe. The AUKUS pact, however, signed in September 2021, committed to the UK to assisting US and Australian efforts to contain Chinese expansionism in the Indo-Pacific region.

Most crucially, the pact committed the UK and US to providing Australia with a new fleet of submarines that, unlike the Royal Australian Navy's (RAN's) current Collins-class diesel-electric boats, would be nuclear powered (the US Navy and Royal Navy only operate nuclear-powered submarines). Just what form this new fleet of RAN submarines takes is on the agenda for Sunak, Biden, and Albanese in San Diego. Some reports have suggested that Australia could decide to build a modified version of the Royal Navy's Astute-class nuclear-powered attack submarine (SSN), which would support the country's shipbuilding industry, while also receiving up to five US Virginia-class SSNs.

IR23 also sets out a number of additional priorities for the UK's defence strategy:

- The creation of a new National Protective Security Authority within the UK's MI5 domestic counter-intelligence and security agency, established with immediate effect, to provide a wide range of UK businesses and other organisations with immediate access to expert security advice;
- The establishment of an Economic Deterrence Initiative to strengthen the power of UK sanctions enforcement, closing off routes for human rights abusers and oligarchs to evade sanctions;
- A doubling in funding for a government-wide China Capabilities programme, including investing in Mandarin language training and diplomatic China expertise. A College for National Security curriculum will also be rolled

out to bolster national security capabilities across government;

- The setting up of a new Integrated Security Fund worth GBP 1 Bn to deliver on the core objectives of the Integrated Review at home and around the world, including in economic and cyber security, counter-terrorism and human rights initiatives. This replaces the existing Conflict, Stability and Security Fund (CSSF);
- A refresh of the UK's Critical Minerals Strategy to ensure the UK has reliable access to the vital components for everyday and future technology;
- An additional GBP 20 M in funding for the BBC World Service, ensuring it can continue to provide 42 vital language services – including in countries targeted by hostile states for disinformation.

Russia mounts large-scale missile attack on Ukraine, but to what end?

(pf) Russia launched a major missile attack against Ukraine on 9 March 2023 on a scale rarely seen previously. Most notably the attack included the use of six Kh-47M2 Kinzhal air-launched ballistic missiles: almost certainly the highest number of Kinzhals Russia has used against Ukraine in any such barrage.

"During the day of March 9 the enemy launched a total of 84 missiles of various types," the Ukrainian government posted on its website that evening. "Thirty-four missiles were destroyed by Ukrainian defenders, another eight did not hit their targets. The enemy also launched 12 air strikes, in particular employing eight Shahed-136 [unmanned aerial vehicles]. Half of them were shot down.

"The level of missile threat across Ukraine remains high."

Ukrainian Air Force (Povitryani Syly Ukrayiny – PSU) spokesman Yurii Ihnat was quoted as saying on Ukrainian TV on 9 March, "The attack is really large scale and for the first time using such different types of missiles. We see that this time as many as six Kinzhals were used. This is an attack like I don't remember seeing before."

The Russian attack clearly targeted Ukraine's utilities infrastructure, leaving half a million people without power in the city of Kharkiv alone. Ukrainian President Volodymyr Zelensky stated on the Ukrainian Ministry of Defence website on 9 March, "Kharkiv and the Zhytomyr region have the most difficult situation. Odesa, the Dnipropetrovsk region, Kyiv and Zaporizhzhia are also facing difficulties."

The attack also led to a loss of power at the Zaporizhzhia nuclear power plant, forcing it to rely on diesel generators for the electricity needed to cool radioactive material for the sixth time since the Ukraine conflict began. The power plant, which is under Russian control but manned mostly by Ukrainians, is the source of much concern from the International Atomic Energy Agency, which fears a disaster at what is the largest nuclear power station in Europe.

Moscow's claimed reason for its latest large-scale missile attack on Ukraine was retaliation for "terrorist actions" conducted across Russia's border into the Bryansk region on 2 March: an incursion made by a pro-Ukrainian Russian nationalist militia called the Russian Volunteer Corps.

However, the wider strategy of such missile barrages is unclear. The targeting of Ukraine's civilian infrastructure, while it heaps further misery and casualties on the Ukrainian people, serves little military purpose and mostly likely galvanises public support for Zelensky's goal of a complete ousting of Russian forces from all Ukrainian territory. The Ukrainians have also become quite adept at repairing the damage: US broadcaster VOA quoted Serhii Popko, head of Kyiv's military administration, as saying that power and water had been restored in the city on 10 March while 30% of residents remained without heating. Electricity was 90% restored in Ukraine's northeastern Kharkiv region, VOA reported local officials as saying, while power was also restored to a third of consumers in Ukraine's southern Zaporizhzhia region.

Photo: Russian MoD

Asked to comment on Moscow's aims with such attacks, Professor Mark Galeotti, Honorary Professor at the UCL School of Slavonic & East European Studies in London and a specialist in Russian military politics, told ESD, "I think the overall strategy is political: trying to demonstrate to both Kyiv and the West that Russia is still very much in the game."

Galeotti characterised the overall situation in Ukraine as "in many ways a game of geopolitical chicken in which both Moscow and the West are trying to project a greater willingness and ability to outlast the other".

One possible reason for Russia to employ Kinzhal ballistic missiles is that their hypersonic speed can defeat Ukraine's air defences. PSU spokesman Ihnat, referring to the Kinzhals as well as Russia's use of Kh-22 air-launched cruise missiles (ostensibly anti-ship weapons), conceded that, "So far, we have no capabilities to counter these weapons."

Use of the Kh-47M2 could also be seen as a form of intimidation in relation to Ukraine's Western allies, as it is viewed by Moscow as one of Russia's latest prestige weapon systems. Galeotti, meanwhile, offered another possible reason for Russia to have expended some of its Kh-47M2s. "I think the use of the Kinzhal," he suggested, "may also have been intended to counter claims that Russia was running low on its more sophisticated and precision weapons: 'See? We've so many we could burn six in one night's bombardment!'"

A 10 March update on the Ukraine conflict by the UK Defence Intelligence (DI) organisation noted that the intervals between major Russian missile strikes on Ukraine are growing. This, DI suggested, is "probably … because Russia now needs to stockpile a critical mass of newly produced missiles directly from industry before it can resource a strike big enough to credibly overwhelm Ukrainian air defences".

A year's-worth of the Russian offensive in Ukraine, along with Russian air operations over Syria from 2015 to 2018 in support of the Assad regime, have clearly demonstrated that Russia's precision strike capabilities are – apart from a small number of systems like the Kinzhal – considerably lacking. Indeed, there is an argument to be made that Russia is targeting Ukrainian infrastructure precisely because it is unable to effectively prosecute attacks against military targets.

Ukraine's forces, on the other hand, are increasingly armed with sophisticated and highly accurate Western weaponry. This creates an overmatch in capability that, combined with the Ukrainian military's significantly higher motivation, could help the Ukrainian operate more offensively and take back territory while Russian missiles continue to pound Ukrainian cities to cause further suffering but no military advantage.

Archer Wheeled SPHs are to Replace UK AS90 System Donated to Ukraine

(pf) The 32 British Army AS90 155 mm self-propelled howitzers (SPHs) being gifted to Ukraine will be replaced by Archer 155 mm 6×6 wheeled artillery systems built by BAE Systems Bofors, the UK Ministry of Defence (MoD) announced on 16 March 2023.

The government-to-government sale is being negotiated by the UK MoD's Defence Equipment & Support procurement arm and Sweden's Defence Materiel Adminstration (FMV), with a final contract due to be signed imminently.

According to an MoD press release, "The first 14 Archer artillery systems will have ownership transferred to the British Army this month and be fully operational by next April."

Photo: Swedish Army

The MoD did not specify in its press release how many Archer systems might be procured beyond the initial 14, but noted that the procurement "enables the UK to quickly replace AS90 until the long-term Mobile Fires Platform delivers later this decade as part of the Future Soldier modernisation programme".

Manned by a crew of three or four personnel compared to the five-man crew of the AS90, the Archer system has a range of 50 km using extended-range ammunition: twice the 25 km range of the AS90, according to the MoD. It has a rate of fire of eight rounds per minute and can fire four rounds in a simultaneous-impact mode. As well as using conventional artillery ammunition, the Archer system can fire BONUS anti-armour rounds and Excalibur precision-guided munitions.

The Archer system has been in service with the Swedish Army since 2016, while on 16 March – the same day the UK MoD announced its Archer purchase – the Swedish government announced that it would send eight Archer systems to Ukraine.

"While continuing to double down on our unwavering support for Ukraine, it's imperative we simultaneously replenish our capabilities at home," UK Defence Secretary Ben Wallace was quoted as saying in the MoD press release. "Archer artillery systems are powerful, protective and can be rapidly deployed. This agreement with a close European ally will sustain the British Army's requirements until the longer-term Mobile Fires Platform comes into service – a programme we are working hard to accelerate."

Lieutenant General Sharon Nesmith, the British Army's Deputy Chief of the General Staff, was quoted as saying, "Archer is a potent, modern artillery system procured at a speed previously unseen in Defence. Today's agreement took only eight weeks to secure and the guns will be in service with the British Army by next Spring.

"Archer fires further and faster than any artillery system previously in service with the British Army; it is a step change in capability and fills a gap left by UK support to Ukraine."

The MoD additionally noted that the UK and Sweden have also agreed to collaborate on bringing together efforts for repair and maintenance of vehicles granted in kind to Ukraine.

The British Army originally received 179 AS90 systems from 1992, but currently has only 89 systems in service. The out-of-service date for these systems had slipped from 2030 to 2032, but procurement of a new UK artillery system to replace them under the Mobile Fires Platform programme is being accelerated so that the system can enter service around 2027. Archer is among the systems vying to fulfil this requirement.

Russian Nuclear Assistance to China Rings US Alarm Bells

(pf) Reported nuclear co-operation between China and Russia was one of a number of strategic threats to the United States outlined during an 8 March 2023 hearing of the House Armed Services Subcommittee on Strategic Forces.

With the subcommittee convened to discuss the US military's financial year 2024 Strategic Forces Posture, its chairman, US Representative Doug Lamborn (R-CO), noted that various open-source media outlets had reported how Rosatom, a Russian state corporation specialising in nuclear energy, is providing highly enriched uranium for Chinese fast breeder reactors.

Lamborn asked the panel convened for the hearing how concerning it was to see Russia assisting China in this way, to which US Assistant Secretary of Defense for Space Policy John Plumb replied, "It's very troubling to see Russia and China co-operating on this. They may have talking points around it, but there's no getting around the fact that breeder reactors are plutonium, and plutonium is for weapons. "So I think the [Defense] Department is concerned," Plumb said. "And of course, it matches our concerns about China's increased expansion of its nuclear forces as well because you need more plutonium for more weapons."

Plumb testified at the hearing that China and Russia have placed nuclear weapons, space warfare and long-range strike at the centre of their strategies to counter the United States and its allies.

"China is engaged in a significant and fast-paced expansion and diversification of its nuclear forces," he said. "Also, Russia and China view space as a warfighting domain."

Photo: US DoD

Furthermore, China also has an ever-growing inventory of sophisticated long-range strike systems that can put US forces at risk at ever-growing ranges, Plumb warned.

As chairman of the subcommittee Lamborn additionally noted the growing threat from North Korean nuclear-capable intercontinental ballistic missiles (ICBMs) and ongoing Iranian attempts to develop a similar capability. He therefore laid out the priorities for the subcommittee as being to accelerate the fielding of hypersonic weapons to all three US services; to adjust the US nuclear modernisation programme to deter both Russia and China simultaneously; and to ensure US missile defences can outpace the North Korean and forthcoming Iranian ICBM threats.

Belarusian Partisans Claim to have Inflicted 'Serious Damage' on Russian A-50 AEW&C aircraft

(pf) Belarusian partisan group BYPOL reported on 26 February 2023 that a Russian A-50 'Mainstay' airborne early warning and control (AEW&C) aircraft located at Maschulishchy air base in central Belarus, operating in support of the Russian invasion of Ukraine, had been damaged by an attack from Partisan-controlled unmanned aerial vehicles (UAVs).

A subsequent report on 28 February from the UK Ministry of Defence's Defence Intelligence organisation noted that, while attribution and damage to the aircraft had not been corroborated, the loss of an A-50 'Mainstay' "would be significant as it is critical to Russian air operations for providing an air battlespace picture".

BYPOL had reported two explosions and damage to the front and middle sections of the aircraft as well as its radome.

The International Institute for Strategic Studies' Military Balance 2023 lists the Russian Aerospace Forces as having three A-50 and seven A-50U 'Mainstay' AEW&C aircraft, although various sources place the number of A-50s being in operational service as lower than this. UK Defence Intelligence stated in its 28 February update that the claimed attack "will likely leave six operational A-50s in service, further constraining Russian air operations" over Ukraine.

Contacted by Reuters on 28 February, BYPOL leader Aliaksandr Azarov told the news organisation that the operation against the Russian A-50, which he claimed had caused serious damage to the aircraft, had taken several months to plan and that "partisans" would try to carry out more actions against Russian military assets in Belarus in the future.

The Belarusian regime of Alexander Lukashenko has lent significant basing support to Russia's February 2022 invasion of Ukraine, but has thus far not committed any military forces to the offensive. Exiled Belarusian opposition leaders on the other hand, led by Svetlana Tihanovskaya, have strongly opposed the Russian invasion.

BAE Systems Inc Appoints Senior VP for Comms


Photo: BAE Systems Inc

(pf) BAE Systems Inc announced that it had appointed Lisa Malloy as its senior vice president for communications on 13 March 2023.

Malloy joined BAE Systems from Intel Corporation, where she most recently served as the head of global government and manufacturing communications. Prior to that she led US government affairs and policy communications for Intel.

Malloy will be responsible for all aspects of the company's external and internal communications and community investment activities. She will report to BAE Systems Inc President and CEO Tom Arseneault and will also serve on the senior leadership team.

Antonio Bueno to become president of GDELS

(gwh) Antonio Bueno is to become president of Madrid-based defence contractor General Dynamics European Land Systems (GDELS), parent company General Dynamics announced on 9 March 2023. He will succeed Alfonso Ramonet, who is retiring at the end of March. Bueno has been with GDELS since 2005. He was initially CFO at the Spanish GDELS subsidiary Santa Bárbara Sistemas and held the same position for GDELS' Tracked Vehicles and Artillery Systems group from 2010. From 2013 he led the Tracked Vehicles and Artillery Systems group as Vice President, while from 2019 until today he has been Vice President and CFO of GDELS.

Photo: GDELS

Oshkosh Defense Files Bid Protest on Recent JLTV Award

(pf) Oshkosh Defense has filed a formal bid protest with the UG Government Accountability Office (GAO) over the US Army's recent decision to award a Joint Light Tactical Vehicle (JLTV) follow-on contract to AM General under what is called the JLTV A2 Program, the company announced on 6 March 2023.


Photo: Oshkosh Defense

Spurning Oshkosh as the incumbent provider, 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 on 9 February 2023.

Oshkosh has been the provider of JLTVs to the US military since being chosen as the winner of the initial JLTV contest in August 2015, with a solution based on its Light Combat Tactical All-Terrain Vehicle (L-ATV). The company was at the time awarded a contract worth up to USD 6.75 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. However, soon after the initial JLTV contract was awarded the US government purchased the data rights to the JLTV Technical Data Package from Oshkosh. 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 an USD 84.9 M JLTV order from the army that was the third such order in two months, with those contracts having a combined value of USD 730 M and covering more than 2,000 JLTVs. In its descriptive guide to bid protests the GAO states that it "shall issue a decision on a protest within 100 days after it is filed".

Plasan to Establish Australian Subsidiary

(gwh) Israeli vehicle and protection system manufacturer Plasan Sasa is to establish a subsidiary in Australia, the company announced on 13 March 2023.

The subsidiary, to be named Plasan-Australia, will be focused on providing the best possible support to local partners and Australian projects in which Plasan is involved as well as improving technology transfer.

Plasan describes its co-operation with Thales Australia since 2009, in which the Hawkei 4×4 was developed and produced for the Australian Army, as its most significant achievement in the region. Plasan is currently working with BAE Systems Australia to integrate survival solutions into the Royal Australian Navy's new Hunter-class frigate. Following co-operation with Hanwha Defence Australia on the K9 self-propelled howitzer and K10 ammunition resupply vehicle, work on the Redback infantry fighting vehicle (IFV) project is to follow. The Redback is being pitched by Hanwha against Rheinmetall's Lynx IFV for the Australian Army's LAND 400 Phase 3 programme, for which an award is expected to be announced shortly.

With the establishment of an Australian subsidiary, Plasan aims to secure the supply chain for the provision of relevant technologies into Australia and to build and sustain their support over the coming decades.


Photo: Plasan Sasa

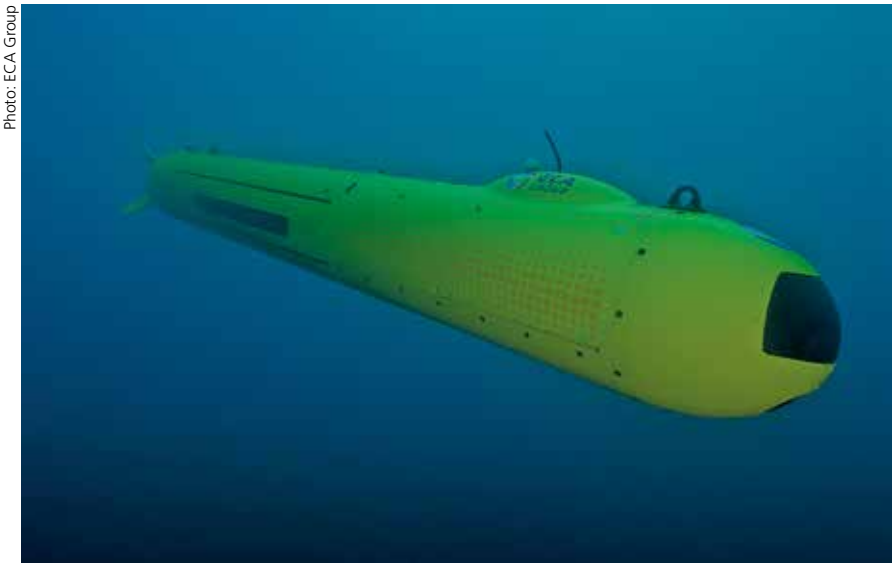
Seabed Warfare: NATO and EU Member State Responses

Luca Peruzzi

The two sabotage events which hit the Nord Stream 1 and 2 gas pipelines in the Baltic Sea on 26 September 2022 have accelerated the plans throughout NATO and European countries for the protection of underwater infrastructure of national interest such as communications cables, oil and gas pipelines, and extraction sites in Economic Exclusive Zone (EEZ) waters, due to the increasing risk of confrontation.

In this vein, there have been a number of recent moves from NATO and the EU to address these risks. On 11 January 2023, the EU and NATO announced a joint Task Force on Resilience and Critical Infrastructure Protection. Later on 15 February 2023, NATO and the EU respectively established an Undersea Infrastructure Coordination Cell (UICC) at Alliance HQ, and on 10 March 2023, the EU Commission announced an updated European Maritime Security Strategy and consequent actions. In addition to these multilateral moves, there have also been various efforts at the national level in NATO and EU member states.

Photo: ECA Group



A18D Autonomous Underwater Vehicle (AUV).

The French Seabed Warfare Strategy

Unveiled in February 2022, the French Seabed Warfare Strategy has already gained two primary ongoing procurement programmes to support deep water survey and intervention. These are the Hydrographic and Oceanographic Capacity of the Future (CHOF) and the Maritime Mine Countermeasures of the Future (SLAMF) programmes.

CHOF aims to renew the hydrographic and oceanographic capacity of the Marine Nationale with a core set of capabilities using disruptive technologies (unmanned platforms in addition to artificial intelligence). Currently in the preparation and definition phase, it includes the procurement of two 90 m next-generation hydrographic vessels and their payload is due to include unmanned vehicles and sensors in order to meet growing needs in hydrography. The two vessels are planned to be delivered in 2027 and 2028 respectively. During the CHOF competitive preparatory phase, the French Defence procurement and technology agency (DGA) awarded a contract to iXblue (now Exail) in September 2022 for a new experimentation campaign of the DriX hydrographic unmanned surface vehicle (USV) and a launch and recovery system study.

The SLAMF programme aims to incrementally renew the French Navy's maritime MCM capabilities, and a cornerstone of this is the joint France-UK Maritime Mine Countermeasures (MMCM) programme led by Thales together with main partners Exail (then ECA Group), L3Harris and Saab. Under SLAMF/MMCM, France will receive MCM modules based on a USV platform operating Thales towed synthetic aperture sonar, Exail autonomous unmanned vehicles (AUVs) and Saab mine disposal remotely operated vehicles (ROVs). The next programme step is to be launched later in 2023, regards the procurement of new mine warfare vessel to replace the in-service Tripartite class mine countermeasure vessels (MCMVs).

According to the new Seabed Warfare Strategy outcomes, in 2022 the DGA respectively awarded Norway's Kongsberg Maritime and France's Exail rental contracts to conduct experiments with HUGIN Superior and the A18D autonomous underwater vehicles (AUVs). The Superior variant of the HUGIN family is capable of operating up to 6,000 m with good sensory, positioning and endurance capabilities. The Exail A18D is a mid-size AUV designed to perform missions at depths up to 3,000 m autonomously, with an endurance of up to 24 hours. Exail is also in the qualification phase of its Ulyx AUV for IFREMER French National Institute for Ocean Science, capable of reaching 6,000 m depths, while Alseamar company provides the well-known SeaExplorer gliders. These experiments are oriented to acquire an initial Seabed survey capability by 2025, comprising one AUV and one ROV pair capable of operating in waters up to 6,000 m in depth, along with an AUV/ROV pair for operations up to 3,000 m in depth. They are intended to be used by vessels of opportunity, in addition to French Navy platforms. A second programme phase increment includes the procurement of two additional 6,000 m AUV/

ROV pairs, and two 3,000 m AUV/ROV pairs, to provide a full deployable capability by 2028. A third increment is also foreseen, consisting of an additional 6,000 m AUV and unspecified dedicated platform.
In late 2021, during the 5th edition of Naval Group's Naval Innovation Days, the company unveiled a new Large ocean-going Unmanned Underwater Vehicle (LUUV) demonstrator, developed in partnership with Thales for the sensor suite and the start-up Delfox specialized in Artificial Intelligence (AI). The 10 tonnes displacement and 10 m long UUV has an endurance which can vary from several days in the current platform configuration to weeks with a longer hull up to 20 m. Naval Group has also developed the D19 medium AUV built on a F21 Artemis heavyweight torpedo base, equipped with modular front-end payload, which can be launched by a submarine, surface vessel or from the shore.

Photo: Naval Group

Naval Group's Large ocean-going Unmanned Underwater Vehicle (LUUV) demonstrator.

United Kingdom

The protection of the UK's critical underwater national infrastructures was brought forward in November 2022, when the UK Defence Secretary announced the termination of the National Flagship programme for dedicated vessels and instead accelerated the procurement of two off-the-shelf platforms called Multi-Role Ocean Surveillance Ships (MROSS). The first of two commercial vessels acquired through the Defence Equipment & Support agency arrived at Cammell Laird shipyard in Birkenhead in January 2023 for modification, before their planned entry into service with the Royal Fleet Auxiliary in Q3 2023. The first vessel, RFA Proteus is a 98 m long, 6,133 tonne offshore support vessel (OSV) built in 2019 by Vard (Fincantieri). According to the UK MoD, it is being modified to conduct a range of missions in support of military operations, namely safeguarding seabed telecommunications cables and oil and gas pipelines. It will also operate as the mother ship for remote and autonomous offboard systems for underwater surveillance seabed warfare. The OSV has a beam of 20 m, a helipad and heave-compensated crane, large working deck and a moon pool for ROVs and AUVs. Once converted, it will be crewed by 24 RFA seafarers and will accommodate 60 Royal Navy specialists who will operate drones when embarked.
The second MROSS is reported to be converted in UK later this year to support MCM and underwater surveillance in British waters. No information has been released on the equipment suite which will equip the two MROSSs, but the national civil and security industry could provide a range of equipment. Among these, Atlas Elektronik UK and Saab UK could offer their ranges of AUVs, ROVs and USVs, already sold to military and commercial operators worldwide.
Under the Mine Hunting capability (MHC) programme, the UK MoD is procuring up to six MCM Maritime Autonomous Systems (MAS) and up to four MCM Logistics Support Vessels (LSV). Replacing the Hunt and Sandown class MCMVs, the MAS and the LSVs will provide expeditionary MCM capability, while the acquired OSV will enable UK offshore operations. In addition to the Maritime MCM systems developed under the joint French-UK programme and being delivered under the first increment of MHC, the Royal Navy has recently acquired the Combined Influence Sweep (SWEEP) system provided by Atlas Elektronik UK, along with Medium Underwater Autonomous Vehicles (MAUVs). The latter comprise Atlas Elektronik UK SeaCat AUVs equipped with high resolution synthetic aperture sonar also provided by the company.
In addition to small and medium unmanned underwater vehicles (UUVs) from L3Harris and Huntington Ingalls Industries (HII) for MCM duties, the Royal Navy recently acquired two Teledyne Marine Gavia AUVs, rated for depths of 1,000 m, under Project Hecla, which is aimed at optimising the Royal Navy's ability to collect and exploit hydrographic and oceanographic information.
Building on the experience with the Manta Extra Large UUV (XLUUV), a technology demonstrator built under a UK MoD Defence and Security Accelerator (DASA) programme, in early December 2022, the UK MSubs company was awarded a contract to build the first XLUUV for the Royal Navy under Project Cetus. The 17 tonne unmanned platform will be 12 m long and 2.2 m in diameter, and capable of "[diving] deeper than any vessel in the current submarine fleet" and having an endurance of up to 1,609 km (1,000 miles) in a single mission. The unarmed battery-powered AUV will operate independently or side-by-side with traditional manned submarines, and is capable of fitting into a shipping container for worldwide deployment.

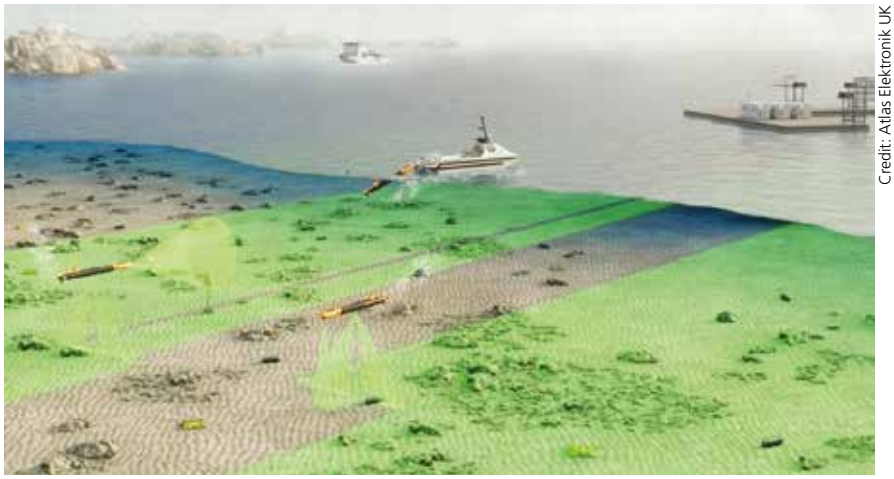

Credit: Atlas Elektronik UK

Diagram showing the SeaCat mine-hunting AUV in operation.

A CG render of the Italian Navy's future submarine rescue ship, SDO-SuRS.

Italy

While elaborating a Seabed Strategy, Italy is working on the 'National Underwater Cluster', which was finally established by the 2023 national budget law approved in December 2022. Conceived as a multi-Ministerial entity, it will bring together industries, universities, research institutions and centres under the supervision of Italian Navy and MoD to coordinate activities in the underwater domain. The Italian Navy and MoD have been frontrunners in the dual-use seabed survey and protection sphere, with of mine warfare components and hydro-oceanographic vessels. More recently, these have included the management and manning of the NATO's Alliance and Leonardo research vessels.

Having introduced the Kongsberg Maritime HUGIN AUV into service in the early 2010s for dual-use operations, since the Nord Stream accident, Italy has intensified the survey of underwater infrastructures of national interest with its fleet of MCMVs. In July 2022, the Marina Militare also signed with Italian Sparkle global network company an agreement to improve the protection of underwater communication infrastructures through joint research and operational procedures. In June 2021, the Italian MoD Naval Armament Directorate (NAVARM) awarded to T.Mariotti shipyard the contract for the construction and equipment suite of a new special forces and diving operations – submarine rescue ship (SDO-SuRS) to be delivered in 2025. In addition to diving equipment and a new generation submarine crew rescue system capable of operating at depths of 600 m, provided by DRASS and Saipem oil and gas services company, the SDO-SuRS will be capable of launching and recovering deep water AUVs and ROVs, the latter provided by Saipem Sonsub.

In February 2023, NAVARM awarded Fincantieri the contract for a new main Hydro-Oceanographic vessel (NIOM), planned to be delivered in 2026. In addition to hydro-oceanographic equipment, the ship comes with deep-water AUVs, unmanned surface vessels (USVs) and unmanned aerial vehicles (UAVs), which can be used for rapid environmental assessment (REA) missions. In the meantime, the Italian Navy is enlarging her fleet of HUGIN 3,000 m AUVs, alongside acquiring an expeditionary capability from MCMVs and other platforms. The service also launched feasibility studies with Intermarine and Leonardo for both new high-seas and coastal MCMVs equipped with a toolbox of unmanned vehicles, alongside coastal hydrographic vessels.

L3Harris Calzoni is conducting an R&D programme for an unmanned MCM system based on an USV with reconnaissance AUV and expandable mine disposal systems (MDSs). DRASS offers the SDOA (Sonar and Drones Open Architecture) whose scope includes the seabed installation of a distributed infrastructure capable of acoustic detection, coupled with other sensors and ROV/UAV docking. Saipem can offer its family of commercial working vehicles, including the the Hydrone family of deep-waters dual role (ROV/drone) vehicles, and the FlatFish AUV. The latter is capable of reaching depths of 3,000 m, with up to 12 hours endurance. A smaller version of the FlatFish with improved endurance and navigation features is at the heart of an Italian MoD's R&D programme to evaluate potential applications in dual-use and military operations.

The Italian MoD has recently launched a market survey for the integration, launch and recovery of AUVs from in-service and future submarines (U212A/U212 NFS). Looking to unmanned ISR and operational underwater platforms, the Italian MoD has an unfunded requirement for a LUUV. Among the Italian companies specialised in the underwater domain are Cabi Cattaneo which provides a range of vehicles and equipment for the Italian Navy's Special Forces and Diving component, DRASS, Leonardo, Gem Elettronica, Elettronica, Avio, Calzoni L3Harris and Fincantieri NexTech, and Wsense.

Photo: Saipem

Side view of the Flatfish ROV.

Germany

On 15 March 2023, the German MoD released the document outlining the new force posture for the Germany Navy by 2035 and beyond. The development of the organisation and the fleet is based on the geostrategic security scenario and threats which the German Armed Forces are expected to confront. Major factors include the Ukraine crisis, the enlargement of NATO to include Sweden and Finland and the developments in the North Atlantic, North Sea and Baltic Sea. In presenting future naval developments, the document points out how vulnerable vital economical underwater infrastructure has been due to the recent sabotage of gas pipelines in the Baltic Sea.

To cope with new surface, air and underwater threats and the speed of operations, Deutsche Marine (the German Navy), will have to be an integral part of national and allied Multi-Domain Operations (MDO) where the trend is clearly towards unmanned systems that can be used in a network shared by the various branches of the

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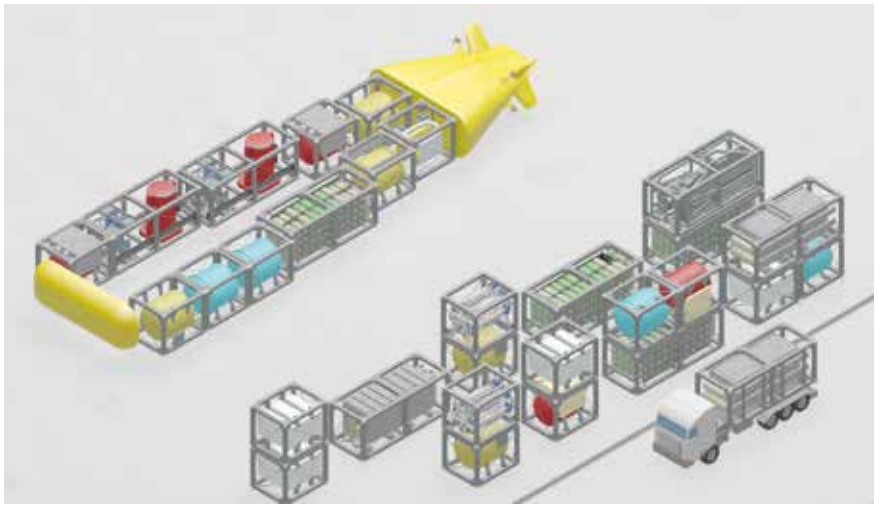


Germany's tkMS-led team is developing a MUM XLUUV.

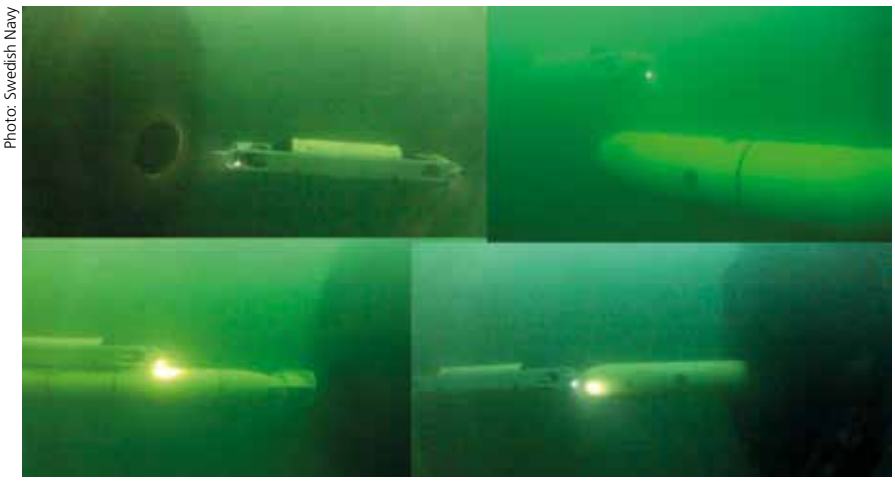
Armed Forces. The underwater dimension is rapidly gaining in importance according to the document. To counter a potential opponent which could have access to the area of interest well in advance of actual operations, Deutsche Marine needs modern underwater sensor technology – both stationary and mobile – alongside AI-supported evaluation capabilities in order to build up and permanently maintain a tactical underwater situation picture. Additionally, the Fleet needs funds to be able to act offensively and defensively under water.

Looking to the envisaged fleet composition, the mine countermeasures, seabed warfare and reconnaissance missions will be carried out by 12 new mine warfare vessels replacing the Type 332 class platforms, along with an undisclosed number of unmanned MCM systems, Germany's first. In addition to the six-to-nine new U212 CD submarines to be procured, the document unveiled a requirement for up to six LUUV for intelligence, surveillance and reconnaissance operations. Moreover, among the operational support platforms, the document maintains three Type 424 class, 130 m long maritime surveillance & intelligence vessels, the construction and fitting out of which was assigned to NVL group in June 2021.

Under the German Federal Ministry of Economic Affairs and Energy's Maritime Research Programme supporting innovative maritime technologies, an industrial team headed by thyssenkrupp Marine Systems (tkMS) is developing a breakthrough large Modifiable Underwater Mothership (MUM) platform to satisfy various applications in the civil maritime industry, but which is expected to have military applications as well. An industrial team including Atlas Elektronik, EvoLogics, University of Rostock, TU Berlin, Fraunhofer Institute, the German Aerospace Centre, and the Institute for the Protection of Maritime Structures, is to begin building and integrate systems in a 25 m prototype in 2023. The MUM is to set a new standard for unmanned underwater operations by early 2025, according to tkMS. The system has a modular structure, including sections sized off 3 m (10 ft) or 6 m (20 ft) shipping containers and a 'flat fish' type design, for its wide beam, as indicated by tkMS. For propulsion and power supply, it uses emission-free fuel cell and Li-ion battery modules. The MUM will be capable of operating 24/7, 365 days a year, independent of wind and weather. It will be capable of carrying multiple smaller UUVs, ROVs and equipment for seabed operations. According to images released by tkMS, its modular design allows the MUM XLUUV to be used for military applications, such as minelaying, anti-submarine warfare (ASW), or reconnaissance.

Germany's Atlas Elektronik has also thus far provided Deutsche Marine with ARCIMS family unmanned surface vehicles, SeaCat AUVs and SeaFox MDSs.

Photo: Swedish Navy



Saab SUBROV ROV operating from a mockup torpedo tube launcher.

Sweden

The surveillance and protection of national waters against underwater operations conducted by the then Soviet Union and today Russian Federation Navy and other agencies pushed the Swedish Armed Forces to develop an integrated underwater, surface and airborne response to this threat in addition to fixed surveillance installations. The Swedish Navy maintains both sophisticated mine countermeasures vessels and submarines, and is today looking to unmanned systems to augment the size of the fleet and added new capabilities.

The next-generation A26 Air Independent Propulsion (AIP) submarines under construction by Saab Kockums will provide a quantum leap in underwater operations, as they are being developed to operate alongside and carry AUVs and ROVs, among other advanced capabilities. The Swedish Navy has been at the forefront of testing and integrating AUVs and ROVs with submarines to conduct seabed and water column survey alongside reported intelligence operations in the crowded Baltic Sea theatre of operations.

In 2019, the Swedish procurement agency acknowledged the availability of its Saab SUBROV ROVs for its submarines. The SUBROVs are handled like a heavyweight torpedo, using the same handling equipment, allowing them to be launched and retrieved from the NATO standard 533 mm torpedo tubes. With a length of 3.1 m and weight of 500 kg in air, the SUBROV has a control system with six degrees of freedom, and LiPo batteries providing an endurance of 6 hours with a maximum operational depth of 500 m. It can be used for a variety of missions, including surveillance, inspection/intervention, MCM and for the recovery of AUVs via the torpedo tubes, as acknowledged by same Swedish Navy.

The navy is presently looking to a new generation of UUVs which could be launched by current and future A26 boats, the latter being equipped with a large Flexible Payload Lock (FPL) for special forces operations as well as the launch and recovery of larger and more capable AUVs such as the Saab Double Eagle ROV/AUV and the single or double hull Sabertooth. The latter combines Saab's military and commercial ROV/UAV technology, driven by Saab's Seaeye division. Capable of going to depths of 3,000 m, with long excursion range, advanced AUV functionality and six degrees of freedom, the Sabertooth can be equipped for a variety of missions and can use seabed-based docking units, where the batteries can be recharged and the AUVs can be sheltered, allowing them to operate for up to six months without maintenance, eliminating surface vessel costs. Saab is also marketing the eWROV, the latest addition to the Saab Seaeye's underwater commercial portfolio. The ROV is completely electrical, including its manipulators, and capable to operating at depths of 3,000 m, with the option to increase this to 5,000 m.

Photo: Saab

Saab's Sabertooth USV

USA

The threat posed by then Soviet and now Russian submarines in the North Atlantic down through the Greenland-Iceland-United Kingdom (GIUK) gap, to the US East Coast, the Mediterranean Sea, and the Pacific theatre, pushed the development of the SOSUS (SOund SUrveillance System) underwater fixed acoustic surveillance network during the Cold War. Today, its remaining sites together with mobile and deployable capabilities come under the Integrated Undersea Surveillance Systems (IUSS) project and Undersea Surveillance Command, with programmes being managed by Maritime Surveillance Systems (MSS) Program Office (PEO UWS PMS 485). These provide flexible and responsive wide

Photo: Kongsberg Maritime

The Hugin Superior AUV.

area surveillance to the Theatre Anti-Submarine Warfare commanders worldwide.
Complementing the Fixed Surveillance System (FSS) under continuous upgrade and the Surveillance Towed Array Sensor System (SURTASS)/Compact Low Frequency Active (CLFA) suite installed on present and future Tactical-Auxiliary General Ocean Surveillance (T-AGOS) ships deployed to the Pacific theatre, the Deployable Surveillance Systems (DSS) project is becoming key to counter the expanding Russian (and Chinese) submarine operations in areas not covered by fixed arrays.
DSS comprises the following systems: Deep Water Passive (DWP), Deep Water Active (DWA) and Mobile Passive Active System (MPAS). Spiral developments to meet the evolving submarine threat will leverage ongoing Navy, Defense Advanced Research Projects Agency (DARPA), and small business research efforts including processing and sensor technology.
Among the DWP systems, the US Navy is continuing to acquire and enhance the Transformational Reliable Acoustic Path System (TRAPS), which was conceived (and now separately provided) by Leidos under the DARPA' Distributed Agile Submarine Hunting (DASH) initiative. TRAPS is a deployable fixed passive sonar node designed to achieve large-area coverage by exploiting advantages of operating from the deep seafloor. To meet similar requirements, the US Navy also has developed and is testing the SURTASS-E which offers the same passive capability packaged into a containers for deployment from vessels of opportunity.
In order to gain underwater situational awareness under iced sea surfaces, in autumn 2022 the US Navy Office of Naval Research has separately conducted trials of the Arctic Mobile Observing System (AMOS), a prototype mobile sensing system incorporating Arctic-capable unmanned underwater vehicles that can be deployed anywhere in the Arctic using a central, ice-based buoy node to provide the critical infrastructure (power, communication, navigation, and environmental intelligence).
The US Navy is also working to contribute to the overall underwater situational awareness picture, integrating the UUVs into the fixed and mobile networking infrastructure and with submarines. Looking to autonomous operations in support of anti-submarine warfare developments, the 80-tonne Orca XLUUV with a modular payload bay, currently being developed by Boeing is a candidate, although the programme is three years late and more costly than initially planned. In the smaller UUV segments, the current Razorback Littoral Battlespace Sensors-Autonomous Unmanned Vehicles (LBS-AUV) based on the HII Remus 600 medium UUV capable of persistent, autonomous, ocean sensing and data collection in support of Navy Intelligence Preparation of the Operational Environment (IPOE), is currently operated via submarine Dry Dock Shelter (DDS), but it will soon be launched and retrieved by torpedo tubes with dedicated equipment. In the meantime, the US Navy has awarded Leidos a contract for developing a more capable medium UUV (MUUV) to be used from torpedo tubes and expeditionary mine countermeasures operations as the current LBS-AUV/exMCM.

Photo: NAVSEA

Boeing's ORCA XLUUV prototype.

Norway

The Royal Norwegian Navy and MoD have contributed to the development of the in-service Kongsberg Maritime HUGIN AUV, whose family of systems is today either on order or in service with 12 customers around the world including US, France, Finland, Poland, Italy, Germany, India, Indonesia, Peru and Norway. Being used for a range of missions including search and rescue, REA, MCM, military survey and seabed warfare, today the HUGIN comes in three main variants – baseline (rated for 3,000 m, 4,500 m, and 6,000 m), HUGIN Superior and HUGIN Endurance. The latter has recently gained an undisclosed naval customer and which delivery will be conducted later this year. The HUGIN Endurance is the largest member of the family with a 1.2 m diameter and 10 m length, yet remaining transportable with a 12 m (40 ft) shipping container, capable of up to 15 days missions and rated for operating at depths of 6,000 m, with a range of sensors focused on mission capabilities and situational awareness. ■

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Underwater Detection, Engagement, and Evasion

Arie Egozi

In order to satisfy the needs of a modern Navy, progress in technology has to happen in the field of underwater weapons and countermeasures. This is because the overall threat has increased and technologies are constantly being upgraded to meet ever-growing challenges.

Since the end of the Cold War, it is believed that submarines, particularly the stealthy American vessels, are essentially immune to dangers posed by underwater detection systems. However, the ability of submarines to conceal themselves through quieting measures alone has decreased as new detection techniques have emerged. These systems use other submarine features, not only emitted noise.

Since early computer processors were unable to handle the complex models required to detect even the slightest changes in the environment generated by a quiet submarine, most of these alternative technologies have been around for a while, but their full potential has only recently been realised. These detection methods can now be used since 'big data' has made it possible to run complex oceanographic models in real-time.

Submarines typically employ a mid-frequency (MF) sonar that ranges from 1,000 to 10,000 hertz (Hz). When compared to low frequency (LF) sonar, which has a frequency of less than 1,000 Hz, the latter has a greater field of view but produces less accurate heading and range data. The people who design and produce devices for underwater detection, engagement, and evasion face an ever-growing challenge, particularly in war situations. To get the best possible picture of the underwater threats and the means to deal with them, ESD talked with members of the Israeli Navy and the companies that supply its underwater tools. This Israeli Navy is involved in operations on a daily basis, on the surface and underwater to counter any hostilities from Iran and its proxies emanating mainly from Lebanon and Syria.

According to foreign sources, an Israeli submarine is stationed in the Persian Gulf, so that Israel will have a 'second strike' capability, in case Iran decides to use its ballistic missiles against Israel. While Iran is undertaking great efforts to achieve a military nuclear capability and invests heavily in its long-range ballistic missile force, Tehran is actively modernising its submarine force. At this point in time, neither ballistic nor cruise missiles can be launched from any of Iran's submarines. Iran started a programme in the 1990s to buy or domestically manufacture mines and torpedoes for all of its sub-surface boats. According to reports, in 2005, it introduced two local production lines for wake-homing torpedoes with ranges of up to 20 km (533 mm and 324 mm). For its submarines, Iran has since developed ballistic and cruise missile technologies. Iran has also successfully test-launched a cruise missile from one of its Ghadir class

Photo: IDF

The Dolphin-II series of submarines is equipped with air-independent propulsion, bringing an important new capability to Israel's undersea fleet.

Author

Arie Egozi is a freelance journalist specialising in Israeli defence matters.

ships on 24 February 2019. The *Tareq* and *Fateh* submarines allegedly share the same capability, according to the Islamic Republic News Agency (IRNA).

Subsurface Threats

In recent years, the Israeli Navy has become a very capable competitor in securing allocations from the Israeli defence budget. Consequently, the Israeli Navy is now receiving the right tools to be able to conduct operations above and below the water. Among its recent acquisitions is the Dolphin-II (or Dakar class) submarine built in Germany. The submarine's sonar and defence systems are notably improved compared to their predecessors, and a significant portion of the systems installed on submarines are developed and manufactured in Israel. Most details surrounding the submarines are highly classified and the German shipyard was asked to cover parts of the submarines under while under construction to keep some capabilities classified.

The submarines are believed to be capable of launching cruise missiles developed in Israel (according to various foreign reports, these are advanced versions of Israeli missiles dubbed 'Popeye'); reportedly, they have a range of 1,500 km and can also be fitted with nuclear warheads.

The other task of the Israeli Navy is to protect the country's long shoreline and the country's EEZ, which includes huge natural gas reservoirs being pumped from the bottom of the Mediterranean. A top Israeli expert who served in the Navy and who asked not to be named, told ESD that Israel now has two fronts that pose an underwater threat. One is the Gaza strip, from where attempts were made in recent years to enter Israel in order to conduct terror attacks. The second threat is Lebanon.

After Hamas in Gaza lost the advantage of its rockets due to the high successful interception rate of the Israeli Iron Dome system, and after all the tunnels dug under the border were discovered and destroyed, the sea has since become the active front. The Israeli expert also noted that the tools that Hamas has for underwater attacks are very basic: "The situation in Lebanon is totally different. Hezbollah, Iran's main proxy, is getting underwater systems and that may include mini-submarines manufactured in Iran." Previous attempts to enter Israel using armed divers were detected and the divers were killed.

Realising that these threats are both real and imminent, Israel has increased its underwater defence and attack capabilities. This capability is based on new advanced submarines and on very advanced underwater systems developed by Israeli companies. The new submarines are just one element in Israel's toolbox to defend against underwater threats of all types.

When it comes to underwater combat, some major requirements have to be dealt with at an early stage. Vice Admiral (retd.) Eliezer Marum, former Commander of the Israeli Navy told ESD that in order to detect hostile submarines, countries take different measures and, in most cases, combine them to achieve the best result. He added that some countries such as the US, have a fixed array of sonars along their most sensitive regions. Other countries prefer to use mobile sonars carried by fixed-wing or rotary aircraft that deploy sonars into the sea when something suspicious is detected or when an intelligence organisation points to the possible presence of a hostile submarine. Marum also remarked that: "There are basic sonars, mostly passive, and if they detect something an active sonar is thrown into the water to get the exact position of the hostile submarine."

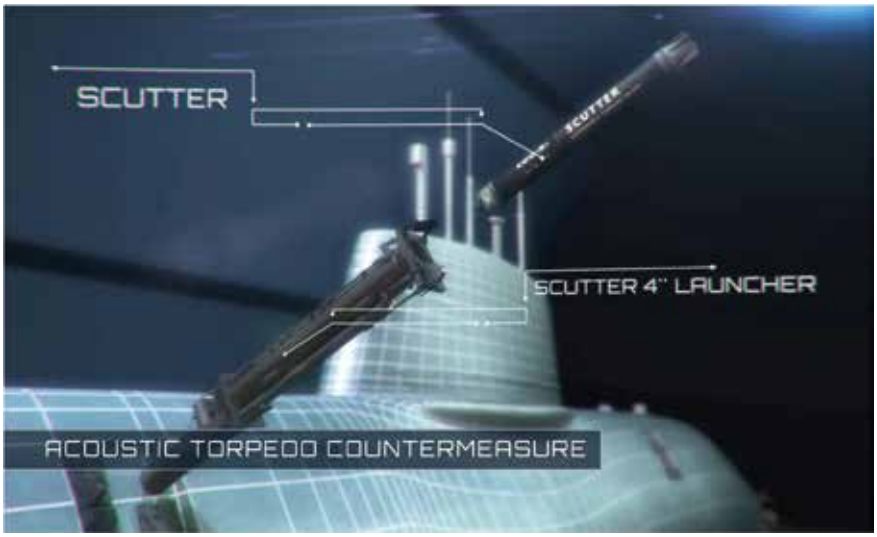
According to Marum, navies also use towed sonar systems. He pointed to the fact that in different oceans, the big difference between the temperature of the water near the surface and at lower depths makes it very difficult for sonars to perform accurate detection. "The best example of this is the Mediterranean. In summer, the surface layer temperature can reach 30 °C. If your detection systems are not capable of going through this warmer layer, detection is almost impossible. This makes this sea a paradise for submarines that are trying not to be detected." Marum also said that this was the reason why the Israeli Navy was investing in additional, detection systems. When a submarine is submerged, it has to stay in uninterrupted contact with its home base. This has prompted many companies to develop unique communication systems for this to happen.

New Tools

It can be said that Israeli companies, especially state-owned Rafael have developed advanced systems of this kind. One is the company notable developments in this field is FloatLink, a buoy that enables the submarine to communicate with its base while in 'deep and silent' mode. While the specifics of this system are classified, its general mode of operation can be shared. FloatLink is ejected from the submarine using its torpedo launching tubes, and floats to the surface. Following this, a SATCOM antenna is then unfolded from the float system, enabling two-way communications. When the transmissions end, the FloatLink self-destructs, thereby minimising the danger of an enemy locating the submarine. In

some scenarios, the submarine operates as an underwater base for 'frogmen' who exit the submarine to carry out different missions underwater or on the surface without being detected.
The Israeli Navy's Yaltam unit specialises in underwater missions and is equipped with highly classified systems that enable them to work underwater when a submarine is used as an operational base.
Rafael has also developed systems aimed at protecting surface ships from torpedoes. Modern acoustic torpedoes, with advanced features that greatly enhance their capabilities, are a major threat to surface vessels. Neutralising these threats requires sophisticated, quick response, and automated countermeasures.
To counter modern torpedoes, Rafael developed the Lescut, described as an intelligent, third-generation reactive countermeasure, designed to identify incoming threats and provide a customised response. According to the manufacturer, the Lescut is launched from a surface ship and is designed to respond simultaneously to multiple torpedoes of various types – both active and passive, and programmed to defeat all types of modern torpedo logic, including range gates, Doppler shift, pulse discrimination, AGC/DVG, and others. The Lescut requires no pre-launch input or tests, shortening the response time and eliminating errors due to incorrect settings or operator mistakes.
Countermeasure operation starts automatically after launch, with the Lescut suspended at its operating depth. It then analyses the environment and selects the appropriate deception signal from its threat library for emission. As a result, acoustic torpedoes home in on the Lescut as the legitimate target, attempting to engage it and thereby allowing the real target to evade the torpedo. The Lescut operates for ten minutes, then self-destructs and sinks.

Photo: Rafael



This CG image illustrates how a Scutter torpedo countermeasure is launched from its host vessel.

Photo: Rafael

The Torbuster is a hard- and soft-kill capable torpedo countermeasure, allowing the user to both deceive and destroy hostile torpedoes.

In modern maritime combat, submarines are exposed to torpedoes launched from ASW helicopters, ships, or other submarines. To counter that threat, Rafael has developed the Scutter, a self-propelled, third-generation reactive, expendable torpedo countermeasure, capable of protecting a submarine from passive and active acoustic homing torpedoes. Rafael says that Scutter has a threat library, based on intelligence programmed by the user, which is used to select the appropriate response. The Scutter is also designed to respond simultaneously to multiple torpedoes of various types – both active and passive.
Scutter is launched immediately following a torpedo alert, moving automatically to its operating depth. It identifies the incoming torpedo, then generates and transmits deception signals. The torpedo attempts to engage and re-engage Scutter until the torpedo's end of run. Scutter then self-destructs at the end of its mission.
Rafael recently unveiled the Scutter Mk3, a third generation (reactive) torpedo decoy. Using a receiver and a threat library, it classifies the attacking torpedo and transmits a tailored response creating multiple legitimate targets for the torpedo to home in on, distracting the torpedo away from the submarine.
Rafael has also developed the Torbuster, which the company claims is the first in-service fourth-generation hard- and soft-kill torpedo countermeasure, and that it is capable of working even in shallow waters. This system is launched from a launcher on the submarine and is claimed to be effective against all acoustic homing torpedoes, actively spoofing the incoming torpedo while sensing its proximity. The company says that once within the predefined kill range, Torbuster detonates and neutralises the hostile torpedo.
Rafael is investing in the development of additional systems for the underwater combat zone, but these are presently classified.
Israeli company DSIT is also very active in developing systems for underwater security. The company's Swordfish offers both passive as well as passive and active low-frequency towed array sonar systems. The company notes that it is capable of underwater search, detection tracking and classification in passive, active and parallel modes.

A Challenging Environment

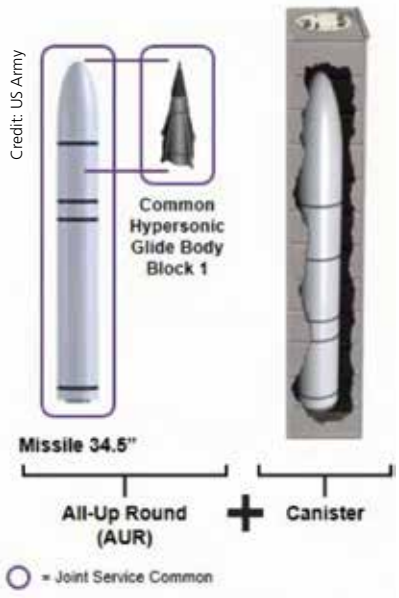
The underwater threats on Israeli assets both on shore and at sea are numerous. This adds to the operational need to protect the Israeli Navy's surface ships and submarines. What has been described in this article represents just a portion of systems against underwater threats that have been developed in Israel.
The underwater threat faced by Israel will only increase as military cooperation between Russia and Iran is raised to an unprecedented level. Iran supplies Russia with armed drones that are used in Ukraine and Russia is helping Iran build a more capable air force and navy. As such, this provides ample incentive for Israel to invest more in underwater systems. ■

Conventional Prompt Strike: The US Navy's Hypersonic Weapons Programme

Sidney E. Dean

The US Navy intends to field its first offensive hypersonic weapon in 2025. These sea-launched boost-glide missiles will enable the globally-dispersed fleet to strike almost any target in the world with conventional warheads, within a one-hour timeframe.

In 2018 the Pentagon tasked the US Navy (USN) with developing an intermediate range offensive hypersonic missile to serve as a basis for service-optimised weapon systems for both the USN and the US Army. The Navy's hypersonic weapon is designated the Conventional Prompt Strike (CPS) system, while the Army's is known as the Long-Range Hypersonic Weapon (LRHW). Each service will field the missile in service-specific launch containers, and integrated into service-specific fire control systems, but both will utilise the same All-Up-Round (AUR) being developed by the USN. The fully assembled missile or AUR will consist of a two-stage solid fuel booster rocket topped by the unpowered Common Hypersonic Glide Body (C-HGB) which carries the non-explosive, kinetic-energy-projectile warhead. The booster stages will have a diameter of 82.5 cm. The AUR's total length appears to be circa 12 m, judging from US Army illustrations depicting the LRHW launch container aboard 13.8 m long Transporter Erector Launcher (TEL) trailers.



The common All-Up-Round (AUR) depicted on the left consists of a 2-stage booster rocket plus the conical Common Hypersonic Glide Body (C-HGB), which is shielded until payload release.

CPS Concept and Profile

The Navy initiated the CPS programme of record in 2019, choosing Lockheed Martin as lead contractor to design, develop and construct the weapon system. Northrop Grumman was tasked with developing the boosters, while Dynetics Technical Solutions received an initial contract to build 20 C-HGB modules for both services.

The CPS is conceived as a hypersonic boost-glide missile. The booster rocket will accelerate the Hypersonic Glide Body (HGB) to hypersonic speeds, reaching an apogee of circa 100 km above sea level. The unpowered HGB will detach from the spent booster and descend quickly, retaining hypersonic speed as it glides towards its target. It will approach its target at relatively low altitude to fly under air- and missile defence sensors until late in the attack run. Unlike ballistic warheads, the HGB will remain fully manoeuvrable, changing course as needed to avoid detection, evade interceptors, and exploit terrain to mask its approach. The precise speed envisaged remains classified, but by definition a hypersonic weapon achieves speeds of Mach 5 or more. Range is also classified, but the CPS is

Photo: US Navy

A (C-HGB) launches on top of a conventional booster rocket in an early flight test in March, 2020.

generally assumed to have a similar range as the US Army's LRHW, or more than 2,775 km.

While the CPS (like the other hypersonic weapons programmes currently pursued by the US armed forces) will be armed with a conventional warhead, it is being developed under the purview of the Navy's Strategic Systems Programs (SSP) office. Given the weapon's global reach, speed and the ability to engage high value targets it is considered a strategic asset, said SSP's director, Vice Adm. John Wolfe. The new weapon is supposed to provide flexibility and tactical/strategic options to the fleet. With CPS-armed ships deployed around the globe, the USN will be capable of striking almost any point on Earth within an hour of launch. The hypersonic missiles can be launched from well outside enemy exclusion zones, such as anti-access/area denial (A2/AD) zones, which is considered especially advantageous in the Indo-Pacific region. Submarine-based CPS can be launched significantly closer to enemy shores, including from within the A2/AD zone, further shortening flight time or attacking targets deep inland. However, hypersonic missiles will augment, not replace, the current missile arsenal; each CPS armed vessel will carry only a small number of hypersonic missiles. In practice, the complex and expensive missiles will be reserved for long-range, time-sensitive or strongly defended high value targets, and to eliminate A2/AD barriers such as air-defence or anti-ship-missile installations in order to open attack corridors for more conventional weapon systems.

Operational Platforms

The CPS will be fielded aboard Zumwalt class (DDG 1000 class) guided missile destroyers and aboard Virginia class (SSN 774 class) attack submarines. Deploying the weapon from a surface ship will require a so-called 'cold start' in which the missile is expelled from the launch tube by a gas generator before firing the weapon's engine. Submarine launch is even more demanding, as the gas pressure must be strong enough to propel the missile out of the water before booster ignition. "Our first challenge was: Can we develop an air launch? Basically pressurised air to get that weapon out of a Zumwalt, right up in the air, so it lights off and we don't have all those hot gases [to deal with]. We've actually proven that we've done that testing … The next challenge is build the underwater launch," Adm. Wolfe said.

Zumwalt Class

On 17 February 2023, Lockheed Martin announced that they had received the full-scale contract to integrate the CPS weapon system on the *Zumwalt* class destroyers. The initial contract awarded in February is valued at USD 1.1 Bn. If all options under the contract are exercised, the total value will rise to USD 2 Bn. The contract will build on the early design work already being conducted by Lockheed Martin under a 2022 contract. Under the new award, Lockheed Martin – acting as general contractor – will provide launcher systems, weapon control, AURs, and platform integration support for the *Zumwalt* class. According to the Lockheed press release, the company, along with industry partners Northrop Grumman and General Dynamics Mission Systems, "is on track to provide the CPS surface-launched, sea-based hypersonic strike capability by the mid-2020s."

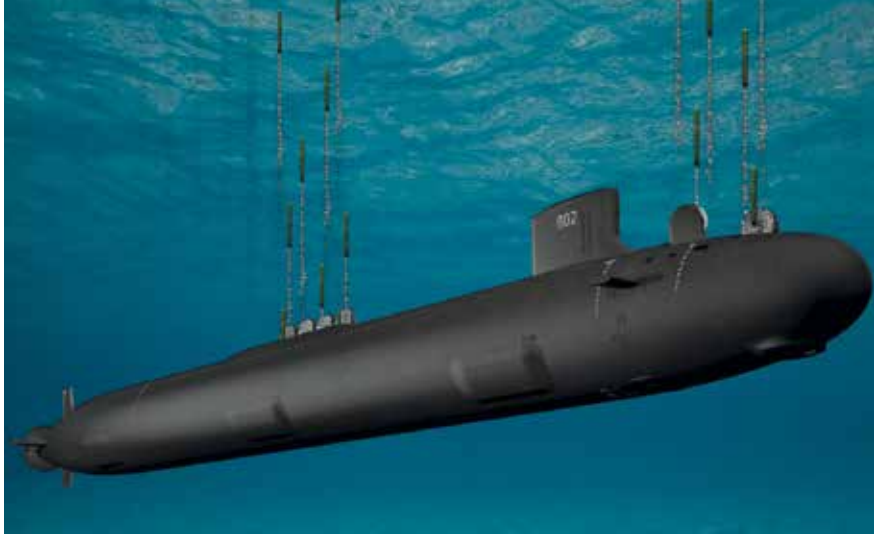
Already in January 2023 the Navy awarded Huntington Ingalls Industries (HII) a USD 10.5m contract to prepare the modernisation work on USS *Zumwalt* (DDG 1000) and USS *Mansoor* (DDG 1001). The planning phase of the modernisation project is to be completed by December 2023. Work will begin in early 2024 at HII's Shipbuilding Division facility at Pascagoula, Mississippi during the destroyers' regularly scheduled maintenance availabilities. USS *Zumwalt* enters its maintenance availability in October 2023 and will be converted first, followed by the *Mansoor*. The third destroyer, USS *Lyndon B. Johnson* (DDG 1002), will be outfitted with the CPS several years later, pending the next scheduled maintenance availability.

Credit: Lockheed Martin

Artist concept of a CPS launch from a surface warship. The image shows a notional configuration in which only one 155 mm gun turret has been replaced, while in fact both turrets will be removed.

Credit: US Navy

The Zumwalt class' two 155 mm deck guns will be removed to accommodate the CPS.



Credit: General Dynamics Electric Boat

Artist concept of mass missile launch from the Virginia Payload Modules.

Installing CPS will require significant modification of the destroyers, including the removal of both 155 mm gun turrets. This will permit installation of four Large Missile Vertical Launch System (LM-VLS) modules on the foredeck, two each on the starboard and port sides. Each LM-VLS is 2.2 m in diameter and can accommodate three AURs, for a total of 12 hypersonic missiles per ship. In addition to the gun turrets, all the associated munitions and support facilities will be removed to make room for the VLS modules and the cold-launch gas system to propel the AUR clear of the ship before firing the booster motor. "We're going down about five platforms to accommodate the height of the missile, which is significantly larger than other missiles in the inventory," said DDG 1000 programme manager Capt. Matthew Schroeder in March 2022. General Dynamics Bath Iron Works will produce the LM-VLS. The firm received a contract in August 2022 to procure long-lead materials, and is expected to deliver the modules by June 2024.

Installing the LM-VLS modules is only a first step. Integrating the hypersonic weapons into the ship's combat system is considered a major challenge. Captain Tyson Young, program executive officer (PEO) for the *Zumwalt* Integrated Combat System, is responsible for managing the modification process to enable deployment of hypersonic weapons aboard the class. Addressing the American Society of Naval Engineers on 1 February 2023, Young explained the additional procedures being planned by the Navy, beyond the structural modifications. "We're integrating an underwater weapons control system with TSC [tactical support center] control in order to affect the data and message transfer to launch the missile. We're virtualising both sets of control systems. My integrated combat system and our TSC […] are going to do lab testing next month and then we're going to do an onboard ship demo both in port and underway," Young stated.

Virginia Class

Following completed integration of the CPS on the *Zumwalt* class, the Navy plans to add hypersonic weapons to the Block V variant of the *Virginia* class attack submarines. Beginning with the second vessel, the Block V configuration will be outfitted with the *Virginia* Payload Module (VPM), a 25.5 m long section being inserted mid-hull, increasing the new attack boats' overall length to 141.5 m. The VPM will be outfitted with four in-line large-diameter launch tubes, each of which can accommodate three hypersonic weapons for a total of 12 CPS per boat. Alternately, the tubes can carry and deploy seven cruise missiles per launch tube, as well as unmanned underwater vessels (UUVs), UAVs, and special operations gear.

Adm. Wolfe stated in November 2022 that the Navy is constructing an underwater testbed for launching CPS prototypes from a VPM-representative module; it will support development of launch procedures by permitting scientists to study the hydrodynamics of the missile as it transits from the launch tube to the surface. "We're starting to build a facility to do underwater launch testing, so that we understand what that weapon will do, even before we get to the first *Virginia* [class vessel]," Wolfe told reporters on the sidelines of the Naval Submarine League symposium on 2 November 2022. The new facility will benefit from experience with existing testbeds used to develop underwater launch techniques for Tomahawk cruise missiles and Trident missiles.

Developmental Testing Progress to Date

Through 2022 the Navy has invested USD 2.6 Bn in CPS development and testing. An additional USD 1.2 Bn have been requested for 2023. The Navy is pursuing a three-step CPS acquisition programme aimed at developing fieldable prototypes and enabling a transition to production. Phase 1 is currently in progress. It consists of a Middle Tier of Acquisition (MTA) Rapid Prototyping programme to develop and demonstrate a hypersonic, cold-gas launched prototype capability. Phase 2 will be the MTA Rapid Fielding phase to introduce CPS on a *Zumwalt* class destroyer. The third and final phase will transition CPS to a major defence acquisition programme at Milestone C. This will lead to fielding the hypersonic weapon on the *Virginia* class SSNs and on the remaining *Zumwalt* class vessels.

The USN devised a master test strategy (MTS) for Phase 1 in 2019. In June 2021 the programme was placed under oversight of the Pentagon's central Director of Operational Test and Evaluation (DOT&E), although the actual testing cycle is still being conducted directly by the Navy. While the Pentagon is seeking to establish the hypersonic weapons capability as rapidly as possible, the testing cycle is moving deliberately step-by-step. The C-HGB was successfully tested in March 2020 by launching it via a conventional booster rocket from the Department of Defense's Pacific Missile Test Range in Hawaii. In 2021 the two solid rocket motor stages of the AUR booster were successfully fired in separate ground-based events at Northrop Grumman's testbed in Promontory, Utah. These three events paved the way for a series of flight tests of the full AUR.

Testing the complete AUR is being conducted jointly by the Army and the Navy through the Joint Flight Campaign (JFC). The goal of the Phase 1 test strategy is to demonstrate an operational capability of the AUR prototype utilising mission-relevant scenarios. The first joint AUR prototype-capability flight test (JFC-1), which was conducted in June 2022 from the Pacific Missile Test Facility in Hawaii, failed due to an unspecified in-flight "anomaly." Both booster stages fired successfully during the test, but the HGB did not reach its target because of an integration issue (which the Pentagon has declined to describe in detail). The Navy announced that it found and corrected the flaw within two months of the test, clearing the way for further JFC events.

Despite the USN's generally optimistic tone regarding the programme's progress, the Pentagon's testing office has expressed some scepticism. According to the DOT&E's Fiscal Year 2022 Annual Report, which was released in January 2023, "the alignment of weapon system requirements to flight test objectives across all three phases of the programme is not yet mature." Current testing continues to focus on flight performance. Neither the ground-based hypersonic-acceleration sled tests nor the flight tests performed to date incorporated operationally representative targets, notes the

Photo: Lockheed Martin

May 2021 live-fire ground test of the CPS' first stage solid rocket motor, which was developed by Northrop Grumman.

report. The same holds for the currently scheduled tests, which limits the collection of reliable lethality data. The report acknowledges that the USN is currently updating the MTS to address programmatic changes and additional performance metrics. These changes will be subject to approval by the Pentagon's testing director.

As the DOT&E notes, flight performance is only one aspect of hypersonic weapon development. Major remaining challenges include developing innovative materials that can withstand extreme environments, and heat-shielding for the outer materials as well as for onboard electronics at sustained temperatures reaching 1,650 degrees Celsius. The impact of such temperatures on aerodynamic performance is also still being studied. As part of this effort, the Navy – in partnership with the Army and other agencies – employs sounding rockets carrying experimental payloads to provide data on the performance of materials and systems in a realistic hypersonic environment. As described by the USN, precision sounding rocket launches fill a critical gap between ground testing and full system flight testing, and support rapid maturation of offensive and defensive hypersonic technologies.

Photo: US Navy

The Navy employs sounding rockets carrying experimental payloads in support of the hypersonic weapons programme. The experiments provide data on the performance of materials and systems in a realistic hypersonic environment.

Test and Evaluation Going Forward

Joint Army-Navy hypersonic missile flight tests are expected to continue through 2028, while each service simultaneously conducts its own parallel testing programme. Four additional JFC test events are planned through March of 2024. Tests JFC-2 and JFC-3 will be geared toward the Army's operational profile, while JFC-4 and JFC-5 will focus on demonstration of the CPS' cold-launch capability. These future JFCs will require an additional update to the MTS. The Navy intends to provide an overall test strategy with alignment of planned missile flights to the planned advances in missile capability for each phase of CPS delivery, including re-evaluation of performance and test objectives. This update should be presented by early FY2024.

Here, again, the DOT&E report criticises the planned approach as too narrow, stating that the Navy has yet to identify test conditions and associated test resources to be evaluated across the three CPS phases "to adequately assess lethality, [survivability] and operational effectiveness in the threat-contested environment. The Navy is considering inclusion of the threat-contested environment in Phase 1 testing, but has yet to commit due to developmental test requirements. These data are necessary to validate and use model and simulation for operational testing, and delays in data collection could increase operational test cost in later CPS phases."

Furthermore, the DOT&E criticises the Navy's failure (to date) to demonstrate the effect of a contested environment on CPS prototype performance. For Phase 1, the service intends to utilise a combination of flight environment modelling and simulation, component testing in a simulated environment, and a full hardware-in-the-loop evaluation to approximate the effect of a contested environment on the CPS prototype's performance. DOT&E notes that "the Navy has yet to provide an overarching strategy to assess CPS performance in contested environments across all three phases of acquisition, risking an inefficient test design across the three phases and the potential need for unplanned test resources in Phases 2 and 3."

Notably, the five planned JFC flight tests are all associated with CPS Phase 1. The Navy has not yet modelled a testing strategy to support programme Phases 2 and 3, although flight testing from the *Zumwalt* in 2025 has already been tentatively scheduled. The DOT&E cautions that the Phase 1 CPS prototype is insufficiently mature to assess suitability metrics, and that the office will not present its assessment of the CPS prototypes' capabilities and limitations

until completion of the Phase 1 flight tests in FY2024; the comprehensive report on the CPS operational effectiveness will be presented following conclusion of Phase 3 testing in FY2029.

Fielding

While the Navy has set specific timelines for fielding the CPS, the programme – like all other US hypersonic weapons projects – currently remains at the prototyping stage. A decision to proceed to an acquisition programme will not take place until the prototype testing verifies the technological and operational maturity of the weapon system, presumably not earlier than 2029.

This will not stop early fielding efforts. The service plans to deploy an operationally capable prototype aboard USS *Zumwalt* in 2025, and conduct a live-fire test at sea by December of that year. The ship will then continue to serve as the platform to certify the operational capability of the hypersonic weapon's deployment from the surface vessels. The Navy hopes to achieve full operational capability of the CPS on the first *Virginia* class vessel beginning in 2029 (the original goal was 2028, but this was deferred because of delays completing the first VPM-equipped submarine).

Even after achieving full operational capability, CPS will remain a niche asset. A January 2023 Congressional Budget Office (CBO) report cites Pentagon plans to acquire 240 CPS missiles (at an estimated unit cost of USD 41 M). The weapons are ultimately to deploy on three *Zumwalt* class destroyers and 19 *Virginia* class submarines (Block V plus the planned Block VI and Block VII variants), for a total of 22 CPS-capable platforms. However, the total production run of *Virginia* Block V through Block VII will not be in service until the late 2030s (if the Block VI and VII are actually procured as planned). The relatively small CPS-capable flotilla should not, however, diminish the strategic value of the weapon system. Realistically, truly 'global' reach is irrelevant for a strategic asset, as threats warranting their deployment will tend to emanate from a relatively small number of hostile actors. Furthermore, CPS is not intended to be the US military's sole hypersonic asset. Operating in coordination with land-based and airborne assets also being developed, CPS will form one leg of a new, conventionally armed but hypersonic strategic triad. ■

Photo: US Navy

The Navy employs sounding rockets carrying experimental payloads in support of the hypersonic weapons programme. The experiments provide data on the performance of materials and systems in a realistic hypersonic environment.

The Missile-Age Shield of Zeus

Doug Richardson

The sinking of the Israeli destroyer Eilat by three Raduga P-15 Termit (SS-N-2 'Styx') missiles on 21 October 1967 spurred the need for the US Navy (USN) to develop an effective counter to this new form of attack. A programme designated the Advanced Surface Missile System rapidly took shape, but was soon renamed Aegis. This was not an acronym, but a reference to an ancient Greek myth which told how the god Zeus and goddess Athena had carried an all-powerful shield of this name.

The resulting ship-defence system was deployed from 1983 onwards on the then-new *Ticonderoga* class cruisers, and teamed a new missile designated Standard Missile 2 (SM-2) with a Mk 99 advanced fire-control system, the SPY-1 passive electronically scanned multi-function radar, the Mk 1 weapons-control system, the Mk 1 command and decision system, and a launcher for SM-2 missiles.

Later examples of the *Ticonderoga* class introduced improved systems. Commissioned in February 1989, *Princeton* (CG 59) was the first to be fitted with the improved SPY-1B radar, while *Chosin* (CG 65), commissioned in January 1991, was the first to receive UYK-43 computers.

Prime contractor for Aegis was originally the Missile and Surface Radar Division of RCA, and later became the Government Electronic Systems division of General Electric, which was sold to Martin Marietta, which in turn was acquired by Lockheed Martin.

The US Navy keeps Aegis updated by a series of four-year-long Advanced Capability Build (ACB) projects. ACB 16 is the latest, and involves four incremental deliveries – Baseline 9.2.0, Baseline 9.2.1, Baseline 9.2.2, and Capability Package 22-1 (originally known as Baseline 9.2.3). This fourth delivery is intended to provide additional capabilities, and to resolve what the US Office of the Director, Operational Test & Evaluation (DOT&E) described as "technical issues with certain hardware configurations". Capability Package 22-1 was used in July 2022 when the USN conducted two SM-2 firings against cruise missile surrogate targets. ACB 16 will be followed in FY2024 by ACB 20.

Photo: US Navy

Seen from left to right, four USN Aegis ships – Vicksburg (CG 69), Roosevelt (DDG 80), Carney (DDG 64) and The Sullivans (DDG 68) – launch a coordinated volley of SM-2MR missiles.

The Aegis system software incorporates artificial intelligence (AI) features intended to detect, and identify emerging threats by exploiting electronic signatures present in the data. As new threats emerge, software updates can be transmitted to the Aegis fleet.

Modernising the Aegis fleet

The first five Ticonderoga-class cruisers had been retired by the end of 2005 – hardly an unexpected fate since they used the mechanically-trained and manpower-intensive Mk 26 dual-purpose twin-arm missile launcher. From the sixth vessel onwards, the Mk 41 vertical launch system (VLS) was installed, but retrofitting this to the Mk 26-equipped ships would have required major structural 'surgery'.

Under an upgrade programme begun in the early 2000s, the oldest VLS-armed Aegis cruisers – from *Bunker Hill* (CG 52) to *Chancellorsville* (62) – were modernised, receiving combat systems upgrades, including Cooperative Engagement Capability (CEC), an improved SPY-1 radar, and an open-architecture computing environment. They have also been given hull, mechanical, and electrical (HM&E) upgrades. Despite this, these ships are reported to be becoming unreliable and difficult to maintain because of their ageing hull and infrastructure.

A follow-on upgrade programme begun in 2015 for later vessels from *Cowpens* (CG 63) to *Port Royal* (CG 73) was intended to update the ships' combat systems and HM&E systems, and extend their service lives from 35 years to 40 years, but this scheme has experienced its own share of problems. The extent of the structural repairs due to take place on each ship once existing equipment had been stripped out was not easy to predict, particularly in the case of older vessels which were likely to be in poorer condition.

Time is running out for all the VLS-equipped Aegis cruisers. *Vella Gulf* (CG 72) was decommissioned in August 2022, followed in September by *Monterey* (CG 61), *Hué City* (CG 66), *Anzio* (CG 68), and *Port Royal* (CG 73). The re-

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Photo: US Navy

Arleigh Burke was the first US Navy Aegis destroyer. This class has a steel superstructure, so may avoid some of the structural problems faced by the aluminium-alloy superstructure of Ticonderoga class cruisers.

mainder are expected to follow by 2028. That list of decommissioned ships contains some surprising entries. *Anzio* and *Hué City* had been placed on reduced readiness ahead of planned modernisation, while *Vella Gulf* and *Port Royal* were the last two Ticonderoga-class ships to be commissioned, and had been retired after only 28 years of service.

The Ticonderoga-class cruisers are due to be replaced by Flight III Arleigh Burke-class destroyers, the first of which is due to be commissioned in 2023. Designed to incorporate an improved sea-keeping hull form, and to have a reduced infrared and radar cross section to their predecessors, the DDG 51 class has been under construction since 1985. Deliveries are expected to continue beyond 2027, giving the type the longest production run of any USN surface combatant.

DDG 51 to 71 were built to the Flight I standard, while DDG 72 to 78 were Flight II, a version able to launch and control the SM-2ER Block IV missile. DDG 79 to 112 were classified as Flight IIA. They featured Cooperative Engagement Capability (CEC), and from *Pinckney* (DDG 91) onwards were fitted with the SPY-1D(V) radar.

No DDG-51s were procured between FY2006 and FY2009, but procurement of Flight IIA standard ships resumed in FY2010 with DDG 113. The first three were classified as Flight IIA Restart vessels, while a further ten were built to the Flight II Technology Insertion standard, which featured some of the improvements developed for the planned Flight III vessels.

Ships procured from FY2017 onwards are being built to the Flight III standard. This includes a new SPY-6 radar (formerly known as the Air and Missile Defense Radar). Part of an updated AEGIS Weapon System known as Baseline 10, this is more capable than the SPY-1 variants installed on all previous Aegis cruisers and destroyers, and allows the ship to simultaneously conduct Anti-Air Warfare (AAW) and Ballistic Missile Defense (BMD) operations.

Laid down in November 2019 and launched in June 2021, *Jack H Lucas* (DDG 125) is the first Flight III standard vessel. It began sea trials in mid-December 2022, finishing these a day early because all objectives had been met. Previous trials conducted at land-based test centres in Moorestown, New Jersey, and at the Pacific Missile Range Facility in Hawaii had used only a single SPY-6 antenna array, but the December sea trials were conducted using all four arrays of the definitive system, and had identified several software issues which are expected to be solved before the next round of at-sea testing.

In the short term, the Flight III version will provide what the USN believes will be the world's best Integrated Air and Missile Defense (IAMD) combat system. Although likely to remain in service through the 2060s, these ships will have a limited ability to accept future upgrades if these require additional space, weight or power.

As with the Aegis cruisers, a modernisation programme began in 2010 with the *Arleigh Burke* (DDG 51) is providing a mid-life upgrade. This includes installing the Baseline 10 version of the Aegis Combat System with an open-architecture computing environment, and a version of the SPY-6(v)4 radar incorporating enhancements intended to improve radar performance in the littoral regions. An improved Multi-Mission Signal Processor integrates the ship's air and ballistic missile defence capabilities.

Enter the DDG(X)

Under current plans, the USN's next Aegis-equipped class will be the DDG(X) destroyers. Expected to have a displacement of around 13,500 tons, these would have the same Aegis system as the Flight III DDG 51, but would have more growth margin in terms of space, weight-carrying capacity, electrical power, and cooling capacity in order to facilitate the introduction of additional or higher-power equipment and weapons (including directed-energy weapons) during their expected service life. Options for future growth include installing Large Missile cells in place of 32-tube VLS cells, or additional VLS or Large Missile cells. Although the USN had planned to procure the first of the new class in FY2030, this date could slip to ensure that the required technologies are sufficiently mature.

Aegis Ashore

As its name suggests, Aegis Ashore (AA) is a land-based version of the system. It uses the

Photo: Huntington Ingalls Industries

Jack H Lucas (DDG-125), the lead Flight III Aegis destroyer, completed its first sea trials in December 2022.

Graphic: US Navy

This USN briefing slide shows the main features planned for the new DDG(X) class Aegis destroyers.

same SPY-1 radar, electronic systems, and vertical launcher as the Arleigh Burke-class destroyers. Intended to counter short- to intermediate-range ballistic missile threats, it is deployed at three sites: the Aegis Ashore Missile Defense Test Complex at the Pacific Missile Range Facility (PMRF) in Hawaii, at Deveselu in Romania, and at Redzikowo in Poland. The Romanian site became operational in 2016. Although the Polish site was originally due to be completed in FY2018, significant construction delays saw this date slip until FY2022.

In December 2017, the Japanese government gave the go-ahead for the planned purchase of two Aegis Ashore systems to be equipped with the new SPY-7(V)1 radar and armed with SM-3 Block IIA or even SM-6 interceptors. The chosen sites were at a Ground Self-Defense Force training area in Akita Prefecture, and the Mutsumi training area in Yamaguchi Prefecture. In practice, the plan was short-lived, and was abandoned in 2020 due to concerns over the likely damage to residential buildings that could be caused by falling spent rocket boosters.

Photo: US Navy

Located at Deveselu in Romania, this Aegis Ashore Missile Defense System is intended protect Europe against ballistic threats from Iran.

Other navies

Aegis-equipped ships are now planned or in service with Australia (three *Hobart* class destroyers), Japan (four *Kongō* class destroyers, two Atago class destroyers, and two *Maya* class destroyers), South Korea (four of six planned KDX-III *Sejong the Great* class destroyers), Norway (four *Fridtjof Nansen* class frigates), and Spain (five *Álvaro de Bazán* class frigates, and five planned *Bonifaz* class frigates).

The displacement of these Aegis-armed ships varies. At 10,600 tons full load, the Sejong the Great-class destroyers are the heaviest, and can carry 32 more missiles than the *Arleigh Burke* class, while the *Fridtjof Nansen* class frigates are the lightest at 5,290 tons full load, so carry a smaller and less-powerful version of the SPY-1 radar.

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Photo: US Navy

South Korea's Sejong the Great was the lead ship of the largest and heaviest type of Aegis cruiser, and is sized to accommodate 80 vertical-launch cells for the Standard Missile family.

Photo: US Navy

Otto Sverdrup is one of Norway's Fridtjof Nansen class frigates, the smallest and lightest class of Aegis-armed ships. It mounts a scaled-down SPY-1 radar and only eight vertical launch cells.

Most of these non-US ships operate Aegis as a defence against aircraft and anti-ship missiles; only the Japanese vessels are BMD-capable. The Japan Maritime Self-Defense Force (JMSDF) currently has eight Aegis-equipped destroyers (DDG). The first was *Kongō*, which was commissioned in 1993, and in 2006-7 was updated to handle the SM-3 block IA missile.

Built to replace the aging *Tachikaze* class destroyers, the Atago class are an improved and lengthened version of the *Kongō* class. Originally equipped with the Baseline 7.1 version of Aegis and armed with SM-2MR Block IIIA/B, they were later updated to the Baseline 9C standard in order to handle the SM-3 Block IA and IB. The *Maya* class were the first Japanese Aegis ships to be built with BMD capability from new. Under the Defense Buildup Program introduced in December 2022, the JMSDF plans to increase the number of its Aegis-equipped destroyers, by adding two more to the current eight.

In 2022, the Japan Ministry of Defense also announced that the JMSDF planned to operate two examples of what it called "Aegis system equipped ships". Intended to replace the originally-planned Aegis Ashore installations, these are expected to be in the 20,000 ton class, so will be the largest combat vessels operated by the JMSDF. Work on the first is to begin in FY2023, allowing entry into service in FY2027, followed by the second in FY2028. The only artist's impression released so far shows a ship armed only with vertical launchers, If deployed only in coastal waters, it could be protected by land-based or air assets, so would not require additional on-board weapon systems and the personnel needed to operate these.

Standard Missile 2

The Standard Missile programme was begun in the early 1960s with the intention of replacing the earlier Tartar and Terrier, which were single-stage and two-stage naval surface-to-air missiles. Taken into service in 1969, Standard MR and Standard ER physically resembled Tartar and Terrier, but were all-electric missiles and used solid-state electronics. They were soon followed into service by improved versions designated Standard Missile 1 (MR) and Standard Missile 1 (ER). Like Tartar and Terrier, these were developed by the General Dynamics Pomona Division, which was later sold to Hughes Aircraft Company, where it became Hughes Missile Systems, and which in turn was absorbed into Raytheon.

For its Aegis-equipped ships, the US developed the Standard Missile 2, which featured an inertial mid-course guidance package that receives command updates from the shipboard fire control system. This minimises the use of shipboard systems during the engagement, allowing the ship to simultaneously engage multiple threats. Each target needs to be illuminated by the ship's radar only during the final phase of the attack when the missile is being guided by its nose-mounted semi-active radar seeker.

Progressive improvements to the SM-2 missile resulted in the Block II, III, IIIA and IIIB versions. These improved missile performance against more demanding classes of target, and the Block IIIB added an infrared guidance mode to help cope with severe enemy Electronic Countermeasures (ECM).

In 1987 the USN began work on the SM-2 Block IV. This incorporated digital technology originally developed for missiles such as Patriot and AMRAAM, and added a tan-

Photo: US Navy

The Kongō was Japan's first Aegis cruiser.

dem-mounted booster with thrust-vectoring control. Development was protracted, and the missile did not achieve initial operational capability until 1999. Although a planned Block IVA upgrade was to have created dual-mode, radio frequency/infrared guidance and modifications intended to improve ABM performance, the programme was eventually cancelled in December 2001. However, the basic configuration of the Block IV version was carried over into what became the Standard Missile 3.

Photo: Missile Defense Agency

Japanese Aegis destroyer Kirishima (DDG-174) launches an SM-3 missile to engage a separating 1,000 km class ballistic missile target on 29 October 2010.

Standard Missile 3

Designed to intercept short- and intermediate-range ballistic missiles, the RIM-161 Standard Missile 3 (SM-3) retains the Mk 72 solid-propellant rocket booster, Mk 104 Dual Thrust Rocket Motor (DTRM), steering control section, and midcourse missile guidance system used by the SM-2 Block IV, but also has a Mk 136 Third Stage Rocket Motor (TSRM), and a kill vehicle that uses a long-wave infrared (LWIR) seeker teamed with a divert and attitude control thruster able to manoeuvre in the early exo-atmospheric phase of flight in order to achieve a kinetic 'kill'.

During a test firing conducted by the AEGIS-cruiser *Lake Erie* (CG 70) at the US Pacific Missile Range Facility in Kauai, Hawaii on 25 January 2001, Flight Test Round 1A demonstrated stability and control through powered flight, followed by third-stage separation and motor burn. The kinetic-warhead kill vehicle successfully detected a target which simulated an incoming ballistic missile.

Block I

Only 11 SM-3 Block I missiles were built, and the first was handed over to the US Missile Defense Agency in 22 October 2004. Following four out of five successful intercepts using prototype missiles, a Block I round launched from the Aegis cruiser *Lake Erie* on 24 February 2005 intercepted and destroyed a short-range target missile launched from the Hawaiian island of Kauai.

Early trials of the SM-3 had used unitary (non-separating) targets representative of 'Scud'-type ballistic missiles, but Flight Test Maritime 04-2 (FTM 04-2) flown on 17 November 2005 was made against an Orbital Sciences medium-range target (MRT-1) vehicle launched from the Pacific Missile Range Facility (PMRF) and had deployed a separating warhead. Lake Erie launched the second production example of the Block I missile interceptor missile, and after a two-minute flight, the kill vehicle intercepted the target warhead at an altitude of more than 161 km (100 miles) above the Pacific Ocean. The ship's Aegis system and PMRF sensors both confirmed a direct hit.

Block IA

When a US National Reconnaissance Office (NRO) radar-imaging spacecraft launched on 14 December 2006 suffered a total electrical power failure within a few hours of being launched, the US Navy was tasked with destroying the spacecraft as it began to re-enter the atmosphere in order to prevent the satellite's unused tank of hydrazine posing a potential health hazard if it landed on the ground.

A potential solution was available in the form of the Block IA interceptor, the first production version of the SM-3. This had been installed for the first time on the *Shiloh* in 2006 as part of the Aegis BMD 3.6 deployment.

One immediate problem was that the kill vehicle of the SM-3 was designed to acquire incoming ballistic missiles, which would represent a relatively hot target when seen against the background of space. The satellite would be travelling much faster than a warhead, and would be an inert cold target. As a result, a small batch of SM-3 Block IA missiles would have to be given modified on-board software, as well as additional instrumentation supplied by the US Missile Defence Agency (MDA), while the operational software of the Aegis system on the ships selected to take part in the operation would have to be replaced with a version optimised for the ASAT mission.

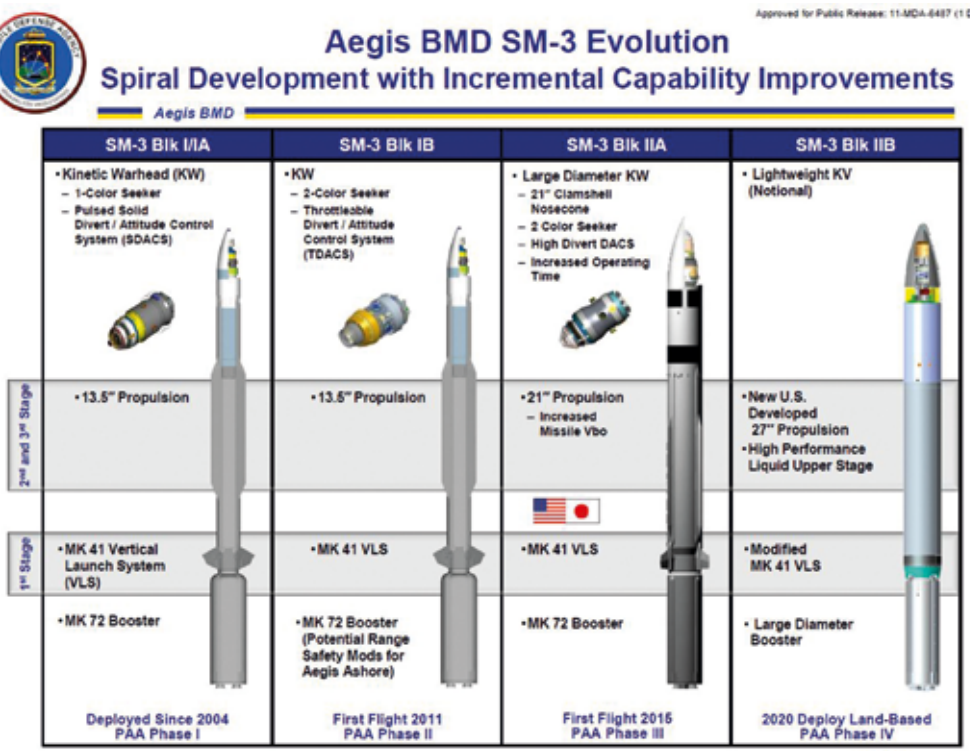
Three ships were assigned to the mission: *Lake Erie* (armed with two modified interceptors), the Arleigh Burke-class (Flight II) destroyer *Decatur* (DDG 73) armed with a single modified missile, and the *Arleigh Burke*-class (Flight I) destroyer *Russell* (DDG 59) which was to serve as an independent source of tracking data. Having detected the satellite and computed a targeting solution, at 10:26 EST on 21 February 2008, *Lake Erie* launched a single modified SM-3 missile from a location west of Hawaii. The resulting intercept took place 246 km above the earth and at a closing velocity of about 9.8km/sec. The resulting fireball suggested a hit as planned on the spacecraft's hydrazine tank.

Block IB

The Block IA missile that became operational in 2014 used a seeker that operated in a single LWIR waveband, but the Block IB developed in conjunction with Japan introduced a two-colour version teamed with an advanced signal processor, changes intended to improve discrimination between threatening and non-threatening objects. An improved Throttling Divert and Attitude Control System (TDACS) gave the kill vehicle better manoeuvring capability during its approach to the target. A follow-on SM-3 Block IB Threat Upgrade (TU) standard incorporated upgraded discrimination algorithms intended to counter more sophisticated threats.

Photo: Missile Defense Agency

Japanese Aegis destroyer Kirishima (DDG-174) launches an SM-3 missile to engage a separating 1,000 km class ballistic missile target on 29 October 2010.



Graphic: Missile Defense Agency

Standard Missile 3 has undergone a steady evolution, but the proposed Block IIB version shown at the right-hand side of this diagram was cancelled.

Block IIA

Block I and IA missiles had teamed a 53.34 cm (21 in) diameter booster stage with a 34.39 cm (13.5 in) diameter missile whose dimensions were similar to those of the earlier Terrier and Tartar. For the next-generation Standard Block IIA, the missile was the same 53.34 cm diameter as the booster, a size that remained compatible with the existing vertical launcher. The profile of the missile was fatter, but much of the extra girth represented internal volume for the additional propellant needed to provide a higher burnout velocity and greater range. It also allowed the carriage of a larger kill vehicle containing more divert fuel, and so better able to cope with higher closing speeds and manoeuvring enemy warheads, giving the Block IIA a limited capability against intercontinental-range ballistic missiles.

The latter feature was successfully demonstrated on 16 November 2020, when a trial designated FTM-44 'Stellar Lance' used a Block IIA round against an ICBM-T2 target launched from the Ronald Reagan Ballistic Missile Defense Test Site on Kwajalein Atoll, with a target location within an ocean area northeast of Hawaii, where the *John Finn* (DDG-113) was located. The ship used the Command and Control Battle Management Communications (C2BMC) network to track the incoming round via off-board sensors, then launched a single interceptor and destroyed the simulated threat.

During a follow-on trial conducted five days later, *Lake Erie* fired an SM-3 missile against a ballistic missile target that was still in the ascent phase of flight. The Aries target had been launched from the Pacific Missile Range Facility on Kauai. As it rose above the ship's radar horizon, it was tracked by the Aegis weapon system, and within two minutes after target launch, the ship fired a development-standard SM-3 interceptor. The missile's kinetic warhead acquired, tracked, and successfully demonstrated aimpoint shift control, and hit the target while the latter was still approximately 161 km (100 miles) above the ocean.

SM-3 Block IIA remains the current production variant, although deliveries for FY2021 were delayed as a result of production being halted due to an investigation into test and component anomalies, and some delivered interceptors had to be re-worked. In June 2022 the company received a USD 867 M Missile Defense Agency contract for further deliveries of SM-3 Block IIA missiles.

Block IIB

The programme to develop an SM-3 Block IIB missile began in 2010, and in the following year Boeing, Lockheed Martin, and Raytheon were awarded contracts for the concept definition and program planning phase. The new variant was intended to provide some boost-phase intercept capability against intermediate and long-range ballistic missile threats, and would be able to counter first-generation ICBMs attempting to attack the continental USA.

It soon became obvious that major changes to the missile configuration were inevitable. In order to achieve the required the desired range and burnout velocity, the Block IIB missile would have to be significantly different to the Block IIA, with a diameter of 68.58 cm (27 in). The resulting missile and its larger-diameter booster would require a larger canister that would require modifications to the vertical launch system.

At first it was assumed that the SM-3 Block IIB interceptors would be based at the existing sites in Romania and Poland, but studies soon showed that the interceptor flight path from the Romanian site was not really suitable for the task of engaging an ICBM aimed at the USA, while the Poland site might have to launch the interceptor during the boost phase of the threat missile. A more suitable location for defence of the USA would be the North Sea. An Aegis ship positioned there would not have to launch its interceptors while the enemy ICBM was still in powered flight.

A major problem in developing a Block IIB missile suitable for both land and shipboard deployment was that its third stage was likely to use liquid propellants in order to achieve the desired performance. However in 1988 the USN had banned the use of liquid rocket propellants aboard its ships due to safety issues and the likely cost of the shipboard systems needed to combat propellant fires.

Although the US Missile Defence Agency had been expected to select one of the three companies in 2013, allowing the development, testing, and eventual production of the new variant, the Block IIB project was cancelled in March of that year.

Future

Another navy is due to become an Aegis user. In May 2021 the US announced the planned sale to Canada of four sets of the Aegis Combat System, four SPY-7 radars, three sets of the MK 41 Vertical Launching System, plus equipment, spare parts and technical support. This hardware is destined for use on the planned Canadian Surface Combatant, a class of frigates intended to replace the *Halifax* class multi-role frigates and the now-retired *Iroquois* class anti-air warfare destroyers. The lead ship of the new class will probably enter service in the early 2030s.

Aegis has now completed 40 years of USN service. According to Raytheon Missiles & Defense, SM-3 missiles have made over 30 successful space intercepts, and more than 400 interceptors have now been delivered to US and Japanese navies. In June 2022 the company received a USD 867 M Missile Defense Agency contract for further deliveries of SM-3 Block IIA missiles.

Assuming that the USN's DD(X) class will have a service life of 30 years, Aegis seems likely to serve until 2060 or longer – almost a century from the time when the USN began the work on what was then the Advanced Surface Missile System. ■

Reaching out: LRASM delivers improved anti-ship range to reinforce deterrent messaging

Dr Lee Willett

On 14 April 2022, the Russian Federation Navy Project 1164 Slava (Atlant)-class cruiser RFS Moskva sank after reportedly being struck by two Ukrainian Neptune anti-ship cruise missiles (ASCMs). In the Russo-Ukraine war, which began on 24 February 2022, the spotlight has fallen largely on the land campaign. However, the Moskva's sinking highlighted several factors underlining the importance of naval matters in the current strategic environment, given returning great power rivalry and the outbreak of conventional conflict.

First, even in a land-focused campaign, war at sea with ships being lost will have fundamental operational, strategic, and political impact on events. Second, the sinking underlined NATO's own long-held concern, that coupling new, long-range anti-ship missile (ASM) capability to aircraft, submarines, and surface ships presents a 360° stand-off threat to any surface ship at sea. This underlines the importance for navies of developing improved ASM capability in both defensive and offensive terms. Third, in parallel to the return of competition and conflict, several Western navies have been recapitalising core capabilities. One such capability is ASCMs. In the context of NATO seeking to enhance collective deterrence and defence and conflict returning at sea, newly emerging ASCM capabilities will play a significant role for NATO navies going forward.

ASMs can be launched from a range of platforms, including fighter and strike/bomber aircraft, large and small surface combatants, submarines, and containers fitted to vehicles or shore sites to provide mobile or fixed coastal batteries. The fact that commercial ships could also carry such containers underlines the extent of the ASM threat. ASM capability can be delivered by ballistic missiles (ASBMs) or ASCMs. Prominent Western ASCM capabilities include the Boeing/McDonnell Douglas Harpoon; Kongsberg's Joint Strike Missile (JSM) and Naval Strike Missile (NSM) family, Saab's RBS15, and Lockheed Martin's Long-Range Anti-Ship Missile (LRASM).

For the United States, and in terms of providing stand-off, air-launched ASCM capability, Lockheed Martin's AGM-158C LRASM meets the US Navy's (USN's) Offensive Anti-Surface Warfare (OASuW) Increment 1 programme requirement to deliver a long-range ASM capability. LRASM meets the requirement to deliver a "near-term solution for the [OASuW] air-launch capability gap that will provide flexible, long-range, advanced, anti-surface capability against high-threat maritime targets", according to Naval Air Systems Command (NAVAIR). LRASM is replacing the USN's AGM-88 Harpoon weapon system.

According to NAVAIR, "When operational, LRASM will provide the first increment of a next-generation offensive anti-surface weapon to the warfighter, and will play a significant role in ensuring military access to operate in open ocean and the littorals due to its enhanced ability to discriminate and conduct tactical engagements from extended ranges."

In sum, a stand-off, air-based capability like LRASM will be central to deterring and defending against long-range, surface ship-based missile threats, in the context of enabling Western surface forces and other assets to enter and push through adversary anti-access/area denial (A2/AD) 'bubbles'

Photos: Lockheed Martin

An artist's impression of LRASM attacking a surface ship target. Delivering and countering anti-ship missiles is a central element of contemporary naval operations.

Author

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that may be inflated around key maritime access points.

LRASM was conceived for two primary purposes. Broadly, it was designed to deliver a new-generation ASCM capability to target heavily defended adversary ships from stand-off range, using both pre-planned and variable attacks. More specifically, it was designed to offset the increasing surface ship threat from China's People's Liberation Army Navy (PLAN), not only in terms of countering the PLAN's growing mass in surface fleet numbers, but to offer capability for 'lancing' A2/AD 'bubbles' in key littoral regions around the first island chain in the South China Sea.

A fiscal year (FY) 2022 US Office of the Secretary of Defense Director Operational Test and Evaluation (DOT&E) report on US defence programmes, published in January 2023, stated that "OASuW Increment 1 [was] the first weapon of an incremental approach to produce an OASuW capability in response to a US Pacific Fleet Urgent Operational Need generated in 2008." "Increment 1 is an accelerated acquisition programme to procure a limited number of air-launched missiles to meet this near-term ... requirement by leveraging the Defense Advanced Research Projects Agency (DARPA) LRASM," the report added.

According to a Department of the Navy Selected Acquisition Report (produced in December 2021 and cleared for publication in April 2022) looking at the OASuW Increment 1 programme, "The development and acquisition of LRASM has been structured to be fielded at a pace relevant to maintain overmatch against long-term strategic competition."

However, since the LRASM programme was stood up in 2008, the world's threats and balances have shifted. Evolving events in the Euro-Atlantic theatre both before and during the Russo-Ukraine war have underlined the fact that surface ship threats and A2/AD constrictions are now global naval challenges, and that strategic competition is having immediate impact.

Alongside events like the sinking of the Moskva, the Russo-Ukraine war has highlighted the strategic importance of several Euro-Atlantic maritime 'choke points', in the context of A2/AD challenges. These include the Skagerrak/Kattegat Straits connecting the North and Baltic Seas, the northwestern Black Sea region between Crimea and Ukraine, and the Eastern Mediterranean region including the Bosporus and Dardanelles Straits that connect the Mediterranean and Black seas. Moreover, increased naval activity in the Barents and Norwegian seas points to the increasing strategic and operational prominence of the Bear Island Gap between Svalbard and Norway, reiterating too the enduring importance of the Greenland-Iceland-UK Gap. In the event of wider conflict across the Euro-Atlantic theatre, each of these regions would likely be significant in strategic and operational terms, with ASM capability required to either enable access through any A2/AD 'bubbles' or to provide a defensive barrier to prevent adversary forces' break-out.

LRASM offers several core capabilities with clear relevance to operating in A2/AD environments. First, when coupled with aircraft, submarines, or surface ships, it provides 'stand-off' capability for operating around or through any such 'bubbles'. Second, reflecting the practicalities of fighting inside an A2/AD 'bubble' where communications may be denied or where Western forces may wish to reduce their own electronic signatures, LRASM is designed to operate within such environments. "The weapon reduces dependency on intelligence, surveillance and reconnaissance (ISR) platforms, network links, and GPS navigation in electronic warfare environments," said NAVAIR. "Semi-autonomous guidance algorithms will allow it to use less-precise target cueing data to pinpoint specific targets in the contested domain."

LRASM is pictured being launched from a US Air Force B-1B Lancer strategic bomber. The missile first reached operational capability onboard the B-1B, with EOC achieved in December 2018.

According to Lockheed Martin, in the contemporary operational environment, LRASM meets the requirement to penetrate sophisticated air defences, including providing precision guidance and targeting, and can deliver day/night and all-weather capability. Moreover, it is designed "to interdict a variety of surface threats at very long range, navigating semi-autonomously to the target, and delivering a precise payload from safe, stand-off range".

Family system

Like other ASCMs, LRASM is developed from a family of missiles. In LRASM's case, the Joint Air-to-Surface Standoff Missile (JASSM) was the baseline system, although LRASM's internal componentry is very different.

Reflecting the broad operational requirements in applying ASM capability and the broad range of platforms that can deliver ASM effect, LRASM is being deployed on the USN's aircraft carrier-based Boeing F/A-18E/F Super Hornet fighter aircraft and the US Air Force (USAF) land-based Rockwell B-1B strategic bomber. Carrier-based F/A-18 deployment will provide the flexibility to manoeuvre the capability around and into A2/AD 'bubbles'. B-1B deployment will provide, in particular, the ability to reach targets at greater distance, including deeper into hostile environments.

Operational deployment on these two airframes was achieved under an Accelerated Acquisition contract, designed to generate early operational capability (EOC). Using the LRASM 1.0 baseline variant, EOC was achieved in December 2018 for the B-1B and November 2019 for the F/A-18E/F.

NAVAIR is looking at other air-basing options, including the Lockheed Martin F-35 Joint Strike Fighter. According to Lockheed Martin, initial fit checks have been completed, within an ongoing integration assessment. Integration efforts also are underway to certify LRASM for the USN's P-8A Poseidon maritime patrol aircraft.

Reflecting the broad deployment options an ASM capability can generate, and the need to spread such capability to help deter an adversary and complicate their planning, the United States is also investing in surface launch options. These include: using in-service Lockheed Martin Mk 41 vertical launching system (VLS) modules, with integration including fitting LRASM with a Mk 114 booster; and developing a deck-mounted launcher.

LRASM is designed to bring range, survivability, and lethality. "Coupling those inherent features with the ability to launch from multiple platforms provides a significant deterrence value to US and allied warfighters in any domain," Jay Pitman, Lockheed Martin's vice-president for Air Dominance and Strike Weapons systems, wrote in an online paper published by the company in September 2022.

Requirement to deploy ASM capability, including across multiple domains, is growing across Western navies. Adaptable capabilities like LRASM are having an impact, here. For example, Australia ordered LRASM for its own F/A-18F Super Hornets, operated by the Royal Australian Air Force (RAAF). The in-development surface-launched capability also provides an option for fitting LRASM across the Royal Australian Navy's surface fleet, including its Hunter-class future frigates and in-service Hobart-class guided-missile destroyers (DDGs) and FFG 7 Anzac-class frigates. According to a Naval News report published during the Indo-Pacific defence exposition in Sydney in May 2022, Lockheed Martin has also proposed an adapted version of LRASM to be fitted on the M142 High Mobility Artillery Rocket System (HIMARS) to meet Australian Army ground-based strike capability requirements.

These options demonstrate the design and requirements flexibility LRASM offers. The potential capacity to deploy a capability like LRASM across different Western countries, across different domains, and across different platforms illustrates the US-led Western focus on generating distributed operations and lethality to offset adversary mass, including around (for example) maritime choke points that may be covered by A2/AD 'bubbles'.

"Ensuring LRASM is capable and integrated across a wide array of domains and platforms (like F-35, P-8, and HIMARS) represents a key facet of our roadmap," a Lockheed Martin spokesperson told ESD on 21 February 2023.

ASM capability

LRASM delivers a 454 kg (1,000 lb) blast/fragmentation warhead. Its sub-sonic speeds, when combined with a low radar cross-section airframe design and anti-jamming capability, help reduce its signature and improve its stealth in contested airspace. Once launched, LRASM navigates to a waypoint using GPS, and then uses a combination of sensors – including radio-frequency (RF) sensing and semi-autonomous optronic/infra-red multi-mode seekers – to locate, identify, and strike targets. LRASM is also fitted

An artist's rendering of an F-35 Joint Strike Fighter (JSF) carrying Lockheed Martin JASSM and LRASM missiles. Fitting LRASM to JSF shows how the USN is seeking to spread anti-ship capability across air and surface platforms.

with a datalink. While LRASM's range is not confirmed publicly, its reach, especially when deployed onboard aircraft, allows target engagement at distance, in principle beyond the range of adversary direct counter-fire capability.

Advancing LRASM through different variants, and adding improved capability including increased range, is critical to out-pacing adversary threats.

Currently, there are three LRASM variants. LRASM 1.0 is the baseline system. In September 2020, a live LRASM 1.0 missile was test-launched during Exercise 'Valiant Shield', off Hawaii. The exercise, hosted by US Indo-Pacific Command (INDOPACOM), is designed to build Indo-Pacific security and stability.

Under an incremental upgrade to deliver LRASM 1.1, the second variant, missile hardware and software improvements are being introduced to enhance targeting capabilities. The LRASM 1.1 programme also is focused on augmenting operational realism within the modelling and simulation infrastructure used to support capability testing and development.

A current area of focus for the USN and US Department of Defense (DoD) is integrated operational test and evaluation (IOT&E) on LRASM 1.1 configuration set against expected operational requirements. Flight test events to support this process commenced in October 2021. In 2022, aircraft captive carry and free-flight testing took place to capture telemetry data to support IOT&E development. The test process included, in August and September, F/A-18E/F aircraft launching three inert-warhead LRASMs at mobile maritime targets, with a view to collecting telemetry and impact data. According to the FY 2022 DOT&E report, LRASM 1.1 EOC declaration is scheduled for the first quarter of FY 2023.

The third version, LRASM C-3, is focused on improving land-attack capabilities while reducing unit cost. According to the DOT&E report, C-3 variant concept of operations development is still to be completed. The report added that an integrated test shot for C-3 is planned for the first quarter of FY 2024, followed by EOC scheduled for the fourth quarter of FY 2024.

While LRASM development is ramping up, the realities of the changing nature of contemporary combat are reflected in the fact that the USN's OASuW programme Increment 2 requirement is targeting development of a hypersonic anti-surface warfare (ASuW) capability, under a programme known as the Hypersonic Air-Launched Offensive (HALO) ASuW requirement. Hypersonic capability – in sum, increased speed – is required to offset emerging air defence threats bringing increased range and sophistication; such capability will also provide greater responsiveness in tackling time-urgent targets. LRASM 1.1 has been funded until an Increment 2 programme of record is established.

LRASM is delivering a significant augmentation in ASM capability for the USN. The question – as it is with every programme, given the implications of the first full-scale conventional war in Europe in almost 80 years – is how well positioned the LRASM programme is to keep up with accelerating requirements in terms of delivering new capability, in numbers, and as fast as possible, to prepare for the practicalities of a 'hot' fight. Speaking at the inaugural Paris Naval Conference at IFRI (the French Institute for International Relations) on 18 January 2023, alongside his chiefs of navy counterparts from the USN and French Navy, UK First Sea Lord and Chief of the Naval Staff Admiral Sir Ben Key said "Loss at sea is an inevitable outcome of brutal war, and that is what happened to the Moskva, and we need to adapt." The Russo-Ukraine war has demonstrated that technology is being introduced quickly and is changing quickly. However, in more conventional military terms, the war has shown that significant amounts of ordnance will be expended quickly and that ships will get hit. ■

A VLS-launched LRASM is test-fired from a surface ship. Deck-mounted launchers can also be used to provide surface ship strike capacity.

Polish Navy Charts a Better Course

Grzegorz Sobczak

In the Polish Armed Forces, the Navy receives the least investment. Even today, when Poland has increased its defence expenditure, the Navy remains lagging behind the land and air forces. However, the Polish Ministry of Defence has recently started paying more attention to the Navy's needs.

Photo: Polish Navy

ORP Ślązak corvette – one of the more modern vessels in the Polish Navy.

Currently, two of the most important ships of the Polish Navy are the *Olivier Hazard Perry* class frigates, ORP Gen. K. Pułaski (272) and ORP Gen. T. Kościuszko (273). Both were built in the late 1970s, and entered service in 2000 and 2002 respectively; both are now close to the end of their service life. Additionally, two relatively new Polish-built corvettes, ORP *Kaszub* (240) 620 type, ORP *Ślązak* (241) 621M type and ORP *Kadm. X. Czernicki* (a mine countermeasure forces command vessel) are still in service. There is also a fleet of smaller auxiliary ships. Some of the most modern pieces of equipment in the Polish Navy are two batteries (each comprising six launchers) of NSM anti-ship missile systems, which were acquired in the last decade.

The growing military threats of recent years have accelerated some programmes and certain decision-making processes. However, the country's land forces remain the most important branch for the Polish Ministry of Defence (MoD), though the Navy is now recognised as being more important than in the past, especially after the Nord Stream 1 and 2 incidents, and also in light of Poland's close cooperation with South Korea in recent weapon systems delivery. Once Sweden and Finland finally become NATO members, the position of the Polish Navy will be more comfortable.

An indication of the changing position within the Polish MoD is the contract signed with Saab for two SIGINT (Signals Intelligence) ships, based on HSwMS Artemis, with delivery planned for 2027. Information about this equipment is confidential, but Poland will spend about EUR 620 M overall.

New frigates

The most important programme involving the Polish Navy's fleet development is the *Miecznik (Swordfish)* frigate programme. In February 2022, from the offered British Babcock Arrowhead 140PL and the Spanish Navantia F-100PL (made by German TKMS MEKO A-300PL), the Arrowhead 140 was chosen, and Babcock became the partner of the Polish frigate manufacturer, PGZ-MIECZNIK consortium, comprising PGZ Stocznia Wojenna (PGZ Naval Shipyard) and Remontowa Shipbuilding.

The Arrowhead 140PL project, based on the British Type 31 frigate, represented a starting point in the development of the final technical requirements for the *Miecznik* frigates. From the outset in March 2022, the conceptual design was developed to improve the manufacturing and maintenance capabilities of PGZ Stocznia Wojenna with the company upgrading its infrastructure, which includes the modernisation of its production halls, the construction of a completely new final assembly, and new equipment line hall.

At the same time, in separate proceedings, an integrated combat system was selected from offers made by, inter alia, Saab, Lockheed Martin and Thales. In the end, Poland selected the Thales TACTICOS (Tactical Information and Command System).

In the second phase of the *Miecznik* frigate programme, based on a proposal from the Polish Armed Forces, the consortium will develop an initial design with a technical and cost analysis included. Additionally, the production potential of the PGZ Naval Shipyard will be increased. This phase was understood to have been completed in January 2023.

The programme's third phase is to build a first frigate – the prototype – equipped with an integrated combat system and be able to conduct qualifying trials. The first metal sheet cut for the first frigate should be made in August 2023 and the manufacturing process should be completed in June 2027. After that, 11 months of trials are scheduled. These will include shipyard captive tests, sea and qualification tests. The overall trial programme will be com-

Photo: Polish Navy

ORP Kadm. X. Czernicki is a mine countermeasure forces command vessel.

Photo: Grzegorz Sobczak

Model of Miecznik frigate based on the British Arrowhead 140.

pleted with delivery of the first ship in June 2029. The delivery of the next two ships is scheduled for September 2029 and August 2030. Combat system integration and trials should be completed by August 2033. All three frigates will then enter into service with the Polish Navy in 2034.

The Polish Navy's *Miecznik* class frigates will be 138.7 m in length, with a 19.7 m overall beam, and 5.5 m of draught with maximum ship displacement of 7,000 tonnes. Naval personnel numbers are planned to be between 100 to 120, with a total crew complement of 160, including helicopter aircrew or Special Forces operators required for specific missions.

The power plant comprises four diesel engines providing power for a maximum speed up to 28 knots (51.9 km/h). The ship will be fully autonomous on 30-day-long mission without resupply at sea and its range of operations will be 6,000 NM (11,112 km) at 18 knots (33.3 km/h).

Miecznik class frigates will have radiolocation systems with increased capabilities compared to the Arrowhead 140. Polish ships will receive three coordinate X-band NS50 radars, with rotating antennas on the top of the mast, and Sea Master 400 S-band radar with four wall antennas, which will bring equipment on these ships closer to AEGIS combat systems.

The anti-air armament of *Miecznik* class ships will be mounted in Lockheed Martin Mk41 Vertical Launch System (VLS) cells, and will comprise the MBDA Common Anti-Air Modular Missile (CAMM), produced in cooperation with Polish company, Mesko. The same missiles will be used in the Polish SHORAD Narew system. Anti-ship capabilities will be provided by Saab RBS-15 missiles, as well as EuroTorp MU90 Impact light anti-submarine torpedoes, which are currently used by the Polish frigates *Kościuszko* and *Pulaski*, as well as Mi-14PŁ and SH-2G Super Seasprite helicopters. Armament will be the Leonardo OTO Melara Super Rapid cal. 76.2 mm gun and the OSU-35 35 mm cannon, developed by Polish industry.

Miecznik class ships will be equipped with a helicopter deck and hangar for rotorcraft selected in the Kondor programme, which is currently in progress.

Minehunters

One of the most important programmes developed by Polish shipbuilders and ordered by the Polish Navy is project no. 258, which involves the *Kormoran* class minehunter. The Polish Navy has never previously used ships developed specifically for this task, but previously minesweepers from 13. Minesweeper Squadron have been used in the role since 2000, when they were upgraded to their current standard.

The contract for one prototype and a further two serial production ships was signed in 2013, with the manufacturing process starting the following year. The first ship was launched in 2015 and in 2017, it entered Polish Navy service after manufacturer and qualification trials. The ORP *Kormoran* (601) is the first programme fully developed by Polish Shipbuilders after a break of 23 years.

The *Kormoran* class is 58.5 m in length overall, has a beam of 10.3 m, and 2.7 m of draught, with maximum ship displacement of 830 tonnes. The ship is powered by two MTU 8V369TE74L diesel engines developing 970 kW for the ship to reach speeds up to 15 knots (27.8 km/h). The second project, no. 258 vessel, ORP Albatros (602) entered service in November, and the third, ORP Mewa (603) in December 2022. In March the same year, the Polish Navy signed another contract for the next three *Kormoran* class ships.

The heart of all systems of the *Kormoran* class is the Ship Combat Tactical – Minehunter (SCOT-M) combat management system developed by Ośrodek Badawczo-Rozwojowy Centrum Techniki Morskiej (OBR CTM, Research and Development Department of Maritime Technology Centre). During tests, the system was significantly upgraded, especially its command centre.

With mine hunting and mine detection in mind, the ship uses three devices: Kongsberg Hugin 1000 AUV, equipped with HISAS 1032 (High Resolution Iterferometric Synthetic Aperture Sonar); the remote controlled Saab Double Eagle Mk III with dual-frequency, broadband sonar with antenna assembly SHL-300; and the SHL-101/TM – a triple frequency wideband, high resolution

Photo: Polish Navy

Newly-built project no. 258 Kormoran class minehunters during sea trials.

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Photo: Grzegorz Sobczak

Core elements – artillery turret and optronic head – of OSU-35K presented at the MSPO 2022 exhibition.

hull-mounted MCM sonar, both developed by OBR CTM.

In the serial production ships ordered, the Hugin 1000 and SHL-101/TM hull-mounted MCM sonar are also used, but the Double Eagle has been replaced by Teledyne Marine Gavia with Edge Tech 2205 side-scan sonar. The last device is well known to Polish Navy minesweeper squadrons, as all three Project 206FM minehunter vessels received one Gavia each in 2013.

Additionally, the serial production ships received the Kraken Robotics Katfish-180 Synthetic Aperture Sonar towfish. The Polish Navy purchased only one set to install on one of these two ships. An additional set will be purchased to be mounted on one of the second batch of *Kormoran* class ships (604-606), meaning each squadron will be equipped with Katfish-180 sonar.

Detected mines can be destroyed by naval divers delivering explosive materials near the identified object. To support the divers, ships are equipped with a hyperbaric chamber and 6.2-m-long jetboats. The second solution for mine destruction is to use the Saab Double Eagle Semi-Autonomous Remotely Operated Vehicle (SAROV), which can deliver Toczek mine countermeasures. The third solution is the use of Głuptak self-propelled, single-use explosives developed by the Gdańsk University of Technology.

The cannon armament installed on the prototype has been the ZU-23-2MR Wróbel 23 mm system, but serial production ships are receiving the newly developed OSU-35 system. Air defence is provided by Grom VSHORAD missiles.

On-board OSU-35K

The Polish defence industry is currently developing its own programme of maritime cannon armaments. PIT-RADWAR and ZM Tarnów have been working together on the naval air defence artillery system OSU-35K, which uses carbon fibre-epoxy composites widely, with the whole turret structure fabricated using the technology. The OSU-35K has its own fire control system which uses TV and IR camera, a laser rangefinder with high measurement frequency (30 Hz), video tracker and an IKZ-50P IFF system integrated in the optronic head, the ZGS-35K. PIT-RADWAR has developed effective stabilisation for the optoelectronic system. The AM-35K cannon is used in the OSU-35K, and is based on the Oerlikon 35 mm barrel. The system is equipped with a belt-fed dual-feed mechanism, so the cannon can use two kinds of ammunition – air bursting munitions (ABM) and sub-calibre ammunition.

The OSU-35K is designed as a universal VSHORAD system. It can operate against aircraft as well as cruise missiles and is equipped with its own BSKO-35K fire control system, however on *Kormoran II* and *Miecznik* class ships, it will be integrated with the ship's combat management system. PIT-RADWAR is working to integrate the OSU-35K with TACTICOS CMS, which will be used on *Miecznik* class frigates.

In November 2022, a new system was installed on the ORP *Albatros* (602), the second in the series of *Kormoran* class ships. In February this year, the third minehunter, ORP *Mewa*, was delivered to the Polish Navy with a final configuration of OSU-35K. In 2023, the system will undergo a series of operational tests. PIT-RADWAR plans to build two turrets initially to install on board the ships mentioned above. Plans for the near future cover three more minehunters, as well as three new frigates.

Photo: Polish Navy

ORP Orzeł is the last submarine in the Polish Navy. Out-dated and defective, it is waiting to be replaced by new submarines selected under the Orka programme.

Submarines Await a Decision

The greatest limitation regarding Polish Navy capabilities is the number and age of its submarines. In the summer of 2021, the last two of the three *Kobben* class submarines were withdrawn from service. Since then, Poland is operating just one Soviet Kilo class submarine, the ORP *Orzeł* (291), built in 1986. The submarine's combat capabilities are very limited, and it can only be used to maintain crew skills.

In the past decade, the acquisition of two new submarines with cruise missile launch capabilities, known as the Orka programme, has been a priority for the Polish MoD. As a temporary solution in 2019, Poland negotiated with the Swedish Navy to receive HSwMS *Östergötland*, an A17 type submarine. Since Sweden did not agree to the Polish MoD's conditions, the acquisition

did not go ahead. In 2018, because the Polish MoD was focused on a new frigate programme, then submarines, the Orka issue disappeared from the public domain. The only important and available piece of information is that the programme is still in the Polish Armed Forces Modernisation plans (2021-2035). The value of this contract is estimated at around EUR 2 Bn.

However, the Polish MoD is still considering the Orka programme, with three major manufacturers continually offering their products. These include Naval Group's Scorpene class submarine with NCM missiles, the thyssenkrupp Marine Systems Type 212CD of, and the Saab Kockums A26 type. Following Spanish company Navantia's 2021 launch of its first S-80 type submarine for the Spanish Navy, it was rumoured in 2022 that Navantia was being mentioned as a potential partner in the Orka programme.

Naval Aviation

A totally separate chapter belongs to Polish Navy aviation. Its relatively modern aircraft include the M28 Bryza in maritime patrol, transport, and ecology patrol versions, as well as PZL W-3WARM SAR helicopters, which have been regularly upgraded to the newest version by PZL Świdnik. The rest of the fleet is close to their end-of-service life or should have been withdrawn years ago, but remain in service to complete certain unique requirements – these include the Mi-14PŁ and Mi-14PŁ/R, Kaman SH-2G Super Seasprite (ship-based helicopters), and old Mi-2s.

In the second half of 2023, the delivery of four new AW101 Merlin helicopters is expected to take place. According to the contract signed in 2019, Leonardo is expected to deliver these aircraft by 2022, however, due to COVID lock-downs and broken supply chains, delivery is delayed. The Merlins are intended to be used on anti-submarine, SAR and combat SAR operations.

The equipment foreseen for these aircraft has not been revealed, except for the low-frequency dipping sonar Folding Light Acoustic System for Helicopters (FLASH) delivered by Thales. Leonardo's Seaspray series 7 multi-mode Active Electronically Scanned Array (AESA) radar fairing can be observed under the fuselages of Polish Merlins tested in Yeovil, UK.

All four helicopters are now in the flight test phase of the programme. Pilots have passed theoretical training, and are currently training on AW101 flight simulators in Norway. Operators of the Thales anti-submarine systems are undergoing training in France.

Photo: Leonardo Helicopters

AW101 for the Polish Navy during flight tests in Yeovil, UK.

With 10 Mi-14s in need of replacement, in addition to these four AW101 aircraft, more Merlins can be expected in the near future.

Besides its fleet of anti-submarine and combat search-and-rescue (CSAR), the Polish Navy needs lighter ship-based helicopters, which will be purchased under the *Kondor* programme. The Polish MoD plans to procure four to eight helicopters with maximum take-off weight (MOTW) of up to 6,500 kg to replace the Kaman SH-2Gs received together with *Oliver Hazard Perry* class frigates. Included in the potential offers are the Bell UH-1 Venom, Airbus Helicopters AS 565 and Leonardo AW159. Helicopters purchased in the *Kondor* programme will be operated from *Miecznik* frigates.

The Polish Navy also plans to purchase tactical, medium-range UAVs in the Gryf programme. The Defence Ministry is keeping silent about this procurement process, however, during MSPO 2022, two potential offers were presented. WB Group signed an agreement with British joint-venture company U-TacS (Elbit Systems and Thales) to jointly offer the Watchkeeper X UAV. The other was the Falco EVO offered by Leonardo.

Elsewhere, some topics have disappeared from public discussions and one of them is the requirement for fixed-wing aircraft with anti-submarine warfare capability. In 2017, the Polish Armament Inspectorate opened a procedure concerning the potential acquisition of three maritime patrol/anti-submarine warfare (MPA/ASW) fixed-wing aircraft with a delivery schedule starting in 2019.

Photo: Polish Navy/Michał Pietrzak

SH-2G Sea Sprite helicopters should be replaced soon as part of the Perkoz programme of onboard based helicopters for the Polish Navy.

Running Light – Fighting the Growth and Weight Spiral

Mark Cazalet

As peer warfare in Europe has reared its head in the wake of Russia's invasion of Ukraine, the pressure on the West's armed forces to modernise their ground vehicle fleets has increased. Militaries turning to industry to meet these requirements have often found that while modern offers are much more capable than those of yesteryear, they are also typically much heavier. This article examines and evaluates some of the approaches aimed at tackling this problem.

Offers aimed at meeting modern armoured fighting vehicle (AFV) requirements have included a mix of upgraded and new-design platforms. Compared to legacy vehicles, common contemporary vehicle requirements include more and better passive armour protection, larger weapons, more capable sensors in greater quantities, active protection systems (APSs), sophisticated networked radios, and various other functionality-adding subsystems. These have in turn necessitated more powerful engines to maintain mobility with the increased weight of the armour and mission systems and to meet their power supply demands.

Photo: GDUK

While offering far greater capabilities than the CVR(T) Scimitar Mk2 it replaces, the Ajax will nonetheless lack the strategic mobility of its predecessor due to its vastly greater size and weight.

Photo: KMW

Although offering greater firepower and protection than even the most modern Marder variant, the Puma has paid a price in increased weight.

More powerful engines often consume more fuel and thus necessitate the addition of auxiliary power units (APUs) or batteries to provide adequate power to the mission systems without relying on the engine alone. Additionally, modern AFV diesel engines and transmissions have become about as small as they can realistically be with present-day engine technology, thus eking more power out of the same weight and volume of engine has become very difficult. All of this means that unless a radical new powerpack design arrives on the scene, it will become more and more difficult to make AFVs heavier while maintaining existing dimensions and mobility characteristics.

The results of increasing capability requirements can be seen when comparing modern AFVs to their legacy counterparts. For comparison, the German Marder preproduction vehicles had a combat weight of around 27.5 tonnes, which increased over time to 33.5 tonnes with Marder 1A3, to an eventual weight of 37.4 tonnes with Marder 1A5. The Marder's intended replacement, the Puma IFV, may appear to have bucked this trend when looking at the vehicle's weight of 31.45 tonnes with the 'A' (air-transportable) armour kit fitted. This 'A' kit should suffice for counter-insurgency operations, and allows the vehicle to remain light enough to be airlifted by A400M. However, peer combat would realistically require the 'C' (Combat) armour kit to be fitted, which raises the combat weight to 43 tonnes. As a more extreme comparison, the UK's Ajax has a combat weight of around 42 tonnes, which is several times greater than the 12-tonne CVR(T) Scimitar Mk2 it replaces.

With the partial exception of some recent Main Battle Tank (MBT) designs being lighter than previous designs, broadly speaking most new armoured vehicles have been heavier than their last-generation equivalents. With the time and expense involved in training a modern soldier and the smaller sizes of modern armies, highly demanding vehicle requirements are not a surprise. Yet it should also be apparent that such weight increases are fundamentally unsustainable. Heavier vehicles typically consume more fuel than lighter vehicles, and wear out driveline or running gear components more quickly, both of which require a larger logistics

Photo: Elbit

As can be seen with light vehicles in particular, the adoption of 'left of boom' solutions such as hard-kill APSs will not necessarily lead to a weight decrease, since the APS is dealing with a completely different set of threats to the passive armour. As such, both are needed if the user requires maximum survivability.

footprint to address. Heavier vehicles may also find some civilian infrastructure such as bridges impassable, tend to get bogged down in muddy ground more easily, and often lack amphibious capability.

Such vehicles may also be too heavy for deployment by commonly-available transport aircraft. Even in cases where the aircraft may be physically capable of carrying the weight of a particular vehicle, the aircraft's loading ramp weight limit is usually lower than the aircraft's total payload, which precludes loading and offloading such heavy vehicles conventionally.

Overall, there are numerous incentives for militaries to shed a few tonnes where they can. Despite numerous efforts, this so far has proven a challenge for modernising militaries, yet there remain a number of avenues which show some promise in this regard:

- Encouraging more 'left of boom' protection solutions (such as signature management and APSs) over passive armour.
- Switching from manned to unmanned turrets.
- Switching from steel to Composite Rubber Tracks (CRTs).
- Development of Unmanned Ground Vehicles (UGVs) for some roles.
- Designing vehicles with smaller crews.

Slimming Down

The relationship between adoption of 'left of boom' solutions and decreasing gross vehicle weight (GVW) has so far remained more theoretical than practical. While plenty of companies have offered APSs, or products aimed at lowering vehicles' thermal, acoustic, and radar signatures, typically such measures have been taken in addition to high passive protection, rather than supplanting it. Consequently, vehicles equipped with these can end up even heavier than their 'right of boom' focussed counterparts. In some ways, this is not a surprise – while signature management solutions can be highly effective, they are still rather risky to use when they are the vehicle's main or only form of protection. For APSs, the problem is that on all armoured vehicles with the partial exception of tanks, they are primarily intended to deal with a different set of threats than the passive armour. On a typical 8×8 or medium-weight tracked IFV for instance, APSs will be needed to provide protection against rocket-propelled grenades (RPGs) and anti-tank guided missiles (ATGMs), but the vehicle will still require passive armour to withstand heavy machine guns or automatic cannons. Given that nothing about this division of responsibilities seems likely to change in future, adopting 'left of boom' protection methods is unlikely to fulfil the promise of weight decreases for armoured vehicles lighter than tanks.

The switch to unmanned turrets offers more promise, as unmanned turrets can be made much smaller and more compact than their manned forbears. This smaller size usually means a lower weight at the outset, and also provides a lower surface area which needs to be armoured, lowering weight even further. Added to this, the armour fitted to unmanned turrets can be less protective and therefore lighter than a manned equivalent, by virtue of the lower risk involved. Penetration of an unmanned turret can result in damage or destruction of the turret's systems, but in most scenarios is unlikely to directly result in loss of life. Unmanned turret designs also offer several other benefits, such as not requiring a large turret ring, or a basket for the crew, meaning that they can be fitted to a greater range of vehicles. Additionally, due to their lack of crew, unmanned turrets often have greater internal and external volume available for mounting mission systems, weapons, or ammunition. As such, these advantages have been sufficient to convince a number of militaries worldwide that the benefits of unmanned turrets can outweigh the local situational awareness and civilian interaction benefits of allowing crew to operate with their heads out of the hatches.

Staying on Track

Composite rubber tracks (CRTs) are a relatively cost-effective means for unsprung weight reduction. To give a recent example, Hanwha stated that their upcoming K9A2 self-propelled howitzer (SPH) had a GVW of 47 tonnes with CRTs, versus 49 tonnes with conventional steel tracks. This considerable weight saving, in conjunction the reduced rolling resistance provided by CRTs, also serves to increase the vehicle's fuel efficiency, and therefore driving range, since the engine needs to do less work to move

Photo: Rafael USA

Unmanned turrets are becoming an increasingly popular means of adding weaponry to a vehicle while keeping the weight gain as low as possible and preserving interior volume.

Photo: Soucy

Weight reduction just one among many of the benefits CRTs bring to the table when compared to conventional steel tracks.

a lighter vehicle at a given speed. The range increase can be quite significant, as shown by the results of a 2017 trial by the British Army's Armoured Trials and Development Unit (ATDU). During the tests, a ATDU drove a Warrior IFV equipped with Soucy CRTs over a 5,000 km distance using a single set of tracks, in a variety of terrain types. ATDU's results showed that compared to a Warrior equipped with conventional steel tracks, the CRT-equipped Warrior's lower fuel consumption increased range by 19% on roads and 31.9% off-road.

When multiplied across a vehicle fleet, such savings also manifest as decreased overall logistics requirements. Added to this, CRTs offer a host of other benefits, such as decreasing the vehicle's acoustic signature, as well as lowering vibration, which improves ride comfort, aids weapon stabilisation on the move and prolongs the life of more sensitive subsystems. Added to this, CRTs' decreased rolling resistance decreases wear on the engine, transmission, and final drives. CRTs also have greater longevity than steel tracks, are virtually maintenance-free, necessitate fewer track changes, no pad changes, and additionally they increase the buoyancy of amphibious vehicles. Lastly, CRTs also tend to be much gentler on civilian infrastructure such as roads, which can be heavily damaged by steel tracks.

Unfortunately, in engineering nothing comes for free, and there are some downsides to CRTs which, although relatively minor, may clash with user requirements. The first is that CRTs have a different geometry to steel tracks, and they may not fit directly on all legacy platforms without vehicle modifications. For instance, CRTs are generally thicker than steel tracks, and the required track to sponson headroom may not be available. Track width can also be challenge on legacy platforms and CRTs sometimes require a larger surface area than steel tracks to provide optimal performance. Having said this, Soucy has offered like-for-like width to ensure conformity legacy platforms, as well as with aircraft internal width or rail gauge widths, to ensure operational and strategic mobility are not compromised.

Given the aforementioned differences in geometry, CRTs are primarily aimed at vehicles under 55 tonnes, and although CRTs could still be used on heavier vehicles above 55 tonnes, these will not operate at their full potential, with lower longevity than appropriately-sized CRTs, which may not be size compatible, depending on the platform. This weight limit is due to heavier vehicles placing more pressure on the track than lighter vehicles, and thus increasing heat generation within the track, degrading it. Compensating for this additional heat generation presently requires making the track less durable than its baseline design. Despite this, depending on mission parameters and specified durability requirements, this reduced durability could potentially still be greater than conventional steel tracks, since CRTs have the durability headroom to work with. Presently, CRTs remain better-suited for tracked vehicles in the sub-MBT weight class, unless the design allows for thicker, wider tracks to be fitted.

A second problem for CRT manufacturers is how they manage heat, given the material properties of rubber. When rubber is compressed or stressed, some of the energy is absorbed in the form of friction inside the rubber. This is referred to as hysteresis loss. While hysteresis is beneficial for absorbing shocks and vibration, it also generates heating. Since rubber is also a good thermal insulator, this means the track's internal temperature can remain high for a relatively long time compared to tracks made of a more thermally-conductive material such as steel. While heat build-up can be reduced by using thinner rubber, composites or a mix of low heat generation compounds, hysteresis-induced heating will still occur, the challenge is controlling that heat build-up to a manageable point where it doesn't affect the integrity of the track.

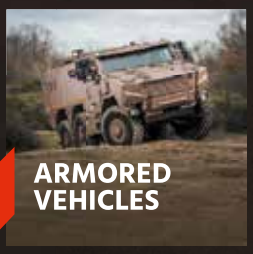
Notably, the Israeli Ground Forces decided against rubber altogether, having initially used rubber components such as bushings,

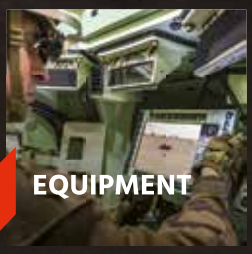
Photo: IDF

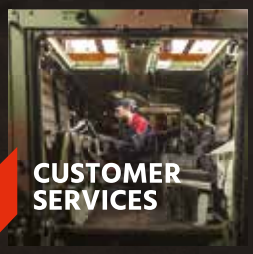
The Merkava III Baz notably got rid of rubber components in the running gear as a means of lowering the vehicle's thermal signature. While this may have been a priority for the Israelis, it will have come at a cost. Many other armed forces have continued to use rubber components in their tracks due to the material advantages they bring.

THE POWER TO CHANGE HISTORY

Nexter, the French leader in land defense, is asserting itself as an industrial prime contractor. Its range of systems and services extends from armored combat vehicles, artillery, weapons to ammunition and robotics. Nexter designs innovative solutions for land, air and sea components, in order to provide French and foreign armed forces with a decisive operational advantage.







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pads, and roadwheel tyres in their tank tracks, but then later opted to avoid any rubber components in the running gear of their Merkava Mk. 3 Baz and Merkava Mk. 4 tanks, opting for all-steel roadwheels and tracks instead. This step was taken to lower the thermal signature of the tanks as much as possible. However, given the extent to which thermal imagers have improved since the Merkava Mk.3 Baz was introduced in 1995, there is an argument to be made that such measures are no longer as effective as they were against last-gen thermal imagers.

Photo: Milrem

Milrem's Type-X demonstrates the degree to which UGVs can be made smaller and lighter than manned vehicles while retaining solid firepower.

Removing the Human

Lastly, militaries are examining the use of UGVs, which provide multiple avenues to weight reduction by virtue of their crewless design. The first major factor is size – if for example a designer wants their vehicle to fit an infantry squad, the vehicle will need a relatively high internal volume, which in turn means larger external dimensions, which in turn increases the amount of external surface area which needs to be armoured. Crewless designs inherently lack this problem, as internal volume can be entirely dedicated to weapons and mission systems. A second factor is the degree of protection required – in armoured fighting vehicle design, most vehicle protection is aimed at protecting the human occupants, rather than mission systems. Consequently, by removing the human component, the degree of passive armouring required decreases.

These factors generate a number of different synergies – if for example an army needs their UGV up-armoured, the armour package can have a much lower weight, since it has to protect a much smaller surface area. In the case of armed UGVs, these will inherently have to use either remote weapon stations or unmanned turrets, benefitting from the aforementioned weight-saving advantages these bring. Given the above, it is unlikely that UGVs would ever need to be as heavy as manned vehicles, and thus would arguably benefit the most from CRTs.

Despite their promise, there remain downsides to UGVs, with perhaps the most obvious being the need to maintain continuous communication throughout their mission. This brings with it the risks of detection by hostile radio direction-finders locating both the UGV and its remote operators, as well as the hazards of signal loss in complex terrain, jamming, and even hacking. Advances in networking, radio communications, and cyber security may serve to decrease these risks, but are unlikely to ever reduce them to zero. As an alternative approach to solving these problems, full automation would probably offer the more promising approach, however making weapon systems capable of operating fully autonomously is fraught with legal difficulties and political risk.

Although full autonomy faces barriers to implementation at present, elements of autonomy can nonetheless be incorporated into the development of smaller and lighter manned vehicle designs with a reduced number of human crew. This trend has previously been seen with the development of autoloader-equipped tanks, which typically use three instead of four crew, and are typically slightly smaller and lighter than their human-loaded counterparts, due to the volume saving permitted by automating away the human loader. The differences can be shown in the table below:

Tank Variant	Autoloader?	Combat Weight (tonnes)
Type 10	Yes	44
T-90M	Yes	48
ZTZ-99A2	Yes	54
T-14 Armata	Yes	55
K2	Yes	56
Leclerc XLR	Yes	57
Leopard 2A7	No	63.9
M1A2 SEPv3 (base configuration)	No	66.7
Challenger 2 TEST	No	74.8
M1A2 SEPv3 (with additional armour, APS, and Mine Roller)	No	83.7

Beyond autoloaders, more ambitious vehicle automation efforts are underway, with perhaps the most notable example being Israel's Carmel programme. In this future AFV programme, Israeli design efforts have coalesced around the working model of two crewmembers supplemented by sophisticated automated subsystems, sometimes referred to as 'virtual crewmembers'. Under the Carmel model, the two human crew effectively function as tactical decision-makers and the 'human in the loop' and/or manual override safeguards, while lower-level functions such as driving, navigation, and portions of the engagement cycle are automated.

This model even envisages fire control as being almost entirely automated, with the machine performing automatic target detection, tracking, ranging, gunlaying, and even recommending a particular weapon or ammunition suited to the target type, then presenting this to the crew for approval to engage. The crew are then free to modify these choices, for instance selecting a different weapon/ammunition for the engagement, but once the crew have given final approval to conduct the engagement, the machine carries out the rest of the attack autonomously. The Carmel model addresses many concerns with full automa-

tion, and doesn't suffer from many of the previously-discussed downsides associated with remotely-operated vehicles.

While promising, even a reduction in vehicle crew sizes may not be a silver bullet solution for vehicle weight reduction, since many roles, particularly Armoured Personnel Carriers (APCs) and Infantry Fighting Vehicles (IFVs) will still require a vehicle with a large internal usable volume to safely transport personnel. Here, since the vehicle's weight is more dependent on the dismounts than crew, reducing the crew is likely to result in only modest gains. Added to this, since APCs and IFVs are some of the most commonly-used vehicle types, it makes sense to build families of vehicles around an APC/IFV base design, and then adapt the configuration to more specialised roles. This factor tends to favour making the baseline family design larger, both due APC/IFV being the 'default' roles, and for the vehicle being more opportunistically adaptable to other roles.

Photo: IAI

The Carmel concept, as shown here on the Carmel Phase 1 testbed, envisions two crew operating the vehicle, supported by various automated subsystems to streamline operation, improve situational awareness, and assist with decision-making.

No Exit?

While the incentives to lower vehicle weights have not gone away, it is also important to remember that modern vehicles have become heavy for good reasons. Very few armies would willingly trade in their modern tracked or wheeled AFV for their less-capable, less well-protected, and less fuel-hungry equivalents of yesteryear. Yet this is not to say that they should stop trying to reduce weight either.

As discussed, there are various weight-reduction approaches which are broadly applicable to a large number of vehicles. While pinning our hopes entirely on 'left of boom' approaches to survivability is probably not realistic, other solutions such as unmanned turrets and CRTs would seem to have gained more acceptance in the market. This does not preclude such gains from being squandered, as an engineer's one-tonne weight saving may become a military planner's invitation to add a requirement for new equipment in the name of capability growth.

Although many of the aforementioned approaches don't work universally, they can nonetheless be applied where they are likely to result in the greatest savings. For instance, MBTs stand to benefit most from crew reductions and use of unmanned turrets, which may in turn make them light enough to use CRTs, saving even more weight. APCs and IFVs may have less flexibility to change their internal volume, but they can still make some savings by implementing unmanned turrets, crew reductions, and CRTs on tracked platforms. Lastly, UGVs can be used to replace manned vehicles for tasks where loss of signal or jamming pose less of a risk.

Obstacles remain for more radical design choices, such as fully automated vehicles, but even here there is room for manoeuvre, and automation can operate as a spectrum rather than a binary choice. If it is legally and politically difficult to implement full autonomy, then implementing forms of partial or reversionary autonomy which do not include fully autonomous fire control would seem an acceptable compromise.

Other solutions, such as implementing Hybrid Electric Drive (HED) technology may also provide a means for meeting power requirements in a more weight-efficient manner. In this vein, the US Army has stated that BAE's M2 Bradley Hybrid Electric Vehicle is anticipated to improve the vehicle's fuel economy by 20% and therefore provide increased range, with no added size, weight and power demands. While this is undoubtedly promising, this particular implementation is a weight-neutral improvement, rather than outright reversing the weight trend. Going for full-electric drive solutions with current battery technology seems even less promising on the weight-saving front, since lithium-ion batteries have fairly poor gravimetric energy density and volumetric energy density compared to hydrocarbon fuels. By way of comparison, gasoline stores around 100 times more energy than a lithium-ion battery of the same weight, or around 35 times more energy than a lithium-ion battery of the same volume.

Looking ahead, battlefield pressures look set to continue incentivising the development and addition of new capabilities, yet many modern vehicles designs already lack the headroom to get that much heavier, and adding more is likely to come with a high price tag. Perhaps sooner rather than later, military planners may be forced to give more thought to what they can take away or change, rather what they can add. ■

Photo: BAE Systems

BAE's M2 Bradley Hybrid Electric Vehicle design has been stated to provide improved fuel economy and increased range over the standard Bradley without increasing weight.

EE-9 Cascavel update

Jean Auran

The Brazilian Light Armoured Vehicle, a success in the 1970s and 1980s, is searching for a new lease of life.

Engenheiros Especializados S/A (Engesa) was once a small Brazilian company building agricultural machinery, before changing direction later on by embarking on a somewhat ambitious project to build armoured vehicles. In the early 1970s, it developed a family of military vehicles that included the EE-3 Jararaca and the EE-11 Urutu. Named after the Rattlesnake, the EE-9 Cascavel is an armoured reconnaissance vehicle equipped with six wheels. This light fire support vehicle is based on a 6×6 truck chassis, comprising a rigid axle connected to the hull by double leaf springs and telescopic shock absorbers, which retains two lateral rockers. It was designed to replace the American M8 Greyhound previously in service with the Brazilian Army. The Cascavel has the peculiarity of using a maximum amount of civilian vehicle parts and shares many elements with the EE-11 Urutu armoured personnel carrier (APC). The vehicle has entered service with the Exercito Brasileiro (EB; ENG: Brazilian Army) and the Corpo de Fuzileiros Navais (CFN; ENG: Brazilian Marine Corps).

Photo: Brazilian Army

'Cascavel' translates to 'Rattlesnake', which is endemic to Brazil. It is also the name of the EE-9 armoured vehicle built by the company ENGESA, which ceased operations in 1993.

Author

Jean François Auran is a retired French Armed Forces officer and a Defence and Security Analyst.

Photo: Brazilian Army

The Brazilian Army theoretically has more than 409 EE-9s, allocated among the mechanized cavalry units. However, a maximum of 201 machines will be modernized.

The vehicle has a crew of three, with the tank commander, driver, and gunner/loader in the turret. Initially powered by a Mercedes engine, it is currently fitted with a water-cooled six-cylinder Detroit Diesel 6V-53N diesel engine producing 212 hp at 2,800 rpm mated to an Allison MT643 automatic transmission. The vehicle can reach a maximum speed of 100 km/h and has a range of over 800 km. The Cascavel has slightly thicker armour than the Urutu, with 16 mm of steel against 12 mm. This has never offered sufficient protection, but the main strengths of the vehicle are its speed and firepower. The engineers have tried several types of turrets, such as the Greyhound turret with a 37 mm gun or the American M3 Stuart tank turret from WWII. Engesa has also marketed a Cascavel variant with the French 90 mm gun from the Panhard AML to compete with more formidable armaments on the international market. This model, intended for export, triggered interest among Middle Eastern countries, with Qatar immediately acquiring 20 vehicles. The Belgian Cockerill Mk.3 90 mm turret was later installed for budgetary reasons and was produced locally. The EE-9 90 mm cannon is capable of firing high explosive (HE), high-explosive anti-tank (HEAT), high-explosive squash head (HESH), white phosphorus smoke (WP) and training shells. In addition, the Brazilian Army developed an armour-piercing fin-stabilized discarding sabot (APFSDS) round. Many developing countries have acquired this cheap armoured vehicle over the years, with its baptism by fire occurring in July 1977 when the Libyan National Army faced the Egyptian Army in a short border war. They have also been deployed in Chad and, more recently, in Iraq. The Brazilian Army deployed the EE-9 during United Nations missions in Mozambique, Angola and Haiti. A total of 1,738 were built, most of which were exported before the company's bankruptcy in 1993.

Vehicles in service in Brazil

The Brazilian Army evaluated the first eight pre-production units in 1976 and ordered an initial batch of more than 100. The Exercito Brasileiro still officially operates more than 400 EE-9 Cascavels of different models. These vehicles are now old and have relatively low availability. Several hundred vehicles are still serving with 30 mechanised cavalry regiments and squadrons. These are units used for reconnaissance and security missions, such as the 16th Mechanised Cavalry Regiment belonging to the 7th Army

Division, with two squadrons of mechanised cavalry. The Cascavel has been the subject of several modernisation projects, particularly in early 2000 with the Fênix Project. Military workshops regularly repair batches of vehicles. The Sao Paulo War Arsenal continues its primary activity of major maintenance tasks, which includes replacing components from the suspension, engine, and electrical systems, hull refurbishment, and swapping out legacy radios for Thales Sotas systems. Santa María (Rio Grande do Sul) and Rio de Janeiro technical facilities have also participate in successive renovations.

On 13 April 2022, the 8th RC Mec reported on its website that the VBR EE-9 presentation was restored after a period of inactivity. Along with this renovation, the Brazilian Army has selected the Centauro II, produced by Leonardo and Iveco under the Armoured Combat Cavalry Vehicle – Medium Wheeled (VBC Cav–MSR –8×8) programme. The Brazilian variant will have a 120 mm armament rather than the 105 mm armament which used on the original Centauro, and is also offered as an option on Centauro II. The overall need of the Brazilian Army is for 221 VBC Cav, even though only 98 vehicles will initially be acquired. The contract is worth up to EUR 2 Bn.

Photo: Brazilian Army

Maintainers carry out verification firing on renovated vehicles.

Recent modernisation projects

There have been many attempts to modernise or revitalise the Cascavel fleet with life extension of these vehicles carried out in different countries. Examples include the Israeli company Saymar Ltd, which restored Chile's vehicle fleet, or the Anham, which has repaired some Iraqi vehicles. In Brazil, the Columbus international company, created by former Engesa employees, has upgraded numerous Cascavels. The Equitron Automação Eletrônico Mecanica company and the Brazilian Army presented the EE-9U standard in 2016 at the Mostra BID Brasil exhibition. The engine installed was the MTU 6R926, developing 320 hp, which, due to its dimensions, required a raising the height of the rear hull roof, and therefore also required raising the level of the turret to allow it to traverse. It features a new steering system, air conditioning unit, run-flat tyres,

improved braking system, independent suspension, auxiliary power unit (APU), modern communications and various other changes. The original 90 mm turret system received new training controls, an anti-tank missile launcher, and a multispectral optronic surveillance system. The vehicle platform was also equipped with a night vision system for the driver.

At the LAAD Defence & Security 2019 exhibition, Ares Aeroespacial e Defesa, a subsidiary of Elbit, partnered with Equitron Automação Eletrônico Mecanica to integrate the TORC30 protected remote turret. The TORC30 was developed with the Army Technological Centre (CTEx) to engage land and aerial moving targets. The turret can be equipped with the Rheinmetall MK30-2/ABM 30 mm cannon.

Photo: Akaer

Opto's day and night vision system, installed on a prototype vehicle modernised by Equitron in 2016, was included in the eventual winning proposal.

Cascavel on the Global Stage

The actual number of vehicles in active service globally is not as high as many think. The National Guard of Cyprus purchased 124 EE-9s in four lots during the early 1980s, however, most of them are still inactive. In 2017, the Zimbabwe National Army's Cascavels were not seen on active duty when the Army led a coup d'état. The situation with Colombian vehicles is not particularly positive either, despite modifications in the early 2010s with the installation of the IGS-4S thermal sight from the South African company Rippel Effect. The Paraguayan armoured vehicles are not in a better situation, even less so those belonging to Suriname, despite a recent donation of renovated Brazilian vehicles. In the Middle East, the technical availability is not much better as it seems to have almost disappeared from the Iraqi order of battle.

AKAER modernisation in 2022

To initiate the modernisation of its Cascavels, the Brazilian Army launched the call for tender n° 01/2021-DF, published on 5 November 2021; it relates to hiring a specialised company to carry out the service modernisation of nine armoured vehicles. The task involved providing two prototypes and a pilot batch of seven armoured vehicles. The deal is valued at BRL 74.6 M (USD 14.2 M). Several groupings of companies submitted offers, including the consortia formed by Akaer, Germany's Rheinmetall with the Brazilian company Equitron, and the Israeli company Elbit Systems in association with Ares. On 24 February 2022, the Akaer group was selected for the next stage and the winner of the tender was officially announced on 4 May 2022. On 7 July 2022, the Brazilian Army Manufacturing Directorate and Akaer Engenharia SA signed the modernisation contract at the Brazilian Army headquarters. The members of the Ground Force consortium selected are Akaer Engenharia, Opto Tecnologia Optrônica and Universal - Importação, Exportação e Comércio. Akaer will be the prime contractor for the project, while Universal is entrusted with system integration and manufacturing responsibility, and Opto will take care of the sensors and onboard electronics. The delivery schedule for the upgraded vehicles will span eight years with the first deliveries was scheduled for the first quarter of 2023. The modernisation should cover between 98 and 201 vehicles.

The technical specifications of the programme indicate the replacement of the powerpack (engine and transmission) and the entire suspension system. The new powerpack is also in the final definition phase, and the first to be offered was the Cummins ISB 5.9 six-cylinder in-line engine, developing 325 hp. However, now the more modern ISB 6.7, developing 350 hp, is being examined. The project also provides for the installation of an electric turret drive system to allow traverse through 360° in 20 seconds. The question of armament has drawn the most criticism, since the gun of the Cascavel will not be modified. The EC-90, a 90 mm/L39 gun based on the Cockerill MK III, when equipped with HEAT rounds, has an effective range of only 1,600 m (using HEAT rounds) and an armour-piercing capability of approximately 250 mm of rolled homogeneous armour equivalent (RHAe), which is insufficient to defeat modern heavy armour. To mitigate this problem, 30% of modernised vehicles will have a third generation anti-tank guided missile (ATGM) system with a semi-automatic command to line-of-sight control (SACLOS) guidance system. Although the model has yet to be chosen, it

Photo: Brazilian Army

The new Cascavel will have significantly improved day and night combat capabilities.

is required to possess a range greater than 4,000 m, and the missile launcher will be capable of elevating from -9° to +20°. The upgrade also involves the installation of modern optronics and fire control system, along with a command and control system supported by sensors distributed throughout the vehicle. Opto will provide the day and night vision system for all three crew. The renovation will also provide a central tyre inflation system (CTIS), air conditioning, and the Harris RF7800 VS 560 radio station, which has also been selected to equip Brazil's Centauro II 8×8 units.

According to Akaer's CEO César Silva, the Army's initiative to adapt the Cascavel to the modern battlefield provides a boost to the Brazilian economy. He stated: "The defence industry incentive contributes to the economic and technological development of our country, in addition to job creation."

Photo: Brazilian Army

Here are the main elements of the modernisation proposed by the Akaer consortium.

Is the Cascavel Outdated?

According to some Brazilian defence specialists, the Cascavel era is already over. With the acquisition of the Centauro 2, any resources to modernise the Cascavel are seen as a wasteful expense with virtually no return, bringing no tactical or operational benefit to the Land Forces. Additionally, the Cascavel's level of armour protection is so light that it is seen as unsuitable for armed escort in modern peacekeeping missions. The integration of Rafael Spike ATGM, a missile that costs more than the vehicle itself, illustrates the highly questionable nature of this modernisation project. Aware of the Armed Force's budgetary constraints, one of the main objectives of this programme is to keep the cost of the modernised Cascavel to a maximum of 30% of the cost of acquiring the new armoured fighting vehicle. This is intended to allow the Brazilian Army to both maintain its operating capacity and fulfil its missions. ■

Travelling Light – Nurol Makina Details its 4×4 Fleet Concept

Turkish manufacturer Nurol Makina has been expanding its vehicle families with new variants, with the aim of promoting a light vehicle fleet concept centred around 4×4s. Emre Akin, Nurol's head of strategic planning, along with another company representative, Brig Gen (retd) Recep Özdemir, provided the ESD with additional details.

Emre Akin told ESD that Nurol Making is promoting its updated range of 4×4 'Heavy Tactical Wheeled Armoured Vehicles' (HTWAV) for use in high-intensity conflict, rather than just low-intensity conflicts, as has been typically the case for vehicles in this class. Brig Gen Özdemir stated that "We started with Yalçın – it was particularly for asymmetric warfare, low-intensity warfare in the beginning," continuing, "we visualised that 4×4 vehicles were developed enough, and their 'golden' capabilities, which are manoeuvrability, mobility, agility, protection, survivability, and payload capacity are quite mature. And just to think of these vehicles in low-scale warfare would be unfair."

Özdemir added that "there are some small countries who cannot allocate enough resources for sophisticated and very expensive weapon systems, like tanks, tracked vehicles, and even 8×8 vehicles." In response to this demand, Nurol Makina has developed a range of variants based on their 18-tonne Ejder Yalçın and 13-tonne NMS (known as 'Yörük' in Turkish) 4×4 platforms, which would be considered heavy wheeled platforms within their class. These two families of vehicles are being offered for the combat, combat support, and combat service support segments within a 4×4 fleet concept. For instance, in the 'combat support' segment, which Nurol Makina envisions as being used just behind the front lines, variant options include anti-tank, very short-range air defence (VSHORAD), reconnaissance, command, and mortar variants. This is intended to provide users with organic capabilities at lower costs compared to 8×8, 6×6, or medium-weight tracked platforms employed in the same role.

High costs for many vehicle types is indeed a problem, and is one of the reasons why armed forces today broadly operate much smaller vehicle fleets than they did during the Cold War. While modern vehicles are generally both more capable and survivable than their forbears, being restricted to operating a smaller fleet of these brings its own restrictions to the battlefield. For instance, a heavy force with fewer vehicles may not be able to cover as broad a front as a force built on greater numbers of lighter vehicles. While each individual element in the lighter formation may be less protected than a heavier alternative, their greater numbers, higher top speeds, and easier deployability can nonetheless create tactical opportunities which may be hard to achieve otherwise.

Availability is another concern, as concentrating sophisticated capabilities

Graphic: Nurol Makina

Nurol Makina presented this slide to demonstrate the wide variety of combat roles which they envision can be credibly filled by 4×4 protected vehicles in place of heavier-armoured and more expensive alternatives.

onto heavier platforms will also make them high-value targets, and very in-demand by low-level commanders during wartime. This puts higher-echelon commanders in the position of having to carefully weigh where these vehicles can be committed to. In this vein, Özdemir stated that at the "battalion plus brigade level, lots of capabilities should be organic, must be under the hand of the commander," adding: "it is not possible to ask the brigade commander: 'Sir, can you please send me four CV90s or four tanks (which are probably assigned to more critical tasks) to conduct this task which is not very challenging considering the mission, enemy and terrain,' but it is possible to ask for tactical wheeled protected vehicles to [carry out] a relatively less challenging task, so these are really very good tools for the low-level commanders, and there are lots of gaps to be filled by using those agile platforms."

In this vein, the employment of 4x4s as weapons carriers allows a force to push organic capabilities such as mobile mortars or light artillery, Counter-UAV (C-UAV) or Short-Range Air Defence (SHORAD), and direct fire support down to low echelons for a relatively low cost. Various forces have already started acquisitions of 4×4-based weapon carriers, with mobile mortars becoming a relatively popular offer in this segment, due to many 4×4 platforms being perfectly adequate for this role, as a representative noted: "You don't need Boxer for this capability." Beyond mortars, following on from the Second Nagorno-Karabakh war and the War in Ukraine, demand for organic mobile C-UAV and SHORAD capabilities in particular is increasing, especially for countries without large air forces. Fulfilling these requirements using heavier platforms is likely to be prohibitively expensive for some armed forces.

'Better' is the Enemy of 'Good Enough'

There are other reasons why it can be advantageous for smaller countries in particular, who tend to have relatively small armed forces to begin with, to operate a larger fleet of lighter, less protected vehicles, than a larger number of heavy vehicles.

Going the lightweight route provides a number of benefits for such users – protected 4×4s are cheaper to procure and operate, repair, and train on than 8×8s, 6×6s or medium-weight tracked vehicles. As Özdemir stated, "Another beauty of these [4×4] vehicles – for tanks, for tracked vehicles, you have to train your guys intensively, you have to spend lots of time for this. If you lose those guys, you have to train new guys, and it takes time. But these [4×4] vehicles are very simple, they are like commercial vehicles."

Secondly, many 4×4 protected vehicles have sufficient payload headroom to be equipped with most of the same armament and mission system options as their heavier counterparts, with the exception

Photo: Nurol Makina

The Ejder Yalçın mortar configuration (Havan), conducts a test firing with its on-board semi-automatically loaded Aselsan Alkar 120 mm mortar.

of large guns and automatic cannons. As an example, the Northrop Grumman M230LF, chambered in 30 mm × 113 would represent the typical upper limit of their armament. Due to the lower roof-mounted weight limits of 4×4s compared to 6×6s or 8×8s, they also will generally not be able to carry as much ammunition, meaning they would need to be resupplied more frequently, but their relative numbers and availability can compensate for this somewhat.

Smaller vehicles can suffer more than their larger cousins in some mobility scenarios, such as fording, obstacle climbing, and trench crossing, where the 4×4 is inherently at a disadvantage compared to tracked, 6×6, and 8×8 vehicles. Having said this, their lower weight and typically lower profile allows 4×4s to more easily navigate civilian infrastructure such as bridges and pass underneath obstacles which would hinder a larger vehicle, and makes them easier to recover when they get stuck.

However, where lighter vehicles really shine is in the strategic mobility department. Modern medium-weight wheeled and tracked vehicles are difficult to transport them in large numbers using aircraft. As an example, it takes three A400M aircraft to transport two Boxer 8×8s, and the process requires decoupling the vehicles' mission modules from their drive modules, loading both mission modules onto one aircraft, while the remaining two aircraft each take a drive module. Although the A400M can carry a payload of 37 tonnes, which Boxer comes close to at a typical combat weight of 36.5 tonnes, the loading ramp's weight tolerance is only 32 tonnes. Thus, the load needs to be decreased before the vehicle can be driven on and off the aircraft. By contrast, something like the Ejder Yalçin, although no featherweight at around 14-18 tonnes (depending on version and configuration), is sufficiently light to drive on or drive off A400M, and at this weight, two could be carried per aircraft. If the vehicle is equipped with a relatively tall roof-mounted remote weapon station, this may be a little on the tall side for A400M and would require removal prior to driving on, but this limitation would apply to most tall armoured fighting vehicles.

Photo: Nurol Makina

Among their other qualities, protected 4×4s have lower visual and acoustic signature than their 8×8, 6×6, and medium-weight tracked counterparts, decreasing their chances of detection.

Photo: Nurol Makina

The NMS (Yörük), is Nurol Makina's the lighter wheeled platform offering in the company's protected 4×4 portfolio. However, it is capable of mounting a wide array of armament options, including ATGMs, MANPADS, and 70 mm rockets.

What is Sufficient Protection on the Modern Battlefield?

On the protection side, 4×4s may lack the same level of passive armour protection as heavier vehicles, however this may be less relevant than it once was. While heavy machine guns and automatic cannons remain very common threats, the proliferation of relatively low-cost but effective Anti-Tank Guided Missiles (ATGMs) and loitering munitions has had two main changes on the battlefield. Firstly, combatants everywhere generally feel more comfortable using these weapons for engaging any kind of target. This was perhaps best exemplified in Syria, where various factions have used ATGMs such as TOW, Fagot, Konkurs, Kornet against everything from heavy to very light vehicles, buildings, and even personnel in the open. Secondly, this has meant that realistically, unless they are equipped with an active protection system (APS), any vehicle with armour protection below the level of a modern tank (and even some tanks) can be reliably defeated

with ATGMs which are fairly common on today's battlefields.

RPGs have also grown in capability, with modern tandem-HEAT warhead varieties having comparable terminal effects to ATGMs. Although even modern RPGs typically have slightly lower overall penetration compared to modern ATGMs, this factor is largely irrelevant for most vehicles on the battlefield, whose armour can be comfortably overmatched at a fraction of their total penetrative capability. Older RPG variants such as the PG-7V and PG-9V families of munitions meanwhile, are usually countered by statistical protection such as bar armour, which can be fitted to heavy or light vehicles alike.

On the topic of survivability, Nurol Makina provided ESD with a first-hand account of an ambush from a soldier working as the driver of an Ejder Yalçın with the Gendarmerie Commando unit based in south-eastern Turkey, close to the Iraqi border. The soldier did not wish to be identified, but described the ambush to ESD, which took place near the town his unit was based:

"In the summer of 2019, when I was working with the Gendarmerie Commando unit in [south-eastern Turkey], we set off for road controls and [searched for] IEDs in culverts, with [our] vehicle in the early morning hours. Together with my commando friends and commanders, we continued to work very carefully all day and the duration of our duty was extended. We had done all the culvert and IED searches. We waited until the evening hours [at a small temporary base]. After taking a break, we received information [from] the military convoy coming from [a town located 52 km from us] and started patrolling. I was [in the lead] with my vehicle that day. We identified a heat source through our thermal camera and stopped while we were on patrol. As soon as we stopped, two [RPGs] hit my vehicle, 10 seconds apart. We tried to exit the death zone [calmly] with my vehicle commander and personnel. We got out of the death zone using the special abilities of our vehicle."

Photo: Nurol Makina

Although they may not have the same trench-crossing capabilities as 8×8, 6×6, and tracked counterparts, 4×4s such as the NMS nonetheless have fairly good off-road mobility. However, operational and strategic mobility are their greater strengths, due to their high on-road mobility and ease of transportability via aircraft.

According to Nurol Makina, both RPGs had struck the engine area of the vehicle, and the vehicle was heavily damaged in the attack, including damage to the electronics and one of the tyres, but fortunately, the RPGs' penetrating shaped charge jets did not strike at the correct angle to cause damage to the engine. Thus the driver was able to continue driving for four kilometres, bringing the crew to safety before leaving the vehicle. Akin added that due to the danger posed by hits on the engine, which would immobilise the vehicle and leave the crew unable to escape, the Ejder Yalçın has the same level of armouring around the engine bay as around the passenger compartment. This provides the engine with protection against machine gun, blast, and fragmentation threats, helping the vehicle to preserve its mobility when hit.

The vehicle is also highly mine and IED-resistant. Recalling another incident featuring the Yalçın, Akin stated that in 2015, Southeastern Turkey, a fertiliser-based IED weighing than 600 kg (somewhere in the realm of >10 kg of TNT equivalent) exploded under the vehicle body. While this caused significant damage to the vehicle and the occupants survived. Akin stated that during tests in 2022, the vehicle's underbody was demonstrated to provide protection conforming to STANAG 4569 Level 4A/4B, translating to 10 kg of TNT equivalent under the body or under any wheel location. This level of protection is being offered as an option depending on user requirements.

Photo: Nurol Makina

High-angle view of the Ejder Yalçın mortar configuration, showing the Alkar mortar's semi-automatic muzzle loading mechanism.

Closing Thoughts

In sum, while protected 4×4 vehicles in the medium-weight category are never going to be capable of doing everything their heavier brethren can do, yet they nonetheless offer a number of compelling reasons for increasing their participation in high-intensity warfare, rather than being left to counter-insurgency operations.

Recalling Ukraine's high-speed counter-offensive around Kharkiv launched on 6 September 2022, after Russia had redeployed many of its more capable forces in the East of Ukraine to protect Kherson in the South. Ukraine's rapid response caught Russian forces off-guard. Although Ukraine's forces used all manner of equipment during the campaign, they notably made use of large numbers of light (some of which unarmoured), or medium-weight protected 4×4s to rapidly move personnel forward. Speed was absolutely key to this operation, as it gave the unprepared Russian forces little time to organise a defence or even sabotage their own equipment before retreating. The result was Ukrainian forces retaking over 500 settlements, and around 12,000 km2 of territory, along with large stocks of captured Russian equipment in working order.

Nurol Makina's proposed force concept may not be the highest priority for users who already operate large, modern medium-weight and heavy vehicle fleets, supported by various other systems on the ground and in the air. However, it is admittedly a rather compelling model for users with more limited budgets, as well as for countries gearing up for a mix of counter-insurgency and high-intensity conflict tasks, or users who wish to increase their share of organic capabilities at very low levels. ■

Photo: Nurol Makina

The pictured configuration of the Ejder Yalçın possesses a good mix-of anti-personnel and anti-armour capabilities, armed with an HMG a GPMG, and two ATGMs. The vehicle is also provided with an armoured engine bay to preserve mobility when hit, and thereby increase survivability in various tactical scenarios.

Attack Helicopters: 21st Century Combat Systems

Sidney E. Dean

Speed, mobility and firepower are more important than ever on the battlefield. Attack helicopters unite all three characteristics like no other land warfare weapon system.

The attack helicopter has its roots in the helicopter gunships – utility helicopters augmented with air-to-ground weapons – used in various conflicts of the 1950s and 1960s. Dedicated attack helicopter programmes emerged in the late 1960s and the 1970s, beginning with the US Army's AH-1 Cobra which first deployed to Vietnam in 1967. Operational priorities have evolved since then. While attack helicopters retain a close-air-support (CAS) role for frontline infantry, they now also count anti-tank, anti-artillery, and counter-air-defence as top-line missions.

Photo: US Army

A US Army AH-64E Guardian with the distinctive AN/APG-78 Longbow fire control radar above the rotor blades.

North America

AH-64 Apache

The AH-64 Apache is the most ubiquitous western attack helicopter, with some 1,200 units currently operational in 16 nations, and standing orders by several additional nations. Almost all aircraft in service today belong to the AH-64D Longbow variant (introduced in 1997) or the AH-64E Guardian (so designated in 2012). The twin-engine Apache is widely considered the most powerful attack helicopter in the world. Its weapons loadout includes the fixed M230 30mm cannon and a selection of Hydra-70 70 mm (2.75-inch) rockets, AGM-114 Hellfire anti-tank guided missiles (ATGM) or Joint Air to Ground (JAGM) missiles, AGM-122 anti-radiation missiles, as well as AIM-9 Sidewinder, AIM-92 Stinger, and Mistral, air-to-air missiles. This enables the AH-64 to engage enemy helicopters and UAVs as well as the complete spectrum of ground targets including main battle tanks (MBT), mobile and fixed radars and missile launchers, hardened and soft structures, and personnel. For tank-hunting missions the Apache carries up to 16 ATGMs plus two air-to-air missiles for self-defence. Sensors on both variants include a day TV system, thermal imaging sight, direct view optics, and the AN/APG-78 Longbow millimetre-wave radar. The distinctive Longbow fire control radar can detect and classify up to 128 potential targets, and engage 16 targets simultaneously; an embedded radio modem enables sharing of radar data with other helicopters and ground forces. Placing the radar atop the rotor blades enables the helicopter to acquire and engage targets while the body of the aircraft remains just below an obstacle such as a treeline or building, taking maximum advantage of the aircraft's nap-of-the-earth (NOE) flying capabilities.

The currently produced iteration is the Guardian version 6 or AH-64Ev6, which began fielding in 2021. It features enhanced capabilities designed for Multi-Domain Operations (MDO), including upgraded sensors, enhanced engagement range, improved networking and a Joint Tactical Information Distribution System (JTIDS) to exchange sensor and targeting data with other platforms via Link-16. The AH-64E's Manned-UnManned Teaming (MUM-T) options have also been enhanced on the v6; the helicopter crew can control the flight path and the sensors of cooperating UAVs, receive UAV footage in real-time, and stream that video to ground systems to immediately update common situational awareness and facilitate tactical decision making throughout the joint force.

In 2022 Boeing presented the concept for a modernised Apache building on the AH-64Ev6. It would feature drivetrain upgrades; greater interoperability through

Photo: US Navy/ PO1 Joseph Buliavac

A USMC AH-1Z Viper attack helicopter lifts off from the amphibious transport dock ship USS San Diego (LPD 22).

mission systems, sensors and sensor fusion, and more resilient cross-domain connectivity; and new payload options including electronic warfare (EW) and, potentially, directed energy weapon systems. To date no service is known to be considering acquisition of this future variant.

AH-1Z Viper

The US Marine Corps (USMC) took delivery of its 189th and final AH-1Z Viper attack helicopter in November 2022. The twin-engine aircraft is currently being acquired in small numbers by Bahrain and the Czech Republic. It is expected to remain in service for the next four decades. The Viper, which is derived from and replaced the USMC's AH-1W SuperCobra, entered Low-Rate Initial Production (LRIP) in 2003 and achieved Initial Operating Capability (IOC) in 2011. The AH-1Z deploys with USMC expeditionary units aboard amphibious warships, and can also operate from fixed or temporary operating bases on land. The USMC defines three core missions: air-to-ground fire support (including suppression of enemy defences ahead of amphibious landings), aerial reconnaissance, and escort of advancing ground forces. The Viper also provides defensive airpower for amphibious warships, locating enemy warships over-the-horizon and engaging them with air-to-ground precision weapons.

Like many attack helicopters it features a narrow hull to reduce the radar cross-section and the likelihood of enemy weapon impact. The aircraft achieves an airspeed of 380 km/h (200 knots) and has a combat radius of 243 km (131 NM). A standard weapons loadout includes the bow-mounted 20 mm M197 Gatling gun, 16 air-to-ground missiles including Hellfire and JAGM, guided or unguided 70 mm rockets, and two Sidewinder air-to-air missiles. The nose-mounted third-generation Targeted Sight System (TSS) multi-sensor optronic infrared fire control system permits long-range identification of targets while the integrated weapons management system provides precision attack capability.

Photo: USMC/SSGT Arthur Shvartsberg

A US Army AH-6M fires rockets and an M-134 Minigun during an offensive air support exercise.

MH-60L DAP / AH-6M Little Bird

The US Army's 160th Special Operations Aviation Regiment (160th SOAR) maintains two dedicated assault helicopter types.

The MH-60L Direct Action Penetrator (DAP), sometimes also termed the 'Defensive Armed Penetrator', is a specially configured Black Hawk helicopter tasked with armed escort and fire support for special operations forces. The day and night, all-weather capable aircraft achieves a cruise speed of 222 km/h (120 knots) and a dash speed of 330 km/h (178 knots); its mission range is 778 km (450 NM), which can be extended through aerial refuelling.

Avionics and self-protection systems include terrain following radar, laser- and radar warning receivers, and AN/AAQ-16D AESOP FLIR with integrated laser targeting system. Wing stubs have been added to the fuselage to provide weapons hardpoints. The DAP deploys a variety of offensive weapon systems in area-fires or precision-fire mode. Options include the 30 mm M230 chain gun, the 12.7 mm GAU-19 Gatling gun, the 7.62 mm M134 minigun, 70 mm rockets, Hellfire anti-armour missiles and Stinger air-to-air missiles. Additionally, pintle-mounted miniguns can be emplaced at the cabin's sliding doors.

The AH-M6 Little Bird light attack helicopter is deployed for CAS of ground forces, direct action missions to destroy armoured and soft ground targets, and escort of special operations/assault carrier helicopters. Like its sister aircraft, the MH-M6 Little Bird special operations light transport aircraft, the AH-6M is derived from the civilian McDonnell Douglas 530. It is small enough to be transported to its operational zone by C-130 or comparable airlifters, and reconfigured for flight within minimal time.

Pilots praise its exceptional manoeuvrability and stability during combat and NOE flight. The single-engine helicopter's two

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Photo: Bundeswehr/Carsten Vennemann

Two Eurocopter Tiger attack helicopters of the German Army.

pilots sit side by side. Aerial performance includes maximum cruising speeds of 233 km/h (126 knots) and a range of 333 km (180 NM). Mission systems include secure UHF, VHF, and SATCOM communications, Forward Looking InfraRed (FLIR) sensors, and a combination of weapons options including 70 mm rocket pods, the GAU-19 and M134 automatic weapons, AGM-114 and AIM-92 missiles. The Pentagon is currently procuring Boeing's most recent iteration, the AH-6 Block III. It incorporates major elements of the AH-64E avionics technology including the glass cockpit and similar targeting sensors. It also features a new, six-blade rotor system. The US Army plans to operate the AH-6 into the 2030s. Boeing also produces an export variant designated the AH-6i.

FARA

The US Army's Future Attack and Reconnaissance Aircraft (FARA) programme is slated for fielding circa 2030. In the armed reconnaissance primary mission, FARA is expected to locate and neutralise enemy air defence and long-range fires forces using air-to-ground weapons including Hellfire and JAGM missiles. A 20 mm chain gun in a bow-mounted turret will provide a 360° field of fire with 60° elevation coverage, irrespective of the aircraft's direction of travel. Advanced avionics, communications, networking and targeting systems will provide high manoeuvrability, survivability, and lethality.

Europe/NATO

Tiger HAD/MkIII

The Eurocopter Tiger attack helicopter achieved operational readiness with the French and German armed forces in 2008. The four-bladed, twin-engine helicopter was subsequently acquired by Australia and Spain, with each nations' aircraft being customised to meet operator demands. Approximately 180 have been delivered to date. From the beginning the Tiger has been considered one of the most advanced attack helicopters, with stealth technology and a digital cockpit incorporated into the first generation.

The mission spectrum includes CAS for ground and special operations forces, direct action/search and destroy missions, armed reconnaissance, air or ground escort, air-to-air combat, and command and control (C2). The currently produced Tiger HAD Block II variant (Hélicoptère d'Appui Destruction; ENG: Support and Destruction Helicopter) can also operate from ships and in the maritime domain. External fuel tanks can be mounted to double mission endurance to five hours.

HAD II avionics include: the EUROGRID battlefield management and digital map display systems; integrated radio, SATCOM and data transfer links to communicate with rotary and fixed-wing aircraft and land forces; and a high-authority 4-axis digital automatic flight control system. Gyro-stabilised roof-mounted sensors include a TV camera, thermal imager, laser rangefinder, laser designator, and a laser spot tracker capable of simultaneously following up to four targets. Roof-mounted sights are cued to the pilot helmet. The defensive EW system includes laser, radar, and missile warning receivers.

Hardpoint-mounted armament includes ATGMs, guided and unguided 68 mm and 70 mm rockets, air-to-air missiles, and pod-mounted 12.7 mm heavy machine guns. With the exception of Germany's UHT (Unterstützungshubschrauber Tiger; ENG: Support Helicopter Tiger) variant which is optimised for anti-armour operations, the Tiger also has a chin-mounted 30 mm chain gun which is optionally linked to the roof-mounted sensors or the crew's helmet-mounted displays to optimise acquisition of ground and aerial targets.

Airbus Helicopters is currently developing the Tiger MkIII upgrade which will refurbish in-service aircraft, optimising them for networked and multi-domain operations (MDO). Airbus expects to equip the MkIII across the board with next-generation weapons, sensors and targeting systems. A new digital avionics suite, battle management system and tactical data management system, coupled with new 25.4 cm (10 inch) cockpit displays, will reduce crew workload and streamline flight/combat operations. The MkIII will improve on its predecessors' interoperability with other aircraft and ground forces through enhanced real-time sharing of threat and mission data and situational awareness. It will also be MUM-T capable, extending the manned aircraft's detection range. The upgrade will keep the Tiger operational beyond 2045.

France and Spain officially launched the MkIII programme in May 2022, following the March 2022 contract signing between Airbus and the European acquisition agency Organisation for Joint Armament Cooperation (OCCAR) as representative of both nations. First flight is expected in 2025, with deliveries to begin in 2029 (France) and 2030 (Spain). Germany has been invited to join the programme but has not yet announced a decision. Airbus is discounting recent French press speculation that Paris might scale back its plans, opting for a simpler and cheaper "MkII+" upgrade. Paris' January 2023 announcement of plans to boost defence spending by one-third would support confidence in a French commitment to the full modernisation programme.

AW 249

Leonardo is developing the AW249 to replace the Italian Army's AH-129 attack helicopter which was introduced in 1990. The new helicopter's official Italian Army designation will be AH-249. The current contract, initiated in 2017, covers the initial prototype and an additional three pre-series units, which will be converted to the final operational configuration once serial production is approved. The Italian Army's requirement is for 48 aircraft.

Photo: Leonardo

Artist concept of the Leonardo AW249 attack helicopter.

Leonardo states that the AW249 is being designed to conduct network-centric operations with "state-of-the-art communications and an advanced battlespace management system. The mission system will enhance situational awareness, reduce pilot workload and increase safety." The open systems architecture will permit regular upgrades, growth and modernisation over the helicopter's circa three-decade service life. The networking architecture will include MUM-T compatibility. Helmet-mounted displays and large area displays at both seats of the tandem-built cockpit will facilitate processing of operational data. While not a low-observable aircraft, the AW249 is being designed to have reduced radar and infrared signatures compared to its predecessors.

The multi-mission aircraft will be classified as NEES (Nuovo Elicottero da Esplorazione e Scorta – New Exploration and Escort Helicopter), and conduct combat, CAS, and escort missions. Shipboard operations will also be possible. The AW249 will utilise the same Rafael Toplite targeting system as the current AW129D configuration. Payload capacity of the six underwing hardpoints will reportedly be double that of the AH-129. Armament will include a chin-mounted 20 mm cannon turret, air-to-ground and air-to-air missiles, and guided/unguided rockets. Hardpoints can also accommodate external fuel tanks to extend the standard three-hour mission endurance.

First flight of the prototype was conducted in August 2022. According to Leonardo, the development and testing programme remains on schedule. Replacement of the AH-129 is slated to commence in 2025. The AW249 will be available for export. In December 2022 Italy announced plans to finalise a contract by mid-2023 to sell seven units to Algeria, the first foreign customer.

T129/T929 ATAK

The medium-weight T129 attack and armed reconnaissance helicopter was derived from the Italian AH-129. Jointly developed by Turkish Aerospace Industries (TAI) and AgustaWestland of Italy under a 2007 contract, the T129 replaced numerous mission systems and weapons with domestically produced Turkish equipment. The mission profile runs the gamut from escort to urban warfare to deep strike and suppression of enemy air defence (SEAD). The T129 was introduced into the Turkish Army in 2014. It is optimised for 'hot and high' operating conditions, improving the suitability for missions in non-temperate zones, and is being marketed internationally. Deliveries to the Phillippines are ongoing. In January 2023, the Nigerian government announced that deliveries were pending, while several Middle Eastern nations and Pakistan have orders pending.

TAI is currently developing the T929 ATAK 2 to augment the T129. The 10 tonne ATAK 2 will have double the take-off weight of the T129, and is designed to fill the Turkish armed forces requirement for a heavy attack helicopter. Unlike the smaller helicopter, it is a purely domestic design, and will be armed with a variety of Turkish munitions including UMTAS ATGMs and Cirit 70mm laser-guided missiles; payload capacity will be circa 1,500 kg. Defensive systems include missile warning sensors and a tail-mounted directed infra-red counter-measures (DIRCM) system to break the target lock of heat-seeking missiles. The T929 is destined to serve with both the army and the navy; in the latter role it will deploy aboard the amphibious assault ship TCG Anadolu. The mission profile includes attack, CAS, aerial warfare, reconnaissance, and EW. TAI hopes to achieve

Photo: TAI

A Turkish Army T129 attack helicopter.

Photo: TAI

Prototype production of the TAI T929 ATAK 2. It will have a 1,500 kg payload capacity.

maiden flight of the prototype in 2023, with the goal of introducing the new aircraft into service in 2025. Whether this is realistic remains to be seen given TAI's decision to utilise TV3-117 turboshaft engines procured from Ukraine's Motor Sich. The June 2021 contract with Motor Sich called for 14 engines to be delivered between September 2022 and 2025, enough to equip seven helicopters.

India

Prachand LCH

The Indian Army and Indian Air Force (IAF) formally inducted the Prachand Light Combat Helicopter (LCH) into service in late September and early October 2022, respectively. The indigenously-developed Prachand weighs in at 5.8 tonnes, and is primarily designed for operations along the Himalayan border with China. According to the Indian government, the twin-engine aircraft is the only attack helicopter capable of taking off and landing at 5,000 m altitudes with a heavy payload and fuel load, and has a combat service ceiling of 5,500 m. The mission profile encompasses combat search and rescue, SEAD, counterinsurgency operations, support for ground forces, and destruction of tanks as well as fortified structures. Another priority mission capability for which the LCH was consciously designed is defeat of enemy helicopters and UAVs.

Photo: Government of India

An IAF Prachand LCH over the Himalayas.

Approximately half of the aircraft components and mission systems are indigenous. The same holds for weapon systems which include cluster bombs, the 3rd-generation Helina and Druhvastra ATGMs, but also the Nexter THL-20 chin-turret and M621 20 mm cannon as well as Mistral 2 air-to-air missiles. Air-to-air engagements utilise helmet mounted sighting to maximise speed and precision. Armour-plated sides as well as reduced visual, aural, radar and infrared signatures contribute to aircraft survivability.

The LCH is the result of a two-decade long development programme which saw the first flight of the prototype in 2010. The aircraft is currently in LRIP, and Hindustan Aerospace Ltd (HAL) is due to supply the IAF with 65 units, and the Indian Army with 95 units. HAL is also offering the helicopter for export. Although the Prachand is considered mission ready, HAL expects to continue upgrading the system while bringing the indigenous component to 55%. It remains unclear what exactly is planned here. In an 8 February 2023 review in the EuraAsian Times, retired IAF Sqdn Ldr Vijainder Thakur emphasised the lack of full-scale networking and MUM-T capability as a shortcoming on the modern battlefield. He also noted that the lack of an all-weather capable radar will limit the LCH's operations under degraded visibility.

21st Century Force Multipliers

There are currently some 3,000 attack helicopters in service with over 70 users worldwide. The high-intensity battlefield of the 21st century, marked by distributed operations, long-range fires, and rapid movement of forces will place a premium on attack helicopters in both offensive and force protection missions. Furthermore, the evolution of sophisticated air-defence systems puts in question the ability of fixed wing tactical aircraft to operate during the early days of a conflict. Here, too, attack helicopters assume the burden of CAS for ground forces as well as degrading enemy air defences through direct action as well as by providing target data for friendly long-range fires, ultimately opening operational corridors for fighter and bomber aircraft. While helicopter gunships and attack helicopters have made major contributions to military operations since the Vietnam War, and figured into Cold War planning on both sides of the Iron Curtain, their importance is greater now than ever before. ■

Balloon Busting:

Uncovering China's Increasingly Pervasive Airborne Surveillance Activities

Peter Felstead

On 4 February 2023 the US Air Force shot down a Chinese surveillance balloon that had overflown US airspace during the preceding week. The event highlighted the significant efforts to which China is going to gather intelligence on US military assets and may signify a more robust response to those efforts.

When the US Air Force (USAF) shot down a Chinese surveillance balloon off the US East Coast on 4 February 2023 it used a fifth-generation fighter to accomplish a mission that even the First World War pilots of the US Army Air Service would have recognised.

The shootdown was made by an F-22 Raptor fighter – the type's first known air-to-air takedown – from the 1st Fighter Wing at Langley Air Force Base, Virginia, with a "senior defence official" quoted by the US Department of Defence (DoD) on 4 February noting that an F-22 "fired one AIM-9X Sidewinder missile at the balloon … from an altitude of 58,000 feet. The balloon at the time was between 60,000 and 65,000 feet [18.29 km to 19.81 km]."

A Long and Looming Flight

The Chinese surveillance balloon had first been detected on 28 January 2023 when it entered US airspace near the Aleutian Islands. From there it travelled over Alaska and Canada before re-entering US airspace over Idaho. Although US President Joe Biden authorised the USAF to shoot the balloon down on 1 February, the US DoD decided to wait until the balloon had passed the US East Coast before engaging it to negate the danger of debris affecting anyone on the ground. As it transited the US mainland, the balloon was seen to loiter over Montana and Wyoming: both states that host USAF intercontinental ballistic missile silos.

General Glen VanHerck, Commander of North American Aerospace Defense Command (NORAD) and US Northern Command (NORTHCOM), said in a 6 February press briefing that as the balloon made its way over US territory, the US military "took maximum precaution to prevent any intel collection" but "did not assess that it presented a significant collection hazard beyond what already exists in actionable technical means from the Chinese".

At the same time, he added, the balloon's flight also provided an opportunity "to collect intel where we had gaps on prior balloons, and … this gave us the opportunity to assess what they [the Chinese] were actually doing, what kind of capabilities existed on the balloon, what kind of transmission capabilities existed".

These activities included flights by US U-2 surveillance aircraft, with one U-2 pilot even taking a 'selfie' on 3 February showing his aircraft overflying the Chinese balloon as it hovered over the central continental US.

The balloon was ultimately shot down about six miles off the coast of South Carolina in a 20-square-mile area that had been cleared of maritime traffic, while a 150-square-mile zone around that site was also cleared of air traffic.

Photo: USAF

A USAF F-22 Raptor takes off from Joint Base Langley-Eustis, Virginia, on 4 February to intercept the Chinese surveillance balloon that had traversed the continental United States in the preceding days. An F-22 downed the balloon that day of the US East Coast using an AIM-9X Sidewinder air-to-air missile.

Photo: US DoD

The pilot of a USAF U-2 surveillance aircraft takes a 'selfie' looking down at the Chinese surveillance balloon that traversed the continental United States before being shot down off the US East Coast on 4 February 2023.

Following that initial event the USAF then embarked on something of a balloon-killing spree, shooting down an unidentified object in Alaskan airspace on 10 February, another over northern Canada on 11 February and a third over Lake Huron on 12 February. Unlike the Chinese surveillance balloon, these objects were shot down soon after being detected as their lower altitude deemed them a hazard to civil aviation. However, by 14 February the White House was admitting that the balloons shot down from 10 to 12 February were probably "benign", according to US intelligence officials, with the magazine Aviation Week reporting on 16 February that at least one of them was likely to have been a 'pico balloon' released by an Illinois-based hobbyist club.

Balloon-based Surveillance

Somewhat disconcertingly, Gen VanHerck admitted in his 6 February press briefing that previous Chinese balloon overflights over the continental United States had gone undetected. "Every day as a NORAD commander it's my responsibility to detect threats to North America. I will tell you that we did not detect those threats. And that's a domain awareness gap that we have to figure out, but I don't want to go in further detail," said the general. "The intel community, after the fact … made us aware of those balloons that were previously approaching North America or transited North America."

It is understood that three balloons entered US airspace during the Trump administration, while a fourth flight prior to the latest event during the current Biden administration.

However, previous balloon flights over the territory of the US and its allies have been detected and acknowledged. On 14 February 2022 witnesses on the ground reported a large circular object floating over the Hawaiian island of Kauai for several hours. Two days later the USAF released a statement confirming that "In regards to aerial activity over Kauai on 2:14: US Indo-Pacific Command detected a high-altitude object floating in air in the vicinity of the Hawaiian Islands," adding that, "In accordance with homeland defence procedures, Pacific Air Forces launched tactical aircraft to intercept and identify the object, visually confirming an unmanned balloon without observable identification markings."

On 18 December 2022 a different, larger, airship-like balloon was observed about 62 miles from Subic Bay in the Philippines: a site now poised to host US Navy assets after a 32-year hiatus.

On 17 July 2020 a balloon and payload structure similar to that which overflew the continental US in February was observed over Sendai in Japan. Another balloon appeared over Taipei, Taiwan, in September 2021, while in March 2022 a balloon was seen flying over Taipei's Songshan Airport, which would be a likely target for any PLA invasion forces.

On 6 January 2022 a similar balloon had been observed over India's Port Blair: a strategic Indian military port in the Andaman Islands close to the Strait of Malacca.

On 13 February John Kirby, the White House's co-ordinator for strategic communications at the National Security Council, acknowledged that "China has a high-altitude balloon program for intelligence collection that's connected to the People's Liberation Army", adding, "We know that these surveillance balloons have crossed over dozens of countries on multiple continents around the world, including some of our closest allies and partners."

US President Joe Biden, said Kirby, has directed an inter-agency team to study the broader policy implications for detection, analysis and disposition of unidentified aerial objects that pose either safety or security risks to the US, adding, "Every element of the government will redouble their efforts to understand and mitigate these events."

Asked by ESD whether the latest Chinese balloon overflight of the US heartland was a step too far for both the Pentagon and the Biden administration, Meia Nouwens, Senior Fellow for Chinese Security and Defence Policy at the London-based International Institute for Strategic Studies, said it was "unclear whether the US decided to shoot down the balloon because it lost patience with PRC [Chinese] surveillance operations, or because the incident played out in the public domain".

Richard D Fisher Jr, a Senior Fellow with the International Assessment and Strategy Center, based in Potomac, Maryland, argued that the balloon flight "was an embarrassing spectacle for most Americans, with bi-partisan outrage over China's blatant surveillance over US nuclear weapons bases finally forcing the Biden Administration to shoot it down".

However, Fisher also suggested that the much more muted US reaction to China's surveillance balloon overflights of Hawaii and the Philippines could have "emboldened Beijing" to push its luck.

The Payload

Various US military and State Department officials have said that the Chinese balloon that was shot down on 4 February was about 91 m (200 ft) tall and had a payload array about the size of a regional jet. As well as solar panels to power onboard systems, the payload included signals intelligence (SIGINT)-gathering equipment, according to the officials. Video of the balloon appeared to show a rudder, small motors and multiple propellers that would have afforded some degree of manoeuvrability.

Fisher noted that the "balloon's technical payload has to date not been revealed but reportedly carried optical, signals and

weather data sensors". The latter sensors, in fact, were alluded to by the Chinese when they acknowledged that the balloon was theirs while insisting it was a civilian platform used mainly for meteorological purposes that had simply been blown off course.

Interestingly, Fisher believes that these meteorological sensors were probably the most important part of the balloon's payload. "The balloon was able to gather far more intimate weather data than satellites," he said, explaining that this date was "crucial for targeting Chinese small multiple independently targetable nuclear warheads and newer hypersonic glide vehicle warheads. Minor changes in atmospheric density or wind direction can greatly impact the accuracy of small and manoeuvrable nuclear warheads."

Fisher added that "after a space war disables most low Earth orbit satellites, China's balloons can continue the surveillance necessary to continue nuclear and conventional warfare".

Photo: US Navy

Sailors assigned to the US Navy's Explosive Ordnance Disposal Group 2 recover debris from a Chinese high-altitude surveillance balloon off the coast of Myrtle Beach, South Carolina, on 5 February. The balloon was shot down the previous day.

Beyond Balloons

China does, of course, have many other platforms for surveilling the US military. During Congressional testimony on 14 February 2023 US Space Force Commander General B Chance Saltzman stated "China's military" has 347 satellites, which would include China's 30 or so Gaofen series of radar and optical satellites, some of which have a resolution of 0.1 m. However, Fisher pointed out that this may not include the growing number of supposedly commercial surveillance satellite constellations – which ultimately are controlled by the military – like the planned 138-satellite Jilin constellation, some of which have a 1 m resolution.

China also plans a broadband satellite series to rival the US SpaceX Corporation's Starlink constellation, said Fisher, noting that many of those satellites can be expected to have optical or radar surveillance capabilities.

Meanwhile, the PLA Air Force (PLAAF) and PLA Naval Air Force (PLANAF) have a fleet of Shaanxi Y-8 and Y-9 four-turboprop aircraft for anti-submarine, electronic/signals intelligence (ELINT/SIGINT), and electronic warfare missions.

In addition, the PLA Navy has many large dedicated ELINT/SIGINT vessels that can assist with missions such as submarine acoustic signature gathering and anti-ship ballistic missile targeting.

Further to these military assets, China's massive fleet of fishing vessels are operated almost like a maritime militia. While often used to assert Chinese presence without resorting to overtly military platforms, the fishing fleet can also be used for military surveillance.

Espionage adds to the mix

Looking at China's growing military power, it is easy to cite instances where Chinese capabilities have advanced in leaps and bounds. Over the last few decades, for example, the PLAAF has gone from operating Soviet-designed, licence-built combat aircraft to flying a home-grown fifth-generation fighter in the form of the Chengdu J-20. China is crucially also now self-sufficient in high-performance jet engines. Thus, despite Russia's belligerence in Eastern Europe, the US military now cites China as the pacing threat in all of its strategic planning. It seems clear that Chinese surveillance and espionage operations have certainly had their part to play in effecting Beijing's technological advances.

"Continuous and all-encompassing espionage against the technology of all nations has been a major foundation for China's meteoric economic rise and its military growth, which may soon surpass the power of the United States," asserted Fisher. "What it cannot buy, China will steal without hesitation, especially if can increase the power of the People's Liberation Army. Chinese Communist Party policies of 'civil-military fusion' require that all Chinese civil entities turn over whatever technology they have that can assist the PLA.

"Ultimately the Western democracies cannot defend themselves without reviving an organisation like the Coordinating Committee for Multilateral Export Controls (COCOM), which prevented much crucial technology from reaching the former Soviet Union," Fisher added.

While also agreeing that Chinese military platform development has included some level of industrial espionage of US and Western military equipment, as well as reverse-engineering of Russian equipment, Nouwens pointed to China's indigenous capabilities now attaining a level where the country's advances in capability are now coming more from within. Citing how the push for great civil-military fusion is incentivising China's private sector to work with its state-owned defence-industrial enterprises to boost innovation, Nouwens said that, "while the latter is easier said than done, China's military procurement of advanced equipment is not dependent on espionage or surveillance anymore in the way that it was decades ago".

As the Pentagon appears, at least, to signal a more robust response to China's more flagrant surveillance activities, it seems likely that the US military and the industry that supports it will similarly double down on measures to mitigate Chinese intelligence gathering. The curtailing of balloon flights, however, will only stop one small part of that effort. ■

US Army Aviation Acquisition Update

Sidney E. Dean

Much attention is paid to the US Army's recent contract award to develop and field the Future Long Range Assault Aircraft (FLRAA). However, the Army also continues to procure several legacy manned rotary aircraft systems.

While every helicopter category in the US Army inventory has undergone numerous overhaul, upgrade or even rebuild phases, the basic design of the major aircraft types can be traced back to the Vietnam War era. In 2009 the Army initiated the Future Vertical Lift programme to investigate technologies and concepts for a new generation of rotary aircraft with enhanced "manoeuvrability, range, speed, payload, survivability, reliability, and reduced logistical footprint" compared with current aircraft classes. Within a few years the service devised a plan encompassing five categories or "capability sets" ranging from a light reconnaissance helicopter to an ultra-heavy rotary airlifter with more payload capacity than a C-130, with the latter to be fielded by 2025. This agenda and timeline were soon recognised as overly ambitious. While the five categories have not been officially abandoned, the Pentagon has opted to concentrate on fielding two medium-lift FVL platforms, namely the Future Long-Range Assault Aircraft (FLRAA) and the Future Armed Reconnaissance Aircraft (FARA).

Photo: Bell Textron

Bell will design the FLRAA based on the V-280 Valor demonstrator.

FLRAA

The FLRAA medium-lift utility helicopter will augment and ultimately replace a portion of the UH-60 Black Hawk fleet, progressively assuming the most challenging missions. The Pentagon conceives the FLRAA as a high-speed, long-range aircraft that will be survivable in contested environments. The intended premier mission will encompass assault transport and support of airmobile infantry, whereby the aircraft's improved speed and range will permit staging assault operations from distributed locations and from beyond the reach of enemy long-range fires. Intra-theatre aeromedical evacuation (MEDEVAC) will be another vital battlefield mission.

On 5 December 2022 the Army announced the selection of Bell Textron to design and build the FLRAA. Bell's V-280 Valor technology demonstrator, which had been submitted for the preceding Competitive Demonstration and Risk Reduction (CD&RR) phase of the programme, will form the basis of the future aircraft. The tiltrotor V-280 meets or exceeds the Army's FLRAA performance prerequisites, achieving over 555.6 km/h (300 knots per hour) during CD&RR testing and promising a combat range of up to 1,281.6 km (800 NM). The aircraft has a crew of four (two pilots and two loadmasters) and carries up to 14 combat equipped passengers, enough for a full squad plus support or specialist personnel.

Since May 2021 the Army has been pursuing a Middle Tier of Acquisition (MTA) approach to the FLRAA programme. As defined by the US Department of Defense (DoD), the MTA pathway is devised for technologies considered sufficiently mature to be rapidly prototyped within an acquisitions programme, or fielded, within five years of MTA programme start. The initial contract awarded in December 2022 is the beginning of a structured approach which will run through the remainder of the decade. The 19 month phase encompassing 2023 and the first half of 2024 will be dedicated to continued preliminary digital design development followed by detailed design, development and delivery of virtual prototypes. This phase is valued at up to USD 1.3 Bn, with the first tranche coming to USD 232 M.

On 28 December 2022, Sikorsky formally contested the contract award. The Government Accountability Office has 100 days to either confirm the contract award or re-open competition. The Army has confirmed that the programme timeline factored in the possibility of a protest, and that any related delays would not impact the overall development cycle.

The Army is currently developing a Test and Evaluation Master Plan (TEMP) to support a Milestone B decision in late FY 23, enabling transition to an Acquisition Category 1B programme managed by the Army's acquisition authority. Physical prototype build is slated to begin in late FY23, with prototype delivery and flight testing to begin in 2025. A Limited User Test (LUT) to address any issues encountered during flight testing is expected in FY27, followed by a Milestone C decision in FY28. Operational fielding of the first Low-Rate Initial Production (LRIP) units and a Full Rate Production (FRP) decision are both slated for FY30. The Army's projected budget for the engineering and manufacturing development (EMD) phase, testing and LRIP is USD 7.1 Bn. Total procurement – over several decades and including foreign military sales – could eventually be valued at USD 70 Bn.

FARA

In 2020 the Pentagon described the FARA as Army Aviation's number one priority. FARA's primary mission will be armed reconnaissance. Since retirement of the OH-58 Kiowa Warrior helicopter in 2013, that role has been delegated to the AH-64E Apache attack helicopter and the (unarmed) RQ-7 Shadow UAV. FARA will fill a critical capabilities gap and permit the Apache fleet to concentrate on the attack mission, while offering significantly greater range and manoeuvrability than the RQ-7.

Photo: Sikorsky

The RaiderX prototype under construction. Mock-up weapons are "deployed" from the internal weapons bay.

The armed reconnaissance aircraft, sometimes referred to as an airborne 'knife fighter,' is expected to neutralise enemy air defence assets and sensors, clearing the path for the more heavily armed Apache attack helicopters or for FLRAA carrying assault infantry. Weapons options are expected to include both kinetic ordnance and electronic warfare capabilities. The improved tactical reach offered by FARA is expected to permit aerial attack operations to be launched from beyond enemy sensor and weapons range.

The Army requires FARA to operate in complex and dense urban, mountainous, desert, jungle and maritime environments. Few specific parameters for the aircraft have been set to date, aside from dimensions (maximum rotor diameter and fuselage length of 12 m to enable urban operations below rooftop level) and a required airspeed capability of at least 333.4 km/h (180 knots). More specific requirements are currently being developed and will be included in the final Capabilities Development Document (CDD) to be presented for approval to the Army Requirements Oversight Council during FY23.

The two remaining contenders for the FARA programme are Bell Textron and Sikorsky. Bell Textron has designated its FARA concept the 360 Invictus. It employs a single four-blade rotor system and a tilted, shrouded tail rotor. Stub wings provide extra lift at medium to high speeds. Sikorsky's concept is based on the S-97 Raider technology demonstrator, and is designated the Raider X. The most visible aspect is the coaxial rotor blade design coupled with a pusher propeller. The side-by-side cockpit layout is also unconventional for an attack and scout helicopter.

The Army's decision to pursue two major helicopter development programmes – the FLRAA and FARA – nearly simultaneously has always been considered daring. As of this time the FARA programme is behind the envisioned schedule, largely due to COVID-associated delays in delivering the new General Electric T901 turboshaft engine developed under the government's Improved Turbine Engine Programme (ITEP). The Pentagon has mandated that both contenders use the new engine in their designs. Competitive flight testing of the technology demonstrators cannot proceed until the T901, which first became available in November 2022, can be installed.

Evaluation of the engineering manufacturing and development (EMD) proposals of both contenders is ongoing. The fly-off competition between the ITEP-equipped concept aircraft is expected to proceed in FY23. A Milestone B decision leading to award of the EMD contract to one competitor is scheduled for the first quarter of FY24. The actual EMD phase is expected to run through the end of FY28, with fielding of LRIP aircraft to operational units circa 2030. As with FLRAA, FARA's FRP is expected to begin in the early 2030s.

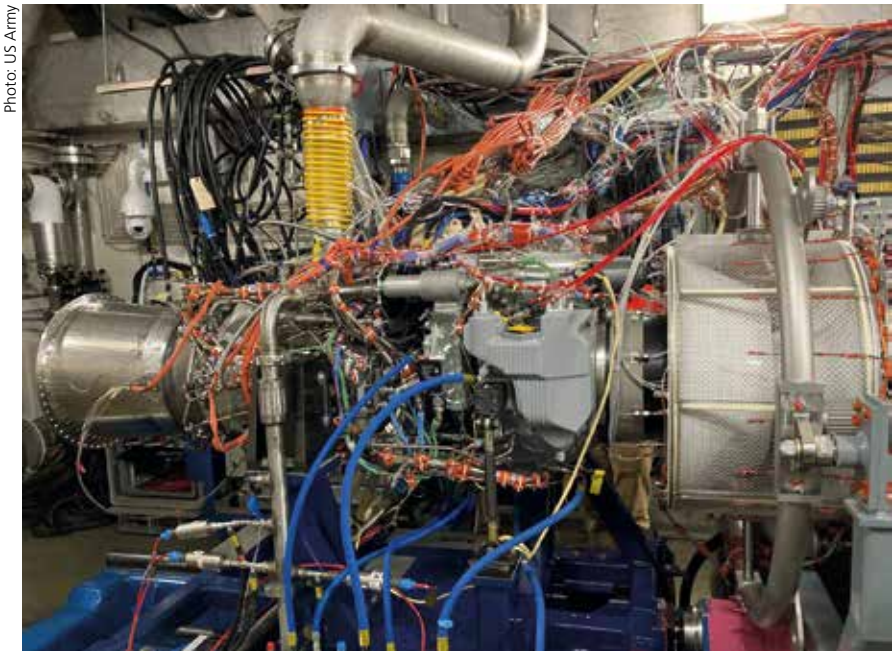
AH-64v6 Apache

The US Army currently operates the Apache attack helicopter in the AH-64D Longbow and AH-64E Guardian variants. The AH-64E continues to be procured in the Version 6 configuration (AH-64Ev6) which began fielding in 2021. The v6 is optimised for service-specific and joint-force multi-domain operations (MDO). The network-centric configuration boasts numerous upgrades to navigation, sensors, targeting and weapons capabilities, including the ability to exchange sensor and targeting data via Link-16 with external platforms in a joint operational setting. The Guardian's Manned-Unmanned Teaming (MUM-T) ability is another force multiplier, enabling reception of Unmanned Aerial Vehicle (UAV) video in the Apache cockpit, control of UAV sensors by the helicopter's crew, and control of the UAV flight path.

Photo: Boeing

Concept of the Modernised Apache attack helicopter.

Photo: US Army



Pre-flight testing of the GE T901 engine destined to power the FARA as well as for backfit onto the AH-64 and UH-60.

Photo: US Army

Both the UH-60M and UH-60V feature a digital or 'glass' cockpit layout.

Deliveries of the AH-64Ev6 are expected to be continue into FY28, with a projected service life into the 2060s. In 2022 Boeing introduced a concept for a Modernised Apache as the next evolution of the AH-64Ev6. Boeing promises drivetrain upgrades to fully utilise the ITEP engine's potential; advanced mission systems to increase interoperability to the network and to reduce pilot cognitive strain and workload; advanced sensors and sensor fusion for better and more resilient cross-domain connectivity; airborne long-range precision munitions, Air Launched Effects (ALE), electronic warfare and (potentially) future directed energy weapon system integration; and advanced sustainment through a more capable and lower life cycle cost airframe. Models and concept art released by Boeing feature extended wings with three pylons each rather than the current two. To date the Army has not announced plans to procure this future variant.

UH-60M/V Black Hawk

Despite the pending introduction of the FLRAA, the Army plans to continue operating the UH-60 Black Hawk family of utility tactical transport helicopters for several more decades. The current fleet encompasses numerous variants, including the UH-60L (produced 1989-2007) and the UH-60M which has been in continuous production since 2006. Additionally, the UH-60V programme will systematically upgrade existing 'L' variant aircraft to the more advanced 'M' model's digital cockpit configuration. Both the 'M' and 'V' variants are digitally networked and capable of supporting joint-force operations.

Sikorsky's parent company Lockheed Martin has announced future upgrades to the UH-60, including the performance enhanced GE T901 turbine engine to increase lift and range; advanced digital vehicle management systems supporting degraded visual environment and automated operations; and digital tools including predictive analytics that reduce aircraft downtime and maintenance costs. Modular Open Systems Architecture (MOSA) will permit rapid integration of emerging technologies to increase flight performance and maintain operational relevance in the future.

The most recent UH-60M multi-year procurement contract was signed in June 2022. Sikorsky will deliver a total of 120 aircraft through 2027. Under this contract, the government retains an option for an additional 135 helicopters to be distributed as needed to the Army, civilian agencies, or foreign military sales. The US Army's current Black Hawk fleet of 2,100 aircraft includes circa 1,200 UH-60M, with a stated ultimate procurement goal of 1,375 units of the 'M' variant.

The UH-60V completed initial operational test and evaluation (IOPE) in August 2022, following delays attributed to both the COVID pandemic and to initial software reliability issues. LRIP was authorised in 2020, enabling equipment of a National Guard aviation unit to perform the IOPE under operationally realistic conditions. A decision on FRP is pending and expected soon. The planned conversion rate of 48 'L' model helicopters to 'V' variants per year is considered too slow, given the current UH-60L inventory of 760 units. The Army is reportedly seeking ways to speed up the process, however, options are likely to be limited by budget constraints.

UH-72B Lakota

In 2006 the US Army selected a militarised variant of the Eurocopter (now Airbus Helicopters) EC-145 to serve as the new light utility helicopter. FRP for the new aircraft, designated as the UH-72A Lakota, was approved in 2007, leading to delivery of 463 units through 2020. In 2020 the Army placed an initial order for 18 units of the upgraded UH-72B variant. The UH-72B has improved performance, due to the stronger Arriel 2E engine, the use of a bearingless five-bladed rotor in place of the 'A'

model's four rotor blades, and a shrouded fenestron tail rotor which also enhances safety on the ground. The 'B' variant also features enhanced cockpit controls, the Airbus Helionix avionics suite, and an auxiliary operator's console for centralised control of sensors and the ground data link. Deliveries began in September 2021.

The active duty Army uses the UH-72A for pilot training at the Army Aviation Centre at Fort Rucker, Alabama. The remaining UH-72A and the UH-72B are assigned operationally to the Army National Guard (ARNG). Both variants are unarmed and have the same mission profile which includes general cargo and personnel transport, disaster assistance, search and rescue (S&R), MEDEVAC, command and control, border surveillance and counter-drug operations.

Photo: US DoD

A UH-72A MEDEVAC helicopter of the Nebraska Army National Guard.

CH-47F/MH-47G Chinook

The CH-47F procured during the first two decades of the millennium is the most recent variant of the Chinook helicopter family. The heavy-lift aircraft conduct a full spectrum of operations including assault transport, S&R, MEDEVAC, and heavy equipment (vehicle, artillery) transport. The Army is planning to acquire a CH-47F Block II version with an improved power train and rotor system, software and avionics upgrades, a strengthened fuselage and a redesigned lightweight fuel system. These changes promise increased speed and range when compared to the Block I version.

CH-47F Block II is an acquisition category IC programme led by the Army's Programme Executive Office (PEO) Aviation. Progress is behind the original schedule following cancellation of a limited user test in FY21 due to technical problems during testing, and the subsequent cancellation of a Mile-

stone C decision planned for late FY21. The Army is currently redefining system requirements which were originally defined in a FY16 TEMP. One major change is the decision, taken in 2021, to abandon development of the Advanced Chinook Rotor Blades (ACRB) which had been expected to significantly improve lift, but which created unresolvable vibration issues during testing. The Army now plans to utilise the legacy fibreglass rotors already used on the Block I configuration.

In 2022 the PEO Aviation, Brig. Gen. Robert Barrie, announced that the remainder of the Block II system upgrades were on track, and that qualification efforts were resourced through 2023. In 2021 the Army awarded Boeing a contract for four production model CH-47F Block II aircraft to be delivered beginning in 2023, with the goal of outfitting an operational unit in 2025. An additional two aircraft were ordered in October 2022, with an advanced procurement contract for a third lot being prepared.

The Pentagon's Director of Operational Test and Evaluation (DOTE) report issued in January 2023 is more restrained than the PEO, referring to the future of the CH-47F Block II as "uncertain." As of January 2023 the DOTE was awaiting the Army's updated acquisition strategy and an update on planned aircraft configuration, information the testing office needs in order to devise a new testing strategy and TEMP. The report notes that operational testing is not currently scheduled. This is likely to change following delivery of the LRIP aircraft.

The service is also procuring an upgraded special operations variant of the Chinook. The MH-47G Block II has 1,800 kg additional load capacity and increased range thanks to improvements including newly designed rotor blades and a more efficient drivetrain, The first MH-47G Block II aircraft was delivered in the fourth quarter of FY20. Contracts to date cover delivery of 36 of the upgraded helicopters for the Army Special Operations Command. The ultimate procurement goal is 69 MH-47G Block II.

Photo: Lockheed Martin

During the Project Convergence 22 experiment in October 2022, a specially configured UH-60M Black Hawk helicopter performed unmanned flight manoeuvres including autonomous resupply missions.

Unmanned/Optionally Manned

Armed forces are displaying significant interest in optionally-manned systems, and US Army aviation is no exception. On 5 February 2022, a Black Hawk helicopter outfitted with the ALIAS (Aircrew Labor In-cockpit Automation System) performed its first unmanned flight over Fort Cambell, Kentucky. The 30 minute flight was part of a Defense Advanced Research Projects Agency (DARPA) programme carried out in conjunction with Lockheed Martin. Lockheed's subsidiary Sikorsky produces the MATRIX Technology system which forms the core of DARPA's ALIAS project. The flight control system can be temporarily mounted on various rotary and fixed-wing aircraft types, and removed again when autonomous capabilities are no longer required. According to DARPA, ALIAS aims to support execution of an entire mission from takeoff to landing, including autonomously handling contingency events such as aircraft system failures. The AI is also equipped to handle flight operations under severely degraded visibility as well as congested or contested airspace.

DARPA has stated that the primary goal is not to create dedicated unmanned variants of manned aircraft, but to relieve overburdened flight crews so they can concentrate on mission management. ALIAS could thus support a human aircrew, or serve as a virtual co-pilot for a single aviator in a two-seat cockpit. However, multiple flights conducted in October 2022 during the Project Convergence 22 experiment demonstrated that an ALIAS-equipped Black Hawk could carry out autonomous supply flights as well as unmanned casualty evacuation missions. Merging the payload and flight performance of the UH-60 with autonomous operations could enhance future logistical support to frontline forces while reducing the risk to human aircrews.

While not yet an acquisition programme of record, ALIAS or a similar modular autonomous flight control system – which goes far beyond standard 'automatic pilot' systems in today's cockpits – could expand options for all the manned helicopter types currently being procured. ■

Photo: Boeing

The CH-47F Chinook Block II during first flight.

Border Protection – Overwatch and Response

Tamir Eshel

The dramatic geopolitical changes in 2022 have caused alarm among countries and caused more attention to be paid to defence and security vulnerabilities. Previously considered secure, borders and shorelines are susceptible to criminal and terrorist activity, exposing essential economic infrastructure and strategic sites to hostile attacks.

Security measures that previously focused on preventing smugglers by regulating the movement of people and vehicles across borders now aim to stem waves of migrants and the trafficking of illegal substances using submarines and unmanned vehicles, or drones. The new world order exposes more nations to terror threats, either cross-border attacks or proxy states supporting terror cells inside those countries. This new reality demands the establishment of broader, more persistent, and highly responsive border protection, integrating existing capabilities with new concepts and technologies to deal with these new challenges.

Nevertheless, the basics of border protection missions remain unchanged: as a nation's perimeter defines its sovereign area, the borderline should be monitored to block unauthorised air, land, or marine traffic, limit all movements to defined passages, and employ security forces to respond to any violation of secured areas. This task is simple to define, but given the variety of threats, it is difficult to implement. In this article, we review some of the challenges and technological solutions made available with modern technology.

Foliage Penetration

In the past, ground surveillance radars were often used to cover large areas. Based on Doppler effect filtering, these radars were tuned to detect vehicles at tens of kilometres and humans at distances of a few kilometres away, alert additional observation means to identify targets and direct security forces to close in on the suspected threats and apprehend them as they attempt to cross the border. The war in Ukraine has highlighted for example the difficulty of sensors in penetrating dense foliage.

While airborne sensors such as synthetic aperture radars (SAR) effectively penetrate foliage, detecting movement in such an environment is more difficult. While most ground surveillance radars operate well in open terrain, they are ill-equipped to detect targets or movements covered by dense foliage, such as forests, shrubs, plantations, or jungles. Low-flying aircraft or small and slow Unmanned Aerial Vehicles (UAVs) also pose different challenges for radars.

Legacy sensors are less likely to detect such targets and, therefore, need assistance in adapting algorithms and filters. Modern Foliage-Penetrating (FOLPEN) radars provide some solutions for detection in vegetated terrain; such radars employ ground-based or overhead sensors from aircraft or drones, enabling radars to penetrate dozens of metres deep into densely covered terrain. To fill this gap, Israel's radar specialist Elta Systems has added the L-band ELM2112FP to its family of ground surveillance radars. This model can detect a human at a distance of 2.5 km and a vehicle from 5 km, even when such targets are tens of metres inside a dense forest.

Counter-Unmanned Aerial Vehicle (C-UAV)

Drones present a challenge to radar surveillance as they are often unseen by radars due to their much smaller dimensions, low-altitude flight, and slow speed. To cope with the challenge, some ground surveillance radars have evolved to meet the challenge posed by UAVs.

For example, Leonardo's TMMR is designed to detect low, slow, small, fast, and high manoeuvring targets. Typical applications include: C-UAV; Very Short-Range Air-Defence (VSHORAD); Counter-Rocket Artillery Mortar (C-RAM); airport/critical infrastructure surveillance; air surveillance gap filler; vehicle protection; and battlefield protection.

Another relatively new radar solution adapted to border security and C-UAV is Weibel's XENTA-C, an X-band drone detection radar that monitors drone activity across borders and other perimeters. As a compact radar, it can be mounted on ground-based installations, packed in a containerised solution for deployment, or mounted on small land-based vehicles, such as pick-up trucks, for rapid deployment as a gap-filler on a forward location. As a C-UAV radar, it effectively detects and classifies drones and delivers tracking info to control centres, frequency jammers, and optronic systems via integration into a command and control (C2) system. As a Doppler radar, it detects the target's movement. When operated against drones, it can detect both the drone's movement and the rotor blades' rotation. Combining both signals is what provides a high probability of detection.

Photo: Weibel

The XENTA-C C-UAV radar from Weibel.

Wide-Area Surveillance

The development of advanced optronic cameras with multi-megapixel sensors has enabled designers to introduce new concepts of optronics systems providing Wide-Area Motion Imagery (WAMI), using high-resolution optronic cameras to take frequent time-lapse imagery or continuous video of a wide area, enabling analysts to look back in time for forensic investigation of certain events. WAMI represents a new approach to intelligence, surveillance, and

reconnaissance that employs an elevated wide-area surveillance sensor system to image, detect, and track every vehicle, every moving dismount, over a designated area of several kilometres in diameter. Typical systems used on light aircraft or drones can cover areas from 2 to 16 km2 with high-resolution imagery, supporting analysts with windows of interest of specific locations or tracking movements of vehicles or personnel throughout the covered area.

Photo: Logos Technologies

A tethered drone equipped with the MicroKestrel WAMI payload.

Typical WAMI payloads from LOGOS allow operators to track multiple targets moving simultaneously in different directions, a popular evasion technique for terrorists and smugglers. The system records and archives everything it sees, allowing users to conduct real-time and forensic analysis, uncovering critical ties between people, places, and vehicles, and identifying patterns of behaviour that might otherwise have been missed. WAMI systems can be mounted on various platforms, including aerostats and tethered UAVs, maintaining persistent surveillance of a city-size area points of interest for weeks at a time. As part of such surveillance, operators can establish 'watch boxes' over specific areas, to trigger automated tripwire alerts.

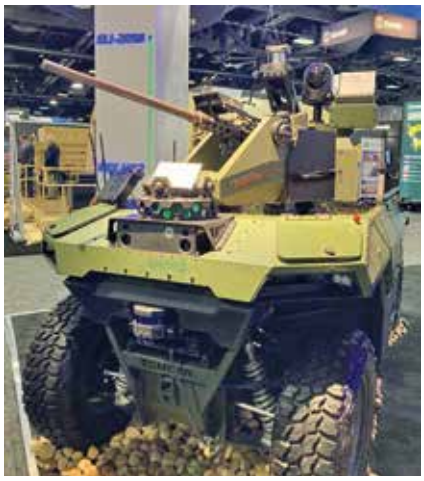
Today's WAMI payloads are not as bulky and heavy as previous systems. Using payloads mounted on small, tethered Class 1 drones, imagery covering days, or weeks, can be analysed to gain insights into patterns of life that help uncover hidden relationships between various actors, locations, and events in the area under surveillance.

Autonomy for Timely Response

Having an all-seeing eye in the sky does not mean border guards can react quickly enough for effective response, especially when long borders are secured by small, widely dispersed teams. When securing a 'hot' border, where hostile activities are expected, and guards do not ask many questions before opening fire, long-range precision weapons will likely be an effective response and deterrent. However, various robotic measures can be employed on more peaceful borders to contain a situation and hold border trespassers until guards arrive at the scene.

Originally used in remotely-operated mode, Unmanned Ground Vehicles (UGV) such as IAI's REX MK2 are today used semi-autonomously. The vehicles are equipped with various sensors, providing them a limited degree of autonomy to respond to situations they may encounter. Other equipment may include laser scanners that can sweep the border fence in search of changes – new openings, appearance of new objects that could indicate the placement of mines or roadside IEDs, gunshot detectors to report on possible engagement by hostiles, and a weapon station providing cameras and weapons to engage targets on demand and under the operator's control. Such UGVs can perform slow but continuous patrols along a borderline without requiring human guards to be present on these missions.

Photo: Tamir Eshel



REX MK2 loaded with sensors and weapon station for autonomous border security patrols.

Photo: Tamir Eshel

Easy Guard ground station from Easy Aerial.

Drones can deploy even faster from pre-positioned sites placed along the fence or in remote operating locations placed along a long borderline. Different missions may require specific solutions. The Israeli company SPEAR UAV has developed the Ninox system. Triggered by a smart fence, radar, cameras, or other means, the Ninox system deploys a tube-launched drone in response to an alert, enabling border protection teams to respond quickly and effectively to real-time threats. Designed as an affordable sensor or weapon, Ninox is cost-effective and compact, enabling the deployment of multiple units along a border fence or on moving patrol vehicles, enabling the operator to direct the payload weighing up to 0.5 kg in wind speeds of up to 10.3 m/s (20 knots), and without requiring drone piloting skills.

A different concept of prepositioned drones includes the Easy Guard ground station that provides a smart, independent drone hangar for take-off, landing, and charging. Drones can be operated in tethered mode or free flight, as needed. It features an automated roof opening and closing and multiple sensors and cameras for environmental

Photo: Spear UAV

An unattended launcher deploys a Ninox micro-drone from a smart fence installation.

monitoring and situational awareness. Such units can be prepositioned at unattended remote sites, mounted on patrol vehicles or unmanned vehicles, providing security forces with an effective response to emergency situations requiring an overhead lookout over a given area.

System integration

Performing the border protection role requires the combination of all different elements into a comprehensive C2 system, depicting the broad situational picture and assigning specific tasks for the different teams performing routine patrols or responding to alerts. Like military C2 systems, border protection and management systems also employ sophisticated information systems to process and correlate the input from multiple sensors and combine those feeds into knowledge, refining it for the commanders and presenting subsets of the relevant information to the response teams tasked with to seeking, intercepting, arresting or elimination of specific targets. In some cases, responses require the activation of other systems, including C-UAV, anti-aircraft, or robotic guards.

Photo: Tamir Eshel

The display of the NIDAR C2 system from MRASS, integrating detection, identification, and action actionable security systems.

A typical system is Anduril's LATICCE, a C2 system that creates a shared understanding of the scene in real time by autonomously passing data from all sensors and data sources, and then refining the information into an intelligent common operating picture. The system uses technologies such as sensor fusion, computer vision, edge computing, machine learning, and artificial intelligence to detect, track, and classify every object of interest in an operator's vicinity. The system's user interface (UI) allows users to visualise and interact with thousands of sensors and effectors in a single UI and seamlessly scale from tactical to strategic views.

Another example, is the NIDAR C2 intelligent border surveillance system from British company MRASS, designed to provide autonomous border and perimeter surveillance solutions. This system's AI-powered NIDAR Core employs an Internet of Things (IoT) approach, using connected electronic sensors and devices to create the situational map for operational decisions. According to MRASS, the system developer, NIDAR Core is a hybrid intelligence solution that exploits expertise through operational logic.

Summary

Collectively, these aspects are integrated into a single situational awareness picture to facilitate efficient border protection operations. Such systems should interface with new and legacy systems and sensors, to integrate all the country's relevant capabilities under one interface, from intelligence gathering and analysis, through mission planning, to the countering of asymmetric threats on land, at sea, and in the air, to form a layered integrated surveillance and defence capability that detects, identifies, alerts, and responds to current and evolving cross-border threats. ■

Lightweight CBRN Protection

Dan Kaszeta

Protecting military and emergency services personnel from chemical, biological, radiological, and nuclear hazards is inevitably a matter of equipment.

In military operations, size and weight are of particular importance. CBRN protection equipment is meant to be issued on a widespread basis across all parts of the military. For an infantry soldier or a special operations operator, every kilogramme of kit must be well-thought out. The issue of 'combat load' or 'soldier burden' weighs heavily in the minds of military planners. Historically, gas masks/respirators (the terminology varies) and protective suits will literally be competing for weight and space in a soldier's kit with grenades, body armour, water, food, and ammunition. Items of kit that are large and/or heavy have faced an impetus to be made smaller and lighter. For things like CBRN protective equipment, which is designed against a threat often viewed as rare or exotic, there is every risk of things like suits and boots losing out to more ammunition or a spare radio battery.

'Lightweight' in terms of CBRN equipment can also take on other meanings besides weight. While 'light' can certainly be measured in terms of actual grammes and kilogrammes, we must also consider other ways in which something is light. In CBRN protective clothing and equipment, this often means lower heat burden. Weight, thickness, permeability, and other aspects of protective clothing can contribute to the heat burden of wearing CBRN protective equipment. Measures to reduce the heat burden can reduce the volume and weight of such equipment items. The opposite works as well, in that reducing factors such as weight and thickness, while maintaining protective capabilities, tends to reduce heat burden. Militaries around the world have had an inexorable urge to make CBRN protective equipment lighter, smaller, and less burdensome. Since CBRN equipment competes with other equipment in a soldier's combat load, making such equipment smaller and lighter means that it is better positioned to win such competitions and less likely to be jettisoned at the first opportunity. Sadly, the annals of military operations are replete with tales of CBRN kit being left in barracks.

Author

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

CBRN equipment can be a substantial source of heat stress, particularly in hot operational environments such as deserts and jungles.

As a matter of seriousness to commanders, wearing full or partial CBRN protective clothing has long had the reputation of reducing soldier performance at both combat and non-combat tasks, reducing morale, and increasing the likelihood of heat casualties. Chemical warfare is a category of threat that can be mostly alleviated by protective measures, but if these protective measures in themselves cause problems, the chemical warfare threat is still one that must be taken seriously.

Military leaders have long known, anecdotally and subjectively, that wearing protective clothing, makes it harder for soldiers to accomplish a wide variety of tasks. Many years ago, the US Army commissioned a serious study of this phenomenon and commissioned a number of studies in the late 1980s and early 1990s. While the detailed findings are available in summary in an Institute for Defense Analysis document through the excellent US DoD's 'Defense Technical Information Center' (DTIC), I can summarise the findings quite readily. Wearing full or partial chemical protective clothing and masks caused serious performance degradation across the board in every conceivable type of military task, both individual and unit tasks.

Protective clothing

Perhaps the area where CBRN equipment has made the most significant strides is protective clothing. In the beginning years of the Cold War, impermeable suits made of material like butyl rubber or rubberised cloth were commonplace as military PPE. Heat stress made such clothing unbearable in many climates, and many

countries, including most of the NATO alliance, migrated towards permeable types of protective clothing, which had lighter heat stress.

The US Army's own progression in chemical protective suit over this correspondent's career is a useful example. The M3 toxicological agent protective (TAP) ensemble could take the better part of an hour to put on, and would easily kill the wearer in hot clothing unless literally hosed down with water. It was never intended for widespread use and was supplanted by permeable suits with charcoal material to absorb and adsorb chemical threats. The Chemical Protective Overgarment (CPOG) of the 1970s and 1980s gave way to the somewhat lighter and better Battle Dress Overgarment (BDO) starting from the end of the 1980s.

Eventually, in the 1990s, non-charcoal textiles with protective capability started supplanting charcoal suits. They have a degree of breathability, lower heat stress, and greater comfort. Newer fabric technologies are launderable, whereas the older charcoal suits were not. The massive Joint Service Lightweight Integrated Suit Technology (JSLIST) programme at the US DoD procured hundreds of thousands of suits and is still in use. JSLIST is over twenty years old now, and due for replacement. Further developments in protective textiles has resulted in a newer US military programme called the Uniform Integrated Protective Ensemble (UIPE) programme.

This US-based example has mirrored the general approach taken by CBRN protection manufacturers around the world. Nobody enters into a CBRN procurement discussion from a standpoint of 'we want thicker and heavier, and this means that basically every CBRN protective clothing manufacturer is trying to make products that maintain protection while being lighter and provide less heat burden on the user. A number of companies around the world are active in this space. OPEC CBRNe (based in the UK) is a leader in the space, with lightweight CBRN suits named for birds – the Falcon, the Kestrel, and the Kite. For some applications, their chemical protective undergarment is a useful tool.

Blücher (Germany) is still a leader in the field, riding on the success of its Saratoga product line that became the US JSLIST suit. Paul Boyé (France) and W. L. Gore (USA) are both active in the area as well, and have participated in some of the US UIPE work. Gore's Chempak selectively permeable fabric draws on their decades of work in the field, which has made "Goretex" a household name. Blauer (USA) fields a line of suits using Gore Chempak. A deeper dive into protective clothing was in this publication in October 2021, and the broad dynamics of that market remain unchanged.

CBRN suits get far more attention than the humble glove, yet gloves are an important part of protective clothing. The US Army studies mentioned above demonstrated that rather a lot of the performance degradation in essential tasks, including combat tasks and vital maintenance tasks, is due to gloves. For decades, thick butyl rubber gloves were the military standard. Such gloves often made many tasks difficult and some tasks, in vital areas of maintenance and medical care, were very difficult indeed. Newer fabric gloves go a long way towards remediating this issue. While these newer gloves are not always lighter in weight, they are definitely lighter in burden upon the operator, and should be considered in this space. CQC (UK) and W.L. Gore are examples of two companies with non-rubber CBRN gloves.

Even more humble than the glove is the boot. This has been an area of less improvement than other components of a protective clothing ensemble. Many CBRN boots and overboots remain the same as ever. However, one aspect of development that trends towards the lightweight is that the same technologies that benefit suits and gloves can make a sock.

Photo: OPEC CBRNe used with permission

The Kestrel represents a newer generation of lighter CBRN protective suit technology.

Photo: Avon Protection, used with permission

Avon Protection's CH15 is an excellent example of lighter "escape" devices

Photo: US Army/Sgt. Preston Malizia

The US JCAD chemical detector and M50-series JSGPM mask are quite lightweight compared to their predecessors.

Perhaps the way forward here is to not actually field unwieldy CBRN boots but to field a sock that can go underneath a normal combat boot.

It should also be noted that there are a multiplicity of protective clothing manufacturers and products in the civil emergency services market. Their specifications are more driven by regulatory requirements than military standards and are usually designed against different use cases.

Masks

CBRN respiratory protection is also part of the lightweight revolution. Protective masks (often called respirators in some countries) are often the most critical component to military CBRN protection and are a valuable part of force protection in contaminated environments. The weight of a mask is important in several ways. First, if it is heavy or large, a mask, which is often carried on the hip of a soldier, may become unpleasant to carry.

Second, heavy masks become a burden when worn and cause discomfort. Such lessons are not always learned by militaries. This correspondent, in his early career in the US Army Chemical Corps, managed a battalion's transition from the old M17A2 protective mask to the then-new M40 mask. A common complaint at the time was that the new mask was significantly bulkier when worn on the hip, compared to the older mask.

The US military clearly moved in a different direction after the M40. The new Joint Service General Purpose Mask (JSGPM), the M50-series, is made by Avon Protection (UK). It is clearly lighter and more compact than its predecessor. But the JSGPM makes another improvement in operator burden, one which points out one of the long-standing issues in filter-based CBRN masks. The US Army claims that breathing resistance is much lower with the M50 series, compared to its predecessors. Breathing resistance is the phenomenon wherein the user has to inhale harder than he or she would in ambient air without a mask, in order to draw air through the filter elements. Breathing resistance increases heat stress, fatigue, discomfort, and other unpleasant aspects of wearing a mask. Masks with lower breathing resistance feel less burdensome, if they are not appreciably smaller or lighter in weight terms. Exhalation resistance is also a factor, it should be noted, as carbon dioxide build-up and heat stress can be issues if there is significant resistance exhaling. Avon's excellent product shows that great improvements can be made in inhalation and exhalation resistance while still maintaining a degree of filtration that meets acceptable military standards.

Lightweight Escape Masks

It is very much worth noting that not every CBRN protection application requires the full burden and operational endurance of a military mask. Many manufacturers have developed lighter systems for quick use by people with less amounts of training. Such items are often referred to with phrases like "quick masks", "escape masks", or similar. These masks and hoods fill a useful operational niche, especially in protection of civilians. Full-spec military masks usually come in sizes, need a bit of training, and need to be properly fitted and maintained in order to afford the full scope of their protection. They are also designed for use in rugged environments for days at a time.

There is ample scope in many scenarios for quick, easy to use, good-enough-to-save-a-life lightweight protection. Such equipment may not meet, or even need to meet, the more stringent requirements placed upon standard military equipment or emergency services equipment, which is usually governed by strict occupational safety standards. There has long been an accepted need for this category of equipment. Some earlier efforts were fraught with difficulty. One product was forced into a recall. However, a number of excellent products are now on the market in this segment that could rightly be considered lightweight.

Once again, we can look at Avon Protection for an example. Their CH15 Compact Escape Hood is a filtered hood which will give at least thirty minutes protection against Sarin and Sulfur Mustard threats, while having quite low inhalation resistance. Impressively, the CH15 weighs only 508 g. For applications where emergency escape, rather than staying to fight the battle, are the imperative, such a product probably does the job.

Other approaches have been tried by other manufacturers. One product of long-standing is the Victim Rescue Unit (VRU), by Essex Products (USA), with longstanding customer bases in the US Air Force and Department of Homeland Security. The VRU makes no attempt to filter air. Instead, it inflates from an oxygen cylinder, while protecting the head with a heat-resistant hood. ILC Dover (USA), perhaps more famously known for NASA space suits and the M40 mask, has a filtered powered device known as the SCape.

Other areas of CBRN equipment: Detection

Most discussions of lightweight CBRN equipment focus, quite rightly, on respiratory protection and clothing. However, no full account of this subject area can ignore developments in other equipment categories that are decreasing in the area of weight and volume. The areas that come immediately to mind are detection and decontamination.

Detection has made enormous strides in reducing size and weight. When this correspondent started his career three decades ago, the state of the art in the US Army were two detection devices, the M8A1 chemical agent alarm and the Chemical Agent Monitor (CAM). The M8A1 was about the size of two shoe boxes and weighed nearly 7 kg. It used a specialty battery that weighed

a kilogramme. The CAM, made by UK company Graseby (now Smiths Detection) was nearly 2 kg. These days, the state of the art in portable chemical warfare detection is the M4 JCAD, also known as the LCD, made by Smiths Detection. An LCD 3.3 is 580 g, with batteries, and those batteries are four commercial AA batteries. The LCD 3.3 is also far more capable that the earlier detectors.

A specific technical development, the use of corona discharge, which alleviated the need for a radioactive source and the shielding material around it, is part of the reason that the JCAD/LCD can be smaller. The other reason that the JCAD/LCD is small is that electronics of every type are getting smaller. We have and use small electronic devices in our daily life that were unthinkable in previous decades. This has affected detection equipment across the CBRN realm. Devices that were once only available as benchtop (or even larger) items are now man-portable or handheld. Examples include gas chromatograph and mass spectrometers, used for chemical identification, and isotope identifiers, used in radiation response.

Decontamination

The last area for consideration in "lightweight" CBRN protection is decontamination. Lightweight is a particularly relative concept in decontamination. At the risk of simplification, military CBRN decontamination can be broadly divided into plumbing and chemistry. There have been improvements in both aspects. Decontamination sprayers and ancillary equipment have become smaller, lighter, and consume less power than many of their predecessors. An example is the American M26 Joint Service Transportable Decontaminating System Small Scale, made by DRS (USA), which is about one fifth of the weight of the old Cold War era M12 Decontamination System that your correspondent trained on in the early 1990s. The key European decontamination players such as Kärcher (Germany), OWR (Germany), and Cristanini (Italy) have all recently produced systems that are lighter and lower power burden than their older catalogue items. There are practical physical limits, but such trends are likely to continue.

Chemistry has made modest inroads in that some of the newer decontamination solutions are more efficient, per gramme or litre, than earlier options. Of course, proprietary decontamination chemicals are in direct competition with low cost or free generics. The 'lighter' option, such as a specialty decon foam, may be far more costly. The economics of decontamination will vary greatly from scenario to scenario and from user to user. In a desert environment, water might be at a premium. On battlefields near coastlines and rivers, water for decontamination may be, in effect, free.

Truly lightweight decontamination for military purposes remains in the future, but some technological breakthroughs show promise. For decades now, scientists have been exploring the subject of enzymatic decontamination. Such an approach would use small amounts of enzymes to work as catalysts to, in layperson's terms, greatly increase the rate of effect of other processes, like water reacting with chemical warfare agents. Where this becomes "lightweight" is that the amount of enzyme needed for nerve agents or blister agents is, in logistical terms, quite small. Exactly how small remains to be seen, but some scientists envisage situations on the order of magnitude of a teaspoon of enzyme in a large tank of water. Different types of chemical threats will likely require different quantities of enzymes.

Conclusion

The overall trend across the industry is towards lighter and less burdensome products. To put it more bluntly, there is not much of a constituency for heavier and more burdensome equipment. Most end users, if given a choice, will opt for lightweight choices if other factors such as protective capability are roughly equal. The most important advances have, clearly, been in individual protection. But advances in other equipment areas are not insignificant.

Photo: Cristanini s.p.a.

Cristanini's Light Decon Trailer is one of a number of military decontamination products that represent the trend in lighter equipment.

Where does all of this lead? Current trends will continue, and necessary equipment will continue to get lighter. Will we get a chemical detector the size of a watch? Eventually. Nobody has quite reached the 'Holy Grail' in lightweight CBRN protection yet. Such a development might take the form of a chemical warfare protective suit that is functionally identical to the normal combat uniform of a soldier. Developments in textiles show that we are not that many years from such a possibility if a major military customer would commit to underwriting such a course of action.

ESD Interviews – Ambassador Haim Regev

Curtis Hand

Photo: Israeli Government

In March 2023, ESD interviewed his excellency Ambassador Haim Regev, Head of the Mission of Israel to the EU and NATO. The interview was conducted by ESD's Curtis Hand.

Ambassador Regev began his assignment as Head of the Mission of Israel to the EU and NATO in August 2021. Previously, he served as the Head of the Middle East Division in Israel's Ministry of Foreign Affairs (2016 to 2021). In addition, he served as Chief of Staff to the Minister of Foreign Affairs, Gabi Ashkenazi (2020 to 2021). Following the signing of the 'Abraham Accords', Ambassador Regev led the normalisation process between Israel and the Arab countries. He served overseas as Deputy Chief of Mission at the Embassy of Israel in Oman (1996 to 1998), Deputy Consul General to Florida (1998 to 2001) and as Counsellor for Congressional Affairs at the Embassy of Israel in Washington D.C. (2004 to 2008). In Jerusalem, Ambassador Regev served in the Department for Middle East Economic Affairs (2001 to 2004) and as Director of the Coordination Department in the office of the Director General (2013 to 2016). Ambassador Regev was born in Israel, and he holds a B.A. in Political Science and Middle Eastern Studies and an MBA with Honors, both from Tel-Aviv University.

Q: What is the role of Israel's Mission to NATO and why is it important?
A: Israel-NATO relations are based on shared values and a similar threat perception. Israel's mission to NATO works to advance Israeli interests in terms of political legitimacy, influence and force build-up of the Israeli defence and security establishment. For NATO, Israel is a valuable and reliable partner in an unstable region from which it can learn, in various aspects: from awareness raising to capacity building, force build-up and its operationalisation. Against the backdrop of Iranian aid to Russia in Ukraine, the alliance has a vested interest in learning from Israel regarding Iranian capabilities. In addition, Israel has an interest in strengthening the capabilities to operate with partners and here the NATO principles of interoperability are of great importance.

Q: How has the relationship between Israel and NATO evolved and, generally, what new dimensions will the ITTP framework address?
A: Israel has a broad and comprehensive cooperation agreement with NATO which includes a wide range of fields, such as: resilience, innovation, CT, Cyber, Women Peace and Security, Arms control, CBRN, climate change and others. We are in the midst of a process to re-formulate the frame of the partnership with NATO. The agreement includes all areas of existing and future cooperation.
In the last couple of years, the relations between the two sides are in a very positive trajectory. Last January, for the first time, the President of the State briefed the plenary of ambassadors (North Atlantic Council) and met the Secretary General, as well as former Prime Minister Bennett (Oct. 2021) and Foreign Minister Lapid (July 2021). In the past year, three heads of divisions from NATO (Political and Security, Intelligence and security and Emerging Security Challenges) visited Israel as part of the deepening cooperation between the two sides and almost every week there is an Israeli activity at the NATO headquarters. The most prominent examples of the cooperation between Israel and NATO: the fields of intelligence - including the exchange of information and the formation of joint assessments, the certification the IDF academy for field medicine as a NATO training centre and participation in various working groups whose purpose is power building.

Q: Why is Israel successful at defence industrial cooperation within NATO – does the fact that Israel is not so much a defence consumer as it is a defence partner for NATO affect this?
A: Since 2018, Israel has an agreement for cooperation with the NATO procurement agency NSPA, the agreement allows Israeli companies to sell through the agency to alliance members. We can't provide data, but I can say that from a bilateral point of view the mechanism is working excellent especially these days that the countries have agreed for new procurement of equipment and weapons.

Q: Considering the close defence cooperation on professional, industrial, and political levels between NATO and Israel, is there a possibility of Israel joining NATO one day?… Or is there a better chance that Members of the Abraham Accords and NATO will cooperate more closely (i.e., intelligence sharing, joint exercises) to address shared regional (EMENA) challenges posed by State and Non-state actors (e.g., Iran, Daesh, et al)?
A: First and foremost, NATO is a Euro- Atlantic alliance hence the allies are from the Euro- Atlantic region. In any case, Israel relies on itself when it comes to its security and defence. However, Israel – NATO relations are based on the sharing of values and Israel is a committed and reliable partner, in an unstable region. Although the relations run deep, there are many topics that we have not discussed, the potential is huge, and we can do a lot together even in partnership agreements. We are currently focusing on our threats and the Abraham accords and defence agreement with Morocco. We include NATO in this, the potential there is also great, and with the help of the new cooperation agreement, we hope to bring it to the next level. ■

New Power Supply for State-of-the-Art Air Defense: VINCORION's Hybrid Systems Help Cut Carbon Emissions

A reliable electricity supply in the field is a backbone of defense capabilities, and as experts in hybridization, VINCORION's power systems can generate this efficiently. As such, the technology company's military power supply solutions play a key role in greening the armed forces. "In addition to tactical advantages, VINCORION's hybrid technology saves a considerable amount of fuel and significantly cuts carbon emissions," says Daniel Zeitler, Director of Product Management at VINCORION. "Equipped with our technology, military land vehicles can emit roughly 29 percent less carbon. And when used to power air defense systems, we can reduce carbon emissions by 33 percent."

Zeitler demonstrates this using the example of VINCORION's cutting-edge diesel gensets, which are available in a number of different performance classes. A state-of-the-art system with 15 kilowatts of power, for example, requires only 1.2 liters of diesel per hour. In contrast, the old system used 2.5 liters per hour. "Our new systems allow us to respond much more precisely to different load profiles and focus on efficiency in the design of the diesel engines," Zeitler emphasizes. "We then use suitable hybrid elements, i.e., power storage modules, to handle peak loads. That gives us another major advantage – the ability to additionally use external power sources." This includes, for example, electricity from the power grid or renewable energy sources. Grid operation has undeniable benefits – the system no longer consumes fuel locally and there's zero wear and tear. And a major tactical advantage is that, in the event of an "emergency," the gensets can switch over independently and without interruption thanks to the hybrid components and automated energy management.

This is because the power generation systems are also used to provide electricity to air defense systems. The power supply plays a major role in modernization as armed forces use increasingly powerful components. This is the case, for example, in the design of new radar systems such as the LTAMDS radar, or in the formation of entire protective shields, which are also intended to grow and have the ability to be linked together via plug-and-fight functionality. At the same time, however, components that conserve resources are also required, both with respect to reducing emissions as well as fuel consumption, and therefore operating costs.

Such components from VINCORION are, for example, part of the well-known Patriot system, for which the company has been a supplier for over 30 years. At an assumed yearly operational time of 2,000 hours per year, a Patriot unit with the older design would emit roughly 7.8 million tons of carbon. VINCORION's new technology can reduce these emissions by more than 2.6 million metric tons – equal to a decrease of more than 33 percent.

But systematically reducing fossil fuel consumption not only lowers costs, reduces emissions, and lessens dependence on non-European sources. Above all, it makes it possible to reduce personnel deployment. As Zeitler explains, "requiring one third fewer refueling operations also means that up to 50 percent of the personnel previously needed to operate the power systems in the field can be deployed in other ways, such as for higher-value activities." In the event of a conflict, this could also eliminate over

Photos: VINCORION

1/3 of the necessary fuel convoys, which would therefore no longer be targeted by the enemy.

German and European air defenses are currently being modernized as part of the European Sky Shield project, and "our contribution is the right power supply for all advanced defense systems that are going to be deployed as part of the European Sky Shield," Zeitler emphasizes. This ranges from individual emplacements to entire interlinked chains of air defense systems.

"At VINCORION, our focus is on power and environmentally friendly power generation. Our new military diesel gensets for the German Armed Forces, which for the first time will be equipped with state-of-the-art exhaust systems that company with the EU Stage V emission standard, are a perfect example. As such, with our innovative technical solutions, we are ready to meet the requirements of tomorrow." The company is working to contribute to the sustainability of the defense technology industry. Moving away from fossil fuels is firmly enshrined in NATO's strategy. No matter what requirements may emerge over the next few years when it comes to greening the military, VINCORION is working to ensure that it is perfectly prepared to continue playing its role as a NATO partner in the future.

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Israel at 75 – Harnessing Defence Innovation

Tamir Eshel

Israel is a significant player in the global defence market, with a thriving defence industry ranked among the world's top ten defence exporters. Israel is widely recognized as a global leader in defence innovation, with a thriving defence industry and a history of developing cutting-edge defence technologies.

Facing constant threats from regional powers and terrorist organisations since gaining independence in 1948, Israel focused most of the country's investments on security and defence. Its small size and limited resources led it to be innovative and efficient. Seventy-five years ago, Israel begged Jewish supporters worldwide to help finance weapons for its defence. Today, Israel is a healthy economy that allocates almost USD 19 Bn for defence expenditure, while its defence exports are more than half that amount, at USD 11.3 Bn in 2021. With the high demand for Israeli-made defence systems and the good reputation of its proven systems, expectations are that this record will be broken this year as Israel's defence exports continue to soar.

What makes a small country become such a dominant military power? Israel is indeed a small country that maintains a large army, and to do that economically, Israel must be innovative in how it manages defence acquisition. Several factors contribute to Israel's defence leadership position – the first is US military aid. Israel relied on US military support for decades to maintain its armed forces and defence preparedness. The USD 3.3 Bn annual military assistance to Israel has been designed to maintain Israel's "Qualitative Military Edge" (QME) in the region. In the past, Israel could invest part of this amount in locally-developed systems. Since Israeli companies could not produce the platforms, they spent their resources trying to augment, complement, and upgrade the US weapon systems Israel acquired, extend their capabilities, and ensure overmatch over similar weapons obtained by any adversary, which aligned with the QME goal. However, this ability has been diminished under the current agreement as the US agreed to increase the amount of aid but waived Israel's ability to spend part of the funding locally.

Photo: Israeli MoD

State support from the Israeli Ministry of Defence (IMOD) in various forms has helped to nurture Israel's defence-industrial ecosystem.

To compensate for these lost resources, Israel's MOD (IMOD) which previously funnelled US aid money to local industry, became more aggressive in pursuing defence sales to foreign countries under government-to-government sales (G2G). Promoting such deals, the IMOD helps encourages cooperation and alleviate competition between Israeli defence contractors. G2G deals are often larger in scale than the sales signed by the individual companies themselves. Moreover, the terms negotiated at the ministerial level enable both sides to reach agreements faster and at lower costs than tender processes. The scope of these programs is broad, from personal equipment and weapons to complete training solutions, air- and missile defence systems, all based on the experience and know-how gained by the fielding of similar systems by the IMOD and IDF.

Another growth vector is the development of exceptional capabilities, including strategic systems that meet the unique needs of the IDF, capabilities that Israel either cannot, or does not want to obtain elsewhere. Examples are devel-

Photo: Israeli MoD

The Directorate of Defence Research & Development (DDR&D) had been an important source of state support for various national projects, such as the Arrow 3 pictured here.

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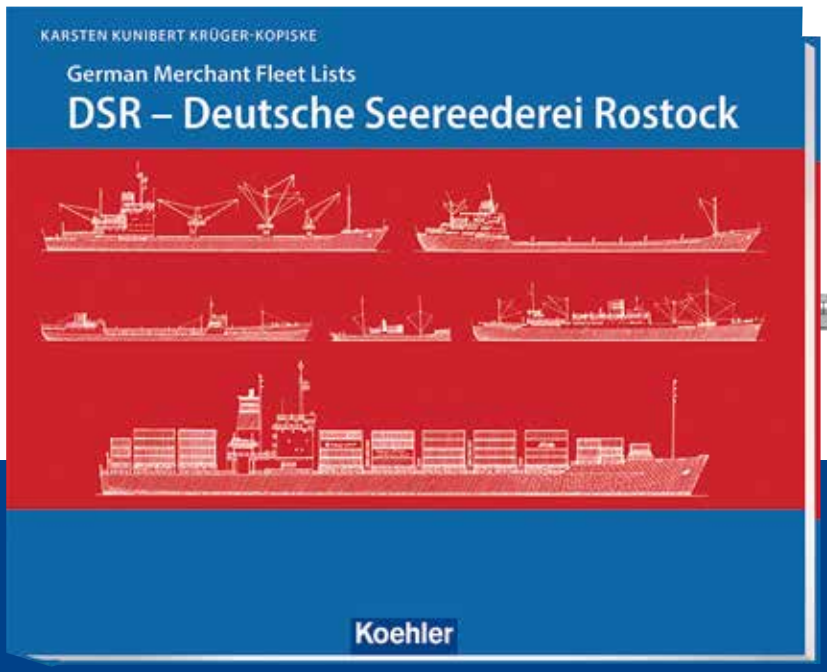

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oping and fielding Israel's spy satellites, multi-layered air and missile defence systems, unmanned and autonomous systems, loitering munitions, and special mission aircraft. The Directorate of Defence Research & Development (DDR&D) at Israel's Ministry of Defence is responsible for seeding, funding, and nurturing Israel's defence innovations. With a budget of several hundred million dollars, DDR&D manages programmes worth billions, incorporating investments from industry and foreign partners.

The third vector is the provision of systems or services that are more affordable than those delivered by the US, thus competing on the programmes that may become more attractive for domestic spending. When matured, such programs become highly competitive in foreign markets.

Until the 1990s, Israel's industrial defence operations were dominated by government-owned enterprises such as IAI, Rafael, IMI, and Israel Shipyards. At that time, the role of the private sector was small. Since then, the landscape has changed, and the publicly-traded Elbit Systems has become Israel's largest defence contractor. Unlike the government-owned companies that relied on a constant share of the business allocated by IMOD, private companies had to fight for every contract. They gained business through successful mergers and acquisitions that began in Israel and expanded overseas to acquire companies such as communications specialist Tadiran and artillery specialists Soltam, continuing the establishment of subsidiaries in key markets in Asia, Oceania, Latin America, Europe, and North America. Privatising some defence companies has also encouraged private investors to step in. The largest was the privatisation of IMI, which contributed to the formation of IWI by the SK group and the expansion of Elbit Systems' Land System Division.

Today, Elbit Systems is Israel's largest defence company, followed by IAI, Rafael, and Tomer as government-owned entities. These companies have acquired majority holdings in new or privately owned companies, such as IAI buying 50% equity in BlueBird. Rafael made similar investments in Aeronautics, mPrest, and SightX. The SK Group has also invested in private companies – and now owns IWI, Israel Shipyards, and private companies Meprolight and Camero. Some of the companies have grown through mergers and acquisitions. Others, such as Bird Aerosystems and UVision, have shown impressive expansion in recent years through organic growth. Both companies can attribute their success to specialisation – Bird Aerosystems in aircraft self-protection systems and ISR, and UVision in loitering munitions.

An exciting trend in Israel's defence industry is establishing an ecosystem of specialist small and medium enterprises (SMEs) focused on defence and security markets. These companies align with the Israeli entrepreneurial startup spirit, backed by funding from innovation labs operated by big corporations, seed money granted by Israel's innovation authority, and R&D funding for specific projects awarded by DDR&D. Based on this initial support, these seeds often mature into innovative defence capabilities that often find enthusiastic customers abroad.

IMOD also assists SMEs in reaching foreign markets through the defence export directorate (SIBAT), by prospecting opportunities, organising visits to Israel for foreign delegations, and the participation Israeli companies in trade events worldwide. Defence exhibitions provide attractive opportunities for startup companies to introduce themselves – Omnisys, Robotican, Smartshooter, Highlander, Easy Aerial, and D-FEND were among over 40 Israeli defence companies participating in the IDEX 2023 exhibition in Abu Dhabi, seeking new businesses and investments in the UAE. Some have already secured investments in this new market which opened to them only two years ago following the Abraham Accords.

As they mature, these startups become opportunities for acquisition by other Israeli companies and foreign buyers. Some gain market attention through public offerings in Israel and abroad. Miniature payload provider Next-Vision, EO/IR and AI specialist Third Eye, and satellite service provider Imagesat traded on the Tel Aviv exchange. Recently acquired by Leonardo, RADA was sold on NASDAQ in the USA. All told, Israel's ecosystem of specialists, coupled with state support, has provided the country with a solid foundation on which to expand its defence-industrial capabilities. ■

Strengthening Europe's Defense Capabilities Amid a Changing Landscape

IAI, Israel's premier aerospace and defense company, is increasingly prominent in the European defense market. With its extensive technology base and vast operational experience, IAI provides a wide range of solutions for countries seeking to strengthen their defense capabilities in response to evolving geopolitical realities.

In recent years, Europe has emerged as a key market for Israeli defense exports, with IAI acting as a prime contractor, subcontractor, and provider of major subsystems in direct and government-to-government (G2G) sales. In this leadership position, IAI has supported European efforts to establish national air defense radar networks, operate spy satellites and airborne surveillance aircraft, and develop advanced intelligence, surveillance, and reconnaissance (ISR). Combined with information fusion and advanced artificial intelligence techniques, IAI's multi-domain intelligence-gathering capabilities provide a strategic pillar in national defense. IAI has also provided missile systems, including anti-ship missiles for naval and coastal defense operations and loitering and missiles for use as deterrent weapons for long-range precision strikes.

Several European countries have leased IAI's HERON and HERON-TP unmanned aerial systems (UAS) for regional and international surveillance and maritime patrol missions. IAI's diverse range of solutions positions the company well to meet the future defense needs of European nations as they adapt to new challenges. Following are some of these activities:

Air Defense: A key priority for many European countries is enhancing their Integrated Air and Missile Defense capabilities. IAI's Arrow-3 exoatmospheric ballistic missile interceptor is critical for providing the top-tier defense layer to intercept ballistic missiles in space, far from their targets. This new capability establishes a multi-layered defense capability that efficiently intercepts targets from short range to outer space. Germany's European Sky Shield Initiative seeks such an air and missile defense system through the joint acquisition of equipment and missiles. Hensoldt, in partnership with IAI/Elta Systems, is implementing new radar systems to extend Germany's air defense network with missile defense capabilities. IAI's BARAK-MX air defense system is crucial for mid-layer protection, offering extended range coverage and networked capabilities. This allows different BARAK-MX assets to operate as a cohesive air defense network or autonomously, providing agile defense against all air threats, including aircraft, ballistic, cruise, and loitering missiles. Using the different interceptors employed with BARAK MX, users can match an optimal interceptor to each target, enabling the air defense systems to use the most efficient battle economy.

UAS: Recent conflicts underscore the importance of UASs as essential weapon

Photos: IAI

HERON MK II

systems. IAI's Heron family of Medium Altitude Long Endurance platforms – including the Heron Mk I, Heron Mk II, T-Heron, and Heron TP – feature fully autonomous operation, comprehensive mission payloads, advanced mission control, and satellite communications for long-range operation and remote basing. The Vertical Take-Off and Landing (VTOL) capable ThunderB and WanderB series mini UAS systems provide similar capabilities for the tactical level.

Loitering Missiles: IAI pioneered loitering weapons in the late 1990s and now offers a range of options, from fully autonomous air-defense suppression weapons to strategic long-range strike, precision missiles for land and naval targets, and tactical "hybrid missiles" operated by individual soldiers.

Autonomy: Using advanced tool kits developed in-house, IAI tailors unique, mission-specific solutions addressing user requirements. Autonomous land and sea platforms are being developed to perform scout missions, secure borders, transport supplies, evacuate casualties, and reduce the burden on soldiers. These systems are being tested in the UK and garner interest from other countries.
Counter-UAS: The increasing reliance on unmanned systems necessitates effective C-UAS capabilities. IAI's Drone Guard system can detect, track, and engage enemy drones.

Modernization: IAI has extensive experience in modernizing and upgrading combat systems, aircraft, and helicopters, from airframe life extension to comprehensive avionic upgrades.

Information and Networking: Among the advanced capabilities that can be added to combat aircraft and other platforms is the network-centric OPAL, providing a secure and encrypted information network enabling information-based multi-domain operations in real time.

IAI's growing presence in the European defense market reflects the company's capacity to address the region's evolving military challenges. As European nations work to enhance their defense capabilities in response to emerging military concerns, IAI's vast array of solutions will continue to play a vital role in strengthening Europe's defense posture for the 21st century.

Barak MX Launcher

Can 21st Century Soldiers Trust Their 20th Century Radios?

Alex Shapochnik

The 21st-century tech revolutions greatly depend on communication technology: autonomous vehicles, drones, smartphones, sensors, IoT, virtual reality - all parts of our business and personal daily lives - rely on high-speed flawless communication. Being adopted by military organisations, and integrated into autonomous systems, intelligence processing, and concepts of operation, resulting in the connection of all dots into a joint environment, these new technologies led to the rebranding of our era's war to 'multi-domain warfare'.

Some of the factors limiting the performance of legacy radio networks are:

RF spectrum: For decades, tactical military networks have operated over a limited frequency range of VHF and UHF bands, spread over a 500 MHz bandwidth. Today, in a typical division-size battle group equipped with an advanced C4I envelope and operating in a limited urban battlespace, the different formations' networks will likely block each other's transmissions rather than enable efficient collaboration.

Data throughput: Today's radios are based on a three-decade-old designs that support a data throughput of hundreds of Kbps at best (like PC modems from the 1990s). They can transfer photos and text, but not live video, often demanded by field commanders. There is just not enough bandwidth to support the present data explosion.

Enemy activity: For over two decades, Western militaries have been accustomed to operating in asymmetric warfare, where only one side dominated the spectrum and was digital and connected, while the other side employed stealth and guerrilla tactics. Operating against conventional modern military forces, an army must consider enemy activity and electronic warfare threats. Both sides extensively employ sophisticated communications and electronic counter measures in the present war in Ukraine.

Interconnectivity: Unlike in the cellular world and the internet, offering ubiquitous connectivity between all users almost anywhere, military networks are still divided into separate groups. Each group shares specific frequency bands and waveforms, traditionally allocated to specific types of communication. Land, air, naval forces, and even different units within the same region have separate networks. High data rate communication is quite rare, often established over point-to-point datalinks, satellite, or line communications. This complex topology prevents efficient interconnectivity and the flexibility required in wartime.

In theory, a company leader who operates under the coverage of a MALE UAS would be happy to receive video footage of the next alley, or a battalion commander to see live footage taken from a boat patrolling near a coast. In reality, even a pilot of the most sophisticated jet cannot receive VISINT directly from a UAV operating in the same area since they do not share common radios. These exotic capabilities are available to special forces but are not within reach of ordinary units.

Photos: Creomagic

Advanced Radio Networks

MANET connectivity is designed to operate self-forming and self-healing networks, delivering stable, uninterrupted broadband that can sustain operations under the most challenging conditions. Such radios use cutting-edge technologies such as Dynamic Spectrum Access technology, also known as 'cognitive radio', to deliver high throughput data connectivity even under massive jamming and extensive interference. MANET capabilities will grow in the upcoming years, with the expected introduction of Artificial Intelligence (AI) algorithms aimed at seeking clear channels, managing agile radio networks, and extracting maximum throughput in a limited bandwidth.

The better-known capabilities of these software-defined radios are Mesh networking and relaying, together with multiple transmission and reception (Multiple Input, Multiple Output - MIMO). These enable the network to retransmit data among multiple radios, making quality video transmission available over long-range links across difficult terrains, such as mountain areas, urban terrain, over the sea surface, and even underground. These radios use advanced waveform with adaptive frequency, bandwidth, and power management. Broadband cognitive radios can form a multi-domain network that thrives in an EW-contested battlefield.

Summary

Spectrum shortages are already a current problem Israeli forces have encountered spectrum shortages in recent operations in the Gaza Strip, where they demonstrated a limited terrestrial manoeuvre, acting as the only modern force in the arena. They suffered from interruptions, narrow throughput and disconnections. Other modern forces, within NATO, which have defined new standards for military communications in the 2010s, have already realised they could barely sustain data communications, even with their brand-new equipment, as some of their units adopted a modest number of helmet cameras, situational awareness, connected sights, and drones, in the last decade. Field tests demonstrated that their communications are not even close to fulfilling the demand for real-time intelligence and situational picture.

Connectivity pressures will exacerbate as the Battlefield Internet of Things (BIOT), with the introduction of wearable sensors and vision systems, augmented reality, and the military metaverse will enter wide-scale military use. Sharing rich sensor data in battle groups must rely on connectivity clouds to provide joint situational awareness, and these will require data transmission beyond the capabilities of today's military radios.

Author

Alex Shapochnik is the co-founder and CEO of Creomagic, an Israeli wireless communications specialist providing mission-critical MANET communications systems for military, first responders, unmanned and robotics applications.

How Do You See Israel – *and Your Company* – Playing a Part in European Security and Defence?

To mark the 75th anniversary of Israel, ESD reached out to a few members of Israeli defence industrial community. We selected a few representative companies of the air, land, sea, and integrated technologies sectors to ask about the role they saw their country and respective companies playing in European Security and Defence.

Photo: IAI

Boaz Levy

Boaz Levy, President & CEO of IAI

IAI's growing presence in the European defence market reflects Israel's, as well as our company's, capacity to address the region's evolving military challenges. IAI offers a broad range of technological advanced systems for Europe. We regard our various collaborations in Europe as highly significant, and it is vital that we do all we can to assist with each other's security and economic development.

IAI has led the development of Israel's multi-layered ballistic missile-defence program, as the prime contractor for the Arrow missile defence system and provider of key elements for other widely-deployed air and missile defence systems. We make use of Artificial Intelligence to convert huge amounts of unstructured data into the applicable intelligence needed to inform operational decision-makers in significant matters that can provide a strategic pillar for Europe's defences.

IAI is proud to be part of Europe's strategy for peace, progress, and prosperity, and we are committed to making our considerable array of solutions available to Israel's European allies. IAI will continue to play a vital role in strengthening Europe's defence posture for the 21st century.

Photo: Israel Shipyards

Eitan Zucker

Eitan Zucker, CEO at Israel Shipyards Ltd. (ISL)

Israel and Israel Shipyards Ltd (ISL) have been playing a significant role in European security and defence for several years. The country has a unique position in the region as a non-European nation with advanced technology and experience in dealing with regional security threats, making it an important partner for European countries in the area of defence. Israel has demonstrated its value as a partner in enhancing the security of Europe. The strong partnership between Israel and European countries is likely to continue to grow in the future as security threats evolve and require new solutions.

Israel Shipyards Ltd (ISL) is a leading shipbuilding and repair company based in Israel. The company has played a significant role in European security and defence by supplying advanced naval vessels to several European countries, including Greece, Romania, Cyprus, and others. These vessels have been essential in safeguarding the region's coastlines, intercepting illegal migration, and combating piracy.

Situated on the Mediterranean coast, the company has easy access to the major shipping lanes that connect Europe, Africa, and Asia. This allows the company quickly and efficiently service the needs of its customers, and to respond quickly to any changes in market conditions.

ISL's naval vessels are designed to meet the specific needs of each country, with a focus on manoeuvrability, speed, and endurance. For example, the Sa'ar 4 and Sa'ar 4.5 class corvettes supplied to the Hellenic Navy of Greece and to Cyprus Navy are equipped with advanced Israeli armament and communication systems making them an effective tool in protecting the south European territorial waters and interests.

ISL has also established strong partnerships with European defence companies, which has led to collaborative projects in the development of advanced naval technologies.

The company's expertise, experience, and commitment to ongoing support and training make it a valuable partner in enhancing Europe's naval capabilities.

Photo: Ophir

Dr Kobi Lasri

Dr Kobi Lasri, General Manager, Ophir Optics, MKS Instruments.

The ongoing Ukraine war and growing tensions between major international players continue to create tremendous opportunities for our industry, including increased demand for advanced, field-proven Israeli defence systems, especially surveillance, UAV, land, and missile defence solutions.

As an Israel-based business, with research and development and manufacturing in Israel, and additional manufacturing in Romania (a NATO member), MKS' Ophir business is an integral part of the effort to spearhead the systems protecting the security of European nations. Ophir is a proud partner to the most innovative emerging defence and security applications introduced by leading OEMs, and thus plays a significant role in European security and defence.

MKS' Ophir business has expanded our manufacturing capacity and capabilities to address the rapidly increasing demands of the defence-industry. Our team has been designing and manufacturing high-precision Infrared (IR) optics, complex zoom lenses and custom components, for combat-proven night-vision and IR imaging optronic systems for more than four decades. Our infrared optical solutions provide high quality imaging performance, over harsh environmental conditions, required for myriad applications including surveillance, counter drone, border control, hand-held thermal binoculars, advanced aviation systems and missile guidance heads.

In a dynamic world, with technological developments that rapidly change our lives beyond recognition, I believe that the Israeli defence industry has an advantage based on field-proven knowhow, breakthrough technologies, and experienced, high-quality human capital. This positions us as a trustworthy, reliable, experienced partner for the most challenging, highly advanced European security & defence system providers.

Photo: Plasan

Dani Ziv

Dani Ziv, CEO of Plasan

Taking part in European security and defence efforts is not an obvious role for a non-European nation, however for Israel, a country built on western values, playing part in European defence efforts is not only a business goal but also a moral imperative.
As a country with an advanced defence industry, and having similar values and being close geographically, European countries are a natural choice for collaboration for Israeli companies, just as they are a natural ally for Israel.

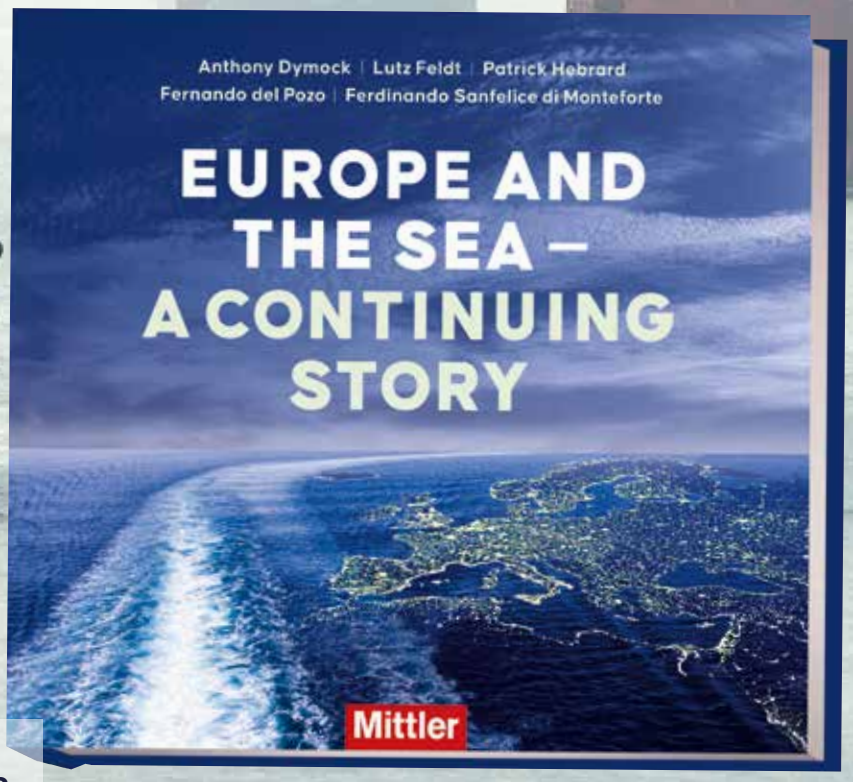
Plasan adds significant value to its European OEM and integrator customers, as an Israeli company and an expert in its field, by bringing state-of-the-art survivability technology which was developed based on requirements and experience gained in Israel, to the European end-user community.

Plasan provides state-of-the-art armour and mine protection technologies to European OEMs, as well as solutions for next generation autonomous and semi-autonomous platforms and an out-of-the-box thinking regarding electrification of the tactical edge, and the new generation of battlefield logistic support. With intimate experience both in asymmetrical conflicts and territorial self-defence, the solutions and ethos that Plasan brings to Europe are closely aligned with the developing needs of European countries to protect their own populations at home and carry out peace-keeping missions on foreign soil. Combining traditional and advanced passive armour together with the latest technologies of hardware and software, Plasan's holistic approach and high value on the protecting of innocent lives is contributing to the safety of European forces wherever they are posted and whatever their missions, in vehicles from the lightest patrol vehicles to the heaviest of tanks.

Israel's future is closely entwined with that of Europe, their security and ours are one and the same.

EUROPE AND THE SEA

A CONTINUING STORY



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Sensor, Shooter, Jammer – The Future of Intelligence, Surveillance, and Reconnaissance in the Urban Battlespace

John Antal

Urban warfare is today and tomorrow's war. The most significant wars in the past three years were fought in urban areas and are the harbingers of battles to come.

Azerbaijan fought Armenian forces in the Second Nagorno-Karabakh War, from 27 September to 10 November 2020, and clinched a military victory when Azerbaijani special forces and light infantry, supported by artillery and drones, conducted a successful infiltration attack to seize the city of Shusha, which is the decisive terrain in Nagorno-Karabakh. The Israel-Hamas War, during 11-21 May 2021, is an exemplar of how to wage modern urban combat as it was fought in the city of Gaza and the tunnels beneath the city. Gaza has an estimated population of 750,000 and the World Population Review website named it as one of the most densely populated cities on earth. Russia's invasion of Ukraine on 24 February 2022, which kicked-off the on-going Russian-Ukrainian War, has been fought over cities, towns, and villages. Battles such as the siege of Mariupol, where outnumbered and outgunned Ukrainian soldiers defended the city from 24 February until their final holdouts in the Azovstal plant surrendered on 20 May 2022, is just one example of urban combat in modern war. As military leaders and systems designers survey these conflicts, the pressing need to study, train, equip, and prepare for urban warfare is obvious and urgent.

A thorough study of urban operations in the Russian-Ukrainian War reveals that conducting a siege of large city, such as Mariupol, which took the Russians 86 days for 14,000 troops, with artillery and airpower, to defeat a defending force of roughly 4,500 Ukrainians, is difficult and usually involves destroying the city and starving the population, a course of action that most Western nations would not accept. The other option, to assault a defended city is a confusing and bloody affair, such as we saw in Kyiv in February 2022, and devours military power at a ferocious rate. Few armies other than the Russian Army and the Chinese communist People's Liberation Army have the manpower or the intentions to wage urban combat the old way. Winning the city fight in the 21st century requires new thinking, but most importantly it requires effective Intelligence Surveillance and Reconnaissance (ISR) that can be used to locate targets for sensors, shooters, and jammers.

Photo: WB Group

Loitering munitions, such as the pictured Warmate from WB Group, are becoming an increasingly on the modern battlefield, particularly in urban environments.

Not Just Sensors, but Sense-and-Strike

ISR sensors work best in open terrain. Buildings and reinforced concrete structures inhibit line-of-sight sensors in urban settings. Several new technologies will improve the capabilities of sensor systems to overcome this in urban settings. The traditional kill chain, using separate sensor and shooter systems, involves a time lag that allows the target to evade the strike. In each of the three wars mentioned earlier, the time lag in the kill chain decreased the effectiveness of kinetic strikes. To decrease this lag, 'sensor-to-shooter' systems have been developed, which allow a user to rapidly characterise a target as legitimate, and then strike it using a range of possible assets. These can shorten the kill chain to a matter of seconds. Further efforts to shorten of the kill chain have led to combining the sensor and the effector into a single package.

Israeli technology companies have shown themselves to be frontrunners in developing robotic systems and loitering munitions. The Israeli-made Harop and Orbiter loitering munitions, for example, played a critical role in Azerbaijan's 44-Day decisive victory in the Second Nagorno-Karabakh War. Israel-based defence company Elbit Systems is building upon

Author

John Antal, US Army (Retired) is a best-selling author and a thought-leader in military affairs. He has written and spoken extensively about the art of war and the changing methods of warfare.

this experience by creating networked, autonomous robots to dominate the battlespace.

Elbit's Legion-X system connects multi-domain robotic sensors of all types into one networked swarm. According to Elbit, "Legion-X is an autonomous networked combat solution based on robotic platforms and heterogeneous swarms… Legion-X provides an advantage in peer/near peer adversary combat scenarios, enabling coordinated deployment of swarms of connected, heterogeneous autonomous platforms and payloads."

The Legion-X network creates 'one-to-many' control (one operator controlling dozens of systems) of air and land robotic weapons. A Wireless Local Area Network (Wi-Fi) is used to exchange voice, data and streaming video. In areas where there is no Wi-Fi, Elbit's broadband tactical data communications network can provide Software Defined Radio (SDR) networking through land or air systems. For added resiliency, the network covers all NATO mobile Frequency bands and does not rely on the Global Positioning System (GPS).

A key element of the Legion-X concept is the LANIUS loitering munition built for urban combat. LANIUS is a beyond line of sight (BLOS) loitering munition with the ability to sense-and-strike autonomously. The system communicates to other connected systems in the network through Wi-Fi or SDR network. Onboard computing and Artificial Intelligence (AI) helps LANIUS avoid collisions with other objects and conducts simultaneous localisation and mapping of its environment. LANIUS is a short-range weapon with a 7-minute flight time that can carry

Photo: US Army/Jerry Woller

A swarm of drones scans the Cassidy Range Complex at Fort Campbell in a scenario conducted 16 November 2021, during the final field experiment for the OFFensive Swarm Enabled Tactics, or OFFSET, program. Researchers with DARPA, designed OFFSET to allow infantry units to use swarms with upwards of 250 drones to accomplish diverse mission objectives in urban environments.

lethal or non-lethal payloads, fly as fast as 20 m/s or hover in one place. The mini-drones can also be launched from a larger, longer-range, drone mothership. To clear buildings, a dozen LANIUS mini drones, armed with high explosive warheads, can autonomously launch from the mothership and search and destroy targets. In future city fighting, soldiers will likely use drones such as LANIUS, in the same manner as grenades were used in WWII room clearing operations, only these smart drones will provide real time video of what is in the building as well as delivering explosive effects.

Photo: Aerorozvidka Drone Unit

Ukraine is using drones for Intelligence, Surveillance, Reconnaissance (ISR) and strike missions to defeat the Russian invaders. In this photo, an R18 drone conducts a bombing test at the 'Shyrokyi Lan' range, in 2020.

Swarm ISR and Strike

Every combat action involves finding the enemy and then striking them. No matter how advanced the weapons, putting human warfighters in harm's way in a city fight is a recipe for casualties. As the fighting in Ukraine's urban areas demonstrates, a city represents a complex battlespace that is dangerous to navigate and difficult to conquer. Urban terrain offers the defending force concealment, hardened positions and the opportunity to ambush in every building and along every road. In the ongoing Russian-Ukrainian War, the Russians have demolished large sectors of towns and cities

Photo: USAF/GS-11 Deb Henley

The US military has used Aerostats for many years to provide real-time, persistent Intelligence Surveillance and Reconnaissance (ISR) information. In this photo, the 84th Radar Evaluation Squadron (RADES) conducted an analysis and optimisation of the Tethered Aerostat Radar System (TARS) to support the Department of Homeland Security (DHS) and Customs and Border Protection (CBP) at Fort Huachuca, Arizona on 13 November 2019.

with various forms of artillery before sending in their troops. New thinking is required to avoid this scenario and the US Defense Advanced Research Projects Agency (DARPA) is hard at work to provide a solution.

DARPA is determined to develop and leverage AI to enhance military robotic systems for urban ISR and combat operations. The Deputy Director of DARPA's Information Innovation Office, Dr. Matt Turek, announced in March 2021, at a Defense Readiness Workshop, that AI is essential to over 120 of DARPA's most important programs. Turek added that DARPA is developing an 'Explainable AI' program, XAI, to enable "third-wave AI systems, where machines understand the context and environment in which they operate, and over time build underlying explanatory models that allow them to characterise real world phenomena." This will create AI-enabled systems that learn their environment to perform a variety of missions. Third-wave AI allows computers to become capable partners, rather than just tools, with human warfighters. An example of human-machine partnering was demonstrated in February 2023 with DARPA's Air Combat Evolution program, which enabled an F-16 Fighting Falcon aircraft to operate independently with AI. The aircraft, renamed as the X-62A or VISTA (Variable In-flight Simulator Test Aircraft), flew several flights under AI control. Such AI will empower an unmanned aircraft to fly as a "loyal wingman" for manned aircraft. When used with loitering munitions, the AI will enhance autonomous and collaborative drone swarming. These tests have placed networked autonomous drones as a top priority for US Air Force funding and development.

DARPA's OFFensive Swarm-Enabled Tactics (OFFSET) program addresses the ISR and strike problem for the urban battle using drone swarms. The DARPA website states that the OFFSET program "envisions future small-unit infantry forces using swarms comprising upwards of 250 unmanned aircraft systems (UASs) and/or unmanned ground systems (UGSs) to accomplish diverse missions in complex urban environments. By leveraging and combining emerging technologies in swarm autonomy and human-swarm teaming, the program seeks to enable rapid development and deployment of breakthrough capabilities." The concept combines collaborative, networked UAV swarms and UGS with soldiers to provide an unparalleled sense-and-strike ability for the urban fight. Swarms of drones will act as both sensors and shooters, isolate buildings or areas in the urban battlespace and conduct urban raids. Instead of swarming soldiers into a city and accepting the heavy human casualties that this would entail, future city fights will swarm with flying and rolling robotic systems. In short, the use of networked, autonomous unmanned systems, employed in swarms, will change the methods of war.

Dominating the Sky and Stratosphere

Real time situational awareness is a force multiplier in a city fight and ISR drones are a basic tool in every modern military force today. Inexpensive, disposable small Unmanned Aerial Vehicles (sUAVs) are available to anyone with a few thousand dollars. Nearly every nation manufactures drones, with the most expensive and capable systems manufactured by China, the US, Europe, Israel, Turkey and Iran. China is a drone superpower as it manufactures 80% of the commercial drones sold world-wide, with most of these being sUAVs. One Chinese company alone, Shenzhen, China based DJI Sciences and Technologies, produces 70% of the world's consumer drones. DJI drones have been used with great effect in the Russian-Ukrainian War, comprising most of the sUAVs used by Ukraine's Aerorozvidka (Ukrainian: Аеророзвідка, "aerial reconnaissance"). Aerorozvidka is a unit of Ukrainian Army drone operators who were drone hobbyists before the war, but have now become expert drone pilots.

Drones offer military capability at low cost. Small quadcopter drones with costs ranging from hundreds to a couple of thousand dollars can be used to see city blocks and can manoeuvre inside buildings, but observing the city battlespace from high and medium altitudes is also necessary to fight in cities. Systems operating from a higher altitude provide a means to unmask enemy forces that are not inside buildings or hiding underground. Manned aircraft can provide medium and high-altitude ISR, but in high-threat environments this mission is accomplished by High Altitude Long Endurance (HALE) and Medium Altitude Long Endurance (MALE) UAVs. Medium and high altitude ISR, however, are not enough when contemplating urban combat in a large city or megalopolis. Persistent ISR is needed. To provide persistent ISR, a multi-layered strategy is required that includes a space layer that uses satellites, a stratosphere layer, and a mid-to-high atmosphere layer. Satellites in orbit around the Earth, either in geostationary orbits or Low Earth Orbit (LEO), provide ISR from space. Manned aircraft, as well as MALE and HALE UAVs provide atmospheric coverage. The gap appears to be in the second layer, the stratosphere, that extends from 7-20 km (depending on latitude) to approximately 50 km above sea level.

To breach this gap, the US Army has been experimenting with unmanned stratospheric ISR systems. Craft operating from the stratosphere can take high-resolution images, transmit and relay communications with relatively low latency, accelerate video-feed and data processing, provide early warning of enemy threats, and can jam an enemy's radar and communications systems, better than satellites in space. These capabilities will be essential for combat operations in a major city. In 2021 the US military emphasised their interest in the stratosphere when US Central Command (CENTCOM) and the US Navy's Surface Warfare Center (NSWC) published a Request for Solutions (RFS) using stratospheric balloons and solar-powered glider UAVs. Tests conducted over the last five years have focused on operationalising the stratosphere for persistent operations in non-permissive environments.

One effort to gain a foothold in the stratosphere is the development of a stratospheric high altitude UAV call the Zephyr, manufactured by Europe's Airbus, and designed by QinetiQ, a UK company. Airbus calls the Zephyr a 'Solar High Altitude Pseudo Satellite' (SHAP-S) that can launch on demand from almost anywhere. Zephyr-8 is one of the latest models of this ultra-lightweight carbon-fibre unmanned aircraft being tested the US Army. It weighs less than 75 kg and has a wingspan of up to 25 m. The wings and tail surfaces are large solar panels that power the aircraft for daytime operation and charge the lithium-sulphur batteries for night-time operation. The Zephyr is so light that six to eight people can carry it for launching as its two propeller-driven engines lift it into the air.

The US Army's Zephyr-8 prototype flew over the southern United States, the Gulf of Mexico, and South America, at 18,288 m (60,000 ft) for 64 days in the summer of 2022, until it crashed in the Arizona desert on 8 August 2022. The US Army did not reveal the precise reason for the crash other than the Zephyr experiencing "events that led to its unexpected termination." Australia also purchased a Zephyr and it crashed on 28 September 2019, when it ascended to 2,438 m (8,000 ft), executed a series of uncontrolled turns, but was disabled by air turbulence, spiralled downward, and broke up during descent. The official reason for the crash was determined to be unstable atmospheric conditions. From 28 January to 4 February 2023, the infamous Chinese Spy Balloon traversed much of the US, before being shot down off the coast of South Carolina. This incident emphasised the military use of the stratosphere. Future urban operations will include, not just dominating the air with traditional air superiority, but also dominating the stratosphere.

Placing sensors and jammers in the stratosphere is a growing military requirement. In most military operations a 'Hi-Lo' mix, combining expensive high-end systems with less-expensive but capable low-end systems provides a battle-winning balance. Balloons can be part of a

Photo: USAF/Senior Airman Elora J. McCutcheon

The US Air Force expects to replace its Global Hawk fleet in 2027 with a more modern and capable system as the Block 40 Global Hawk fleet is no longer survivable against modern air defence. In this photo, an RQ-4 Global Hawk is towed across the flight line on Grand Forks Air Force Base, N.D., on 23 October 2020.

'Hi-Lo' solution for urban operations and can be configured to support swarms of unmanned vehicles with Wi-Fi connectivity, to network the drones in dead spaces such as urban canyons. This type of 'Hi-Lo' mix provides redundancy, resiliency and is less expensive than flying manned or HALE and MALE unmanned systems. The latest Lighter Than Air (LTA) systems can carry large and sophisticated ISR and communications packages to provide persistent surveillance, network connectivity, and electronic warfare (EW) support over a city. Military LTA craft, called Aerostats, can operate in the stratosphere to provide ISR for Counter – Unmanned Aerial Vehicle (C-UAV) defence.

Aerostats can be either tethered or free-flying. These high-flying balloons operate above the altitude of aircraft but below the altitude of satellites, from 18,288 m (60,000 ft) to 30,480 m (100,000 ft) above the ground. One of the leading defence firms involved in military aerostats is the American defence corporation Lockheed Martin. The company was involved in military balloons with the US Navy before WWII, and its latest models, are not your grandfather's blimp. The US has used tethered tactical aerostats at lower altitudes, for surveillance along the southern US border to combat drug trafficking. Since 2013, the Lockheed Martin 420K Aerostat System was the only ISR and communications balloon in daily use in the US until the Biden administration cut off funding and decided to ground them in late 2023. Another Lockheed Martin tactical aerostat model, specifically designed for military persistent surveillance and communications at lower altitudes, is the Lockheed Martin 74K Aerostat. The craft is 35 m long and is tethered with a fibre optic transmission cable. It can carry a payload of 500 kg.

Higher-flying craft can provide a significant wide area surveillance and communications advantages for urban combat operations. Lockheed Martin's High Altitude Airship (HAA) can operate in the stratosphere and provides the ability for unmanned persistent and sustained geostationary ISR, EW, and communications over a city. Due to the typical altitudes it operates at, it is impossible to shoot down with most Short-Range Air Defence (SHORAD) systems. No tether is required as the HAA can manoeuvre in the airspace, directed from a ground station or satellite relay. The usual payload for aerostats includes a surveillance radar, inertial navigation system, thermal imaging and day cameras, and an electronic intelligence and communication intelligence package. Although the US has not armed its balloons, and has no intention to do so, other countries may not be as hesitant. Armed aerostats operating in the stratosphere could become weapons platforms to conduct precision bombardment.

ISR and Strike for the Next Urban Battle

The world is getting more dangerous. The likelihood of a great power war appears to be rising, with the possibility of multiple major wars breaking out at the same time. Fighting in towns and cities is the primary setting for combat in the current Russian-Ukrainian War and the primary lesson from this fighting is that urban combat cannot be avoided. If China were to invade Taiwan, most of the combat would likely occur in an urban battlespace. As much as we wish to avoid battles in cities, it is unlikely, and we must prepare, train and equip to do so. Technology cannot address the challenge of urban combat alone, but it offers an alternative to the bloody fighting playing out in Ukraine.

The future of ISR in the urban battlespace will be characterised by swarming-capable sense-and-strike systems, and means for domination of the airspace and stratosphere above a city. Platforms that provide highly precise multi-domain ISR at safe ranges will improve the network, provide a means to jam enemy systems, and enable drone operations to win the city fight. AI, microminiaturisation, and autonomous unmanned systems are driving these changes in warfare.

In the next decade, military forces will transform from fighting as a network of independent capabilities, as we fight now, to a swarm of systems. In a 2014 study titled "Robotics on the Battlefield Part II the Coming Swarms" by Paul Scharre, the author predicted: "Emerging robotic technologies will allow tomorrow's forces to fight as a swarm, with greater mass, coordination, intelligence and speed than today's networked forces. Low-cost uninhabited systems can be built in large numbers, 'flooding the zone' and overwhelming enemy defences by their sheer numbers. Networked, cooperative autonomous systems will be capable of true swarming – cooperative behaviour among distributed elements that gives rise to a coherent, intelligent whole."

In urban combat, these unmanned systems will provide the mass, reconnaissance and strike abilities that are required to win an urban fight without excessive human casualties. As military forces deploy swarms of networked drones, these will provide ubiquitous ISR and strike capabilities. Dominance in war will soon belong to swarms of networked robotic platforms that can sense, strike, and jam enemy forces autonomously. These weapons will not be inexpensive, but in the next war they will ignite a transformation as significant as the machine gun and the tank did the 20th century. To adapt to these changing methods of warfare, we must think differently and act in time. ■

Supplying the Skies – NATO's Multinational MRTT Fleet

Ole Henckel and Mark Cazalet

The Multinational Multirole Tanker Transport Unit (MMU) is a key component of NATO's air-to-air refuelling (AAR), strategic aeromedical evacuation (Strat AE), and air transportation capabilities. Now, 11 years after the concept was first agreed upon, it is beginning to provide its members with critical aerial capabilities.

On 23 March 2023, NATO's Multinational Multirole Tanker Transport Unit (MMU) officially attained Initial Operational Capability (IOC). This means that the unit, equipped with Airbus A330 MRTT aircraft, is now capable of conducting limited air-to-air refuelling, transport and medical evacuation missions.
Originally, the ceremony was to take place as early as January 2022. However, this date could not be met due to delays caused by the COVID pandemic. However, the fleet had already flown its first missions before this formality. For instance, the MMU was involved in the evacuation of military and civilian personnel from Afghanistan in 2021 and has been supporting NATO air policing missions on the Alliance's eastern flank since 2022.
The mission of the Multinational Unit is to provide reliable and global air refuelling, material transport and medical evacuation. Currently, the fleet consists of seven A330 MRTTs, but this is set to increase, with delivery of two more aircraft planned for 2024. In addition, a tenth aircraft was reported to have been ordered in December last year, according to an article in the Journal of the Joint Air Power Competence Center (JAPCC).

Photo: Mark Cazalet

A frontal three-quarter view of a MEDEVAC configuration MRTT, tail number T-054.

Photo: Mark Cazalet

A single-seat Eurofighter Typhoon (31+06) following successful coupling with the MRTT's drogue refuelling system.

The Path to MMU

A total of six nations are involved in the Multinational Multirole Tanker Transport Fleet (MFF) project, of which the MMU is the operational arm. In addition to the Netherlands, the lead nation of the project, Belgium, Norway, the Czech Republic, Luxembourg and Germany are also involved. The inclusion of further members is possible, but not currently planned.
The six participating nations jointly provide the personnel for the unit and share the costs according to their purchased flying hours. The MMU expects 1,100 flight hours per aircraft, per year. Currently, Germany has booked 5,500 flying hours, the Netherlands 2,000, Luxembourg 1,200, Belgium 1,000, the Czech Republic 100, and Norway 100. According to the JAPCC Journal article, Belgium wants to finance another MMU aircraft as part of its Armed Forces Strengthening Plan (STAR) and thus increase its flying hours account to over 2,000.

The origin of the MMF programme dates back to a 2012 initiative by the European Defence Agency to address the European air-to-air refuelling capability gap. In 2016, the MMF programme was officially launched with the signing of a Memorandum of Understanding (MoU) between the Netherlands and Luxembourg. Germany and Norway followed in mid-2017,

Credit: Mark Cazalet

Two Eurofighter Typhoon Aircraft approach the MRTT to await refuelling during a training flight.

Belgium in early 2018, and the Czech Republic in late 2019.

The establishment of the Multinational Multirole Tanker Transport Unit (MMU) began in 2019, reaching its first major milestone with IOC attainment. In order to achieve Full Operational Capability (FOC) status, firstly, the required personnel numbers need to be trained, certified and made ready for deployment. Secondly, the necessary infrastructure and materiel to operate the unit must also be in place. According to a spokesperson for the MMU, FOC status is to be achieved with the delivery of the ninth machine, slated for the end of 2024. The MMU should then be in a position to comprehensively fulfil its mission.

The procurement of aircraft for the MMU is being conducted through OCCAR (Organisation for Joint Armament Co-operation), while the owner of the A330 MRTT fleet is NATO. For this reason, NSPA (NATO Support and Procurement Agency) is also responsible for management of the fleet. This structure has created a multinational pool of aircraft, which the participating countries can access according to their shares. In addition, there is also the possibility of selling flying hours of the fleet to other NATO and EU states, so that the circle of beneficiaries of this pooling and sharing can extend beyond the MMU states. The aim of this concept is to make expensive but strategically important capabilities such as air transport, air-to-air refuelling and medical evacuation as cost-effective and accessible as possible. In this way, smaller states such as Luxembourg or the Czech Republic have access to capabilities that they would otherwise hardly be able to finance.

According to the MMU, the following order of prioritisation exists to deal with possible situations where multiple members simultaneously request access to the fleet, going from highest to lowest:

1. Deployment in the event of a national emergency or crisis in direct support of the citizens of the requesting MMF member.
2. Deployment in the event of a perceived or actual armed conflict or crisis involving the MMF member.
3. Deployment in the context of national support to EU, NATO or UN missions.
4. Deployment in the framework of support to national humanitarian missions.

Aside from the bureaucratic challenges that arise in the context of multinational units, such as the need to align rules and procedures, there is also a certain loss of national autonomy associated with this concept. For example, what happens if an MMF member wants to transport goods to a country through the MMU, but all other members refuse this transport? According to a spokesperson for the MMU, such an operation would be possible, but would require that the MFF member transporting the goods to have sufficient staff of their own to carry out the flight independently. Accordingly, there is no obligation on the part of the other MFF members to provide personnel in such a case.

The MMU is stationed at the main operating base in Eindhoven (Netherlands) and at the forward operating base in Cologne (Germany). In future, five aircraft and 250 staff are to be stationed in Eindhoven, with four aircraft and 120 staff planned for Cologne. The planned basing location of the tenth aircraft is still unclear.

The MRTT Aircraft

The aircraft used by the MMU is the Airbus A330 MRTT, a heavily modified variant of Airbus' twin-engine commercial model. In terms of dimensions, the aircraft is 58.8 m in length, with a wingspan of 60.3 m, and a height of 17.4 m. The aircraft is manned by 11 crew, comprising two pilots, an air-to-air refuelling operator or loadmaster (depending on the mission), and eight cabin crew. The baseline configuration is capable of transporting a total of 267 passengers, or a total of 45 tonnes of payload, with a lower deck volume of 120 m3 for cargo. However, there is also a MEDEVAC configuration, which replaces some of the seats of the baseline variant with medical equipment, including with six intensive care units, 21 medical seats, and 16 stretchers.

The aircraft is powered by two Rolls-Royce Trent 772B turbofan engines, providing 320 kN (72,000 lb) of thrust each, providing a cruising speed of 224 m/s (Mach 0.71), and a top speed of 253.6 m/s (Mach 0.73). The aircraft has a maximum range of 8,334 km (4,500 NM), and a service ceiling of 12.5 km (41,000 ft). In terms of defensive systems, the aircraft is equipped with a Directional Infra-Red Countermeasure (DIRCM) system to provide protection against missiles equipped with infra-red seekers. In terms of refuelling capabilities, the aircraft can be equipped with either tail-mounted boom or wing-mounted probe and drogue refuelling systems, depending on the aircraft it needs to refuel. The refuelling system is controlled from the on-board air refuelling console, and is capable of delivering fuel at a flow rate of 1,800 kg/minute, which equates to approximately 2,200 litres/minute.

During ESD's visit to the MMU FOB at Cologne on 06 February 2023, ESD staff were given the opportunity to ride along on one of the MEDEVAC configuration aircraft while it performed an AAR mission at an 'air refuelling anchor' over Germany. During the flight, the aircraft demonstrated its capabilities by refuelling nine Eurofighter Typhoon aircraft of the German Air Force which had arrived from various different airbases.

Credit: Mark Cazalet

A twin-seat Eurofighter Typhoon (30+42) having successfully coupled with the MRTT's drogue refuelling system.

For the flight, the aircraft was equipped with a drogue refuelling system, and flight staff on board the aircraft told ESD that while equipped with two drogue refuelling pods, double refuelling was technically possible, but for safety reasons, they don't rend to refuel two aircraft simultaneously. Instead, the system used is to allow an aircraft on one side of the aircraft to refuel, while a second waits in on the other side. Once the first aircraft is finished refuelling and pulls away, the second aircraft on the other side moves in, while a third aircraft moves in to wait its turn on the other side, and so on.

Training of MMU crews is presently being carried out in Seville, Spain. MMU staff told ESD that mixed crews have flown missions, but more typically the mixed crew flights have tended to operate out of Eindhoven, while operations out of Cologne more typically use German crews.

With the MMU having attained IOC and due to attain FOC in 2024, alliance members of the MMU can look forward to having attained a critically-important set of interoperable aerial capabilities, which will provide wide-ranging benefits to the alliance as a whole. ■

As Real as it Gets

JC Menon

Armed forces are looking at high-performance synthetic environments to accomplish more of their training and mission rehearsal.

Modern military operating environment is ever changing and increasing in complexity. As warfare and systems become more complex, so do requirements for military training. Recognising the need to be able to sense and understand the complexities, militaries across the world are trying to orchestrate integrated responses at an increasing tempo, and fully indulge in immersive training environments, that replicate the multiplicities of current and future conflict zones. Towards this goal, governments and defence forces are increasingly looking at high performance and cost-effective alternatives such as the use of simulation and synthetic environments to prepare their personnel for analysis, training and mission rehearsal, and operational decision-making.

Photo: RAF

The Chief of the Air Staff, Air Chief Marshal Sir Mike Wigston opened Gladiator, at the Air Battlespace Training Centre at RAF Waddington on 15 February 2023.

In February this year, the UK Royal Air Force (RAF) announced the opening of a new distributed synthetic multi-domain integration training system, christened Gladiator. "Gladiator will enable our forces to trial, test, and practise their tactics in a secure environment, linked across all operational domains. It is an invaluable training tool for the next generation of warfighters across air, space, land, cyber and sea," said Air Chief Marshal Sir Mike Wigston, Chief of the Air Staff.

Through incremental acquisition, Gladiator will evolve allowing the UK to undertake synthetic training for air, land and maritime forces, all on a secure network and safe in the knowledge that the training cannot be observed by adversaries.

Gladiator is provided by Boeing Defence UK and operated on an MoD network. Typhoon and Lightning II pilots based out of RAF Coningsby, RAF Lossiemouth and RAF Marham will be the first to fly virtual missions using Gladiator. There are opportunities for maritime and land platforms to use the system with Protector, Type 45, Type 26, Apache, Crowsnest, Poseidon, E-7 Wedgetail and other platforms expected to join. UK pilots will also use Gladiator to conduct synthetic training exercises with the US and NATO.

Synthetic training complements live training opportunities and enables delivery of effective combat forces. But a number of factors impact the UK's ability to complete all necessary training in a live environment. These include airspace constraints, environmental considerations, cost, and operational security. Gladiator will overcome these limitations by safeguarding highly classified information while linking together simulators across the country and beyond.

Stuart Lafferty, Flight Simulation and Synthetic Trainers (FsAST) team leader, said: "With Gladiator we can fly a large number of aircraft together at any one time, which in real-life training would be almost impossible and not cost effective. Gladiator is about allowing pilots to do things they couldn't normally practice in the real world. In addition, pilots won't be ageing aircraft, burning jet fuel or firing expensive weapons – these are important environmental and financial benefits to the Ministry of Defence (MoD)."

UK serious on synthetic environment

Recently the UK Strategic Command asked Improbable, a UK technology company to supply its synthetic environment platform to deliver a multi-domain virtual world for operational planning and decision support.

CAE had helped the Strategic Command establish the project in the first year to create a prototype Single Synthetic Environment (SSE) that supported a detailed simulation of a part of the real world. CAE will continue to support in the second year as a key technology partner in the SSE ecosystem.

"We are excited that a SSE will provide the environment for realistic, credible but also affordable planning, training and mission rehearsal to meet the challenges of modern warfare complexities. Our aim is to foster the innovation which will underpin defence transformation, and an investigation of the technical viability and potential utility of an SSE is an ambitious and ground-breaking project which supports that aim," observed Major General Jim Morris, Director of Joint Warfare at UK Strategic Command, the major organisation of the British Armed Forces responsible for leading integration across all domains - cyber, space, maritime, land and air.

SSEs provide a safe virtual proving ground to create and test all sorts of ideas, from policy choices about the size and shape of the armed forces, to design of new systems and technologies and exploring how best to use them. The SSE being jointly developed by Improbable and UK Strategic Command delivers a simulation demonstrator which models the conven-

tional physical domains (maritime, land and air) as well as aspects of space, cyber and the information environment.

"In an increasingly complex world, where threats to national security demand a rapid and coordinated response, we continue to demonstrate that the SSE is a unique and powerful capability with the potential to give Britain a truly competitive edge over its adversaries," said Joe Robinson, CEO of Improbable's Defence business.

The Ministry of Defence's Training and Simulation Systems Programme (TSSP) will also be rolling out VBS4 and VBS Blue IG to support the UK's training, experimentation and mission rehearsal needs. VBS4 is whole-earth virtual and constructive desktop trainer and simulation host that allows users to create and run a vast range of military training scenarios anywhere on Earth. It provides a virtual training environment for land, air and sea training, mission rehearsal applications, and experimentation at any location on Earth, while VBS Blue IG is a whole-earth image generator software, which rapidly integrates with existing third-party host simulators and BISim's VBS4.

The VBS4 and VBS Blue IG, developed by Bohemia Interactive Simulations (BISim), a wholly-owned subsidiary of BAE Systems, have passed defence virtual simulation's (DVS2) full operating capability (FOC) acceptance tests. DVS2 is the UK MoD's common virtual simulation tool, providing interoperable, accessible, and deployable virtual simulation capability across the MOD and Industry. The DVS2 capability enables simulated activity across all levels of training, as well as operations planning and rehearsal, decision support, and research and development.

Photo: British Army

British Army Soldiers engage in live training during the Army Warfighting Experiment 2021 at the Salisbury Plain Training Area.

US Army also developing SE

The US Army's Synthetic Training Environment (STE) cross-functional team is developing a single environment that will allow soldiers to train together from anywhere in the world. The current room-sized simulators will be replaced by portable laptop-powered AR/VR headsets that easily can be transported to soldiers for use anywhere at any time.

The integrated STE system comprises three foundational capabilities: the Training Simulation Software/Training Management Tools (TSS/TMT) software, Reconfigurable Virtual Collective Trainer (RVCT) hardware, and One World Terrain (OWT). "With STE, the army won't have to deal with the logistics of scheduling and transportation of soldiers to training centers, where they compete for precious training time," said Harry Buhl, STE lead investigator for Raytheon Intelligence & Space, a Raytheon Technologies business. "They can train at their home stations with minimal overhead, or even while deployed," Buhl added.

STE will train for air, land, sea, space and cyber using virtual and constructive environments that will be initially synthetic-virtual to replace the army's ageing and costly simulators. The TSS//TMT foundation will expand to bring in live training, from squads at home stations to brigade combat teams at combat training centres,

Photo: British Army

British Army Soldiers engage in VR-based training during the Army Warfighting Experiment 2021 at the Salisbury Plain Training Area.

and constructive training for commanders and their staffs across distributed locations. The US Army's STE, of which TSS/TMT supplies the central software capabilities, allow military leaders and instructors to set up complex virtual battles, coordinating with thousands of Artificial Intelligence (AI)-powered allies, and fighting against artificially intelligent or instructor-controlled adversaries, with realistic AI behaviours and at theatre-wide scale. Soldiers will also be able to repeat these training missions many times over, facing new challenges that will help them to better prepare for live training and enhance their readiness for operations.

US Army's One World Terrain (OWT) programme, which supports current and future combat missions, is on track to become the army's authoritative source for foundation geospatial content and terrain data—from training to operations and targeting. The army will be able to draw terrain data from STE's OWT data and soldiers will be able to interact either through PC-based soldier stations or through STE's RVCT. "We have got to make every round fired count, whether it is live, virtual or constructive, train as many echelons as possible," said Brig. Gen. Charles Lombardo, Deputy Commanding General of the Army's Combined Arms Center-Training (CAC-T). "What the STE will provide us and what you can help deliver is a natural persistent environment where we can do that every month."

Maxar Technologies, provider of space solutions, was recently awarded the Phase 3b of the OWT prototype contract by the US Army. The OWT programme delivers 3D global terrain capability and associated information services that support a fully accessible virtual representation of the physical Earth through the Army network. "The evolution of OWT shows how 3D terrain and information services are becoming essential tools for planning and decision-making not just for the US Army but for a wide range of military, civil and commercial institutions," Tony Frazier, Maxar's Executive Vice President and General Manager, Public Sector Earth Intelligence said.

In 2022, Maxar's Phase 3a work focused on improving 3D terrain dataset fidelity and refining the automation processes to generate realistic terrain derived from Maxar's satellite imagery for high-fidelity modelling and simulation systems, as well as terrain data export capability for operational mission command information systems.

In Phase 3b, Maxar will focus on enhanced conflation with open-source geospatial data and enhanced training areas using multi-source collection, high-resolution insets. The OWT prototype will evaluate the use of small unmanned aerial collections and the geo-registration of existing US Army terrain datasets. OWT is expected to reach full operational capability by 2024.

Recently, the US army also awarded a contract to Cole Engineering Services (CESI) to build a RVCT prototype. CESI has subcontracted Bohemia Interactive Simulations (BISim), a developer of advanced military simulation and training software, to deliver significant components of the US Army's next generation of collective training technology. CESI is also building a Soldier Virtual Trainer (SVT). This prototype project will extend upon the STE modular open systems architecture to deliver an immersive SVT capability that empowers soldier-led training at the point of need.

The SVT combines and integrates several individual soldier training capabilities such as weapon skills development, joint fires training, and use of force. Each SVT capability is integrated and delivered through the SVT Core, which provides common hardware and biometrics powered by the STE-Information System (STE-IS) software.

Defence Firms Invest in SE Platforms

The global synthetic and digital training solution market size is estimated to reach about US$18 billion by 2026. Defence companies in the industry are expanding their investment research and development to guarantee that militaries get the finest possible solution environment.

Leonardo, which is part of the tri-nation Global Combat Air Programme (GCAP) is building a 'battle lab' for the study and evaluation of the future sixth-generation air combat system. To support this, Leonardo has created an environment that combines physical systems, synthetic and immersive reality. The aim is to validate new operational concepts well before a demonstrator or flying prototype will become available. The digital simulator reproduces what a sixth-generation fighter cockpit could look like, where only the stick and throttle of an aircraft are physical, and everything else is virtual/using augmented reality. This interface will provide the pilot with an immersive experience when operating the fighter of the future.

Raytheon is also building the Synthetic Training Environment Soldier Virtual Trainer, or STE SVT, used for virtual reality to train squads of soldiers in multiple scenarios while using real and virtual weapons. The new virtual simulator is designed to train dismounted infantry and uses the latest technological advances to deliver highly effective training at a moment's notice from any location.

"Live training will always be the final test before the Army sends units into combat; it's graduate-level training," Buhl said. "But before live training, they'll do their undergraduate training in synthetic-virtual and constructive worlds. Soldiers can rehearse a mission dozens of times without risking life or limb. They can practice battle drills, emergency situations and mission-critical tasks – what is known as high-consequence training – that can't be replicated safely in live training, like having an engine fail on a real aircraft."

With the likes of the US and UK making continual advances in their pursuit of a fully-fledged collective training environment, the future of armed forces training looks to be on the cusp of a major revolution. ■

AUKUS – A New Security Reality

David Saw and Mark Cazalet

AUKUS is a trilateral security arrangement between Australia, the United Kingdom (UK) and the United States (US) that came into being in September 2021. It reflects the shared concerns of the three signatories about the evolution of the Indo-Pacific security environment in the context of the economic and military challenge from China. Of course what the three AUKUS nations see as a perfectly acceptable security arrangement does not reflect how China sees things. Inevitably Beijing views this as yet another unjust effort to limit Chinese rights and to apply more diplomatic and strategic pressure on China.

The arrival of AUKUS as a factor in the Indo-Pacific security equation was unexpected by most and it certainly caught France by surprise and ended up costing Paris a lot of money. While France continues to be annoyed at how AUKUS came about, and the fact that it was excluded and not consulted, this new security arrangement could be extremely significant and have immense strategic implications. On the other hand, there is a danger that it could just turn into yet another diplomatic talking shop, with very limited concrete measures resulting from AUKUS. That being said, if AUKUS delivers in the key areas that have been discussed by the three countries then it could have a major impact on the strategic situation in the Indo-Pacific. Demonstrable successes could also lead to other regional states wanting to join with AUKUS in a broader security partnership offering a significant boost to regional strategic stability.

A Changed Environment

Central to how AUKUS came about was Australia's perception of its strategic situation and of the steps that it needed to take to manage that situation, both in the current circumstances and into the future. To understand Australia's strategic situation, it necessary to provide some context through looking at some pertinent data about the country. The data in question is drawn from the US Central Intelligence Agency (CIA) 'World Factbook' publication.

Australia is the world's smallest continent, but with a land area of 7,741,220 km2, it is the seventh-largest country in the world, the largest country in the southern hemisphere, and the largest country without land borders. The Australian population is estimated to be 26,461,166 and 86.6% of this population lives in urban areas, the majority of which are on the periphery of the country/continent.

Photo: Australian DoD

HMAS Farncomb (SSG 74), one of six Collins class submarines (SSK) in service with the Royal Australian Navy (RAN), alongside at the Japan Maritime Self-Defense Force (JMSDF) Funakoshi Fleet headquarters in Yokosuka in November 2022. The Japanese Soryu class submarine (SSK) was considered as a replacement for the Collins class.

The country is incredibly well endowed with natural resources. These include: alumina, coal, iron ore, copper, tin, gold, silver, uranium, nickel, tungsten, rare earth elements, mineral sands, lead, zinc, diamonds, opals, natural gas and petroleum. Australia is the largest exporter of coal in the world, with a market share of 29%. While coal has lost its lustre as a fuel source in Europe, in Asia it remains a vitally important part of the fossil fuel energy mix. Australia is also a major exporter of agricultural products, these include: sugar cane, wheat, barley, milk, rapeseed, beef, cotton, grapes, poultry and potatoes.

According to the World Bank, in terms of Gross Domestic Product (GDP), Australia is the 13th largest economy in the world. In terms of exports, Australia's largest trading partner is China accounting for 39% of exports. In comparison Japan accounts for 15% of Australian exports and the Republic of Korea 7%. In terms of imports, China is the largest supplier accounting for 25% of Australian imports, the next largest supplier of imports is the US with 12%, followed by Japan with 7%.

China is important across so many areas of the Australian economy, according to a Reuters story from January 2023: "Australia's education sector, which generated AUD 39 Bn (USD 27.66 Bn) in export earnings before the pandemic, has strong ties to China, with roughly 150,000 nationals enrolled in Australian universities." With China relaxing its harsh COVID protocols and bringing in rules that will not recognise degrees gained via online learning, Chinese student numbers in Australia could grow even further.

The fact that Chinese students could be returning to Australia is a sign that relations between Beijing and Canberra are improving, in a departure from their trend in recent years. Despite the size and importance of trade links between the two countries, relations between China and Australia have

Photo: UK MoD

HMS Anson, the fifth Astute-Class attack submarine for the Royal Navy, leaving the BAE Systems shipyard in Barrow-in-Furness in February for His Majesty's Naval Base Clyde in Scotland from where she will undergo sea trials. A British SSN design remains one of the options for Australia.

been poor. China imposed trade sanctions on Australian coal, barley, wine and other commodities and services. Prior to the imposition of an unofficial ban on imports of Australian coal in 2020, Australia was the second-largest supplier of coal to China. In 2021 and 2022, there were no imports of Australian coal into China. However, according to media reports in early January, China Energy placed orders for Australian coal in January 2023.

There are a number of factors that have led to this thaw in relations between China and Australia, one that cannot be underestimated is the decision by the Chinese government to relax its excessively draconian anti-COVID strategy. This presented an opportunity to open up to the world and to explore new diplomatic and economic possibilities. Mention should also be made of Australia's own stringent anti-COVID measures, so perhaps both sides were slightly more open-minded than previously.

Another important factor is that there was a change in the Australian government after the May 2022 election, with the Labor Party winning a majority of seats and Anthony Albanese becoming Prime Minister. The previous Prime Minister Scott Morrison resigned as leader of the Liberal Party after conceding the election. From China's perspective, the ousting of Morrison was a positive development – he was seen as difficult and his role in the formation of AUKUS hardly endeared him to Beijing. Elsewhere, the French government and naval industry were probably content with the fall of Morrison, as he managed to cause them considerable grief.

Developing improved relations with the Albanese government is in China's interest, if they can weaken Australia's perception of China as a destabilising factor in the regional strategic equation, that would prove very helpful. Another line of attack to diminish AUKUS is the expense that Australia will incur from the acquisition of nuclear attack submarines (SSNs), a central element of AUKUS. In parallel, there will be references to a destabilising regional arms race and nuclear proliferation. It is quite clear that it is not in China's interest that Australia gains an SSN capability and develops closer defence relations with the US and, to a lesser extent, the UK.

Starting Points

Fundamental to the Australian security strategy are a number of treaties signed with the US, the first of these is the Australia, New Zealand, and US Security (ANZUS) Treaty signed in 1951. More recently the US and Australia signed an agreement on closer bilateral defence and security cooperation in 2014, as a part of this the US Marine Corps (USMC) and US Air Force (USAF) aircraft conduct frequent deployments to Australia. Australia also has Major Non-NATO Ally (MNNA) status with the US; as such, Australian and US forces conduct frequent joint training exercises.

Beyond long-standing political and cultural ties, there are also significant links with the UK in a defence context, both nations are signatories to the Five Powers Defense Arrangements (FPDA), along with Malaysia, New Zealand and Singapore, signed in 1971. In the event of the threat of an attack or an actual attack, the signatories agreed to consult on what steps should be taken in response. More recently, bilateral defence relations between Australia and the UK have been closer and more codified via the Treaty for Defence and Security Cooperation signed in 2013. Beyond that, there is the Australia-UK Ministerial Consultations (AUKMIN), this is a bilateral forum for the discussion of defence, security and other issues. The UK and Australia also have a more concrete manifestation of defence collaboration via the Type 26 frigate programme from the UK and the building of the Hunter class variant for the Royal Australian Navy (RAN).

First and foremost for Australia is its defence relationship with the US, and both nations have become increasingly concerned over China's military build-up. It was not just about the number of sophisticated systems that were being fielded by China, it was the expansion of China's strategic reach. For the first time since the collapse of the Soviet Union, the US Navy is facing a peer-level competitor. Moreover it is a competitor that has been out-building the US Navy and fielding large numbers of modernised units. From Australia's perspective, the rise of Chinese maritime power coupled with its increasing economic power was becoming their primary strategic challenge. The close economic links between Australia and China were increasingly seen as a vulnerability. This perception was increased as China imposed trade sanctions on Australia.

A Question of Submarines

The RAN SEA 1000 Future Submarine programme was put into place to find a successor to the six Collins class (Kockums Type 471 design) diesel-electric, guided missile submarines (SSG) that had been commissioned into the RAN between 1996 and 2003. The Collins class had been a complicated and controversial defence programme in Australia, but eventually after many years of effort and extra expenditure they had managed to resolve most of the problems. The Collins replacement programme got underway in December 2007, received the SEA 1000 project designation, and then evolved to cover the acquisition of 12 submarines to be built in Australia. To meet the requirements of the project, SSK designs from France, Germany, Japan and Sweden would be evaluated.

In November 2015, Naval Group (at that time DCNS) from France submitted their proposal for the final stage of SEA 1000, which was based on the Shortfin Barracuda Block 1A design. This was an SSK variant of the Barracuda class SSN design as used by the French Navy. In April 2016 it was announced that the Naval Group proposal had been selected, with programme cost being stated at AUD 50 Bn (equivalent to EUR 30 Bn at that time). SEA 1000 was then designated as the Attack class by the RAN. The original plan was that work would commence on the programme in 2023 and would continue over 25 years, with HMAS Attacker, the lead boat of the class to be delivered in the 2030s.

The timeline of the submarine programme indicated a long-term relationship between Australia and France, however this was intended as more than a defence-industrial relationship. It was also a strategic security relationship as France is itself an Indo-Pacific nation via its overseas territories (France d'outre-mer) in the region. Forging a strong security partnership with Australia was absolutely in the national interest of France.

As time went on, doubts began to surround the submarine programme, firstly there was

Photo: US Navy

USS Oregon (SSN 793), a Virginia class attack submarine (SSN), returns to the Naval Submarine Base New London in Groton, Connecticut in October 2022. Commissioned in May 2022, USS Oregon is one of the most modern SSN in US service. Australia is considering the Virginia class as an SSN solution.

cost escalation, as an official figure in October 2020 referred to a total programme cost of AUD 80 Bn, a 60% rise in costs over a little more than four years! At the same time, doubts were being expressed over the share of work available to Australian industry. Negatives were starting to surround the Attack class programme.

The End is a Start

A further set of factors then came into play, these were based on what the RAN actually wanted to do with its submarine force. How they envisaged submarine operations in the Indo-Pacific was going to require a submarine capable of extended range operations and long endurance, they then had to take into account the current and future operational capabilities of their most likely strategic competitor and adding this all together, it was reaching the limit of what an SSK could achieve. In reality, for many years, the submarine requirements of the RAN were a requirement for an SSN. The reason the SSN solution had never materialised was a strong anti-nuclear posture at a political level, no nuclear industry in Australia and the cost of acquiring SSNs.

At the end of 2020/start of 2021, all of these different factors came to a head. China imposed economic sanctions on Australia, Chinese naval expansion continued at an incredible rate, thus destabilising the regional strategic equilibrium. In response, Australia sought to draw closer to traditional allies in the form of the US and the UK, in terms of wide ranging defence and security cooperation. Australia then came to the conclusion that it needed and could afford an SSN force, and that acquiring such a force would be possible via defence collaboration arrangements with the US and UK.

This led to an Australian government announcement on 16 September 2021 that: "Australia, the United Kingdom and the United States have agreed to the creation of an enhanced trilateral security partnership – AUKUS." The statement continued: "AUKUS will build on the three nations' longstanding and ongoing bilateral ties, and will enable the partners to significantly deepen cooperation on a range of emerging security and defence capabilities, which will enhance joint capability and interoperability. Initial efforts under AUKUS will focus on cyber capabilities, artificial intelligence, quantum technologies, and additional undersea capabilities."

As a part of this the Australian government stated: "The first initiative under AUKUS is for Australia to acquire nuclear-powered submarine technology, leveraging decades of experience from the US and UK." Due to this Australia would no longer proceed with Attack class submarine programme. The point to remember here is that France knew nothing about AUKUS and did not suspect that the Attack class would be cancelled. The end result was major damage to Franco-Australian relations, although under the Albanese government a healing process seems to be taking place.

Working with the US and the UK, Australia has developed a strategy for SSN acquisition, industrialisation, operational factors and sustainment.

The Next Steps

On 13 March 2023, Australia's chosen path forward was revealed in a joint announcement in San Diego from President Biden, Prime Minister Sunak, and Prime Minister Albanese. The announcement stated that Australia's acquisition of an SSN capability would take place in three phases.

Under the first phase, the US and UK would train Australian sailors to operate SSNs, with the US deploying four Virginia class submarines and the UK deploying one Astute class submarine to Australia's HMAS Sterling Naval port located near Perth on a rotational basis. The initiative is known as 'Submarine

Photo: Australian DoD

HMAS Sheean (SSG 77), boat five of six Collins class, enters the port of Hobart, Tasmania. The submarine missions envisaged by the Royal Australian Navy (RAN) were essentially beyond the capabilities of conventional submarines, the nuclear submarines to be acquired via AUKUS finally recognise that fact.

Rotational Force-West' (SRF-West), and is due to commence in 2027. Australia will also construct shipbuilding and maintenance facilities in Adelaide to prepare for the following phases.

Under the second phase, Australia is slated to procure three Virginia class submarines, with the option for a further two, from the US as an intermediate SSN capability. These are due to begin entering service in the early 2030s.

Under the third phase, Australia and the UK will jointly produce the future submarine design dubbed 'SSN-AUKUS' for both navies. This will be based on UK's the SSN(Replacement) (SSN(R)) programme to replace the Astute-class, but will be modified from the original design. The SSN will be designed by BAE Systems, powered by a Rolls-Royce nuclear reactor, and will incorporate unspecified US submarine technologies. The design and development of SSN-AUKUS will commence in 2023, although it is worth noting that some of the groundwork has already been covered under the SSN(R) programme. The submarines are due to be constructed at BAE Systems' Barrow-in-Furness facility in the UK, and presumably at the Adelaide facility in Australia. The first UK boats are expected to be delivered in the late 2030s, while Australia is slated to receive its first boats in the early 2040s.

Photo: BAE Systems

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

As part of the agreement, Australia will not enrich or reprocess spent nuclear fuel, nor produce its own nuclear fuel for its SSNs. The fuel is due to be provided by the UK and US in the form of sealed, welded units which will not require refuelling during their useful life. The work share of nuclear fuel supply is so far unclear, but presumably the US will supply the fuel for Australia's Virginia class boats, while the UK will be the supplier for 'SSN-AUKUS'. It is also presently unclear whether Australia would retire or aim to continue operating their Virginia class boats once their 'SSN-AUKUS' boats have entered service.

In taking this 'best of both worlds' approach, defence-industrial relations between the three powers have been strengthened considerably, and Australia is due to secure a credible SSN capability through the 2030s and 2040s. However, as should be expected, such a move is likely to generate a corresponding response from China. While the form of this response is not yet known, the strategic situation in the Asia-Pacific region does not yet appear bound for calm waters. ■

Keeping Alliance SOF "A Step Ahead" – The MSAP TC in Zadar

Tim Guest

Training helicopter air crews in the art of transporting special forces on operations of all kinds, day or night, in all weathers, is crucial to enhance interoperability and readiness between member states. Enabling those crews to train in one place is why the Multinational Special Aviation Programme Training Centre (MSAP TC) in Croatia was established.

MSAP is a training facility for helicopter crews who conduct the insertion and extraction of Special Operations Forces (SOF). Supported by NATO Special Operations Headquarters in Mons, Belgium and two mentor nations – Poland and the US -- the MSAP TC is available for the entire NATO Community. This article takes a look at the MSAP TC from inception to the present.

Background and Opening

The Multinational Special Aviation Programme Training Centre has just entered its fourth year of operations. Back in late 2018, four allies, represented by the defence ministers from Bulgaria, Croatia, Hungary and Slovenia, signed an MoU to create the MSAP, with a training facility in Zadar, Croatia. The new training centre (TC) was to be dedicated exclusively to training rotary-wing air crews in the art of conducting SOF insertion and extraction operations. NATO's Deputy Secretary General, Rose Gottemoeller, said at the time that, that in a changing world, NATO had to continue to adapt to meet evolving security threats and with SOF having proven to be a highly valuable and versatile tool for responding effectively to many such challenges, it made sense to establish the new training centre to enhance their skills. The establishment of the MSAP TC, as a co-operative arrangement, was underpinned as emblematic of the innovative approach NATO Allies and partners were now taking to enhance the collective defence capabilities between all members of the alliance.

The whole concept of the MSAP TC had been launched three years earlier with a Letter of Intent (LoI) signed in June 2015 between the defence ministers of those same four nations. That was followed in September 2016 by the countries' chiefs of defence signing an LoI, and underscoring its intended focus on multinational training co-operation. The new aviation training programme was to be established in a gradual manner, expanding training opportunities offered to SOF over time and, in the process, creating an important new asset within NATO that would contribute to the alliance's adaptability and readiness.

Photo: MSAP TC

In June 2021, advanced flight training took place at MSAP TC during night conditions. using night vision devices.

Photo: Croatian MoD/ T Brandt

MSAP TC conducted its Joint Personnel Recovery Flight Training in September 2022.

The TC was scheduled, at a Memorandum of Understanding (MoU) signing in 2018, to have its doors open by the end of the following year.

True to that scheduling and solid efforts by the Croatians, the new MSAP TC at Zadar opened in mid-December 2019, dedicated, from the outset, to training air crews responsible for transporting alliance SOF operatives. Represented at the opening, which was hosted by Croatian Deputy Prime Minister and Minister of Defence,

Damir Krstičević, were defence ministers and representatives of the four participating allied nations, as well as Chief of the General Staff of the Croatian Armed Forces, General Mirko Šundov, and the NATO Assistant Secretary General for Defence Investment, Camille Grand. The Commander of NATO Special Operations Headquarters, Lieutenant General Eric Wendt was also present, but it was Grand who said at the time that the MSAP epitomised what the alliance was all about, that allies achieved more together than they ever could individually, and that by committing to training the next generation of SOF aviation crews in one place, it laid the foundations for ever more seamless joint operations.

Photo: MSAP TC

Picture taken during advanced flight training in June 2021, using night vision devices.

Plans announced at the opening were for academic training to begin in 2020, before the start of flight training in 2021. The reason Zadar was selected for the new facility was because of its geographic location; with easy access to mountainous, sea and island settings, it offers training opportunities for helicopter crews in a wide variety of topographical environments and challenging possible scenarios.

Despite the arrival of COVID, the 2020 academic year went ahead as planned, and the MSAP TC's first group of students graduated from a first training module in October 2020. Flight training got underway in 2021, and in September that year, the team at Zadar convened a special aviation gathering for senior Special Operations' commanders, in order to discuss future training programmes for SOF aviation, as well as to demonstrate the full capabilities the training centre now had to offer. Emphasising the importance of the MSAP TC in his opening address, Croatian Director of General Staff, Major General Ivica Olujić, stressed how the centre offered exceptional facilities and opportunities for aviation crews from across Bulgaria, Croatia, Hungary, Slovenia, though with support from Poland and the US. Opportunities to train together, not simply in one location, but a location that offers experience of such diverse terrain. He commented on how the new programme, by integrating Croatian Special Operations Command and Aviation Special Operations, was also an exceptional opportunity, at a national level, for Croatian Special Operations and Air Force (HRZ) to gain experience, exchange knowledge, and develop their capabilities of working together.

MSAP TC's Director, Colonel (at the time) Tomislav Pušnik, together with Colonel Raffaele La Montagna, NATO Special Operations Headquarters Director, Air Development Programme, delivered an overview of the programme, its history and the objectives of the training programme to the distinguished audience; this was the first time such a distinguished and relevant SOF 'assemblage' from across the alliance had come into direct contact with the programme. Pušnik explained the relevance of the centre for the Special Operations Air Task Unit, and gave the assembled guests a full idea of MSAP TC capabilities, what training at the centre would impart on all participants, as well as how, by alliance nations coming together for the same training, would enhance the interoperability between NATO member SOF and assets. Indeed, when it comes to interoperability, MSAP instruction and training focuses on the use of a common approach for joint training missions to ensure student pilots understand they are learning the necessary skills expected by, and throughout, the alliance. At the time, Pušnik said, "The security situation in the world is rapidly changing. In the future, it is hard to predict conventional conflicts, so we should be a step ahead." How right he was, considering where we are now! And he continued by saying that the best way to keep ahead was to organise small units on a tactical level, which would be capable of reaching strategic effect. Hence, the reason for MSAP TC.

As the centre was now well into its first flight training year, with flight courses having started in June 2021, the September 2021 gathering was treated to an afternoon tactical demonstration displaying the importance of special operations aviators and operatives working together to capture a high-value target in two different scenarios. In each, the ground operatives required close co-ordination with the aviators to ensure rapid infiltration and exfiltration, while at the same time, ground operatives worked closely with Joint Terminal Attack Control (JTAC) to call in close air support. Commenting on the demonstration, NATO's Special Operations Headquarters Senior Representative at the event, Colonel Christopher Cassem stated, "The capabilities demonstrated today highlight the importance of combined air and ground training in special operations. Together, their joint capabilities are ready to respond to any threat, from any direction, at any time."

Planning together is mission critical for special operations aviators and operatives, hence being a chief element of MSAP TC training and highlighted on the day. Also impressed with what he'd seen, Major General David Tabor, US Special Operations Command Europe Commander at the time, (now, since mid-2022, Director of Programmes, USAF), said, "I'm excited about the future that the MSAP holds, not only for Croatia, but for the entire alliance, because while this is about building capabilities and capacity to defeat our common adversaries, it is also about reinforcing friendships."

High Visibility

The MSAP initiative is one of what NATO calls its High Visibility Projects (HVPs), which focus on delivering the most critical capabilities in an accelerated manner by creating political commitments in the form of agreements signed by defence ministers. An initial document, also called a Letter of Intent (LOI), as described ear-

lier in MSAP's case, outlines the general co-operation idea and is signed by the defence ministers involved in the project. It is followed by the signature of an MoU, again, as described earlier in the case of this programme; this is a legally binding document specifying the details of co-operation. The MoUs provide the necessary legal framework for the execution of the implementation phase towards the delivery of the specific capability. The high-level political involvement dramatically increases the prospects of expedient and tangible progress.

All that explained, MSAP is actually one of only three HVPs covering the area of SOF. The other two sister projects, for the sake of continuity, are C-SOCC (Composite Special Operations Component Command) and R-SOCC (Regional Special Operations Component Command).

In the MSAP case, all of the four participating allies were assigned NATO targets to establish Special Operations aviation units with vertical lift capabilities by 2025, and they made the decision to work together to fulfil those targets. The MSAP initiative and LoI launched by the four allies here, agreed to collaborate to provide a Special Operations Air Task Unit, with the training component identified early on as the most promising opportunity for co-operation. Indeed, it was a training-specific agreement that was signed by their Chiefs of Defence in September 2016 and the rest, as they say, is history, as described earlier.

Yet why is the MSAP TC so important? As highly trained soldiers in small, elite units, SOF conduct a broad range of operational scenarios in many demanding regions around the world, but there are challenges in providing the necessary training to such teams in an economical manner. However, by pooling resources at the MSAP TC, the participating allies experience cost-effective, specialist training on one site, though one that is expected to expand its training opportunities further and may also increase the number of participating allies, in due course. At this time, the facility is funded and staffed equally by the four participant nations, with each having the right to use MSAP in proportion to its financial contributions and contributions in kind. The host nation, Croatia, provides the necessary infrastructure.

Photo: Croatian MoD/ T Brandt

In September 2021, the MSAP TC conducted a three-week Joint Personnel Recovery Flight Training course.

Photo: Croatian MoD/ T Brandt

The September 2022 JPRFT involved all MSAP nations: Bulgaria, Croatia, Hungary and Slovenia.

MSAP provides a unique opportunity for allied SOF aviation crews to train together, intensely, in one, geographically-versatile, helicopter training area to strengthen SOF interoperability, increase operational readiness, and enhance NATO's overall deterrence and defence capabilities.

Recently at MSAP TC

In September 2021, the MSAP TC conducted a three-week Joint Personnel Recovery Flight Training (JPRFT) course in which all MSAP nations: Bulgaria, Croatia, Hungary and Slovenia, participated together for the first time with aircrews and SOF. The training was conducted at the Pukovnik Mirko Vukušić barracks in Zemunik, in the wider Zadar area, as well as on training areas and ranges of the Croatian Armed Forces. As well as participants from the Croatian Air Force (HRZ) and SOF Command, training was supported by other units from Croatian Armed Forces, including the Croatian Army. Aircraft used during the training, included an Mi-171Sh helicopter from Croatia, two AS 532 helicopters from Bulgaria and Slovenia, and an H145M helicopter from Hungary. The HRZ's OH-58D Kiowa Warrior helicopters and Pilatus PC-9 aircraft also participated in some of the training segments.

Illustrating just how high profile the MSAP Programme has become over a relatively short space of time, at the end of this extensive training period, the MSAP TC held a Distinguished Visitors Day (DV Day), which was attended by Bulgaria's ambassador to Croatia, Mrs Genka Vasileva Gergieva, US Counsellor and chargé d'affaires, Mr Mark Fleming, Bulgarian Defence Attaché, Brigadier Yoan Pavlov, as well as representatives and commanders of Croatia's MoD, the HRZ, and special forces commanders, as well as opposite numbers and other distinguished guests from the other three allied nations.

Then, in December 2021, a ceremony and gathering took place at the Colonel Mirko Vukušić barracks in Zemunik, to mark the MSAP TC's 3rd Anniversary. The event was attended by the Commander of Croatia's Special Forces Command, Brigadier Ivan Miloš, together with the HRZ's representative and commander of its 93rd Wing, Brigadier Krešimir Ražov, along with officers and non-commissioned officers from the barracks. The occasion saw MSAP TC director, the now 'Brigadier' Tomislav Pušnik, and his deputy director, Hungarian Colonel Dezso Takacs, present certificates of appreciation to the commanders of the armed forces' units, which have, over the past three years, provided exceptional support in the daily academic and flight-training work of the MSAP TC. Brigadier Pušnik said that their support had ensured the centre's ability to deliver top-quality, effective training during this period.

Photo: Croatian MoD/ T Brandt

During the JPRFT, aircraft used included an Mi-171Sh helicopter from Croatia, two AS 532 helicopters from Bulgaria and Slovenia, and an H145M helicopter from Hungary. The HRZ's OH-58D Kiowa Warrior helicopters and Pilatus PC-9 aircraft also participated.

Future

The importance of MSAP TC is why it is supported by the NATO Special Operations Headquarters at Mons in Belgium, as well as benefitting from informal ties with the Special Operations aviation communities of selected allies. As already stated, this SOF cooperation between so many nations, in one place, is said to be unique to NATO. With alliance standards applied throughout by all participants passing through the TC, not only is it set to increase interoperability amongst the four initial participant nations, but also throughout the alliance, and potentially beyond, with other NATO partners. Such potential stakeholders may decide to join MSAP in the future, which could lead to a further expansion of the centre's scope.

For the moment, the four founding MSAP allies will continue to explore the feasibility of similar multinational arrangements between them, which might be of mutual benefit, including in other areas essential to the effective functioning of their Special Operations aviation units, such as in acquisition, logistical support, or infrastructure. ■

Accelerating Advantage: NATO's DIANA Programme Picks up Speed in Harnessing Technological Innovation

Lee Willett

Armed forces have been wrestling for some time with the challenge of how to integrate innovative technologies more rapidly into military operations. This requirement has become ever more pressing with the return of state-based competition, and now, conflict. NATO and its member states established the DIANA technology innovation process to harness new technology and deliver it across the alliance. Now, with the onset of the Russo-Ukraine war, the need for NATO to maintain its defence technology edge and the role of processes like DIANA in underpinning this are ever clearer.

Maintaining technology edge to deliver renewed operational advantage is central to NATO's recapitalisation of its collective deterrence and defence posture. Set against this strategic requirement, at its Brussels Summit in June 2021 NATO began laying out a technology roadmap to improve co-operation and interoperability between alliance member states in developing, deploying, and integrating new technology. With an intent to link 'start up' technologies more rapidly to operational requirements and 'end users', at the summit NATO announced the establishment of a civil-military technology construct titled the Defence Innovation Accelerator for the North Atlantic, known simply as DIANA.

As set out in Brussels, the next step on DIANA's development pathway was to have the concept's functional mechanisms in place by the Madrid Summit, scheduled for June 2022. Then, on 24 February 2022, Russia launched a full-scale invasion of Ukraine.

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Photo: NATO

At the Brussels Summit in June 2021, NATO announced the establishment of DIANA.

Collective Response

By the time of the Madrid Summit, the global significance of the return to high-end conventional war in Europe was clear. Alongside reinforcing NATO's collective stance in support of Ukraine, the post-Summit Communique underlined how the alliance was strengthening strategic and operational postures to reinforce wider deterrence and defence. Here, the Communique underlined the significance of technology development and more rapid delivery of improved military capability. "We are establishing [DIANA] and launching a multinational Innovation Fund to bring together governments, the private sector, and academia to bolster our technological edge," it stated.

Building on from Madrid, where DIANA's Charter was approved, DIANA is aiming to declare initial operating capability (IOC) at the Vilnius Summit in July 2023; according to a NATO statement in October 2022, this is when DIANA effectively will 'go live'. Full operating capability (FOC) for the DIANA process is set for 2025. The period until then will enable NATO to assess DIANA's development, and understand what further development may be required.

The Russo-Ukraine war is both shaping and reflecting DIANA's approach.

"What Ukraine is showing us is something we already knew, and was one of the reasons for setting up DIANA. It's that innovation plays a crucial role on the battlefield," stated David van Weel, NATO's Assistant Secretary General (ASG) for Emerging Security Challenges, told ESD in an interview on 1 March 2023. Pointing to the effects of using uncrewed systems, artificial intelligence, or commercially sourced space-

Photo: US Navy

Hypersonic missile systems are emerging rapidly as an area of technology focus in current military operations, and in innovation programmes like DIANA. Here, the US Navy launches a hypersonic missile from the NASA Wallops Island Flight Facility, Virginia in October 2022.

based surveillance, van Weel said "There's all kinds of innovations that are changing the battlefield, and that was the reason for setting up DIANA." In addition, van Weel highlighted how new technologies are being quickly integrated into operations. Shortening the cycle between invention and adoption is precisely what DIANA is designed to do, he explained.

End Goal

DIANA's aim is to establish an 'ecosystem' of technology innovation stakeholders – including academic, scientific, and industrial research and development (R&D) communities, 'start up' innovators, defence industrial companies, and the military end-user – to establish a continuous cycle of innovation designed to exploit development priorities within emerging and disruptive technologies (EDTs). DIANA's current areas of EDT focus include: artificial intelligence (AI), autonomy, 'big data' processing, biotechnology and human enhancement, hypersonics, novel materials and advanced manufacturing, energy and propulsion, quantum technologies, and space.

DIANA's intent is to exploit relevant, viable technologies to support development into operational capability within reasonable timeframes. To enable rapid development of technologies for application against what are referred to as defence and security 'problem sets' or 'challenges', DIANA is prioritising dual-use technologies, whereby the commercial market requirement for the particular technology may help accelerate its development.

The intent to connect innovators and operators is designed to strengthen trans-Atlantic innovation to solve these 'challenges', van Weel told a media briefing on NATO innovation in October 2021. Making this direct connection between innovator and operator will establish an integrated process running from 'ideas to impact' to enable 'challenges' to be met by developing a relevant capability, van Weel added. Making such connections is also intended to enable the defence 'customer' and technology 'supplier' to better understand each other's role in the process.

The framework around which to build the structure for connecting the different components of DIANA's 'ecosystem' consists of five primary parts: a network of test centres, providing dedicated laboratory and other equipment development facilities to support testing, evaluation, verification, and validation of new technologies developed to tackle emerging 'challenges'; an accelerator programme connecting 'start ups' to the 'challenges', and helping the 'start ups' better understand the process; two head offices (one each side of the Atlantic) to co-ordinate test centre and accelerator programme outputs; a 'rapid adoption service' to enable early and quick transition of technology solutions, including into national procurement pipelines; and a supporting financial infrastructure, designed especially to assist 'start ups' moving through the DIANA process.

As regards the two head offices, Estonia and the UK will co-host the European office. Canada has offered to host the North American office.

Several parallel themes are being developed around DIANA, overlaying its work. First, there is significant focus on developing interoperable technologies. Second, there is significant focus on using existing national and NATO technology development infrastructure, although DIANA will work independently from NATO procedures including procurement processes to maintain flexibility in the technology it tackles and how to procure it (including facilitating national access to such technology). Third, DIANA's 'ecosystem' is intended to be resilient in the context of assisting innovators in mitigating risk of technology transfer to potential adversaries.

Stepping Stones

Throughout 2022, NATO officials provided updates on DIANA's development progress. In April, at a press conference following an alliance foreign ministers' meeting in Brussels, Secretary General Jens Stoltenberg said that DIANA's capacity would be established around an initial network of 60 innovation sites across Europe and North America.

In a media briefing prior to the meeting, van Weel noted that these 60 sites would include

Photo: NATO

NATO Secretary General Jens Stoltenberg briefs media prior to a NATO Foreign Ministers meeting in Brussels on 6-7 April 2022. Stoltenberg stated that NATO's DIANA technology innovation programme would be established initially around a network of 60 sites across Europe and North America.

50 test centres and 10 accelerator sites. He added that this footprint would continue to grow up to and through FOC. Demonstrating the continuing development, as of March 2023 the number now is 72 (63 test centres and nine accelerator sites).

ASG van Weel also detailed the structure for how technologies would be downselected against requirements. First, every two years, the allies will agree on the strategic direction that identifies the 'challenges'. The strategic direction will also prompt 'challenge programmes', based around notification of specific end-user requirements against which innovators can propose technology solutions. Second, innovators will be selected to receive grants and mentoring to guide them through the accelerator site process, with such innovators able to demonstrate their technology to end-users and enabling technologies showing potential for meeting the 'challenges' to be taken forward. Third, technologies demonstrating potential may be integrated into national programmes to support further development in meeting end-user requirements.

DIANA in practice

While DIANA is still growing into its structure, its technology work – and its strategic significance within the alliance – means it is flashing brightly on NATO stakeholders' radars.

DIANA as a multinational construct reflects broad NATO principles of connecting and integrating different national stakeholders. Several NATO operational organisations that also integrate different national stakeholders are tasked with technology development. Such organisations will look to link up with DIANA; in turn, DIANA can act as an alliance-wide interlocutor to ensure all such organisations are aware of and engaged in the leading-edge technology DIANA is developing.

DIANA's aim to rapidly integrate emerging technologies into operational use is a mission statement widely reflected across other NATO technology development stakeholders. Such stakeholders are seeking to accelerate technology innovation and integration, particularly through operational experimentation (OPEX). When such operational stakeholders are looking to exploit technologies similar to those DIANA is developing, opportunities may present themselves for technologies being developed under DIANA to be integrated more rapidly into OPEX activity.

Autonomy, for example, is a priority technology for DIANA and for alliance operational stakeholders. In September 2022,

Photo: Dr Lee Willett

A combination of an uncrewed surface vessel (USV) launching an uncrewed underwater vehicle (UUV) is tested in operational experimentation at NATO's 'REPMUS'/'Dynamic Messenger' exercise in September 2022. Autonomous capabilities are a central focus for DIANA's technology innovation process.

NATO Allied Maritime Command (MARCOM) led the alliance's inaugural 'Dynamic Messenger' exercise, which took place in southern Portugal in tandem with the Portuguese Navy's annual maritime uncrewed systems exercise 'REPMUS' ('Robotic Experimentation and Prototyping with Maritime Unmanned Systems'). 'Dynamic Messenger' is designed specifically to accelerate the introduction of maritime uncrewed systems into naval orders of battle (ORBATs) through increasing their involvement in OPEX at sea, with particular focus on integration into command-and-control structures.

At the exercise press conference, then-NATO MARCOM Commander Vice Admiral Keith Blount pointed to DIANA's prospective importance in accelerating technology integration through collective procurement. While such an approach can offer economies of scale, "it's also about being able to buy and employ things quickly, and it's about the rapidity with which you need to get stuff into service," said Vice Adm Blount. In this context, he continued, "DIANA is a really interesting initiative: still in its early days, but showing much promise."

DIANA's collective approach to technology development and procurement can also help support alliance member states with smaller defence budgets and less technology innovation and development capacity. It enables those without such means to access key EDTs more quickly, Vice Admiral Guy Robinson, Chief of Staff at NATO's Supreme Allied Command Transformation, told the press conference.

Going forward, with DIANA focused on experimentation and testing with end-users, OPEX activities like 'Dynamic Messenger' may offer early opportunity to test and exploit technologies being developed under DIANA. "I think there's great synergy between them," van Weel told ESD. "You could imagine that innovators who are working on challenges within the DIANA complex could make use of an exercise like 'Dynamic Messenger' to field that experiment." He added, "Innovators that are present at 'Dynamic Messenger' are liable to get into a DIANA accelerator programme."

Moreover, the Portuguese Navy's Maritime Operational Experimentation Centre – located at Troia, the navy's facility that hosts 'REPMUS' and 'Dynamic Messenger' – has been assigned as a DIANA test centre, including being tasked with developing AI, autonomy, data, and new materials technologies. "It's a great example of making use of existing infrastructure in specific areas of expertise," said van Weel.

Late in 2022 and continuing up until IOC, NATO and its member states began discussing national contributions to DIANA's procedural structure and technology focus. In December, DIANA's Board of Directors (stood up in October 2022 as part of the governance structure established to provide guidance on DIANA's direction, and consisting of one board member from each NATO country) announced that energy resilience, secure information sharing, sensing and surveillance will be DIANA's priority EDT focus areas for 2023. These areas provide the strategic direction shaping the first challenges DIANA will address, NATO said in a statement on 12 December. "This strategic direction gives the DIANA Executive clear guidance on the development of

pilot programmes we will launch in [early] 2023," said van Weel, in the statement.

Notably, all three areas have featured prominently in the Russo-Ukraine conflict. Under DIANA, technology solutions should be designed to help NATO allies prepare for anticipated and unanticipated energy disruptions, ensure that data can be protected and trusted, and improve situational awareness and forecasting (in both the physical and digital domains), the statement said.

ASG van Weel told ESD that several key steps will be taken in building up to IOC and on to FOC. NATO aims to provide an update on the number of test centres and accelerator sites that have been approved. "The number will quickly grow in the coming weeks," said van Weel. New locations must go through an approvals process: once approved, news will be posted on the DIANA website, which itself was set up in late February. The challenges emerging from strategic direction guidance will be launched prior to the Vilnius Summit. Innovators will then be able to pitch technologies against these 'challenges' for evaluation by the DIANA staff.

NATO is also building DIANA's initial staffing footprint. Before the Summit, DIANA staff may be installed in an office in London as part of the European headquarters. The first managing director will also be appointed to lead DIANA's staff.

DIANA aims to start its accelerator programme by the end of 2023, connecting innovators to the 'challenges'. Between IOC and FOC, NATO will continue to build DIANA's test centre and accelerator site numbers and infrastructure, establish the North American regional headquarters in Canada, and start to maximise DIANA's technology output. "FOC delineates that we have the full capacity of challenges running (probably around 10 on an annual basis), that we have regional offices not only in London but also Canada, and that we have all the anticipated test centres and accelerator sites connected to DIANA," van Weel told ESD.

Back in December 2022, in a social media commentary released from the Antalya Diplomacy Forum, van Weel discussed the impact of new technology on society and DIANA's role in harnessing how such technologies develop in the modern world. Emerging technologies like AI are fundamentally impacting how the world functions, including how future conflicts are fought, he said, with this impact already seen in the Russo-Ukraine war. Traditionally, many novel technologies have developed through military R&D, before finding wider commercial and civil impact, van Weel continued. "Nowadays, it's the other way around," he said. "The difficulty is that most of them are being developed for commercial use, and not for military use. The challenge is how do we reconnect these innovation 'ecosystems' and make sure we have a dual-use application so that the military can benefit also from the defence and security implications of these new technologies." DIANA, and the NATO Innovation Fund, "[will be] looking for innovators that have answers to the technology problems we are facing today to help us be better and more innovative in the world of tomorrow," he added.

DIANA is clearly a significant move in accelerating innovation in and harnessing of technology. However, the Russo-Ukraine war and the operational and technology requirements it is generating almost daily reflect a new element to the challenge – that DIANA, NATO, and NATO member states need to harness innovation and get it to the end user even more quickly. ■

Security & Defence in a Turbulent Brazil

Tim Guest

Though it boasts the second largest military in the Americas, Brazil's new government has its hands full, as it attempts to bring about stability after the turbulent exit of the previous president.

This article looks at aspects of Brazil's defence and security in relation to recent political developments, its standing as a Major Non-NATO Ally (MNNA) of the US, and how that offers major co-operative opportunities for the country's defence, as well as highlighting regional challenges facing the new government and the country's security forces, not least the deforestation of the Brazilian Amazon.

Politics of the Moment

Brazil's new leader, Luiz Inácio Lula da Silva, or Lula as he is known, is the country's 39th president, having won a knife-edge election to beat the divisive incumbent, Jair Bolsonaro, currently residing in Miami, though poised to return in March, if latest reports, at time of writing, are to be believed.

For Lula, who officially took office on 1 January 2023, governing Brazil isn't something new. He was also the 35th president between 2003 and 2010, so knows better than most what typically awaits, although the state of play left behind by the previous government is anything but typical, with Lula, in his first speech after regaining office, vowing to 'rebuild a country in terrible ruins' and denouncing the policies of the divisive and destructive Bolsonaro.

Having won the October 2022 election, one of Lula's first moves was his announcement that José Múcio, a veteran politician and negotiator, would be Brazil's next defence minister. Lula called him a friend who could not be 'better prepared to look after defence', saying he expected Múcio would handle the job and that the armed forces would fulfil their main mission of looking after the country's security. Múcio will certainly need to ensure relations between the armed forces and the new president get off on the right foot, for while many posts in the previous right-wing government were held by members of the military, this is something unlikely to continue in Lula's new leftist administration. The good news from several accounts, so far, is that senior military officials, past and present, already seem to have indicated their support for the new defence chief, saying, the first civilian defence minister since 2018 was a wise choice that has been well received by the armed forces.

Photo: US Army/Cpl Jacob Wachob

Protecting the Amazon is one of Brazil's greatest security challenges. The image shows US and Brazilian soldiers conducting a simulated medical evacuation mission in Resende, Brazil, 8 December 2021. The training mission was part of exercise Southern Vanguard.

That said, things got off to a rocky start with the riots on 8 January 2023 and the apparent attempted insurrection that marred the start of this new presidency – over 1,000 people were arrested after thousands of pro-Bolsonaro demonstrators stormed and vandalised government and judicial buildings. Even members of the army were suspected of playing a part, though this

Photo: Rafaela Biazi, via Unsplash

Brazil has South America's largest aggregate armed forces, renowned as some of the most capable and effective operatives in the world.

Photo: USMC/Lance Cpl David Intriago

USMC troops in support of Special Purpose Marine Air-Ground Task Force UNITAS LXIII provide cover for a Brazilian amphibious assault vehicle conducting an amphibious assault training event during exercise UNITAS LXIII in Itaoca, Brazil, 16 September 2022.

has since been dismissed as unfounded by the new defence minister. Although the dust is still settling, with other disturbances having taken place and trials and prosecutions still expected after full investigations, Lula is now getting on with the business of government. In line with security and the bolstering of key relationships at the top of his agenda, his first overseas visit came in the form of a trip to Washington DC in early February, to meet Joe Biden and to rebuild and refresh positive relations with the US.

Amazon Security on the Agenda

One key item on the agenda was the protection of the Amazon rainforest with both presidents pledging to co-operate, and with the US announcing its intention to fund forest conservation to the tune of anywhere from USD 4.5 Bn to USD 9 Bn made to Brazil's Amazon Fund, depending on what Biden can get approved. During the visit, the US special presidential envoy for climate, John Kerry, and Brazil's Environment Minister, Marina Silva, also took part, with Kerry having apparently already been to Brazil to meet the new administration and agree on the details of this fresh environmental cooperation. Kerry said the forest had to be protected against those destroying it, which was a test for all humanity and vital – as the "lungs of the Earth" – in the fight against climate change, which, itself, poses an overarching threat to global security.

Brazil's military is a key, established overseer of the Amazon's protection, with the Brazilian Air Force, (Força Aérea Brasileira, FAB), conducting activities under the Amazon Protection System, or SIPAM. With average annual deforestation in the Brazilian Amazon having reached a 15-year high during the Bolsonaro years, the FAB and defence ministry have their work cut out if they are to achieve the new president's announced goal of striving for zero deforestation. Importantly, during Lula's first term as president, deforestation dropped off sharply. He has now committed to re-invigorating environmental protections and programmes with the aim of eliminating deforestation altogether, but that will only be possible with the full support of the new defence minister and his relevant commanders. Only time will tell how Amazon protections improve under this new government.

Defence, Security and MNNA Status

Also discussed, according to a vague White House statement, was the two leaders' interest in intensifying bilateral cooperation in, amongst other things, defence. Brazil has been a Major Non-NATO Ally (MNNA) with the US, a designation assigned to it in 2019 under the Trump Administration, though 18 other nations were also assigned this status by previous US administrations. Other MNNAs include: Argentina, Australia, Bahrain, Brazil, Colombia, Egypt, Israel, Japan, Jordan, Kuwait, Morocco, New Zealand, Pakistan, the Philippines, Qatar, South Korea, Thailand, and Tunisia. Under US law, being an MNNA provides foreign partners with certain benefits in areas of defence trade and security cooperation, although it does not involve any security commitments.

According to the US Department of State, the full gamut of benefits and privileges Brazil has gained as an MNNA, are:

- Eligible for loans of materiel, supplies, or equipment for cooperative research, development, testing, or evaluation purposes;
- Eligible as a location for US-owned War Reserve Stockpiles to be placed on its territory outside of US military facilities;

Photo: FAB/Edwaldo Costa

The FAB flies humanitarian missions as well as missions in cooperation with other government agencies, such as the Federal Police, to counter illegal activities. Humanitarian missions often deliver basic commodities to the Yanomami, a group of approximately 35,000 indigenous people who live in some 200–250 villages in the Amazon rainforest on the border between Venezuela and Brazil.

- Can enter into agreements with the US for the cooperative furnishing of training on a bilateral or multilateral basis, if the financial arrangements are reciprocal and provide for reimbursement of all US direct costs;
- Eligible, to the maximum extent feasible, for priority delivery of Excess Defence Articles transferred under section 516 of the Foreign Assistance Act (if located on the southern or south-eastern flank of NATO);
- Eligible for consideration to purchase depleted-uranium ammunition;
- Eligible to enter into an MOU, or other formal agreement, with the US Department of Defense for the purpose of conducting cooperative research and development projects on defence equipment and munitions;
- Allows firms of an MNNA, as with NATO countries, to bid on contracts for maintenance, repair, or overhaul of US DoD equipment outside the US;
- Allows funding to procure explosives, detection devices, and other counter-terrorism research and development projects under the auspices of the Department of State's Technical Support Working Group.

For Brazil, MNNA status offers the country a crucial tool to bolster its technological capabilities and aid its role in the regional security challenges it faces; the designation also provides a channel for constructive dialogue between the two countries on any mutually relevant security issues. It gives Brazil privileged access to the US defence industry and offers opportunities for joint military exchanges, exercises, and training with the US DoD. In 2020, for example, Brazil received more than USD 100 M of US defence materiel and services. At another level, however, being an MNNA represents having a formalised partnership in the areas of defence and security with the US, and one that could become much closer and strategic in its aims.

Indeed, perhaps the biggest strategic concern in the region is the influence and reach of China, for which Brazil's MNNA status could play a major role in reducing that potential threat. In recent years, China has extended its presence in many ways, from vaccine diplomacy to huge investments underpinning infrastructure projects across the country; Brazil actually became a founding member of the Asian Infrastructure Investment Bank, which was created by China as a direct development financing alternative to the World Bank. Though Brazil is not (yet) a participant in China's Belt and Road Initiative, and even if this were to be a possibility in the future, there would be good reason for its MNNA status to be nurtured in order to enhance defence and security ties with the US to the extent that they eliminate that as a possibility and help ensure that Chinese influence in the region is reduced.

Photo: FAB/Edwaldo Costa

Humanitarian mission flown by FAB into a remote region.

Regional Threats

Bordering almost every other country in South America, Brazil has a major role to play in maintaining regional stability, particularly when it comes to countering transnational criminal organisations. Its MNNA status has a major part to play in enabling it to function effectively in this regard. Across the continent, security conditions have been deteriorating for many years with increasing deforestation due to often illegal agricultural practices, the narcotics trade, illegal gold mining, as well other activities, such as human trafficking.

Across the Brazil-Colombia border, for example, contraband smuggling in the form of narcotics and arms is a major problem, as well as illegal migration, trafficking in wildlife, plants, and timber, and also major illegal exploitation of mineral resources. As if these are not enough for the security forces to handle, Colombian insurgent incursions into Brazil's territory remain an issue.

The smuggling of firearms and narcotics is also an ongoing problem along the Uruguay-Brazil border and between Venezuela and Brazil, Colombian-organised illegal narcotics and paramilitary activi-

Photo: US ANG/Maj Michael O'Hagan

A pararescue airman assigned to the 103rd Rescue Squadron of the New York Air National Guard's 106th Rescue Squadron, works with a Brazilian counterpart on a simulated casualty on board one of the wing's HC-130 Combat King II search and rescue aircraft during a medical evacuation mission as part of Exercise Tapio in Campo Grande, Brazil, 24 August 2022.

ties penetrate Brazil's border region with Venezuela.

The country is, undeniably, a significant transiting hub, as well as a final destination, for cocaine, most of which enters Brazil from those neighbouring countries which produce the drug, typically Bolivia, Colombia, and Peru. From Brazil, much of that cocaine is then smuggled to West Africa and Europe. However, an increasing amount remains in-country where it feeds major domestic drug consumption; Brazil has now become the world's second-largest consumer of cocaine hydrochloride and cocaine-derived products.

With that in mind, through its MNNA status, the capabilities of Brazil's security and military forces in counternarcotics, border security, and counterterrorism can still be bolstered and enhanced, which, in turn, will help the US to increase its own national security in relation to some of the most sophisticated criminal organisations in the region, whose reach stretches far beyond Brazil's borders.

Photo: USMC/Cpl Ethan Craw

Members of Special Boat Team 22 train Brazilian counterparts on the steps and procedures of a visit, board, search, and seizure (VBSS) during UNITAS LXIII, 13 September 2022. UNITAS is the world's longest-running maritime exercise, and was hosted by Brazil in 2022.

In recent years, Brazil has increased the pace of modernising its military, with US cooperation and activities between armed forces playing a major part. In early 2021, it was agreed at senior military level to develop partnerships and hold military exercises together under a five-year plan. Things got underway in December that year, when US and Brazilian forces held a combined exercise, CORE 21 (Combined Operations and Rotation Exercise), which was the first combined event performed by US troops in Latin America. Taking part was a 750-strong task force from Brazil's 5th Light Infantry Battalion and 240 marines from the 101st US Army Air Assault Division. And in September last year, a longstanding, multinational maritime exercise conducted annually in Atlantic and Pacific waters around Central and South America, UNITAS LXIII, took place with Brazil as host nation. Two US Naval vessels and a submarine joined more than 20 ships and 5,500 personnel from 19 partner nations for training operations off the coast of Rio de Janeiro to enhance security cooperation and improve coalition operations.

Forces Behind Brazil's Defence and Security

As far as budgets are concerned, in 2021, the country allocated 1.3% of its GDP to defence spending, making it the 105th-highest spender in the world on its armed forces. These, in turn, are equipped with a mix of domestically-produced and imported weapons, largely from Europe and North America. And while Brazil's domestic defence industry, (which has several joint ventures with other nations' defence industries), is capable of designing and manufacturing equipment for all three of its military services, as well as materiel for export, the US and a number of European nations are today the leading suppliers of military equipment to the country.

Facing all of the country's security challenges are Brazil's Armed Forces, which comprise the Army, (Exército Brasileiro – EB), the Air Force/FAB, and the Navy, (Marinha do Brasil – MB), the latter consisting of Naval Aviation, (Aviação Naval Brasileira), and the Marine Corps, (Corpo de Fuzileiros Navais). In total, the country has some 360,000 active military personnel, of which approximately 220,000 are in the Army, 70,000 in the Navy and 70,000 in the FAB. These figures are the highest numbers of military personnel for any Latin American country, or any nation in the Southern Hemisphere. Contributing to these numbers is the compulsory 12-month stint of military service/conscription for men between the ages of 18 to 45 years; women make up some 9% of Brazil's Armed Forces' personnel.

As for domestic security, Brazil has three national police forces: the Federal Police, Federal Highway Police, and Federal Railway Police, each of which has domestic security responsibilities and report to the Ministry of Justice and Public Security. Then, within the state police forces, there are two distinct units: the civil police, which performs an investigative role, and the military police, charged with maintaining law and order in the country's 26 states, as well as Brazil's Federal District, which is situated in Brazil's central highlands and is home to the nation's modern, purpose-built capital, Brasília. The military police, despite its name, comes under the control of the Ministry of Justice, rather than the Ministry of Defence.

Final Thoughts

Without MNNA status, such exercises, together with the acceleration of its military modernisation programme, might not be as straightforward. It's a fact that Brazil has South America's largest aggregate armed forces, renowned as some of the most capable and effective operatives in the world and which frequently take part in international peacekeeping operations in Africa, the Caribbean, and South America. The nation's MNNA status is an opportunity not only for Brazil, but with huge support from the US, to upgrade its military capabilities and technological sophistication, to mutual benefit. Through greater investment in its armed forces, their equipment, and additional capabilities in new domains, such as in space, Brazil will be able to achieve a critical edge in meeting, head-on, its traditional regional and domestic security threats. ■

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