

DEFENCE PROCUREMENT INTERNATIONAL

SUMMER 2021

**URBAN WARFARE
TRAINING** GETS A DOSE
OF REALISM



**THE CLIMATE
THREAT**
AND WHY DEFENCE
IS NOT EXEMPT

**THE NEW
SPACE RACE**
AND DUAL-USE
TECHNOLOGIES

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FROM THE EDITOR

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Welcome to the Summer 2021 edition of *Defence Procurement International*. After a lengthy global shutdown of the defence exhibition circuit, we're looking forward to the all-new hybrid DSEI event at ExCeL London from the 14-17 September.

It will be great to meet face to face again, after a two-year hiatus from shows, and hear how you are all adjusting to the new reality we now live in. Not only have we endured a pandemic, which has claimed more than 4 million lives, but by the time you read this, the 20th anniversary of 9/11 will have come and gone. It will be an even more poignant occasion this year, given the events that have unfolded recently in Afghanistan.

Many of you are in the business of designing and building great feats of auto, marine and aeronautical engineering, but the return of a Taliban government in Afghanistan is a stark reminder that the character of warfare has fundamentally changed, and so too must the equipment and tactics to fight it.

Many will argue the War on Terror has been won. But the terrorist attack — which killed 13 US service members and hundreds of Afghan civilians at Hamad Karzai airport in Afghanistan, in the closing hours of the largest non-combatative evacuation in military history, and the billions of dollars of military equipment gifted to the Afghan National Army, that is now in the hands of the Taliban, suggests that something went fundamentally wrong in the global War on Terror.

Those I spoke to for our appraisal of US and NATO forces withdrawal from Afghanistan, believe a litany of mistakes were made. Will lessons be learned, however? There was never a clear strategic objective in Afghanistan, other than avenging the attacks on the World Trade

Centre. But no one, not even the former Soviet Union succeeded in conquering the Taliban's predecessors, mujahideen armed with their AK-47 rifles and shoulder-launched Stinger-type missiles. No matter how sophisticated the equipment conventional forces have at their disposal, it is no match for insurgents that are like a "flea on a dog."

Operating in the grey zone is also something we explore in this issue. Unconventional warfare is not something the West is noted for, and many adversaries are using not only information, but also private military companies to operate in the shadows and exert strategic influence. How can conventional forces learn to operate in the sub-threshold and use information to greater advantage?

Many will welcome the Ministry of Defence's Integrated Review and its nod towards emerging technologies like AI. But are machines going to be any better at learning the lessons of war than humans? AI could help frontline commanders or soldiers in the field better connect the dots — people, places and locations — to get a clearer picture of what is really happening on the ground so they can make better-informed decisions at lightning speed. Sub-threshold warfare requires new equipment, and new tactics. ■

Best wishes,

Anita Hawser
 Editor

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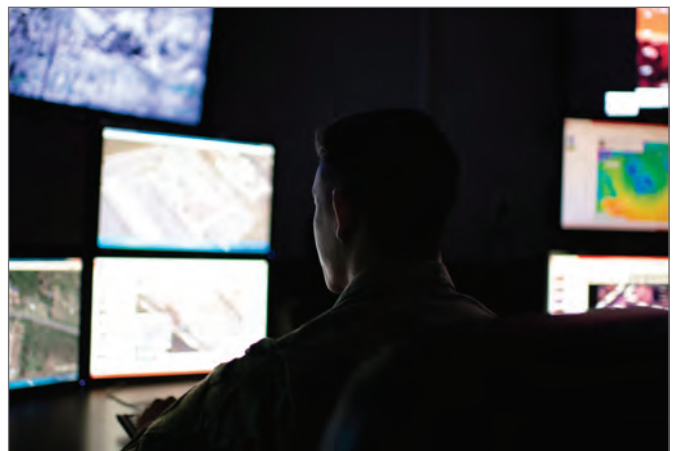
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A US Marine carries a baby as families are processed through the Evacuation Control Center (USMC photo by Staff Sgt. Victor Mancilla)

COUNTING THE COSTS

With foreign forces leaving Afghanistan, 20 years after they first entered the country to avenge the attacks on the World Trade Center, many are counting the incalculable human costs and asking whether lessons will be learned as the Taliban sees off yet another invading force.

By Anita Hawser

On the 30 August at 15:29pm East Coast time, the last C-17 aircraft lifted off from Hamad Karzai airport in Kabul, marking the end of the largest non-combatant evacuation in military history and the US's mission in Afghanistan. "Tonight's withdrawal signifies the end of the military component of the evacuation, but also the end of the nearly

20-year mission that began in Afghanistan shortly after September 11, 2001,” stated General Kenneth McKenzie, Commander of US Central Command. “It’s a mission that brought Osama bin Laden to a just end, along with many of his Al-Qaeda co-conspirators and it was not a cheap mission. The cost was 2,461 US service members and civilians killed, and more than 20,000 who were injured.”

For those still carrying the physical and mental wounds of the 20-year war in Afghanistan, the fact that the conflict ended almost exactly how it began when a US-led military coalition first invaded the country in 2001, must seem like a cruel irony. Before the US-led invasion toppled the Taliban government, they controlled approximately 90% of the country. Today, with the exception of Panjshir Valley, a remote region of the country, which continues to push back against the militants, the Taliban are back in control and ready to form a government. On August 15, they seized the presidential palace in the capital Kabul and billions of dollars worth of US-gifted military equipment (weapons, armoured vehicles, helicopters) once used by the Afghan Army against them.

As the US and NATO allies raced against time to evacuate as many of their citizens and vulnerable Afghans before the 31 August deadline set for all occupying forces to leave Afghanistan, in a strange twist of fate, the US found itself having to rely on the Taliban to help secure Hamad Karzai Airport against terrorist attacks. With just days to go before the last US flight out of the capital, a suicide bomb attack at Kabul airport carried out by an ISIS affiliate calling itself Islamic State Khorasan Province (ISKP), claimed the lives of 13 US service members — the first military casualties in the country since February 2020— and more than 100 Afghan civilians.

During a Pentagon press conference following the attack, General McKenzie stated that some attacks had been

thwarted by the Taliban, and that the Taliban were used to protect Afghans and US soldiers. He said the Taliban had been useful and that they shared a common purpose; to ensure the US occupation ended on 31 August. Gen. McKenzie said the US had relied on MQ-9 Reaper drones, gunships, air force aircraft and attack helicopters fitted with thermal cameras to thwart terrorist attacks at the airport. But as the last 20 years have demonstrated, all the sophisticated weaponry in the world didn’t make much of a difference in the end to the outcome in Afghanistan.

“Indicators that it would go wrong have been around for 150 years,” says Peter Lee, a Professor of Applied Ethics at the University of Portsmouth and a former RAF chaplain who worked in a military hospital in Cyprus, which treated casualties from both the Iraq and Afghanistan wars. “The UK invaded Afghanistan in the mid- and late-1800s and in 1919. On all three occasions they retreated in hopeless defeat,” he says.

Even the military might of the former Soviet Union in 1979 and 1989 was no match for the Taliban’s predecessors, the mujahideen with their AK-47 rifles and shoulder-launched ground-to-air Stinger-type missiles for bringing down helicopters. “With those basic weapons and a willingness to die for their cause against an enemy that didn’t appreciate their tactics, eventually the mujahideen wore them down and out of that the Taliban emerged,” says Lee.

Dr. Frank Ledwidge, a senior lecturer in law and strategy at the University of Portsmouth and author of *Losing Small Wars*, the first highly critical analysis of Britain’s experience of the 9/11 wars, says the British were fighting a foe in Afghanistan that was highly determined and couldn’t be eliminated. Ledwidge, who served several years as a military intelligence officer in the Balkans and Iraq and was the UK’s justice adviser in Helmand and Libya, says many middle-ranking officers realised their mission in

Afghanistan was a “busted flush” once it had shifted to nation building. “Western forces may have won every tactical engagement during the war,” he says, “but there was no clear strategy that led to any real settlement.” The Taliban’s return to power shows the lack of awareness by the West as to what was really happening on the ground, he says.

The US should have learned from the Vietnam War, says Lee, just how difficult is it to beat a determined insurgency. “It reminds me of a book called *War of the Flea*,” he recalls, “which described insurgency warfare like a flea on dog. It is never going to kill the dog, it just has to keep irritating and driving the dog mad. The Taliban never had to beat the US, it just had to make the financial and human cost severe enough that the UK, US and other NATO forces would withdraw. All the massive military advantage, the technology, all of that proved strategically unable to win this war for the US, UK and NATO. The Taliban with their rudimentary weapons have seen off another invading force.”

HUMAN COSTS

Of all the military hardware and equipment used by NATO forces against Al-Qaeda and the Taliban in Afghanistan, the MQ-9 Reaper Remotely Piloted Air System (RPAS) stands out for many reasons. The Reaper was the British and American’s ‘eyes in the sky,’ providing intelligence for ground forces on the movements and location of insurgents, and their Hellfire missiles provided a precision-strike capability, when needed.

The UK’s 10 MQ-9 Reapers were acquired as part of an Urgent Operational Requirement coming out of Operation Herrick in Afghanistan. The Royal Air Force’s (RAF’s) first Reaper Squadron, 39 Squadron based at Creech Air Force Base in Nevada, flew its first operational sortie in Afghanistan in October 2007.

According to the RAF, during Reaper operations in Afghanistan, only 459 weapons were fired — less than one

weapon for every 120 hours flown. Most of the Reaper operations — more than 160,000 hours — involved non-armed reconnaissance. RPAS like the Reaper were meant to be devoid of the “risk and rigour” associated with traditional military operations. But Lee says to this day, many of the RAF Reaper pilots still experience different degrees of mental trauma, including PTSD, from the missions they flew in Afghanistan.

During the course of researching his 2018 book *Reaper Force: The Inside Story of Britain's Drone Wars*, Lee interviewed 90 RAF Reaper personnel. Many of these

pilots, he says, watched people being killed up close in real time over a number of years, which adds up to a huge catalogue of potentially traumatising imagery. The Reapers were fitted with an infrared (IR) sensor, a colour/monochrome daylight electro-optical TV and an image-intensified TV. On June 2011, one of the RAF Reaper crew members who Lee interviewed watched the death of a US Marine on the ground in Helmand Province. “The crew member watched as this Marine stood on an IED and was killed instantly,” says Lee. “The Reaper pilot was probably the last person to see

this young Marine alive.” That story is the basis for the last chapter in his book, titled *Remembering*, which he says is poignant given the distressing events witnessed in the last few weeks of August as Afghans fled life under Taliban rule.

“So many families who lost loved ones and many who bear the psychological scars are left with big questions, was it worth it? Will there be any long-term benefits? There were benefits while the UK and the US were still in Afghanistan, but no sooner have military forces moved out and that has ended extraordinarily rapidly,” observes Lee. Recently, he reviewed 10



“
So many families who lost loved ones and many who bear the psychological scars are left with big questions, was it worth it? Will there be any long-term benefits?
”

Evacuees aboard a US Air Force C-17 Globemaster III aircraft (USAF photo by Senior Airman Taylor Crul)

of his 90 Reaper Force interviews with the help of a psychologist. He says there are all the indications of “moral injury” — watching terrible things happen, but being unable to stop the horror before their eyes, despite having all the weaponry at their fingertips. “The cost of the war in Afghanistan will not be just the trillions of dollars spent, but the incalculable cost in human terms, which will last for decades.”

TERRIBLE CHOICES

In the US, he anticipates there will be a significant blame game. Russia has already indicated it is willing to work with the Taliban leadership, as has China. “What we find now is a situation where the West do not have the political will to intervene again and depose the Taliban and we have China and Russia willing to work with them. A stalemate will ensue. The Taliban will remain in power until they are deposed internally, but I can't see that happening, for 10, 20, maybe 30 years.”

With US influence in the region evaporating rapidly, Lee says those working in the civil or diplomatic service in the UK or the US now need to hold their nose, swallow hard and persuade political leaders to at least talk with the Taliban and come to some sort of arrangement. “As long as the Taliban keep ISIS and Al-Qaeda out of Afghanistan that would be enough,” he says. “If ISIS and Al-Qaeda are given land to train [in Afghanistan] there would be a price [to pay] for that. That is about all the West can realistically aim for. The ethics of war are often about choosing between two terrible choices. The least worst option is to ensure there is no Al-Qaeda or ISIS resurgence in Afghanistan under the Taliban.”

Ledwidge says the focus should now be on holding to account those that prolonged the war in Afghanistan, even when it was obvious it was a “busted flush,” with a public inquiry, similar to the Iraq Inquiry Report. Veterans from Afghanistan suffering physical injuries or PTSD also need to be looked after. “A lot of them are falling through the cracks,” he says. “That is the single biggest cost of the war.” ■

AFGHANISTAN IN NUMBERS

TOTAL COST OF THE WAR:
\$2.3 TRILLION
 Spent by the US on operations in Afghanistan and Pakistan since 2001

£22.2 BILLION
 The total cost of the UK's Operation Herrick as at April 2021

DIRECT WAR DEATHS IN AFGHANISTAN AND PAKISTAN
 FROM OCTOBER 2001-OCTOBER 2019:

2,298
 US service members killed

1,145
 Allied troops killed

3,904
 US contractors killed

73,253
 National Military & Police

TOTAL CASUALTIES: 241,000 people have been killed in the Afghanistan and Pakistan war zone since 2001.

CASUALTIES POST-9/11 WAR ZONES: 71,000 Afghan and Pakistani civilians killed as at April 2021

Over 7,000 US service members have died in Iraq, Afghanistan, Pakistan, and elsewhere.


30,177 suicides among US service members and veterans of the post 9/11 wars. Four times as many US service members have died by suicide than in combat in the post-9/11 wars.

HOW MANY PEOPLE EVACUATED FROM AFGHANISTAN

123,000 civilians evacuated by US and Coalition forces from Afghanistan over 18 days in August 2021

73,500 people evacuated were third country nationals and Afghan civilians, including consular staff and vulnerable Afghans

7,500 civilians on average evacuated per day



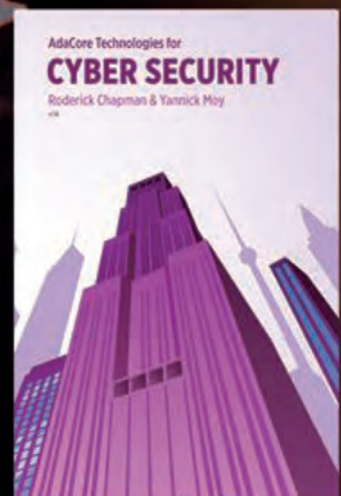
Sources: (Costs of War, Watson Institute of International & Public Affairs, US Centcom and UK Ministry of Defence)

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ON THE EDGE

Could recent changes to the US's Foreign Military Financing agreement with Israel, lead to Israel's defence industry losing its competitive edge and increasing its dependence on US technology?

By Arie Egozi



Former US Defense Secretary Mark T. Esper tours the Iron Dome display with Israeli Minister of Defense Benny Gantz, Tel Aviv, Israel, Oct. 29, 2020. (DoD photo by Lisa Ferdinando)

Israel's defence forces and industrial base are the envy of countries the world over. Israeli defence companies export cybersecurity, missile defence systems, unmanned aerial vehicles, radar, and electronic communications systems to

many countries throughout Asia, Europe and the US. Its defence forces operate some of the most advanced equipment in the world, including the US's fifth-generation F-35 Joint Strike Fighter and the Iron Dome missile defence system.

However, a lot of the technological innovation and advanced defence equipment Israel is known for is inextricably linked to the generous financial package of economic and military aid it receives from the US under its Foreign Military Financing (FMF) programme. At almost 60% of the total global FMF budget, Israel is the largest FMF recipient. To date, the US has provided \$146 billion (non-inflation-adjusted dollars) in bilateral assistance and missile defence funding to Israel, which has been used to ensure Israel maintains a "qualitative military edge" over more populous neighbouring militaries and potential adversaries.

The FMF programme is also credited with creating a vibrant Israeli defence industrial base, which includes names like Rafael Advanced Defense Systems, Elbit Systems and Israel Aerospace Industries (IAI). In September 2016, the US and Israel signed a third 10-year Memorandum of Understanding (MOU) for a \$38 billion defence aid package under the FMF program for the period 2019-2028. The 2019-2028 FMF aid agreement is the largest ever granted to Israel by the United States.

Yet, compared with previous FMF agreements, it introduced a number of changes, which could have severe consequences for Israel's defence industry. The main change is that the new agreement substantially reduces the amount of aid money which Israel's Ministry of Defence can convert into Israeli shekels (NIS) and use for defence-related procurement from local companies.

Under previous FMF agreements, Israel was allowed to spend up to 26% of US assistance on Israeli-manufactured equipment. This was referred to as Offshore Procurement or OSP. But the 2016 agreement will see OSP phased out gradually until its complete removal in 2028. Israel must also report "in detail," how any converted monies are used. The Israeli Institute for National Security Studies (INSS)

estimates that, compared to 2018, the phasing out of OSP will mean the loss of \$1.2 billion a year of aid money that the Israeli Ministry of Defense cannot use for local defence procurement. To remain eligible for defence contracts financed through the FMF, the expectation is that Israeli defence contractors will have to merge with US companies or open US subsidiaries.

GROWING US RELIANCE

Some argue the phasing out of OSP is likely to increase Israeli dependence on US defence technology, while harming local industry’s ability to invest adequate amounts of money in R&D. “The industries here are in a very bad situation that will get even more problematic as the percentage of US dollars from the FMF that can be exchanged to Israeli currency, will decrease until it completely vanishes,” one senior Israeli defence source stated.

The INSS says that the terms of the current FMF MOU could see Israel’s defence industry lose its edge over competitors globally in technology and innovation. “The local defence industry will experience a gradual decline, coupled with growing reliance on the US for preserving Israel’s technological and operational edge,” INSS researchers stated in a July 2020 report, *Israel’s Defense Industry and US Security Aid*.

After the US canceled the sale of the F-35 combat aircraft to Turkey, following its controversial decision to purchase the Russian-made S-400 air defence system, some Israeli companies hoped that sub-contracting planned to be performed by Turkish companies would be transferred to Israel, but this never happened.

Some Israeli companies have secured work as part of deals to purchase American-made platforms. IAI is contracted to manufacture more than 800 pairs of F-35 wings, as part of Israel’s contract to procure 50 F-35s for the Israeli Air Force. But at the same time, the US is blocking the sale of phased out American made fighter aircraft by Israel to third countries. Last year, attempts



Rafael Defense Systems and Raytheon will establish an Iron Dome Weapon System production facility in the US (Copyright: Raytheon)

to revive a plan to sell used Israeli Air Force F-16’s to Croatia, failed as a result of US objections. In May, Croatia signed a contract to buy 12 French-made Rafale fighter aircraft for \$1.2 billion for its air force instead. Meanwhile, Israel’s phased-out F-16s are still looking for a buyer.

To mitigate against the impact of losing business, Israeli defence sources say that the only solution is for local defence companies to transfer development and production to the US. Elbit Systems has set up a US subsidiary to win more business there. State-owned Israeli defence companies have also begun the



process, but it may not be enough to deal with the changing reality.

ISRAEL EYES EXPORT MARKETS ANEW

In December 2020, in an effort to strengthen the capabilities of its US subsidiary, Elbit Systems signed a

definitive agreement to acquire Florida-based Sparton for \$380 million. Sparton develops and supplies electronic systems for undersea warfare to the US Navy and allied forces. The transaction is subject to US regulatory approvals, which could take a number of months. Joseph Gaspar, executive vice president and Chief

Financial Officer of Elbit Systems, says the company's US operations include more than 2,500 employees. "The products and systems are manufactured in our plant in Fort Worth, Texas and by our US supply chain." Gaspar says a small part of the work paid by the US dollars converted into shekels is performed in Israel. "The decrease in the converted amount has no significant effect on Elbit's business," he says. "Moreover, the expected growth in the US part (non-convertible) will positively affect our US operations."

One likely outcome of the current situation is the minimal easing of some of the strict export restrictions placed on Israeli defence systems. "The Israeli Ministry of Defence will have to look at the international market differently," one industry source stated. "In other words, allow for the export of Israeli developed defence systems to countries that have not been eligible to acquire Israeli-made systems." The new normalization agreements between Israel, the UAE, Bahrain and Sudan, creates some immediate potential deals.

Israeli sources say that Saudi Arabia and the UAE are evaluating the possible purchase of the Israeli-made Iron Dome air defence system to defend against attacks by Houthi rebels. Washington has reportedly been informed of Israel's intention to sell Iron Dome to Saudi Arabia. Israel pointed to the failure of Saudi air defence systems to foil a major attack on Saudi Arabia's oil facilities. On 14 September 2019, different drones and missiles were used to attack the state-owned Saudi Aramco oil processing facilities. The attack was performed by Houthi rebels in Yemen supposedly operating under direct orders from Tehran.

One Israeli defence source who talked on condition of anonymity, said that if the UAE and Saudi Arabia decide to purchase the Israeli missile defence system, the deal will be with Rafael's American partner, Raytheon. "This of course will have to



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get the approval of the Israeli Ministry of Defence,” the source said. Sporadic efforts are being made to find ways to compensate for the impact of the current FMF agreement.

Maj. Gen. (ret.) Yoav Har-Even, President and CEO of Rafael Advanced Defense Systems says the company has been working in the US for 27 years. “Throughout the years, we’ve signed numerous joint ventures with American companies for the joint development, production and marketing of air, land and marine systems,” he says. American-based companies involved in those partnerships include Boeing, General Dynamics, BAE, Lockheed Martin, Northrop Grumman, Raytheon, DRS and many others.

Har-Even says Rafael’s plans to increase operations in the US are aimed not only at overcoming the gradual decrease in the portion of the FMF funds that can be exchanged to Israeli local currency, but to increase sales in the US to a very advanced customer, which in many cases prefers locally made systems. Subsystems of the Tamir, the Iron Dome interceptor and the company’s Spike missiles, are made by Raytheon in the US. “We plan to enhance this activity because the Israeli defence budget will have less local currency, but also to open new markets in the US for our systems,” says Har-Even.

Rafael has already established one such company managed by an American retired general. “This company, RSGS, already offers the US Army two main technologies – the Fire Weaver, networked sensor to shooter communication system and technologies developed by Rafael to enhance the capabilities of combat vehicles,” says Har-Even, adding that Rafael’s footprint in the US is impressive. “Four Abrams tank divisions will be equipped with our Trophy active protection system, two Iron Dome systems will be deployed by the US Army. Iron Dome interceptors will also be integrated in the US Marines Corps defence systems against aerial threats and



Rafael’s Trophy APS on the US Abrams tank (Copyright: Rafael Defense Systems)

the Litening targeting pod is one of our best-selling systems.”

Har-Even says full production of Iron Dome in the US by Raytheon is now under evaluation, with a recent announcement about the establishment of a new joint venture with Raytheon for all round-up production of the Iron Dome’s SkyHunter missile interceptors in the US. Rafael’s SPIKE NLOS missile has already been demonstrated to the US Army for operation on its Apache helicopters. “We’re going to prove its capability under different combat sceneries soon,” says Har-Even. Rafael manufactures two layers of Israel’s multi-layered defence system against rockets and missiles—the Iron Dome and David’s Sling. “We are now upgrading these systems based on the combat experience of the IDF and new technologies,” says Har-Even.

Some years ago Israel Aerospace

industries (IAI) opened a US production facility called Stark Aerospace, which now manufactures some sub-systems of the IAI Arrow 3 ballistic missile interceptor, which are then shipped to Boeing, which makes some major parts of the Arrow. IAI recently appointed Col. (Res.) Amir Geva, vice president of North American Affairs, to lead the process of implementing the aid agreement between Israel and the United States.

Israeli defence companies are taking steps to better position themselves when no Israeli currency is available to them as part of the FMF. These efforts will no doubt increase as the date for completely phasing out Offshore Procurement under the FMF draws closer. ■

ABOUT THE AUTHOR

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THE CLIMATE THREAT

Climate change is a threat multiplier for defence. Extreme temperatures, rising sea levels and melting ice sheets will cause increased instability and geostrategic competition, making it harder for the military to operate and restricting its freedom of manoeuvre.

By Anita Hawser

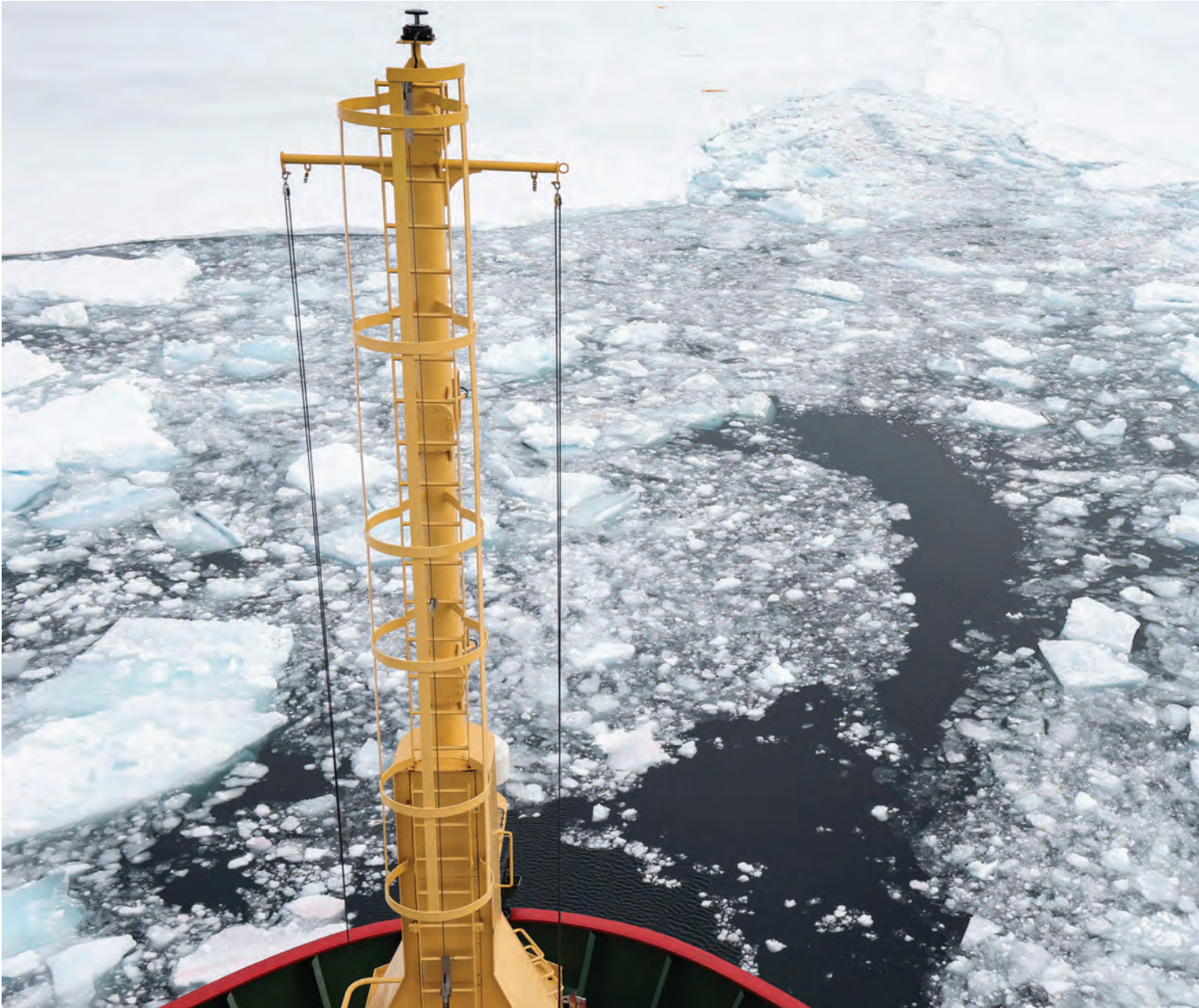
Hypersonic missiles, Russian military build-up in the Arctic, invisible enemies in cyberspace or bioterrorist threats — these are the things that usually keep NATO commanders awake at night and legitimise countries' increased spending on defence. But a different kind of threat looms, which is less about military spending and power, and more about setting strategic

priorities. "The character of warfare is changing fast; so is the climate," Lt. Gen. Richard Nugee, the UK Ministry of Defence's (MoD) Climate Change and Sustainability Strategy Lead writes in the foreword to the Department's Climate and Sustainability Strategic Approach, published in March 2021. Climate change is the defining challenge of our time. Many countries have pledged to achieve net-zero

carbon emissions by 2050. In the UK, France and Germany, these targets are enshrined in law. It is not yet clear how countries will get there, or whether these targets will even be enough. But as one of the biggest contributors to government's greenhouse gas emissions, defence is being asked to redouble its efforts to combat climate change. According to the Watson Institute of International



An image of a female polar bear and her cub on the sea ice, taken from *HMS Protector*. (UK MOD © Crown copyright 2021)



HMS Protector breaks through the ice: In the Arctic, disruptive ice caused by climate change could result in the loss of freedom of manoeuvre (MoD Crown Copyright)

& Public Affairs at Brown University in Boston, the US Department of Defense is the world's largest institutional user of petroleum and correspondingly, the single largest institutional producer of greenhouse gases (GHG) in the world. From 1975 to 2018, the DoD's total GHG emissions were estimated to be more than 3,685 million metric tons of CO2 equivalent. "US military emissions are, in

any one year, larger than the emissions of many countries," the Institute states in a November 2019 report: *Pentagon, Fuel Use, Climate Change and the Costs of War*. "In 2017, for example, the Pentagon's total greenhouse gas emissions (installations and operations) were greater than the greenhouse gas emissions of entire industrialised countries, such as Sweden, Denmark and Portugal and also

greater than all CO2 emissions from US production of iron and steel."

The UK MoD's much anticipated Climate Change and Sustainability Strategic Approach sets out the threats posed by climate change and how defence must work over the next 29 years to mitigate their impact through three interlocking ambitions; adaptation and resilience, sustainability and net zero, and global leadership. In



March this year, the US Army stood up its Army Climate Change Working Group (ACCWG), which will develop the Army's Climate Strategy and Climate Action Plan.

NO EXEMPTION FOR DEFENCE

ACCWG is composed of major stakeholders from across Army headquarters and various commands. Together, they represent the Army's core

functions of equipping, training, sustaining and maintaining installations. Explaining the rationale behind the working group, Jack Surash, Senior Official Performing the Duties of the Assistant Secretary of the Army for Installations, Energy and Environment, says the complex, dynamic and pervasive effects of climate change require an Army-wide response.

The UK's Climate Change and Sustainability Strategic Approach clearly frames climate change as a problem not just for governments, but also for defence, which accounts for half of the UK central government's emissions. Lt. Gen. Nugee, the report's author, is a retired British Army officer who served in Iraq and Afghanistan and held several senior roles, including Defence Services Secretary (2015–2016) and Chief of Defence People (2016–2020). Before leaving the Army he led a review into Defence climate change policy, a topic he is passionate about. In his own home, he has installed solar panels and a house battery, he says, which serve as his main source of heating and electricity for eight months of the year. He has also planted thousands of trees around his house. But it is going to take a lot more than a few solar panels and tree planting for defence to make a meaningful impact on climate change.

The most important part of the 128-page report he produced for the MoD on climate change, says Nugee, is the chapter titled, *Why Climate Change is Relevant to Defence*. "When I started writing the report, some people were not convinced climate change was even relevant to defence. I've been accused of damaging operational capability," he says. "I think the exact opposite is true. Theoretically, defence can claim an exemption from carbon reduction targets, but I don't think we should. You can't exempt yourself from the world and say it is not happening to us. We need to pay attention. If we do nothing to support the government in getting to net zero by 2050, we will increasingly be seen as unpopular. It is

important to have the public's confidence. If we don't, ultimately, it could impact our ability to recruit."

In defence, climate change is often framed within the context of land and buildings the MoD manages. As one of the largest owners of Sites of Special Scientific Interest (SSSI) in England; slightly larger than those managed by the National Trust or Forestry Commission; the MoD certainly has a responsibility to ensure the future environmental resilience and biodiversity of these sites. Equally, the buildings that make up the defence estate, where the military lives, works and trains, should become more energy efficient.

But Nugee's report talks not only about defence's impact on climate change, but also the impact climate change will have on military installations, equipment, supply chains and operations. Equipment — fighter jets, aircraft carriers, naval vessels — the military relies on for strategic effect and projecting power globally, could be impeded by climate change or operate with increased levels of risk. With surface sea temperatures in the Gulf predicted to rise by up to 40 degrees by 2035-2040, Nugee says naval vessels can no longer rely on cold water to cool their engines. In the Arctic region, where countries are scaling up their military presence, "disruptive ice" between summer and winter, caused by climate change, could result in the loss of freedom of manoeuvre unless the hulls of naval vessels in future are hardened.

CLIMATE AND SECURITY

Extreme temperatures, rising sea levels, and increased frequency and intensity of extreme weather events, will also test the resilience of military installations, critical infrastructure, and potentially create harsher conditions for military operations and missions. In July 2019, the US Congressional Research Service revealed that the more than 1,700 global military installations on coastlines the Department of Defense manages could be at risk from rising sea levels.



“

You can't exempt yourself from the world and say it is not happening to us. If we do nothing to support the government in getting to net zero by 2050, we will increasingly be seen as unpopular. It is important to have the public's confidence. If we don't, ultimately, it could impact our ability to recruit.

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Ice patrol ship HMS Protector seen from an ice flow in the Arctic Circle
(UK MOD © Crown copyright 2021)

Humanitarian and natural disaster relief efforts are likely to be dialled up a notch as drought, soil erosion and marine environmental degradation cause famine, floods, loss of land and livelihoods, which could exacerbate state fragility, fuel conflicts, and lead to displacement, migration, and human mobility. "Disasters at home and abroad are likely to grow in intensity and frequency," according to the MoD's Climate Change and Sustainability Strategic Approach. "Defence will face new challenges and will need to collaborate with new types of partners to deal with them." By 2035, estimates suggest that the base temperature of the Sahel in Africa, will create an environment in which humans have never lived, Nugee told an International Institute for Strategic Studies webinar earlier this year. "That is likely to result in not only a diminishing food source, but the displacement of millions of people migrating from the Sahel."

Climate change is a serious threat to US national security interests and defence objectives, says Surash. "It can cause humanitarian disasters, undermine weak governments and contribute to long-term social and economic disruptions." Warming temperatures also open new theatres of operations for military and commercial use, he explains, while extreme weather events and rising sea levels threaten infrastructure and economic output, trigger large-scale population displacement, and exacerbate food and water insecurity.

"I'm most concerned about the nexus between emissions and military capability," says Lt. Gen. Nugee. In April last year, despite the shutdown of global economies and travel during the pandemic, daily global CO2 emissions only decreased by 17%, compared with 2019 levels. If the UK is to meet its ambitious goal — set in law — of cutting carbon emissions by 78% by 2035, compared with 2019 levels, then society's priorities will need to fundamentally change, says Nugee.



Natural disasters at home and abroad are likely to grow in intensity and frequency (MoD Crown Copyright)

“Defence will be asked, what are your emissions, and what are you doing about it? If we don’t have an answer, we could be ordered to reduce our emissions in a short space of time, which means we could end up having to cut certain military capabilities. But if we do it now, we can hopefully have the best of both worlds. We need to have a route to net zero.”

INITIAL ACTION PLAN

When it comes to the defence estate, Nugee says the technology is already there to help make it more energy efficient. “It’s a question of choice and using the time wisely to set up procedures and investment.” As part of a £45 million Net Carbon Accommodation Programme, the Defence Infrastructure Organisation, working alongside partners like Landmarc Support Services, are installing 38 new carbon efficient accommodation blocks across the UK Defence Training Estate.

“The Training Estate has its challenges for sustainability,” states Derek Walter, Landmarc Sustainability Manager. “Firing weapons and driving heavy vehicles can all have a negative impact on the natural environment if these risks are not managed effectively. It is therefore our duty to maintain and promote the ecosystem of this important landscape to provide both a safe and sustainable training environment.”

As part of its route to improving sustainability and contributing to net zero, the MoD’s Climate Change and Sustainability Strategy Approach divides the next 29 years into different ‘epochs’. The first epoch, from 2021–2025, is about setting the foundations, it says, working with suppliers to identify ways to reduce emissions in the supply chain through the equipment defence uses and contract conditions set. It talks about carbon reduction targets running through yearly defence plans.

Epoch two (2026–2035) is about setting more ambitious carbon reduction targets. For example, by 2035, defence’s built estate should have reduced its carbon emissions by at least 30%. In the last decade, the MoD says it has already reduced emissions across its estate by 50%. Moving forward, the Strategic Approach talks about prioritising energy efficiency and decarbonisation initiatives across its estate, as well as assessing carbon sequestration (capturing and storing) opportunities. In the US, since fiscal year 2008, Surash says the US Army has reported a close-to-20% reduction in GHG emissions from its installations, which was driven by increased building efficiency and onsite renewable energy generation.

By 2025, the MoD’s Strategic Approach talks about: “No decisions on future capabilities [being] made without evidence-informed assumptions on a

climate-changed world.” Climate-change implications will need to be considered consistently across all levels of military decision-making, it states. “A lot of this will evolve over time,” says Lt. Gen. Nugee. “I’m optimistic we can find solutions to replace fossil fuels that are as good if not better.” While it will be expensive to transform existing vehicle fleets outside of their current refurbishment plans, the strategy talks about leveraging new energy technologies from the commercial sector, which could allow defence to move away from current power options.

Surash says climate change impacts are already informing the US Army’s choice of supplies, equipment, vehicles, and weapons systems, as well as how and where its vehicles are transported and postured. Nugee says defence suppliers and industry may need to be incentivized to sequester the equivalent amount of carbon it is emitting. “There needs to be a way we can operate with industry,” he says. In the first five years (2021-2025), the MoD will need to set parameters and procedures, which are integrated into every procurement decision and requirement sent to industry. “It’s going to take a number of years, but it’s something that nobody else in government is doing, yet”

Many will ask how defence’s operational effectiveness can be balanced against meeting its sustainability and emission reduction targets? Surash says the US Army views its progress toward climate change adaptation and mitigation as one of the ways in which it can maintain operational effectiveness. “The Army’s climate change responses will increase platform efficiency and enhance freedom of action, strengthen installation resilience, reduce supply chain vulnerabilities, and ensure soldiers are trained for increasingly austere and hostile operating environments.”

In the war against climate change, the military will need to call on all its expertise in handling crises, as learning how to operate in a climate-changed world will become the new norm. ■



A Warrior Infantry Fighting Vehicle from Princess of Wales Royal Regiment at sunset during an exercise
(MoD Crown Copyright)

A WARRIOR'S END

WHAT NEXT FOR THE UK'S ARMoured INFANTRY?

With the Warrior Capability Sustainment Programme scrapped, the British Army losing a third of its Challenger 2 tanks, and now the AJAX IFV programme beset with problems, is the Army's war fighting doctrine in tatters?

By Peter Antill

The recent Defence Command Paper (DCP) entitled "Defence in a Competitive Age,"¹ which followed the UK Government's Integrated Review, contained what many had feared, despite the large boost for defence spending announced in late 2020, all three services faced cuts of some kind.

For the British Army, not only will this mean a reduction in its authorised personnel strength, from 82,000 to 72,500 (although the actual number of troops is nearer 76,000) and the loss of a third of its Challenger 2 tanks, but the entire Warrior Infantry Fighting Vehicle (IFV) fleet will be retired from service, being replaced by a mixture of Boxer and the AJAX armoured fighting vehicles (AFVs). However, there continue to be problems with the AJAX procurement programme.

The Warrior has had a relatively long service life and served with distinction in several conflicts, including the Gulf War, Bosnia, Iraq and Afghanistan. The Challenger 2 tank had not been updated since it entered service in 1998. Now an £800 million contract has been awarded to Rheinmetall BAE Land Systems to make the next iteration of the much loved tank, Challenger 3, "the most lethal tank in Europe," according to the UK Ministry of Defence (MoD).

But even the Challenger 2 upgrade was in doubt at one point, with some arguing that heavy armour was "a Cold War anachronism." In oral evidence given to the UK government's Defence Committee, Brigadier (Ret'd) Ben Barry, Senior Fellow for Land Warfare at the International Institute for Strategic Studies, maintained that "tank heavy armour, or, for that matter, medium and light armour, is part of a 21st-century combined arms battle."

WARRIOR NO MORE

The Warrior Infantry Fighting Vehicle was not so lucky. A number of ad hoc and theatre upgrades had been around for many years, with the MoD having looked at upgrading the Warrior's armament (the

30 mm Rarden cannon) as early as 1991. In 2005, it launched the Warrior Lethality Improvement Programme (WLIP), which eventually became the Warrior Capability and Sustainment Programme (WCSP) with a contract being awarded to Lockheed Martin in 2010.²

However, cost increases and delays continued to plague the project. By 2012, "the Warrior Capability Sustainment Programme now had an estimated full operational capability date of 2020 with production starting in 2018. The original aspiration of upgrading 643 vehicles had by now slipped to less than 400."³ By the time of the Paris Air Show in 2017, it was apparent that all was not well with the project. In-depth discussions took place between Tony Douglas, then CEO of the MoD's Defence Equipment and Support (DE&S), and Marilyn Hewson, former President and CEO of Lockheed Martin, as none of the 12 demonstrators with replacement turrets and weapon systems had been delivered.

Added to that, the UK government had initiated a 60-day spending review in the wake of the devaluation of the pound following the Brexit referendum. The National Audit Office (NAO) had issued a stark warning over the high levels of risk in the MoD's Equipment Plan. In 2018, the MoD confirmed that the WCSP was now delayed by at least 13 months with a new In-Service Date (ISD) of 2023 and cost growth of £200 million.

By mid-2020, the programme was still dogged by problems (mainly related to the installation of the cannon and integrating 21st century technology into a 1970's vehicle design). According to Stephen Lovegrove, Permanent Secretary at the MoD and its highest ranking civil servant, the WCSP was looking at an ISD that had slipped almost three-and-a-half years and was £227 million over budget.⁴ Despite signs of improvement, the decision to retire the entire fleet was taken as part of the Integrated Review and presented in the DCP, which stated:



"Modernising the Army will mean some legacy platforms that have already been extended beyond their planned life will be retired. In doing so, the Army will be able to invest new funds into accelerating the in-service date of the Boxer armoured vehicle and enhancing its capability We will no longer upgrade Warrior but it will remain in service until replaced by Boxer, which we expect to happen by the middle of this decade."⁵

CAN BOXER FILL THE VOID?

Originally designated a Multi-Role Armoured Vehicle (MRAV), the Boxer



Can the Boxer fill the void left by the scrapping of the Warrior CSP? (MoD/Crown Copyright 2021)

programme started shortly after the end of the Cold War as a project between France and Germany that would replace a number of legacy systems. The UK joined the programme in late 1995. Over the next several years, not only did the countries taking part in the programme change (France left, the Netherlands joined), but buy-outs and mergers within the European defence industry meant that the composition of the winning consortium (ARTEC) changed as well.

All this led to delays in moving the project forward and the UK's interest

began to wane. Not only was it becoming increasingly involved in the conflicts in first Afghanistan and then Iraq, but the Boxer's design was steadily evolving, gaining better armour protection and weaponry, but also weight. The UK pulled out of the programme in July 2003, citing a requirements mismatch — the Boxer could no longer be transported by a C-130 Hercules aircraft and was unsuitable for the force projection role originally envisaged.⁶

Given that the Warrior IFV has been a fundamental component of the UK's

armoured infantry battalions and was central to its Armoured Infantry 2026 programme, how will Boxer fill the (rather large) void left by Warrior? A key component of the 2015 Strategic Defence and Security Review's (SDSR) Joint Force 2025 concept, included the formation of two Strike Brigades, designed to be a 'medium' brigade⁷ lying somewhere between an armoured infantry brigade and 16 Air Assault Brigade.

It was to be made up of 5,000 personnel in three battalions, equipped with the new AJAX AFV and a Mechanised

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Modernising the Army will mean some legacy platforms that have already been extended well beyond their planned life will be retired. In doing so, the Army will be able to invest new funds into accelerating the in-service date of the Boxer.

”

A Warrior IFV and Challenger 2 (MoD/Crown Copyright)

Infantry Vehicle (MIV), in a wheeled, 8x8 configuration. In an interesting twist, to fulfil the requirement for the MIV, the UK ended up rejoining the Boxer programme 15 years after it left. Joint Force 2025 has been replaced by Integrated Force 2030, which still envisages the UK Armed Forces returning to a more flexible, mobile stance.

The Army will be reorganised into three divisions (1st, 3rd and 6th), each having a particular role, with the 3rd Division designated to undertake high-intensity operations. This division will be able to draw from a range of different brigade types, now known as brigade combat teams (all of which will be more self-sufficient), including Heavy, Deep Recce Strike, Light, Air Manoeuvre and Combat Aviation. But questions remain — are the Deep Recce Strike and Heavy brigades directly related to their predecessors (Strike and Armoured Infantry) and if so, what really sets them apart from each other if they are all equipped with Boxer?

Since the publication of the DCP, additional details have been revealed about the MoD's desire to procure additional vehicles. In response to a Parliamentary question about the UK's Boxer order, the UK Minister for Defence Procurement, Jeremy Quinn, stated that the MoD is "looking to enhance and uplift the size of the total UK Boxer order as we work to implement the Integrated Review."⁸

Currently, the MoD plans to procure 523 Boxer AFVs across four variants — APC, Equipment Support, Ambulance and C4I (Command Control Communication Computers and Intelligence). The UK has not ordered a turreted version of the Boxer, but the British Army is looking at possible lethality enhancements to enable an IFV variant to be procured in the future.

In addition, the UK is looking to replace the AS90 self-propelled gun (SPG), one possible candidate being the Boxer-based Remote-Controlled



AJAX prototype near its assembly site in Merthyr Tydfil, Wales (MoD/Crown Copyright)

Howitzer 155 mm (RCH155) built by Krauss-Maffei Wegmann. The UK's Boxers will be equipped with Remote Weapon Stations mounting heavy machine-guns, general purpose machine-guns and grenade launchers. Some vehicles are also expected to be equipped with the Javelin anti-tank missile, which can be fired from under armour.⁹

AJAX PROBLEMS MOUNT

A key component of how the Army intends to fight future wars, the AJAX family of combat reconnaissance AFVs are designed to both replace the Combat Reconnaissance Vehicle (tracked) fleet as well as act as a carrier for the Army's digital "backbone" and bridge the gap between mechanised and information warfare. It was also heralded as a divisional reconnaissance asset that would augment the Strike Brigade's firepower.

The Army chose an advanced version of General Dynamics Land Systems Ascod platform in 2010 and awarded a contract for 589 vehicles across six variants in 2014. The total cost to the MoD currently

stands at £4.62 billion (\$6.29bn) with £2.65 billion (\$3.6bn) having been spent so far. A total of 116 vehicles have been built, and the 25 vehicles that make up the Initial Operating Capability having already been accepted.

The programme, however, has been plagued by delivery and technical problems drawing criticism from various government agencies, the House of Commons Defence Committee and the Defence Secretary, Ben Wallace. As well as suffering delays — it was originally supposed to commence delivery in 2017 — other problems have included an inability to reverse over an obstacle more than 20 cm high, as well as excessive noise and vibration, which was so serious it affected crew's health and led to two suspensions of testing.¹⁰

While General Dynamics Land Systems UK (GDLS-UK) and the British Army have stated they are working hard to rectify the problems, one wonders how successful they will be. Although the excessive noise can be mitigated by the use of different headsets, the excessive vibration has led



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SUPPORT IN THE EXTREME



An AJAX prototype (MoD/Crown Copyright)

to problems such as the main armament being unable to stabilise while on the move, damage to electronic systems, a high rate of component failure, the idler and road wheels sheering off and crews suffering symptoms that would indicate that prolonged use of the platform would impact their health.

What makes things worse are the issues with quality control that GDLS-UK have had with vehicle components, especially the hulls, which are manufactured in Spain. These have included inconsistent lengths, hulls sides not being parallel, sub-standard welding, and variable hole spacing. All this means that the vibration issue is not appearing in a uniform manner, complicating its detection and resolution, as it unclear as to how much of it is to do with the design of the vehicle and how much is to do with the failure to build the vehicle to specification.¹¹

Even if these problems are sorted out, it is unclear as to whether AJAX remains the best way to fulfil the Army's requirements. With the reduction in the number of Challenger 2 tanks available and the (apparent) wholesale elimination of the armoured infantry capability, support assets that enable the operation of heavy armoured vehicles such as AJAX will be scarcer and more concentrated. If placed within the Heavy Brigade Combat Teams alongside Challenger, AJAX cannot

act as an IFV or undertake divisional reconnaissance duties.

If put in the Deep Recce Strike Brigade Combat Team, AJAX will struggle to

operate independently. Plus its weight, complexity and size make it unsuitable for use with lighter forces in rapid power projection operations. When reconnaissance can be undertaken first by aerial platforms such as Wildcat and then passed down to lighter, lower signature vehicles, and unmanned aerial vehicles (UAVs), one has to question what place does AJAX have in the future British Army?

The Army did not expect to lose Warrior in the review and so for the moment, its warfighting doctrine is in tatters. A decision on AJAX is also needed. What's concerning is that the latter might pre-empt and pre-determine the former. An alternative to AJAX is perfectly viable, but the Army must be clear on what its requirement is, so it can make a balanced and well-informed decision.¹² ■

FOOTNOTES

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PROTECTOR REMOTE WEAPONS SYSTEMS: REBRAND, REFRESH AND ROBOTIC CAPABILITIES

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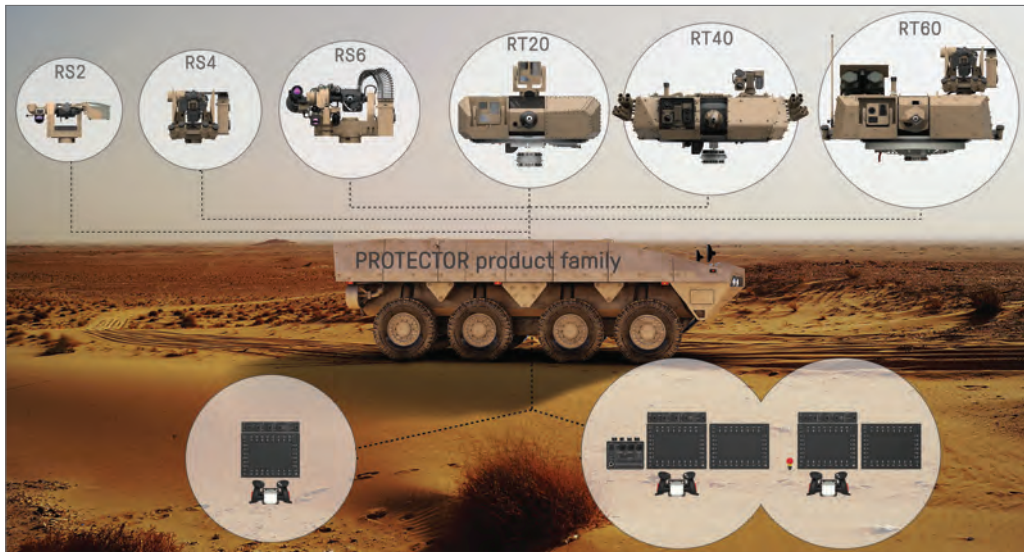
whether on land or sea. Integrated on mobile or static platforms, the systems enable remote operation of payloads ranging from small-calibre weapons to medium-calibre automatic cannons. The systems are modular, with all variants of the PROTECTOR family sharing the same baseline technology.

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The US Army QinetiQ and Pratt Miller RCV(L) platform with PROTECTOR RS4 (CROWS J) - Photo provided by Kongsberg



All Kongsberg RS and RT are still controlled via a common human-machine interface (single or double screen), and both can be controlled by one, two or more operators. Key to the multi-user and wireless fire control capability is the secure packed based transfer, which can be transmitted via Ethernet or wireless link.

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As the sole provider of the US Army’s CROWS, Kongsberg is delivering a secure, network-

REBRAND

Recently, Kongsberg completed a rebranding of its PROTECTOR RWS portfolio. The PROTECTOR name remains, with the systems being divided into two categories: The PROTECTOR RS category refers to all remote systems and includes the RS2, RS4 and RS6; the PROTECTOR RT category refers to all remote turrets and includes the RT20, RT40 and RT60.

Kongsberg Systems are selected in open competition because of significant investments made in their technology and systems, to bring mature technologies to market. This shortens the development and fielding timeline for customers, allowing Kongsberg to deliver a superior product. The global integration of PROTECTOR RWS provides significant benefits to customers, including commonality among forces and a mature and robust logistics chain.

CROWS TECH REFRESH

When Kongsberg first answered the requirement for the US Common Remotely Operated Weapon Station (CROWS) programme, the company established a technology roadmap that would benefit all its systems. Legacy systems still share 80% parts commonality with the latest CROWS, and through the Tech Refresh programme, CROWS customers maximise their system’s maintainability without sacrificing performance. Tech Refresh mitigates obsolescence while adding significant capability. Kongsberg can uniquely do this because of its investment in technology, logistics and sustainment.

Kongsberg continues to invest heavily in future systems, always accounting for significant modularity within its products, which allows for integration of various weapon systems. Kongsberg is moving into heavier weapons systems and cannons and, on the other spectrum, providing RWS capability for even lighter weapons and applications, all with the same technology at the core to leverage commonality.

based, MUMS capability under the existing CROWS contract. The capability includes wireless control and fire of a variety of crew-served and anti-tank weapons, integration of Kongsberg’s Cortex ICS for enhanced situational awareness, and advanced target sharing and hand-off between weapons systems.

This feature led to the US Army selecting Kongsberg to provide wireless fire control capability to support its future medium calibre lethality needs for the light and medium Robotic Combat Vehicles (RCV). This decision created a common architecture across all current robotic lethality fire control for crew-served, medium calibre and anti-tank weapons. In addition to the fire control architectures for both RCV-Light (RCV-L) and RCV-Medium (RCV-M), Kongsberg weapon systems — RS4 (fka CROWS J) and RT40 (fka MCT-30) respectively — have been selected as Government Furnished Equipment (GFE) for the Army’s RCV phase 2 experimentation.

“By overcoming the challenges presented by remote lethality, Kongsberg is paving the way for commonality across a variety of vehicle platforms — manned, optionally manned or unmanned,” said Scott Burk, vice president, Kongsberg Defense US. “Beyond lethality and scalability, in conjunction with other Kongsberg medium calibre systems and medium-weight systems being delivered, soldiers have the advantage of service-wide commonality. This will have tremendous positive impacts on training, provisioning and sustaining all US Army weapon systems.”

Following a recent exercise for RCV-L and RCV-M, Maj. Gen. Ross Coffman, director of the Next Generation Cross-Functional Team for Army Futures Command stated: “It’s really exciting what we’ve proven out thus far, not only are the robots working extremely well, the payloads are accurate and effective. We are seeing an increased stability or increased range that we didn’t think was possible previously.”

In another US Army programme, CROWS was integrated onto a robotic squad surrogate. Control of the weapons systems can be performed by dismounted soldiers, another larger vehicle in the convoy, or nearby air platforms, thanks to advances in cross-domain networking and hardened connectivity.

PROVEN WITH LIVE FIRE DEMONSTRATIONS

Kongsberg first demonstrated its wireless fire control capability for the RCV-L architecture, firing both a Javelin anti-tank guided missile (ATGM) as well as the weapon system's 12.7 mm machine gun (.50 M2) from a legacy CROWS M153, mounted on an unmanned ground vehicle (UGV).

The June 2019 live-fire demonstration was carried out at Redstone Test Center in Alabama. Kongsberg also successfully demonstrated secure transmissions of video and fire-control data, including command signals over radio from the weapon system and the missile.

In May 2021, in collaboration with the US Army, Kongsberg and the Javelin Joint Venture (JJV) conducted a multi-platform Javelin demonstration firing from three different vehicles, which were

each equipped with different configurations of the KONGSBERG Common Remotely Operated Weapon Station-Javelin (CROWS-J) and PROTECTOR RS6 Remote Weapon System (RWS).

During the demonstration, three different KONGSBERG remote weapon station configurations on three unique ground platforms fired Javelin, successfully engaging targets each time. Using QinetiQ North America's Robotic Combat Vehicle-Light (RCV-L), KONGSBERG executed a fully remote firing of Javelin using CROWS Tech Refresh control components. This was a first for the Army's official RCV-L platform and demonstrated Tech Refresh's backwards compatibility with legacy CROWS systems.

Over the last 20 years, Kongsberg has delivered more than 20,000 remote weapon systems to 26 nations. The vast majority of systems have been produced for the US military, outfitting more than 20 platform types, including Stryker brigades, Joint Light Tactical Vehicles (JLTV), Marine Corps ACV and AAV, Robotic Combat Vehicle (RCV-L and RCV-M), and maritime platforms, including MkVI Patrol Craft. The extensive growth in platform integration is matched only by Kongsberg's technology investments and growth of the products' capabilities. ■

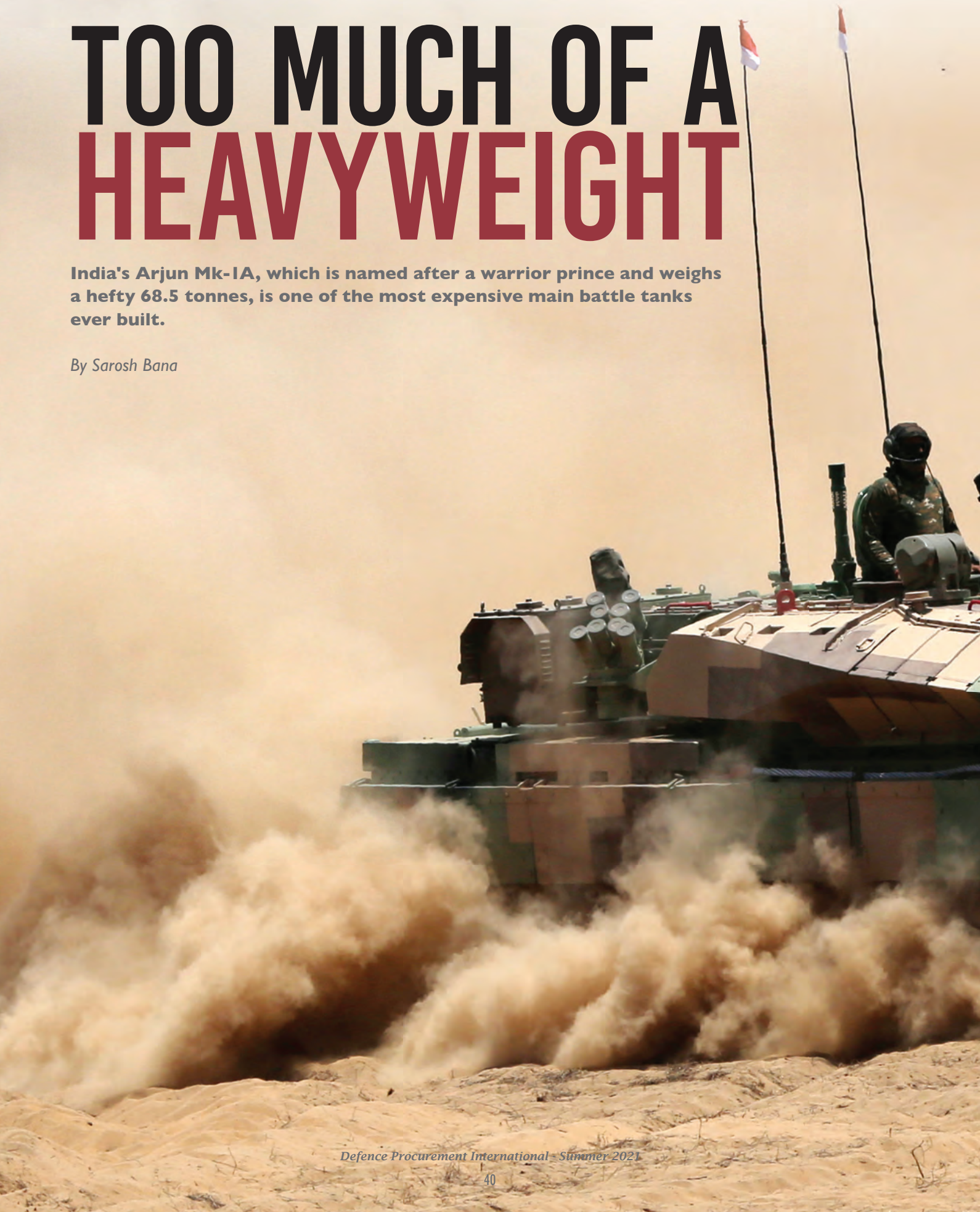


The US Army RCV(M) Textron RIPSAN M5 platform with the PROTECTOR RT40 - Photo provided by Textron

TOO MUCH OF A HEAVYWEIGHT

India's Arjun Mk-1A, which is named after a warrior prince and weighs a hefty 68.5 tonnes, is one of the most expensive main battle tanks ever built.

By Sarosh Bana



With a unit price of approximately \$10 million, India's Arjun Mk-IA is the most expensive battle tank ever made, surpassing the \$8.5 million K2 Black Panther MBT developed by South Korea's Hyundai Rotem and the \$4 million plus LeClerc main battle tank built by GIAT Industries, renamed Nexter Systems.

Weighing in at 68.5 tonnes, the Arjun Mk-IA is also one of the heaviest tanks, which makes it deployable only in limited terrain like roadless deserts, and certainly not at the Himalayan heights India's future

wars are likely to be fought. Flanked by two hostile neighbours, Pakistan and China, India's planning processes are today moulded by the threat of a two-front war.

In February 2021, India's Defence Acquisition Council (DAC) approved the purchase of 118 Arjun Mk-IA MBTs for the Indian Army at a staggering cost of \$1.5 billion (Rs8,380 crore), making it one of India's largest ever domestic defence contracts. The only other domestic defence contract that has dwarfed the Arjun MK-IA in terms of price tag was the \$6.4 billion awarded recently to the public sector

Hindustan Aeronautics Limited (HAL) for 83 of its single-engine fourth generation multi-role 'Tejas' Light Combat Aircraft (LCA).

Named after the warrior prince who is the main protagonist of the ancient Indian Sanskrit epic Mahabharata, the Arjun Mk-IA was designed by the Combat Vehicles Research and Development Establishment (CVRDE) and produced by Heavy Vehicles Factory (HVF), both based in Chennai. The CVRDE and the HVF are among the 52 laboratories of the Indian Ministry of Defence's (MoD's) Defence Research and Development Organisation (DRDO).



The Arjun Mk-IA tank during field trials (Copyright: DRDO)

The contract was initiated by the DAC as an Acceptance of Necessity (AoN) issued to the Indian Army for two regiments of these armoured behemoths. The Army will, in turn, issue a Request for Proposal (RFP) to the DRDO, with the process for the contract possibly taking over a year to conclude. The contemplated schedule is for all the Mk-1As to be delivered to the Army by 2025-2026.

THE ARJUN'S BATTLE-FIELD EDGE

Apart from its hulking weight, the tank is a formidable and reliable asset for any army, and has convincingly outperformed the Russian T-90, which has been the mainstay of the Indian Army's armoured corps. The Arjun Mk-1A requires a crew of four to operate, namely, a commander, gunner, loader and driver, while the T-90 only needs a crew of three.

The latest order, however, for the Arjun Mk-1A is likely to be the last as the Indian Army is keen on procuring lighter tanks. The Arjun Mk-1A's size — 10.6 metres long, 3.9 metres wide and 9.5 metres high — and weight means it will need to be transported either over dedicated broad gauge tracks, or freighted aboard limited rolling stock developed at great cost or on special road transporters that are under procurement.

Tanks have largely been deployed by the Indian Army in the deserts of Rajasthan bordering Pakistan where the sands pose a major challenge for other equipment. The Mk-1A has a prolonged pedigree, with the development of its precursor, the Arjun Mk-1, having commenced in 1972 with the aim of replacing the Soviet-legacy T-72, which is still in service. The fateful delays the Mk-1 encountered also pushed its intended weight of 48 tonnes to 62 tonnes eventually, although it is still lighter than its contemporary successor.

The Arjun Mk-1A was meant to have entered service a decade earlier, but the Army pressed for 71 technological and combat upgrades, including 14 major improvements. As a result, the new variant has enhanced firepower, advanced land navigation systems, high mobility, excellent protection and crew comfort, and improved night-vision capabilities.

“The superior armour-defeating capability of the indigenously developed munitions, the Fin Stabilised Armour Piercing Discarding Sabot (FSAPDS) and the High Explosive Squash Head (HESH), both fired from the 120 mm calibre rifled gun, give the Arjun MBT an edge over contemporary world tanks,” stated CVRDE's director V. Balamurugan.

“A computer-controlled integrated fire control system incorporating day-cum-night stabilised sighting system guarantees a very high first round hit probability and reduced reaction time to bring effective



The Arjun MBT Mk I paraded on Republic Day (WikimediaCommons)

fire on targets.” In addition, an anti-helicopter round to combat air threats is also under development. The Mk-IA’s maximum speed is 70 kmph, and its maximum speed cross country is 40 kmph.

Its electro-slag refined gun steel tube is autofrettaged to withstand higher gas pressures, autofrettage being a metal fabrication method, which is theoretically similar to shotblasting. A thermal jacket prevents irregular temperature distribution on the tube due to weather fluctuation. The tank’s secondary weapons are a co-axial 7.62 mm machine gun for anti-personnel and a 12.7 mm machine gun for anti-aircraft and ground targets.

The gunner’s main sight comprises a day-sight, thermal-sight, laser range finder and stabilised head common to all the three channels. The day-sight provides dual magnification, while the thermal imager provides night vision to the gunner and commander to observe and engage



Indian PM Narendra Modi hands over the Arjun MBT Mk-IA to the Indian Army (Copyright: DRDO)



targets in total darkness or in conditions of smoke, dust, haze and light camouflage.

Integral with the main sight is the laser range finder by which targets can be ranged accurately. The commander’s panoramic sight enables all-round surveillance of the battlefield, regardless of the turret motion. All round protection from anti-tank ammunition is achieved by the newly developed Kanchan modular composite armour produced by DRDO’s Defence Metallurgical Research Laboratory (DMRL).

The Arjun Mk-IA is about 70% indigenous, with imported systems and components including its MTU MB838 ka-510 1400 HP diesel engine (at 2400 rpm), semi-automatic Renk RK 304-I transmission system and Bosch gun control equipment, all from Germany.

The gunner’s main sight is from Belgium’s OIP Sensor Systems. The MBT’s fire control system is from Israel’s Elbit Systems, which has also collaborated with DRDO in developing the Battlefield Management System and Laser Warning Control System.

Its DST (formerly Diehl) tracks have been licence-built by Indian firm L&T.

The Indian Army currently fields more than 3,000 MBTs across 67 armoured regiments. These include around 1,900 44-tonne T-72M1s imported from the Soviet Union in the 1980s, 1,000 48-tonne T-90S, the first of which were imported in 2004, and 124 Arjun Mk-Is, which entered service between 2004 and 2011.

In April 2021, the Indian MoD floated a Request for Information (RFI) to seek prospective vendors for jointly building in India around 350 light (25-tonne) tanks. If and when procured, these tanks will form almost six regiments in the Army, and are likely to be deployed in mountainous terrain, such as the Ladakh region, where they provide greater manoeuvrability than India’s much heavier Russian and Arjun tanks. ■

ABOUT THE AUTHOR

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HOW MUCH IS LEFT

During Operation Iraqi Freedom, a Challenger 2 tank and its crew survived being hit by 70 RPGs. But surviving the UK Ministry of Defence's Integrated Defence Review has been just as challenging for the 23-year-old tank. Will Challenger 3, put the British tank back at the cutting edge of NATO?

Peter Antill

Before the emergence of the global Covid-19 pandemic and the UK government's focus on its response to the ensuing healthcare and economic crisis, the British Army's beloved Challenger 2 tank looked like it was destined for the scrapheap.

Ahead of the Integrated Defence Review, whose publication was postponed from autumn 2020 until March this year, there were rumblings that the Army was contemplating scrapping its fleet of 227 Challenger 2 tanks, which hadn't been extensively upgraded since they entered service in 1998.

Some saw them as a "Cold War anachronism," while others argued that tank heavy armour still had a role to play, as demonstrated by recent conflicts in Ukraine, Azerbaijan and Armenia. Despite its success in Iraq and Bosnia (Challenger 1 was the British MBT during the First Gulf War), a lack of significant upgrades has made the Challenger 2 look out of

date against other NATO tanks such as Germany's Leopard 2, the US Abrams Main Battle Tank, and entirely new tank designs such as Russia's T-14 Armata, which features a remote-controlled turret and active protection system.

Despite a significant defence spending boost in 2020, totalling an extra £16.5 billion over four years, the UK Ministry of Defence (MoD) still has to contend with a £13 billion "black hole" in its Equipment Plan. It is also focused on how wars are likely to be fought in future using cyber warfare, information operations and cutting-edge technology, such as robotics and artificial intelligence. What future do tanks have in this new high-tech vision of war?

This, combined with restructuring of the UK Armed Forces to project military power globally, meant that despite the boost in the defence budget, tough spending decisions had to be made.¹ This was confirmed with the publication of the Integrated Review, *Global Britain in a Competitive Age*, on 16 March this year, followed by the Defence Command Paper, *Defence in a Competitive Age*, which was launched on 22 March.

The Challenger 2 tank emerged from the review intact, but only just. The Army decided to upgrade only 148 of its 227 tanks to Challenger 3 status, which will see them fitted with the latest 120 mm high-pressure L55 smoothbore gun from Rheinmetall, an upgraded engine with a new cooling system and suspension to improve accuracy when firing in transit.

The whole life cost of the Challenger 2 Life Enhancement Programme (LEP) is estimated to be in the region of £1.3 billion. In technological terms, it is expected "to put the British Challenger tank on the cutting edge of NATO's armed forces."



T IN THE TANK?



The Queens Royal Hussars' Challenger 2s, about to breach Abatus, an obstacle formed from felled trees during a training exercise. (UK MOD © Crown copyright 2020)

EARLY HISTORY

When the Challenger 2 MBT (FV4034) entered service in 1998, its 120 mm L30A1 tank gun, which was rifled, made it unique among NATO tanks, as did its Dorchester second-generation Chobham armour. It is the third tank to bear the 'Challenger' name in British Army history. The first was the A30 Challenger, a World War II-design incorporating the chassis of a Cromwell tank and a 17-pound gun.

The second was the Challenger 1 (FV4030/4), the British Army's MBT from

1983 to 2001, a design that had its origins in an Iranian order in the mid-1970s for a more advanced version of the Chieftain MBT (FV4201). The Iranian revolution meant the order was cancelled and the British Army adopted the design (known as Shir 2) as the Challenger 1. The current Challenger 2 fleet stands at 227 vehicles remaining from the 408 originally ordered, which were built by Vickers Defence Systems (now part of BAE Systems) at the former Royal Ordnance Factory in Leeds.

The tank has seen active service in

Bosnia, Kosovo, and Iraq. As a result of several incidents during the British Army's operations in Iraq, deployed Challenger 2s were upgraded to a new Theatre Entry Standard (TES), informally nicknamed 'Streetfighter', which included a passive armour package developed by Rafael Advanced Defense Systems, additional armour on the underbelly, a new CCTV camera at the rear, a new forward-looking thermal sight for the driver, a remote weapon station and IED jamming technology. At the same time,



Cyclops Squadron, Royal Tank Regiment, Barakat Training Area, Oman on Exercise Saif Sareea 3 in Oman. Previous exercises found the Challenger 2 experienced problems with dust and sand ingress and overheating problems in desert conditions. (UK MOD © Crown copyright 2020)

the Challenger Lethality Improvement Programme (CLIP) looked to replace the L30A1 rifled gun with a Rheinmetall 120 mm RH-120 smoothbore gun used in the Leopard 2, M1 Abrams and K2 Black Panther. This upgrade would have the advantage of enabling the Challenger 2 to use standard NATO ammunition, including the use of tungsten-based kinetic energy penetrators, which do not have the same political and environmental objections as depleted uranium ones, and avoid the inevitable shortage of rifled 120 mm

ammunition due to the production lines being closed some years ago.²

More recently, the British Army unveiled the Streetfighter II concept, with two Challenger 2 tanks being modified and put through their paces at the urban operations facility at Copehill Down village on Salisbury Plain. Upgrades included greater lethality vis-a-vis infantry with machine-guns mounted on remote weapon stations and one Challenger 2 mounting the Brimstone anti-tank guided missile (ATGM) system for engaging heavily-armoured targets at long range. Communication systems were improved to allow for infantry to directly communicate with the tank crew, along with additional cameras and Elbit Systems UK's IronVision platform to enable the crew to see 360 degrees around the vehicle in real-time.³

A FAIT ACCOMPLI

In December 2005, the MoD's Defence Industrial Strategy recognised the need for a Capability Sustainment Programme (CSP) to extend the service life of the Challenger 2 into the mid-2030s and upgrade its lethality, mobility and survivability.⁴ The CSP was planned to be complete by 2020 and was to combine all the upgrades from CLIP. By 2014, the CSP programme had been replaced by the Life Extension Programme (LEP), which was similar in terms of replacing obsolete components and extending the tank's service life from 2025 to 2035.

In August 2016, the UK MoD awarded contracts for the LEP Assessment Phase to Team Challenger 2 (a consortium, which included BAE Systems and General Dynamics UK), CMI Defence / Ricardo, Rheinmetall and Lockheed Martin UK / Elbit Systems UK.⁵ In November 2016, the MoD shortlisted the teams led by BAE Systems and Rheinmetall Landsysteme for the project, which was then worth around £650 million (\$802 million).⁶

Events started to move somewhat quicker at this point. In October 2018,

BAE Systems unveiled its LEP technology demonstrator, the "Black Night," which had a Safran commander's sight, a Leonardo thermal imager for the gunner and DNVS 4 night sight, as well as improvements to the turret mechanics, a laser warning system and an active protection system.⁷

A few months later in January 2019, Rheinmetall unveiled its demonstrator, which included a completely new turret with a digital architecture, day and night sights for both the commander and the gunner and the 120 mm L55 smoothbore gun. In June, both BAE Systems and Rheinmetall declared they had formed a joint venture company (Rheinmetall BAE Systems Land – RBSL). While both were initially expected to produce competing proposals for the LEP contract, in the end, RBSL only showcased the Rheinmetall proposal at DSEI 2019.⁸

The MoD was effectively handed a fait accompli, which it seems to have grudgingly accepted in written evidence to the House of Commons Defence Committee in late 2020.⁹ In March 2021, the MoD confirmed that 79 Challenger 2 tanks will be retired and the remaining 148 will be upgraded and redesignated Challenger 3¹⁰, an upgrade that will include Rafael's Trophy Active Protection System (APS).¹¹

POST-BREXIT EUROPE

Even with these updates, Challenger is due to be replaced sometime in the mid-2030s, as part of the MoD's Future Ground Combat System (FGCS). Interestingly, the French and Germans are looking at replacing their current tank fleets (the LeClerc and Leopard 2 respectively) at roughly the same time, with Krauss-Maffei Wegmann, Rheinmetall and Nexter working to develop the first European MBT. The Franco-German Main Ground Combat System (MGCS) or "EuroTank" is a project similar to the one that resulted in the Eurofighter Typhoon.



Challenger 2 tanks of The Queen's Royal Hussars (MoD/Crown Copyright)

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The UK has been granted observer status on the MGCS, so as to inform its FGCS programme. But it could also be a prelude to deeper involvement and be seen as a test case for future defence procurement collaboration in a post-Brexit Europe.¹²

However, as with all multinational procurement projects, compromises will have to be made. There have been differences historically between the military doctrines of the UK, Germany and France, which means each country places a slightly different emphasis on whether tank designs should focus on mobility, firepower or protection.

Ultimately, it was a failure to find a design acceptable to its own national requirements that led to France leaving both the Eurofighter and Boxer programmes, both of which suffered considerable delays. The Eurotank programme must build on the lessons learned from these and other multinational projects if it is to avoid suffering a similar fate. ■

ABOUT THE AUTHOR

Peter Antill graduated from Staffordshire University in 1993 with a BA (Hons) in International Relations and gained an MSc Strategic Studies from Aberystwyth in 1995 and a PGCE (Post-Compulsory Education) from Oxford Brookes in 2005. He worked at Cranfield University at Shrivenham from June 2009 to 2019, creating a defence acquisition body of knowledge. His interest lies in examining defence procurement and logistics within the realm of military history.



SOLDIERS

OF

Private military companies continue to expand their global presence as nations recognise the benefits of operating in the shadows.

By Staff Writers

FORTUNE



The recent discovery of a tablet computer, which was allegedly owned by a member of the mysterious Wagner Group in Libya, has sparked a new wave of interest in the private military organisation by Western media. The tablet, which contained information ranging from manuals for anti-personnel mines and IEDs, to reconnaissance drone footage and maps marked in Russian, are seen as testament to the group's ever growing presence in the Middle East, Africa and other

politically volatile regions of the world.

In recent years, interest in the group has significantly increased, mainly due to a number of missions it conducted in Syria and some African states, which were primarily completed within the interests of local governments. The latter, as a rule, used the services of the Group in order to deal with terror threats and massive rebel movements within their territories.

In Russia, the activities of the Wagner Group usually receive mixed reviews, but most Western analysts consider it as a

A contractor from Russian PMC Vegacy Strategic Services in Syria: Unlike the Wagner Group, Vegacy's primary mission is military training (Source: Twitter)



An unconfirmed photo believed to be of Wagner Group members at an unidentified location (Source: Twitter/Security Service of Ukraine)

military structure, which acts solely within the interests of the Russian government and its geopolitical targets. Russia, however, denies any connection with the group.

Sean McFate, an Adjunct Associate Professor – Center for Security Studies at Georgetown University's School of Foreign Services remarks: "The Wagner Group is a mercenary company that serves Russia, at least at the moment. They have operated in Ukraine, Syria, and throughout Africa. Additionally, they are rumored to have been in Venezuela in 2018. Some mistakenly think of them as a GRU (Russian military intelligence) militia, but this is incorrect."

McFate says the Wagner Group is a non-statutory force with alleged ties

to Russian oligarch Yevgeny Prigozhin. Prigozhin, however, regularly denies allegations of his affiliation with the Group and has filed a number of lawsuits against media outlets that publish such reports.

According to McFate, mercenaries are Russia's latest weapon of choice. Wagner Group is Moscow's "tip of the spear" in Africa and the Middle East, he says, and it is the first time Russia has conducted expeditionary military operations on those continents since the Cold War.

RUSSIAN MERCENARIES IN AFRICA

McFate's position is shared by other analysts, who say Russia is trying to increase its influence in African countries

through private military companies (PMC), providing military assistance to governments in Libya, Sudan, the Central African Republic (CAR), Madagascar and Mozambique. According to analysts, Russian mercenaries have been arriving in Africa since 2017, trying to re-establish ties with their former partners during the Soviet era. The Wagner Group plays an important role in these plans. With respect to Africa, analysts says Russia is striving to implement the "Syrian scenario" on the continent. With the help of mercenaries, it is ready to support regimes faced with internal threats and limited by an arms' embargo or some other isolation measures.

In 2019, some Wagner Group members

from Syria arrived in Libya to provide military support to General Khalif Haftar, whose Libyan National Army was besieging Tripoli. The Wagner Group has some modern weapons, including drones, self-propelled anti-aircraft missile and cannon systems, MiG-29 fighters and Su-24 bombers. According to the Turkish Anadolu news agency, the mercenaries are stationed at air bases in the Libyan cities of Sirte and Jufra, east and southeast of Tripoli. Thus, they actually hold one naval and two air bridgeheads at the southern flank of NATO.

According to the Pentagon, the Wagner Group's presence in Libya is supported by the UAE, which has denied such allegations. Another area of activity in Libya for the Group is recruiting and training of specialists from neighbouring countries in the region to participate in hostilities on the side of the Libyan National Army (LNA). As a rule to conduct their foreign missions, Russian PMCs use fictitious companies that are registered outside of the country and are used only within the framework of one assignment. The recruitment of rank-and-file mercenaries is carried out using social networks. Recruiters are looking for specialists with real combat experience in hotspots of the world (Chechnya, Ukraine, Georgia, Syria).

At the same time the Wagner Group not only participate directly in hostilities, but also escort civilian ships, conduct an audit of the safety of oil and gas offshore platforms, involved in sabotage operations, logistical support, aerial reconnaissance, and also guard facilities in the interests of Russian business. Currently, the Wagner Group is thought to be present in approximately 15 countries. Its highest priority is said to be Libya, Sudan, CAR, Madagascar and Mozambique. Despite its generally negative portrayal in the West, representatives of many regional governments said that the presence of the Group allows them to disrupt attacks of various international terror groups, including the Islamic State.

McFate, however remains skeptical, regarding the peace-support missions of the Wagner Group. "When you privatise war, it changes warfare in profound ways," he says. "First, the laws of the souk apply to strategy in ways that four-star generals do not understand. Second, it is divorcing war from the nation-state. When the super-rich or Fortune 500 can hire mercenaries to wage war for any reason they want, they can become super-powers. Third, more mercenaries means more war. There is plenty of historical evidence that soldiers of fortune start or elongate wars for profit. Or act as bandits in between contracts. International law is important to stop them; who will go into Libya and arrest all those mercenaries? The UN? NATO? Nope. Also, mercenaries can shoot your law enforcement dead, making them ungovernable. Mercenaries are here to stay, like it or not."

SNEAKY WARS

McFate says the world forgets that mercenaries are the norm throughout human history. "Private security contractors

date back to the Old Testament," he says. In a paper titled, *A Historical Perspective of Mercenaries*, Col. George Dodenhoff US Marine Corps School of Naval Warfare, says: "Mercenaries were common to all armies, but were engaged for a single campaign only." The Battle of Hastings in 1066 featured "soldiers of fortune from a dozen other nations who were attracted by the prospect of conquest." Some of the most famous mercenaries were the Swiss who fought in Europe's armies, specifically the French Army, between the 15th and 19th centuries.

It is only in the last 200 years that mercenaries were outlawed, says McFate, but now they are returning. This year, one of the most influential PMCs, Executive Outcomes (EO), which was founded in South Africa by Eeben Barlow, a former lieutenant-colonel of the South African Defence Forces, was revived after a 22 year hiatus. Barlow is reported to have reformed the organisation because he was asked to by various African governments.

Formed in 1989 as the former apartheid regime in South Africa was disbanding,



PMCs during the Siege of Ghouta in Syria (Source: Twitter)

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disillusioned SADF soldiers found gainful employment with Executive Outcomes, which trained Angolan soldiers and later fought on behalf of Angola and rescued governments from guerrilla groups looking to seize control of diamond fields. In addition to supplying governments with a private army, EO also supplies or advises on equipment (weapons, vehicles). On its website it talks about EO Land Systems, “coming soon,” and in a section on equipment, states that it “advises government and armed forces on where the equipment can best be sourced, at competitive prices.” It claims this approach has saved African governments large sums of money.

McFate says Barlow never failed in any of his missions, whereas Erik Prince, Blackwater's infamous founder, is considered 'unprofessional' by the mercenary community, as he never really succeeded in a mission. It seems there is a code of honour even among soldiers of fortune. “The market for force today is at a critical juncture,” says McFate. “The time of regular warfare is over.” Operating in the so-called 'grey zone,' will require equipment and soldiers to be used in new and different ways, says McFate. “It's about fighting sneaky wars in sneaky ways.”

McFate says there are things conventional forces could learn from private military companies like EO, which he describes as innovative and entrepreneurial. “They're lean and mean and very creative.” Although PMCs are adept at operating in the grey zone, the rank and file of organisations like the Wagner Group, says McFate, are not loyal to Putin. “They could potentially be bought out and change their tactical calculus,” he explains. One day you could hire mercenaries, and the next you could be fighting against them, ventures McFate.

So how can conventional militaries compete in a world where war is less about how many billions you spend on aircraft carriers or fighter jets, and more about deniability and being sneaky? At



Syrian servicemen being trained by Russian military instructors from PMC Vegacy Strategic Services (Photo by Mikhail Voskresensky)

the Royal United Services Institute's Land Warfare Conference in June, McFate floated the idea of a Foreign Legion, a part of the military run by British officers under British chain of command, which comes from all over the world. “They would need to do a five-year contract, which avoids problems of accountability and using proxies,” he explains. “It would mean massive boots on the ground could be deployed for long periods of time.”

In 2019, the British Army outlined plans to rebalance the Field Army to ensure that it “can compete with and defeat adversaries both above and below the threshold of conventional conflict.” The 6th Division was returned to service to enable the Field Army to operate in the grey zone without using force to modify the enemy's behaviour. Instead, the division will rely on “novel information effects,” such as cyber, electronic warfare, intelligence, information operations and unconventional warfare through niche capabilities such as the

Specialised Infantry Battalions. “The Army needs to be ready not to fight the war we last fought, not the war we'd like to fight or anticipate to fight, but the war we may have no choice but to fight,” General Mark Carleton Smith, Chief of the General Staff of the British Army stated at the RUSI conference.

McFate says the British Army's 6th Division is a good start. “A lot of weight needs to be put on experimental units which are much better than conventional forces” he says. “While the US, NATO forces and the UK would be very hard to beat in a conventional fight, we suck at unconventional warfare,” says McFate.

Threats are becoming trickier to identify, attribute and evidence, which is where PMCs are most comfortable operating. Who might be hiring PMCs in future? It's certainly not just Russia, as events in Libya and other conflicts have demonstrated. It is likely to be anyone with national security interests, says McFate, who can swipe a cheque. ■

WHEN FAILURE IS NOT AN OPTION

Leading provider of high-performance lighting devices Streamlight® Inc. share their knowledge to help procure adequate lighting tools for mission success.

Any mission is fraught with potential danger. An enemy or high-risk situation can lurk around every corner and in every shadow. And while darkness can be an ally in completing operations, it can also be used by enemy forces in unexpected ways. As such, every operative needs to have reliable, sufficient lighting tools that go above and beyond the typical requirements to ensure mission success and, ultimately, their safety and that of their unit.

Trusted around the world in many industries – from fire and rescue services to law enforcement and the military – the team

at Streamlight have worked closely with frontline operatives to ensure they offer lighting solutions for every eventuality. Employing a Streamlight personal lighting device or weapon-mounted light could be the deciding advantage in perilous operations.

Defined by innovation in delivering effective, efficient and high-performance lighting tools, Streamlight's research and development team puts in the necessary time and effort to make sure their products help to eliminate threats and save lives. Creating new products can take anywhere from months to



Streamlight's Sidewinder series offers many functions and features for military personnel



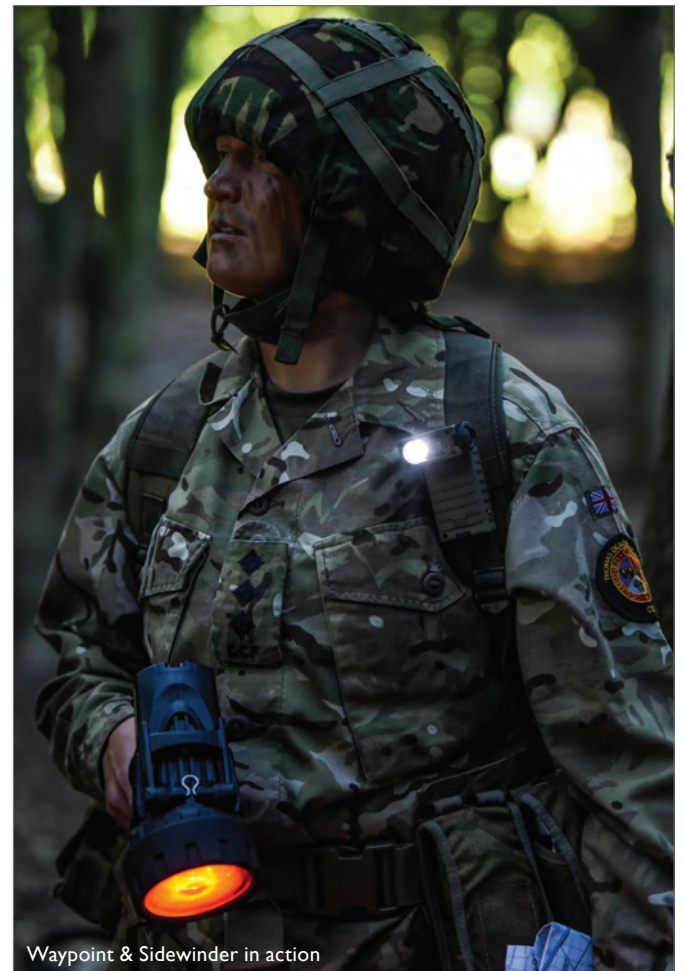
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VERSATILITY & COMPATIBILITY

Before you begin your search for the right flashlight, you should pin down what is required of the light(s) and how much versatility is desired. With fewer devices that cover all needs, operatives will be able to efficiently deploy lighting and focus their full attention on the task at hand, which is vital in high pressure or life or death situations.

For example, you might think a standard flashlight that clips to a vest or helmet at 90°, that is bright enough to see what's in front of you and illuminate a map is required. But what if the team also needs to use strobe settings for signalling and/or a low-power mode to prolong battery life when unexpected events occur, and they find themselves a long way from base behind enemy lines? In a case like this, a light from the Streamlight Sidewinder® series would be a good tool to have.

The Sidewinder® series offers many functions and features – such as being waterproof, including night vision compatible LEDs and filters, having the ability to mount on a belt, helmet, vest and more — making these lights some of the most versatile military lights in the world.



Waypoint & Sidewinder in action

years, depending on the complexity of the product. Features and output may change, but Streamlight's commitment to quality and innovation remains the same.

Streamlight President and CEO, Ray Sharrah, explains: "We are revolutionising LED lights, making them brighter, safer and incredibly durable. After we've met the challenges involved in designing and engineering a light, we put it through the most demanding industry testing to ensure the highest levels of performance and dependability."

Some of the company's latest product advancements have created a range of lighting options. From illuminating vast areas and projecting a defined beam of light up to a mile away to operating virtually undetected in IR mode, there is a Streamlight lighting tool for almost any application.

Additionally, some units have multiple settings and features, while many are built to be virtually indestructible. Indeed, there are so many options available, it may be hard not to base final decisions on price and aesthetics. Consider the importance and application of the lighting tool you need to inform your choice. We've called upon 47 years of experience at Streamlight to highlight a few key factors to help procurement decisions.

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In a similar scenario, a weapon-mounted light for long guns can benefit night-time missions by filling dark rooms with light while clearing a building, but aside from just providing light, a strobe setting could be utilised to confuse and disorient the enemy and give the operative an upper hand. Streamlight's ProTac® rail-mounted series provides high-lumens, focused beams and easy-to-operate ambidextrous on/off switches, and a unique TEN-TAP® programmable switch that allows for personalisation of the device's light output upon activation.

BATTERIES

Another important factor to consider is the power source, either by way of disposable or rechargeable batteries. Disposable batteries are inexpensive, have excellent storage life and generally offer long run times. However, rechargeable flashlight batteries feature extraordinarily low operating expenses in the long run— as little as a penny per day — and are well suited for frequent use.

Battery life indicators are a useful tool too. Streamlight includes them on several models to highlight when batteries need replacing or recharging. Knowing the device has ample power is one less thing to focus on pre-operation.



Compact weapon-mounted light with laser



The Sidewinder®


BRIGHTNESS & RUNTIME

As you might imagine, brightness and runtime have a close relationship; often, the brighter something is, the quicker the battery will drain. Therefore, it's important to utilise the appropriate lighting modes a flashlight provides. Runtime is measured from the initial light output value (that's 30 seconds after the light is turned on with fresh batteries) until the light output drops to 10% of the initial value, measured in hours.

As for brightness, this is measured in 'lumens' and stands for the total quantity of emitted light energy from the portable light source on its highest setting, powered by fresh batteries. Lumens can range from single digits (great for reading a map undetected) to terrain-scorching thousands. There may also be multiple lumen values if the flashlight benefits from different lighting modes. However, beam intensity, distance and type can determine the effectiveness of a light in different applications. When considering a light for your application, be sure to determine the runtime and brightness that is necessary for success.

Strategy plays a huge part in every mission, and lighting should be an important consideration that is never overlooked. Internationally regarded products, like Streamlight lighting tools, will provide your operatives with the confidence and trust needed to improve the odds of success in any operation. ■

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A DOSE OF REALISM

Using high-tech gaming engines, smart mannequins fitted with sensors, and a system that offers thousands of room and building variations, 4GD brings a new level of reality to immersive close combat training.

By Anita Hawser

Rob Taylor, a former Royal Marine and director of 4GD, a UK-based company, which specializes in developing unique close-combat training facilities, knows only too well the limitations of urban warfare training.

Before shipping out to Afghanistan as part of the UK's Operation Herrick while still a Marine, he was sent to the Stanford Training Area (STANTA) in Norfolk, where a 12.5-acre (51,000 m²) replica of an Afghan village was built to give soldiers a sense of what they could expect when they got there.

To add a healthy dose of realism, the mock village was manned by Afghan nationals, ex-Gurkha soldiers and amputee actors, who pretended to be members of the Afghan National Army, locals or casualties. The village comprised homes, a market and even a mosque. Real helicopters evacuated wounded soldiers and soldiers trained to prepare for mortar attacks and detecting Improvised Explosive Devices on roadsides or in homes.

Photo: MoD/Crown Copyright

At the height of the war in Afghanistan, mock villages like these popped up in different locations all over the world as NATO members prepared to do battle in a country whose formidable terrain and urban environments would soon become familiar to soldiers.

Taylor says the mock Afghan village, complete with alleyways and walls, and smells (sewage, cooking) did a relatively good job of transporting him almost 6,000 km away. But eventually, he says, the collection of buildings and rooms in the mock village became all too familiar. “You knew who the enemy was going to be and the setup of the buildings didn't really change. These types of environments also don't stress the command that much.”

Afghanistan aside, urban warfare training facilities in general, says Taylor, haven't changed that much since the Cold War. “They're typically empty breeze block buildings in the middle of nowhere,

with no people. You need something that reflects the normal ebb and flow of the urban environment. You want soldiers to be surprised and see how they react to people, smells and sounds. That's why I started 4GD.”

With declining defence budgets to spend on large-scale collective training exercises, and the military's increased focus on sustainability, Taylor and his team of ex-veterans at 4GD wanted to deliver training solutions to soldiers at the battalion or garrison level so they could train wherever and whenever they want, as many times as they wanted, without having to travel or be all together.

AVOID CITIES

The great military strategist and theorist Sun Tzu said to avoid or isolate cities, rather than becoming embroiled in combat in them. It's not difficult to see why. Urban operations are possibly the most stressful

and challenging environment any soldier can fight in. Every city is different in terms of its layout, the height, shape and mixture of buildings. They also feature subterranean tunnels, sewers and railway lines, which the enemy can use to great effect.

The sounds typically associated with battle —gunfire, explosions and helicopters—are interspersed with the usual chatter and buzz of urban life. Urban terrain usually favours defending forces who can rely on local knowledge to give them the upper hand against much more sophisticated and well-armed forces. One only has to look at Israel's efforts to take Beirut in the 1982 Lebanon War against the Palestine Liberation Organization. Using massive firepower and a smaller infantry untrained in urban operations, Israel had to mount a painstaking clearing operation against an elusive enemy, which easily blended into the local population.

A British Army Review 2019 Special



4GAV, the special effects and video monitoring system in the SmartFacility, is controlled via a tablet (Photo courtesy of 4GD)

Report on Urban Operations says, “the best way to carry out urban opps is to try to avoid urban operations.” Yet, with the majority of the world's population predicted to live in cities in the 21st century, most wars in future are likely to be fought in urban centres. But it is a reality few forces seem to be adequately prepared for, judging by General Mark Milley, Chairman of the Joint Chiefs of Staff and Chief of Staff of the United States Army's remarks:

“In the future, I can say with very high degrees of confidence, the American Army is probably going to be fighting in urban areas. We need to man, organize, train and equip the force for operations in urban areas, highly dense urban areas, and that's a different construct. We're not organized like that right now.”

MORE IMMERSIVE

4GD's new Level 2 SmartFacility training solution for the British Army's 16 Air Assault Brigade in Colchester, Essex, marks a significant step change in urban warfare training. The complexity and regularity of close quarter battle training can be easily increased using a combination of synthetics, special effects, gaming engines and SimWall, a rapidly reconfigurable, non-ballistic modular panel system, which offers thousands of room and building variations, all reconfigurable within minutes.

Taylor says it can create external spaces internally, allowing soldiers to practise approaching buildings not just moving from one room to another. SimWall can even be used to create a tunnel above the surface. “You can do it 100 times over, change all the walls around, but every time it is different,” said Private Fin Doherty, C Company, 2 Para, talking to Forces News about the new SmartFacility. “You can never prepare yourself too much.”

Taylor says 4GD has created an environment where it is safe for soldiers to fail. “Losing is much more important than winning. If they mess it up, they can do it again and again and again. Previously



The SmartFacility can also simulate night ops

if you messed it up, you didn't get another shot at it. We're trying to create facilities that mix it up one day, and are completely different the next.”

To make the training more immersive, 4GD uses 4GAV, a special effects and video monitoring system. Using a combination of smoke, light (white/IR), sound, smell and environmental simulation (SFX), it is designed to immerse the user in a high-fidelity combat simulation. This interactive special effects system, delivers either sensor activated and reactive, or instructor-initiated effects, designed to

heighten realism and replicate real-world effects on the soldier's cognitive load.

Sounds typically associated with urban warfare such as helicopters, gates closing and opening and people talking, are used. “Approaching targets, moving down alleyways, is a lot more difficult to replicate, which is why audio is important,” Taylor explains.

Dummy explosives are used to recreate the effects of booby traps. “You have to train to expect threats from everywhere,” he explains. “We have the ability to improve, adapt and change different

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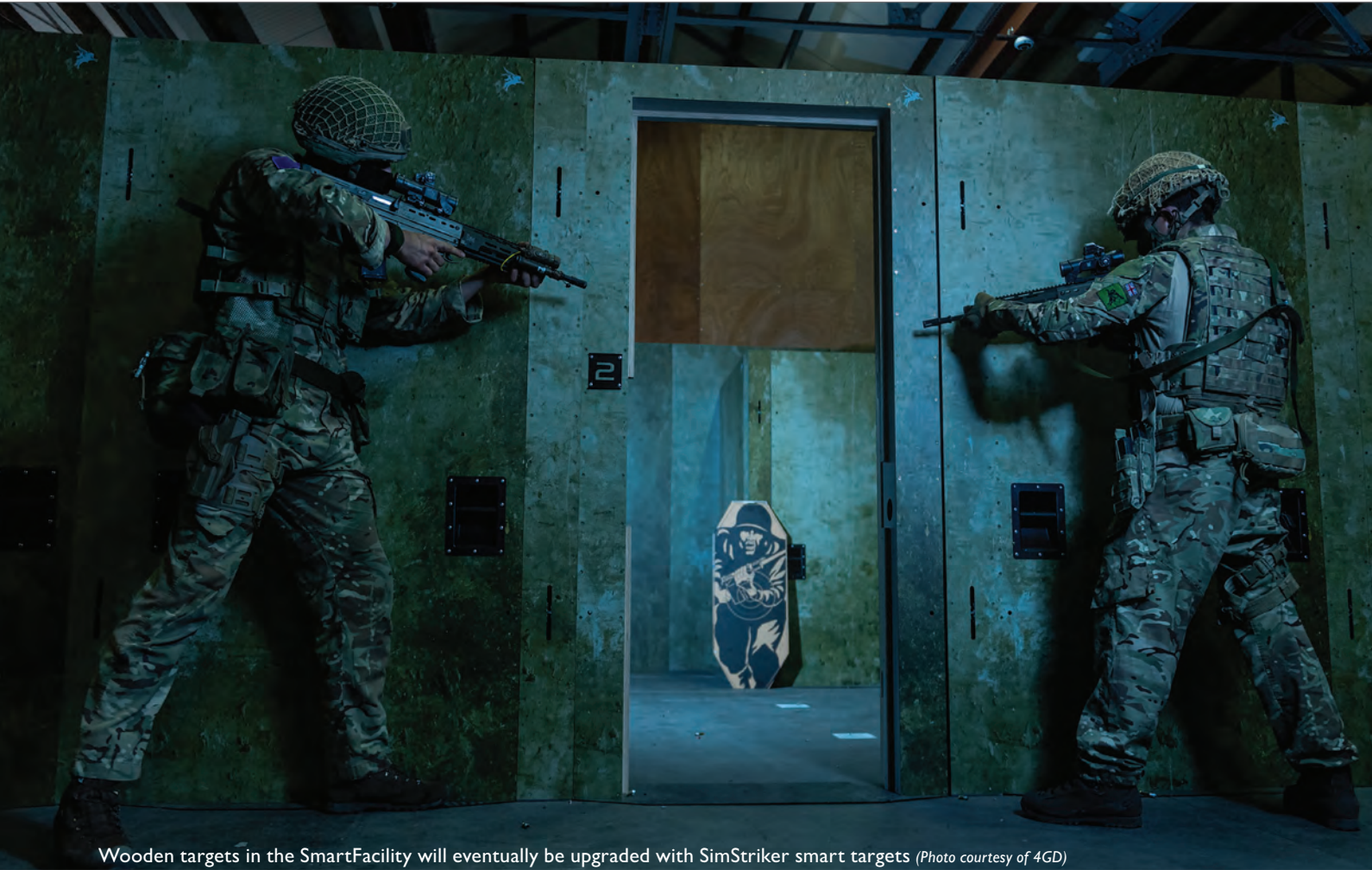
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Wooden targets in the SmartFacility will eventually be upgraded with SimStriker smart targets (Photo courtesy of 4GD)

doors and windows.” Using cutting-edge gaming engines, Taylor says it can simulate aspects with much higher complexity. Drones, mortars and artillery can be overlaid for enhanced fidelity. Special effects can be controlled via a tablet or sensors hidden throughout the facility. Everything in the SmartFacility is video recorded so commanders can review soldier's performance “step by step, room by room.” 4GD's tactical performance data collection and analysis system, ECFECTUS, even captures biometric data (eye tracking, head movement, weapon movement) of soldiers for post-training review.

Major Murray McMahon, Commanding Officer, C Company 2 Para, says traditional

wooden targets in the SmartFacility will eventually be upgraded with remotely operated mannequins, or SimStriker smart targets, that move up and down on a piston. SimStriker mannequins are fitted with sensors to record soldier's fire rate and accuracy. Soldiers are assessed on how they move around the facility, and how lethal effects are applied. “This will make our airborne elite even more effective,” he told Forces News.

Taylor says data captured from soldiers' performance at the SmartFacility in Colchester could feed into Army urban warfare doctrine. “The data we capture is powerful,” he explains. “It can highlight things such as whether there is a massive tendency for

the British Army to use right-handed only weapons and how that relates to tactics when soldiers are operating in an urban environment.”

One thing we've really pushed, he says, is how do we train like we fight? “Collective training is just draped in things that are not going to be there in reality. To find training effectiveness we need to replace collective training with disconnected training. We're trying to create an environment in the SmartFacility, where you still get the benefit of physical training with people. But if it is more disconnected you can minimize the cost of moving large training assets and troops around the world.” ■



IF SCIENTISTS MAKE **BIOLOGICAL** WEAPONS



Biological security has risen up the agenda as a result of Covid-19. But scientists and academics are now warning of the threat posed by the life sciences, whose benign research into some of the world's most deadliest pathogens could be repurposed to deliberately cause harm.

By Anita Hawser

Chemical weapons delivered by perfume bottle or bombs packed with chlorine and sarin nerve gas have captured public and media attention in recent years. Given the attacks—mostly nerve agents such as sarin or mustard gas and chlorine—reported in Syria's bloody civil war, the novichok poisonings of Russian ex-spy Sergei Skripal and his daughter in Salisbury in 2018, and Russian political opponent Alexei Navalny in 2020, the renewed focus on the threat posed by chemical weapons is understandable.

Whilst any nerve agent used to cause injury or death is classed as a chemical weapon, the novichok used in the Salisbury and Navalny attacks was not included in the 1997 Chemical Weapons Convention's Schedules of chemicals, which specify chemicals identified for the purpose of verification. Following protracted negotiations by delegates to the Organisation for the Prohibition of Chemical Weapons (OPCW), an amendment was finally made to the convention's schedules in June 2020 to include novichok in the CWC's Schedules, the first time since the convention came into being that new compounds were added.

US Marine Corps photo by Lance Cpl. Rhita Daniel



3rd Medical Battalion Corpsman sanitises facility for USS Theodore Roosevelt sailors during an outbreak of Covid-19 on board the vessel (Photo by Staff Sgt. Jordan Gilbert)

Now as a result of the Covid-19 pandemic, which has claimed more than 4 million lives globally, a group of academics and scientists from London Metropolitan University's Biological Security Research Centre (BSRC) are calling for the 1972 Biological and Toxic Weapons Convention (BTWC) to be similarly strengthened to account for the growing risk of deliberately caused disease as a means of terrorism. The Covid-19 pandemic has heightened concerns around the impact of disease outbreaks on modern society and pushed the question of biological security higher up the political agenda.

In a research paper, *Biological and Chemical Security After COVID-19*, Professor Lijun Shang, Project Leader and Director of the BSRC, and Professor Malcolm Dando, an associate member of the BSRC and Leverhulme Emeritus Fellow at the University of Bradford, argue that the public, governments and scientists do not fully understand the dangers from natural, accidental and deliberately caused disease to humans, animals and plants. The next bioterrorist threat may not come from

jihadi groups, rogue states or terrorist organisations, but the very scientists who are researching these deadly pathogens to advance medical treatments and scientific breakthroughs.

BIOLOGY FOR HOSTILE PURPOSES

Chemical and biological weapons are often referred to as “the poor man’s atom bomb,” mainly due to the relative ease with which anyone can access the materials to build them. Nuclear weapons, on the other hand, require more advanced industrialised capabilities and access to scarce and “tightly controlled” materials. At the height of ISIS’s reign in Iraq and Syria, the fear was that British jihadis would develop ricin and anthrax bio weapons in “secret terror labs” to poison food and water supplies.

Dando says the US is on recent record stating concerns about the compliance of China, Iran, North Korea and Russia with the Biological and Toxic Weapons Convention (BTWC) and the Chemical Weapons Convention (CWC). But it is

the benign research activity taking place in life science labs that could pose the greatest bioterrorist threat. “Scientists play a key role in any technology development, including the development of any potential ‘weapons’ — even if they do not intend their research to be used for harmful purposes,” says Shang. “Therefore, it’s imperative to educate scientists and raise awareness of the risk of ‘dual use’— the ways in which benignly-intended research can be repurposed to deliberately cause harm.”

The life sciences are advancing at a rapid rate, observes Dando, and there is an increased possibility that modern understanding of living systems could be used to reinforce norms in biological and chemical weapons. “Given the rise of hybrid warfare and the normalisation of assassination attempts with lethal agents, in the next two to three decades, the use of chemical and biological agents to attack living targets could become more commonplace,” he asserts.

Dando says there has been much discussion in the life sciences community



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over the last 10 years about gain-of-function research on deadly viruses. This research is intended to facilitate knowledge, understanding and eventually disease prevention and cure, but he says it could clearly be used for hostile purposes. It is a story that has played out before in the history of biological weapons development. “In the last century, as society gained a better understanding of viruses, the focus in offensive programmes moved from pathogenic bacterial to pathogenic viruses,” says Dando.

DESIGNER DISEASES

Biological weapons have been used and developed for centuries. Improvised biological weapons, which were either bacteriological, viral or toxins, were distributed using the bodies of plague victims, smallpox-contaminated clothing or ricin poisoning. In 1797, Napoleon flooded the plains around Mantua in Lombardy to enhance malaria. The growing dangers began in World War I, explains Dando, as new knowledge regarding the microbial causes of diseases began to be applied. “Chemistry was more advanced and therefore more dangerous,” he says.

“We do know that a good number of

major states did weaponise pathogens and toxins effectively during the last century.” The traditional route, Dando explains, was to assess natural pathogens, toxins or chemicals discovered by research to see if they fitted the requirements for use. States would then try to modify and develop them to be more useable and effective. In WWI, Germany used anthrax to infect animals and feed.

“The paradigm case is anthrax as it has a spore that is very resistant to environmental degradation, but is deadly when activated in the victim,” Dando explains. “The first effective biological weapon was anthrax developed by the UK in World War II with the objective of wiping out the German cattle industry in retaliation if it was subject to a biological weapons attack.”

During the Cold War, naturally occurring pathogens such as anthrax were weaponised by both sides. Even very contagious agents like smallpox were weaponised by the former Soviet Union. “Weaponising a very contagious agent was a major step as it was therefore not controllable after use,” explains Dando. But these were not optimized for storage and maintenance or military

use, the Combating Terrorism Center (CTC) at West Point writes in an August 2020 article on *Engineered Pathogens and Unnatural Biological Weapons: The Future Threat of Synthetic Biology*.

Influential research at the turn of the century, says Dando, suggested that the biotechnology revolution would bring a paradigm change that would allow weaponeers to turn their focus from the agent to the novel targets revealed by modern research. “This is a much more dangerous situation,” he argues, “as the defence has a chance against the traditional approach, but with a multitude of new targets defence would be much more difficult.”

The biotechnology revolution reveals many new targets that could be used to cause “selective malfunctions in the human machine,” says Dando. As these various targets could be attacked by multiple different agents, an arms race in chemical and biological warfare would now favour the offense, he argues. “As we gain the ability to modify all aspects of the operations of living systems this would present an existential threat to the human species if it was allowed to happen.”

The Combating Terrorism Center paper argues that the threat posed by gene therapy, designer diseases, viruses that can easily move between insects, animals and humans or are resistant to a host’s immune response, could become reality, rather than fantasy, as a result of advances in synthetic biology. “The extent and impact of SynBio on future state-on-state conflicts and terrorist violence will increase as the tools and techniques of this discipline continue to mature and diffuse throughout the scientific community, as well as among the novice citizen-scientists in the do-it-yourself biology labs that have emerged around the world in recent years.”

Some of the more worrying SynBio advances that the CTC points to in its paper include the synthesizing of virus and bacterial genomes. In 2005, it says



Sailors leaving the USS Theodore Roosevelt in Guam during a Covid-19 outbreak on board (Photo by US Navy)



“
Given the rise of hybrid warfare and the normalisation of assassination attempts with lethal agents, in the next two to three decades, the use of chemical and biological agents to attack living targets could become more commonplace.
”

A researcher at the US Centers for Disease Control, working with influenza virus under biosafety level 3 conditions, with a respirator inside a biosafety cabinet
(Photo credit: James Gathany - Public Health Image Library)

researchers from the US Centers for Disease Control (CDC), the Mount Sinai School of Medicine, the Armed Forces Institute of Pathology, and the Southeast Poultry Research Laboratory reconstructed the 1918 pandemic influenza virus. Other researchers were able to reconstruct the horsepox virus using information from public databases.

LAB BIOSAFETY

Speculation continues to surround the origins of the Covid-19 virus. The World Health Organization's initial investigation, which ended in February this year, was inconclusive about how the virus jumped from animals to humans. In the next phase of the investigation, WHO chief Tedros Adhanom Ghebreyesus has called for "audits of relevant laboratories and research institutions operating in the area of the initial human cases identified in December 2019." This suggests WHO has not ruled out a link to research labs in the vicinity of where Covid-19 first emerged in China. However, China has resisted calls for lab audits.

The Wuhan Institute of Virology, which was initially linked to the Covid-19 outbreak, is one of many High/Maximum Containment (Biosafety Level 4) Laboratories that handle some of the most deadliest pathogens (Ebola, Marburg viruses) for research and diagnostic purposes. A 2017 World Health Organization (WHO) report put the number of BSL-4 maximum- and high-containment facilities around the globe at more than 50. At the time of its 2017 report, the majority of BSL-4 laboratories were located in North America or Western Europe.

A number were also being built in Asia, China, Japan and sub-Saharan Africa. While there has been a great deal of work done on laboratory biosafety and biosecurity, Dando says there are still laboratory accidents and security breaches even in advanced countries. "This gap in the web of prevention is particularly

worrying as the number of BSL-4 labs doing potentially dangerous work increases around the world. The pandemic is likely to increase this trend."

The 2018 UK Biological Security Strategy is designed to protect against the threat of natural, accidental and deliberate disease against humans, animals and plants. But to achieve that, Dando and Shang argue a great deal more needs to be done. "We need to be sure that laboratory biosafety and biosecurity are well understood and implemented, and that the life science community understands and is engaged in dealing with the problem of dual use (biosecurity beyond the laboratory door)," says Shang. "Effective biological security education needs to equip them to undertake this task. It has to be understood that there is no use in having oversight systems in place if the people involved do not see the need for them. This is the area where our work is focused."

In 2018, a BWCT Meeting of Experts (MX2) looked specifically at the topic of genome editing and developing guidelines for voluntary codes of conduct for biological scientists, as well as biosecurity education. On the 9 July 2021, the Tianjin Biosecurity Guidelines for Codes of Conduct for Scientists was endorsed by the InterAcademy Partnership (IAP). The Codes of Conduct are designed to be fundamental and inherently adaptable to diverse contexts and can be used to develop new or enhance, supplement and update existing codes of conduct to fill the gaps in biosecurity governance at national and institutional levels.

CODES OF CONDUCT

The Tianjin Guidelines will next be submitted to the Ninth Review Conference of States Parties of the Biological and Toxin Weapons Convention in order to garner wider international recognition. However, Dando and Shang say successful implementation of these measures in national and professional

codes of conduct will require considerable improvement in biological security education given the currently low level of awareness about the dangers of dual use among life scientists around the world.

To help address this educational challenge they have devised an innovative cartoon series in multiple languages aimed at improving biological security awareness and education amongst life scientists in different countries. "Innovative methods have to be found to achieve better and faster results," says Dando. "Some scientists work in their own fascinating worlds seeking to achieve anything possible, but don't always consider the implications of their work being used for unintended purposes. That is why that we tried to think of some novel approaches to raise awareness, such as our cartoon project."

With BWCT members scheduled to meet this autumn for a five-year-review conference, Daniel Gerstein a senior policy researcher at research firm the Rand Corporation, writes: "This forum could provide an important opportunity to consider the implications of COVID-19 on the likelihood of, preparations for, and response to a deliberate biological attack." Dr Simon Whitby of Bradford University, who co-authored the report with Shang and Dando, says it is essential that states' parties promote the full and effective implementation of the BTWC by enhancing its institutional capacity, developing compliance mechanisms, and establishing a systematic process for assessing the security risks and benefits of life science advances.

Government also needs to provide more funding, says Dando, not only to develop scientists' understanding of the technology and the risks, but also among life scientists to understand the implications of potential misuse. "The task for society now is to strengthen these barriers, before the prohibition is eroded in different ways and we see the development and use of chemical and biological weapons become commonplace." ■

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Nitro-Chem Chemical Works

Nitro-Chem Chemical Works is the largest producer of TNT in the North Atlantic Treaty Organisation. The company also produces other explosives such as hexogen and octogen, among others. The explosives produced in Bydgoszcz go to over a dozen countries around the world, including the United States, Canada, Turkey, Israel, France, Great Britain, Sweden and Spain. The company also supplies the Polish Army, other uniformed services and companies of the Polish Armaments Group.

"Nitro-Chem" produces TNT counted in thousands of tons per year. Since 2015, more than 80% of the plant's production is

exported. One of the most important events for Nitro-Chem was the signing of a contract to supply certified TNT to the United States Army. Trinitrotoluene is used there to make MK-series bombs and 155 mm calibre ammunition.

In addition to manufacturing explosives for the Polish Armed Forces and allied armies, the company also provides filling services of the mines, aerial bombs (for example, LBOB-100 bombs) and various calibres of artillery and mortar shells with explosives. Nitro-Chem Chemical Works is considered to be the centre of ammunition reloading in Poland.



MK82 aerial bomb

NITRO-CHEM CHEMICAL WORKS SPONSORED STATEMENT

A significant moment for the development of the plant was the launch of the MK82 aerial bomb reloading line in 2019, which is used in the Air Force around the world on aircraft such as the F-18, AMX, Tornado, JAS-39 Gripen, Hawk, Eurofighter Typhoon, F-15, F-16, Mirage 2000, F-111, AV-8B Harrier. Nitro-Chem received a certificate from RWM Italia, a globally recognised ammunition manufacturer, which is part of the Rheinmetall Defence group, confirming the completion of the MK82 Production Technology Transfer process. Produced in Poland and certified by RWM Italia, the bomb meets the high quality requirements set by NATO armies and their coalition partners and is fully interchangeable with the MK82 bomb produced in Italy.

The Bydgoszcz-based company also specialises in the production of civil blasting agents for companies in the rock mining, geophysics and road works sectors for domestic and foreign customers. Recently, Nitro-Chem Chemical Works acquired new customers from the Faroe Islands and Portugal and signed a contract with a contractor from France. Under this order, the company will produce approximately 150,000 T-500 type TNT boosters.

This is complemented by the production of plastic films for the packaging industry. In addition, Nitro-Chem carries out research and development projects important for the independence and security of the state, cooperating with Polish scientific institutions, research units and companies of the Polish Armaments Group Capital Group. Success confirmed by awards resulted in research work on the first Polish low-sensitivity K-43 material. A projectile filled with this composition minimises the risk of unintentional detonation. The prototype ammunition is designed for the RAK self-propelled mortar.

K-43 composition is a mixture of TNT and nitrotriazolone. The technology of its production is the result of developmental research conducted by Nitro-Chem together with scientists of the Military University of Technology and unique tests carried out in accordance with NATO standards by the Military Institute of Armament Technology.



Trotyl



T-500 type TNT boosters

The low-sensitivity K-43 material has earned praise from experts. In 2019, during the International Defence Industry Exhibition in Kielce – one of the largest defence industry trade fairs in Europe – Nitro-Chem Chemical Works received the “Defender” award. The innovative technology was also recognised in 2020 by the committee of the “State Security Leader” competition.

Nitro-Chem Chemical Works are a part of the Polish Armaments Group - one of the biggest defence concerns in Europe. Polish Armaments Group includes dozens of industrial plants, service facilities and research centres that are key to the Polish defense industry. ■

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2018 key figures



SpaceX Falcon Heavy Demo Mission (Photo by SpaceX)

THE NEW SPACE

Space has always been a military domain, but now they are having to share it with a growing number of commercial satellites and weapon systems designed to disrupt or destroy essential satellite communications.

RACE

By Anita Hawser



Space is getting a little overcrowded. Since Russia launched the first artificial satellite, Sputnik 1, in 1957, there are now approximately 6,000 satellites orbiting the earth. In 2020, more than 1,200 satellites were launched into orbit, according to Geospatial World. By the end of April this year, there were another 850 launches, an increase of 66% on 2020. By 2028, there could be an estimated 15,000 satellites in orbit. More than half of the satellites launched are for commercial purposes, providing essential services such as internet communications, environmental and border monitoring or GPS navigation.

“Pretty much everything is dependent on space,” says Nick Shave, vice-president for Strategic Programmes at Inmarsat and chair of the UK space industry’s trade association UKspace. “It’s how we get broadband out to a ship in the middle of the ocean.” Communication satellites provide essential comms for global maritime distress services. Inmarsat’s Global Government business unit also provides satcom services to support the missions of governments around the world, including all “5-Eyes” and NATO nations. “As one of the largest civilian procurers of satellites, we’re seeing significant demand in all markets for satellites,” says Shave.

But if it becomes a ‘free for all’ in space, it will increase congestion, says Clive Oates, business development lead Five Eyes Nations at Surrey Satellite Technology. He was speaking at the inaugural Space-Comm Expo at Farnborough in July. A free for all is exactly what is happening in space. Elon Musk’s SpaceX plans to launch eight times the number of satellites currently in orbit and Amazon has just received approval for an internet constellation of more than 3,000 satellites. “More operational satellites are going up now for commercial operators rather than nation states,” observed Katherine Courtney, a non-executive director, strategic advisor, and former

CEO of the UK Space Agency, at Space-Comm. She chairs the Global Network for Sustainability in Space.

As the space race gathers pace, it is causing a “space junk” problem. About 60% of the satellites now orbiting earth are defunct satellites —space junk —according to the World Economic Forum. In addition to space junk, there are thought to be 34,000 pieces of space debris, bigger than 10 centimetres in size, orbiting Earth. Space debris is hazardous for critical space assets such as satellites.

RESILIENCY AND SUSTAINABILITY

Yet, Courtney says there are no protocols for dealing with broken-down satellites in space. “Since 1957, we have been doing space innovation without paying attention to sustainability,” she says. There is also no code of conduct for behaviour in outer space, Group Captain Rayna Owens, Deputy Head of Capability (Ops) at the UK’s new Space Command stated at Space-Comm. That makes it difficult to understand threats. “There are incompetent operators that get uncomfortably close to other satellites,” she explained. “But who defines what is too close? There are a lack of norms. It is an escalating problem.”

Space is also an increasingly hostile and contested environment. In 2007, China confirmed that it had shot down one of its own weather satellites using a ground-based medium-range ballistic missile. In 2019, India became the fourth country after the US, China and Russia, to conduct an anti-satellite (ASAT) missile test. Dubbed Mission Shakti, which means ‘power,’ the test involved shooting a ballistic missile into outer space to destroy an Indian satellite approximately 300 kilometres above the earth’s surface, in what is known as Low Earth Orbit (LEO) — 100 km to 2,000 km from earth.

ASAT weapons have been developed since the 1950s and are either kinetic or non-kinetic (laser dazzlers, jamming and



cyber interference). They can potentially destroy or interfere with the operation of satellites in orbit, which could easily become a national security issue, says Shave of Inmarsat, particularly given the critical role satellites play in military communications and operations, search and rescue, natural disaster response, and even financial services.

Paul Day, business development executive for Space at Raytheon UK, says there is also the threat of malign actor



The US Space Force successfully launched the Tactically Responsive Launch-2 (TacRL-2) mission on a Northrop Grumman Pegasus XL rocket from Vandenberg Space Force Base

activity in outer space — deliberately moving satellites in the pathway of other satellites or not operating them safely. During a keynote address at the 36th Space Symposium, a weeklong gathering this summer in Colorado of military, commercial and academic space experts, Secretary of the US Air Force Frank Kendall said China has moved aggressively to weaponise space, which led to a change in the United States' military strategy several years ago. "Both conventional

deterrence and conventional operations depend on access to communications, intelligence, and other services provided by space-based systems," he stated. "As a result, our strategic competitors have pursued and fielded a number of weapons systems in space designed to defeat or destroy America's space-based military weapons systems and our ability to project power," he said.

At the same symposium, Gen. John Raymond, Chief of Space Operations, US

Space Force (USSF), said China and Russia continue to build an entire spectrum of threats, including "reversible jammers" and ground-based laser systems capable of blinding or damaging satellites. "China has a satellite with a robotic arm that is in orbit today. This technology could be used in the future to grab other satellites. Both have ground-based missiles capable of destroying our satellites in orbit. They have continued to test those weapons over the last year," Raymond said.



Gen. John Raymond, Chief of Space Operations, USSF

The Office of the Director of National Intelligence's Annual Threat Assessment of the US Intelligence Community, dated 9 April 2021, claims potential adversaries are "developing, testing, and fielding an array of nondestructive and destructive counter space weapons—including jamming and cyberspace capabilities, directed energy weapons, on-orbit capabilities, and ground-based ASAT capabilities—to target US and allied satellites."

Space is now recognised as an 'operational' or war fighting domain. On December 20, 2019, in a world first, the newest branch of the US Armed Forces, the US Space Force was stood up within the Department of the Air Force. Its responsibilities include developing guardians, acquiring military space systems, maturing military doctrine for space power, and organising space forces to present to Combatant Commands.

The UK is also taking steps to "monitor, protect and defend" its interests in space. The 2021 Integrated Review and the Defence Command Paper set out the UK's ambition to be "a meaningful player in space" by 2030, based on a mix

of sovereign capabilities and "burden-sharing" with allies.

Over the next decade, the UK Ministry of Defence (MoD) will invest approximately £5 billion on recapitalising and enhancing its satellite communication capabilities, through the delivery of the Skynet 6 programme and a further £1.4 billion on space-related capabilities, including a new Space Command, staffed by the Royal Navy, British Army, Royal Air Force, civil servants and commercial partners.

A new National Space Operations Centre, which will track activity in space, will also be established, alongside a new UK-built intelligence, surveillance and reconnaissance (ISR) satellite constellation and a new Space Academy, to develop the skills and training of defence space personnel. "With all the things that are happening in the space domain," Group Capt. Owens stated at Space-Comm, "we need to understand what that means and identify what is normal versus not normal [in space]. We need to make sure we have the right C2 systems, sensors and data."

BALLOONING BUDGETS

The increased threat posed by adversaries in space saw the Pentagon request a record \$16.7 billion for space-based systems (spacecraft, launch vehicles, command and control systems, ground terminals) in its 2022 budget. "The Department of Defense is faced with an ever-changing, rapidly evolving threat landscape, which includes the space domain," a USSF spokesperson told *Defence Procurement International*. "To maintain our competitive advantage, we must deliver capability at speed to outpace potential adversaries." But even with the amount of money the US is spending, space is not anything one nation controls. "They [the US] cannot do it on their own," said Capt. Owens. "They need to collaborate with other nations."

Among the largest development efforts for the USSF are a Next-Generation

Overhead Persistent Infrared (OPIR) system to better detect enemy missiles and provide greater resiliency against counter-space weapons; a Global Positioning System Enterprise and various satcom projects:

- Next-Generation OPIR: \$2.5 billion in R&D funding is requested for a Next-Generation OPIR system — a new space-based missile warning system that will replace the current Space Based Infrared System (SBIRS).
- GPS Enterprise: The USSF budget also requested \$1.1 billion in R&D funds for the Global Positioning System Enterprise, which includes satellites, command and control, and user equipment. The USSF is also requesting \$601 million in procurement funding for two GPS III satellites.
- SATCOM: \$848 million in R&D funding is requested for various satcom development projects. This includes \$160 million for the Evolved Strategic SATCOM (ESS) programme. Boeing, Lockheed Martin and Northrop Grumman are developing ESS prototypes. The final design will replace the current Advanced Extremely High Frequency (AEHF) system.

The Space and Missile Systems Center (SMC) also established the Space Safari Program Office within SMC's Special Programs Directorate. Space Safari will directly respond to high priority and emergent combatant command requirements or special projects. It is modelled on the US Air Force Life Cycle Management Center's Big Safari office, which is responsible for the sustainment and modification of specialised mission aircraft. Similar to Big Safari, Space Safari uses mature technology and existing production lines.

In June, the Space Safari Program Office supported the USSF in its first Tactically Responsive Launch-2 (TacRL-2) mission, which saw an integrated space domain awareness satellite launched from Vandenberg Space Force Base, California on Northrop Grumman's Pegasus commercial space launch vehicle.

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TABLE I: ORBIT AND SATELLITE SERVICE TYPES

	LEO Low-Earth Orbit	MEO Medium-Earth Orbit	GEO Geostationary or Geosynchronous Orbit	HEO Highly Elliptical Orbit/ Molniya Orbits
Altitude (km)	100–2,000	2,000–24,000	35, 786	600–40,000
Orbital period	90 minutes	2–12 hours	24 hours	12 hours
Satellite service types	Communications Imagery intelligence/ Earth Observation Megaconstellations Space surveillance	Global Navigations Satellite Systems (GNSS) Telecoms	Communications Telecoms Terrestrial weather Missile launch detection/ infrared sensors Space surveillance Signals/Electronic intelligence GNSS space-based augmentation systems (SBAS) Regional Navigation Systems	Communications Missile launch detection/ infrared sensors Earth Observation Signals/Electronic Intelligence
Satellite examples	Iridium Keyhole LANDSAT SPOT Digital Globe OneWeb Gaofen Lotos Starlink Kuiper Space-based Wide Area Surveillance System (SWASS) Helios CSO RADARSAT IceEye Sapphire	GPS GLONASS Galileo Beidou SES	Wideband Global SATCOM Skynet Syracuse Sicral Inmarsat SES EUMETSAT Space-based Infrared System (SBIRS) CLIO TRUMPET Geostationary Satellite Situational Awareness Program (GSSAP) Gaofen European Geostationary Navigation Overlay Service (EGNOS) Quazi-Zenith Satellite System (QZSS) Navigate with Indian Constellation (NAVIC)	Molniya Meridian Sirius SBIRS Gaofen

Data source: Freeman Air and Space Institute

Photo: jim-strasmaview of SpaceX launch

The three-stage, air-launched rocket was carried aboard the company's modified Stargazer aircraft and released into LEO. "[The] tactical launch demonstrated rapid and responsive technologies, and what it means for the continuous Space Force support to the warfighter," said Lt. Col. Ryan Rose, Chief of the Small Launch and Targets Division. "The team completed the launch vehicle design, build, integration and testing in only four months from contract award, and then executed the launch within a few weeks of call-up."

COMMERCIAL DYNAMISM

A USSF spokesperson says the Space Safari program is able to quickly survey the community and pull from existing efforts within SMC, Launch Enterprise, and the Air Force Research Laboratory's Space Vehicles Directorate at Kirtland Air Force Base to integrate and deliver in record time. "The biggest lessons learned from the TacRL-2 pathfinder mission," the spokesperson says, "were the importance of partnerships and improving processes to go even faster on future missions. The Space Safari team established great partnerships with Launch Enterprise and the Air Force Research Laboratory's Space Vehicles Directorate, which ultimately led to mission success." The Space Safari team also has the capability to pull "off the shelf" space capabilities and then integrate onto existing platforms, which increases the speed of delivery, while reducing cost. "Space Safari is an end-to-end integrator, and the team will consider any technology that could improve the success, speed and cost of our missions, whether that be satellite buses, payloads, ground, launch assets or any other technology required for our efforts," a USSF spokesperson stated.

Space has always been a military domain, but the space race has seen start-up satellite and space companies springing up across the globe. Between 1958 and 2009, almost all of the investment in space was by major public institutions, like NASA and the European Space Agency. But in the past



First Space Force graduates (USAF Photo by Sarayuth Pinthong)

decade, according to a report by QinetiQ entitled: *Shared Space: Defence, security, and a collaborative model for tomorrow's space industry*, private investment has risen sharply to reach 15% of the total spend. "In 2020, despite the pandemic, such spending hit a record \$8.9 billion and annual global revenue from space-based services exceeded \$300 billion for the first time," the report states.

The MoD's Integrated Review talks about a "new civil/military space strategy," which will see the development of a commercial launch capability by 2022. Given that the commercial space sector is innovating at a rapid pace, the concept of 'dual use,' technologies —capabilities that serve both commercial and military purposes in space— is gaining traction. Advances in the commercial sector have brought the cost of launching satellites down.

But dual use technologies also present challenges for the military. Commercial satellites are not radiation hardened or as well protected against jamming or cyber attacks as military communications satellites. With an increasing number of weapon systems (precision-guided

munitions, UAVs) reliant on information provided by space-based assets to correct their own positioning to hit a target, commercial space technologies could present more risks than opportunities.

"Multi-domain operations in space is about the integration of commercial, civil and military space," explains Day of Raytheon. "But if we wish to be successful, we have to be able to operate within set norms." For example, he says, multi-domain operations in space will require the integration of different security classifications for data. "You will also need assured supply within the commercial space sector," he says, "to reduce the possibility of commercial off-the-shelf (COTS) technology introducing potential cyber and security risks." Dual use could also mean that commercial space technologies become legitimate targets for anti-satellite capabilities.

Commercial space technologies are disruptive and far more accessible to non-space players, but how can defence best harness this commercial dynamism? Success in space, for the commercial, civil and military could well depend on the answer to this question. ■

CAUSES AND MITIGATION TECHNIQUES OF SECOND ORDER DISTORTION IN RADIO FREQUENCY FIBRE OPTIC LINKS

By J.W. Caton & J.L. Korson, Microwave Photonic Systems

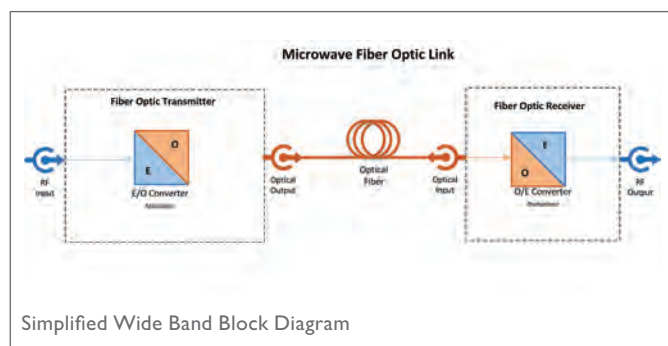
While third order intermodulation (IMD3) performance is frequently a primary concern in microwave fibre optic links, even order intermodulation distortion performance is commonly overlooked because second order intermodulation products (IM2) are considered “out of band” and may be filtered. However, in broadband systems, filtering may not be a suitable or effective remedy, as the second harmonic (2F1) may be presented adjacent to a frequency of interest, F2. In the following sections we briefly address some of the sources of these second order distortion products and possible mitigation approaches.

SOURCES OF SECOND ORDER DISTORTION

The IMD2 performance of a microwave fibre optic link is usually a composite of the second order performance of the fibre optic transmitter, the fibre link itself, the optical receiver and any auxiliary RF amplifiers included in the system. For the purposes of this discussion, a simplified block diagram of a basic fibre optic transmission link is considered.

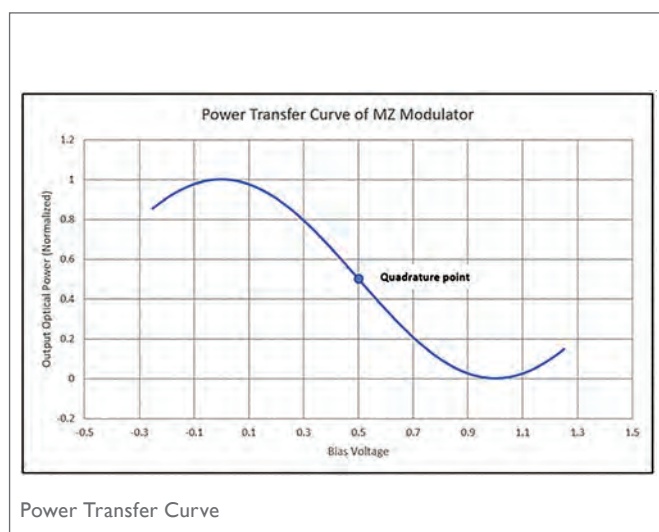
Let’s assume that the Electrical to Optical (E/O) converter is a broadband, 10 MHz to 40 GHz, 1550nm, externally modulated fibre optic transmitter that employs a Mach-Zehnder modulator (MZ) as this type of transmitter can exhibit excellent second order performance.

The fibre is standard SMF-28 single mode optical fibre. The Optical to Electrical (O/E) converter consists of a single optical photodiode that converts the modulated optical signal to an electrical microwave output.



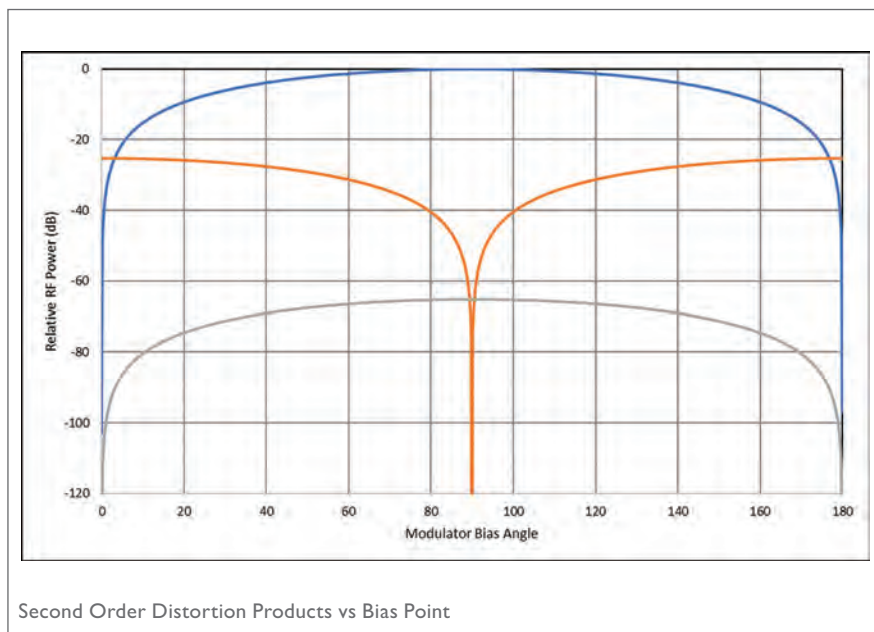
MACH-ZENDER BASED TRANSMITTERS

A technical advantage of using a MZ based optical transmitter is that, in an ideal case, the modulator generates no IMD2 products. One can see from the diagram below, that the MZ modulator exhibits a symmetrical transfer function around its quadrature bias point. As long as symmetry is maintained, no second order products are generated.



However, in any practical implementation, maintaining the modulator’s bias point, “exactly” at its quadrature point is not as straight forward as the graph implies. LiNbO3 modulators are both piezoelectric and pyroelectric, which causes the optimum bias point to change with temperature and mechanical stress variations. They are also subject to manufacturing variations that can exacerbate this bias drift.

From the plot below, we can see that small changes in bias voltage can cause relatively large changes in the second order distortion products of MZ based transmitters. The plot on the next page shows that the minimum second order distortion bias point occurs at the quadrature point and the second order products (in orange) diminish asymptotically as we approach this ideal bias point.



IM2 MINIMISATION TECHNIQUES IN MZ MODULATORS

As seen in the transfer curve, the ideal quadrature bias point occurs at the half power (optical) point. This characteristic is exploited in most “traditional” approaches to quadrature bias control approaches.

Typically, during factory calibration, the ratio of modulator input power to output power is determined and stored in some non-volatile memory or hardware. The control loop attempts to maintain this power ratio through bias voltage manipulation.

While these types of bias control systems were easy to implement and provided second order harmonic performance in the -50 to -60 dBc range, they were not without design faults. These simple bias control systems assumed that the opto-electrical characteristics of the components contained within the transmitter do not change with time or environmental changes.

Unfortunately, these assumptions are rarely true and the variations of the internal optical will eventually degrade the second order performance of the transmitter. Remember, very small changes will result in a noticeable degradation of the second order performance level. To overcome these performance limitations, externally modulated transmitters must employ more sophisticated bias control techniques. Fortunately, modern transmitter designs have made it possible to compensate for these environmental and aging effects.

ADVANCED PILOT TONE DRIVEN SOLUTIONS

While many technical papers have opined about the unsuitability of pilot tone based bias control loops for microwave

photonic transmitters, control loop approaches that do not degrade the Spur Free Dynamic Range (SFDR) of the link or generate associated undesirable mixing products have been developed.

Pilot tone based bias control loops do not come without system implementation compromises, and any resultant solution must consider the impact to increased Size, Weight, and Power (SWaP) characteristics.

Second harmonic performances of better than -85 dBc are achievable using these advanced approaches.

OPTICAL FIBRE CONTRIBUTION

Another commonly overlooked source of second order distortion products is the optical fibre itself. In applications that employ significant lengths of optical fibre, or very high optical launch powers, significant second order products can be generated. The

primary mechanisms for this second order distortion generation are caused by the dispersive characteristics of the fibre and its sensitivities to optical power. These effects normally can be mitigated through diligent and thorough link design, but they can also be actively compensated for when necessary.

More complex systems that leverage the advantages of optical wave division multiplexing (WDM), to increase the total fibre link bandwidth, capacity present additional system design challenges.

PHOTODIODE BASED RECEIVER CONTRIBUTION

The photodiode, used to convert the RF modulated optical carrier back to an electrical signal, is also a source of second order distortion generation in microwave fibre links. It is typically advantageous to maximise the amount of optical power applied to the optical receiver. Link Gain, Noise Figure, and Spur Free Dynamic Range are all negatively impacted by low incident optical receiver powers, however these high power optical carriers can cause significant second order distortions.

The causes of second order linearities in photodiodes is a complex subject, and actual performance depends greatly on the design of the photodiode chip itself. Simply, any change in the photo-diode’s characteristics, that are a function of photo-current, will cause second order distortion. The following figure is a plot of DC photo-current vs input optical power of a typical microwave photodiode. The diode saturation effect, shown below by the deviation from the linear response, is a primary source of even order distortion products.



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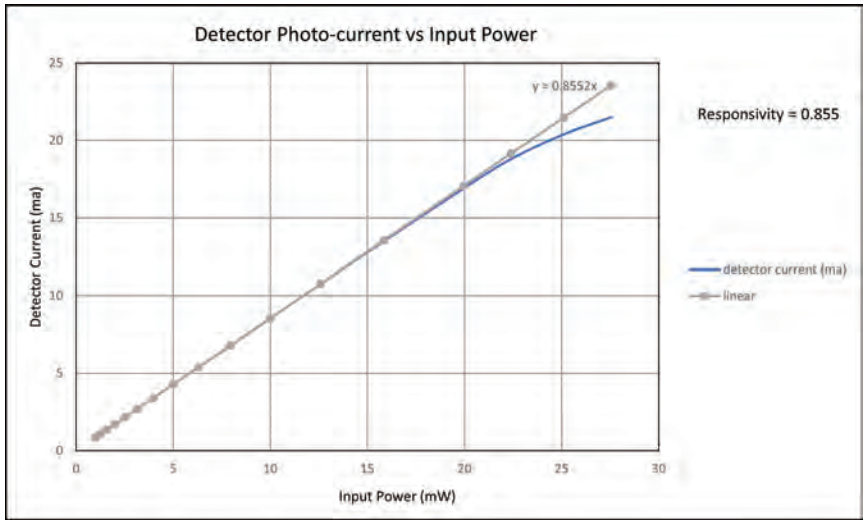
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DC Photo-Current vs. Input Optical Power

As the actual optical loss of a given fibre link may be unknown, inconsistent, or variable, it is not always easy to predict the optical power that the receiver will experience in the field.

To help mitigate these unknowns, optical receivers that can be designed to compensate for many of the known causes of photodiode induced second order distortions. Below is a block diagram of such a receiver.

By placing a voltage controlled optical attenuator in front of the photodiode, the receiver can adaptively optimise the level of the applied optical signal incident on the receiver photodiode. The bias voltage applied to the photo-diode can also be optimized for the specific system application.

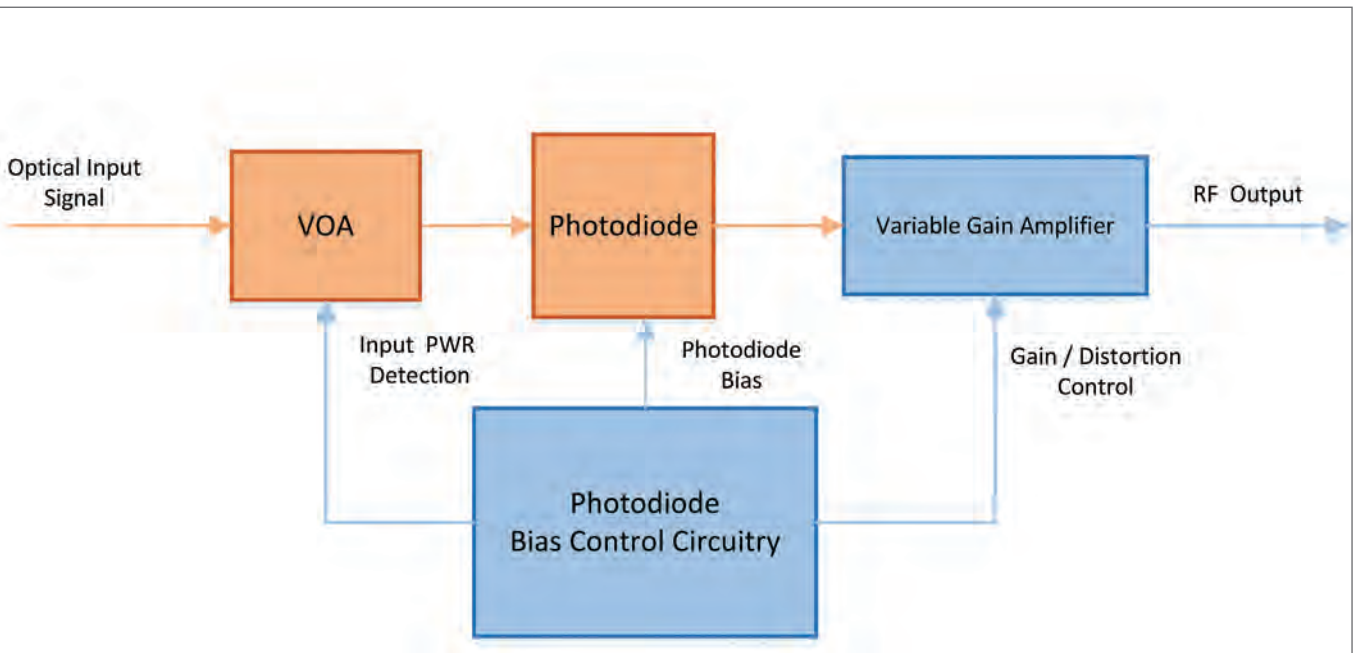
RF post amplifiers can be used to normalise the resultant gain variations or act as post-distortion compensators.

MINIMISATION TECHNIQUES IN PHOTO-RECEIVERS

The most straightforward method of minimising photodiode induced second order distortion is through proper system design and the selection of a photodiode that remains linear at the anticipated optical input power.

SUMMARY

Recent design advances in fibre optic transmitters, receivers and system design have significantly improved the performance of analog fibre optic links. It is still important for the system designer to consider both the third and second order performance of any broadband fibre optic link design. ■



Compensated Optical Receiver

GAINING AN INFORM

In a world of hybrid and ‘sub-threshold’ warfare, machine-derived insights could help commanders operate at speed. But first they need to put the right foundations in place for AI to thrive.

By Anita Hawser

(Photo by Technical Sgt. Luke R Sturm)

ATION ADVANTAGE

The year is 2025, and the UK is still reeling from a state-led cyber attack five years earlier, which took out the Ministry of Defence's (MoD) "antiquated IT network," along with all UK government departments, and rendered most of its "cutting-edge military equipment" useless.

Out of the ashes of the devastating cyber attack was borne a revitalised MoD, the result of a 2021 National Security Review spearheaded by a tech

entrepreneur who'd been parachuted in by the country's new PM to build a "digital backbone," which fuses information from across government, the field, allies and other real-world information. An artificial intelligence (AI) analytics platform inside a new Integrated Strategic Command Centre flags potential anomalies or threats, giving the MoD the competitive edge it needs to survive in a constant era of competition.

In this fictional account taken from a comic-book titled: *Below the Threshold*,

digital warriors use AI and information to gain a competitive advantage over their adversaries. Rob Bassett Cross, founder and CEO of Adarga, an AI analytics company, says the comic book, which it developed to highlight what AI-powered intelligence could potentially mean for defence, went down well with high-profile stakeholders across defence and government. The comic set the tone for the March 2021 Integrated Defence Review in which AI was positioned as

one of the key emerging technologies to be leveraged by the military. The Review talks about AI as a “key enabler of military capability, across the whole of defence.” An “AI defence strategy,” is due to be published this year by the MoD and a new Centre for Artificial Intelligence, which will “accelerate the development and exploitation of these critical technologies from the battlespace to the back office.”

Adarga’s comic book appears to be partially based on Bassett Cross’s own experiences as a former British Army Officer on combat operations in the Middle East, Central Asia and Africa, and the technologies he wished he had at his disposal back then. “When I served in Iraq and Afghanistan, I was overwhelmed with data — emails, news, unstructured data — which I couldn’t read quickly enough,” he explains. “That meant my decisions were not as accurate or as timely as they could be, which had an operational impact. I thought there must be a better way of doing this. How do you use technology to resolve some of these challenges?”

Bassett Cross got his first real taste of AI after leaving the Army and working for J.P. Morgan where he says the blinkers

were lifted in terms of how data was used to make decisions. He started working with AI models developed by pharma companies to develop treatments for rare or difficult-to-treat diseases. These models use the AI techniques of machine learning, natural language processing (NLP) and graph databases to discover life-changing medicines. “When I looked at what the pharma sector was doing, I knew I had a use case in defence,” says Bassett Cross.

“In Afghanistan, it could have helped me solve things like making connections between people, places, organisations and events, which is useful information when you’re out somewhere and you want to know what happened at a particular location and what implications that could have. AI might have enabled me to change my plan, and think of a different one before I went out.”

In June, Adarga, the company Bassett Cross founded in 2016, announced a strategic partnership with QinetiQ to bring AI-powered intelligence to defence. In 2018, an AI Lab – a single flagship for AI, machine learning and data science — was established at Dstl in Porton Down. The

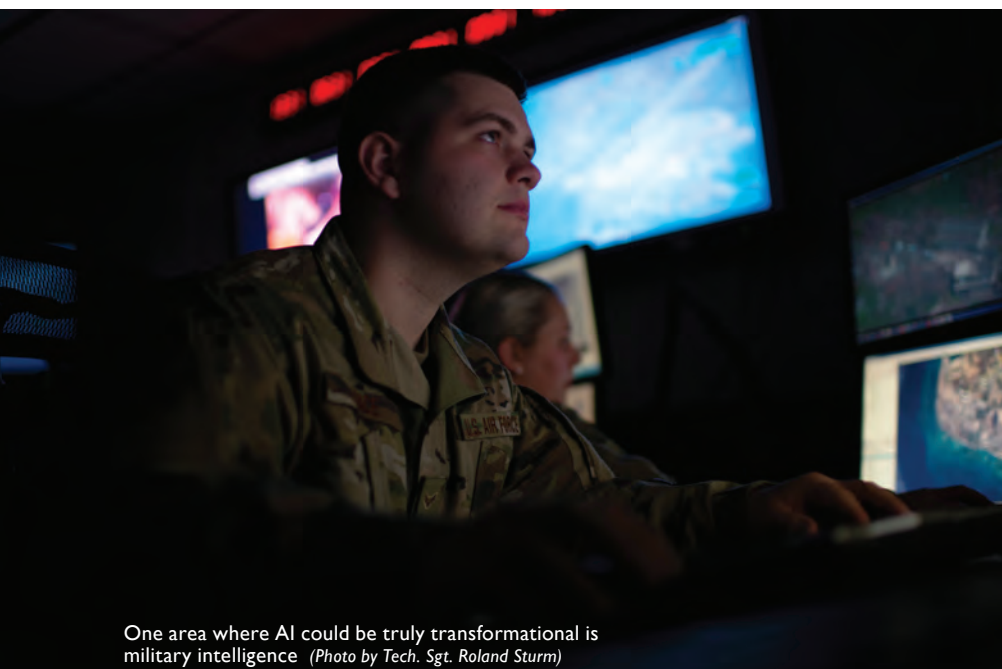
lab is meant to enhance and accelerate the UK’s application of AI-related technologies to defence and security challenges. The Royal Navy’s NELSON project, will help the Navy forge a brand new digital, data and AI path across the maritime domain. But the main objective of Adarga and QinetiQ’s partnership is to give defence access to cutting-edge AI solutions and to leverage advances that have already been made in the commercial sector.

The strategic partnership will leverage Adarga’s enterprise AI analytics platform to analyse large volumes of unstructured data (emails, videos, social media, and images containing text) to push out insights to defence users much more quickly than humans could process that information. The aim, says Dr. Vicki Saward, Information Advantage Campaign Director at QinetiQ, is to reduce the cognitive burden on the soldier. “Having an information advantage is about having information in the right place at the right time to help you make the right decision,” she explains, “which results in a better operational outcome. You can have so much information, but you can’t analyse it in time.”

BETTER OUTCOMES

One area where AI could be truly transformational, says Saward, is military intelligence. “It will enable analysts to operate at the next level.” But there are still a lot of unknowns, she says, in terms of the extent to which it can be integrated and what role it will play in decision making. “We need to ensure we understand what the specific technologies are capable of. Ultimately, it needs to be relevant to the end user and address a real operational need.”

There will always be a requirement for human intuition, wisdom and experience, says Bassett Cross. However, humans are overwhelmed by information, and will have to rely more on machine-derived insights in future, he says, to help make decisions and to operate at speed.



One area where AI could be truly transformational is military intelligence (Photo by Tech. Sgt. Roland Sturm)

“Having an information advantage is not just about putting more radars on the battlefield,” he explains. “It is also about what is happening on social media or what the press are saying. Commanders need to think about more things all the time, but the time to make these decisions has evaporated.” So how can the military leverage AI to gain an information advantage?

Basset Cross says they should start with small steps. “Use AI, and understand it, before you start relying on it. Banks have taken small steps. They didn’t go straight to the complex Hollywood scenarios the technology can’t support.” Adarga recently deployed its AI platform to the British Army, the first live deployment of AI to the Field Army, which will use its software under a multimillion pound, multi-year software licence to exploit the vast, untapped and growing amount of data at the Army’s disposal.

“We’re working with the Field Army to help them understand information and lessons gathered from decades of operations and trainings,” says Basset Cross. “If you can pull all of that information together in a common format and help people access it, it will improve the intellect and agility of forces. If you’re planning an exercise in two weeks, AI could enhance how you plan and exercise better. Equally, if data pulled from across the Army is pooled with different global information, it can help you see whether tactics from two years ago are still relevant today.”

BREAK DOWN DATA SILOS

Basset Cross likens AI to a skyscraper. The penthouse at the top is where you want to get to. Below are the floors and foundations. “The floors are all the data you need and the foundations are your digital infrastructure. If you don’t have the foundations in place, you can’t achieve the full potential of AI,” he says. “The infrastructure needs to be AI ready and data-driven.” Saward says the Army needs to understand how it can fuse vast amounts

of information that is operationally relevant and present it to users. “We need to bring that data together in one place so we can apply AI,” says Keith Mallon, Business Development Leader for Land Information Advantage at QinetiQ. “But that is challenging in the military environment as there are a lot of legacy systems. We need to break down data silos.”

Some of the stumbling blocks AI projects typically encounter are the lack of strong technical foundations and poor data governance. Machine-learning models are only as good as the data they are trained on, but many organisations struggle to source high quality data. AI also requires robust legal and ethical frameworks to address issues pertaining to data privacy and bias, and in the context of defence, AI models must be trusted, resilient and reliable.

For Adarga, that means its computational linguistic models need to be highly accurate and trained on the abbreviations and nuances that are important to military personnel. Basset Cross says it has to explain how each of its many machine learning and deep learning models function. “We need to demonstrate to users why the model has arrived at this decision. The way we train the models is very robust. We’re not asking the model to determine who the bad guy is, as that would be open to potential flaws. We’re allowing humans to apply their judgement.”

The military isn’t the only sector looking to capitalise on the insights AI provides. It will have to compete with the commercial sector for scarce AI resources such as data scientists. “Defence is going to need to think about how it can bring in those information skills, which are not routinely found in a high proportion of the population,” says Mallon of QinetiQ. Most armies today also fight as a Coalition, which presupposes some level of commonality, standardisation and interoperability for operational effectiveness. “If we have different ways of using AI and machine



Rob Basset Cross, CEO of Adarga

learning and different cultural, ethical and legal norms, that could limit interoperability in future,” says Saward.

Ultimately, the biggest challenge, says Basset Cross, is culture not technology. “A digital infrastructure makes the human hierarchy much flatter and leaner,” he says, “which means decisions don’t need 20 layers of humans.” That is the exact opposite of how most armies operate today. “We’re not trying to replace the commander at HQ,” says Basset Cross. “That may happen well into the future, but we’re a far cry from there yet. We’re trying to automate information quality and accuracy to enhance decision making.”

A 2018 Joint Concept Note on Human Machine Teaming by the UK Ministry of Defence’s Development, Concepts and Doctrine Centre, states that realising the potential of robotic and AI technologies will depend on understanding the relative strengths of humans and machines, and how they best function in combination to outperform an opponent. “...the effective integration of humans and machines into our war fighting systems – is the key; and we should not forget that we are in a race with our adversaries to unlock this advantage. The clock is ticking, as new technology capabilities accelerate.” ■

BRINGING ASSET INFORMATION TO LIGHT DURING DARK MODE OPERATIONS

Matt Medley, Industry Director, Aerospace & Defense Manufacturing, IFS

As military operations across land, air and sea become increasingly distributed, keeping an up-to-date view of equipment status requires a robust digital backbone. This backbone has certainly grown over the last 12 months, as more organisations progress on the journey to maintaining Total Asset Readiness™, near 24x7 visibility into the status of their personnel and equipment, through a connected network which feeds crucial data into an overarching software system. But any break in this connectivity can pose a serious threat to this force-wide view and impact mission success.

The importance of supporting access to organisational information from anywhere is reflected in the business world too. Gartner listed 'anywhere operations' as one of its top strategic technology trends for 2021, defined as "an IT operating model designed to support customers everywhere, enable employees everywhere and manage the deployment of business services across distributed infrastructures."

CONNECTIVITY STRETCHED TO BREAKING POINT

A recent study from RAND Corporation, an American non-profit global policy think tank created by the Douglas Aircraft Company to offer research and analysis to the United States Armed Forces, illustrates this move to 'distributed operations' perfectly in the context of the Air Force. The study focuses on a set of emerging concepts for 'distributed operations' that call for a larger number of airbases to complicate enemy targeting and use a more decentralised command and control approach.

In direct response to increased air and missile threats posed to larger main bases, the study notes that the U.S. Air Force is shifting toward concentrating on conducting missions from smaller forward operating locations or bases (FOBs). In order to maximise visibility, there needs to be consistent connectivity between a main operating centre or base (MOB) and these distributed FOBs. RAND then rightly highlights that any disruption to this connectivity by enemy attack on long-distance communications systems, including satellites and long-distance fibre, can seriously compromise mission success.



Forward operating environment



Asset ready

There are also planned instances where units will be conducting operations in 'dark mode'. A small percentage of top-secret military operations will, by their sensitive nature, take place in a disconnected environment, without outside-world connectivity and with a purposely minimised electronic signature.

BEHIND EVERY ASSET IS A COMPLEX DATA CHAIN

Militaries need the ability to continue operating a network at a moment's notice, even when all outside connectivity is lost, and then incrementally re-sync information such as engineering & maintenance data, technical records and more. Although this may sound simple, this is a very complex undertaking from a data architecture perspective.

Let's take an aircraft as an example. When transferring an aircraft from an MOB to a new forward operating node, it is not only the physical asset which is being sent. Its logistics support material needs to move with it, from up-to-date technical records to physical spare parts.

During operations, the aircraft's systems will probably be connected via internet, radio, satellite internet, VoIP, 99% of the time—but it's the 1% of time it may spend disconnected which opens potential problems in data consistency. Without consistent information on what has taken place in the field, such as maintenance, the MOB or home station cannot gain a single version of the truth on the aircraft's status and availability—limiting a commander's ability to make decisions, particularly if they're making decisions about a mission from the other side of the world.

This scenario of course applies to many military assets, you only need look at naval equipment, which commonly operates at huge scale and in disconnected environments. This scale is only set to increase, as current U.S. Navy plans highlight a force-level goal for an even more distributed fleet architecture, including 382 to 446 manned ships and 143 to 242 large unmanned vehicle systems by 2045.

BACK AND FORTH INFORMATION TRANSFER IS A PRE-REQUISITE

Flipping the scenario around, there will also be key equipment updates that will be communicated out from an MOB and need to be received by personnel in an FOB. Entire assets come with an allowable baseline configuration, which will be subject to change and updates on a regular basis. In defence operations, the Central Engineering Authority (CEA) creates and maintains the maintenance and equipment baselines, and baselines at autonomous bases must remain as up-to-date as possible.

Two-way data exchange ensures all parties are viewing timely and accurate information, and this data-driven approach directly translates into better strategic decision-making. The answer to Total Asset Readiness in distributed operations doesn't lie in "quantity"—for example more maintenance personnel to keep assets running—it lies in "quality" data—consistent, accurate and timely information to drive more efficient asset management.

SECURITY MUST REMAIN TOP OF MIND – CONTAINERISED SOFTWARE INFRASTRUCTURE IS KEY

To effectively manage disconnected operations, the underlying software infrastructure requires the capability to aggregate, consolidate and store data, while providing physical and software-based hardening against attack. Incremental reconsolidation from supporting software is the most effective way to facilitate secure two-way information exchange between an MOB and FOB.

This is where containerised architecture is key and involves bundling an application together with all of its related configuration files, libraries and dependencies required for it to run in an efficient and bug-free way across different computing environments. Containerisation meets the challenges of scale, rapid deployability and being self-contained as secure, standalone software.



THREE CRITICAL FOCUS AREAS FOR DISCONNECTED OPERATIONS SOFTWARE SUPPORT

Military operators require purpose-built software to address the unique challenges of operating from remote and austere environments in the following focus areas:

1. Asset compliance and baseline updates

Supporting software should be able to address the core requirement needed to transfer assets between nodes for military operations, including asset transfers (air vehicle and loose inventory), baseline transfers along with the asset, and technical records transfers along with the asset. Workflow management functionality should prepare deployments and imports of assets from MOB to FOBs and inversely from FOBs to MOB. When assets are transferred, baseline updates and a portion of their technical records are automatically transferred. Conversely, bases can view the batch number their location is using and request an update from MOB or CEA.

2. Technical Records Repository

In situations where technical records for an asset are created

in multiple internal or external systems, command or central maintenance management requires an aggregated view of an asset's technical records. A Technical Records Repository (TRR) should enable planners, reliability departments and others to view the full set of historical records for maintenance performed and usage accrued on an aircraft or component. Bases that perform maintenance can keep the central TRR up-to-date by sending technical record updates through the built-in workflow manager feature.

3. Integration with core maintenance system

This disconnected operations functionality should be fully integrated into core maintenance management software, eliminating the need for data duplication. This integration delivers a complete spectrum of military equipment maintenance management in a single integrated business platform.

TOTAL ASSET READINESS GUARANTEED

Underlying software has to be able to collect, analyse and re-sync data from disconnected operations to ensure all stakeholders have a completely accurate picture of their military assets, wherever and however they may be deployed. Only then can military organisations truly be able to maintain that all important Total Asset Readiness. ■



GREATER RESILIENCE, BETTER PERFORMANCE, MORE SECURE, LESS COST

Huber+Suhner

Radio Frequency (RF) signals have been distributed over coaxial cables for decades, but for today’s mission critical government/military/intelligence operations it can be limiting, expensive, and can pose security risks.

To overcome these limitations, RF systems engineers are turning more and more to RF distribution over optical fibre (RFoF). In RFoF systems, electro-optical (E/O) converters are used to convert RF to optical at the signal source, then transmitted along a length of single-mode optical fibre to the destination where optical-electrical (O/E) converters convert signal back to RF.

Optical fibre’s main advantages include extremely low transmission losses and immunity to electromagnetic, radio or other types of signal interference. These benefits bring improved security, performance, readiness, and resilience at lower overall costs.

WHY DISTRIBUTE RF SIGNALS OVER FIBRE?

Greater bandwidth and distance — Optical fibre can carry significantly more bandwidth than coaxial cables with less signal impairments. This reduces the need for expensive amplifiers and

other signal condition equipment while allowing the signals to span much greater distances.

High security — Optical fibres are much more difficult to tap than coaxial cables and any disturbance is much easier to detect and locate.

Future proof — Transmission of RF signals over optical fibres is independent of the RF signal format, frequency, and bit rate, so the optical fibre can be used to transmit virtually any commercial RF signal. As RF signal formats change over time and bit rates increase, the same optical fibre infrastructure can be used without any need to be upgraded. Operators can even distribute different signal types through the same fibre infrastructure for maximum flexibility.

Cable cost and size — Optical fibre cables are a fraction of the size and weight of coaxial cables and are much simpler and less costly to install and maintain. Optical fibre cables are also inherently more reliable than coaxial and much less susceptible to corrosion and other environmental effects.

SUPERIOR DISTRIBUTION EFFICIENCY

Wavelength Division Multiplexing (WDM) allows users to combine up to 80 or more channels onto a single fibre.

COAX VS. FIBRE COMPARISON	Coaxial	Single mode fibre
Representation distance bandwidth products	100 MHz km	100.000+ MHz km
RF attenuation/km @ 1 GHz	>45 dB	0.4 dB
Cable diameter (inch)	1/2	1/8
Cable weight (lbs/km)	450 lbs/km	15 lbs/km
Minimum bend radius (inch)	7	1
Data security	Low	Excellent
EMI immunity	OK	Excellent

WHY SWITCH IN FIBRE VS. SWITCH IN COPPER?

Switching in fibre using all-optical switches allows users to take full advantage of the benefits of fibre optics end-to-end, including:

- High level of security from antenna to receiver
- Redundant paths are easy to configure and inexpensive
- Future-proof: any frequency, any data range, any modulation format – today and in the future; end-to-end

All optical switches have an extremely compact form factor (1u for a 48x48 switch) and ultra-low power consumption.

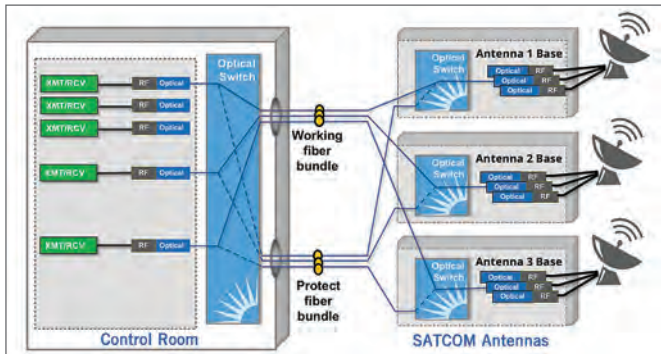


Fig 1: Typical optically-switched satellite ground station RF-over-Fibre architecture

THE ULTIMATE ALL-OPTICAL SWITCH FOR RF-OVER-FIBRE APPLICATIONS

The analogue nature of RF-over-Fibre requires a switching infrastructure that does not degrade the RF signal. This requires a high-performance, all-optical switch with ultra-stable operation as well as low back reflections and low insertion loss.

HUBER+SUHNER Polatis’ ultra-reliable switching solutions have been meeting the needs of mission-critical RFoF applications in some of the most rugged environments for over 15 years. All-optical switches provide superior specifications and features required for this application, including:

- Lowest insertion loss – Less than 1 dB optical insertion loss minimises signal impairment.
- Unmatched performance – The only all-optical matrix switch with virtually no jitter and very low return loss.
- Ultra-low cross talk – Better than 100 dB RF isolation between channels at any frequency.
- Broad range of matrix sizes – Unparalleled choice of symmetric and asymmetric port configurations for any size deployment.

The patented Directlight™ high-performance switching technology minimises impairments to RFoF signals traversing the switch connections. HUBER+SUHNER Polatis’ technology uses integrated position sensors to directly align optical collimators to make and hold dark-fibre connections which eliminates the need for signal dithering that can degrade RFoF signals.

This is a critical advantage over MEMs-based all-optical switching technologies, which use mirror dithering as part of the alignment process, to make and hold connections, which adds unwanted signal modulation.

In RFoF systems this MEMS-based excess modulation is mixed directly with the RF signal, adding to the signal noise floor and degrading the RF signals as shown in Fig 2.

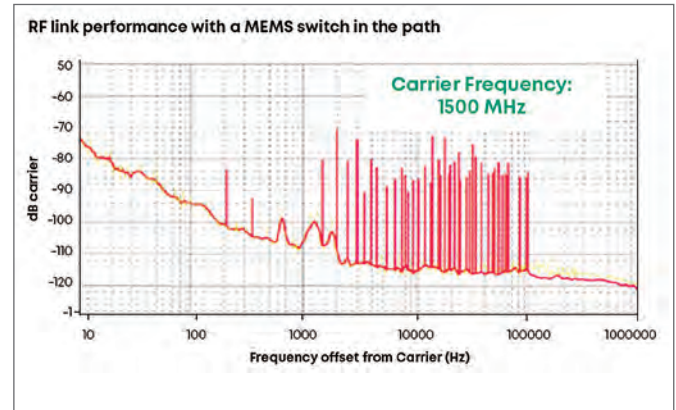
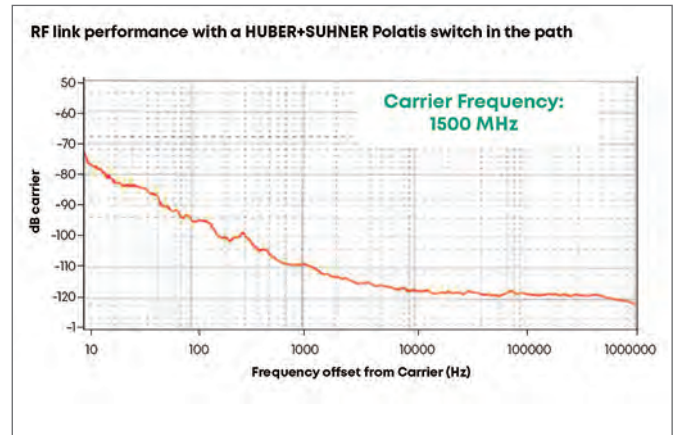
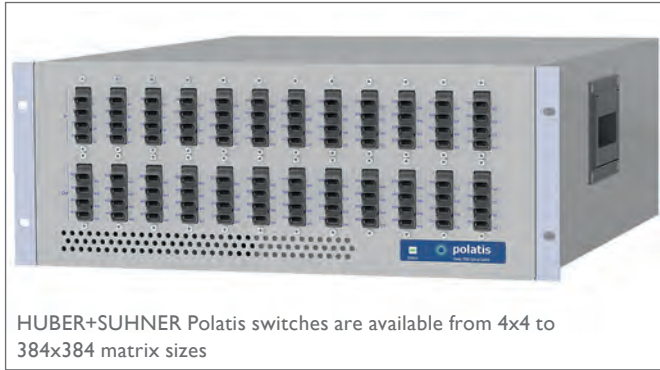


Fig 2: Customer measurements of RF/optical link phase noise via all-optical switches

USE CASE – SATELLITE GROUND STATIONS

With a fibre network and all-optical switching, organisations can now deploy highly secure solutions with capabilities that are not possible with traditional coaxial-based systems. In a typical satellite ground station deployment there are significant benefits of an all fibre-based approach that provide organisations with key advantages:

- Control rooms can be safely located further away from antennas.
- Provisioning can be done remotely, automatically, and instantly, even from across the world.
- Satellite dishes can be shared by different organisations.
- Data can be easily rerouted around failures.



HUBER+SUHNER Polatis switches are available from 4x4 to 384x384 matrix sizes

THE HUBER+SUHNER ADVANTAGE: END-TO-END RF-OVER-FIBRE SOLUTIONS

In addition to the superior all-optical switch products, HUBER+SUHNER can supply all of the other best-in-class RF and fibre optic components and systems needed for end-to-end RF-over-Fibre solutions.

HUBER+SUHNER provides RF cables, connectors and RF-to-optical transceivers, multiplexers if running different channels on a single fibre, and a host of fibre and RF cabling and cable management products. The company offers complete turnkey solutions for RF signal distribution from antenna to control room.

RF-OVER-FIBRE SOLUTIONS

RF-over-Fibre (RFoF)

Frequency range from 1 MHz to 20 GHz
 Available in simplex and duplex systems
 Single mode solution enabling distances of >100 km
 Standard modules available in 1, 6 and 12 ports*
 QMA and Q-ODC-12 as standard connectors*

GPS-over-Fibre (GPSoF)

Frequency at 1.5 GHz
 L1 + L2 Bands
 Single mode solution enabling distances of >100 km
 Available as a single port or 4 port receiver module
 QMA and FC as standard connectors*

LAN-over-Fibre (LANoF)

Data rate: 1000 Base-SX (1 Gbps)
 Single mode, duplex solution enabling distances of up to 20 km
 Standard modules available in 1, 6 and 12 ports*
 RJ45 and Q-ODC-12 as standard connectors* ■

* Customised configurations, bands and connectors on request
 For more information, visit our website www.hubersuhner.com



RF-over-Fibre (RFoF)

LAN-over-Fibre (LANoF)

GPS-over-Fibre (GPSoF)

HPI-High Pressure Instrumentation

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HIGH PRESSURE INSTRUMENTATION

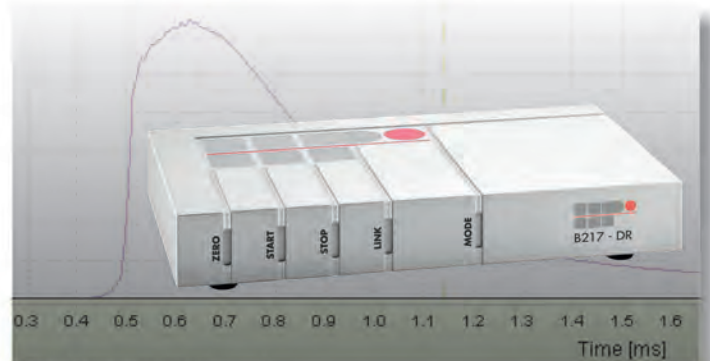
Is the number one supplier when it comes to Ballistic Measuring Equipment for interior-, exterior- and terminal ballistic applications. The Sensors, Hardware, specific Software and Data Recording Systems are applied in R&D, acceptance and routine tests by manufacturers of ammunition, weapons, military and civil Proving Ranges. Continuous developments, uncompromising quality, high accuracy and worldwide service make HPI stay ahead of the rest.

A new field of HPI's activities is the supply of measuring equipment for testing Protection Material such of helmets, body armor, armored steel plates and safety glass according to NIJ Standards.

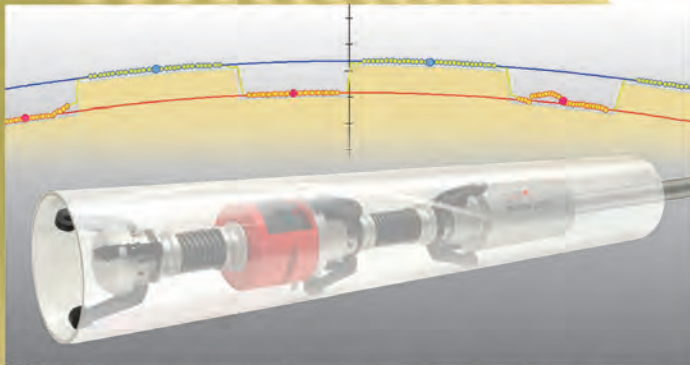
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NATO and CIP**



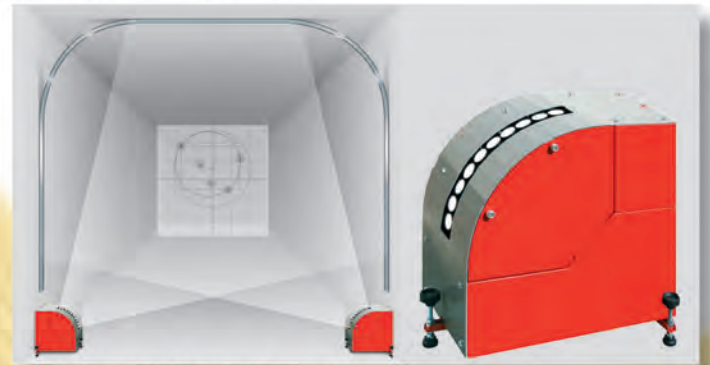
Piezoelectric High Pressure Transducers – GP Series



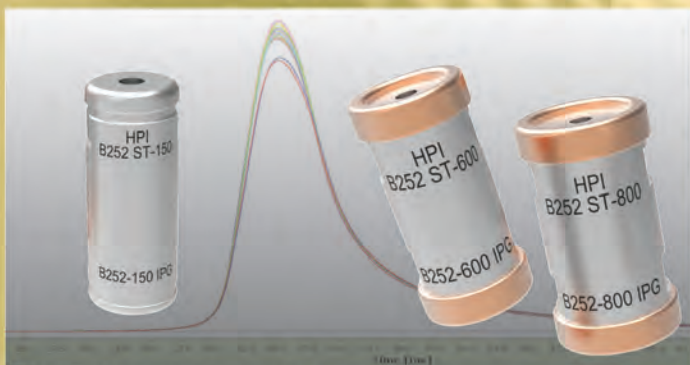
B217-DR Data Recorder



B285 LBG Laser Barrel Gage



B590 Optical Target System



B252 IPG Internal Piezo Gauge



B262 MSS Memorizing Shock Wave Measuring System



B481 Doppler Radar System



B472 Precision Light Screen, B462 Measuring Frame

With the Royal Navy's Carrier Strike Group on its maiden deployment, sustaining and operating the new carriers, the F-35B aircraft on board, and support vessels, is likely to stretch budgets. But is there a way to make aircraft carriers, and the combat aircraft they fly, even more powerful and cost-effective?

By Tayfun Ozberk

Aircraft carriers are the symbols of a country's soft and hard power. They are often referred to as "50,000-ton diplomats" because they play critical roles in peace and conflict by assisting countries' policies through flag diplomacy. In addition, the aircraft carriers provide regional airspace control by moving the airpower they carry from one region to another.

Being a global power in the age of force projection entails being confronted with a variety of operational areas, sometimes concurrently. As a navy's most valuable asset, aircraft carriers can contribute to a variety of operational areas in addition to their primary mission, such as neutralising the target area before an amphibious operation, hitting targets in the depths of the coast, and providing close air support to amphibious elements that land. Combat jets on aircraft carriers can also support surface assets with Anti-Surface Force Air Operations missions as well.

One of the leading operators of aircraft carriers, is the UK. Throughout history, aircraft carriers played an essential role in establishing the UK's maritime superiority in various regions across the world. During the Falklands War, British aircraft carrier capabilities allowed the UK to conduct amphibious operations on the Falkland Islands, 8,000 miles from the UK. At the time of the war, the Royal Navy still maintained two aircraft carriers, HMS Hermes and Invincible, which carried the Sea Harrier, a short take-off and vertical landing/vertical take-off landing fighter jet, made especially for

the Navy. While the Sea Harrier was no match for Argentina's much faster Mirage fighter aircraft, at least on paper, by the time the Falklands War was over, they had downed 21 enemy aircraft with no air to air losses.

But the Falklands War was the climax of the United Kingdom's maritime superiority and aircraft carrier efficiency on the high seas. HMS Hermes was later sold to India and HMS Invincible was turned into scrap. Following the Falklands War, the Navy reduced its investment in aircraft carriers, until its global vision was revived with the commissioning of the first new Queen Elizabeth class aircraft carriers in 2017.

In April this year, the Royal Navy's all new Carrier Strike Group, led by the 65,000 tonne HMS Queen Elizabeth, set sail for the Indo-Pacific region on its maiden deployment. But there is a cost to creating a global perception of power. In addition to boasting naval strength, it is critical to operate carriers in the most cost-effective manner possible to ensure sustainability.

However, the Queen Elizabeth's ability to carry only vertical take-off and landing (VTOL) aircraft is the most significant disadvantage for British carrier task groups. The F-35B Lightning II is the only fixed-winged jet option in these circumstances. Despite all the advanced features F-35B jets have, the operating cost of a single jet is approximately \$33,000 per hour¹.

The Carrier Strike Group's Full Operating Capability, which is expected by 2023, will include two Lightning II

squadrons (24 aircraft in total) operating from one of the two Queen Elizabeth class carriers. According to a Public Accounts Committee report on delivering Carrier Strike, the programme's whole life costs for 48 jets to 2048 would be £18.4 billion.

The cost of operating carrier task groups (fast jets, helicopters, destroyers, frigates, nuclear submarines, support vessels, minesweepers) is already enormous. Support costs include the cost of maintaining, repairing and upgrading equipment, and operating items, including fuel, port fees and stock. When the high flight and maintenance costs of the F-35B aircraft are factored in, it is clear that budgets will be significantly stretched.

DEPLOYING F-35B ON THE BRITISH CARRIERS

An aircraft carrier is the capital ship of a fleet because it allows a naval force to project air power anywhere in the world without relying on local bases to stage aircraft operations. The F-35Bs bring airpower to a new level thanks to their optical targeting systems, data fusion and electronic warfare capabilities.

F-35Bs are exceptionally effective aircraft, especially when it comes to neutralising adversary assets with Anti Access/Area Denial (A2AD) capability and attacking strategic targets from afar. The recognised maritime and air picture can be established quickly, thanks to the link and data fusion. Moreover, after being equipped with the Naval Strike Missile, the F-35B jets will be able to engage the enemy's high-value units from beyond the stand-off range. With these features, we can say that the F-35s will make aircraft carriers more powerful.

The number of F-35s required on an aircraft carrier should be determined by the "mission" of the carrier task group as well as the "opposing force's capabilities." For example, suppose an amphibious operation is to be carried out in the Baltic or Black Sea. In that case, the primary task is to neutralise enemy elements

CREATING A PERCEPTION OF POWER



The Royal Navy's HMS Queen Elizabeth aircraft carrier (© Crown copyright 2020)

with long-range weapons that provide A2AD. In this context, the issue that must be considered when developing a force composition is risk and threat assessment and the presence of other air assets with long-range weapons in addition to the F-35B. In this case, the bare minimum of F-35Bs should be determined for this task, and the remainder of the force should comprise other supporting elements.

To meet these operational requirements, the Royal Navy has been working on Project Vixen, which was first revealed as a programme to evaluate the use of fixed-wing unmanned aerial vehicles from the Queen Elizabeth class aircraft carriers. The project is expected to provide affordability and cost-effectiveness while conducting operations with shipborne F35s. Project Vixen primarily focuses on air early warning (AEW) or air refuelling rather than elements that can

support F-35B aircraft as a strike force, as the Navy's carriers can only operate vertical landing air assets and cannot deploy AEW and tanker aircraft.

In June 2020, the Royal Navy announced² its intention to use heavy-lift drones for aerial refuelling³, which is compatible with Project Vixen. In June 2021, the US Navy took the first steps using this technology by performing the first air-to-air refuelling with its MQ-25 Stingray unmanned carrier-borne tanker. The unmanned aerial tanker will most likely be a Stingray derivative.

The main purpose of the Crowsnest-fitted Merlin helicopters, which entered into service⁴ in March 2021, is to provide sensor coverage over the HMS Queen Elizabeth carrier group. However, the Navy's plan is to move a carrier-based Airborne Early Warning capability from Merlin helicopters to

'Vixen'⁵ fixed-wing drones by 2030. Vixen is expected to have the AEW capability of the Carrier Strike Group and rejuvenate the Merlin fleet.

While the Vixen project is expected to provide strike assistance to the F-35B jets, the asset capabilities are currently unclear. On the other hand, the Lightweight Affordable Novel Combat Aircraft (LANCA) concept looks to offer increased capability, protection, survivability, and information when deployed alongside combat aircraft.

Under the network-centric architecture, LANCA could act as a wingman to the F-35Bs on the battlefield, similar to the Loyal Wingman concept being developed by Boeing Australia for the Royal Australian Navy. Turkey is also working on an unmanned jet concept named MIUS (Muharip Insansiz Hava Araci – Combat Unmanned Aerial Vehicle)⁶ which Turkish drone-producer Baykar unveiled in July.



Boeing's MQ-25 Stingray demonstrates the first unmanned aerial refuelling of a US Navy F/A-18 Super Hornet (Photo courtesy of Boeing)

The drone is expected to feature AI-based autonomous manoeuvring capability and carry missiles or other munitions under the wing. Turkey intends to operate MIUS in a loyal wingman role in conjunction with the future TF-X National Combat Aircraft.

The F-35Bs can control the combat drones in a network-centric architecture, and they can carry out small and medium-sized strikes against land and surface targets using missiles and munitions. With such a network-based system, the F-35B would have complete control over the UAV, including the ability to fire the drone's missile. This option would boost the Joint Strike Fighter's ammunition capacity. Deploying many drones alongside a few F-35Bs would distort the enemy's recognized air picture and confuse the operator while determining target priority. The use of UAVs to decoy would aid the F-35B's survival.

HOW CAN A COMBAT DRONE SUPPORT F-35BS?

Supporting the F-35Bs with unmanned systems capable of launching cruise missiles or long-range munitions would reduce the number of F-35Bs used and, thus, their cost. As saturating the enemy's air defence is a very risky operation, unmanned aerial vehicles can be deployed to ease the weight off of the F-35s before they engage.



The arrival of the first Merlin helicopters onboard HMS Queen Elizabeth for her up and coming Carrier Strike Group deployment. (MoD/Crown Copyright)

On the other hand, the fifth-generation fighter jets are sophisticated and expensive systems. As a result, instead of deploying these aircraft for high-risk missions, UAVs are a more plausible option if they are capable of completing the task. Aside from the operations carried out with the F-35B, the UAVs to be deployed on the aircraft carrier will also be beneficial in anti-submarine warfare (ASW). The UAVs can cover the submarine danger zone with electro-optical sensors for 24 hours, disrupting the snorkelling plans of

diesel-electric submarines that need to recharge their batteries at certain periods. Furthermore, unmanned aerial vehicles (UAVs) capable of carrying sonobuoys, such as the Sea Guardian, will contribute to submarine seeking efforts with acoustic sensors. The F-35's capabilities have boosted airpower to a new level. On the other hand, maintaining this power requires a cost balance, which necessitates precise and efficient planning. As a result, deploying helicopters and UAVs alongside the F-35s on aircraft carriers for ASW, aerial refuelling, suppressing and saturating adversary air defence systems, electronic warfare, and AEW purposes, appears to be the most feasible option for achieving a cost-effective force composition. The number of F-35s and supporting air assets deployed on the aircraft carrier should be determined in accordance with mission requirements and enemy capabilities.

Sustainable power is expensive. Therefore, good planning is a must. ■

ABOUT THE AUTHOR

Tayfun Ozberk is a former naval officer and defence analyst based in Turkey.

FOOTNOTES

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ROOTED IN INTELLIGENCE

AI will be central to future combat aviation capability, but its application for lethal use requires clear ethical and humanitarian principles to be outlined.

By Atul Chandra



The Franco-German-Spanish Future Combat Air System will feature AI at the core of its 'System of Systems' approach, which will comprise a manned New Generation Fighter (NGF), Remote Carriers and Combat Cloud. Together, they will form the New Generation Weapon System (NGWS) (Copyright: Airbus)

Global militaries are now rapidly advancing research in the field of Artificial Intelligence (AI) and their military applications, recognising that it will be a key differentiator on the future battlefield. Work on AI-based military applications has seen dramatic advances over the past decade, driven by access to hitherto unprecedented levels of

processing power and availability of large databases of near-real time information.

Advanced and developing nations alike are grappling with developing a common understanding of AI and its military applications and identifying which elements are relevant for military application. "At the tactical level, AI is more about the intelligent automation of functions, like those on

platforms aiming for autonomous systems," says Ignacio Montiel Sanchez, the European Defence Agency (EDA) project officer for information technologies research. "But at the strategic level, this goes straight to (AI-enabled) intelligence and support to decision-making, which immediately gets more complicated for co-operation, given the sensitivities from the different parties."

In an effort to promote and coordinate AI innovation across its Member States, the European Defence Agency (EDA) launched a preliminary effort in February 2019 aimed at creating an AI blueprint. This culminated in December 2019, when the EDA outlined its definition for AI along with issuing an AI glossary and taxonomy. The EDA has settled on a 'minimum common denominator'

definition of the functional perspective of AI, with the following definition: "AI is the capability provided by algorithms of selecting, optimal or sub-optimal choices from a wide possibility space, in order to achieve specific goals by applying different strategies, including adaptivity to the surrounding dynamical conditions and learning from own experience, externally supplied or self-generated data."

The prominent role of AI within the Franco-German-Spanish Next Generation Weapon System / Future Combat Air System (NGWS/FCAS) programme is now driving AI research within partner nations. Between 2019-2025, France alone will invest €100 million annually on AI research for its armed forces, with collaborative combat being one of the six priority areas for investment. The extensive use of AI



AI will be used to assist FCAS pilots in decision making by acting as a virtual assistant and sorting the most relevant information from the aircraft's sensors. (Copyright: Dassault)

to support FCAS pilots sets it apart from previous generations of fighter aircraft. The maiden flight of the New Generation Fighter demonstrator being developed under the FCAS programme is slated for 2027 with an operational sixth-generation fighter to be available by 2040.

MAKING AI CENTRAL TO COMBAT CAPABILITY

While FCAS programme leaders are of the view that AI will enhance human capabilities rather than replace them; it will be key for the successful implementation of a manned sixth-generation fighter operating alongside an advanced Unmanned Aerial Vehicle used as a “Loyal Wingman” or smaller less advanced “Remote Carriers.” AI will be crucial in managing pilot workload and aiding decision making. Loyal Wingman UAVs can be used to undertake a variety of high-risk missions such as target strikes, surveillance, and Electronic Warfare (EW). This is made all the more important as an autonomous large UAV would require a reliable and jam-free satellite link, which could prove troublesome while operating in contested environments. As a result, it would be preferable if the Loyal Wingman or Remote Carriers could be controlled from a piloted aircraft over a local network. This would make them much more resilient against jamming. AI could also be used to automatically generate mission plans, adjust sensors based on the operating

environment and terrain along with undertaking predictive maintenance tasks.

A June 2019, white paper titled, *The Responsible Use of Artificial Intelligence in FCAS - An Initial Assessment*, written by a group of Airbus Defence and Space engineers, identified eight major AI use cases for the FCAS programme:

- Mission Planning and Execution
- Target Detection
- Recognition and Identification
- Situational Awareness
- Flight Guidance, Navigation and Control
- Threat Assessment and Aiming Analysis
- Cybersecurity and Resilience
- Operator Training and Reduced Life Cycle Cost (RLC).

A report on the FCAS programme, submitted by France’s Foreign Affairs Defence and Armed Forces Committee to the French Senate in July, proposed that partner nations consider AI as a “transversal pillar” of FCAS that must be developed with the broadest possible scope of application. The other pillars of the NGWS/FCAS programme are the New Generation Fighter (NGF), Engine, Remote Carriers, Combat Cloud, Simlab along with Sensors and Stealth, which were two new programme pillars added in 2020.

The implementation of AI technologies in combat aviation is viewed as key to maintaining European aerospace superiority, in the face of increasing strategic and geopolitical threats. “The protagonists of the 21st century will be faster moving, more sophisticated and more volatile,” Dr. Bruno Kahl, President of the German Federal Intelligence Service stated in a strategic threat analysis for 2040 posted on the website for the FCAS programme. “The battlefield will be influenced by a large mix of state, non-state and quasi non-state actors. This will make it more difficult to distinguish between friend and foe. Digitalization, automation and technological innovation will give rise to a ‘glass battlefield’ that — in contrast to the complex and opaque ‘fog of war’ of earlier eras — will shed

light on the current situation and deliver information that is highly beneficial to tactical decision-making.”

ETHICAL ISSUES RELATED TO LETHAL AUTONOMOUS WEAPON SYSTEMS

In April 2019, while speaking at the DATA IA institute in Saclay, France’s Armed Forces Minister Florence Parly presented a new strategy on AI and defence. Discussing the ethical and legal aspects of AI during the presentation, she made the French view on the matter clear, stating: “France refuses to entrust the decision of life or death to a machine that could act fully autonomously and beyond any human control. Such systems are fundamentally contrary to all our principles. They have no operational interest for a country whose armies respect international law, and we will not deploy them.”

The use of Lethal Autonomous Weapon (LAW) systems in the future will mark a major change from the present, where armed drones always feature a human operator undertaking targeting and engagement of targets. This ensures armed drone operations are governed by the same legal framework as other weapons systems. However, international laws related to the use of LAW systems are still not in place and further discussions are needed to arrive at a clear legal framework consistent with the ethics and principles of international humanitarian law. Considering the centrality of AI on NGWS/FCAS, the French Ministry of Defence established a Defence Ethics Committee, which was due to submit initial guidelines for applying AI to weapons systems by Summer 2020. ■

ABOUT THE AUTHOR

Atul Chandra is an aerospace and defence journalist based out of India. His articles have appeared in numerous international defence publications, including *Flight International* and *Asian Defence Technology*.

A-29 SUPER TUCANO: AGILE AND ADAPTABLE

Embraer Defense & Security

When the A-29 Super Tucano first entered service in 2004 with Força Aérea Brasileira (FAB), few would have anticipated the impact the aircraft would have on subsequent operations around the world. It was designed and

built to meet an emerging requirement from the FAB to detect, defeat and deny freedom of manoeuvre of illegal trafficking across Brazil's international borders.

Moreover, the FAB also required this new platform to support



A-29 Super Tucano

advanced training to generate flexibility and optimise the fleet. In turn, this drove the design team to create an aircraft that was to prove perfectly matched to a range of missions, especially in low-intensity conflicts. The aircraft's specific qualities reflect those initial demands from Brazil's military: a rugged multi-mission aircraft with significant payload and range that can operate remotely in a harsh operating environment. The home comforts of acres of tarmac were not for the A-29 Super Tucano: This aircraft needed to operate from unpaved surfaces and without cumbersome Ground Support Equipment.

The capabilities of the A-29 have not been lost on the 16 air forces across five



continents who subsequently procured and continue to procure the aircraft today. Those air forces identified the impact the aircraft would have on operations at both the tactical and strategic level. The Fuerza Aérea Colombiana (FAC) testify to the tactical advantage the Super Tucano conferred, and how that directly led to a reversal in fortunes of FARC, the Colombian guerilla group.

Moreover, as the Colombian and other Air Forces began to exploit the aircraft's abilities, so the product evolved to support the continuous advancements in weapon, sensor, self-protection, communications and other systems the aircraft supports. So, today the Super Tucano is a modern 21st Century ISR and combat platform with fourth or fifth generation avionics delivering precision-guided munitions, collecting and sharing time-critical information, operating as part of a fully-networked operational environment.

AN AIR ASSET FOR LOW-INTENSITY CONFLICTS

It was not just the significant operational success of the A-29 that caught the attention of other potential operators. The aircraft also proved to be extremely cost-effective to procure and, critically, operate. The Super Tucano's low cost-of-ownership made it an attractive option for air forces with more modest budgets. Not only did the aircraft cost less to acquire, it also needed a smaller logistic tail to keep it flying. This in turn impacted favourably on other aspects of expenditure including personnel, training and infrastructure, driving down the cost across multiple operational elements, which allowed air forces to exploit the Super Tucano multi-mission capabilities.

Several air forces also adopted the aircraft as an advanced trainer. Its ability to simulate combat missions and upload and download flight data made it a highly effective training platform. Air forces soon realized that they could effectively 'download' flying hours from more expensive aircraft to deliver similar effects. The optimisation of this training effect was further enhanced when militaries began to see the potential for JTAC and FAC training. The Super Tucano became the ideal platform for some air forces and armies to train for, and enhance effective air-land interoperability, without diverting high value fast jet assets from their primary role.

The management of high-value air assets is an enduring challenge for air force planners. They are faced with an ever more complex operating environment where adversaries have demonstrated the will and capability to undermine operational capability and legitimacy by mixing conventional and unconventional forms of conflicts. UK Joint Doctrine Publication 0-30 UK Air & Space Power correctly identifies that:

"In the contemporary operating environment, air power needs to be agile and adaptable, so the physical component must provide capabilities that can fulfill a wide range of tasks. There is also a balance to be struck between investing in the right type, quality and quantity of equipment."

This is sound and effective policy, but actual procurement activity reminds us that Air Chief Marshal Sir Hugh Dowding's observation that: *"The best defence of the country is the fear of the fighter,"* is still relevant. The challenge arises when those assets are diverted to low-intensity conflicts where the capability overmatch is only matched by the significant costs associated with operating those aircraft types. Evidence abounds of this profligacy; the United States Air Force Secretary observed in February 2018: *"We should not be using an F-22 to destroy a narcotics factory in Afghanistan."*



This captures the problem with the enduring and endemic nature of low-intensity conflicts often associated with counter-insurgency operations. The campaigns tend to last, and the adversary can shift their focus in response to strategic need. They also tend to outlast political will and defence budgets; the insurgent knows this and will adopt the Fabian Strategy of ‘playing it long’. So, the premise is that smart air forces understand that commitment to counter-insurgency campaigns will last for decades and require sustainable capability solutions.

MULTI-MISSION CAPABILITIES

The value of the Super Tucano, testified in 2021 by both the Philippines and Nigerian Air Forces, is that it delivers a highly effective, tried and tested platform, mounting advanced sensors, data, self-protection and weapon systems. Critically these and other operators can afford to operate the A-29 against the insurgency for as long as it takes. High availability (over 90%) provides added assurance in the delivery of mission effectiveness.

The logic of this approach is not lost on other air forces who may not have an insurgency on their doorstep but may be required to support these types of operations, as part of a coalition, or independently as required. Arguably for many of NATO’s newest and smaller air forces, assuring territorial integrity from the air is simply too expensive. However, contributing to coalition operations by delivering Precision Guided Munitions from a networked affordable platform is a realistic proposition. Air forces may also be required to optimise limited defence budgets by exploiting the Super Tucano’s multi-mission ability to readily adapt to support advanced training, air surveillance, or close air support missions.

In summary, the journey of the Super Tucano from concept to 21st Century mission effectiveness has been guided by the exploitation of a highly capable platform combined with improving sub-systems, driven by evolving operational demands. Air power needs to be agile and adaptable and delivering against this principle is as much about the vision of a supplier as it is the imagination of the air force. ■

NOT TOO TAXING

Italian light aircraft company, Blackshape, is transforming the civil and military training landscape with its ultra lightweight and fuel-efficient aircraft, which are big on data, and getting the most out of cadets and their training. *By Anita Hawser*



The Blackshape Gabriél BK160-TR, the first purpose-built training aircraft in the last 50 years (Photo by Blackshape)

Blackshape, which is based in the Apulian Aerospace district in Monopoli, Italy, is shaking up the civilian and military training market with its light training aircraft constructed wholly from carbon fibre. When it comes to training cadets, specific characteristics need to be thought about carefully, says Luciano Belviso, Blackshape's CEO and founder. "The aircraft needs to be very safe and forgiving. Cadets also need to perform a number of sorties, which should be challenging. I recall an old flying school motto: "Training aircraft need to be easy to fly, but difficult to fly well."

There were no purpose-built trainers dedicated to the training and assessment of the next generation of cadets, so Blackshape designed and built the Gabriél BK160TR aircraft in 2017. The aircraft is entirely constructed of carbon fibre and took just eight months to build from first sketches. "The average age of military training aircraft is approaching 50 years," explains Belviso. "The biggest difference with respect to legacy training fleets is that our training solution allows us to monitor the performance of cadets."

One of the pillars of Blackshape's BK160, which it calls its 'flying lab,' is its ability to record all data, not just for safety purposes, but also biometric data such as the pilot's heart rate, blood pressure, facial expressions and pupillary reflex. "Our approach is similar to what happens with larger transportation aircraft," explains Belviso, "which have proper flight recording systems. That means you can provide a proper debriefing to the cadet on their technique. This is an incredible advantage in terms of the cadet's awareness and also beneficial for learning as instructors can understand the precise degree of performance of every cadet, which allows for the identification of the best cadets, and for those who experienced difficulties to be corrected."

Blackshape's aircraft are built with safety in mind. The BK160-TR features also optional, ballistic parachute and anti-blast fuel tanks, plus temperature and fuel



The cockpit of the Gabriél BK160-TR (Photo by Blackshape)

capacity sensors. With dual controls, the instructor can easily intervene, if needed, while carrying out a detailed assessment of a cadet's skills.

The BK160 is used by airlines such as Transavia, part of Air France–KLM group, to train pilots. Belviso says Blackshape is also working with a number of military training programmes in Europe, Asia and Africa. "We've been training Air France–KLM cadets on the *Gabriel* for three years now and have had excellent feedback," he says. "The output of cadets is reported to be much higher."

In July, Blackshape debuted the *Gabriel* BK160 and BK160-TR at the EAA AirVenture Oshkosh show, one of the largest international air shows for aviation lovers. As part of the Italian industrial group, Angel Company, which develops high-tech solutions in mobility,

aerospace and defence, Blackshape's aircraft appeal not only to the training market, but have also demonstrated their utility for Intelligence, Surveillance and Reconnaissance missions. In 2014, its ultra-light two-seater aircraft for the recreational market, *Prime*, took off from the flight deck of Italy's *Cavour* aircraft carrier and flew over South Africa.

Blackshape also developed a tactical ISR configuration, BK-ISP, which successfully completed the first phase of OCEAN2020 in 2019, the largest EU-funded defence research project for maritime surveillance co-ordinated by the Italian Navy and led by Leonardo. The BK-ISP featured different payloads (EO/IR, radar) in two role-fit wing pods, as well as Optionally Piloted Vehicle (OPV) capabilities to conduct specific ISR manned and unmanned missions.

During the demonstration, the BK-ISP provided augmented situational awareness to the Italian Maritime Operations Centre, headquarters of the Naval Squad Command (CINCOMNAV), and demonstrated how remotely-piloted fixed wing, prop-driven vehicles can support surveillance and interdiction operations at sea.

Belviso says the BK-ISP can carry a payload of up to 250 kg, which is larger than most unmanned aerial vehicles. "A major limitation for UAV systems is that they can only fly in segregated airspace," he says. "We can operate a manned configuration or control it from a ground station. Our platform also competes quite well with rotary wing systems, which are expensive and slower." Blackshape is currently working on developing an ISR capability for smaller naval vessels. ■



Blackshape ISP configuration (Copyright: Blackshape)

SUCCESSFULLY DEVELOPING SAFETY-CRITICAL SYSTEMS FOR THE LONG-TERM

AdaCore

Safety-critical systems have grown in significance and are now fundamental to delivering military capabilities. For example, you can't test your military airborne platform and its mission systems if the vehicle management system isn't certified first. It simply can't take off.

Delays in safety-critical system development, therefore, risk the successful delivery of Initial Operational Capabilities, impacting major project milestones (and payments to contractors). Any delays can have wider repercussions — if a safety-critical system in a helicopter hasn't been certified then it can't be deployed on a new naval ship, leaving potential holes in your capability.

This is a big issue in your risk register when you start a project. Successful safety-critical development requires the right tools and the right engineering discipline to ensure that software is fit for purpose and that any issues are uncovered quickly. You need to get it right first time — the further into projects any problems are discovered, the longer the time and the greater the cost required to fix them.

Safety-critical systems also need longevity to match the length of service of the platforms they are deployed on, while being scalable enough to change as requirements evolve. By implication, safety-critical systems should be secure, through the

use of specific dual-purpose engineering tools and techniques such as AdaCore's SPARK Pro - (<https://www.adacore.com/sparkpro>). This article explains the pain points of safety-critical development and how to build a strategy for success.

THE CHALLENGES OF DEVELOPING SAFETY-CRITICAL SYSTEMS

Developing any software brings challenges, but due to its fundamental position within military projects, and specific requirements, safety-critical development has to overcome multiple specific pain points.

Firstly, every project starts as a blank canvas. There are multiple decisions to make and options to choose from, around areas such as the overall architecture, programming language and capabilities. There is no single route to success, but it is vital to understand the options and make the right choices at the beginning, before you start development.

Secondly, and linked to the longevity of platforms, you need to avoid hardware obsolescence. Software is eternal, hardware less so. That means you must ensure your safety-critical software can work with changing hardware without requiring a time-consuming and expensive rewrite. Again connected to long lifespans, software



UK MOD(© Crown copyright 2021)

needs to be stable. Once developed and verified the underlying logic cannot be changed. If required, you have to be able to simply compile it to new processors to take advantage of newer technology.

Finally, managing costs is key. This is a particular concern in the UK as safety-critical systems are created infrequently, meaning there is a lack of recent experience, knowledge or previous code that can be used.

DELIVERING SUCCESSFUL SAFETY-CRITICAL SYSTEMS

Engineering discipline is central to effective development of safety-critical systems. That means taking a rigorous approach that applies the same high standards to software as would be applied to physical parts of the project, such as the armour of a tank or the fuselage of a plane.

Given that even the best human developers can miss potential issues, projects need to invest in tools that can enforce this engineering discipline, automatically flagging problems for investigation. For example, AdaCore's SPARK Pro tool - (<https://www.adacore.com/sparkpro>) (based on the Ada 2012 language) guarantees a wide range of software integrity properties such as freedom from run-time errors, enforcement of safety properties or security policies, and full functional correctness (compliance with a formally defined specification).

Using open source tools and languages gives multiple advantages to projects. It enables transparency, where any issues and vulnerabilities are discussed (and fixed) in the open rather than being hidden away. Users benefit from an active ecosystem dedicated to improving tools and languages, creating and sharing resources around best practice.

For example, Thales created and made freely available its adoption guidelines for the Ada language - (<https://www.adacore.com/books/implementation-guidance-spark>) so that everyone can benefit from them. Open source communities and consortia, such as the High-Integrity, Complex, Large, Software And Electronic Systems (HICLASS) project, aim to increase collaboration around specific problems, such as safety-critical projects. Finally, open source software reduces risk. It avoids the use of proprietary technology, which could lead to tool obsolescence if a vendor drops a tool or decides to dramatically increase its price. In open source there are no licence keys to lock you out.

The longevity of safety-critical software also offers advantages when developing for new platforms. Companies can reuse existing software of known pedigree that is proven and still deployed on live platforms on their new projects. While this software may have been written 30 years ago, it still delivers the core capabilities required, bringing down costs and reducing the need for new development.

Given their specialist nature, companies need the right partners when developing and verifying safety-critical systems. They need



to work with tool vendors that have the right combination of powerful technology that enforces engineering discipline and the experience to help reduce project risk.

Vendors can help with understanding the results tools produce in areas such as code audits, and have expertise in providing materials in the right format for independent review/certification. A good example of this is QinetiQ. It partnered with AdaCore when modernising the development environment for its Trials Control System (TCS) - (<https://www.adacore.com/press/qinetiq-selects-mentorship-service-spark>). TCS is a command and control system designed specifically for the training, test and evaluation of military equipment. By using the vendor's Mentorship Service, QinetiQ received hands-on guidance from AdaCore's formal software verification experts through tailored on-site training, virtual project meetings and extensive follow-up support.

The need for effective safety-critical development is growing. This brings new challenges, but these can be met through a combination of engineering discipline, the right open source tools, reuse and partnership. It is therefore vital to engage early with the right partners to make the right choices to deliver long-term success.

For over 25 years, AdaCore has provided critical support to the global defence industry when developing military grade software-based systems adhering to stringent safety, security and dependability requirements. By providing solutions based on internationally recognised standards and open source technology, our customers are guaranteed complete supply chain security through transparency and traceability.

Our world-class open source software development and verification tooling experts have supported over 1,200 projects and 500 clients worldwide in high assurance and high capability applications, meeting demanding project requirements around safety, security, platform availability and budgets. We work with leaders from the global military industry such as BAE Systems, Boeing, Lockheed Martin, Airbus, Leonardo, Raytheon Technologies, Rolls Royce, General Dynamics, QinetiQ, MBDA and Thales. ■

Contact AdaCore at <https://www.adacore.com/company/contact/inquiries>.

SCHIEBEL'S UNRIVALLED CAMCOPTER® S-100 UNMANNED AIR SYSTEM (UAS) CAPABILITY

Schiebel

The CAMCOPTER® S-100 currently has more than 100,000 flight hours under its belt, with over 10,000 maritime flight hours and about 2,000 deck landings. The UAS is currently flying all over Europe for the European Maritime Safety Agency (EMSA) conducting maritime surveillance in Finland, Estonia, Spain and Romania.

In the execution of Schiebel's contract with EMSA, the CAMCOPTER® S-100 provides simultaneous maritime surveillance services to several EU Member States. The most recent operations are being conducted in the northwest of Spain, where the CAMCOPTER® S-100 supports the Spanish authorities in carrying out different operational tasks, including maritime traffic control, pollution prevention and fisheries control. While the flights provide additional, complementary means to Spain's sea search and rescue agency, SASEMAR, in preventing and curbing pollution, and controlling maritime traffic, they also serve

the national fisheries authorities (Spanish Secretary-General for Fisheries) working to protect sea-fisheries resources and to ensure their sustainable development.

In addition to the EMSA deployments, Schiebel's clients include 14 navies worldwide, one of them being the Royal Australian Navy (RAN). In July 2021, the RAN awarded Schiebel with a three-year extension contract for the sustainment of its CAMCOPTER® S-100. The extension allows the RAN to continue to experiment and develop knowledge using the S-100.

After winning the RAN contract back in 2016, Schiebel has built on its initial acquisition contract resulting in this substantial extension. The contract includes field support services, engineering and logistics elements, as well as the creation of a sovereign Australian CAMCOPTER® S-100 training capability delivered by Schiebel Pacific. Building on its vast experience, Schiebel also demonstrated the CAMCOPTER® S-100 to the Hellenic Navy and US Navy this



CAMCOPTER® S-100 conducting maritime surveillance in Spain



CAMCOPTER® S-100 conducting maritime surveillance in Romania

operations include commercial drone flights, test flights as well as training flights for pilots.

The LUC, which is also valid in the European Union and EASA member states, is an important step for the UAV market. It opens further opportunities in regards to flying in civil airspace by allowing the operators to carry the responsibility for their operations, making the whole process more efficient and structured.

The CAMCOPTER® S-100 is the only VTOL UAS of its class being operated extensively around the globe. Schiebel has more than 20 years of experience in developing and producing UAS and has 35 customers worldwide. The company is currently bidding for the UK's Flexible Tactical Unmanned Air System (FTUAS)

Summer. In Greece, the S-100 showcased in a one-week trial its range, endurance and speed, as well as its maritime surveillance and detection capabilities, to the Hellenic Navy.

The US Navy showcase was a combined demonstration sponsored by the US Office of Naval Research (ONR) on a commercial vessel off the coast of Pensacola, Florida. Schiebel and Areté demonstrated the CAMCOPTER® S-100 and its capabilities, as well as Areté's Push-broom Imaging Lidar for Littoral Surveillance (PILLS) system.

Another milestone for the company was receiving the Light Unmanned Operator Certificate (LUC) as the first UAS manufacturer in Europe. On 25 February 2021, Schiebel was issued the LUC, which enables the company to self-authorise operations, within the defined scope and privileges, in civil airspace without applying for authorisation. For Schiebel these

programme, as well as the Naval Shipborne Unmanned Aerial System programme for India's Navy. ■



CAMCOPTER® S-100 US Navy demonstration

LINCAD'S ARMADA OFFERS SOLUTION FOR BATTERY TRANSPORTATION, LABELLING, CONDITIONING AND STORAGE

LINCAD

Transporting Lithium-ion batteries is not a straightforward business. According to IATA regulations that came into effect in 2016, lithium-ion batteries must be at a 30% state of charge (SoC) or less before they can be transported safely. This is to ensure that the batteries remain as stable as possible while in the air.

Battery consignments intended for transport by air must carry official printed labelling to confirm that they have been correctly prepared and conditioned. Equally, there are rules and best practice guidelines around how batteries should be stored when not in use. This involves discharging them to 50% SoC for optimum storage conditions to maintain good long term battery health.

All of these rules and regulations add up to a logistical headache for sectors that rely on the efficient transport and storage of Lithium-ion batteries. These sectors include not only the demanding defence arena, but also commercial customers and organisations working in logistics that rely on batteries and power packs being where they need to be on time, and in safe working order.

That is where a battery conditioning system comes in to play, such as the Armada from Lincad. The UK battery, charger and power management systems supplier launched its six-channel, multi-chemistry battery conditioner in 2018.

Designed primarily for military applications, the Armada provides the ideal solution for automatically charging and



Armada



Lithium-ion batteries must be kept at a 30% state of charge (SoC) or less before they can be transported safely.

discharging batteries, ready for air transport or long-term storage. It is designed for use with Lithium-ion and other battery chemistries, as well as being compatible with IrDA and SMBus smart batteries, plus those with no communications interface. The Armada enables batteries to be discharged down to 30% or less, ensuring that they comply fully with the IATA regulations around state-of-charge during transit.

The Armada from Lincad is highly durable and versatile, making it perfect for hostile military environments. It is powered by a universal AC mains supply and can be mounted on a bench or 19" rack. The system can also accept software updates from a laptop, PC or mobile device to allow a high degree of future proofing. The conditioning system has an AC input of 90–240V and weighs approximately 16 kilos for ease of transport.

The Armada system works with Lincad's entire range of specialist batteries and can also be used with third party batteries that have been designed for use by military, defence and other demanding sectors. It is also compatible with Lincad's conditioning equipment label printer system, adding another stage of the battery air transit and storage process to its list of logistical capabilities. Clear, comprehensive printed labelling can help users tell at a glance which batteries are being transported and the state of charge of each one. This is crucial information to ensure the safety of everyone on board a flight transporting the batteries. Being able to read the statistics at a glance also helps prevent delays and miscommunications when the batteries are being checked into, or out of the cargo hold of the plane.

Lincad's labelling system can be installed as a factory add-on to the Armada and allows up to 16 conditioning units. This means that a grand total of 192 battery conditioning channels can be connected at any one time for rapid, user-scalable labelling. Each automatically printed label bears the relevant battery's chemistry type, state of charge and importantly 'recharge by date' to provide a traceable indication of its suitability for transport and/

or storage. It can be customised to include all appropriate pieces of information and alternative label types can be added to reflect new conditioning equipment operating modes.

Peter Copplestone, Director of Operations at Lincad said, "The Armada from Lincad really is a 'one-stop-shop' when it comes to battery management on the move. We already have the UK Ministry of Defence as a major customer and are also looking at various European defence forces. The Armada delivers significant logistical and operational benefits for defence, commercial and logistics organisations. From discharging batteries to meeting storage and air transport restrictions, to printing labels to correctly identify states of charge and conditioning status. The system facilitates safe handling and storage of many different types of batteries and then recharges them when they arrive in situ, ready for immediate use."

Lincad is a privately owned company, operating out of premises in Surrey in the UK. It has built up an enviable reputation after 30 years of experience in the design, manufacture and supply of bespoke batteries, power management systems and chargers. While Lincad mainly works with defence customers in the UK, Europe and beyond, it also sells its products to commercial and logistical organisations. Lincad's power management solutions are prized for their efficacy and high performance as much as they are for their bespoke design and customisation capabilities.

Lincad's engineers take pride in keeping pace with the technological and regulatory demands of its customers. The Armada is an excellent example of this, because it has been created specifically to help customers meet exacting IATA air transit regulations that have come into force in recent years. These regulations exist to protect the health and safety of those overseeing the transport of vital equipment and the batteries that power it.



Armada conditioning batteries

The Armada also enables batteries to be discharged for safe storage and recharged when they need to return to an operational state. This is in direct response to the defence sector's increasing reliance on having batteries available, at the optimum state of charge during demanding manoeuvres in hostile conditions. ■

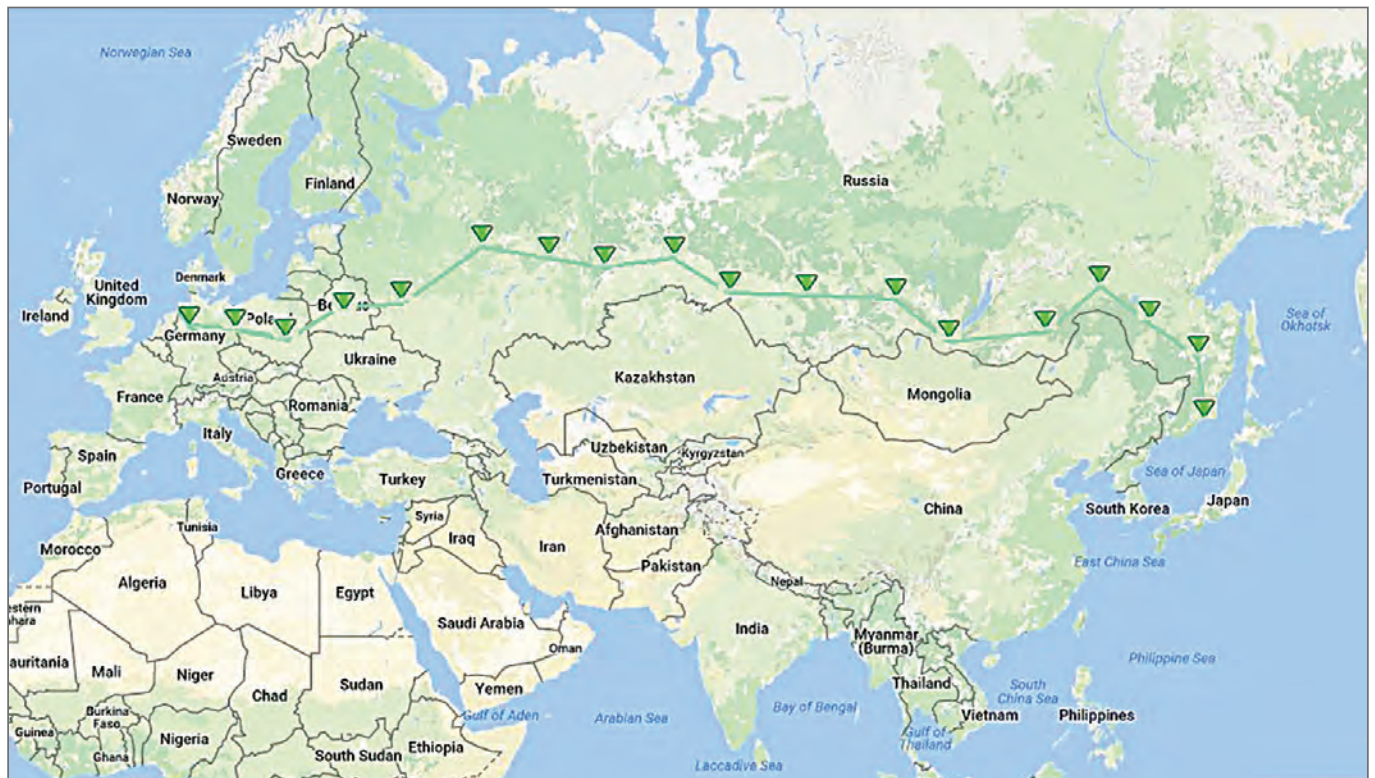
THE MOST SOPHISTICATED TRACKING SECURITY FOR GLOBAL SUPPLY CHAINS

Zenatek

In military supply chains, tracking regulation and security fall under the control of military logistic departments and authorities.

One might assume that these authorities provide cargo monitoring at its best. Unfortunately, there is evidence to suggest that this assumption is not warranted. There are military deployments in which tens of thousands of containers or pallets per year remain unaccounted for, without a proper e-tracking system. Such waste or misplacement of costly resources is bad enough, especially if the resources represent depreciating or perishable assets. Much more importantly, the troops involved may suffer the consequences of improper tracking and may not be as well protected or as well fed as they should be.

Obviously, improperly tracked or missing containers hold not only food items and supplies necessary to sustain the troops and keep them healthy, but also equipment and material, including vehicles, air conditioners, earth moving equipment, and more. It is not unusual for key shipments to arrive late, or to miss transshipment. They may even be untraceable in ports and countries suffering critical logistics issues themselves. Moreover, some transporters have been known to hide their problems, keeping missing containers in certain port yards or other “off-the-grid” facilities. Such transporters are not always happy that clients may want to monitor and analyze the whole transport process to be sure their money has been well spent. There is also the problem of frequent overcharging of demurrage fees to clients.



Tracking of goods equipment from Europe to Russia

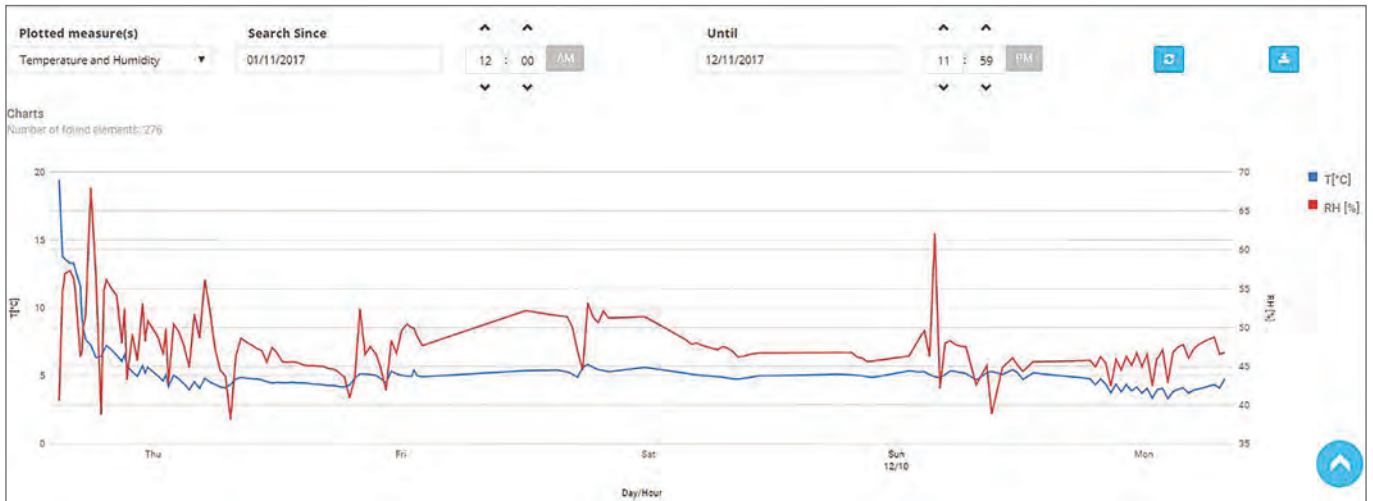


Chart of temperature and humidity related to a transport of ammunition

With modern, technologically advanced real-time monitoring provided by Zenatek Tracking Service (ZTS), these problems can be eliminated quickly and efficiently. Our service is very reasonable and cost-effective, and we have a proven track record of excellence in the field. Today, we track goods globally and have recently expanded our service, extending it to a much broader range of goods without sacrificing the discretion our client's demand.

ZTS was designed with an eye to maintaining strict cost control. Our primary aim was to develop a rock-solid goods tracking system that would remain affordable while meeting the needs of our service's end users. We have created a system that is intentionally simple and stable, based on user-friendly web-based software. For practical purposes, it is not necessary to verify the location or positioning of the goods every 30 minutes. Nor is it necessary to implement overstated monitoring requirements that increase battery costs and may lead to the hardware device being returned to the sender. However, it is critically important to have the capacity to determine and trace all shipments' routes, and to receive immediate alert notices when something unexpected or unpleasant happens to a shipment. These alerts are sent by Zenatek's web-based system via e-mail to any computer, smartphone or other device assigned by the client.

To provide an accurate geographical position for a monitored shipment at any point, the ZTS tracking device may use its internal GPS, which is compatible with the GPS/Glonass standard and is also Galileo-ready. Alternatively, it can leverage information from mobile network cellular towers. The user can remotely configure all of the system's communication parameters, even after a shipment has departed the loading point.

ZTS can also store a container's packing list, password-protected, in the web-based application, together with lading

documents and health certificates, thereby enabling the receiver to trace the shipment's contents and route with a mere finger-click on a tablet. The ZTS device will also trigger alarms when a reefer container's internal temperature and humidity deviates from a predetermined level set by the client. It then alerts the user when the temperature and humidity return to the required level. Additionally, it will alert the user if flammable goods within a container are approaching the point of ignition, or if a container's doors or a pallet's seals are subjected to tampering. It will similarly alert the user if a container or pallet is turned on its side, capsized or involved in a destructive incident.

The ZTS device has geo-fencing capability. This means that if a trailer or container is placed in a new location or moved to another part of the current port, the device will wake up and alert the user. The device also provides geo-coded proof-of-delivery information to the client, who can then rest secure in the knowledge that the shipment has reached its destination, and that there has been no unauthorized opening of a container's doors or tampering with a pallet. The device conforms to international regulations, including FCC and EU standards, not to mention that it is also HERO compliant.

Other currently available tracking technologies do not fare well in performance comparisons with ZTS, and some of those products can be very expensive. In fact, some operate based on monthly fees, or payments per communication received by the client, or both. Zenatek, on the other hand, designed and manufactured ZTS with affordability in mind. ZTS devices need not be retrieved at destination points because all traced route and shipment information is in the system and has already been transmitted – the devices may be used on a "one-way" basis. This eliminates all costs associated with unit and data recovery

ZENATEK SPONSORED STATEMENT

tasks, such as recovery personnel costs, and unit forwarding, reconfiguring, and restocking. These aspects of ZTS in particular make it ideal for military logistics applications.

Pallets may be transported and tracked in containers; they may be transferred to train or truck, and then reloaded into containers based on any intermodal chain. ZTS will track accurately and provide status reports throughout, monitoring for any damage, tampering, interference, or deviations.

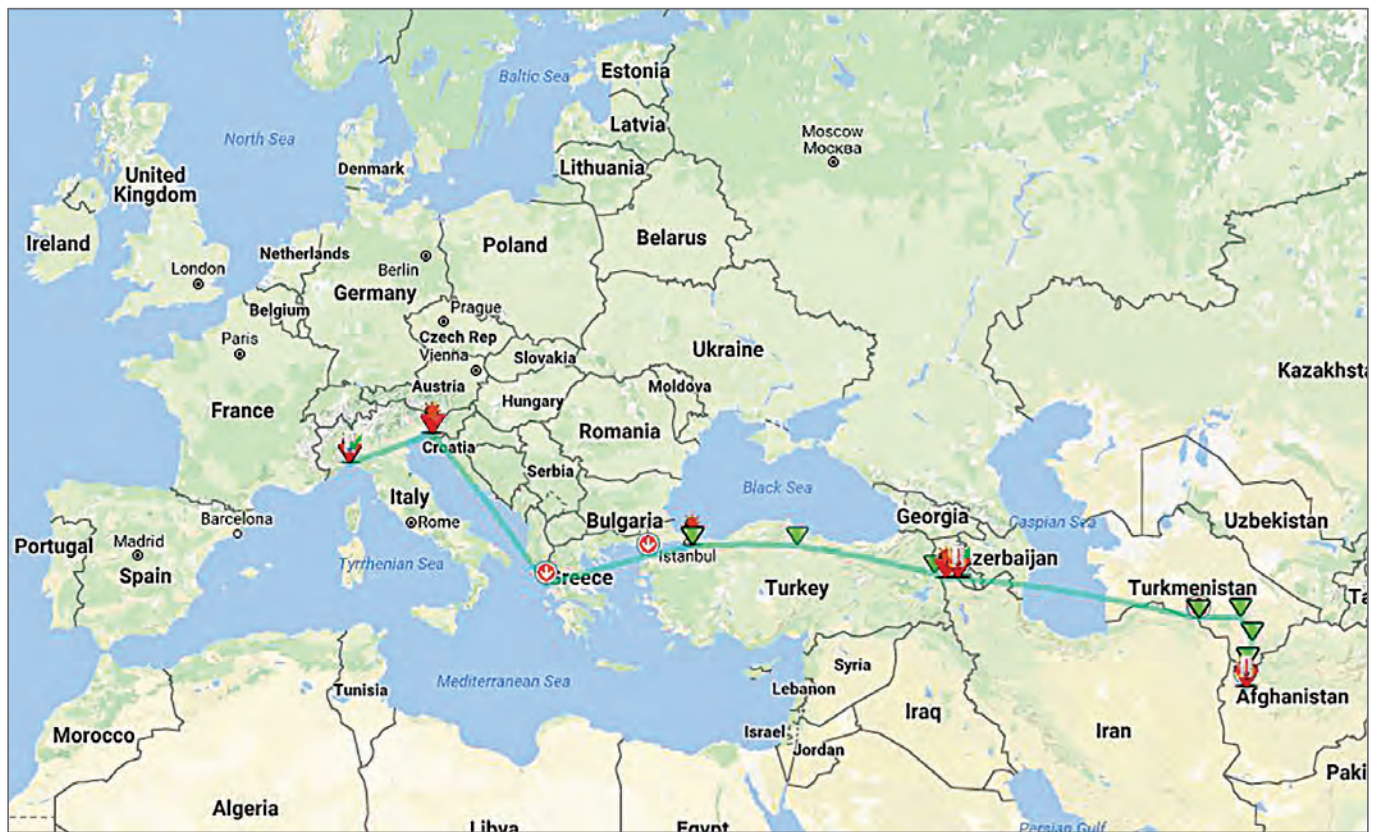
Real-time status updates and event alerts allow users to respond quickly to changes and emergencies. ZTS affords users the possibility of prompt, effective damage control, even to the extent of rerouting an entire shipment if necessary. The benefits are obvious, particularly with respect to time-sensitive or temperature-sensitive shipments.

Users can also elect to provide receivers with access to ZTS web-based applications, so that they are equally informed as to a shipment's status and current location. Clients can predetermine the range of the information to be made available; they may change access to and frequency of status updates for any or all of the available information. All data is contained within an encrypted data stream for full security, maximum confidentiality, and protection.

Today, one of the mostly frequently used tracking technologies is RFID (Radio Frequency Identification). Unfortunately, RFID technology depends on the acquisition of a costly infrastructure of porticos and hardware at fixed sites, or unreliable hand-held transceivers that need constant maintenance. In fact, an RFID device could, at least theoretically, be manipulated to form part of a weapon (for instance, as a triggering device) designed to attack a specific shipment.

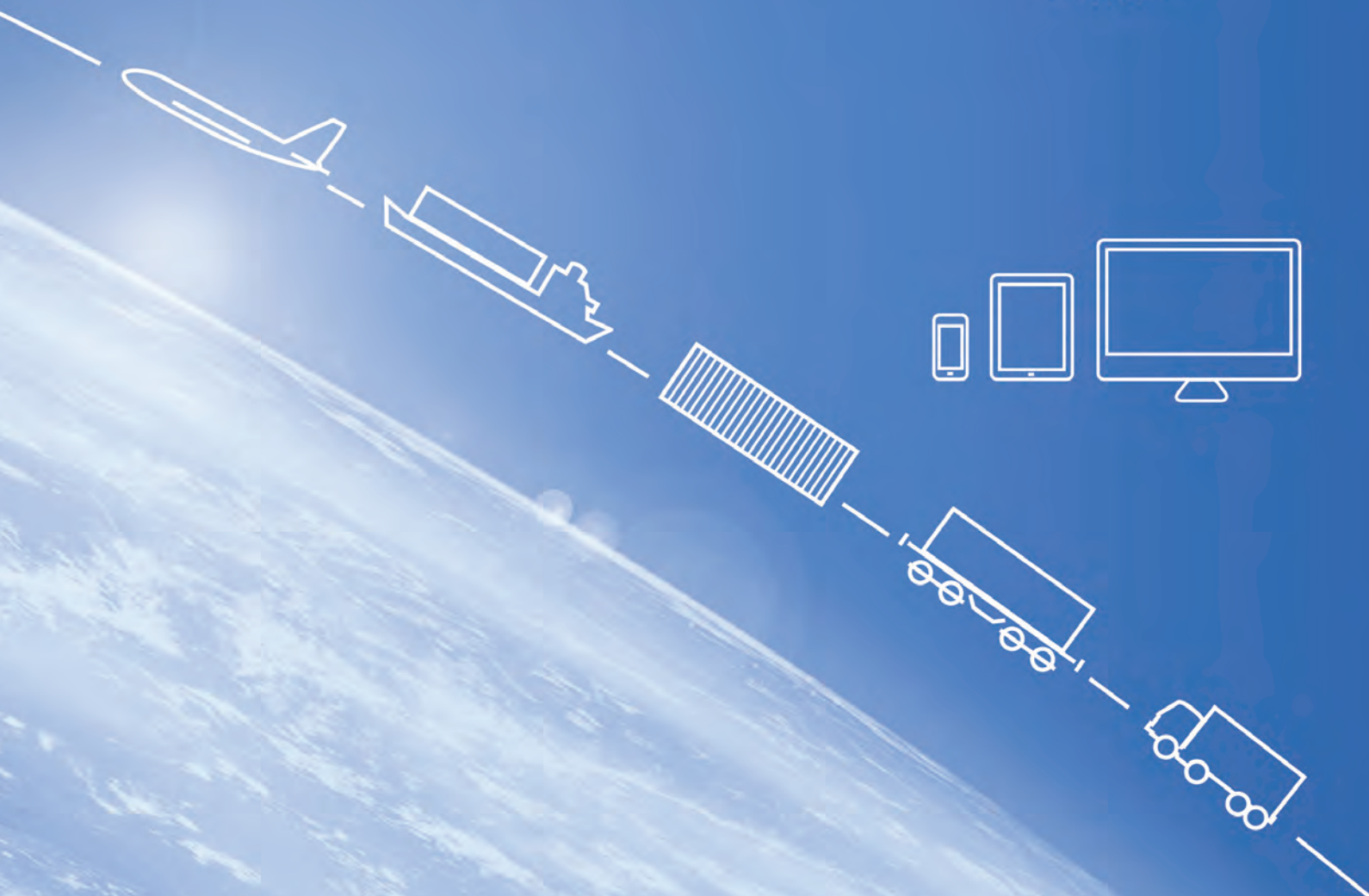
ZTS leaves RFID technology and its associated problems and expenses behind. With ZTS, clients now have access to a one-price solution that includes all costs associated with the technologies and services provided.

We live in a world that seems increasingly insecure, and there are those who would resort to violence in their attempts to disrupt international civil and military supply chains. The threat of terror attacks targeting global logistics through vulnerable transport systems can never be eliminated, but it can certainly be reduced. The continuing use of unchecked and unmonitored containers, pallets, trailers, and rail cars, when viewed in combination with current business practices in many congested ports, represents a hidden but very real danger. With Zenatek service these potential threats can be seriously reduced. ■



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