THE TRUSTED SOURCE FOR DEFENCE TECHNOLOGY ANALYSIS

ARMADA INTERNATIONAL

DECEMBER 2018/JANUARY 2019. Issue 06.

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A US Marine Corps chemical, biological, radiological and nuclear defence specialist wearing a Mission Oriented Protective Posture level four (MOPP-4) suit at Camp Pendleton, California, 16 February. 16, 2018. (*USMC*)

THE TRUSTED SOURCE FOR DEFENCE TECHNOLOGY ANALYSIS

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THIS MONTH ON ARMADAINTERNATIONAL.COM

■ SENER AND BABCOCK DELIVER THE SIXTH UPGRADED AB-212 HELICOPTER UNIT TO THE SPANISH NAVY

The engineering and technology group SENER and Babcock have delivered the sixth helicopter to successfully complete its life extension program (PEVH in its Spanish acronym) to the Spanish Defence Ministry's General Armaments and Materials Department (DGAM in its Spanish acronym).Thanks to this program, seven Spanish Navy AB-212 helicopters that became operational in 1974 will have their useful life extended by at least 15 years, thanks to the addition of advanced equipment and avionics. The seventh and last unit will be delivered by the end of 2018.

■ US COAST GUARD CONTRACTS PRIORITY 1 AIR RESCUE FOR HOIST OPERATOR TRAINING

Priority 1 Air Rescue (P1AR), a world leader in helicopter Search and Rescue (SAR) mission operational support and training, is pleased to announce that it has been awarded a contract by the United States Coast Guard (USCG) to provide instructor led ab-initio to advanced level helicopter hoist operator training for flight mechanic aircrews operating both the MH-65 D/E and MH-60T helicopters.

■ U.S. MARINE CORPS AWARDS RHEINMETALL PRODUCTION ORDER FOR MK281 MOD3 40MM PRACTICE AMMUNITION

The United States Marine Corps has just contracted with Rheinmetall to produce and deliver 40mm practice ammunition.The ammunition, specifically the 40mm x 53 MK281 MOD3 High Velocity Practice Day/Night Marking Cartridge, will be produced in Camden, Arkansas and shipped from

American Rheinmetall Munitions (ARM), a Rheinmetall subsidiary based in Stafford, Virginia. Total order volume amounts to US$59 million (€51 million).

■ BELGIUM LAND COMPONENT

Nexter and CMI Defence have signed a cooperation agreement which is in the continuity of the intergovernmental agreement between France and Belgium concluded within the framework of their strategic partnership in military cooperation, as well as the appointment by the French government of Nexter group as winner of the "Motorized Capabilities" program (CaMo).

Editorial

Russia's strategic reach demonstrated

The arrival of two Russian Air Force Tupolev Tu-160 Blackjack supersonic bombers on 10 December into Maiquetia airport near Caracas in Venezuela should be viewed not as a gamble by Russia's President, Vladimir Putin, but an act based on the conviction that it is very unlikely to result in a crisis or dramatic response from the United States.

While this is no re-run of the 1962 Cuban Missile Crisis, the aircraft are effectively on the southern border of the Caribbean Sea, and within easy reach of the US mainland. During the Cold War this would have been regarded by the United States as a major strategic threat and provocation, although there have been previous visits of the bomber to Venezuela in 2003 and 2008.

Seen as Russia's response to the US Air Force's Rockwell B1 Lancer, the Tu-160 is not a new aircraft. Its first flight was in 1981 and serial production began in 1984. Like the B1 Lancer, both are supersonic bombers with a variable sweep wing and are capable of delivering nuclear weapons. At a speed of over Mach 2 at 40,000 feet, were the aircraft to permanently be based in Venezuela the threat to the United States would be strategically increased, although as yet there is no declaration of intent to do this.

The aircraft type is also undergoing modernisation to a Tu-160M2 standard at the Kazan Aviation Plant which will equip it with more modern and powerful engines. It will also be based around a single airframe and carry the latest cruise missiles, although deliveries and not expected until the early 2020s. It is nevertheless more of a capability increase than a 'game changer'.

But this seems to be part of the Russian government's long-term and expanding plan to regain strategic presence and influence around the world. On the Black Sea, NATO warships patrol off the Crimea in a bid to show support to Ukraine, an act which is certain to be seen in Russia as a challenge in its own 'back yard'. The firing on, and seizure of, three Ukrainian naval vessels in November was a move to deny Ukraine commercial access to its ports on the Sea of Azov and perhaps proved that such actions could not be prevented by NATO.

Patrolling in 'home waters' is a challenge has also been extended the other way. In 2008 the Russian battlecruiser *Peter the Great* with its support vessels travelled to the Caribbean and exercised with the Venezuelan Navy for a few days before travelling on to South Africa and India where this time it exercised with the Indian Navy. After a six month world tour it returned home.

Russia's support of Syria's President Bashar al-Assad has been a landmark event in Russian power projection. With a joint force operating in a hot war on the shores of the Mediterranean, the message to the international community has clearly been to demonstrate that, like its NATO adversaries, it can deploy and operate an expeditionary force over the long term. While still not at the same level as NATO countries, Russia's power projection looks set to grow.

ANDREW DRWIEGA,
Editor

Russian MOD

The Luch Design Bureau's multirole Korsar MALE UAV is entering production equipped with an electronic warfare (EW) system.

RUSSIA'S RAPID UAV EXPANSION

In eight years Russia has increased its operational UAV fleet to over 2,000 systems, with new types currently under development.

David Oliver

Since the beginning of the anti-terrorist operation in Syria in September 2015, Russian unmanned aerial vehicles (UAVs) have performed more than 23,000 flights amounting to a total of 140,000 flight hours. Headed by a specialised department of the General Staff of the Russian Armed Forces, commanded by Major General Alexander Novikov, the UAV units have provided round-the-clock monitoring of the ground situation throughout Syrian territory. In addition, Russia claims that the use of unmanned aircraft ensured the effective use of precision weapons on the infrastructure of international terrorists and at the same time excluded possible casualties among the civilian population.

General Novikov has stated that the Russian Army now has some 1,900 UAVs in service and unmanned aviation services have been created in the headquarters of military districts and formations, with UAVs being used in almost all operational and military training activities.

Exercise *Vostok* 2018 in September 2018 involved more than a quarter of a million troops and included some 1,000 aircraft, helicopters and UAVs. Special tactical exercises involving UAV crews took place at three training grounds in the Leningrad, Voronezh and Moscow regions during which UAV crews gathered intelligence for motorised rifle, tank, artillery units, and escort reconnaissance groups over various terrains. These exercises involved some 500 servicemen and up to 20 unmanned aerial systems (UAS) including Grushas, Eleron, Granat, Orian-10 and Forpost.

The Grusha is a hand-launched short-range mini-UAV produced by the Izhmash JSC, now part of the Kalashnikov Group, which has entered the inventory of Russia's Baltic Fleet. The Eleron-3 is a short-range tactical tailless delta UAV with a maximum takeoff weight (MTOW) of 5.3kg carrying a 1kg payload. Manufactured by ENICS JSC it has a speed of 56 knots (104km/h) and operates at a maximum altitude of 13,123 feet (4,000m).

The Izhmash Granat-4 has a MTOW of 30kg, with a 3kg payload. With a 3.2m wingspan it has a cruising speed of 49kts (90km/h), an operational range of up to 70km, and a maximum flight altitude of 11,500ft (3,500m). The 3.1m wingspan Orian-10 manufactured by the Special Technology Centre is one of Russia's most prolific UAVs. With a MTOW 16.5kg carrying a 2.5kg payload it has a speed of up to 80kts (150km/hr), a mission radius of 500km and a flight endurance of 16 hours. The Orian-10 is launched by a collapsible catapult and

Russian MOD

The medium-range Orian-10 UAV has been used operationally in Syria and over the Ukraine.

recovered by parachute landing.

The Forpost is a Russian license-produced version of the Israel Aerospace Industries (IAI) Searcher II long-endurance multirole UAV.

Following collaboration with the Austrian company Schiebel in 2011, the Russian company OAO Gorizont (Horizon) has been building the rotary-wing Schiebel S-100 Camcopter UAV under license for the Russian market. Based in Rostov-on-Don, Horizon manufactures electrical and optical equipment, navigation radar modules and systems and equipment for monitoring land, coastal and marine environments.

During the 2014 Winter Olympic Games and Paralympics, a Horizon Air S-100 operated from Sochi up to 50km from the Black Sea shoreline around the Olympic village. The Russian built S-100 has also been evaluated by the Russian Coast Guard and successfully tested aboard the Russian Rubin-class Maritime Border Patrol vessels being built for patrolling the Black and Caspian seas, with the UAV.

After trials carried out on the icebreaker *Captain Sorokin* in the Baltic Sea the Horizon Air S-100 was selected to operate from Russia Navy's new generation icebreaker, *Viktor Chernomyrdin*.

The research and development company Radar MMS is developing a small unmanned helicopter, the GSV-37 Breeze, for the Russian Navy. The Breeze is designed for monitoring large areas from the air, providing search and rescue, patrol and security, and counter-terrorism support. The MTOW of the UAV is 35kg, and it has an endurance of 90 minutes operating up to 3,280 feet (1,000m).

The annual Falcon Hunting international UAV contest was part of the Russian International Army Games 2018 involved teams from Belarus, Iran, Kazakhstan and Russia. This year, the competition held at the Matibulak training ground in Kazakhstan included a new element, air reconnaissance at night over enemy forces. The three-day event culminated in the participants competing to find objects in three reconnaissance districts with the area from nine to 25 square kilometres at a distance from 10 to 35km from starting position of the UAV.

The host team from Kazakhstan team

Russian MOD

More than 200 Eleron-3 short-range tactical UAVs manufactured by ENICS JSC are in service with the Russian Armed Forces.

David Oliver

An unmanned VTOL Horizon Air S-100 displayed on a portable helipad has been deployed to Russian Navy icebreakers.

won the 2018 Falcon Hunting contest with Russia in second place and Belorussia in third. A month after the Falcon Hunting competition, forces returned to Kazakhstan in October to participate in the tactical exercise Search 2018 at the Matibulak and Gvardeisky training grounds for Collective Security Treaty Organisation (CSTO) countries,. Troops from Armenia, Belarus, Kazakhstan, Kyrgystan, Russia and Tajikistan took part in the Search 2018 manoeuvres. The Russian forces in the exercise were represented by scout units and special forces (SOF) units of the Central Military District, a total of over 300 troops, supported by two Sukhoi Su-24MR in-telligence aircraft, and Orlan-10 and Forpost UAVs.

LESSONS FROM UKRAINE

While the Russian Armed Forces' UAV capability is being rapidly expanded, recent operations of their first generation systems have shown how vulnerable they are to both ground and air attack. Russian Orlan-10s have been actively used against the Ukraine during the armed conflict in the Donbass region although aerial reconnaissance by unmanned aerial vehicles is banned by the Minsk agreements. Ukrainian officials have claimed to have shot down or captured at least ten Orlan-10s and two Forpost UAVs since 2014. In October 2018 a Russian Orlan-10 was reported to have been brought down by a Mi-24 helicopter operated by Ukrainian Air Force, over city of Lysychansk in Ukraine.

Russia's priority is now to develop a new generation of medium altitude long-endurance (MALE), high-altitude long-endurance (HALE) and armed unmanned aerial systems.

The Korsar UAV being developed by the Rybinsk-based Luch Design Bureau, part of Ruselectronics Group, was first shown in public during the 2018 Victory Day Parade in Moscow. Powered by a piston engine with a pusher propeller, the 6.5m wingspan 200kg Korsar has a maximum speed of 80kts (150km/h) and 120km mission radius.

In September 2018 the Kronshtadt Group, a subsidiary of Joint-Stock Financial Corporation Sistema, unveiled a strike-capable variant of the Orion-E MALE UAV. With a wingspan of 16m and an MTOW of 1,000kg the Orion-E is capable of automatic take-off and landing carrying surveillance payloads of up to 200kg. It has service ceiling of 24,500 feet (7,500m), a range of 250km and an endurance of 24 hours.

The Reaper-class air vehicle has an electro-optical/infrared (EO/IR) turret as well as a laser rangefinder/target designator. Additional sensors, including an electronic intelligence system, high-resolution photo camera, or a radar can be carried as well a variety of guided and unguided air-to-ground weapons. The air vehicle can be disassembled and transported along with its technical support systems and ground control station (GCS) in a standard cargo container.

The Kronshtadt Group is also developing an even more advanced version of the Orion-E designated Orion-2 that will be the first HALE UAV in the company's portfolio. The air vehicle is understood to have a MTOW of 5,000kg, a maximum flight altitude of nearly 40,000 feet (12,000m) and a speed of 189kts (350km/h).

The Russian Navy also has a requirement for ship-based unmanned aerial systems (UAS) which is being addressed by a number of advanced UAV projects. The Fazan is a vertical take-off and landing (VTOL) tail sitting air vehicle to fulfil a

The Radar MMS VTOL GSV-37 Breeze UAV has been evaluated by the Russian Navy.

Kronshtadt

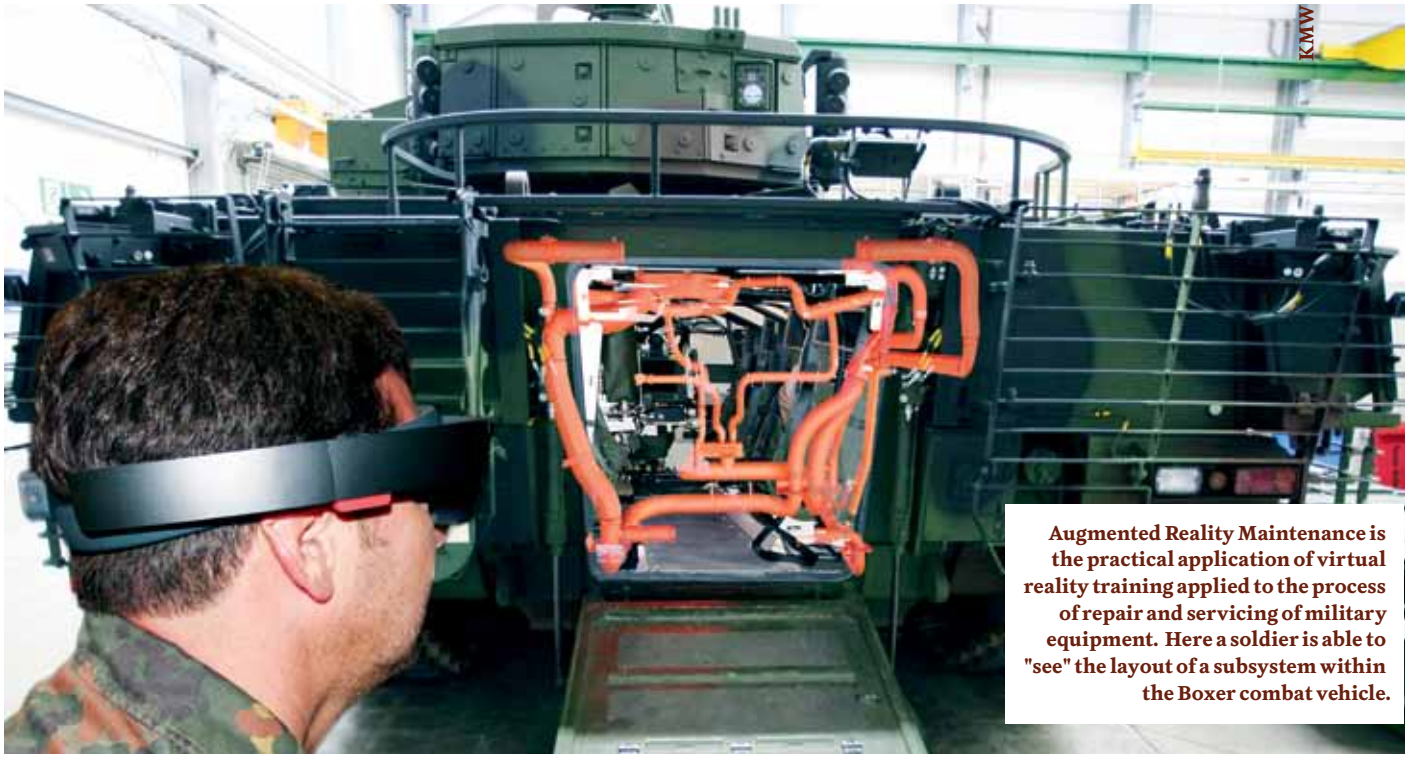
The Kronshtadt Group is developing Russia's first strike-capable MALE UAV, the Orian-E.

number of urgent military tasks including reconnaissance and surveillance, in particular, during the operations from ship's deck, as well as vertical replenishment (VERTREP) missions. The MTOW of the Fazan will be up to 500kg with a 60kg payload. The cruising speed is predicted to about 189kts (350km/h), a range of 1,000km and an endurance of six hours.

The Russian Navy Commander-in-Chief's directorate has revealed that a modular UAS is being developed for its Project 22160 corvettes and is now being prepared for trials. The UAS includes two co-axial Radar MMS BPV-500 VTOL UAVs. With an MTOW 500kg the 5m-long air vehicle can carry a 150kg payload over a range of 320km and 5.5 hour endurance.

Equipped with an optronic sensor system and SAR/MTI radar, the system is designed for aerial monitoring of large areas, including for on-ice reconnaissance, support of search and rescue operations, surveillance and anti-terrorist missions. Over time, UAVs may be armed with missiles and bombs, which will enable them to perform combat duties. The BPV-500's co-axial design ensures high hovering accuracy, making it less vulnerable to cross winds which is essential in landing on to a small ship. The air vehicles and their equipment including the operator's workstation, can be accommodated in one or two standard cargo containers placed on deck of a ship.

In the last five years Russia has also made huge leaps in unmanned technologies. In 2011 Russia possessed only 180 UAV systems. That figure now stands at 2,000. The majority of those platforms have been assigned to land and airborne forces with capabilities limited to intelligence, surveillance and reconnaissance. Russia's armed forces currently have no armed UAV capability although over $10 billion (€9bn) has been earmarked for combat UAV programmes by 2020. A



Augmented Reality Maintenance is the practical application of virtual reality training applied to the process of repair and servicing of military equipment. Here a soldier is able to "see" the layout of a subsystem within the Boxer combat vehicle.

FIELD MAINTENANCE IN EXPEDITIONARY OPERATIONS

Keeping an army effective and up to strength is the job of the maintainers, who can now call on a wide range of technology to help with this task, from health monitoring systems to virtual reality repair guides.

Stephen W. Miller

For today's military commander one of the most critical concerns is the readiness of his unit's weapons and equipment. The technical term is system availability, and refers to equipment ready for operations at any given time. A lack of sufficient mass can mean a reduction in firepower or being able to concentrate the right size of formation at a precise place and time.

Maintaining a high availability is particularly critical for forces engaged in expeditionary operations. Here a commander is strictly limited to that equipment that has been brought by sea or air and must keep these systems running and fully capable not only to conduct operations but to maintain enough strength until resupply is available.

Maintenance and repair in expeditionary operations faces unique challenges not faced by units with established rear area facilities, as most activities need to be self-sustaining. While it is true that systems have become more complex and challenging to maintain and repair, similarly a number of technologies have surfaced that have facilitate these activities and allow them to be accomplished more rapidly and at a lower organisational level.

INTEGRATED HEALTH MANAGEMENT SYSTEMS (IHMS)

In the past, maintenance was performed based on an arbitrary schedule based on a certain period of time such as annually or upon reaching a set number of miles or hours. This schedule maintenance often did not reflect actual wear or need. On the other hand repair was made only when a failure actually occurred and something broke. The former could occur in the middle of an operation, thus, robbing the commander of assets until repair was completed. The IHMS seeks to allow predictive maintenance and repair by continuously collecting, storing and cataloguing data from various components of the vehicle, aircraft or other subsystems on their use and status.

This data base is then analysed either by onboard computers or down-loaded by maintainers and compared to a broad historic data base to identify potential component failure before they occur.

Lino Massafra, vice president Sales and Marketing for North Atlantic Industries, an IHMS manufacturer, states: "By identifying potential faults and failures, the proper corrective action can be taken. Such decisions enable the maintainer to better schedule maintenance based on actual performance and condition of an asset itself or any of its parts rather than when a component fails." IHMS can be incorporated in many platforms but has been particularly attractive in aircraft and vehicles. It offers new possibilities for achieving more efficient

maintenance and repair, as well as, significantly reducing down-time.

The practical value of the continuous monitoring of subsystem performance and status was illustrated by a Bell/Boeing representative in describing the IHMS incorporated into the next generation V-280 Valor tiltrotor. The V-280's system not only detects a failing part but can automatically report this back to the maintenance team on the ground even while the aircraft is in flight. With this information the ground crew can obtain the necessary parts and execute a repair as soon as the aircraft returns. With the introduction of wireless digital data networks and integrated messaging this same capability is possible for virtually any system. Predictive repair actions can anticipate and pre-emptively correct a failure.

INTEGRATED ON-BOARD DIAGNOSTICS

When IHMS and local processing capacity can be combined the result is integrated on-board diagnostics. On-board diagnostics both offer an initial indication to the crew of a potential fault or failure as well as a conduit for more indepth analysis by maintainers. These systems continuously monitor and in some cases record a history of the performance of various key components on the host system. As a result they allow for the early detection of a problem allowing intervention before it becomes more serious. Oshkosh Defence's Command Zone incorporates on-board diagnostics as part of a broader integrated vehicle digital network. The Command Zone will not only self-diagnose but can periodically or when a condition occurs, report its status to outside monitors. In this way the readiness of the system is know to maintainers who can anticipate and plan corrective maintenance. The result is true 'conditional maintenance' which can lead to scheduled maintenance allowing the system to be ready for anticipated operations.

LINE REPLACEABLE UNITS (LRU)

Recognising that maximising system availability is the primary objective of maintenance and repair actions it directly follows that the time and effort required to get a system, especially a critical tactical system, back into action should be ideally as short as possible. The LRU approach is a response to this. Equipment is designed so that components can be easily accessed and removed and replaced. Repair of the LRU component will occur later; the attention of the front line maintainer is in getting the host system back in operation as quickly as possible. Initially adopted for aircraft, the practice has been widely adopted to ground and naval systems. Hennie Smit, business development manager at Denel Vehicle Systems explained that 'optimising to maximise operational availability is a key objective in our combat vehicle designs. For example the RG35 emphasises rapid replacement of subsystems with minimum

DEMONSTRATION TOUR OF ANSAT AND MI-171A2 HELICOPTERS IN SOUTHEAST ASIA

Potential customers from Vietnam, Cambodia, Thailand and Malaysia had an opportunity to learn about functionality of brand new Mi-171A2 and Ansat helicopters during their demonstration tour through Southeast Asia. The first demonstration of the new products by Russian Helicopters (part of Rostec State Corporation) was held on November 16 in Vietnam.

Mi-171A2 and Ansat helicopters finished their participation in Airshow China 2018, an international exhibition which took place in Zhuhai (China) on November 6-11. The helicopters were displayed statically, and demonstration flights were arranged as part of the airshow flight program. Afterwards, both machines flew to Hanoi (Vietnam), Phnom Penh (Cambodia), Pattaya (Thailand), Kuala Lumpur (Malaysia) for demonstration flights.

"Following Airshow China, I can note that interest in Russian helicopters increases significantly, especially after their participation in the exhibition's flight program. Russian Helicopters has reliable partner relationships with Southeast Asian countries, so we expect that the demonstration of Mi-171A2 and Ansat helicopters' functionality will allow us not only to hold meaningful negotiations with potential customers, but also to sign soft contracts for these machines," said Andrey Boginsky, CEO of Russian Helicopters.

He added that, generally, Southeast Asian operators highly appreciated helicopters made in Russia, especially for firefighting, as well as transport and building and assembly work in hard-to-reach areas.

Also, Russian Helicopters rapidly develops the service center infrastructure in the region. Helitechco, a Russia-Vietnam joint venture, has operated since 1994. It repaired over 80 civil helicopters of state and commercial customers from Vietnam, Laos, Cambodia, India, Australia and New Zeeland. Helitechco is the only repair service in Southeast Asia where professionals from Mil Moscow Helicopter Plant monitor the repair processes.

In February 2018, a memorandum of intent was signed with a Thai company Datagate. Assistance on arranging a service center for maintenance of Russian helicopters in Thailand is among areas of cooperation mentioned in the document. This center is expected to provide with routine and repair operations, troubleshooting, and replacement of components. Additionally, parties determined a capacity for supply of replacement parts and repairing assemblies for civil helicopters under stand-alone contracts.

Ansat is a light twin-engine multi-purpose helicopter massively produced by Kazan Helicopters. According to the certificate, the helicopter design allows transforming it into a freight or passenger version suitable for transportation of up to 7 people. High-altitude tests of Ansat have been successfully completed, which confirmed the possibility of its use in mountainous terrain at altitudes up to 3,500 meters. In August 2018, the Federal Air Transport Agency (Rosaviatsiya) gave Kazan Helicopters an approval for the main change in increasing the capacity of several assemblies and systems of Ansat based on the results of certification, which makes the helicopter more attractive for operators and potential customers.

The helicopter equipped with the medical module can be used to administer first aid and evacuate patients even in difficult terrain and remote areas with lack of transport accessibility. Moreover, the Ansat medical module provides for patient resuscitation, intensive therapy and continuous monitoring of the injured persons' vital functions during their transportation to hospital.

Mi-171A2 is the latest modification of Mi-8/17/171 helicopters. The helicopter is equipped with VK-2500PS-03 engines with a digital control system, as well as with more efficient X-shaped anti-torque rotor and an updated lifting rotor with composite blades and a refined airfoil section. The cruise and maximum speeds of the Mi-171A2 helicopter are 10 percent higher and the payload capacity is 25 percent greater than that of the mass-produced Mi-8/17 helicopter. The helicopter can be used successfully day and night, in high altitude, extreme temperatures, high humidity and over water.

Mi-171A2 is equipped with KBO-17 digital on-board glass cockpit equipment suite, including both the aircraft navigation system and the data display general helicopter equipment system, which allowed to reduce the crew up to two members. Video cameras improved the view while operating with external load. The safety level was increased due to using terrain awareness warning and collision warning systems.

The helicopter provides passenger transportation and is available in transport, passenger, and VIP versions.

RUSSIAN HELICOPTERS

South-Tek Systems

The N2Gen HPC-1D Deployable Field Nitrogen Generator is a stand-alone system that provides high purity pressurised N² on-site. Fully deployable it operates using either line or military generator set power allowing it to be employed in garrison and in remote field environments where N² would be unavailable.

steps.' Suspensions can be replaced by removing only four bolts and even the entire driver's dash can be removed and replace in under 15 minutes. The LRU approach is equally useful in correcting battle damage as it allows forward repair actions that would otherwise be impractical or require a vehicle to be evacuated and out of action.

3D PRINTING

Having the right part to make a repair can be key. The deployed force can only bring with it a limited number of parts so if the one required is not in-hand it is impossible to make the repair. Over the last few years the use of 3D printing technology has been investigated that allows for a specific part to be fabricated on site even in the field. A Adaptive Manufacturing project officer from the US Marine Corps Systems Command at the recent Modern Day Marine Expo explained: "The 3D technology, also called adaptive manufacturing, can 'print' a single part needed on demand. The technology and processes essentially transforms digital files into physical objects. The digital file might be created by scanning an existing object or by using design software. Software transmits instructions to the 3D printer, and the printer 'prints' the object by adding layers of material until it produces a completed product."

The US Navy began utilising 3D printing onboard ships in 2014 to replicate parts. Since then the US Marines and US Air Force have begun to integrate the capability into its maintenance and support structure. Both the US Army and Indian Army have programmes to integrate direct digital manufacturing into their supply chain. A key benefit is its ability to get parts to the user faster thereby reducing down time waiting for repair. In addition, it can be possible to transfer the digital data necessary to reproduce a part from a distant facility to a user site, thus, permitting them to print it locally no matter where they are located. The approach also lends itself to fabricating parts for older equipment that is no longer in production and for which spares can be difficult to find.

The use of 3D printing is particularly attractive for expeditionary forces. Making use of on-site 3D printing can eliminate the need to carry stocks of spare parts and, to reduce costs, help make them more productive and battle-ready. Since some supplies may be invented in the field, it may also make the armed forces more innovative. In addition, 3D printing requires only the cheaper raw materials and not the finished products.

The US Marines have already demonstrated a field deployable 3D manufacturing system called X-FAB. It utilises CAD-software-equipped computers; a repository of approved, 3D printable digital blueprints; a hand-held 3D scanner; an uninterrupted power supply; a Cosine large-format 3D printer; a LulzBot TAZ; and a Markforged desktop composite printer, all of which are Material Extrusion Machines. Although currently capable of only manufacturing in plastic metal Powder Bed Fusion machines are being added. Parts have already been fabricated by X-FAB and made available in just a few hours versus obtaining them through the parts ordering system which could require days or weeks.

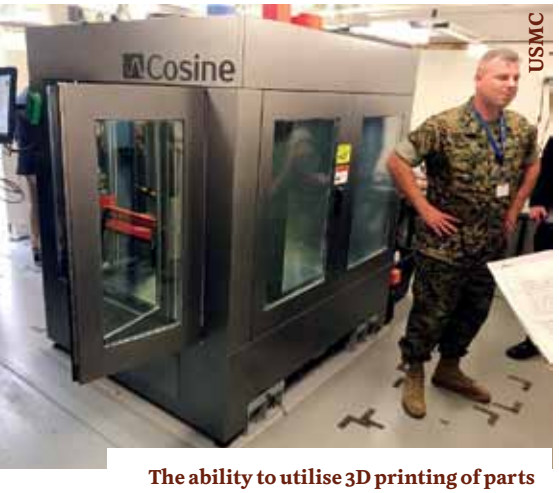
3D printing becomes even more attractive when combined with the IHMS and real-time fault reporting. Having an on-site part manufacturing ability reduces the concern that the part needed might not be in on-hand stocks. It could potentially be fabricated as required and be available when the aircraft returns or to supply the contact team.

ON-SITE CONSUMABLES

The need for self sufficiency goes beyond part. Many pieces of equipment including vehicles, aircraft, and artillery require various fluids or special gasses for functions like suspension ride control, recoil systems, fire suppression systems, night vision and optics, even tires. At home station these can be provided by a vendor that delivers to ones door. When deployed or in the field the maintainers must bring these products which many of which are hazardous and can be dangerous to store and transport especially in a combat zone. Having the ability to generate these products on demand and on-site anywhere offers the advantages of largely eliminating these dangers while also assuring product is available whenever needed.

One such product is pressurised nitrogen (N_2). It is used in night vision systems, vehicle suspensions, helicopter struts, various control systems, fuel tanks and UAV and aircraft tires. Pressurised N_2 cylinders are heavy, difficult to handle and dangerous if damaged. 'The US Marines were one of the first to introduce fully deployable on-site field N_2 generators' explained Scott Bodemann senior vice president at South-Tek Systems. "They integrated our compact stand-alone N_2 Gen low pressure nitrogen generation unit into their electro-optics maintenance systems which were employed in both Iraq and Afghanistan. These field shelters included everything necessary to service and repair sights and night vision. The N_2 Gen draws nitrogen from the air, operates off portable power, and provides nitrogen anywhere eliminating the need for outside suppliers. The systems allowed the Marines to rapidly repair and return sights and NVGs to combat users. The increasing introduction of advanced active suspensions and other military uses of nitrogen caused South-Tek to also develop a fully deployable N_2 system for high pressure nitrogen, the N_2 Gen HPC-1D. Operating from both line power or a generator set it can be used in garrison and the field. It offers N_2 for combat vehicles like the General Dynamics Stryker and Patria AMV, the latest tactical trucks with advanced suspensions like JLTV, artillery including the BAE M777 155mm howitzer, and both fixed wing and rotor aircraft..

An often overlooked field requirement is the need to recharge fire suppression systems. These include the extinguishing agent tanks of automatic fire protection systems of combat and tactical vehicles and aircraft, as well as hand held fire extinguishers. The US Army has developed the Fire Suppression Refill System (FSRS) to provide this capability in the field. The entire system is contained in a hardback



The ability to utilise 3D printing of parts for military systems has been successfully demonstrated. The US Marines are using an expeditionary field 3D printing facility shelter prototype called X-FAB.

shelter that can be carried on aircraft or ship for deployment and placed on a trailer mobilise to be moved on land.
Dan Malinowski, project manager at the Tank and Automotive Command shared: "An inoperable fire suppression system on a system will deadline it meaning it cannot be used. FSRS assures that frontline maintainers can readily repair the system and get the equipment back in service."
The first FSRS will be fielded to the US Army in 2019.

VIRTUALLY ASSISTED MAINTENANCE AND REPAIR

The growing complexity of military systems has increased the difficulty of maintaining and repairing them. This is coupled with the push to both conduct these actions at the lowest level and at more forward locations where resources are more limited places significant challenge to maintainers. A key question is how to provide these technicians the knowledge to undertake the essential tasks necessary to get aircraft, vehicles, weapon systems and other equipment back in service. One solution being offered is though the use of 'virtual reality'. Already increasingly being adopted in simulation for training Krauss-Maffei Wegmann (KMW) has expanded this technology to its application the individual maintainer in real-time. Dr. Joachim Schauss, sales manager for Training and Simulation described the system as "not unlike a virtual reality vision video game where the wearer is shown not only a 3D representation of the vehicle (or other system) but is taken through a repair process step-by-step. This can be purely virtual as training or process familiarisation or as an overlay on the actual equipment. The later would guide the maintainer though each necessary step in the repair or maintenance procedure."

Using Augmented Reality allows a maintainer to take on any number of tasks with a higher confidence even if he has never done it previously. It further ensures that the procedure is performed as intended, thus, eliminating errors that could compromise the process. It is more efficient than using either printed or even video manuals since the users is virtually submerged in the process even as he is doing it. The system also allows for remotely displaying the actions taken by the maintainer in real-time permitting his actions to be overseen by a supervisor who can offer addition guidance. For a maintenance unit in a deployed or forward situation the use of augmented maintenance training permits its members to undertake a wider array of maintenance and repair tasks without having personnel necessarily trained in that specific equipment. As a result repairs can be accomplished that might otherwise need to be deferred for lack of on-site expertise. This coupled with the use of IHMS and on board diagnostics and LRU "replacement rather than repair'" facilitates getting equipment back in service more quickly and closer to the final user.

FUTURE MAINTENANCE AND REPAIR

The appearance of these various technologies has the potential to revolutionise how maintenance, repair and service are conducted. Employed within an approach that capitalises on the new and unique complementary capabilities these technologies offer would have major impacts on how andat what level these actions are conducted. Repair activities could occur as soon as a failure or predicted failure is identified. Employed as part of an integrated maintenance, service and repair and parts supply process these technologies increase the independence and self-sufficiency of forward and deployed forces. The result is faster execution of repair actions with equipment back in service sooner. This then make more assets available to execute missions where and when needed. In the end this 'new' approach to maintenance and repair becomes a capability and combat power multiplier that can provide the critical margin between operational success and failure. A

Commonwealth of Australia

The Royal Australian Navy (RAN) Armidale-class offshore patrol vessel (OPV) HMAS *Larrakia* anchored off Port Moresby, Papua New Guinea. The Armidale-class vessels are to be replaced by the Arafura-class OPVs.

AUSTRALIA'S MARITIME SURVEILLANCE CHALLENGE

With a large coastline and vast territorial seas, Australia faces robust surveillance and wider maritime security challenges.

Dr Lee Willett

In a previous office of the Royal Australian Navy's (RAN's) Sea Power Centre-Australia in Canberra, there used to hang a map that provided a unique perspective on Australia's maritime security challenge. The centre of Australia sat in the centre of the globe-shaped map. Apart from archipelagic island chains running northwest off the map from just north of Australia's northeast coast, all that could be seen beyond the Australian continent out to where the map image curved like the globe itself was blue water.

While different maps provide different perspectives, this particular chart seemed to encapsulate not only the distance inherent in Australia's geo-strategic disposition but also its maritime security challenge writ-large.

With a land mass of such size and no other country present on that island continent to share in providing the maritime security burden, Australia faces an extensive and enduring challenge in delivering maritime security in and around its own waters. The enduring nature of this challenge is reflected today in both strategic debate and system developments.

In terms of the latter, recent activities have highlighted Australia's enduring requirement to strengthen its maritime surveillance capability. In early November, Australia's Department of Defence (DoD) commenced Exercise *Autonomous Warrior* 2018. Led by the country's Defence Science and Technology organisation and supported by the RAN, *Autonomous Warrior* was designed to assess "how autonomous and artificial intelligence technologies can help [Australia] maintain a winning edge across the spectrum of maritime, land, and air operations, from surveillance to high-end warfare", according to Commodore Steve Hughes, the RAN's director of littoral operations and its sponsor for the exercise.

During *Autonomous Warrior*, which took place from 5-23 November in and around Jervis Bay, including at the HMAS Creswell shore training establishment, a collection of 26 Australian and international organisations tested 13 air, eight ground, 14 surface, and three underwater vehicles, according to reports. This collection highlighted the role of all domains in delivering maritime surveillance.

As with other countries, Australia sees unmanned systems as providing a key option for delivering wide-area maritime surveillance, with such systems used in partnership with air- and surface-based manned platforms that provide the ability to investigate suspicious targets.

CAPABILITY

Demonstrating the multi-domain approach to delivering maritime surveillance, in late June 2018 the DoD announced the purchase of the first of six Northrop Grumman MQ-4C Triton unmanned aircraft systems, within a contract for all six valued at $5.1 billion. In a statement released at the time of the acquisition announcement, Australian defence industry minister Chris Pyne said reconnaissance and surveillance over the Indian and Pacific oceans, as well as across Southeast Asia and Antarctica, is one of Australia's most important contributions to the Five Eyes defence and security co-operation arrangement it shares with Canada, New Zealand, the United Kingdom, and the United States.

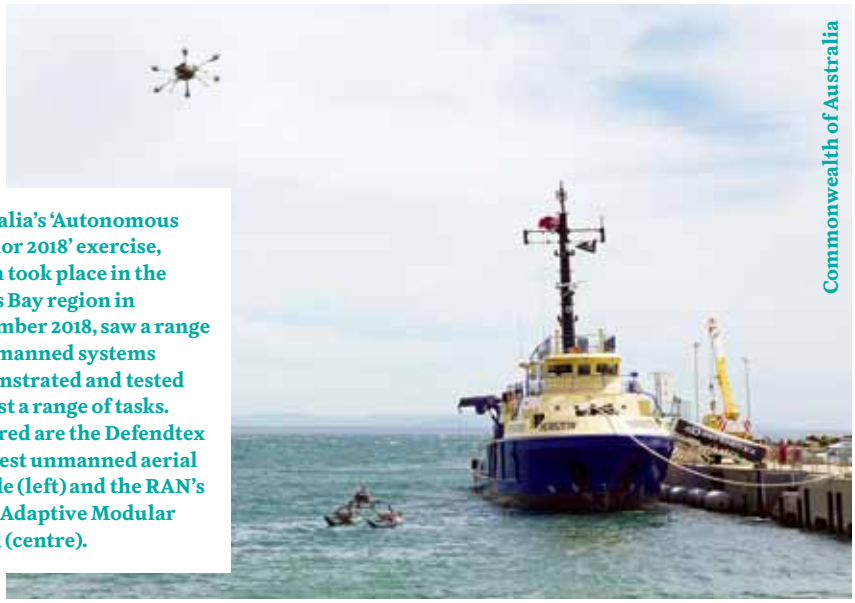
Triton will be operated by the Royal Australian Air Force (RAAF). According to the RAAF, the vehicle will be used for

maritime patrol and other surveillance roles. Bringing both low- and high-altitude surveillance - in the latter case up to 50,000 feet (15,240m), the major capability benefits offered by Triton include its ability to conduct 360-degree surveillance over distances of up to 2000 nautical miles, the RAAF noted. A defence spokesperson told *Armada* that mission time includes "the ability to spend more than 24 hours in the air on station".

Australia's Tritons will operate from RAAF Base Edinburgh, South Australia. They will be flown from ground stations by crews consisting of a pilot and a co-pilot. The six aircraft are scheduled to arrive in the 2023-25 timeframe.

It is intended that Triton will operate closely with Australia's 12-strong fleet of Boeing P-8 Poseidon maritime patrol aircraft (MPAs), with the P-8 fleet itself expected to be fully operational by 2022. In a statement, the DoD said Triton "will complement the surveillance role of the P-8A Poseidon aircraft through sustained operations at long ranges as well as being able to undertake a range of intelligence, surveillance, and reconnaissance (ISR) tasks." "Together these aircraft will significantly enhance our anti-submarine warfare and maritime strike capability, as well as our search-and-rescue capability," the DoD continued.

The combination of air-based manned and unmanned capabilities can make a significant contribution to the wide-area surveillance requirement inherent in maritime security, especially for a country with Australia's maritime coverage challenges. In this context, Triton can deliver the sustained wide-area coverage; the P-8 can also support such coverage (especially given its low-to medium-altitude operating envelope), but it can complement Triton's wide-area surveillance capabilities by focusing on particular targets. The defence spokesperson told *Armada* that Triton "will be able to share data in real time with the P-8A Poseidon, providing these manned aircraft with the information to support their missions". Together when fully operational, the spokesperson continued, Triton and P-8 "will fly twice as many hours as the (Orion) AP-3C (MPAs) they replace".



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Australia's 'Autonomous Warrior 2018' exercise, which took place in the Jervis Bay region in November 2018, saw a range of unmanned systems demonstrated and tested against a range of tasks. Pictured are the Defendtex Tempest unmanned aerial vehicle (left) and the RAN's Wave Adaptive Modular Vessel (centre).

Nick Childs, senior fellow for naval forces and maritime security at the International Institute for Strategic Studies (IISS) in London, said Australia's Triton purchase "underscores how strategically significant ISR and situational awareness have become in the increasingly contested and congested maritime arena."

"It is clearly a complementary capability to the P-8s and offshore patrol vessels (OPVs), but also with some unique attributes, like


US Navy

An MQ-4C Triton unmanned aircraft system approaches the US Navy's Naval Air Station Patuxent River, Maryland after completing a cross-country flight from Northrop Grumman's California facility in September 2014. Triton will bring a significant increase in maritime surveillance capability for Australia.

range. It can offer greater persistence than the P-8, and greater speed of coverage than surface platforms," Childs told *Armada*.

While air-based surveillance provides broad and sustained maritime coverage, ultimately – whether it is a naval, commercial, or civilian platform that must be investigated more fully – surface ship presence is critical.

Here, the RAN's 12 new OPVs, being delivered under Project Sea 1180-1, will play a key role. On 15 November 2018, construction of the first ship got underway at ASC's Osborne naval shipyard in Adelaide, South Australia. It was also revealed that the 12 OPVs will be known as the Arafura class. The Arafura Sea lies to Australia's north, and Deputy Chief of Navy Rear Admiral Mark Hammond said in a statement that the class name "encapsulates the significant role (Australia's) maritime regions have in the nation's security and economic prosperity, importantly the littoral regions around the Australian continent".

Displacing 1,700 tonnes and measuring 80m in length, the 12 steel-hulled, Lürssen-designed but Australian-customised, Arafura-class OPVs are replacing the 13, 300-tonnes, aluminium-hulled Armidale-class OPVs and the two Cape-class OPVs leased by the DoD.

According to the RAN, the primary requirement of the Arafura class "will be to undertake constabulary missions, maritime patrol and response duties." Rear Admiral Hammond noted that the new OPVs bring "a much more capable class of ship with greater range, endurance, (and) improved accommodation for the crew staying at sea longer, and in every respect ... will outperform older patrol boats". The Arafura-class OPVs' greater size and displacement will bring extended range and endurance to the RAN's at-sea presence, as well as providing opportunities for a wider equipment fit that prospectively includes unmanned systems (for example, through using containerised mission fits).

According to the defence spokesperson, "The OPV will be the primary military asset for maritime patrol and response duties", supporting Australian Defence Force (ADF), other government agency (including the Australian Border Force (ABF)), and allied maritime security and border protection requirements, including surveillance, interception, and boarding tasks relating to suspected illegal activities occurring within Australia's area of strategic interest.

First-in-class OPV *Arafura* is scheduled to enter service in 2022. The defence spokesperson added that "the twelfth vessel (is) planned to join the fleet in 2030". According to the RAN, six Arafura OPVs will be based at HMAS Coonawarra in Darwin in Australia's Northern Territory, four at HMAS Cairns in north Queensland, and two at HMAS Stirling in Western Australia.

Currently, the in-service Armidales are supported in delivering maritime security by the RAN's two Cape-class OPVs, Australian Defence Vessel (ADV) *Cape Fourcroy* and ADV *Cape Inscription*. According to the RAN, the Cape-class patrol ships conduct "a range of constabulary duties (including) tracking, intercepting, stopping, and boarding other vessels." The Cape- and Armidale-class vessels both operate two crews to maximise at-sea availability.

CO-OPERATION

Emphasising the multi-agency element of delivering effective maritime surveillance, the ABF – which sits within the Home Affairs department – provides both air- and sea-based platforms for generating coverage at sea.

James Goldrick – a retired RAN rear admiral and currently a fellow at the Lowy Institute, Sydney – has argued that combining


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Australia's Minister for Defence Industry Christopher Pyne inspects a model of the Arafura-class OPV at ASC's Osborne naval shipyard, Adelaide in November 2018. The Arafura-class OPVs will begin entering service in 2022.

The RAN's Cape-class Australian Defence Vessel (ADV) Cape Fourcroy is pictured departing from HMAS Coonawarra in Darwin, Northern Territory to participate in Operation 'Resolute'. 'Resolute' is the Australian Defence Force's contribution to the cross-government effort to secure Australia's maritime borders and offshore maritime interests.

defence and ABF assets under the Maritime Border Command (MBC) has created "a highly effective mechanism for surveillance and response" for Australia.

In an assessment of the country's maritime security requirements and capabilities published by the Lowy Institute in April 2018, Rear Admiral Goldrick pointed to an increasing maritime security demand for Australia. He noted too that "a nation with limited resources and vast maritime commitments must inevitably rely on ... a civil and military combination" such as the partnership between the DoD and the ABF.

Migration management has been a significant maritime security challenge in Australia in recent years, both as a political issue and as an operational challenge for the RAN and the ABF. However, Australia's range of maritime surveillance challenges extends across the operational spectrum from low-end maritime security risks to higher-end military threats.

In terms of maritime security, an August 2018 paper published by the Australian Strategic Policy Institute (ASPI) noted an increasingly challenging future for Australia. The report's authors – Dr John Coyne, Ashleigh Sharpe, and Dione Hodgson – argued that "In coming years, it seems a very real possibility that Australia's MBC vessels will face increasingly aggressive encounters with illegal fishing fleets operating within or at the borders of Australia's (exclusive economic zone (EEZ))."

According to the ABF itself, "Australia has 36,000 kilometres of coastline and an offshore maritime area of nearly 13 million square kilometres." It also noted the "significant collaboration between the ABF and ADF [in ensuring] appropriate assets are available to meet operational requirements."

Two prominent maritime patrol and surveillance capabilities provided by the ABF are eight Cape-class OPVs and 10 Dash 8-200 maritime surveillance aircraft.

The Cape-class vessels completed replacement of the Bay-class OPVs in 2015. Goldrick referred to the Cape class as providing "a quantum leap" in capability. According to the ABF, the 57.8m, aluminium-hulled Cape-class ships "have greater range, endurance, and flexibility" and can operate to the edge of Australia's EEZ. In terms of endurance, for example, the ABF noted that the vessels have a 4,000nm unsupported range. With Australia's EEZ also reaching out across the Southern Ocean into the Antarctic region, the vessels' enhanced capability for operating in more testing conditions such as higher sea states is an important design characteristic.

Underscoring the maritime surveillance role and capability of the Cape-class vessels, the ABF stated the OPVs are designed to "identify, track, [and] intercept an extended range of threats in the maritime domain", can launch two 7.3m ship's boats to conduct boarding and search operations, and also are able to gather intelligence and hold evidence and individuals at sea.

Australian presence in the Southern Ocean region also is supported by the ABF's larger cutter, *Ocean Shield*. At 110m in length and displacing 8,300 tonnes, it is the ABF's largest vessel and is available for operations 300 days per year. The ship operates in northern waters as well.

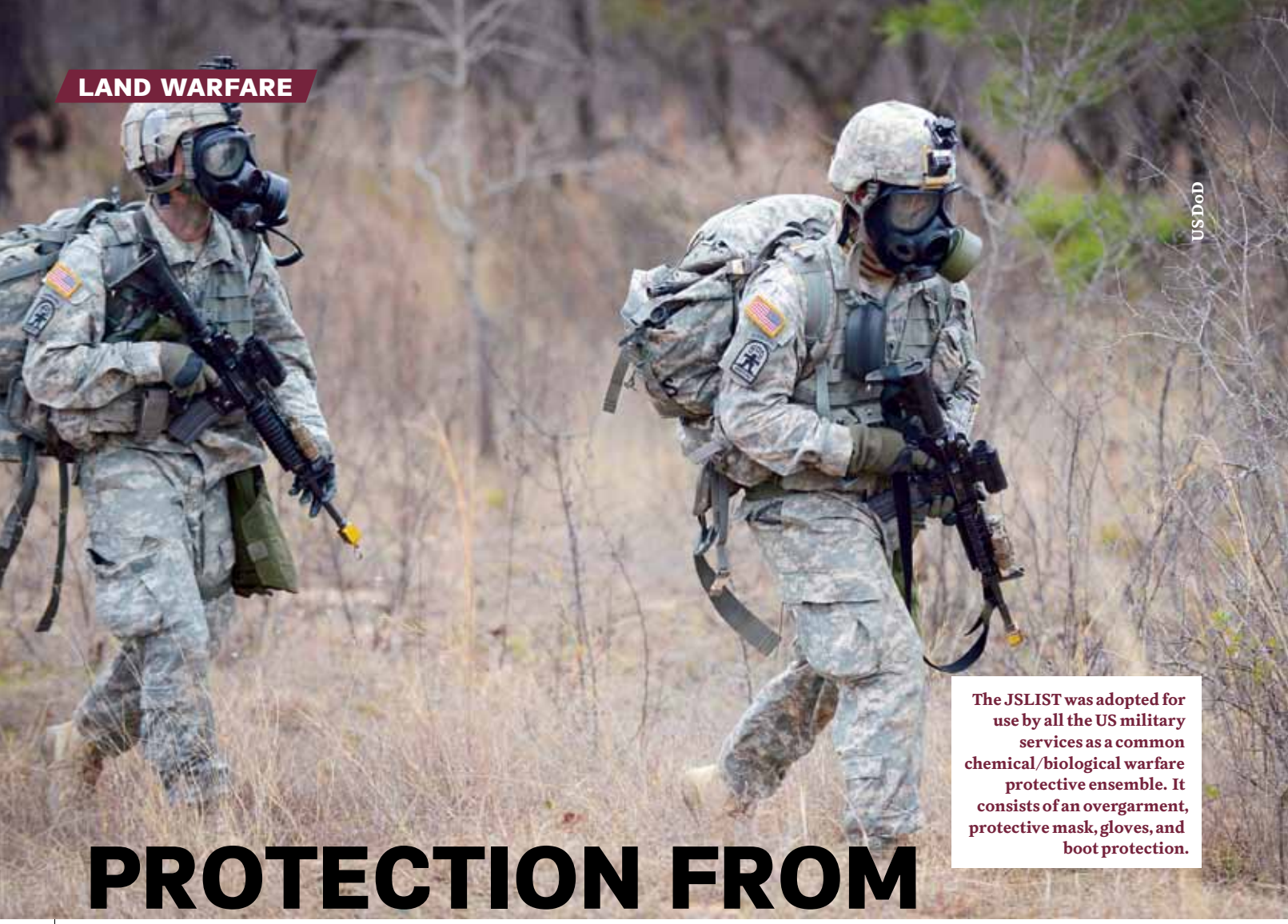
Supporting surface-based operations is an air-based maritime surveillance capability delivered by the Dash 8s. The aircraft are operated by Cobham Aviation Services under the Coastwatch contract signed with the ABF. According to Cobham, the Dash 8 fleet "is fitted with a suite of sophisticated sensors fully integrated and networked in real time via high bandwidth satellite communications". The aircraft, Goldrick wrote, "have been specifically modified for surface surveillance, including an extensive sensor fit and tailored data management system". The current 'Coastwatch' contract runs until 2021.

ENDURING CHALLENGE

In the ASPI report, which surveyed patrol and coastal combatant craft programmes across Association of South East Asian Nation (ASEAN) members, the authors argued that the RAN and ABF assets are "advanced and highly capable", with small numbers offset by an array of robust surveillance capabilities.

What is noticeable across all of the platforms discussed above is the emphasis on increasing range and endurance. However, Australia's growing range and endurance requirements – along with the increasing complexity of the threat – will continue to raise the question of whether current force levels and even Australia's effective combination of civil and military coverage provide sufficient capacity to meet the challenge. For example, the 12 OPVs – although being more robust in capability – will be replacing a larger collection of platforms. Goldrick noted also that "operations in the Southern Ocean require at least one vessel of the size and capability of the 8000-tonne *Ocean Shield*."

While capability is increasing and cross-agency co-operation is showing benefit in presence and command and control, the question of whether numbers will continue to meet growing demand endures. A



US DoD

The JSLIST was adopted for use by all the US military services as a common chemical/biological warfare protective ensemble. It consists of an overgarment, protective mask, gloves, and boot protection.

PROTECTION FROM CHEMICAL WARFARE

The quick detection of chemical warfare agents and the protection of troops on the battlefield is growing in importance, particularly in static locations and areas where troops may concentrate operationally.

Stephen W. Miller

The possibility of encountering a Chemical, Biological, Radiological and Nuclear (CBRNE) weapon is a concern that rests in the background of any modern military operation. It is a contingency that must be accounted for even in cases where it is prohibited by international convention and the use of such weapons might appear unlikely.

The reason for this caution is because being caught unprepared could result in devastating casualties and serious disruption of operations. Of all these threats it is chemical warfare (CW) weapons that have gained recent notoriety primarily because they have been openly utilised in several conflicts including by the Assad regime against its opposition in Syria. The results here in common with Iraq's use of such weapons in the Iraq-Iran conflict from 1980 to 1988, have been horrendous primarily because those attacked were unprepared and not equipped to protect themselves against the agents. This is especially true in Syria which has continually targeted non-combatants. These attacks were not tactical but rather sought to create fear. However, a strong case can be made that CW has historically rarely had a decisive battlefield impact especially when used against a prepared modern military force.

Even given the non-decisive effect of CW, undertaking the measures necessary to prepare to confront CW or biological (bio) warfare agents has a detrimental impact on the ability of soldiers to perform their duties. Should a CW attack occur, each soldier must respond immediately donning the necessary protective equipment to protect themselves from exposure. And their time to react is measured in seconds. This means they must have their protective breathing mask with them at al times and be wearing uniforms that resist agent penetration. The latter are generally specially designed specifically for CW protection and are often worn over the normal battle dress. These can be bulky, uncomfortable, and hot. Many such protective uniforms are impermeable or do not breath thus capturing the wearer's body heat which, even in temperate conditions, can lead to heat stress. In high temperature environments this likelihood is multiplied even without physical exertion. The high activity experienced by soldiers in combat can make

heat exhaustion, as well as dehydration, serious problems. Even the most simple task when 'suited up' becomes difficult and endurance drops rapidly. An Institute for Defense Analysis report, *The Effects of Wearing Protective Chemical Warfare Combat Clothing on Human Performance*, 1991, by Henry Taylor and Jesse Orlansky prepared for the US Department of Defense (DoD) found that "even without heat stress the ability of combat and support personnel to tasks in all arms was significantly degraded". This was found in force-on-force exercises to more than double the projected casualties.

CW agents fall into four categories, each with different properties and protection challenges. Nerve agents attack the nervous system and are fast acting but do not linger. Blister agents destroy cell tissue on contact and can be formulated to last for longer periods. Choking agents are inhaled and inflame the bronchial tubes and lungs. Blood agents disrupt the oxygen carrying capability of blood. They are fast acting but also dissipate quickly. Agents can be gas, liquid, or powders with he later two can be persistent.

PROTECTION WITHOUT STRESS

For many years individual CW protection for soldiers was provided by overgarments that used impermeable materials with a protective breathing mask. The protective mask used special filters to absorb CW agents while the overgarment was like a rain coat keeping the agents from contacting the skin. These type of garments are still used in what are referred to as Level A protective suits such as the Dupont Tychem HazMat suit used by both military and civilian responders in special teams. These fully encapsulate the wearer but are generally used only for limited periods specifically because of the overheating and wearer fatigue they induce. Lightweight impermeable jackets, trousers, and boot covers or just capes are also used to provide short term protection, for example, to cross a contaminated area. These are generally disposable and use materials like Dupont's Tyvek, or PVC based materials.

The United States military standardised a CW protective ensemble that used a carbon liner which was employed through the first Gulf War. Although more suitable for general soldiers use than earlier approaches it was bulky, did not breath, had reduced efficiency if wet and tended to lose the carbon making the wearer black. Adverse feedback after the use of this ensemble in Operation *Desert Storm* I saw the US services seek alternate solutions that would reduce the physiological impacts. In fact, CW protective ensembles were already in use by several coalition forces in the desert that successfully addressed these concerns. The French wore an outfit manufactured by the company Paul Boye which offered no additional stress although it too used a carbon layer but was designed to be similar to a normal battle dress uniform.

Another filter technology used carbon spheres bonded to a liner. This spherical approach was promoted by the German company Blücher as Saratoga and adopted by the US military as the overgarment part of the Joint Service Lightweight Integrated Suit Technology (JSLIST). Haven Technologies in the UK has teemed with OPEC CBRN to offer the Kestrel and Phoenix

Non-permeable CW protective clothing can be effective and useful for short term applications but is generally for one-time use. They are often lightweight and typically inexpensive but have the disadvantage of creating a heat burden on the wearer.

ensembles. The former OPEC business development manager Chris Jackson stated that Kestrel "is a medium weight garment that is 30 percent lighter and ideally suited to high heat burden environments." Kestrel was selected by the Australian Government in 2016 for its armed forces.

RESEARCH & DEVELOPMENT

Several research and development initiatives are being pursued with the specific objective of offering personal CW protection while alleviating the physiological burden on the soldier. One approach is incorporating CW resistance into standard battle dress uniforms meaning that it would not always be necessary to have special over garments that must be acquired, carried and worn. Eliminating an additional clothing layer also would reduce the heat burden and bulk.

WL Gore has developed both impermeable and selectively permeable CW protective fabrics, including Chempak. Jason Rodriguez, the company spokesperson explained it is a "very lightweight outer garment for limited short duration use. The later allows body heat and perspiration to exit but prevents CW agents from penetrating. This keeps the wearer cooler." This fabric is often designed as an undergarment with the normal battledress worn over it. It can be worn longer and is less bulky so can be more comfortable.

Nanotechnology is also being explored as a potential approach toward providing lighter and breathable CW resistant textiles. The use of nano-fibrous coated webs show promise in offering a fabric that integrates the absorbent while being impervious to liquid and droplet agents yet allowing body heat and perspiration to exit. It is further considered that this protective uniform will be more durable and provide overall greater wearer comfort.

Even with the considerable attention being rightly given to better CW protective clothing it should be recognised that field and lab studies have confirmed that the greatest burden on the soldier is wearing the protective mask. This is especially the case with high physical activity. To at least partly alleviate this concern commanders will designate various levels of individual protection often referred to MOPP (Mission Oriented Protective Postures). These range from MOPP 0 where only the normal combat gear and uniform are worn to MOPP 4 which requires the entire protective ensemble from boots and gloves to head hood and protective mask. Other MOPP levels require fewer of the ensemble pieces but they must still be carried and ready for immediate use. This would rest with a command 'judgment call' based on an assessment of the perceived CW threat.

CW DETECTION

Complicating the desire to use a lower MOPP is the fact that the presence of CW agents may not be obvious to human senses at least not before they have begun to inflict their debilitating effect on those that have been exposed. Some CW agents are also intentionally designed to be persistent with the ability to retain their effectiveness for long periods of time. As a result, units can easily enter a contaminated area without realising it. Therefore, continuous monitoring for the presence of CW agents and its rapid detection is critical. These systems need to be simple, reliable and accurate as false alarms would require suiting up reducing the performance of the unit's personnel. Both fixed site and portable

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Bertin

CW agent detection needs to be continuous, comprehensive and immediate. Bertin Instruments Second Sight M2 is designed to these demands. It provides 360 degree scanning every 3 minutes day or night and alarms within 10 seconds.

detectors are required since both forward combat units and those behind the lines are likely CW targets. In fact, the delivery of persistent CW agents on command posts, artillery, supply sites and airfields is considered a valuable tool in that these are easily located and highly susceptible to disruption.

The simplest CW detection technology is detection paper. These range from basic strips such as the M8 and M9 carried by a soldier, to the M18A3 kit used by tactical chemical teams. Using a process called Colorimetrics, the process is based on the reaction that occurs when CW agents interact with the substance on the paper. A specific visual colour change will occur depending on the specific CW element present. These are inexpensive and simple and especially effective for liquids and aerosols. They are susceptible to false readings however and may be affected by moisture.

For more accurate detection hand held systems are utilised. The French company Proengin's AP4 series of handheld, fixed and vehicle mounted detectors use flame spectrometry technology to detect and identify CW agents. A spokesperson shared that "it operates under field conditions despite wet or high humidity even in the presence of multiple chemicals. It detects nerve, blister, and vomiting CW agents as well as many toxic industrial compounds." Smiths Detection offers its HGVI which employs multiple sensors using IMS (Ion Mobility Detector), PID (photoionisation), and TGS technologies working together. It not only detects CW and industrial agents but gamma radiation as well, all in a compact 3.4kg unit.

Airsense Analytics has developed a system offering "enhanced detection of chemical agents as well as TICs and hazardous compounds. Its GDA-P allows teams to be aware of not just CW agents but also other hazardous substances. This ability is increasingly essential at a time when non-military actors without access to CW weapons may entertain the use of alternate solutions. Another system that addresses both CW and TIC (Toxic Industrial Chemicals) is the Next Generation Chemical Detector from Owlstone, developed for the US Army. Less than one kilogram, it will alarm to CW in under 10 seconds and can be hand or vehicle carried. It is also programmable to accept additional or new threats.

Size is an important factor in personal CW detectors since they add to the soldier's load. The Joint Chemical Agent Detector (JCAD) offered by BAE Systems is handheld and can accumulate, report and store CW events in its onboard memory allowing later detailed correlation. JCAD utilises Surface Acoustic Wave (SAW) technology that can identify multiple CW agents simultaneously.

One of the preferred responses to CW attack is to avoid areas that have been contaminated by their quick identification. Real-time stand-off detection is key to this. The Joint Chemical Stand-off Detector (JCSD) uses ultraviolet laser technology and can be tripod or vehicle mounted. A positive identification of up to 20 CW and 30 TICs is achieved in under two minutes. Another long-distance CW detector is Northrop Grumman's Mobile Chemical Agent Detector (MCAD). A spokesperson indicated that the system "is entirely passive and it is capable of indemnifying CW and TICs at 5km using a library of recognition algorithms. Additional substances can be programmed to expand this library.

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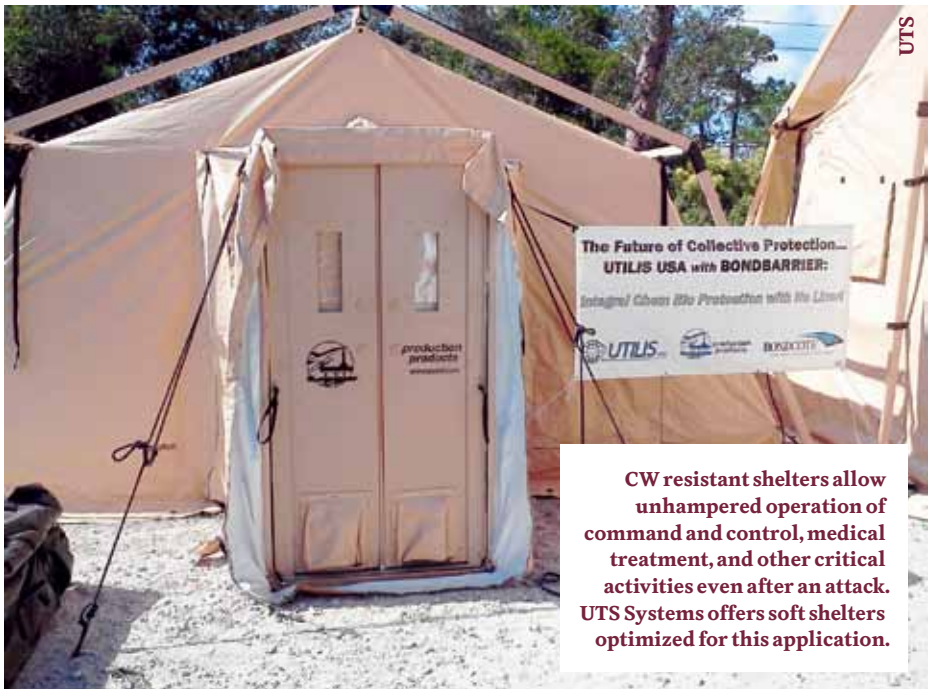


UTS

CW resistant shelters allow unhampered operation of command and control, medical treatment, and other critical activities even after an attack. UTS Systems offers soft shelters optimized for this application.

The unit can be wireless controlled and connected to a communications network. MCAD has proven effective over land and sea environments.

ABB's Compact Atmospheric Sounding Interference (CATSI) is another stand-off detection system developed by Defense Research and Development Canada. It has a 5km range using proven Fourier-Transform Spectroscopy (FTS) to automatically detect and identify agents. The system is fielded with the Canadian Forces. Bruker Daltonik's RAPIDPlus can be vehicle, ship or tripod mounted that uses passive infrared sensors to detect CW and TICs in 360 degree scanning also using FTS.

Bertin Instruments' Second Sight MS Gas Detector, a tripod mounted system uses an uncooled multispectral infrared camera that can detect CW and TICs including mixed agent clouds at 5km. It has a 360-degree scan continuously every three minutes with selectable fields of view of 12, 30 or 60 degrees. It will provide a positive detection in less than 10 seconds.

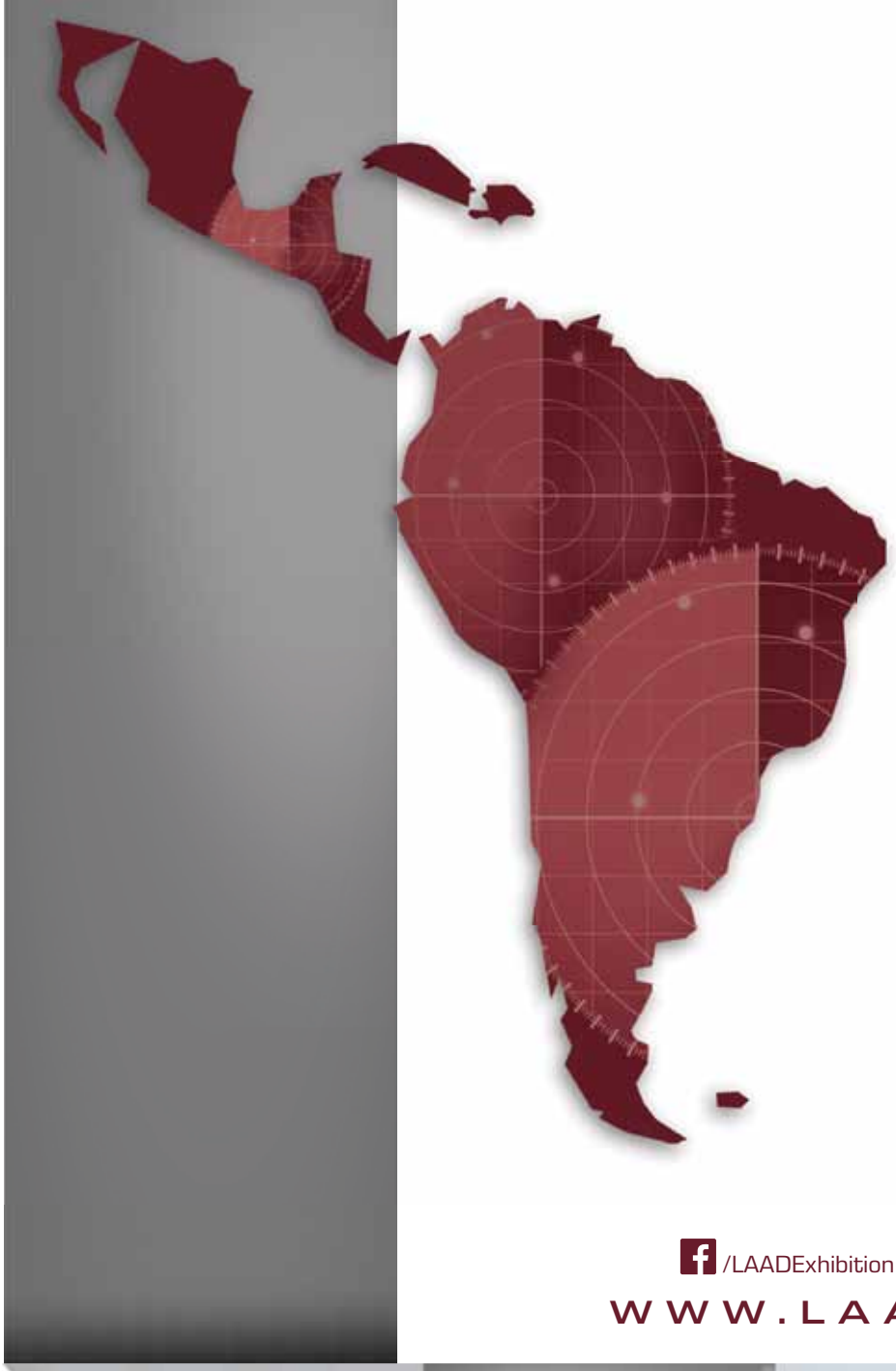
The attention given to early stand-off detection reflects the view that the best response where CW may be used is identifying and locating the impacted area as quickly and accuracy as possible. This precludes the need to take protective action that reduces operational effectiveness which is an appropriate response for mobile forces but not an option for those units and activities that require fixed locations. Even the most basic reaction of taking cover in tents and shelters if sufficient early warning is provided can also limit exposure. Several companies have recognised the benefits offered by soft shelters which are not only resistant to CW agents but can also be used as decontamination compounds after an attack. Warwick Mills in New Ipswich, New Hampshire, uses patented fabric impregnated a chem-bio layer in a laminate. The company is also developing a self-decontaminating laminate that reliably destroys agents. UTS Systems offers soft shelters that not only resist CW agents but include air lock entries and CW filtration of the environmental control unit (ECU).

CONCLUSION

The effectiveness of the CW attack on a military target is more measured by the level of disruption that it presents rather than the casualties that it produces. By requiring operators to don protective suits and to exhibit additional safeguards in performing even routine tasks efficiency leads to a drastic reduction in effectiveness: artillery rates of fire may be reduced, aircraft mission turn-around times may be longer, service and maintenance made difficult if impossible, and people and resources must be redirected to decontamination efforts. A

A US Marine Corps chemical, biological, radiological and nuclear defence specialist wearing a Mission Oriented Protective Posture level four (MOPP-4) suit at Camp Pendleton, California, 16 February, 2018.

USMC



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DVIDS

Members of the the Lithuanian National Defence Volunteer Forces (KASP) move across an objective during exercise Saber Junction 2018 at the Joint Multinational Readiness Center in Hohenfels, Germany, September 22, 2018.

CHANGING CONOPS TO FIT THE RIGHT FIGHT

As NATO special operations forces (SOF) begin to wind down counter-insurgency and counter-terrorism campaigns against Daesh combatant groups in the Middle East, commanders are considering measures to enhance the capabilities of small unit teams who might be called upon to conduct very different concepts of operations (CONOPS) in the future.

Andrew White

From a western perspective, the task of evolving SOF CONOPS represents a shift towards countering higher capability and near peer threats represented by China; the Democratic People's Republic of Korea (DPRK); Iran; and the Russian Federation - a fact which was outlined in the latest edition of the United States 2018 National Defense Strategy, published in February 2018.

Signed off by defence secretary Jim Mattis, the strategy described how the United States (US) and, by association, NATO and non-NATO aligned partners were witnessing a period of 'strategic atrophy' in which their traditional competitive military advantages were being eroded.

"Inter-state strategic competition, not terrorism, is now the primary concern in US national security," the strategy highlighted, before adding: "This increasingly complex security environment is defined by rapid technological change, challenges from adversaries in every operating domain, and the impact on current readiness from the longest continuous stretch of armed conflict in our Nation's history.

"We face an ever more lethal and disruptive battlefield, combined across domains and conducted at increasing speed and reach - from close combat, throughout overseas theatres, and reaching to our homeland. Some competitors and adversaries seek to optimise their targeting of our battle networks and operational concepts, while also using other areas of competition short of open warfare to achieve their ends (e.g., information warfare, ambiguous or denied proxy operations, and subversion). These trends, if unaddressed, will challenge our ability to deter aggression," the strategy warned.

These observations retain significant consequences for the international SOF community - a thread which was expressed at the SOF Industry Conference in Tampa, Florida on 22 May 2018, by the Commander of the US Special Operations Command

(USSOCOM), General Tony Thomas. Addressing representatives from more than 70 international SOF partners as well as industry delegations, Thomas described how their community was being effected by an "emerging operating environment".

Thomas highlighted how SOF small units conducting direct action, logistics or information operations, are being faced with "...an increasingly difficult task of making more and more accurate and timely decisions than ever before".

"They are operating at the edge of communications and logistics networks plagued with bandwidth and signature constraints," he said. "Our challenge is in developing, testing and fielding systems that enable us to make those decisions and take those actions at the right time rapidly and consistently," he continued before explaining how adversaries were benefiting from advancements in data science, artificial intelligence, automated systems and secure communications.

With these specific threats in mind, Thomas described how by the end of his tenure in command of the USSOCOM in 2019, he will have signed off the Programme of Objective Memorandum (POM) which will drive the organisation's force development over the next decade.

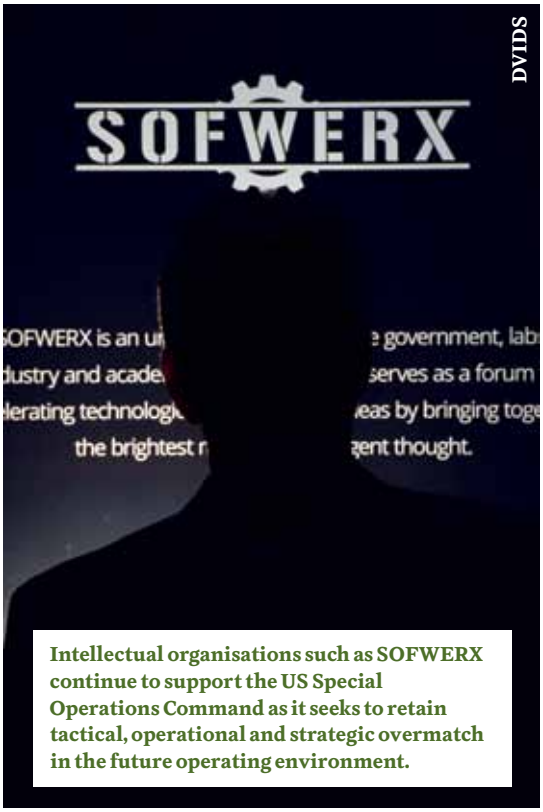
"INCREMENTAL IMPROVEMENTS TO LEGACY SYSTEMS WILL NOT GIVE US THE ADVANTAGE WE NEED FOR FUTURE SUCCESSES." -
GENERAL TONY THOMAS, COMMANDER, USSOCOM.

"In this POM, (USSOCOM) will address our future fixed wing and rotary wing requirements. We will lay out our path forward on surface and sub-surface mobility and ground mobility. We will define our investments in SOF-specific space and cyber programmes; precision weapons; and cutting edge communications networks."

However Thomas warned: "In this rapidly evolving environment, for the purposes of future combat involvement, we should consider the technology and platforms that today's SOF use as already legacy systems whose sunset is nearly upon us. Incremental improvements to legacy systems will not give us the advantage we need for future successes."

According to the National Defense Strategy, new technologies of interest to joint forces and SOF, allowing them to more efficiently operate across future threat environments include "computing, big data analytics, artificial intelligence, autonomy, robotics, directed energy, hypersonic (weapons), and bio-technology".

"New commercial technology will change society and, ultimately, the character of war. The fact that many technological developments will come from the commercial sector means that state competitors and non-state actors will also have access to them," the strategy concluded.



Intellectual organisations such as SOFWERX continue to support the US Special Operations Command as it seeks to retain tactical, operational and strategic overmatch in the future operating environment.

INTEROPERABILITY

Seeking to secure and maintain strategic, operational and tactical overmatch over high capability and near peer adversaries in future operating environments, SOF entities around the world look set to focus on interoperability and cooperation with partner nation forces.

Speaking to *Armada International*, defence sources associated with the NATO Special Operations Headquarters (NSHQ) in Mons, Belgium, described how strengthening of existing alliances and the attraction of new partners remained a "long-term strategic" objective for SOF commands.

Such a concept continues to be regularly witnessed across the contemporary operating environment, with examples including Exercise *Saber Junction 18* which was conducted between 4-30 September at the US Army's Joint Multinational Readiness Centre in Hohenfels, Germany.

Featuring personnel from the US Army's 20th Special Forces Group (SFG) and the Lithuania National Defence Volunteer Force (KASP), the exercise was designed to assess the ability of participating forces to "execute land operations in a joint, combined environment" as well as promoting interoperability.

According to participating officials, the exercise allowed SOF the opportunity to work alongside the KASP to conduct "irregular warfare in enemy occupied territory (in order to) to set conditions on the battlefield that will ensure the success of conventional forces".

NSHQ sources described to *Armada International* how the exercise replicated a future CONOP for SOF and conventional forces to support 'foreign internal defence' operations - a threat which continues to grow in prominence following the method Russia employed during the 2014 annexation of Crimea, Ukraine.

The Baltic States of Estonia, Latvia and Lithuania in particular, continue to work closely with NATO SOF partners as part of the Alliance's Collective Defence strategy to ensure procedures remain in place to counter similar insurgent activities by Russian proxy and/or conventional force elements in the future.

According to members from 20th SFG's Operational Detachment Alpha (ODA) teams, the primary mission of the exercise was to work with indigenous forces to facilitate the entry of conventional forces in the form of the US Army's 173rd Airborne Brigade.

"Integral to that is taking out air defence systems so they could safely project their forces through a mass tactical airborne operation and air assaults. With the KASP we were able to conduct reconnaissance and identify and destroy those high pay-off targets," a 20th SFG member revealed.

"Here we are working with the KASP, where we need to figure out how to blend in with the populace; use their transportation systems; obtain supplies on the local economy; and rotate safe houses nightly without revealing that we are part of an exercise.


US Army

After nearly 10 years of collaborative research from the Army, industry and academia, the Micro Autonomous Systems and Technology, or MAST, concluded during a three-day event at Aberdeen Proving Ground, Maryland, in August 2017.

"SOF cannot fight without conventional forces support; we are dependent on each other. We don't have the capacity to take on an entire enemy brigade; SOF must set the conditions for the conventional fight," explained the 20th SFG source.

"Working with the KASP helps us integrate our operational tempos for planning into joint missions that we feel might replicate future potential conflicts." The exercise had featured a variety of irregular warfare missions including intelligence-gathering and ambushes.

Elsewhere, the international SOF community continues to enhance cooperation levels on a SOF-to-SOF basis as well, in order to further exploit the force multiplying effects of force elements against Violent Extremist Organisations (VEOs).

Examples include Exercise *Rim of the Pacific* (RIMPAC), conducted across the island of Oahu, Hawaii, over the course of July and August 2018. Designed to increase interoperability and cooperation between SOF components across the Indo-Pacific region with consideration of VEOs.

Organised by US Special Operations Command Indo-Pacific (SOCPAC), the exercise saw the involvement of US SOF as well as force elements from Japan's Special Boarding Unit; South Korea's Naval Special Warfare Flotilla; India's MARCOS; Indonesia's KOPASKA; the Philippines' NAVSOG; and Peru's Naval Special Warfare Command.

According to Major Kevin Boyd, SOCPAC public affairs officer, *RIMPAC* focused on cooperation between partner nation forces in the execution of ground and helicopter assault forces; submarine operations; airborne insertion; and small boat missions.

"RIMPAC allows SOF from regional partner nations to come together in a training environment and devote time to complex problem solving which allows our partner nations to combat VEOs which are a threat to shared values in the region," Boyd explained.

"RIMPAC allowed SOCPAC units the ability to train in the maritime environment off platforms of the US and partnered nations that US SOF doesn't often get to train on, nor do our partner forces, which is invaluable in our ability to interoperate. The global maritime environment is too large and complex for any one nation or military force to safeguard. *RIMPAC* helps participants foster and sustain the cooperative relationships that are critical to ensuring the safety of the region. SOF jointly utilises forces across maritime, land and air environments to secure the peace of the region," he concluded.

JOINT ENVIRONMENT

SOF are also expected to increase focus upon joint operations, including greater levels in cooperation with conventional and unconventional forces as well as other government agencies and organisations.

Examples were highlighted in a report by the Rand Corporation, published in July and designed to encourage a more holistic 'whole of government' approach to countering current and future threats.

The "An American Way of Political Warfare" report included calls for a "Political Warfare" capability to augment the existing conventional and unconventional capabilities of the US government which defence sources confirmed would have implications for the SOF community.

The report warned how the US government has proven itself to be "ill-equipped to address the use of non-conventional means by revisionist, revolutionary, and rogue powers".

Citing a series of existing threats relevant to both current and future operating environments, the proposal warned how the US appeared "seemingly impotent" against cyber attacks and Russian influence campaigns designed to destabilise the country; as well as DPRK's "nuclear posturing" which continues to be monitored despite ongoing negotiations between President Trump and the DPRK leader, Kim Jong-Un.

"The US continues to rely heavily on conventional military capabilities - typically focused on destroying the enemy and occupying its terrain - not in contests where adversaries instead compete for influence and legitimacy among the populations," the report continued.

Referring to the ability of USSOCOM force components to "capture or kill terrorists on a global scale", the report questioned whether such a specialised capability in conjunction with conventional capabilities, had proven effective in these more political warfare-focused contests.

"US successes have too often been short term and limited to those cases in which adversaries engage in traditional warfare—e.g., Daesh's collapse in Syria was foretold after defining territorial control as a core tenet of its success," the report continued before suggesting whether the wider Department of Defense (DoD) was optimally prepared to engage emerging high capability and near peer threats.

Rand Corporation, which retains close research and development ties with

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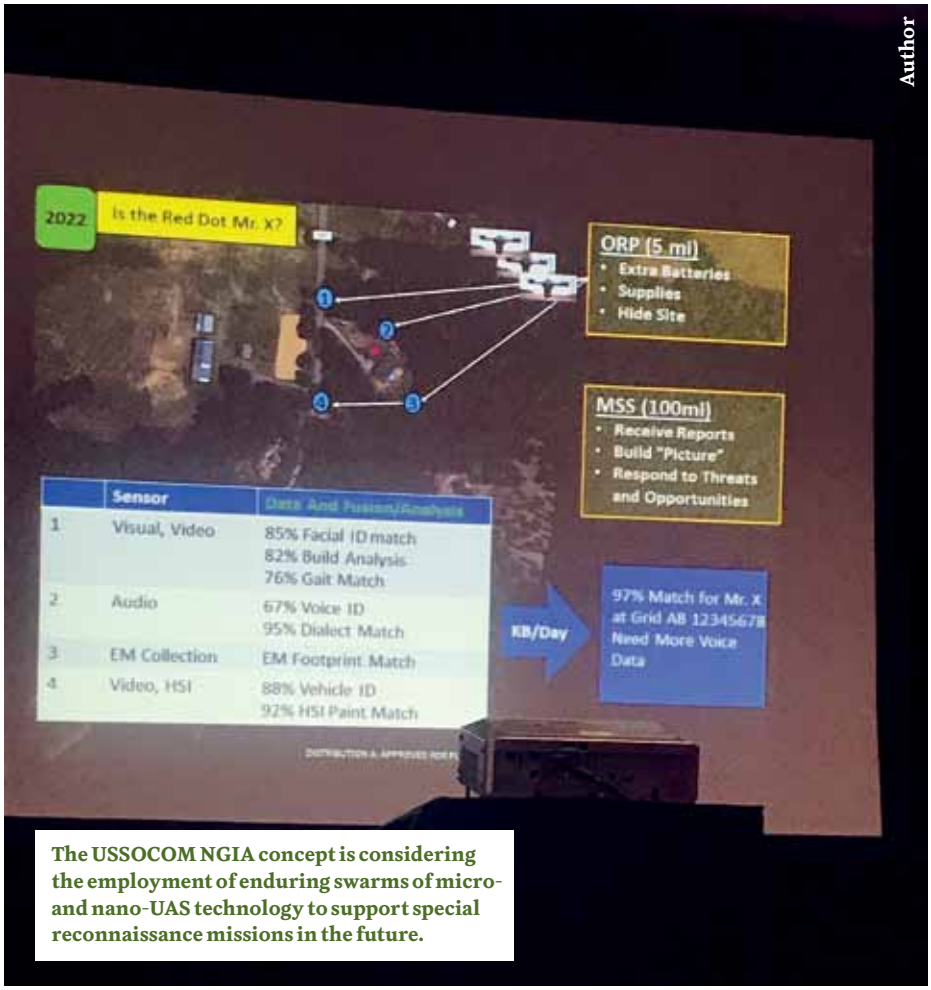

The USSOCOM NGIA concept is considering the employment of enduring swarms of micro- and nano-UAS technology to support special reconnaissance missions in the future.

USSOCOM, suggested the establishment of a National Political Warfare Centre (NPWC) capable of orchestrating joint operations with support from SOF, as well as input from the various 'Three Letter' intelligence and security agencies and wider DoD and Department of State agencies.

Describing a series of new concepts of operation which could be aligned across the NPWC, the report illustrated how SOF could be used to support expeditionary diplomacy and covert political actions around the World.

NEXT GENERATION TECHNOLOGY

As General Thomas suggested, any uplift in demands placed upon the international SOF community in relation to increasing roles across the future operating environment must be supported by next-generation technology.

As NSHQ sources explained to *Armada International*, dominance in the area of information warfare will only increase in importance as SOF small unit teams seek to maintain tactical overmatch over high capability and near peer adversaries in particular.

Such a concept was demonstrated to representatives from across the SOF community at a SOFWERX event conducted in collaboration with USSOCOM's Program Executive Office SOF Warrior on 30 July. The exercise, which focused on Next Generation Information and Identification and Awareness (NGIA) warfare, is further augmented with a Capability Assessment Event, hosted by SOFWERX between 31 October and 1 November, USSOCOM officials added.

Aimed at providing capabilities for SOF to identify and facilitate novel methods of accessing data across the battlespace, the NGIA concept aims to identify state of the art technologies to support the integration of standoff biometrics; technical sensors; and advanced data architecture and analytics.

This, according to official sources, will complement traditional intelligence capabilities in order to "enable identification in near-peer, sensitive, and less permissive environments" while providing SOF small unit teams with the ability to integrate "multiple domain sensors to collectively derive high-fidelity information on identities, locations, and actions".

Areas of Interest related to NGIA include micro- and nano-technology; metadata analysis; edge computing; unattended sensors; autonomous vehicles; enduring power sources; mesh networks; multi-domain sensor fusion; and electro-magnetic spectrum (EMS) detection.

"Technologies and concepts should address the inter-related problems of gaining/maintaining persistent access, collecting and characterising data and fusing data to inform decisions," official documents explained. "This includes information gathering and data aggregation as well as the architectures and analytical tools associated with the information and aggregation. Preferred technology will allow sifting of information gathered prior to transmitting/returning to requester to minimise the bandwidth required," it was added.

PEO SOF Warrior provided *Armada International* with an initial consideration regarding NGIA CONOPS, centred around the employment of unmanned aerial systems (UASs) capable of supporting the collection of "high fidelity information on identities, locations and action".

A representative from the Joint Special Operations Command (JSOC) illustrated an example CONOP relating to NGIA which featured a swarm of micro and nano vertical take-off/landing (VTOL) UAS' and unattended ground sensors which could replace small unit teams have been traditionally relied upon to conduct special reconnaissance missions.

This CONOP could significantly reduce any risk of compromise of the mission by enemy forces or local populations while also exploiting artificial intelligence technology to optimise the processing, exploitation and dissemination of data to support follow-on actions.

Illustrated in a diagram, the CONOP showed a base location situated at a 'tactical bound' away from a target area, which could allow UAS' to travel back and forth from the target to a central processing, logistics and power hub.

This would provide extension in mission duration with recharging stations and would allow UAS' to swap-out payloads dependent upon mission parameters, thereby providing commanders with a range of electro-optical and infrared cameras through to LIDAR and hyper spectral imaging tools, EMS and audio detection solutions. A

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DoD'S BUDGET STRATEGY MISMATCH

Andrew Hunter

The US Department of Defense's (DoD) budget for fiscal year (FY) 2019 illustrates Charles Dickens famous opening line from a Tale of Two Cities, "It was the best of times, it was the worst of times." It is easy to see why 2019 is the best of times for the defence budget. At over $685 billion in discretionary funding, 2019 exceeds the DoD's budget peak during the Reagan defence buildup of the 1980s in constant dollar terms. It is exceeded only by defence budgets in the peak years of the wars in Iraq and Afghanistan. FY19 follows a 2018 budget which grew defence spending by over $65 billion, adding another $15 billion and capping of a dramatic two-year growth spurt. Better yet, the 2019 budget was enacted before the beginning of the fiscal year, something nearly unheard of in recent US budgets, and it is partnered with a National Defence Strategy released early in 2018 that dedicates DoD to a renewed focus on preparing for war with potential peer competitors.

What's not to like about a defence budget delivered on time, at a robust level, coupled with a relatively clear strategy to guide its use? As is usually the case in defence budgeting there is a catch, or in this case, several catches. The first catch comes with how the defence budget increases of the last two years came about, which played a large role in how they were allocated. The defence increases of the last two years were the result of congressional defence hawks, prominently the late Senator John McCain and his House counterpart, Representative Mac Thornberry, who pushed the Trump Administration relentlessly to increase defence spending. They built their case for higher budgets largely on the basis of a crisis in readiness, with aviation mishaps providing some of the primary evidence of the problem. Not only were congressional leaders the primary instigators of the increase, most of the big defence increase provided in 2018 was not requested by the Trump Administration, and so was allocated by Congress.

Congress largely steered these increases into high profile weapons systems, aviation programmes being the largest beneficiaries, and the 2019 budget did little to shift this focus. The defence strategy played a marginal role in the major resource allocation decisions of this period at best. The second catch comes with what the budget doesn't do. It doesn't put substantial new funding into developing the next generation of military capabilities, something the strategy suggests will be necessary to combat peer competitors. The 2019 budget initiates no major new modernisation initiatives beyond those it inherited from the outgoing Administration, most of which are focused on modernising the nuclear triad. The third catch is the continuing erosion of buying power of the defence dollar. The average cost of each active duty military service member is increasing again after dipping slightly after the cuts of the Budget Control Act. If this trend continues, it will become even more challenging to modernise US forces as personnel and O&M costs crowd out modernisation funding.

The mismatch between the 2019 budget and the National Defence Strategy is the original sin of the Trump defence buildup. Defence leadership has openly acknowledged the disconnect, pointing to the 2020 budget as the first that they expect to truly reflect the new strategy. DoD's efforts to address the disconnect lead to two central possibilities. The first is that there is a massive correction coming in the defence market, as DoD's investment posture is realigned in a more strategy-focused direction. Such a realignment would likely affect the industry's balance of power in unpredictable ways. This shift would likely have the biggest impact on the Army, where the disconnect between strategy and budget is most apparent. Such a shift could have ramifications for the international defence market, as the US Army may more aggressively consider purchases of foreign technology to aid its modernisation and compensate for its lack of research and development investment over the last decade. The second possibility is that the latest defence strategy will come in time to be seen as simply a piece of fine rhetoric, one that describes an approach to defence that is fine in theory, but which bears little resemblance to actual practice. If this outcome occurs, it would certainly not be the first time that a post-Cold War Pentagon strategy document languished unimplemented. However, it would deal a substantial blow to efforts to sustain the robust defence funding levels currently planned by the DoD, perhaps setting the stage for future defence cuts as US budget pressures increase. A

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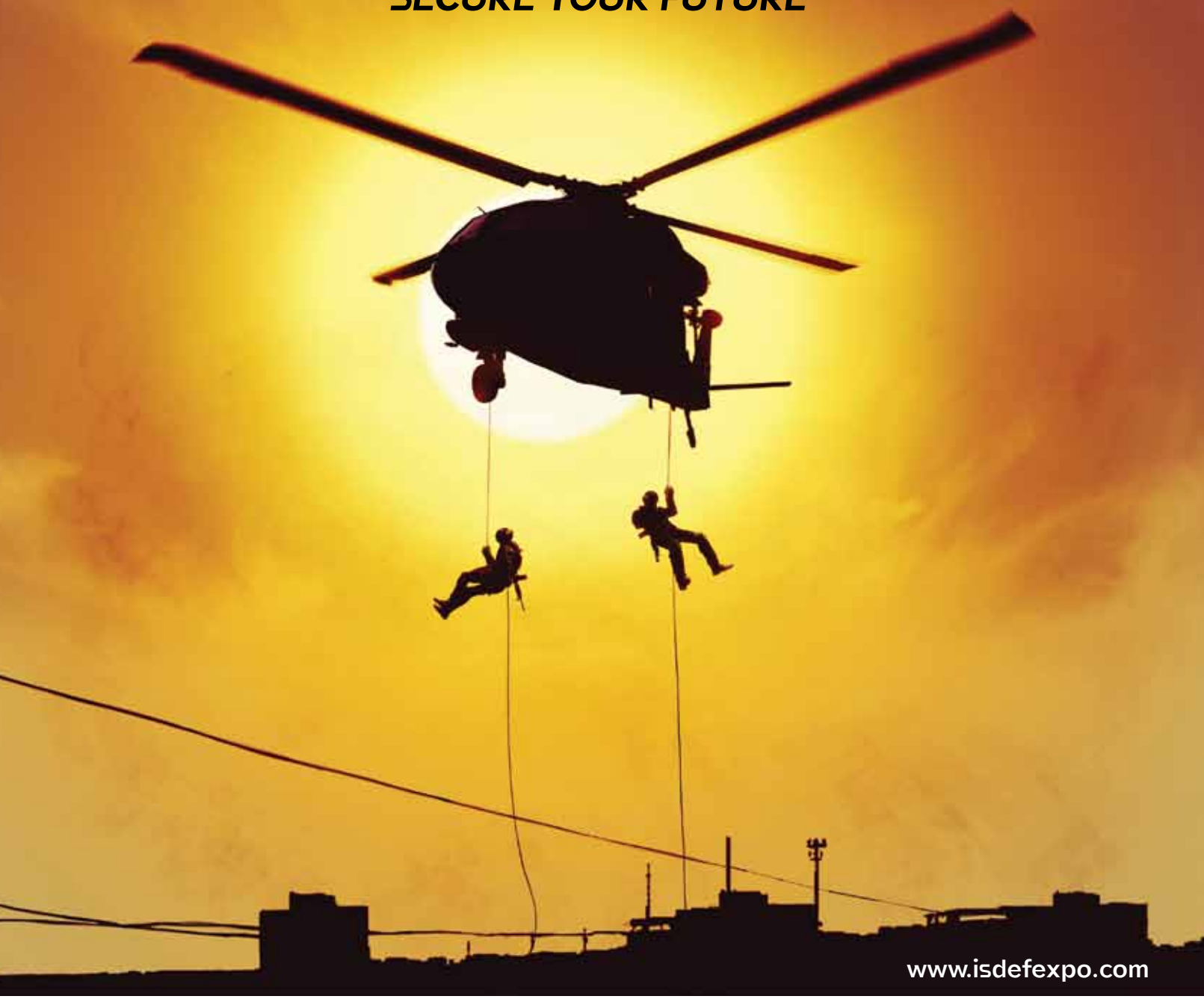

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