THE TRUSTED SOURCE FOR DEFENCE TECHNOLOGY ANALYSIS

ARMADA INTERNATIONAL

JUNE/JULY 2018. Issue 03.

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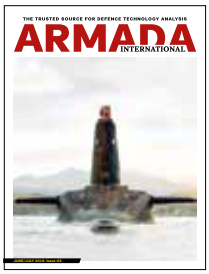

ON THE COVER:
HMS Victorious, one of the Royal Navy's four Vanguard-class strategic missile submarines departing HM Naval Base Clyde, Faslane, Scotland. (*MoD*)

THE TRUSTED SOURCE FOR DEFENCE TECHNOLOGY ANALYSIS

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**ENTIRES HIGHLIGHTED WITH RED NUMBER ARE FOUND IN COMPENDIUM*

THIS MONTH ON ARMADAINTERNATIONAL.COM

■ BRITISH MINISTRY OF DEFENCE ANNOUNCES THEY WILL RE-JOIN THE BOXER PROGRAMME

The UK Ministry of Defence (MOD) has announced that they will re-join the Boxer programme via the Organization for Joint Armament Cooperation, or OCCAR, a move that will allow them to procure the Boxer 8×8 vehicle to meet the requirements for their Mechanised Infantry Vehicle (MIV) programme.

■ RUSSIA'S 2018 COMBAT AIRCRAFT PRODUCTION

In January, the Russian Ministry of Defence announced that the Russian Aerospace Forces are to receive more than 100 new and upgraded aircraft, including Sukhoi Su-35S and Su-30SM multi-role fighter aircraft, Su-34 attack fighter aircraft, Russian Helicopters Ka-52, Mi-28 and Mi-8 of various modifications, as well as other types of aviation hardware. Last year, up to 200 aircraft and helicopters, and more than 100 units of air and missile defence systems were delivered.

■ SAAB SIGNS FRAMEWORK AGREEMENT WITH FMV FOR CARL GUSTAF AMMUNITION

Saab has signed a Framework Agreement with the Swedish Defence Materiel Administration (FMV) to enable efficient procurement of ammunition to the Carl-Gustaf weapon system. The agreement allows FMV to purchase every kind of combat and training ammunition available, as determined by the needs of the Swedish Armed Forces.

■ THALES GOALKEEPER SCORES AGAIN AND AGAIN IN SEA ACCEPTANCE TRIALS

The first Goalkeeper Close-In Weapon System of the Royal Netherlands Navy equipped with the Upkeep modifications contracted in 2012, was subjected to the Sea Acceptance Trials (SAT) and passed all tests with flying colours.

Editorial

Gearing-up for peer-to-peer warfighting

The discussion around the prospect of fighting a peer or near-peer adversary is growing louder and more intense at military gatherings in the United States and other NATO and allied countries. The senior leaders of the United States Army Aviation proved to be no exception during the recent Army Aviation Mission Solutions summit (25-27 April) in Nashville, TN.

While the threat of terrorism is still recognised as a clear and present danger across the global community (see the feature on special force military assistance programmes on *page 28*), the involvement of Russian forces in countries including the Ukraine and Syria, as well as China's widening foreign policy ambitions backed by its own burgeoning armed forces, particularly the Chinese Navy, have had a 'smelling salts' effect on how the US military is viewing future conflicts.

"We can no longer assume that our post Cold War dominance will be the same as [when we were] the world's only remaining super-power," stated General James McConville, Vice Chief of Staff, US Army, during his keynote address at the summit. He predicted that a new era of 'great power competition' was arising.

Following the attacks of 9/11, the US and its allies have invested heavily in fighting extreme terrorist groups, both operationally and in terms of equipment purchased to fight in asymmetric environments principally in Iraq and Afghanistan. Vehicles such as Mine-Resistant Ambush Protected (MRAP) transports, helicopters to ensure manoeuvre, and the honing of counter terrorism tactics, techniques and procedures (TTPs) have set the armed forces in a COIN posture.

"While military attention was focused on 16 years of counterter-insurgency operations, our adversaries have been studying us - making intellectual, organisational and material investments designed to give them an advantage in future wars," warned McConville.

"We anticipate we will be contested in the air, on land, at sea, in cyber and in space. We will fight in an anti-access area denial (A2AD) environment and will not enjoy the air and sea superiority that we have long taken for granted," he asserted.

With comments more aligned to the military's industrial partners he said that the intent was to re-gain the overmatch [in forces] and to retain a decisive advantage. That, he said, would require a highly responsive and efficient modernisation enterprise strategy, together with swift implementation.

"We must not produce better tools if what we need are different tools. It is not about faster horses, but new ways of manouver on the battlefield," he challenged. Recalling numerous past programmes failures he added: "We cannot risk ... future credibility on massive programmes that over promise and underdeliver then die under their own fiscal weight."

Therein lies a probelm that has always proved difficult to overcome.

ANDREW DRWIEGA,
Editor

Airbus

The first German Navy Sea Lion maritime NH90 flew from Donauwörth on 8 December 2016.

GERMAN NAVY'S ROTARY-WING CHALLENGE

This special report outlines the challanges being faced by the German Navy in preparing its NH90 helicopters to replace its aging fleet of Sea King Mk.41s

David Oliver

The German Navy is facing extreme challenges with its rotary-wing assets. Its ageing fleet of 21 Westland Sea King Mk.41 Search and Rescue (SAR) helicopters, the first was delivered in 1974, is to be replaced by 18 NH90 Sea Lions, while a replacement for its 22 Sea Lynx Mk.88A anti-submarine warfare (ASW) helicopters has yet to be selected.

The procurement of the Sea Lion was politically motivated and there was no competition. The German armed forces' original requirement was for 272 NH90 Tactical Transport Helicopters (TTH), although this is now reduced to 82 currently being delivered to the German Army. Ordering 18 maritime variants went some way to address the shortfall in production at Germany's Airbus facility at Donauwörth.

The introduction of the Sea Lion presents the commander of Air Wing 1 at Nordholz with mounting problems, including recruiting, training and retaining naval helicopter pilots for complex new equipment. According to Commander Jan Keller, recruitment is at all time low and of those who apply, few are physically or mentally qualified. Those selected gain basic rotary-wing training at the International Helicopter Training Centre at Bückeburg before being posted to Naval Air Squadron (MFG) 5 at Nordholz.

CAE

The CAE upgrading the German Navy Sea King FMS at Nordholz.

MFG 5 is short of operational Sea King and Lynx crews, and instructors and the navy is currently leasing a civilian EC135, from the Cuxhaven-based company DL Helicopter, to meet its helicopter training requirements.

Although the out-of-service date for the Sea King is 2023 and airframes are already being withdrawn from service, last year CAE performed a range of updates to the Sea King full mission simulator (FMS), including the addition of the latest-generation CAE Medallion-6000 image generator with Common Database (CDB) architecture. The enabled German Navy to conduct a range of training tasks including ship deck landings and night vision goggle (NVG) training. A further upgrade including the installation of new Sony K4 projectors is planned for this year.

The German Navy also signed a contract in August 2017 with HeliOperations UK to train German Navy aircrew in SAR operations using two ex-Royal Navy Sea King HU.Mk5 helicopters at its Portland base in Dorset.

Cdr Keller is tasked with having five

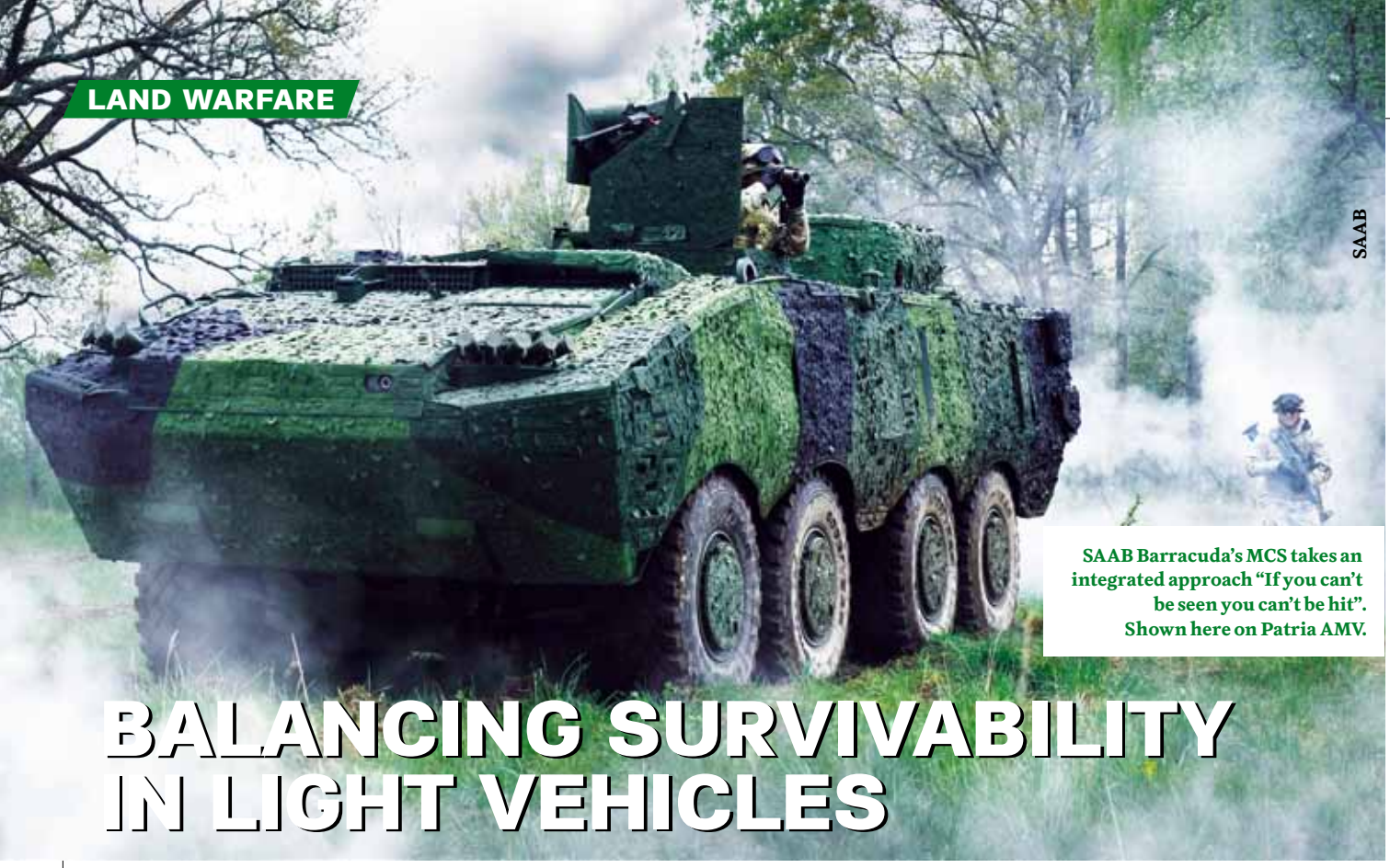
qualified Sea Lion instructors by the time the first three helicopters are delivered in Q4 2019. These will have to be trained either at the German Army's NH90 TTH facility at Bückeburg or at Rotorsim in Italy. However, they will not have a Sea Lion FMS available for at least another year.

Even before the specifications for a simulator can be issued, MFG 5 will have to evaluate the new helicopter's primary SAR role before a training syllabus can be formulated. The Sea Lion simulator will be procured through the NATO Support and Procurement Agency (NSPA) and the requirement is expected to include an FMS and a rear-cabin crew trainer.

CAE has a long history of supporting the German Navy's flight simulators and is expected to be a leading contender in bidding for the Sea Lion FMS. It is proposing to base its offer on the recent contract to provide Qatar Emiri Air Force (QEAF) with a comprehensive NH90 training solution. This will comprise CAE 3000 Series NH90 FMSs, certified to Level D, with a six degree-of-freedom (DOF) electric motion system and a high-performance vibration platform. They will have a high-fidelity CAE Medallion-6000XR visual system and a direct projection 220- x 88-degree extreme field-of-view dome display. The NH90 simulators will also feature the Open Geospatial Consortium Common Database (OGC CDB) architecture.

The QEAF training system will include a rear-crew trainer for training tactical coordinators (TACCO) and sensor operators capable of networking with the FMS, and a winch and door gunner trainer.

When the German Navy Sea Lions are deployed, it is anticipated that an additional range of roles including maritime reconnaissance, special forces missions as well as personnel and materiel transportation tasks by be added that will have to be reflected by simulator upgrades.



SAAB

SAAB Barracuda's MCS takes an integrated approach "If you can't be seen you can't be hit". Shown here on Patria AMV.

BALANCING SURVIVABILITY IN LIGHT VEHICLES

Without the protection of heavy armour, there are still a variety of options available to improve crew survivability in light armoured vehicles.

Stephen W. Miller

Tactical armoured vehicles provide both protection and manoeuvre. For light armoured vehicles, the level of protection is balanced by the need to assure mobility is maintained. This can be tactical mobility on roads and cross-country across varying terrain. It may also maximising agility through rapid acceleration, tight manoeuvrability through a high power to weight ratio. Further, a light vehicle can be a prerequisite for transportability by either aircraft or helicopter. The value of the capability to deploy armoured vehicle assets with expeditionary forces is likely more important today. The crucial advantages of having protected mobility immediately on the ground and available for aggressive combat operations was most recently demonstrated in Operation Serval in Mali.

A light armoured vehicle is generally designed with either a lower weight and/or a lesser level of protection. The Lockheed Martin C-130 Hercules is often the benchmark aircraft with its ability to lift 19,090kg (42,000lb) of payload.

The challenge is in determining how to meet this airliftable weight yet achieve an optimum level of protection. The goal is to include features that contribute to the combat diktat: "1 - don't be detected, 2 - don't be seen, 3 - don't be hit, 4 - don't be penetrated, and last 5 - don't be killed".

DON'T BE DETECTED OR SEEN

These are closely connected. To avoid detection the vehicle can be optimised to go in the widest range of terrain, offering the most route options. Signature reduction including reducing the vehicle's profile and integrating camouflage and concealment helps to avoid being seen. Niklas Ålund, a former Swedish Army officer and Saab Barracuda business development manager suggests that "counter-surveillance and counter target acquisition can be successfully addressed by camouflage, concealment and deception (CCD). CCD applied to vehicles has been shown to offer the advantage of reducing detection, recognition and engagement accuracy on an order of 30 to 50 percent in force-on-force combat experiences." Barracuda is renowned for its integration of techniques and complementary technologies in a manner that are easily applied and employed to degrade or defeat multiple sensors and spectrums, including visual, infrared (IR), thermal, and radar. This is combined with the vehicle's capacity to respond quickly and rapidly to move from cover to cover. From the survivability standpoint, the agility and ability to accelerate quickly are far more important than top speed.

DON'T BE HIT

Avoiding being hit can mean using threat detection systems like laser-warning and gunshot detectors. Acoustic gunshot detection technology has received increased attention due to its use in the Iraqi insurgency. QinetiQ North America's EARS family of gunshot localisation systems are discretely located on vehicles and can provide a firer's position in a quarter of a second offering both a visual grid location and audio alert. Raytheon's Boomerang operates whether the vehicle is moving or stationary detecting incoming shots within 30 metres. It also differentiates between non-ballistic events and outgoing shots fired from the vehicle. Such detectors are becoming standard equipment for combat vehicles offering the crew the ability to immediately respond to a threat. The Ajax Shot Detection System from Thales UK, announced in March 2018, will be included on the British Army's BAE

Systems Ajax combat vehicle. It will give the crew a 360-degree threat-detection capability.

Laser warning devices fitted to combat vehicles offers a pre-engagement threat alert as they sense the energy of a laser targeting the vehicle and advise the crew of the direction of the threat. The US Marines outfitted their Light Armoured Vehicle (LAV) with Goodrich's WR-2 in 1996. Its latest advanced VVR-3 is capable of detecting laser range-finders, designators as well as beam-riding missiles at a 360 degrees azimuth and 55 degree elevation. Elbit Systems also provides units including Multi-Threat Detection Systems (MTDS) that can also sense, categorise and pinpoint radar/RF sources.

When an alert occurs the vehicle can deploy screening smoke from its onboard launchers to hide its movement to cover. Renaud Thétiot, business development manager for Lacroix indicated that its "GALIX offers both instantaneous screening (in under two seconds) combined with longer 40 second duration addressing visual to infrared threats." The latest configurations integrate automatic sensing and up to 360 degree coverage whereby only the launchers facing the threat are fired. This system also calculates the winds and advises the driver and commander the best direction to maintain coverage.

This is when exceptional automotive response to accelerate and rapidly move to cover is critical. Achieving this is partly a function of having a good horsepower to vehicle weight ratio coupled to a responsive transmission/drive. However when off-road the limiting factor, especially for wheeled light combat vehicles, has been the suspension. The introduction of active-suspension systems has solved this allowing cross-county travel at double or triple speeds previously possible, while also providing a smoother ride. The Horstman designs 'utilise on-board sensors and computer-controlled motors, which power the dampers movement. Inserting a positive force through pressurised nitrogen into the suspension causes the wheels to raise and lower as the vehicle traverses various terrains improving the stability of the vehicle by up to 70 percent" according to the manufacturer. Other hydro-pneumatic suspension solutions are offered by Hendrickson with its HHP and HPAS and Oshkosh's TAK-4i which not only improved ride but also accepted greater payloads.

Another aspect to retaining mobility is being able to continue to move despite running gear combat damage. For wheeled combat vehicles this is provided by run flats – typically inserts or fills in the tires. Hutchinson's VFI (Variable Function Insert) and VPPV are widely used allowing the vehicle to travel up to 48km (30 miles) even with several tires penetrated. Another is the Rungard Runflat Insert System (RIS) made with lightweight polymer materials and engineered to prevent shattering under ballistic attack. It supports the combat vehicle allowing running with flat tires at 50km/h (31mpg) for a range of 100km (62 miles) on road, or 50 km (31 miles) off-road.

DON'T BE PENETRATED

For light vehicles simply adding more armour to the vehicle can be a limited option as it also increases the weight. This increase can compromise other desired capabilities including air transportability and acceleration. As a BAE Combat Vehicles spokesperson divulged: "currently there are no affordable technology advances foreseen that will dramatically reduce armour weight". Thus, vehicle developers are working with protection providers like IBD Deisenroth Engineering of Germany toward alternate approaches. One answer is to offer a basic level of protection possibly against small arms and mines/IEDs with the ability for later up-armouring. IDB's Advanced Modular Armour Protection (AMAP) system has composite armour modules that can be fit in the field to meet various higher threats. Many of the latest armoured vehicle designs, such as the Patria AMV are designed to accommodate these packages. One of the objectives in the introduction of add-on and modular passive armour it is to make it possible to configure a vehicle with a 'transport weight' that allows it to be carried in a cargo aircraft yet achieve a desired protection level when deployed.

Add-on or appliqué armour can also be employed to enhance ballistic protection. These are typically smaller panels often using composites that are attached to the existing vehicle armour. Versions are offered that can be installed in the field. The QinetiQ North America's LAST Armor (Light-appliqué Armor Systems Technology), for example, includes a modular, removable and lightweight external (or internal) placed armour. It is ceramic or metallic/composite composition that is customised to each vehicle to provide up to STANAG (STANdardization AGreement) Level IV protection. The version successfully employed in the Gulf War in 1991 utilised a hook and loop attachment system, although the company recently displayed a magnetically attachment approach that requires no base. TenCate Advanced Armor also provides customised add-on solutions that add least possible weight while providing maximum protection including against multiple strikes.

Another protective solution focuses primarily on defeating hand held anti-armour weapons like the rocket propelleg grenades (RPGs). QinetiQ North America's Q-NET RPG protection can defeat this specific threat at a very low weight by using a suspended offset cord 'net' around the vehicle. AMSAFE Bridport's Tarian RPG protection systems takes a similar approach. They are ideal for light vehicles in that they are easily installed, have minimal impact on weight and stability and can be field repaired.

Of particular promise are Active Protection Systems (APS). The criteria for APS on lighter vehicles are stricter than for heavy armour. Some like Artis LLC's Iron Curtain, explained Mr Brian Detter

Raytheon

Active Protection Systems (APS) for light vehicles must be light weight, compact, and easily integrated. Raytheon's Quick Kill APS is being perfected as a universal system adaptable to multiple platforms.

Qinetiq

Qinetiq's Q-Net mounted on an Oshkosh M-ATV provides protection against lightweight handheld anti-armour weapons.

an executive at the company, "are specifically designed toward use on lighter tactical vehicles where system weight is a prime concern". Rheinmetall's Active Defence System (ADS) is another that eliminates the projectile from penetrating. Raytheon's Quick Kill APS can intercept and shoot down threats, including RPGs and anti-tank missiles. General Dynamics Ordnance and Tactical Systems' Iron-Fist offers both a soft kill electro-optic jammer and a hard kill interceptor. A spokesperson stated: "It uses two independent sensing techniques: radio frequency (RF) and passive infrared (IR) and has 360 degree, high angle coverage."

DON'T BE KILLED

The final layer of the vehicle's defence is working to assure its survivability or most importantly that of the crew. Should all else fail and the vehicle is successfully engaged either by a projectile or mine/IED the design must mitigate the damage and limit the effects to the embarked soldiers. The solutions can differ if the destruction is primarily the result of blast as in a mine or a ballistic or chemical energy shaped charge penetration.

Ballistic and shrapnel threats are the purview of passive armour. Placing the soldiers in an armoured "'citadel', as in the Denel Vehicle Systems RG-35/ NIRM JAIS, allows the focus to be on protecting the occupants. Incorporating existing vehicle storage and/or floatation cells into the armour envelope as done in IVECO's SuperAV is another way to enhance protection

IEDs or mine defence lies in channeling the blast forces away from the vehicle's crew compartment and reduce the shock transmitted to personnel on board. This former is facilitated by the Vee-hull shape

Author

Blast resistant/shock absorbing seats (these troop seats are in the latest US Marine Corps AAV7) have been shown to significantly reduce injurty to soldiers.

hull and the designed-in sacrifice of suspension and other components. Personnel must be isolated not only from the resulting blast shock, but also the vehicle lifting and fall which itself causes casualties. A part of the answer lies in the provision of blast resistant and shock absorbing seats for all crew and passengers.

One of the major challenges for seat designers is that each vehicle and each personnel station within the vehicle can have a different space. In the Stryker, for example, there are at least four different space claims (driver, commander, gunner and troops) with different mounting and operational requirements. QinetiQ North America has focused on its BlastRide technology; passive energy-attenuating seats that would best integrate into cramped vehicles spaces. SCHROTH Mine Blast Protected Seat Systems use a tubular lightweight design with a resettable Energy Absorbing (EA) system and All Belts to Seat (ABTS) designed into the seat. MED-ENG in Canada offers commander and driver's Blast Seats that can raised for heads-out viewing and troop seats that can be customised for installation in new and retrofitted vehicles.

Other additional blast attenuating features are secure seat harnesses, double hulls, suspended floors, and shock pads. The last, like those from SKYDEX and Viconic Defense, reduce the shock loads transmitted to the legs, major problems, by as much as 71 percent. Even provisions for stowing and securing items with the vehicle become critical as these can become projectiles themselves in a blast incident.

For limiting the damage and injury caused by penetration of a vehicle, developers are able to draw on interior spall liners, compartmentalisation of ammunition, automatic fire suppression, explosive proof fuel cells, and internal armoured bulkheads. Automatic Fire Extinguishing /Suppression Systems (AFES/AFSS) require millisecond detection and response. Kidde Aerospace and Defense AFES uses optical fire sensors coupled to fast acting, high-rate discharge extinguishers. As in the Amerex-Defense's AFSS response times from the start of the fire until extinguishment are typically well under 200 milliseconds. These are designed to prevent explosive fires almost before they get started. Systems are fitted inside engine and crew spaces as well as externally to suppress tire and track/roadwheel fires. Experience has shown that a second hit is not unlikely when engaged so having a second shot capable AFES such as provided in HTL/Kin-Tech Division of Pacific Scientific's design is highly useful.

Vehicle fuel cells are critical vulnerability. Preventing fuel leaks and explosions are major contributors to vehicle survivability. A Hutchinson spokesperson suggested that its "SAFETANK self sealing outer coating seals entry and exit holes instantly eliminating leaks while internal fillers inhibit ignition of fuel vapor". Aero Tec Labs' BallistiCoat converts existing tanks to explosive-proof including adding layers of aramid fibre and coatings for shrapnel protection. Fuel Safe Systems has provided puncture resistant, non-explosive, ballistic fuel tanks, fuel bladders, and armoured self-sealing fuel tanks for 30 years. Its blast protected, ARM-R-SAFE and self-sealing ARM-R-COAT fuel cells are certified to resist 7.62mm and even heavy .50cal machine gun bullets.

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US Navy

An unmanned US Navy X-47B overflying a test range in the United States.

UNMANNED AIR FORCE FOR TODAY AND TOMORROW

The development of unmanned aerial systems keeps pace with the debate on the extent of autonomy such aircraft will retain.

Justin Bronk

The debate about the unmanned future for air forces tends to separate those involved into relatively polarised camps. Some firmly believe for ethical or legal reasons, or by dint of long personal experience that faster and more sophisticated computers will not be able to replace an airman in the cockpit of high end fast jets. On the other hand, there are many who believe that it is not only possible but inevitable that the days of the manned fighter are numbered. In order to get a better understanding of this topic, several concepts around methods of control need to be understood.

The first is a category under which most unmanned combat aircraft fall under – remotely piloted aerial systems (RPAS). These aircraft are controlled from the ground in real time by a flight crew, often using controls which would not look out of place in a typical cockpit. Depending on the ranges and operational roles which a given RPAS is designed for, this control might be by direct line of sight datalink, or by satellite link relayed from almost anywhere in the world. The most famous examples of this type of combat aircraft are the US Air Force's (USAF) General Atomics MQ-1 Predator and MQ-9 Reaper which are typically flown over conflict zones such as Afghanistan and Syria by crews sitting in airconditioned control cabins at Creech Air Force Base, Nevada, USA.

There are clear advantages to the RPAS approach to air warfare, within permissive airspace at least. The removal of the pilot from the cockpit allows a much lighter, simpler design since there are no ergonomic or life support requirements, and the space and weight saved allow for more fuel and a greater usable munitions and sensor payload for a given airframe size. Since RPAS are typically not designed for air-to-air combat, or indeed any high-G manoeuvres, they feature long, thin, high aspect ratio wings and a lightweight fuselage, along with a very efficient turboprop or turbo-fan engine optimised for subsonic speeds. These factors together, coupled with the removal of aircrew endurance as a limiting factor, allow modern RPAS systems to routinely fly for more than 30 hours at a time, with some boasting over 48 hours endurance. Crews on the ground can rotate, typically every eight hours, providing constant vigilance on target for extended periods at the cost of increased manpower required per airframe. All combat actions are undertaken through realtime command from the ground, including target acquisition, classification and weapons release, as well as subsequent battle damage assessment. As such, there is little to differentiate RPAS combat operations from strikes conducted by manned fast jets except insofar as the RPAS crew will usually have spent a great deal longer observing the target area prior to and after the strike, and can even call on a legal officer for clarification during the process.

Primarily due to their far greater persistence over target areas, cheaper operating costs and superb intelligence, surveillance, target acquisition, and

reconnaissance (ISTAR) capacity, RPAS such as the MQ-9 Reaper have proliferated and developed extremely quickly over the past 15 years to the point where they are currently the weapon of choice for ISTAR and close air support for the United States and many other nations.

However, there are several pressing reasons why it is highly unlikely that RPAS will supplant manned combat aircraft in contested air environments. The first is due to the time delay inherent in a satellite control link. There is an unavoidable delay of an-ywhere between one and just under four seconds between information or command signals travelling between the aircraft and the ground-based crew. This means that for a highly dynamic and split-second timing-dependent task like air to air combat, nape of the earth flightpaths or ground strafing, a remote link is unlikely to be possible. The few seconds between something being registered by the sensors on the RPAS, being transmitted back to the control station and then the control inputs made in response

A US Air Force MQ-9 Reaper armed with four GBU-38 Joint Direct Attack Munition (JDAM) prepared for a mission at Kandahar Airfield, Afghanistan February 2018.

being transmitted back from the control station to the RPAS are potentially highly disadvantageous or even prohibitively slow in these situations.

Secondly, for tasks which required or might require rapid changes in direction, altitude and attitude of flight, satellite links are likely to be impractical as the command-line-of-sight between the aircraft's antenna arrays and the satellite's will be repeatedly broken during rapid manoeuvres and command of the aircraft lost for potentially crucial seconds.

Thirdly, and perhaps most importantly, direct remote control of unmanned air systems (UAS) represents a vulnerable and predictable attack surface for hostile forces. In the case of verylow observable (VLO), or 'stealthy' RPAS such as the secretive Lockheed Martin RQ-170, it may be much easier for hostile forces to detect and either jam or even highjack the command link than to attack the aircraft directly using conventional weapons. This was illustrated by the capture, intact, of an RQ-170 by Iran in 2011. The fact that Iranian forces were able to cause the stealthy batwinged spy aircraft to land apparently under control without self-destructing or notable damage strongly supports the Iranian claim that its electronic warfare specialists were able to disrupt and override the command link between the top-secret RQ-170 and its ground station, despite being unable to track and engage it with conventional anti-aircraft defences. Iran is considered a 'near-peer' rival, so this capability is probably less impressive than those possessed by states such as Russia and China which are typically the threats against which new NATO air force combat air platforms are designed.

The second major category of unmanned combat aircraft are those which are typically classed as unmanned combat aerial vehicles (UCAVs). These systems are not directly 'flown' but rather automatically fly and carry out reconnaissance and in future strike, suppression of enemy air defences (SEAD) and potentially even air superiority missions according to instructions either programmed in before takeoff and/or

US Air Force

updated by human controllers mid-flight. This sort of system can be described as man-on-the-loop rather than man-in-the-loop since there is still human oversight and discretion in setting mission and engagement parameters, but the machine interprets those instructions and executes those commands as best it can with the situational awareness and programming available.

UCAVs as opposed to RPAS offer many potential advantages over manned fast jets in high end warfighting scenarios going forwards, albeit with significant legal and ethical questions raised about what impact they would have on the political nature of war and meaningful human control.

As with RPAS, the removal of the pilot from a UCAV design saves complexity, payload, space and also allows for a lower radar cross section than a manned fighter. In addition, a UCAV could theoretically be designed to pull far more than the 9G that a human pilot can sustain if aerodynamics and thrust-to-weight allow, giving an edge over a fast jet in terms of manoeuvrability for within visual range combat and missile evasion. A higher proportion of the airframe can be given over to fuel storage allow-ing greater range, and endurance is not limited by human crew, enabling almost limitless time of station with sufficient air-to-air refuelling (ATAR) support.

The removal of the human training requirement for a UCAV as opposed to a fast jet or an RPAS also promises to greatly reduce through life costs since a UCAV would not need to fly missions in peacetime for training, to maintain qualifications or famil-iarisation. This is where a huge part of the attraction of UCAVs lies for air forces looking to a future where the price of their manned platforms will, if current trends continue, drive fleet sizes below usefully deployable levels. The purchase of a fast jet can be usefully understood as an air force

buying a certain number of airframe flight hours rather than a single aircraft per se. The majority of the several thousand hours of airframe life which fast jets are built to serve for are spent training and maintaining the skills with pilots need to conduct modern air combat operations. Since a UCAV would not be subject to training or currency requirements, each airframe purchased could provide far more 'combat' hours to an air force than a manned equivalent since the UCAVs would only have to be flown for frontline tasks and largescale exercises. This would either enable air forces to maintain a larger number of frontline airframes for a given operating and procurement budget, or to generate more combat sorties from the same number of airframes compared to a manned platform.

China's AVIC 601-S Hongdu.

This class of unmanned system is already in testing and, in all likelihood, operational use by various countries. The all-but confirmed American Northrop Grumman RQ-180 stealthy reconnaissance UAV, the BAE Systems Taranis and Dassault/Saab nEUROn technology demonstrators, and multiple Chinese projects identified thought leaked photographs testify to the determination of countries around the world to exploit the potential of extremely stealthy UAVs able to operate within heavily defended airspace without relying on vulnerable and detectable satellite datalinks for direct control.

The next logical step is to arm these systems to carry out strike and perhaps especially suppression of enemy air defences (SEAD) missions within defended airspace in order to lower the risks to manned combat aircraft. However, herein lies a major ethical and moral dilemma. Since, as previously discussed, communicating via satellite links risks denial by jamming, and detection possibly leading to the loss of the aircraft, UCAVs would sacrifice much of their survivability, flexibility and responsiveness if tied to such rules of engagement in high-threat environments. On the other hand, relying on pre-programmed rules of engagement and target selection and prioritisation algorithms would in effect hand decisions over the use of lethal force in rapidly changing or unexpected situations to a machine – something which Western popular opinion and mainstream politicians are unlikely to allow, at least in the absence of a recognised existential military threat. However, the multiple penetrating UCAV designs being trialled as part of China's AVIC 601-S programme, as well as Russia's deployment of 'combat robots' in Ukraine and Syria suggest that other rival powers may well be less constrained by moral and ethical concerns about UCAV technology than the West.

In the air superiority domain – traditionally the most critical fighter pilot's role – many senior and extremely experienced pilots still firmly believe that it will be a long time yet before a UCAV can replace the manned fighter. However, two factors are increasingly forcing others to take the opposite view – that in fact UCAVs could do the job of manned fighters as well if not better in the near future. The first factor is the development of control progammes such as the University of Cincinnati's ALPHA which was able to consistently beat some

BAE Systems Taranis demonstrator programme for unmanned combat aerial vehicle (UCAV) technology

of the most experienced fighter weapons instructors using only modest commercial computer hardware by exploiting 'fuzzy logic' techniques in 2016. The traditional arguments about computers being unable to process all the potential variables and unanticipated developments in split second aerial encounters are being challenged by innovative programming and ever more capable and affordable hardware.

Secondly, the inability of current generation UCAV prototypes to rival the supersonic performance and extreme agility of manned fighters is being increasingly mitigated in terms of air to air combat by advances in missile technology and sensor integration. Put simply, a formation of extremely low observable UCAVs able to share and cross reference their sensor picture to ensure superior situational awareness are likely to have a superior capability to position for optimal engagement parameters even without to options provided by supersonic dash capability and high manoeuvrability. When engaging, ramjet powered missiles such as MBDA's Meteor already offer hugely increased 'No-Escape-Zones' compared to legacy missiles as well as much greater energy retention for terminal manoeuvring and jam resistance which combine to suggest higher probability of kill per shot regardless of launch platform kinematics at BVR ranges. Up close, the latest generation of dogfighting missiles such as the ASRAAM, AIM-9X, Python 5 and K-74M are all capable of outmanoeuvring the most agile of manned fighters and most can be launched at targets far off boresight including 'parthian shots' at threats behind the launch aircraft. With such tools, UCAVs and manned fighters alike and increasingly unlikely to survive the 'merge' in a WVR engagement regardless of manoeuvrability. Given these dynamics, the cost effectiveness and endurance benefits of UCAVs which would enable more effective sorties for a given budget might swing the cost-benefit equation for high end air combat force design towards the unmanned option within the foreseeable future.

However, it is worth remembering that the vast majority of an air superiority fighter's frontline activities are not high-end air to air combat, but more mundane tasks such as Quick Reaction Alert, airspace policing and shows of force. Whether politicians and the public would be willing to have 'robot fighters' intercepting unresponsive airliners, or preprogrammed rules of engagement dictating the actions of UCAVs acting in an airspace policing role during international standoffs is a very different question to whether a UCAV could substitute for or replace the manned fighter for air superiority missions. Furthermore, as events in Syria, Iran and elsewhere have demonstrated, countries are typically much more willing to risk hostile action against military aircraft if they are unmanned – so the replacement of manned fighters with UCAVs could lead to an increase in kinetic flare ups during international crises which in turn could prove destabilising to say the least.

In the end, the programme timescales for current manned fighter procurement programmes such as the F-35 and F/A-18E/F will probably ensure that at least in Western air forces, unmanned aircraft will remain a growing complement to their more traditional manned fast jet counterparts for the foreseeable future – at least in the absence of a major war which forces change. However, for China in particular which is essentially aiming to build a world class air force from a low base without the sort of entrenched programme structures found in western defence establishments, the lure of large scale UCAV adoption in the near future may prove irresistible.

The Huntington Ingalls Industries

Newport News Shipbuilding delivered USS *Washington* (SSN 787) to the USN on 26 May, 2017.

EVOLVING NUCLEAR POWERED SUBMARINES

The design of nuclear submarines is changing to incorporate technological developments that can increase their operational scope.

Tim Fish

Few states have the ability to design, build and operate nuclear-powered attack submarines (SSN) or nuclear-powered ballistic missile submarines (SSBNs). These platforms are the ultimate weapon for both sea control and for a nation's deterrent capability but require serious financial commitment from any defence budget to both acquire and then operate and maintain over their lifetime.

Those countries that have built up an SSN and SSBN capability are committed to retaining it. The United States (US), United Kingdom (UK), France, China and Russia all possess SSBNs and SSNs with Brasil and India operating SSNs. It is illegal to sell an SSN overseas but Brasil is building one with French assistance and India uses an SSN on loan from Russia while it builds a programme to develop its own capability.

Nuclear submarines have changed over recent decades. The original boats from the 1950s and 1960s were designed with a teardrop shape for hydrodynamic effect and were equipped with basic conventional weapons such as torpedoes and mines. But the shape has changed through better production methods with big parallel pressure hulls, while additional weapon capability is also being added to SSNs.

Ian Parker, head of business development – submarines at BMT, told *Armada International*: "We used to put on conventional weapons, torpedoes and mines, then anti-ship missiles like Boeing's Harpoon, then land attack systems such as Raytheon's Tomahawk cruise missile, now there is space unmanned underwater vehicles (UUVs) and [other] payloads. So suddenly in order to achieve a balanced design putting all that equipment inside, you drive the size bigger and bigger. That is why you have seen successive classes of submarines getting bigger incrementally both to incorporate the increased capability and to actually build in the stealth characteristics that you require."

But although both SSBNs and SSNs are increasing in size it is for different reasons. Parker said that SSBNs are focused on remaining undetected and it is the stealth characteristics that drive size. For this type there is no need for a large weapons compartment, just self-defence systems. It is the nuclear missiles in the middle of the boat that are what is important. For SSNs however it is the addition of all the new payload capabilities alongside stealth that drive size.

New stealth and payload capabilities are being implemented in all the major nuclear submarine construction programmes. In the West, the US continues to operate its 14 Ohio-class SSBNs and has plans to replace them with 12 Colombia-class (SSBN-826) boats in addition to a rolling programme of Virginia-class SSNs to replace its Los Angeles-class.

In the UK, four new Dreadnought-class boats will eventually replace the four Vanguard-class SSBNs and the Astute-class SSNs are coming into service to take the place of the Trafalgar-class. In France, the four Redoutable-class SSBNs have

left service with four Triomphant-class taking their place and the country has also embarked on a programme to replace its Rubis-class SSNs with the new Barracuda/Suffren-class.

Elsewhere despite Russia's difficulties over the past two decades since the fall of the Soviet Union, it has managed to keep its SSBN and SSN fleet active and has pushed ahead with the Borey-class SSBN programme and new missile system to keep its nuclear deterrent up to date. The Project 885 Yasen-class SSNs will replace its Cold War era Akula- and Alfa-class boats.

In China, the navy is slowly building a sea-based nuclear deterrent capability with its Type 094 (Jin-class) SSBN. The US Office of Naval Intelligence (ONI) believes there are four of these type operational with a further four expected by 2020 and there is a new Type 096 SSN programme. India has the Arihant SSBN and has had along running programme to build more.

But to stay ahead of the competition the US Navy has introduced a set of new improvements to its SSN fleet with the successive Block upgrades of the Virginia-class. With plans to eventually sustain a fleet of 66, it is launching two per year under a multi-year procurement contract with General Dynamics and Huntington Ingalls shipyards. This class is set to remain in production to the middle of the century and it has the opportunity to bring in new technology incrementally across successive Blocks.

The Virginia-class were first introduced in 1998 and have reached their third Blocks with fourth and fifth due to enter service in the coming years. In cooperation with the Defense Advanced Research Projects Agency (DARPA) the latest Virginia-class boats host new propulsion elements such as propulsor systems, the external storage and launch of weapons, different sonar arrangements, and the simplification of hull, mechanical and electrical (HME) systems with increased levels of automation to reduce crew size and workload and improve internal ergonomics. A BAE Systems spokesperson told *Armada* that in early 2016 that company was selected to provide "propulsors, spare hardware, and tail cones for Block IV Virginia-class subs."

When the class was introduced they were fitted with new mast systems, upgraded sensor packages and other C4ISR systems. However, a unique element that was installed in the Block III submarines onwards is the Virginia Payload Tube (VPT). Block III and Block IV boats have two large diameter tubes in the front of the boat, which replace a dozen Tomahawk Land Attack Missile (TLAM) launch tubes. Each VPT can host six TLAMs and this is possible because the design of the front end of the submarine was changed away from a spherical bow array.

The next development in the Block V boats that will start production next year is the a Virgin-ia Payload Module (VPM), a step on from the VPT which is instead fitted amidships extending the length of the boat and providing an additional four tubes. Unlike the TLAM tubes, the new payload tubes are multipurpose.

BAE Systems is reputed to be a "key provider of propulsor systems for the Virginia-class (SSN 774) attack submarines, and the payload module tubes for the Block V version of the SSN 774s."

According to the company: "The Virginia Payload Module contains four large-diameter payload tubes, each capable of storing and launching up to seven Tomahawk land-attack cruise missiles. The payload module will bring an additional 28 missiles to each Block V Virginia-class submarine, tripling their payload strike capacity."

A Congressional Research Service report in December 2017 on the Virginia-class SSNs states: "The VPM ... contains four large-diameter, vertical launch tubes that would be used to store and fire additional Tomahawk cruise missiles or other payloads, such as large-diameter unmanned underwater vehicles (UUVs)."

It added: "The four additional launch tubes in the VPM could carry a total of 28 additional Tomahawk cruise missiles (seven per tube), which would increase the total number of torpedo-sized weapons (such as Tomahawks) carried by the Virginia class design from about 37 to about 65—an increase of about 76 percent." This would triple the number of shore targets that each submarines could hit.

The USN has stated that the reason for

Royal Navy

HMS *Agincourt*, an Astute class SSN, is one of the largest, most advanced and most powerful attack submarines ever operated by the Royal Navy.

US Navy

The USS *John Warner* (SSN-785) is a nuclear powered Virginia-class attack submarine. On 14 April 2018, while on her first deployment, the submarine fired six Tomahawk cruise missiles at targets inside Syria in what was believed to be the first combat use of her class of submarines.

introducing the VPM is to replace the TLAM strike capability that will be lost when the four guided missile submarines (SSGNs) retire from service in the 2020s. The SSGNs themselves were a development of the SSBN, but these boats were a unique result of the times. BMT's Parker believes that we are unlikely to see any similar boats in the future as they were adapted from the SSBN role following the Strategic Arms Reduction Treaty (START) talks during the Cold War and were an existing asset that the USN could modify for the guided missile land strike mission.

General Dynamics was contracted in 2016 for $19 million to develop the VPM with a further contract awarded a year later for $126m for long lead items to build the Block V submarines with the VPM. The cost of each VPM is slated at $340m, which is 13 percent of the total cost of $2.7 billion for each boat.

But now the USN wants to remain ahead of the new Russian and Chinese boats and has introduced a set of new features on the Block III boat USS *South Dakota*, which will be used as a technology demonstrator platform. One new element is what the navy refers to as "acoustic superiority", which Naval Sea Systems Command (NAVSEA) said included quieting technologies for the engine room to make the submarine harder to detect, a new large vertical array and additional quieting coating materials for the hull. These will be fitted to the Block V Virginias onwards and the new Colombia-class SSBNs.

Parker notes: "The most significant trend we have is the drive towards better stealth, because submarines want to be invisible in the water and the laws of physics prevent that. You have to work really hard to make yourself invisible through counter detection and radiated noise."

He added: "It is about how you mount machinery and how to stop noise being transmitted into the water. How you mount pipework, putting items in modules, rafts, not having equipment mounted to the hull, streamlined shapes, propulsors vs propellers, how much you need to operate hydroplanes to change course of platforms, it really comes down to minute detail."

The USN is implementing a Tactical Submarine Evolution Plan (TSEP) that will insert technologies into the Virginias in mid-contract but it expects to be able to bring these improvements into the design stage of its future attack submarine programme SSN(X) due to start delivering in the mid-2030s that will replace the Virginias. USS *South Dakota* is in post-shakedown availability this year following delivery and will conduct sea trials to test the new equipment during 2019-2020.

The USN's Programme Executive Office (PEO) Submarines is also committed to SSN(X) having the capability to launch and control multiple UUVs simultaneously. So far UUVs have been deployed from torpedo tubes, the 76mm (3in) countermeasure launcher and even the waste disposal unit but usually one at a time. The next step is to have a dedicated UUV launch and recovery unit, with charging ability and then design the submarine platform with this in mind.

But this means looking at ways of controlling UUVs and this requires advances in underwater communications and data transfer capabilities. The PEO wants to introduce these capabilities incrementally through latter batches of Virginia-class SSNs, likely Blocks VI and VII.

DARPA has a programme called Blue Wolf with the ambition to develop a UUV that can fit inside a 51mm (2in) diameter container and that can operate at greater ranges and at speeds than earlier systems to conduct new missions and capabilities. DARPA is also looking at counter-UUV technologies to protect submarines against the unmanned threat.

The Navy and General Dynamics Electric Boat (GDEB) are developing a prototype UUV launch and recovery system called the Universal Launch and Recovery Module (ULRM) from a cruise missile launch tube that is being tested aboard one of the SSGN submarines and is being configured to operate from a VPM as well.

GDEB has said that the vehicle works by acquiring a buoy at the top of the missile tube using a transponder. It deploys, completes its mission – ISR or mine warfare – then returns and connects to the buoy before being recovered into the tube. The company said that the UUV will have about a 152cm (60in) diameter and be seven metre (23ft), filling the missile tube. It is controlled using laptops so at this stage the plan is to use the submarine's existing infrastructure.

DARPA is also looking at new acoustic hull coatings, machinery improvements, new vertical sonar arrays on each side of the boat and an enhanced propulsor design. It is also running the Hybrid Multi Material Rotor Full Scale Demonstration (HyDem) project that will look at "applying breakthroughs in materials, material system technologies, and multidisciplinary design methods to a Virginia-class submarine rotor, a critical component in submarine performance."

The Colombia-class SSBNs are benefitting from the spiral development of the Virginia-class and will include many of its improvements. This is one way to keep costs down so that technologies are not

HMS *Victorious* was the Royal Navy's second Vanguard-class SSBN submarine. it carries Trident ballistic missile, the UK's nuclear deterrent.

Royan Navy Vanguard

developed from scratch for each class of boat. But the Colombia-class will also have a couple of major new developments.

PEO Submarines has stated that the Colombias will have an electric drive. The boats will still have a nuclear reactor to generate heat and steam but instead that will be used to drive turbines that will generate electricity and propulsion. This is one way of reducing noise, fewer mechanical parts such as reduction gears and pinions with an electric motor instead. This means developing a completely new advanced propulsion system and even moving away from propeller blades, which inevitably cause a certain amount of cavitation and noise.

It is a major technological risk. But the USN values stealth capability enough to the extent that it is willing to put in major investment to the programme. Press reports in 2017 have highlight flaws in the development of the new pre-production prototype electric drive system due to overheating, but the navy insists have been fixed and testing of the components will take place throughout 2018 and will not impact the overall delivery of the class. A final production motor will be built that will be used for further testing. To continue the spiral development to the next generation it is likely that the SSN(X) boats will have electric propulsion systems.

The company is also building the Common Missile Compartment (CMC) for the Colombia-class SSBNs that will also be used in the UK's Dreadnought-class. This continues a close relationship that has existed since 1963. Both types of deterrent submarines will use the Trident II D5 missile that will be replaced in the 2040s and therefore will need to host a successor submarine-launched ballistic missile system to the D5 or be available for other uses. ULRM is slated for use from the CMC.

GDEB is building quad-pack missile tubes for the SSBNs and expects an initial test installa-tion to take place in August. The Colombia-class boats will each contain four quad packs for a total of 16 missile tubes with the UK opting for three quad packs in each Dreadnought boat offering 12 missile tubes, although only eight will contain SLBMs.

Most of the main design and propulsion advances in SSNs and SSBNs took place in the 1980s and 1990s but there are still improvements in capability particularly with new payloads, a larger weapon inventory and stealth enhancements being introduced in new classes of boat. It is because of these incremental improvements the West still remains about a generation ahead of its rivals but at ever increasing cost that will have to be managed on a spiral development process, bringing benefits from one class of nuclear submarine to the next.

OWN THE NIGHT

The need for night vision is the norm not the exception in warfighting, not only on land but in all three domains.

Michael J. Gething

Harris Corporation

This image shows the current OMNI VIII standard of I2 tube

The US military has a phrase when referring to night vision (NV) equipment and its aplication – they talk of 'owning the night'. This is down to the fact that they have invested billions of dollars in developing the various technologies to see in the dark. While it is acknowledged that the US Army's Night Vision and Electronic Sensors Directorate (NVESD) is the world leader in the field of NV, the technology to achieve this capability is by no means exclusive to the United States.

Over the last 20 years, NV equipment has developed to a stage where it can be used by an individual soldier on the ground, in armoured fighting vehicles (AFVs), on naval vessels and on all types of military aircraft and helicopters; to say nothing of static sites for surveillance and observation. It can be used as a stand-alone system, such as the night-vision goggles (NVGs) worn by soldiers and aircrew, or integrated within a fire-control system (FCS) for use on combat platforms, be they for land, sea or airborne applications.

There are two main streams of technology connected with NV: image intensification (I2), which involves the collection and conversion of ambient light photons into electrons that are then multiplied by a cascading process before being reconverted back into visible light, with-in a small (usually 18mm-diameter) tube; and infrared (IR), or thermal, imaging (TI), which detects radiant heat. Each stream brings its own specific solutions to the challenge. The choice of which to use has depended on the application's suitability to the mission.

Image intensification covers the visual and near infrared (V/NIR) part of the spectrum from 0.4 to ~0.9 microns. As with all technology, I2 has evolved and today's tubes are Gen 3, with a thin barrier film on the microchannel plate (MCP) within the tube. Within the US, both the Harris Corporation (formerly Exelis, originally ITT Night Vision) and L-3 Warrior Systems (formerly Northrop Grumman Electro-Optic Systems, originally Litton EOS) produce I2 tubes for domestic and international use. Harris offer the Pinnacle range of I2 tubes and L-3 Warrior Systems, the Ultra range. Both products have a longer life than earlier models as well as improved performance.

As might be expected, the NVESD, guards it fiercely, with the export of US-manufactured I2 tubes to countries beyond close US allies being restricted to sensitivities defined by a measure known as the 'Figure of Merit' (FoM). This value is obtained by multiplying the tube's resolution (in line-pairs per millimetre) by its signal-to-noise ratio (SNR). To this restriction, there are also the International Traffic in Arms Regulations (ITAR) to be considered. It is not surprising, therefore, that non-US companies – notably, but not exclusively, instanced by the Franco-Dutch company Photonis – have developed equivalent products (such as the XR5 Onyx tube) that in some criteria exceed and in others fall just short of US specifications but remain ITAR-free.

The principle use of the I2 tube today is in the night-vision goggle (NVG), head- or helmet-mounted, sometimes singularly (in

a monocular or biocular configuration), sometimes as a pair (in binocular format). Generically, such systems are practically ubiquitous but they suffer one drawback – there must be some form of light about, in order to be intensified. A blinding glimpse of the obvious?

Perhaps, but when US and coalition forces found themselves in open country or mountainous terrain in Iraq and Afghanistan, the lack of sufficient (usually urban) ambient light meant that NVGs were almost useless on moonless nights or with occluded skies blanking starlight. In such conditions, thermal detection began to assume a more predominant role for the soldier, as TI technology was developing and thermal sensors shrunk. Thus hand-held observation devices or thermal weapon sights became more practical.

The TI camera uses a photon detector comprised of an exotic material such as indium anti-monide (InSb) and mercury cadmium telluride (MCT, CMT or HgCdTe) for its sensing detector array, and required cryogenic cooling to deliver the sensitivity required for imaging, as well as optics and processing elements. Such systems were usually made available in either the mid-wave infrared (MWIR) spectrum of 3-5 microns or the long-wave infrared (LWIR) spectrum of 8-12/14 microns. Early models were big, clunky and noisy; with applications restricted to larger systems installed on naval weapon and AFV fire-control systems.

As with I2, there is a drawback to TI. While it can produce an image in total darkness, the distance TI can 'see' depends on the atmospheric conditions across different parts of the spectrum: MWIR is generally considered more suitable for hot and humid climates; while LWIR is more suitable in cooler, drier climates. Thus performance can depend on the climate in the combat zone and, of course, the 'fog of war'.

As a means of penetrating the dust, haze and smoke encountered on the battlefield, camer-as tuned to the short-wave infrared (SWIR) spectrum (~0.9 to 3 microns) as well as the visible-to-near-infrared (V/NIR) spectrum (0.4 to ~0.9 microns), have been evolved. These use reflected "light" and are better able to penetrate atmospheric detritus, with the added advantage that bright light or flashes will not degrade performance.

Such SWIR and V/NIR cameras are now becoming available with a resolution and weight than can be accommodated on a head-mounted NVG for the foot soldier. Sensors Unlimited (part of UTC Aerospace Systems) market while the Warrior HWH (handheld/weapon/helmet) SWIR viewer, using an indium gallium arsenide (InGaAs) FPA of 640x480 resolution, covering the 0.7 to 1.1 micron range; while Photonis USA offers the Lynx CMOS solid-state imaging sensor with 1,280x1,024 resolution across the V/NIR spectrum.

In addition to man-portable system applications, SWIR sensors are fast becoming part of the imaging package offered by manufacturers for other platforms: ground vehicles, warships and airborne platforms (fixed- and rotary-winged, manned or unmanned).

The advent of uncooled thermal detectors (microbolometers operating in the LWIR spectrum) has taken a little longer to evolve, mainly due to the need to refine the detector materials to a sufficient degree to eliminate the need for cooling. Obviously, without a cooling system, the end product has a reduction in weight and possibly power. For operators of NV systems, the advent of uncooled detectors in the early years of the 21st Century offered a reduction in the SWAP (Size, Weight And Power consumption) equation, although they have yet to attain the sensitivity of cooled systems. For the future, HOT (Higher Operating Temperature) arrays are emerging, which will require less cooling, reduce SWAP, and increase reliability. Uncooled detectors have, however, made man-portable systems practical.

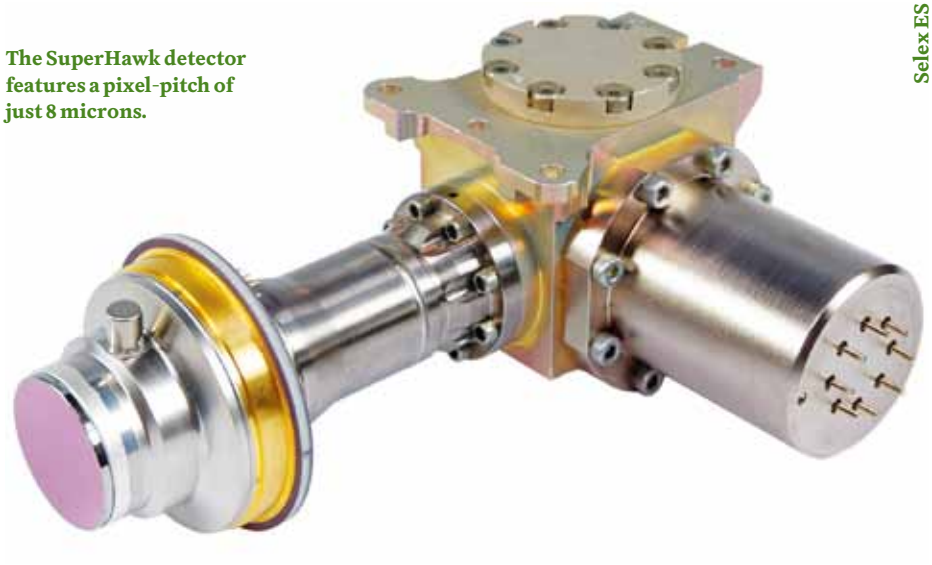
The sensitivity of a TI camera depends on the number of pixels in the detector's focal plane array (FPA), expressed, for example, as 320x240 – this being the most common FPA format some 15 years ago. The number of pixels in an FPA depends of their size (or pixel-pitch). The 320x240 format would probably have a pixel pitch of 25 or 30 microns, depending on the detector material. Thus, the higher the number of pixels there are in an FPA, the better the image resolution and, depending on the optics, the longer the range. A reduction in pixel pitches results in a higher pixel counts. So, in 2003, a 640x480 FPA with a 20 micron pixel pitch was considered HIGH definition. Production detectors with pixel pitches of 17 and 15 microns are now the norm, with 12 microns emerging, and 10 and seven microns under development.

By way of example, in 2015, Leonardo (then Selex ES) launched the Superhawk – an MWIR detector with a cooled FPA and pixel-pitch of just eight microns, providing a 1,280x1,024 pixels. This offers four times as many pixels as a conventional 640x512 pixel FPA with a 16 micron pixel pitch. It is claimed that the SuperHawk is able to capture better than HD-quality images in total darkness by detecting temperature differences as small as 1/50th of a degree.

There is, however, a drawback to shrinking pixel size in the form of potential signal leakage between neighbouring pixels (known as 'cross-talk'), which can lead to image blurring. To overcome this, Leonardo uses a technique that physically isolates the


UTC Aerospace Systems

The Warrior HWH viewer, shown in helmet-mounted and hand-held variants, is configured with an InGaAs SWIR detector.



The SuperHawk detector features a pixel-pitch of just 8 microns.

Selex ES

individual pixels from each other. Known as the mesa pixel format, it creates an inter-pixel 'trench' eliminating signal cross-talk between pixels which can cause image blurring, producing the sharpest possible image, the company says. The Superhawk's detector uses MCT infrared-detecting crystals created by the MOVPE (Metal Organic Vapour Phase Epitaxial) process, a technology the company has developed over 30 years.

The benefits of a shrinking pixel-pitch shrinks invariable enhance the system it serves. For a given physical size, the more pixels that can be accommodated within the FPA, the higher the resolution available. Conversely, for a lower pitch can reduce the physical size of the FPA, making the resulting imager smaller and lighter. Either solution makes higher-resolution arrays practical for larger multi-sensor systems (such as an AFV or naval FCS or static force/site protection application) as well as smaller products (such as weapon sights and digitally-fused night-vision goggles). For the former, full High Definition resolution (1,024x766, 1,280x720 and1,280x1,024) are now available, with the prospect of larger configurations to come.

By way of rounding off what is very much an introductory feature, rather than a long list of products and manufacturers, here are three illustrations of systems involving EO/IR (electro-optic/infrared) sensors to provide night-vision, across naval, airborne and ground platforms.

Submarines may not be the first choice of warship to be associated with NV but, in April 2015, the US Navy contracted L-3 KEO (formerly Kollmorgen Electro-Optics) for the development, first article production and support of a non-hull penetrating, Low-Profile Photonic Mast (LPPM) for its Virginia class nuclear attack boats as a follow-on to the current AN/BVS-1 Photonics Mast Program (PMP). Initiated in 1995, when Kollmorgen was awarded the PMP contract, the AN/BVS-1 comprised an EO/IR suite comprising an MWIR staring array thermal imager; a low-light-level TV camera, using electron-multiplying charge-coupled device (EMCCD) technology; a colour HD (high-definition) TV camera and an eye-safe laser rangefinder, all contained within an 46cm (18in)-diameter sensor head.

Among the improvements on the LPPM (apart from its reduced diameter of about 19cm (7.5in)) is the addition of a SWIR camera (adept at penetrating haze and fog). In addition, the production LPPM will have an HD colour camera, an ERC (extended resolution camera), an eye-safe laser range-finder and a full-up electronic warfare antenna suite. The significance of using the LPPM is its ability to replace the existing PMP without major structural changes to the submarine while retaining full integration with the existing data interfaces.

In the air, sensor turrets (or gimbals) have sprung up on many in-service surveillance platforms, helicopters and UAVs (unmanned air vehicles), all containing EO/IR sensors in various combinations. For fast-jet combat aircraft, the targeting pod has developed. One of the earliest such pods is the Litening from Israel's Rafael Advanced Defense Systems. Sold in large numbers worldwide (including a parallel development with Northrop Grumman in the United States) the latest iteration is the Litening 5 pod.

This features HD (1,280x1,024 pixel) MWIR detectors and colour Full HD (1,920x1,080 pixel) CMOS daylight cameras, plus a standard definition (640x512 pixel) SWIR sensor. In addition, Litening 5 has a laser suite, comprising rangefinder, designator and marker (illuminator). The system itself has been totally updated internally with a new air conditioning unit, a new electrical section with an 'empty' bay to allow for future expansion plus a new datalink.

On the ground, observation and sighting systems for AFVs have traditionally been 'under armour' but, in recent years modular 'above armour' systems have emerged. An example would be the MX-GCS system from L-3 Wescam. This is a twin-axis independent sighting system designed for medium and large-calibre vehicle-mounted

A Litening 3 targeting pod under an RAF Tornado GR.4 – the Litening 5 pod is externally the same but much improved internally.

Author

The MX-GCS 'above-armour' surveillance and FCS system.

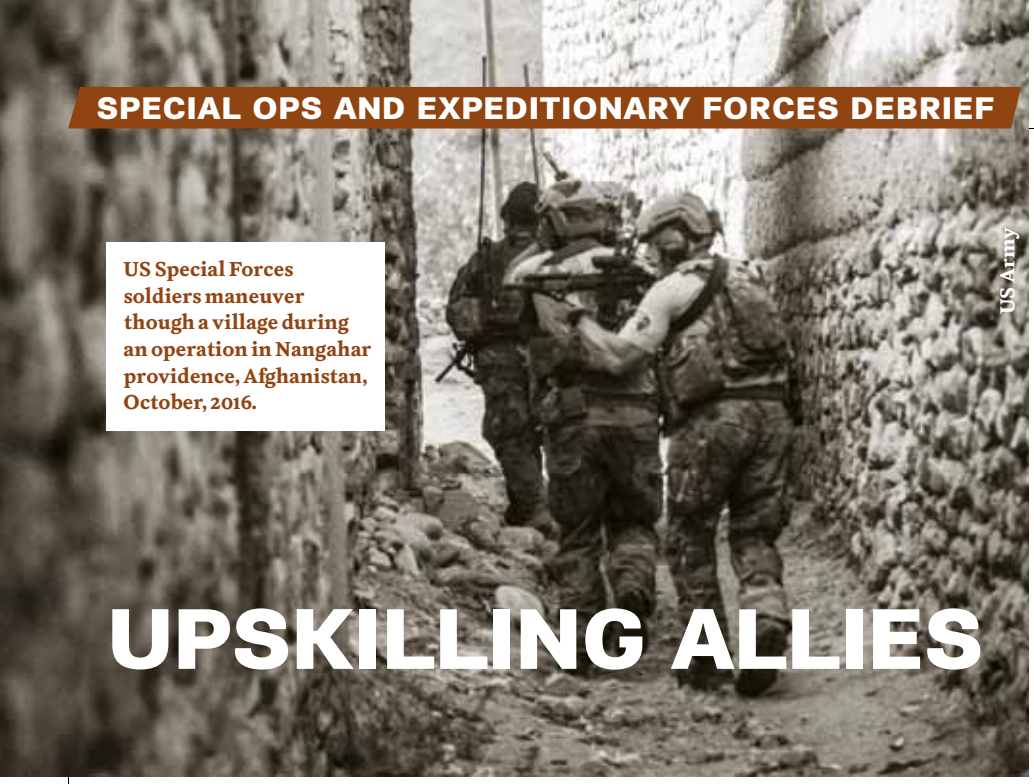
L-3 Wescam

weapons from 20 mm to 120 mm. The baseline payload configuration includes an HD daylight imager, a cooled MWIR sensor and an eye-safe laser rangefinder. Optional payloads include a long-range optical spotter, laser illuminator/pointer, a cooled/uncooled LWIR sensor, a laser designator, and a SWIR imager.

At the other end of the ground warfare scale, thermal sights are shrinking in size. Leonardo DRS used the DSEI 2017 show to promote its Sniper Precision Acquisition Rifle Thermal Night (SPARTN) sight – a clip-on sight to be mounted forward of the day optic telescope on the sniper's weapon of choice. This uses a cooled MCT 640x480 FPA detector with a 12-micron pixel pitch, operating in the MWIR band.

Night vision is no longer a 'nice-to-have' extra: it has become an essential element of modern warfare that no military force can afford to ignore in the 21st Century.

Note: *Mike Gething was formerly editor of Jane's Electro-Optic Systems 2003-2015*



US Special Forces soldiers maneuver though a village during an operation in Nangahar providence, Afghanistan, October, 2016.

US Army

UPSKILLING ALLIES

Military Assistance campaigns have become one of the most favoured concepts of operation employed by the international special operations force community.

Andrew White

Designed to optimise the force multiplying effects of already very small units, the Military Assistance (MA) model continues to evolve with special operations force (SOF) teams seeking to extend their reach and influence to even the most remote of areas.

Such missions allow SOF to develop not only the specialist capabilities of partner nation forces but in addition, achieve their own strategic objectives without committing larger numbers of SOF or conventional forces.

Speaking to *Armada*, Lithuanian SOF (LITHSOF) Commander, Colonel Modestas Petrauskas, referred to the MA mission set as one of the most "traditional mission sets currently being undertaken by western-type SOF components."

This, he explained, had resulted in MA now being regarded as one of the key SOF capabilities alongside direct action, special reconnaissance, counter terrorism, hostage rescue operations and support of homeland security missions.

"Ongoing globalisation expands the boundaries of the area of operations on the global scale thus increasing demand for Global mobility, connectivity and integration," he stated while acknowledging the importance of partner capacity building operations.

Arguably the most recent and successful MA campaign to be executed over recent years saw a coalition of special operations task groups (SOTGs) employed in northern Iraq and Syria to counter the presence of the self-proclaimed Islamic State (IS) in the Middle East.

At its height, the US-led Special Operations Joint Task Force (SOJTF) Operation Inherent Resolve witnessed participation from special operations units from Australia, Canada, Denmark, France, Germany, Norway, the UK and US who were tasked with the support of indigenous SOF elements from Iraq and Syria.

Having reached its peak in October 2017 with the successful recapture of major IS strongholds in Mosul, Iraq, the coalition is currently drawing down its support of major combat operations across northern Iraq.

Generally numbering anywhere between 20 and 60 operators in strength, this international coalition of SOTGs were spread geographically across the vast rural, suburban and urban swathes of northern Iraq and southern Syria with a mission to 'train, advise, assist' and sometimes 'accompany' the indigenous security forces on operations.

This effort was designed to support Iraqi SOF, Kurdish Peshmerga special mission units and various other Syrian anti-regime forces in combat operations. However, the campaign was also designed to further assist the development of the units, allowing them to mature yet further into the future and provide a standalone capability without interference from the West.

Even though many of the SOTGs were operating under a variety of different national caveats, allowing for varying degrees in participation and rules of engagement, the collective effort of SOJTF Operation Inherent Resolve resulted in the near eradication of enemy combatants from IS strong-holds across Iraq and Syria.

SOTGs were tasked with supporting indigenous SOF units with intelligence, surveillance, target acquisition and reconnaissance (ISTAR) capabilities; training in close quarter combat and urban warfare; as well as (in certain cases) advisory roles and accompaniment on the ground during of-fensive action missions. Examples of such cooperation included the deployment of Australia's SOTG, which was officially acknowledged for the first time by the government on 18 October 2016.

According to government sources, this deployment centred around not only the training of ISOF units in small unit tactics and close quarter battle (CQB) drills, but also specialist support in improvised explosive device (IED) training and the supply of sniper teams and Joint Terminal Attack Controllers (JTACs) to call in close air support. Similar capabilities were provided by other coalition participants.

The success of the operation had been deemed so highly successful by the commanders of not only the SOJTF but also the conventional force commanders of Operation Inherent Resolve, that the MA campaign looks set to be further replicated around the world as armed forces seek to optimise the force multiplying effects of SOF as well as extend ties internationally as part of 'partner capacity building' missions in both training and operational environments.

MILITARY ASSISTANCE DEFINED

According to a US Joint Special Operations University (JSOU) report, published in February 2018 by the Tampa-based organisation, MA missions often fall under the operational remit of Foreign Internal Defence (FID) campaigns.

In the report, entitled "Growing SOLO (Special Operations Liaison Officer): Expanding the Spectrum of SOF Advisory Capabilities", it is described how MA operations are able to support indigenous partner forces in terms of 'indirect support,

direct support (not involving combat operations), and combat operations'.

According to the report, the application of SOLOs in support of MA campaigns provides much more than just assistance in combat operations. It provides a means to leverage "security assistance programmes as well as exchange programmes and joint/multinational exercises to help build strong national infrastructures through economic and military capabilities that contribute to self-sufficiency".

Highlighting current doctrine associated with the US Special Operations Command (SOCOM) 2020 vision, the JSOU report describes how such SOF missions can "actively build enduring relationships through training with partner nation forces and assisting like-minded nations as they address the underlying causes of extremism".

Acknowledging recent efforts in Iraq, the report also highlighted ongoing MA operations in Afghanistan where a similar coalition of international SOF and SOTGs, also coordinated by a centralised SOJTF model, continues to act in an advising and training capacity to help the development in the capability of the Afghan National Security Forces in order to provide "... sustainable security, trans-parency, justice, and opportunity for the Afghan people".

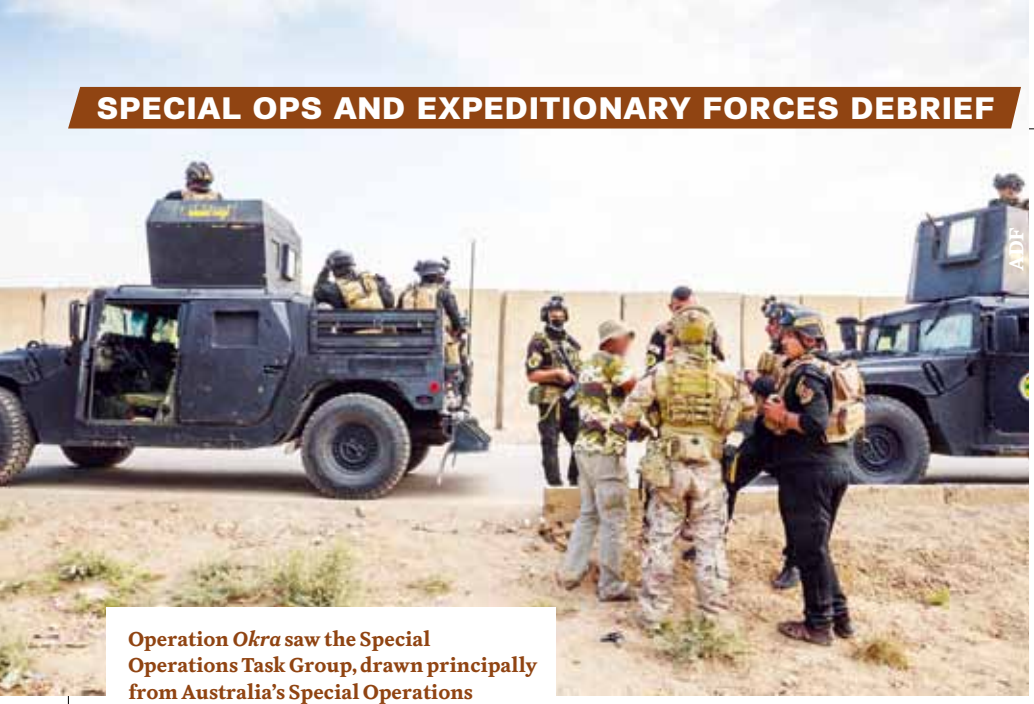
Ongoing work includes the forward deployment of SOTGs across the country, embedded with in-digenous SOF and special mission units from across the Afghan National Army (ANA) Special Operations Command; as well as special mission units from the National Directorate of Security (NDS) and GDPSU. Training includes the focus on small unit tactics, techniques and procedures (TTPs) associated with counter-insurgency, counter-terrorism and other irregular warfare capabilities.

However, the JSOU report goes a step further to suggest SOTGs conducting MA operations should also be seeking to extend influence beyond the tactical level to incorporate even greater levels of influence across high-operational, strategic and ministerial level initiatives.

"Assisting countries by addressing the underlying causes of extremism and the development of security forces that can provide transparency, justice, and opportunity are both tasks that would be consistent with the more high-operational/strategic and ministerial level initiatives typically associated with security sector reform," the report added.

Defence sources at NSHQ, speaking to Armada on condition of anonymity, explained how such a concept was already in progress on a global scale. However, sources did concede there was room to further extend the concept across the contemporary operating environment although it would require additional manpower levels-something which remains highly sought after throughout the international SOF community.

"To accomplish these tasks, the broader (US)SOCOM 2020 vision for SOF activities describes a globally networked force that includes interagency, allies and partners with the collective ability to rapidly and persistently address regional contingencies and threats to stability," the JSOU report continues to describe.



Operation *Okra* saw the Special Operations Task Group, drawn principally from Australia's Special Operations Command training, advising and otherwise assisting the Iraqi armed forces to defeat Daesh in Iraq.

"USSOCOM's SOF Operating Concept expands the list of SOF strategic partners to include "interagency, intergovernmental, multinational, non-governmental, commercial, and academic partners in this Global SOF Network [and] many of these strategic partners primarily operate at the high-operational/strategic and ministerial level of a government, which suggests that the additional SO-LOs that the concept calls for stationing in U.S. embassies could reasonably end up providing advice to high-operational/strategic and ministerial representatives in a partner nation."

The report concludes: "Broadening the baseline scope of SOF advisors to include both the high-operational/ strategic and ministerial levels of a partner nation's defence establishment appears to be an appropriate evolutionary step in SOF tasking".

EUROPEAN MEASURES

Such an uplift in high-operational and strategic influence is being illustrated in Europe where SOF components across the Baltic States continue to benefit from ongoing cooperation with NATO special operations components as they seek to counter emerging threats arising beyond the Alliance's eastern border with Russia.

Estonian, Latvian and Lithuanian SOF components continue to work closely with NATO partner forces as well as each other during exercises, as illustrated by the annual Exercise Flaming Sword which is designed as much to display a 'show of force' to Russia as it is to develop the indigenous small unit TTPs in line with NATO doctrine.

According to Petrauskas, Exercise Flaming Sword comprises the largest multinational SOF live exercise in the Baltic Region bringing together Allies and Partner nations to rehearse a collective defense scenario.

Describing LITHSOF representation within NSHQ, Modestas explained how his organisation continues to benefit from opportunities to connect and develop with international SOF partners.

"In order to contribute to connectivity and networking, LITHSOF organises the annual Flaming Sword to helps to get allies and partners as well as other services and agencies to think and train contingencies collectively ranging from crisis to collective defense scenarios.

"LITHSOF is also a strong proponent of Regional SOF capabilities development, where we also steadily progress together with Estonia, Latvia and other stakeholders," he continued to explain.

"Every year, it is planned and organised as a comprehensive, interinstitutional and interagency field training exercise throughout the territorial land, waters, air and electronic space of Lithuania," Modestas explained to Armada International.

"The training audience of the exercise is linked with other national Lithuanian Armed Forces exercises, as well as other NATO and regional SOF exercises. Different national and international institutions, SOF units from various NATO Allies' and Partners' countries take part in this exercise every year."

Referring to the current state of international SOF cooperation and MA operations, Petrauskas described how his Command continued to witness the emergence of an expanding Global SOF Net-work, where NSHQ and USSOCOM J3 staff officers play "important roles".

"This is especially important when facing borderless modern threats as well as staying on the top of innovations and technologies available to push SOF capability development further," he continued to describe.

"Collectiveness is also key to success to Lithuanian as well as Alliance security. Therefore, Lithua-nian SOF continuously strives in expanding SOF networks of connectivity and integration with allies and partners.

"Lithuanian SOF is fond of strategically important relations with US SOF, hence why a Lithuanian SOF officer is working currently in USSOCOM J3-I and USSOCUER representative permanently embedded within Lithuanian SOCOM," he added while referring to SOLO or Liaison Officer (LNO) equivalents.

It is precisely this type of MA which allows LITHSOF and its Baltic counterparts in Estonia and Lativa, to benefit from NATO partners including the US Special Operations Command Europe (SOCEUR) which continue to work 'hand in hand' to enhance the effectiveness of identification of threats, deterrence effort and to prepare for potential contingencies.

OPERATIONAL EXERCISES

MA operations are not without their dangers. Remaining at the tactical edge of MA operations, NSHQ sources explained to *Armada* how many ongoing efforts continue to blend the training environment of indigenous security forces with operational requirements.

Such an example was clearly illustrated on 4 October 2017 when four US Army Special Forces personnel were killed in action in Niger following a retasking which saw them accompanying indigenous forces on the ground.

Deployed as part of a wider SOTG, personnel were operating in Niger as part of a partner capacity building programme designed to counter the activities of Violent Extremist Organisations (VEOs) across West Africa, as confirmed by General Joe Dunford, US Chairman of the Joint Chiefs of Staff in a congressional hearing on 23 October 2017.

"The US Special Operations Task Force accompanied 30 Nigerien forces on a civil-military reconnaissance mission from the capital city of Niamey to an area near the village of Tongo Tongo," Dunford explained.

"On 4 October, US and Nigerien forces

began moving back South and en route to their operating base, the patrol came under attack from approximately 50 enemy using small-arms fire, rocket-propelled grenades and technical vehicles."

However, on 6 March, General Thomas Waldhauser Commander of the US African Command (AFRICOM), informed another congressional hearing how the SOTG's Small Unit Team had been conducting a Key Leader Engagement in a village before being redirected to assist in an arrest operation targeting a VEO high value target in the local area suspected of kidnapping a US citizen.

The firefight which ensued saw the SOTG personnel killed in action following an ambush on the non-standard commercial vehicles. Questions were later asked about the lack of organic fire support and rapid reaction forces.

On 9 March, US Africa Special Operations Command (SOCA Africa) officials confirmed the latest iteration of a training programme would be taking place between 9-20 April 2018 at multiple locations in Niger, Burkina Faso, and Senegal.

"*Flintlock* is an annual, African led, integrated military and law enforcement exercise that has strengthened key partner nation forces throughout North and West Africa as well as western SOF since 2005," a SOCAFRICA spokesperson explained.

"In 2018, *Flintlock* will be hosted by Niger with key outstations at Burkina Faso and Senegal. The exercise is designed to strengthen the ability of key partner nations in the region to counter VEOs, protect their borders, and provide security for their people. Additionally, the exercise bolsters partnerships between African and western nation SOF and law enforcement agencies," it was added.

Participating SOTGs from across NATO and non-NATO entities includes representation from the various special operations components of Austria, Belgium, Canada, Denmark, Germany, Italy, the Netherlands, Norway, Poland, Spain, the UK and US. This year, SOF and special mission units from Burkina Faso, Cameroon, Chad, Mali, Mauritania, Niger, Nigeria, and Senegal will participate in the training programme.

Further defining Exercise *Flintlock's* ability to not only train indigenous security forces but also assist in an operational context, a spokesperson for SOCAFRICA explained how the 2018 event would also feature a network of C4I (command and control, communications, computers and intelligence) capabilities across the various training areas.

This, officials confirmed, will provide West African partner nation forces with experience and knowledge in coordinating special operations over wide areas of interest.

CONCLUSION

MA concepts of operation look certain to feature prominently across not only the contemporary but future operating environments of SOF, particularly as they provide a deniable and smaller footprint than conventional forces.

However, should they be employed, SOTGs conducting MA operations must receive the full compliment of support ranging from logistics, medical and joint fires capabilities allowing them to effectively undertake missions in as safe environment as possible.

CYBER WARFARE AND THE FUTURE OF NATIONAL SECURITY

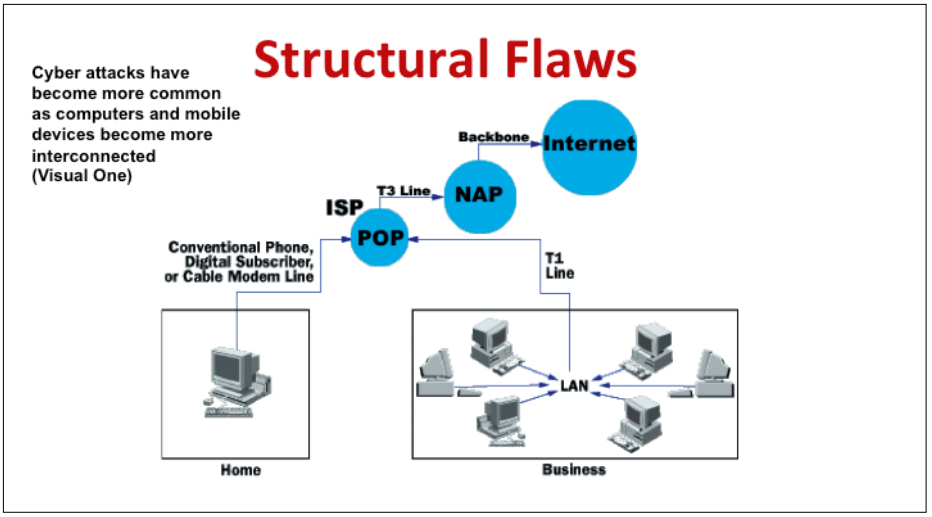
Differentiating between cyber crime, cyber sabotage and cyber warfare.

Robert Torgerson

"Cyber warfare is not a long-term intractable threat" to major western nations, according to Dr. Paul J. Springer, a professor at the United States Air Force (USAF) Air Command and Staff College. He added that "it is entirely likely" cyber attacks may eventually disappear.

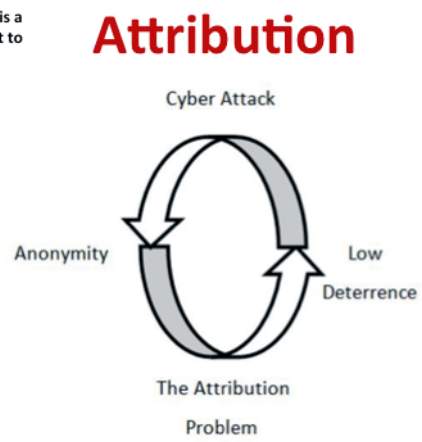
In his presentation, made at the Philadelphia Foreign Policy Research Institute (FPRI) on 30 April, Springer distinguished between cyber crime, cyber sabotage, and cyber warfare. If it is cyber crime, he stated perpetrators are going after the good things to steal, such as a corporate's "intellectual property." He showcased this problem by reporting that 59 percent of all "tracked adversaries" target the US; with 49 percent also targeting the European Union.

When it comes cyber crime, the highest percentage of individual victims are found in Russia (92 percent); China (84 percent) and South Africa (80 percent) with the victims more likely to be male and millennial (75 percent), as compared to baby boomers. He also said they are principal users of mobile internet and social networking sites, and more likely to be using pirated copies of Microsoft Windows, making them vulnerable to attack.



Cyber sabotage has a principal goal and

In cyber sabotage attribution is a huge problem make it difficult to deter attackers. (Visual Two)



that is destruction. Dr. Springer cited this as a typical approach carried out by some countries including Syria and North Korea in particular, as well as leading non-state terrorist groups. Cyber is unique in that attribution is a big problem and deterring the action is difficult.

According to Dr. Springer, present day cyber attacks fall essentially into six categories:

Malware - essentially malicious software such as ransom ware designed to damage or control a computer system.

Phishing attacks - fake 'official' emails enabling hackers to log onto bank or PayPal accounts.

Man-in-the-middle attacks - hackers insert themselves between a user/computer and the web server.

Cross-site scripting - malicious code is injected into a website targeting visiting browsers.

Distributed Denial of Service (DDoS) - a network of computers overload a server

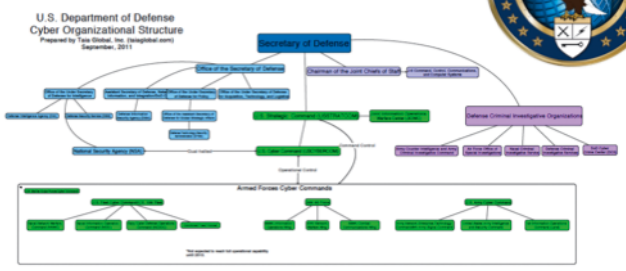
Dr. Paul J. Springer, a professor at the United States Air Force (USAF) Air Command and Staff College

All parts of the US have experienced Cyber events (Visual Three)

CYBER ESPIONAGE

UNITED STATES CYBER COMMAND

US DoD organizes its Cyber response through its major service branches Air Force, Army and Navy. (Visual Four)



with data, shutting it down.

SQL injection attack - corrupt data makes a server divulge key financial and personal data such as credit card numbers and use names.

Dr. Springer acknowledged that cyber crime, sabotage and espionage were major civilian problems globally that amounted to $400 billion in costs in 2015. He stated this figure is expected to rise rapidly, and increase to $2 trillion by 2019, attributing the prediction to Lloyd's of London. He said cyber attacks are becoming more common as computers become more interconnected.

Cyber warfare was described as an action practiced by nation states or publicly hostile non-state actors such as Daesh or Al Qaeda.

Three major attacks on Middle East nuclear reactors were highlighted showing why cyber warfare holds interest as an option for major nations. Two were conventional air strikes against nuclear reactors: the June 1981 Israeli Air Force (IAF) Operation Opera to shut down the Iraqi reactor at Osiark; and, the 2007 IAF strike against the Syrian reactor at Deir ez-Zoe. He contrasted these large manpower and equipment intensive attacks which destroyed their targets against the well-known 2010 release of the Stuxnet virus that shut down the Iranian Reactor at Natanz. Previously, Iran's reactors appeared impenetrable to a cyber attack. Dr. Springer stated this virus was released via USB devices given to unwitting victims to install on their own machines. Although he stated the perpetrators of the 'Stuxnet attack' were never officially confirmed, suspicion rests on a joint US-Israeli large and powerful Western nation states whom he did not identify (but has been widely reported as a joint US-Israeli operation). He stated this contrast shows the value of cyber warfare if it can be achieved delivering dramatic results with minimal or no combatant and collateral damage. In other words, cyber is a force multiplier.

The US manages its cyber activities through US Cyber Command which is co-located with the National Security Agency outside Washington DC. He said the Department of Defense has about 60,000 military personal assigned to cyber duties spread across the Air Force, Army and Navy. There are no official plans to make cyber a stand-alone service branch, instead it retains the capability within current service branches.

Dr. Springer stated if adversaries launched a major cyber attack on the US, the national response could include nuclear weapons. He believes this threat of overwhelming deterrence combined with present status of cyber capabilities possessed by hostile nation states is deterring any such attack from happening.

He cited Russia and its State-approved hackers regarding ransomware attacks with a desire to be paid in bitcoin. He called these "mildly annoying" and playing on people's fears. He said Russia has many sophisticated actors and sees cyber as a leveler, but he said they are not a "scary state" actor despite past threats to Georgia and Estonia.

China he classified as more sophisticated with a cyber 'army', but that it is not innovating as rapidly as the US. The Iranians have the educational resources to become major players, citing an virus attack (called Shamoon) in August 2012 where they forced Saudi Aramco oil production to be cut by 20 percent by shutting down 30,000 computers which eventually had to be replaced. This resulted in Saudi Arabia heavily engaging in the international deal with Iran over its nuclear capability (from which President Trump has now withdrawn).

He described North Korea as a country where only 30,000 people have access to the internet and so, while meddlesome, the nation has no real capacity to devise cyber attacks. He cited an example where North Korea was threatening the US with an National Security Agency (NSA) written programme supplied via WikiLeaks, which the US quickly shut down.

He said that the nation states for the most part were not actors to be feared, but that non-nation states try to be, but can't pull it off. He said Al Qaeda is not good at cyber warfare, but does produce a 'glossy' cyber magazine. Others could at best be problematic and troublesome, but not major players at present.

According to Dr. Springer, computer security is rapidly changing and within the next 10-15 years, major cyber threats will likely disappear as the fundamental way computers work changes.

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DISRUPTION AND THE DEFENCE MARKET

Andrew Hunter

When it comes to equipping the modern infantry, it is increasingly clear that changes are afoot. Perhaps nothing signals this more clearly than the recently announced plan to reorganise the United States Marine Corps (USMC) ground combat element. According to Marine Corps Commandant Robert Neller, the Marines are reorganising and adding more lethal weaponry to their rifle squads in the form of Heckler & Koch M27 automatic rifles and Saab M3 MAAWS (Carl Gustav) shoulder-launched weapons, and they are distributing handheld devices and unmanned aerial vehicles (UAVs) to those squads as well. More weapons upgrades and personnel assigned to tasks such as coordinating intelligence, countering UAVs, and providing logistical support for these new weapons are being added at the company level.

Capabilities previously reserved for higher echelons are flowing down to the company and platoon level, and firepower is being more evenly distributed. In other words, some of the barriers and distinctions that defined and limited roles within the infantry are breaking down as firepower, communications, and ISR capabilities increasingly come in smaller, more mobile, and more flexible packages. The breaking down of barriers between previously distinct functions and disciplines is one the hallmarks of our age, driving by a combination of Moore's law and the increasing digitisation of every conceivable technology. The implications of this shift will be highly disruptive not just for the traditional echelons of ground forces, but for defense industry as well. And in fact these two disruptions are intimately tied.

It is tempting to see the defense industry as static. Competition on individual defense contracts, which has never been terribly high, has either been stagnant or decreasing in recent years. But this trend may mask the extent to which defense industry players face competition. In many cases, they are competing not just for individual contracts, but for the very existence of their position in the table of equipment. Previously separate sectors of industry that can now provide nearly identical capabilities and weapons. For example, radios acting as electronic warfare systems, jammers carrying out cyber attacks, cameras performing many of the roles of radar, and vice versa. In the case of the USMC, infantry-born weapons and intelligence capabilities are starting to supplement if not supplant those provided by both ground and air vehicles. This trend may be emerging more slowly in defense industry than it did in the tech industry, but it is emerging nonetheless, and it is breaking down barriers between previously separate functions and disciplines.

One of Amazon's warehouses - almost a 'just-in-time' supply centre that could be increasingly used by the military.

The defense industry has always had its share of firms that operate in a range of different businesses. General Dynamics builds tanks, ships, aircraft and electronics. Firms like this have usually done this by operating as conglomerates; groups of essentially separate businesses with a common corporate headquarters. But consider a company like Amazon. Is Amazon a bookseller, a supermarket, a department store, a music company, a web services firm, or a tech company? It is not difficult to say that the best answer is probably 'all of the above.' Amazon has disrupted previously separate industries as diverse as publishing, music, movies, and newspapers, and it has entered these markets by leveraging a common core competency, namely its ability to connect buyers and sellers and deliver what its customers want through its apps and website.

Don't look now, but Amazon is also becoming a defence company. It already provides a secure on-line marketplace for the US intelligence community, and is also well positioned to provide both a secure marketplace and cloud computing services to the US Department of Defense. And while Amazon may not initially seem very relevant to how infantry squads are organised and equipped, it may increasingly become part of the conversation. As Ford and General Motors work feverishly to prepare to compete with Uber, Google and Apple in building cars, anyone who assumed that the technology revolution might be less meaningful for industries focused on manufacturing than for those that focus on content should beware. With the increasing focus on 3D printing and other forms of additive manufacturing, who's to say whether future infantry forces might not download many of the designs, accessories, and modifications they want for their gear from on-line merchants?

Disruption in defense markets is coming, but it won't happen overnight. The major constraint is not technological, financial, or legal - it is personal. People resist change, those in military organisations perhaps more so than most. Military customers are generally able to dictate their requirements to the defence market. Disruption in the defence market then will be paced by how willing the military is to let different capabilities compete in the provision of equipment. And that is why the USMC decision to reorganise its ground element, all the way down to the structure of its rifle squads and the equipment they carry, may be one of the more consequential changes in defence in 2018.

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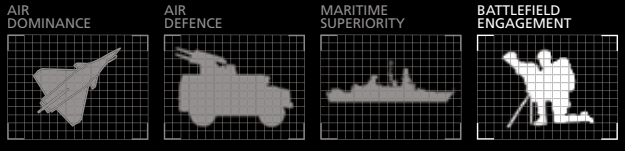

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