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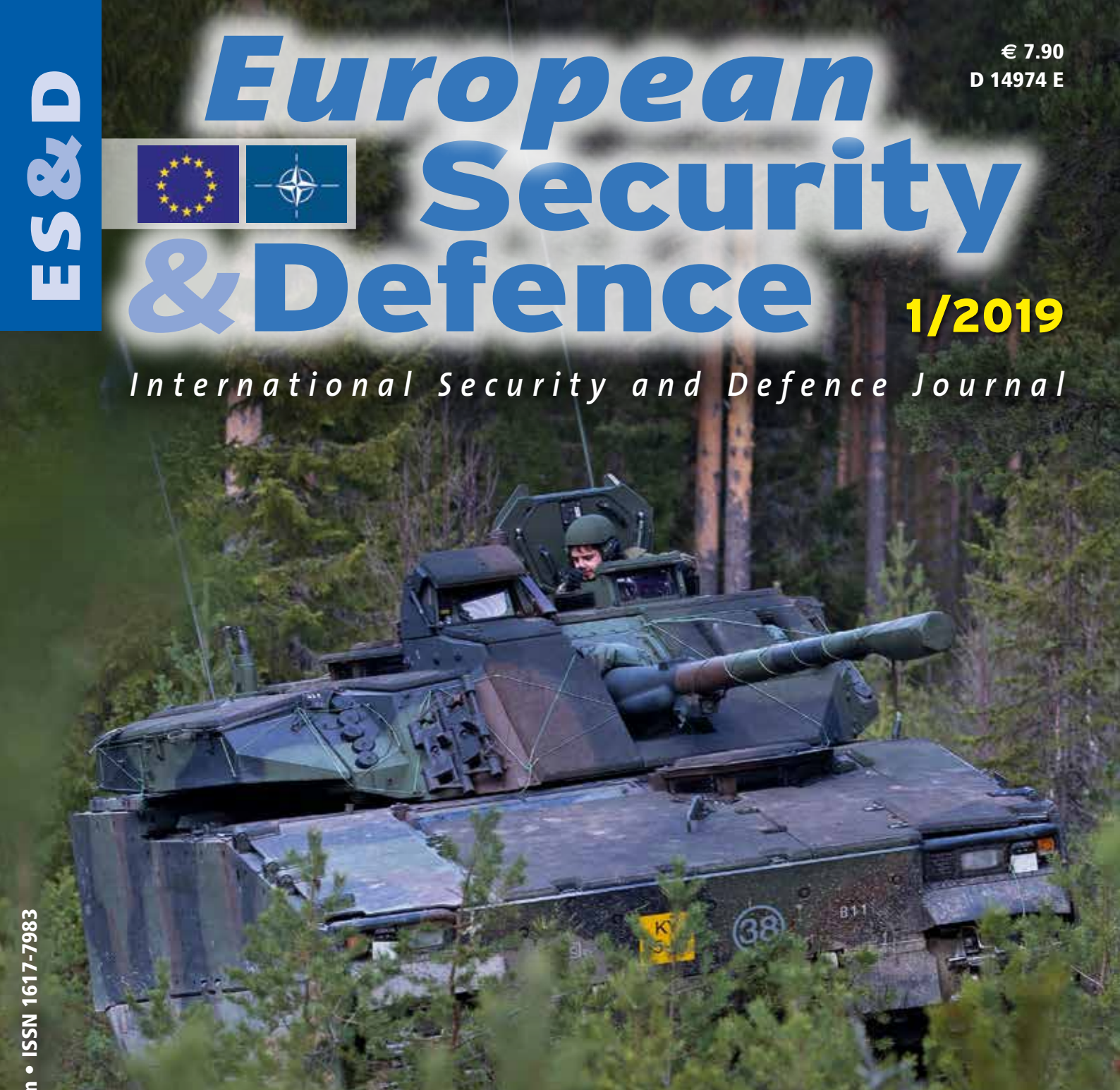

Armoured Vehicles

- UK Programmes
- US Army Armoured Systems
- Tyre and Track Technology
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- Armoured Ambulances
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Improved Protection for Vehicle-Borne Task Forces

As always, most of us started the New Year with wishes for peace and happiness. However, in countless continued conflicts large and small, people are being killed, maimed or injured, landscapes and cultural treasures are being destroyed, defaced and damaged, and national assets and resources are being plundered and squandered. In land-based operations to defeat these threats and their accompanying realities, the focus falls on soldiers, security forces and first responders who – often at the risk of their own lives – protect people, enforce justice and guard assets on behalf of their governments.

These are dangerous jobs, and there is a clear duty of care upon the employers for the health and well-being of their "human assets". To be and remain operational those assets require high-quality, effective, reliable equipment, and this is particularly evident with the military and military armoured vehicles. The greater the threat, the more important it is that the people know they have been furnished with the best possible materiel: the best human performance is encouraged through this simple fact. The optimisation rule is still the iron triangle of firepower (effectiveness), mobility and protection.

Firepower is a perennial theme, with calibres, rates of fire and effective ranges increasing on a regular basis: modern light armoured vehicles tend to be fitted with old-style (though not old in technology) medium – and heavier – calibre turret-mounted guns, often reinforced with rocket and missile systems to engage ever-more-protected, often agile, mobile targets.

Mobility can seem to be the rather simple, if not boring part of the triangle. However, a careful look dispels that notion! Fuelling and emissions: operational range, the diesel v. petrol argument, multifuel capabilities and military emissions exemptions come to mind. Track technologies: "proper" expensive steel tracks lasting thousands of miles v. cheaply designed and cheaply made tracks worn out in scores of miles: segmented v. steel v. band tracks: and there is still no winner in "Tracks v. Wheels". Transmissions, differentials, wheels, tyres, also provide evidence of deep study, careful analysis, and the best compromise – within an acceptable weight limit. Firepower and protection test that limit.

Protection has been important for several years as the IED / C-IED battle for operational dominance has played out, underscored by smaller and increasingly effective anti-tank weapons, frequently including land mines. While the integration of passive and / or active protection into existing and new vehicles was the dominant topic in recent years, the focus has shifted perceptibly onto the electrical energy requirements of military armoured vehicles. A dead battery or two no longer means no phoning home. Devices for communication, navigation, sensors for reconnaissance and protection, sensors and electrically operated effectors must be reliably supplied with electrical energy while driving and at a standstill.

And so the battery pack effectively governs firepower, mobility and protection. An auxiliary power generator is physically only suitable for larger combat vehicles such as Main Battle Tanks or Infantry Fighting Vehicles. Tactical vehicles require modern energy storage systems with low weight that are able to deliver high current and power over a wide range of applications, burst or sustained. Modern intelligent energy management can extend operational time well beyond earlier limits, making "silent watch" or even "stealthy advance" possible in the truest sense of the phrases.

The definitive characteristics of any armoured vehicle lie in how the vehicle, as a system, balances the mutually incompatible demands of significant firepower, high mobility and effective protection. From concept to design to execution to deployment, every aspect of the armoured vehicle must be widely and deeply considered: clarity and precision from the soldiers in terms of goals and requirements pays off in accuracy of execution from the prime contractor – provided, of course, that they are talking to eachother! Technical risk is also mitigated through talking: small vehicle numbers, limited financial resources, inefficient and time-consuming procurement and production processes add up to a glacial pace of acquisition and modernisation; the processes themselves are rarely discussed.

The duty of care includes speeding up the processes and improvements, not only to increase protection, but also to sustain motivation.

Gerhard Heiming

Masthead

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Some Actual Signs of Progress

An Update on British Armoured Vehicle Programmes

David Saw

From 1945 until German reunification in 1990 and the end of the Cold War, the primary component of British military strategy was the defence of the Inner German Border (IGB) by the British Army of the Rhine (BAOR).

Historically, this was a major shift in British strategy, as it required a continental commitment over the global maritime commitment that had previous dominated British strategy.

Photo: BAE Systems

The turret of the BAE Systems BLACK KNIGHT tank upgrade demonstrator. BAE Systems were selected, along with Rheinmetall, for the Assessment Phase (AP) of the CHALLENGER 2 Life-Extension Programme (LEP). BLACK KNIGHT features an IRON FIST Active Protection System (APS) from IMI Systems (now Elbit) amongst other enhancements.

This strategic change was inevitable as Britain sought to end its imperial commitments and confronted the fact that its economy was unable to support a global role, even if a British Government has desired to undertake such a role. More and more, the focus was on NATO-related missions and, as a fundamental part of the British contribution to NATO, BAOR had a privileged position in terms of funding and other support. Unfortunately, Britain's less-than-stellar economic performance for much of the post-1945 era inevitably impacted on defence spending, with the end result being that there was never enough money to meet all of the demands set by the defence strategy of the time. It was even more unfortunate that so much money was wasted on projects that were subsequently cancelled or that weak programme management saw massive cost overruns on procurement programmes. To be fair, waste and mismanagement in defence budgets were not a problem that was limited to Britain alone.

The best description of all of this would be that British defence strategy was set by politicians who did not understand it, the Treasury (Britain's finance ministry) did not want to pay for it, the civil service and military leadership were unable to manage it and those tasked with providing equipment to support the aims of the defence strategy had a hard time delivering it. Again this litany of defence woe is not limited to Britain; other countries have had, and continue to have, their own issues in this regard. What is worth mentioning though is, despite all of the problems within the British defence ecosystem, that BAOR remained a serious military capability for so many years and played a vital role in the NATO deterrent that protected Europe through the years of the Cold War.

The Peace Dividend

The end of the Cold War and the changed political and strategic landscape in Europe, and indeed globally, at the start of the 1990s presented Britain with an enormous challenge. What was needed was a new defence strategy that contained a vision of the British role in the world and what defence commitments were needed to support that role. Building on that, the military leadership would then define the force structure necessary to meet these defence commitments, while at the same time developing the operational requirements that would provide the equipment needed to make the operational vision a reality.

Unfortunately, developing a new and comprehensive defence strategy has proven elusive for British politicians in the post-Cold War era. There was undoubtedly real enthusiasm for redirecting spending from defence towards more politically useful areas as a part of the so-called "peace dividend". There was also real enthusiasm for defence reviews, force restructuring and

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the budget cuts that would inevitably result. Today, nearly 30 years after the end of the Cold War, British politicians have still avoided articulating a defence vision for the country and this continues to hamper the ability of Britain's armed forces to develop the force structure they need to conduct operational tasks.

Political Uncertainty

The end result of all of this is that short-term thinking becomes the norm, with this leading to a form of decision-making paralysis infecting all aspects of the defence ecosystem in Britain. Fundamentally, British Governments avoided making any hard decisions about a post-Cold War defence strategy and that has had a negative effect on the British armed forces. While the lack of a clear long-term strategy might have been survivable, the fact that the politicians wanted to be at the centre of events saw the military being committed to overseas operations lacking the means necessary to bring those operations to a successful conclusion. Operation Telic in Iraq from 2003 until 2009 and Operation Herrick in Afghanistan from 2001 to December 2014 revealed enormous deficiencies in the British Army in terms of leadership, equipment, equipment acquisition and in a host of other areas. What remains a concern is whether the appropriate lessons have been learned from the British involvement in Iraq and Afghanistan, or whether it has proven more prudent at a political and institutional level to ignore the more embarrassing errors that characterised those foreign adventures.

Political issues will continue to impact on the British Army for the foreseeable future; front and centre will be the impact of Brexit, assuming that the politicians can actually deliver on a course of action whether it be leave, remain or avoid making a decision. Then comes British involvement in European defence initiatives, they have committed to the future European military force, although it remains unclear how this will be managed if Britain is no longer in the EU. Added to which you have NATO commitments to take into account and whatever out-of-area adventures that the British Government might decide to become involved in.

Photo: UK MOD

In September 2014, the British Government announced a GBP3.5Bn order for 589 SCOUT Specialist Vehicles (SV) from General Dynamics Land Systems-UK, including 245 AJAX reconnaissance vehicles. After the failure of the TRACER, FRES and MRAV programmes, SCOUT was the first successful new armoured vehicle programme in Britain for many years.

Photo: UK MOD

The WARRIOR IFV was first delivered to the British Army in 1987, and 788 vehicles were acquired in multiple variants. Under the WARRIOR Capability Sustainment Programme (WCSP) Lockheed Martin UK (LMUK) was awarded a contract to upgrade up to 380 vehicles. This programme is now in doubt, due to cost issues and structural problems with the WARRIOR.

The current situation, then, is that there is little political leadership or direction as far as the military is concerned in Britain, hardly surprising with so much else going on. Furthermore there is no doubt that the Treasury continues to believe that the Ministry of Defence (MoD) receives far too much money and is wasteful in how it spends it. Not really a positive picture, but if the MoD and the military think they have it bad under the current rudderless Conservative government, the alternative is even worse. The Labour Party, the main opposition party in Britain, has swung far to the left, and – should they come to power – it is inevitable that defence spending will be massively reduced. It would also be prudent to expect significant programme cancellations.

Recruitment Difficulties

While ongoing political uncertainty at the highest level is a major problem, the British Army has other significant issues to deal with. The regular army is supposed to number 82,000 personnel, a number that in reality is far below what is necessary to meet all of the missions that it has. The factor that is supposed to make up the difference is reserve forces, which have the advantage of being cheaper to run than regular forces. The problem is that the regular army is 6.3% under its regular strength, with only 77,440 fully trained regular soldiers. Recruitment has not been up to the levels required; indeed, recruitment targets have not been met since 2012, and retention of trained personnel remains difficult.

The fact that the army is 6.3% under strength does not sound that bad, but the numbers are actually worse. In early January, the Times newspaper published an article on army strength after a Freedom of Information (FOI) request for MoD data. According to the Times: "7,200 troops are not fit to be sent abroad because of health matters while 9,910 more are limited in the roles and tasks they can perform on exercises and operations in other countries." Other non-deployable troops include those under the age of 18 and those who have not completed training.

Armour Overview

The deficit in troop strength is only one of many problem areas that the British Army has to deal with; another cause for concern is with equipment. According to a report published by the House of Commons Defence Committee in June 2018, "Beyond 2%: A preliminary report on the Modernising Defence Programme (MDP)", there are: "serious deficiencies in the quantities of armour, armoured vehicles and artillery available to the British Army."

In the last declaration made by Britain under the Treaty on Conventional Armed Forces in Europe (CFE) in 2017, they stated that the British Army had 234 CHALLENGER 2 tanks, two CHIEFTAINs, and a single CENTURION. The CFE declaration only covers equipment that is deployed in the UK, Germany, Gibraltar and Cyprus and does not include armoured vehicles deployed at the British Army Training Unit Suffield (BATUS) in Canada. The House of Commons Defence Committee reported that, after the government Strategic Defence and Security Review (SDSR) of 2010, the number of CHALLENGER 2 tanks was reduced by 40%. It is now believed that the CHALLENGER 2 fleet numbers just 227 tanks. First deliveries of the CHALLENGER 2 came in 1998, with deliveries completed in 2002, and a total 386 tanks and 22 Driver Training Tanks (DTT) were acquired. The number of CHALLENGER 2 tanks that are actually fully operational is less than the fleet size of 227.

Photo: Bundeswehr

A Bundeswehr BOXER armoured vehicle participating in the NATO Trident Juncture exercise held in Norway in October 2018. The BOXER has been selected to meet the British Army Mechanised Infantry Vehicle (MIV) requirement, and a first batch of 500 vehicles is to be ordered in four variants. A second batch of 300 vehicles will be ordered later.

The other part of the British Army armoured vehicle fleet is designated as Armoured Combat Vehicles (ACV). In its last CFE declaration, the army listed 1,377 ACV and 513 derivatives of ACV. There were 336 WARRIOR vehicles listed as ACV, with 110 listed as ACV derivatives. First deliveries of WARRIOR to the British Army commenced in 1987, and some 788 vehicles were originally acquired.

The FV432 family of armour vehicles first entered service in 1963 and by the time production had ended in 1971, a total of 3,000 vehicles had been produced in multiple variants. The last CFE declaration listed 458 FV432 and 228 FV432 derivatives in service. BAE Systems upgraded over 500 FV432 units to the FV432 MK.3 BULLDOG standard with deliveries from 2006 onwards for service in Iraq. The youngest FV432 in service is now some 48 years old, and the vehicle is expected to remain in service for the foreseeable future.

The first of the CVR(T) family of armoured vehicles entered service with the British Army in 1973, for CFE the declaration covered 254 SPARTANs as ACV and 104 SULTAN command vehicles as ACV derivatives. Not listed was the FV107 SCIMITAR which is used in the armoured reconnaissance vehicle role, some 50 of these vehicles were upgraded to the SCIMITAR MK II configuration by BAE Systems under a contract awarded in December 2010. It is intended to retire the survivors of the CVR(T) fleet by 2026.

All of this confirms that the legacy British Army armoured vehicle fleet is not in the best of health; it was never intended that this situation would arise, and over the years there were numerous attempts to commence procurement programmes for new vehicles or for significant capabilities upgrade programmes for less aged members of the vehicle fleet. The problem was that post-Cold War the army was trying to define the force it wanted to be and the equipment that it would need and was unable to do so. The level of uncertainty around what was required in the future was further increased by long-term involvement in Iraq and Afghanistan.

Back in 1988, work commenced on a programme that was aimed at replacing the British Army CVR(T) and FV432 fleets, and potentially the WARRIOR, under the name of the Future Family of Light Armoured Vehicles (FFLAV). This would have been a massive programme, covering as many as 7,000 armoured vehicles. FFLAV then evolved into a study rather than a procurement programme, but it did set the scene for some active procurement efforts.

In 1992, the Tactical Reconnaissance Armoured Combat Equipment Requirement (TRACER) programme got underway with the aim of creating a new system to replace the CVR(T), with a projected in-service date of 2004. At the end of the 1990s, TRACER would be linked to the US Army Future Scout and Cavalry System (FSCS) in a collaborative programme, with Britain aiming to purchase 700 vehicles and the US Army some 1,200. US and British requirements then diverged leading to the end of the programme. TRACER would be cancelled in 2002.

Another programme from the 1990s was the Multi-Role Armoured Vehicle (MRAV), a wheeled armoured vehicle requirement. To meet the MRAV requirement, Britain joined the European VBM/GTK programme in

1995, two competing vehicle proposals were evaluated and in 1998, a vehicle was selected that would later become the ARTEC BOXER. Unfortunately, in July 2003, the British Government would end British involvement in the programme, citing the fact that the vehicle was too heavy amongst other reasons. In 2018, Britain would ask to rejoin the BOXER programme as the prelude to placing an order for a substantial number of vehicles.

Photo: UK MoD

The CVR(T) family of vehicles entered service with the British Army in 1973. The variant shown here is the SCIMITAR MK II; 50 vehicles were upgraded to this configuration by BAE Systems under a contract awarded in December 2010. The last CVR(T) vehicles are due to be retired from the British Army in 2026.

With FFLAV, TRACER and MRAV gone, the next armoured vehicle effort was the Future Rapid Effects System (FRES). The programme officially got under way in April 2004 and the intention was to develop a new light armoured vehicle to replace legacy systems with an in-service date of 2009. There was lots of enthusiasm about FRES: it was an ideal capability for a light/medium-weight force, it could be deployed by A400M or C-17 and would have all sorts of wonderful capabilities that nobody was ever very specific about!

The FRES requirement was constantly changing and by December 2008, the National Audit Office stated that £319M had been spent on the FRES Assessment Phase. Prior to that, in November 2008, the government stated that the FRES Assessment Phase was having a total cost of £608M. FRES as originally envisaged was never purchased. For most of the 2000s, British armoured vehicle acquisition efforts could be characterised as a masterclass in how to run armoured vehicle procurement efforts.

Real Progress

Eventually, out of the wreckage of all of these programmes and the vast sums of money spent, something tangible emerged in September 2014 when the British Government announced a £3.5Bn order for 589 SCOUT Specialist Vehicles (SV) from General Dynamics Land Systems-UK. The order comprises the following: 245 AJAX reconnaissance vehicles, 93 ARES reconnaissance support vehicles, 112 ATHENA command vehicles, 50 APOLLO support repair vehicles, 51 ARGUS engineer reconnaissance vehicles and 38 ATLAS recovery vehicles. Service entry is due in 2020.

Another important British programme is the WARRIOR Capability Sustainment Programme (WCSP). Lockheed Martin UK (LMUK) was awarded the WCSP development contract in 2011 and up to 380 vehicles, in five variants, could be upgraded. Initially WCSP was to cover 245 vehicles, with the numbers and types of the remaining 135 vehicles to be decided later. This seemed like a very logical programme, allowing WARRIOR's service life to be extended out from 2025 until 2040, but matters have not worked out as planned. Costs have escalated and structural problems with some WARRIOR vehicles have called into question the whole upgrade strategy. At this point, WCSP appears to be a very vulnerable programme.

The need to upgrade the existing capability is the reasoning behind the CHALLENGER 2 Life-Extension Programme (LEP). In December 2016, competitive Assessment Phase (AP) contracts for CHALLENGER 2 LEP were awarded to BAE Systems and Rheinmetall Land Systeme GmbH. These AP contracts will set the scene for a decision on the winner of the CHALLENGER 2 LEPthis year, if the programme schedule is being adhered to. There is still a lot of uncertainty surrounding this programme, as regards how many tanks will be upgraded and what level of upgrade complexity the end-user desires versus the level of procurement funding available.

In October 2018, BAE Systems unveiled a CHALLENGER 2 upgrade concept known as BLACK KNIGHT that provided some insight into what they are offering for the LEP. The vehicle featured an IMI Systems (now part of Elbit) IRON FIST Active Protection System (APS), laser warning system, improved thermal imaging system and other enhancements. CHALLENGER 2 LEP could totally transform the capabilities of this tank; the issue is whether the upgrade programme will be allowed to.

Back when Britain was in MRAV, the intention was to purchase 775 BOXER vehicles, but as previously noted they withdrew from the programme in 2003. In March 2018, the British Government announced that it intended to rejoin the BOXER programme to meet the British Army Mechanised Infantry Vehicle (MIV) requirement for an 8x8 wheeled armoured vehicle. Britain intends to purchase these vehicles via the Organisation for Joint Armament Cooperation (OCCAR) and the contract should be settled this year. Deliveries will be from 2023 onwards, with final deliveries in 2030. Initially, the British Army will order 500 BOXER vehicles in four separate variants: standard infantry vehicle, command vehicle, ambulance and repair vehicle. A second batch order for an additional 300 vehicles is to be settled at a later date.

With AJAX and BOXER, Britain appears to have resolved some of its armoured vehicle issues, which is a welcome development given the legacy of failure in terms of British armoured vehicle procurement since the 1990s. However, the WARRIOR WCSP programme remains troubled and is seen by many as vulnerable to cancellation. Finally, this year should decide the destiny of CHALLENGER 2 LEP, but as stated above, the numbers of vehicles and the full scope of the upgrade have yet to become clear. Potentially out of four armoured vehicle programmes there is positive news on 75% of these efforts, but the unsettled nature of British politics could yet derail these armour programmes. ■

"We offer a capability that has not been seen in Europe before."

Photo: Oshkosh

Interview with John M. Lazar
Oshkosh Defense, Regional Vice President
International Programs

ESD: What significance does the JLTV programme have for your company?
Lazar: JLTV allows our company to offer the most mobile, the most highly protected, most integrated light tactical vehicle. The vehicle has gone through over 100,000 miles of testing. It offers us the opportunity to provide the greatest value proposition to the Army at the most inexpensive price. So that is what it means to us. It means to us we are offering vehicles to the US, our allies and coalition partners and ensure that our soldiers, the Marines, the airmen can get to the mission, can accomplish the mission, come back from the mission in one piece, protected.

ESD: What are the special features of your vehicle with regard to protection and mobility?
Lazar: Our vehicle offers advanced levels of protection with a much higher degree of mobility and agility above today's light tactical vehicle, the HMMWV. For reasons that are easy to understand we cannot mention the exact protection level in public. The second key feature is to have a vehicle of that size that can go 70% faster than any other 4x4 vehicle on the market right now. The mobility is incredible. The wheel has half a metre of travel over rough terrain at high speeds. Can you imagine going up to a 113 km per hour over extremely rough terrain and your soldiers do not feel that impact? All of that energy is absorbed by our TAK-4i suspension. Thus the soldiers inside do not feel that energy. Besides, the suspension system leads up to less impact in wear and tear to the entire truck. We have found through testing over 100,000 miles that the reliability expressed in Mean Miles Between Mission Failures exceeds US government standards significantly.

ESD: How many different versions of the vehicle can you offer?
Lazar: Right now the US Government is buying two variants – the 4-door variant and the 2-door variant. The 2-door variant comes in a Utility configuration and the 4-door variant comes in a General Purpose, Heavy Guns Carrier, and a Close Combat Weapons Carrier configuration. There are other variants planned for the US Government. All variants allow for being operated with different kits. The US Army, for example, has designed over a hundred kits that can be placed on the vehicle. For our US Marine Corps customer as another example we have a fording kit. Not everyone wants a fording kit. So there are over a hundred kits that have been designed for the vehicle ranging from silent watch kits for reconnaissance to extra demands on power consumption.

ESD: What about the advantages in connectivity, networking, communication?
Lazar: We have a plug-and-play with the US Army standard connectivity and integration into the network. We have a scalable open and secure network, equipped with distribution for the power; so it is clean power throughout the entire vehicle. Our electronic suite is consistent with what the US Army demands, but Oshkosh Defense as an integrator of systems has the experience to integrate whatever item our allied and coalition partners demand. You have perhaps seen it at recent shows; at Eurosatory for example, we integrated an FN system, and at this year's AUSA as in the years before we showed our capability to work with other companies, too. We wanted to show our customers a capability they had not necessarily seen before. This year we worked with IMI which you probably know has been bought by Elbit, and demonstrated their IRON FIST APS solution. That system is being tested right now. The year before we worked with Rafael and demonstrated the integration of another active protection system, TROPHY LIGHT. By doing so we underlined our ability to work with these companies and integrate their systems. We know how to succeed in integration.

ESD: Is it possible to reuse subsystems already integrated with other vehicle as for example the HMWWV?
Lazar: Absolutely. Let's look at a HMWWV with some type of weapon system on it. The JLTV is designed to take that weapon system directly from the HMWWV and integrate it to the new vehicle with very little engineering. That is exactly what the US Army is going to do. It is a great opportunity for our allies and coalition partners who already have the HMWWV, especially the shelters. The Utility variant of the JLTV accepts HMWWV shelters. So again, no additional engineering is needed. If a country looks for an immediate capability, JLTV offers that by the integration of systems currently operated on a HMWWV, whether they are weapon systems or shelters.

ESD: At what stage of development is the TerraMax autonomy kit, and is it possible to integrate it in a JLTV as well?
Lazar: Oshkosh Defense is a leader in autonomous systems. We have not yet had a demand to consider this unmanned ground vehicle technology for JLTV. But I am sure if we did have a demand we would be able to do it successfully.

ESD: The modularity of protection systems is a state-of-the-art demand. Does the JLTV meet this demand?
Lazar: The JLTV has a monocoque capsule providing crush resistance and a certain level of ballistic protection. The B kit put on the truck allows blast protection and additi-

onal ballistic protection to that monocoque capsule. The soldiers which are of utmost importance are always protected. Our customers can decide whether they want the JLTV to be in the standard configuration or whether they need the B kit for additional blast protection.

ESD: And the soldiers in the field can add B kits themselves?
Lazar: That's right, but it takes a certain level of maintenance.

ESD: What will change when you switch from the current status to full rate production?
Lazar: Right now JLTVs are running down the line. Far more than 2,300 of them were produced so far in 2018.

ESD: Thus it is only a different name for the same production process?
Lazar: Right. All we are going to do is to increase our production in order to meet the US Army numbers. There is no change. We are looking forward to it because the vehicle is going to give the US Army a capability that they desperately need. So we are very excited about it.

ESD: The market experts expect a lot of potential for additional sales of the JLTV to foreign customers. What countries do you currently focus on?
Lazar: That is a great question. We have a lot of NATO countries that are very interested in our vehicle. So there is certainly interest in Western Europe and in Central Europe. Right now we respect our clients' courtesy and will only talk about what has been announced formally by the UK and Lithuania. We think we offer a capability that has not been seen in Europe before – at a price that beats the market.

ESD: European customers usually demand cooperation with local companies. What is Oshkosh`s position towards these demands?
Lazar: Generally, any MoD will tell us for example what weapon systems or what type of radios it wants on the vehicle. Accordingly, it is our task to establish a partnership with indigenous military companies producing the systems the military wants to work with. Our customers can rely on our experience as system integrator. Thus, Oshkosh Defense is looking forward to introducing the JLTV to our NATO allies as a vehicle with unique characteristics regarding protection, mobility and the low overall total cost of ownership.

The interview was conducted by Peter Bossdorf.

JLTV Features

(gwh) The Joint Light Tactical Vehicle (JLTV) is a protected all-purpose vehicle. The ten tonnes vehicle is air-transportable – internally by the C-130 HERCULES and externally by the CH-47 CHINOOK or CH-53 SUPER STALLION. The chassis has TAK-4i wheel suspensions with a wheel travel of 508 mm. A 224 kW diesel engine based on the General Motors DURAMAX accelerates the JLTV up to 110 km/h via a fully automatic Allison transmission. The empty weight is 6.4 tons, so that around 3.5 tons are available for payload, protection and mission packages.
Bearings for weapons are installed as required. Standard weapons include the Common Remotely Operated Weapon Station (CROWS) for a 40mm grenade-launcher, a .50 machinegun, and launchers for ATGM.
Thus far, four variants have been developed and delivered to the US Army:

- The M1278 Heavy Guns Carrier – General Purpose (JLTV-GP) base vehicle,
- The M1279 Utility (JLTV-UTL) base vehicle,
- The M1280 General Purpose – General Purpose (JLTV-GP) base vehicle,
- The M1281 Close Combat Weapons Carrier (JLTV-CCWC) base vehicle.

There is also an accompanying trailer (JLTV-T) with which an additional payload of up to two tons can be carried.

Photos: Oshkosh

The 4-door variant in the Heavy Guns Carrier configuration

The 2-door variant in the Utility configuration

US Army Armoured Systems Programmes

Sidney E. Dean

The US Army's armoured forces are suffering from the results of repeated deferment of modernisation. US military leaders concede that potential battlefield opponents – in particular Russia – have achieved technical parity with American Main Battle Tanks (MBT).

This parity largely extends as well to Armoured Fighting Vehicles/Infantry Fighting Vehicles (AFV/IFV), Armoured Personnel Carriers (APC), and auxiliary armoured vehicles. The service is currently working to regain a short-term edge over potential adversaries, while simultaneously working to formulate a long-term armour development and acquisition strategy to support its evolving Multi-Domain Battle concept. However, the Army faces two major obstacles to its armoured modernisation programmes:

Graphics: BAE Systems

A M109A7 PALADIN SP Howitzer in Alaska. The first M109A7 was delivered to the Army in 2015.

Technology

Key aspects of armoured technology have reached a temporary zenith. This is particularly true for armour itself. The last significant improvement was the development of composite ceramic armour beginning in the 1960s. The only way to increase passive protection against modern anti-tank threats today would be to add on additional armour, but currently serving vehicles are already nearing their maximum weight-bearing capacity.

Money

Despite recent defence budget increases the Army still lacks the resources to replace all armoured systems (and other vital weapons and equipment) with brand new concepts, especially since the future of defence spending levels remains uncertain.

For the most part, the Army is forced to incrementally upgrade legacy systems by incorporating new but proven components to enhance performance. Given past experience with some highly ambitious development programmes – which ended up over-priced, under-performing, delayed, and ultimately cancelled – this may not be a bad thing. It will also field enhanced combat systems much more quickly than developing vehicles from scratch. On the negative side, it prevents or delays US ground forces from achieving the desired breakthrough effect which would propel the US Army well ahead of competitors.

Autor

Sidney E. Dean is President of the Transatlantic Euro-American Multimedia LLC.

Upgrading Current Weapon Systems

Selective, targeted upgrading of currently fielded armoured vehicles is intended to increase firepower, survivability and mobility while simultaneously extending service life. Several armoured vehicle families are currently undergoing enhancement. Increased Russian bellicosity has persuaded the US Army to accelerate some upgrade programmes, in part by lowering requirements and limiting testing. "That does require some willingness to accept a system that's not 100%," said Major General David Bassett, in October 2017 at the AUSA (Association of the US Army) annual convention. "Immediate, capacity-driven schedule is significantly more important than long-duration or high-risk technology," said Bassett, who served as head of the Programme Executive Office – Ground Combat Systems (PEO-GCS).

Graphics: BAE Systems

A BAE Systems concept graphic showing future armoured vehicles armed with a large-calibre cannon and tactical rockets, and networked with unmanned ground and air combat systems

M1 ABRAMS

The Army has initiated the upgrade of the M1A2 ABRAMS MBT to the SEP v3 configuration. The core goal of the SEP v3 is to improve the Size, Weight, and Power-Cooling (SWaP-C) ratio of the tank and prepare it to receive new technologies. Enhancements include: new gunsights and an enhanced fire control system to increase accuracy and engagement speed; increased power generation and distribution to support additional electronic equipment; enhanced communications and networking capabilities; the Joint Battle Command Platform blue/red force tracker for enhanced situational awareness; Improved FLIR; improved displays and man–machine interfaces; an Auxiliary Power Unit to power electronics while stationary (permits shutting down the main engine, saving fuel and reducing heat and noise signature); an Ammunition Data Link (ADL) to enable the use of programmable advanced 120mm munitions; an improved armour package for hull and turret; the Duke V3 counter-IED EW suite; and a lower-profile version of the CROWS Remote Weapon Station. Taken together, these upgrades increase both lethality and survivability. GDLS delivered the first six SEP v3 initial production version tanks in October 2017. In July 2018 the Army signed a delivery order for GDLS to upgrade 100 more M1A1 ABRAMS MBTs to the SEP v3 configuration. The delivery order is part of an Army Requirements Contract signed in December 2017 through which the Army can upgrade up to 435 M1A1 ABRAMS tanks to the M1A2 SEPv3 configuration. The first combat unit should be equipped with the SEP v3 in 2020. Fielding of the SEP v3 is projected to begin in 2020.

The next upgrade – SEP v4 – is already planned. It will focus on enhanced lethality. The centrepiece so far is a 3rd generation high-resolution Improved FLIR (IFLIR) to enable target acquisition, discrimination and engagement at significantly increased range and under obscured visibility. Other enhancements will include laser-warning receivers, a full-colour daylight camera and a cross-platform laser rangefinder/target designator. The SEP v4 will also deploy the Advanced Multi-Purpose 120mm shell, which can be programmed to produce a variety of effects now produced by various specialised munitions. Testing will begin in 2021. A production decision for SEP v4 is expected in 2023, with fielding in 2025. SEP v4 should keep the ABRAMS operational into the 2040s.

Photo: US Army

The first ABRAMS M1A2 SEP v3 production vehicle shown here was delivered to the Army on 4 October 2017. The ABRAMS M1A2 SEPv3 is seen as a great step forward in reliability, sustainability, protection, and onboard power.

M2 BRADLEY

The BRADLEY IFV is being upgraded in tandem with the ABRAMS in order to ensure a capabilities balance within the brigade and to ease maintenance/logistic support. In June 2018, the Army awarded BAE Sys-

Photo Credit: US Army

A STRYKER Infantry Carrier Vehicle DRAGOON firing 30mm rounds during a live-fire demonstration in Maryland in August 2017

tems a contract for conversion of the first 164 BRADLEYs to the A4 configuration; in addition to M2 IFVs this figure includes some M7 BRADLEY Fire Support Vehicles. The work is expected to complete in June 2018. Follow-on contracts are expected. The M2A4 upgrade is focused on improving the SWaP-C ratio; it features a new drivetrain, suspension, tracks, power system and advanced electronics. It also has enhanced survivability, in part because the M2A4 – unlike previous iterations – will have the electricity generation and computing capacity to carry an Active Protection System to defend against anti-tank weapons. The follow-on M2A5 variant will add the same lethality enhancing systems as the ABRAMS SEP v4, ensuring operational viability into the 2040s.

M1296 STRYKER DRAGOON

The combat-enhanced upgrade of the M1126 STRYKER is the M1296 STRYKER DRAGOON produced by GDLS. The M1296 comes in two variants. One replaces the STRYKER's CROWS mount and .50 calibre machine gun with the Kongsberg PROTECTOR MCT-30 turret housing a 30mm XM813 automatic gun. The second variant integrates JAVELIN anti-tank missiles on the Kongsberg CROWS III turret (known in this configuration as the CROWS-J), while retaining the machine gun mount. The DRAGOON retains the capacity to carry a nine-person infantry squad.

Enhancing the STRYKER's firepower is a response to a 2015 Urgent Operational Needs Statement by the 2nd Armoured Cavalry Regiment based in Germany. The production lot of 83 vehicles with the 30mm gun and 86 JAVELIN-armed vehicles was completed in June 2018. Additionally, the CROWS-J turret will be fielded to 240 vehicles of another brigade beginning in 2020. Across the fleet the STRYKER is being upgraded with enhanced blast-resistant double-v hulls and strengthened suspensions.

Auxiliary Systems

Armoured combat units rely on auxiliary weapon systems to support the main fighting vehicles. The Army's modernisation programme includes these auxiliary systems, and enhances their ability to conduct combined-arms operations.

M109A7 PALADIN: The armoured self-propelled M109A7 howitzer mounts the gun and turret of the M109A6 howitzer on the new M2A4 BRADLEY chassis so that the howitzer can manoeuvre effectively with armoured brigade combat teams. The new configuration also boasts an electric gun-drive and rammer. In December 2017 the Army awarded BAE Systems the contract for the third LRIP lot; the contract includes the option to begin full-rate production.

M88A2 HERCULES recovery vehicle: BAE Systems has upgraded 36 M88A1 Heavy Equipment Recovery Combat Utility Lift Evacuation Systems (HERCULES) to the M88A2 configuration. The HERCULES is capable of unassisted recovery of damaged ABRAMS MBTs and all other US Army armoured vehicles.

Manoeuvre SHORAD: SHOrt-Range Air Defence (SHORAD) has been recognised as a serious shortfall, especially in the European theatre. The Army has initiated an Interim Manoeuvre SHORAD (IM-SHORAD) programme to equip four battalions with a total of 144 STRYKER vehicles with a Leonardo DRS sensor and weapon suite which includes the Reconfigurable Integrated-weapons Platform (RiwP). This remotely operated turret can carry a selection of air defence weapons including STINGER and HELLFIRE missiles, an M230 chain gun (30mm) and a coaxial 7.62mm machine gun. The IM-SHORAD prototype is expected in 2019, with deployment of first operational units in Europe in 2020. IM-SHORAD is intended to bridge the gap until a future or "objective" SHORAD programme of record is initiated.

Photo: Boeing & GDLS

A STRYKER Mobile SHORAD Launcher – a STRYKER prototype configured for the SHORAD role with HELLFIRE missiles

Photo: Natan Flayer, Wikipedia Creative Commons

TROPHY system with AESA radar (left) and a dummy launcher on a MERKAVA MBT

Graphic: US Army

The Armoured Multi-Purpose Vehicle in the General Purpose and MEDEVAC configurations

Active Protection Systems

Armoured vehicles have been relying on modular reactive armour as added protection against anti-tank munitions. The Army is now turning to Active Protection Systems (APS). These consist of a mission processor, sensors, electronic jammers and ordnance mounted on tactical vehicles. The sensors identify and track incoming anti-tank missiles, RPGs and shells; the mission processor evaluates the threat and calculates the response; the ordnance is fired at these incoming projectiles, destroying them before they can impact the vehicle. The Army is evaluating three different APS systems. The Israeli-made (Rafael) TROPHY system is being procured for the ABRAMS tank under a contract finalised in June 2018. The first of four tank brigades covered under the contract is expected to be fully equipped with TROPHY by 2020 and will be deployed to Europe. Final testing of the US-configured TROPHY variant will be conducted parallel to LRIP.

The IMI IRON FIST LIGHT system has been selected for the BRADLEY M2A4. An initial contract for 138 units to outfit the first brigade was announced in December. Budget shortfalls will stretch execution of the contract through 2020. Qualification testing will continue parallel to deliveries.

For the STRYKER, the Army has narrowed the field to two APS contenders, and conducted a live-fire "rodeo" in November to compare the two directly. The competitors are Rafael's TROPHY VPS, a lighter variant of the full TROPHY chosen for the ABRAMS, and the Rheinmetall/UBT STRIKE SHIELD. A decision is expected in early 2019.

These active protection systems are generally considered an interim measure. Defending against increasingly potent future threats will require a more effective weapon. Ultimately the Army wants to acquire a single, open architecture Modular APS (MAPS). Research into MAPS was initiated in 2014; elements of the proposed system were tested at the Tank Automotive Research and Development Center (TARDEC) in 2018. The MAPS base kit is scheduled to move into the vehicle programme portfolio by mid-2019. The Army hopes that MAPS will prove so effective that future combat vehicles can be constructed with less armour.

New Armoured Combat Vehicles

While the primary effort is currently directed at maintaining and enhancing the combat effectiveness of legacy systems, the Army is working on new armoured vehicles as well.

Photo: IMI Systems

IMI Systems' IRON FIST Active Protection System has been selected for the BRADLEY IFV.

Armoured Multi-Purpose Vehicle

The Armoured Multi-Purpose Vehicle (AMPV) will replace the Vietnam-era M113 armoured personnel carrier in units at the brigade level and below. The AMPV is based on the M2A4 BRADLEY chassis, minus the turret, and will keep pace with the M1 and M2 in combat. Five variants are planned, including an armoured personnel carrier, a field ambulance, a medical treatment vehicle, a command vehicle and a mortar carrier; BAE has been independently developing an engineering vehicle as a sixth variant. The vehicle can be outfitted with bar armour, reactive tile armour, and radio jammers to defeat projectiles and IEDs.

BAE Systems won the contract in 2014. A total of 29 prototypes for the programme's engineering, manufacturing and development (EMD) phase were delivered to the Army in March 2018. Operational testing is ongoing, with a Milestone C review in early 2019. If Milestone C is declared, LRIP could begin that year, with priority given to two brigade sets (131 vehicles each) for Europe. Fielding a total of 3,000 AMPVs is expected to occur 2022–2036. A separate programme will upgrade rather than replace the M113 vehicles deployed at echelons above brigade.

Mobile Protected Firepower Light Tank

The Mobile Protected Firepower (MPF) light tank is intended as an air-transportable escort for airborne infantry and other light units – a capability the US Army currently lacks. The programme was initiated in 2015. In December 2018 the Army awarded EMD and rapid prototyping contracts to two contenders, BAE Systems and GDLS. Under these contracts each firm will provide 12 prototypes within 14 months. Final selection for one manufacturer is expected by 2022, with fielding of the first operational vehicles by 2025. The Army plans an initial purchase of 26 vehicles, with an option for another 28 production units. BAE is offering the 105mm M8 BUFORD Armoured Gun System (upgraded with new electronics, a new engine, and improved protection); GDLS is proposing the 27-tonne, 120mm-armed GRIFFEN II demonstrator (utilising the chassis of the British AJAX scout vehicle, topped with a scaled-down version of the M1A2 turret).

Next Generation Combat Vehicle

At some point, the Army will need to develop a completely new heavy weapon system. The Next Generation Combat Vehicle (NGCV) programme is currently exploring the Army's options for "a lightweight, powerful, tracked vehicle that will far exceed the capabilities of current Army ground vehicle platforms." This time around, the Army intends to avoid mistakes made with the Future Combat System (FCS) programme which was terminated in 2009. FCS was envisioned as a family of high-performance combat vehicles based on breakthrough technologies which, at the time, were simply not within reach.

NGVC is intended to be optimised for the Army's new Multi-Domain Battle concept which centres on comparatively small, highly mobile units conducting dispersed but coordinated operations. The concept requires a considerably smaller logistics footprint (that is, its fuel consumption is considerably reduced) than that of current heavy forces.

The Army has accelerated the NGCV program in light of increased challenges from peer-level opponents. At the AUSA conference on 9 October 2018, Brigadier General Ross Coffman, director of Army Futures Command's NGCV cross-functional team (CFT), clarified that the programme would field a family

Photo: Rheinmetall

The LYNX Infantry Fighting Vehicle will be paired with Raytheon weapons, sensors and system integration expertise to provide the US Army with an advanced, modular, combat-ready solution.

Photo: BAE Systems

The M8 BUFORD Light Tank (background) with a BRADLEY IFV (M2A3 configuration)

of five vehicles. He stated that the current priority would be the Optionally Manned Fighting Vehicle (OMFV) intended to replace the BRADLEY IFV. Coffman said that a request for proposals (RFP) would be issued no later than January 2019. A competition of prototypes is planned over the next few years. The goal is to field the OMFV by 2026. According to NGCV Program Manager Colonel James Schirmer, this accelerated schedule (NGCV was originally envisioned for fielding circa 2035) means that only mature technologies, already integrated into a functional system already in service, can be considered. To date, three competitors have emerged for the OMFV competition: BAE Systems' CV90 mk4 IFV, GDLS' GRIFFIN III (a heavier variant of the GRIFFIN II), and the Rheinmetall/Raytheon LYNX KF41 IFV. Others may still enter the race. Requirements include a carrying capacity for a nine-person infantry squad and a turret capable of mounting a 50mm gun.

Development of an NGCV replacement for the ABRAMS MBT will begin in 2023. The Army has not yet decided on details of that weapon system. This will enable the Army to consider completely new "clean sheet" concepts. "It doesn't have to be a tank, it just has to be large and lethal," General Coffman said in October. "We don't want to stifle any initiative based on [preset notions]." The Army is encouraging industry to present all technologically viable options.

Future Technologies

A number of currently developing technologies could flow into the ABRAMS replacement NGCV and other combat vehicle programmes.

Nanotechnology: Advanced-composite materials based on nanotechnology and nano-grain metals are being studied in hopes of yielding lightweight but more resilient armour. Colonel Schirmer cautions that advances in developing ultra-light armour are currently not moving fast enough to benefit the NGCV Program.

Electric Drive: In October 2017 Donald Sando, head of the Capabilities Development and Integration Directorate of the AMCE, declared that the NGVC could run with electric motors and high-capacity batteries. Alternate proposals for the NGCV include hydrogen fuel-cells and hybrid hydrogen/diesel propulsion systems.

Directed Energy Weapons: New engines and turbines are significantly increasing the capability of armoured vehicles to generate electricity, opening the way for deployment of energy-dependent weapon systems. The FY 2019 defence budget includes assessing the viability of including a 50 kW laser in the objective Manoeuvre SHORAD system. The assessment could last up to three years. If successful, the laser system could transition to inclusion in the objective M-SHORAD programme in 2022, with fielding forecast circa 2024. The laser could be deployed against UAVs of all size classes, as well as against incoming shells and rockets. Previously, Boeing and GDLS teamed in 2017 to produce a 5 kW laser SHORAD prototype mounted on a modified STRYKER. Additionally, high-powered lasers and railguns are under consideration for the NGCV as well.

Unmanned/Optionally Manned Armoured Vehicles: Replacing the ABRAMS with an unmanned or optionally unmanned vehicle is on the table. Benefits would include: reduced profile due to smaller size; lighter weight; and considerably better fuel efficiency. Colonel Schirmer cautioned in October that reliable remote control over tactically relevant distances (a minimum of three kilometres) cannot currently be guaranteed. Likewise, artificial intelligence capable of independent manoeuvre over broken terrain is still under development. Securing robotic systems from enemy cyber warfare is another major concern. ■

Sustaining Wheeled Mobility

Charles Keyworth

The prime concern of any vehicle commander is to protect his troops and fulfil the mission. For the driver it is to keep moving, as mobility is key to survival.

Both requirements can be extremely testing in a wheeled vehicle if it suffers a puncture, blow-out or ballistic attack. The solution is to keep the deflated tyres firmly in place on the wheels by adding a runflat with beadlock or just a beadlock itself inside the tyres. These solutions will keep the deflated rubber of the tyre firmly on the wheel rim and, in the case of a runflat, provide a substitute for the tyre. If the tyre loses contact with the rim, the driver will lose control and the mission impeded.

In the case of a security, VIP or cash-in-transit type vehicle, the need will be to get to a place of safety where the tyre can be changed – normally a short, less than 5 km, distance away. For an AFV, the need is very different; the vehicle needs to continue on its mission and may have to travel fast over long distances of up to 100 km, and the runflat will need to guarantee that this can be achieved.

There are solutions.

Photo: via author

HMMWV with a flat tyre

Wheel Well Filler Systems

For police, cash-in-transit or VIP vehicles which primarily operate on tarmac roads, thee importance is to keep the tyre on the rim and to get the vehicle out of danger to a position of safety within a few kilometres where the tyre can be changed. This requires a device which fills the well of the wheel. This is needed for fitting the tyre, but in the case of a puncture can result in the tyre sliding into it. The well filler system prevents this happening.

The wheel filler band locks the tyre onto the wheel, allowing the driver to retain control of thevehicle, reducing the risk of an accident and to continue to a safe place to change the wheel or seek assistance, reducing the risk of personal injury.

Lightweight, so as not to affect fuel consumption, acceleration and braking, and with no moving parts, well filler systems do not affect the balancing of the wheels, are maintenance free and fitted for the life of the vehicle and its occupants.

Beadlock Systems

A beadlock solution locks the tyre into place and ensures that the tyre will not slip on the wheel. The critical element of the solution is that it firmly pushes the beads of the tyre against the wheel flanges so that the tyre does not slip and prevents the vehicle losing traction.

Beadlock systems also increase the mobility of vehicles operating in soft terrain such as mud, sand and snow, where increasing the footprint improves traction. This is achieved by the crew decreasing the tyre's air pressure. For example, a 4x4 at low pressure can easily exceed the footprint of an 8x8 at service pressure. This mobility is only achievable if the wheels are equipped with a tyre bead locking device. Without this, the tyre will spin on the wheel. As a result, the vehicle capabilities are enhanced by increased traction and braking, improved steering control, minimising the chances of rollover caused by the unseating of the tyre and preventing foreign materials from entering the tyre.

Two-Part and Three-Part Wheels and Bead Clamp

The armouring of an SUV puts additional stresses on the wheels, tyres and, when deflated, the runflats. The additional weight takes the tyres to their load limitations, raises the vehicle centre of gravity, and with aggressive driving under ballistic attack or just getting away from a dangerous situation, can make the experience for a passenger very exciting

The options available include using a two-part wheel which clamps the bead onto the rim or fitting a beadlock device. The former works by locking one side of the tyre onto the wheel so that it not only stops the tyre from slipping when it is deflated but also keeps the tyre in contact with the road surface.

Author

Charles Keyworth is a sometime freelance writer and professional observer of the defence industry with a particular focus on matters to do with wheeled vehicles and logistics. He has spent many years in the defence industry after serving in the British Army as an infantryman.

Photo: Rodgard

The Rodgard BPX Runflat

Photo: Tyron

On the left is a wheel not fitted with a well filler, showing the rim coming into contact with the road. On the right, the wheel is fitted with a Tyron MultiBand, which stops the tyre from falling into the wheel well.

These multi-part wheels are typically made of steel or aluminium. A three-piece wheel consists of the two main parts of the wheel with a locking ring. In the US, most users have gone to a two-part solution due to possible dangers of the locking ring coming off during installation. However, it is still used in other parts of the world, as it is much cheaper. Another advantage of the two-part wheel is that it can be changed at the side of road, whereas a three-piece wheel needs an hydraulic press to install the locking ring, which requires additional equipment normally found in a workshop.

Photo: Europlast-Nycast

Europlast-Nycast offers runflat systems consisting of a multi-segment ring made of cast polyamide with modified elastomers with standardised fastening components. This patented, extra strong dynamic connection does not suffer component fatigue and provides dimensional stability in a temperature range from -40°C to +160°C. The rings are designed for all single and multi-piece rims in sizes from 15" to 27" as well as for different tyre types and wheel loads.

Runflats for VIP Type Vehicles

For VIP vehicles and those that need to keep moving for some distance on a tarmac road, arunflat becomes a necessity. These, in effect, replace an inflated tyre but utilise the flat tyre to keep rubber in contact with the surface. They normally allow sufficient control to be maintained and allow the vehicle to continue. There are a number of suppliers producing the systems in plastic, composites, polyester elastomer and rubber. These types of runflats are available in different rolling diameters depending on the aspect ratio of the tyre and the operation of the vehicle so as not to get impingement between the runflat and the tyre in normal operation, with the higher versions giving the ability to go further but adding to the cost.

For this type of vehicle, lighter composites, which are often cheaper than rubber, can be used. This material works well on tarmacadam type roads where there is little likelihood of hitting potholes or rough ground, which can lead to the runflat breaking.

Why Rubber for Military and 4x4s?

Moving to the Armoured Fighting Vehicle market, this introduces a long-running discussion of the benefits of composites versus rubber. Rubber, which is inherently malleable, enables over-manufacture of the beadlock system to overcome the tyre and wheel manufacturing tolerances and also allows for different makes of tyres where the tolerances can be over 20 mm. During installation, the rubber guarantees that the tyre beads are firmly secured against the flanges of the wheel to ensure beadlock.

There are a couple of significant reasons for using rubber rather than composite/plastic when designing runflat systems for off-road 4x4 and military vehicles.

Firstly, rubber will absorb shock from impingement caused by kerb strikes, potholes and operating in a generally hostile environment. Rubber drastically reduces the vibration and stresses that are transmitted through the runflat to the wheels, axles and drive shafts allowing you to continue with little change to the handling of the vehicle whilst retaining a degree of comfort for the driver and passengers.

Secondly, rubber is a compliant material and prevents damage being caused to the tyre from impingement between the runflat and the inside of the tyre. The tyre manufacturers have sent out circulars with regards to these problems. Michelin states that: "Metal, hard plastic or other non-compliant materials will create damage to the interior surfaces of the tires when used in off-road and/or reduced inflation pressure". Bridgestone issued the following statement: "Devices made of hard or rigid materials such as metals, plastics or composites, may cut, tear, scrape or abrade the innerliner, body plies and/or bead areas of the tyre. Such damage may occur intermittently depending on the operating conditions and may not be immediately apparent from a visual inspection of the tyre exterior. However, the damage may progress to splitting, blistering, bulging and/or separation of tyre structural plies and cause

pressure inflation loss or tyre failure. Only install runflats/beadlocks devices made from flexible material."

Advantages of Beadlock

The less obvious reason for using rubber rather than composite and probably the most important is the need for "beadlock". Without adequate compression of the tyre beads against the flanges of the wheels (beadlock)the vehicles are going nowhere, with only the "drag"' from the deflated tyres, the wheels will slip on the tyres and that is on level ground, let alone trying to negotiate any obstacles or hills.

Military vehicles are required to continue their mission and/or return to base with one or all of their tyres deflated. Defence forces demand a guaranteed minimum runflat distance performance of 50 km, preferably 75 km, with two or more tyres deflated and a minimum of two hours off road negotiating hills and obstacles like kerb strikes.

So why not composite or hard material?

The answer is in the manufacturing tolerances of the wheels and tyres. Michelin says that there is a bead tolerance of +/-3 mm on all their 20-inch military tyres. Therefore we have a total bead variance of 12 mm; add to this the wheel tolerances, and we have up to 20 mm. On composite runflats, the width has to be under-manufactured, otherwise the runflat will either break during installation or the wheel will not seal properly. In any event, it is not technically possible to guarantee adequate compression to prevent the tyres from slipping or spinning on the wheels. With rubber, the runflat is over-manufactured to allow for these tolerances and during the installation, the rubber compresses the tyre beads against the flanges of the wheels, guaranteeing the beadlock.

An additional necessity for beadlock is to prevent foreign objects like sand, stones and dirt getting inside the tyres. When the runflats are installed, a high-temperature synthetic lubricant is inserted into the tyres to reduce friction. Any sand and dirt will mix with the lubricant and reduce the distance you can travel.

Composites Do Have a Place

Composite runflats do have a role to play in protecting vehicles. They are lighter and less expensive to manufacture and are designed to fit the existing single piece wheel. They work very well on vehicles using the public highways, like armoured limousines and heavy vehicles like water cannons operating in riot situations. However, they do have some drawbacks as they have to be under-manufactured across their width, otherwise the runflat will break during installation or the wheel will not seal properly and therefore it is impossible to guarantee adequate beadlock to prevent the tyres from slipping or spinning on the wheels. This may not be a consideration for vehicles on public roads.

Summary

In summary, the days of tyres spinning helplessly on a wheel are gone. Using either composites or rubber, the tyre can be retained or locked in place and the vehicle can be driven to a place of safety. If the vehicle is to go off road, the state of the ground dictates that not only does the tyre need to be locked to the wheel but a runflat tyre, a solid structure, is needed. This needs to be able to absorb the shock from impact resulting from kerb strikes, potholes and operating in a hostile environment. Rubber drastically reduces the vibration and stresses transmitted through the runflat to the wheels, axles and drive shafts with little change to the handling of the vehicle whilst retaining a degree of comfort for the driver and passengers. ■

Developments in Armoured Vehicle Track Technology

Tim Guest

Track technology for armoured vehicles is undergoing change, and while traditional steel systems remain the mainstay of most vehicle fleets, exciting innovations like Composite Rubber Track (CRT) look set to change the status quo and impact vehicle manoeuvrability, crew comfort, logistics and overall vehicle performance in the future.

Since the emergence of tracked armour in World War I, the majority of continuous steel and rubber-padded tracks for armoured vehicles have changed little in overall construct: road wheels roll over the track, then carry it, as it is picked up and laid back down on the ground by the vehicle.
For comparison's sake, before focusing on CRT and recent corresponding track trial results, this article looks briefly at traditional track systems to enable the reader to understand what CRT potentially means for future armoured vehicle fleets and their crews.

Traditional Systems

Assembled as a series of links to ensure flexibility, the continuous track of traditional systems engages a sprocket wheel that transmits power from the engine and effectively pulls the vehicle along the steel track. The links of traditional steel tracks are joined with pins, which are subjected to huge tensile loads determined by the weight of the vehicle and the kind of manoeuvre conducted. Transmission power reaches each track through corresponding left or right sprocket wheels, while the weight of the vehicle keeps the track firmly on the ground.
To ensure vehicles move freely over all surfaces and can manoeuvre easily in arduous conditions and at high speeds, steel links typically incorporate rubber pads, which act as solid lubricant to reduce wear, noise and vibration.
Two types of traditional track are single-pin and double-pin. Single-pin, as used in the M113 family and lighter armour, has a single cast shoe with integral lugs on both leading and trailing edges, with slots that engage the sprocket wheel, and a projecting horn, which guides the track centrally along the road wheels. On its upper face, the shoe incorporates a rubber road wheel pad, with a replaceable track pad on its lower surface. Lugs on the front edge of one shoe interlock with the lugs on the rear edge of the next. A single pin pushed through rubber bushes in the lugs connects shoes to each other. Road wheel pads are intended to resist wear and are bonded to the track. Replaceable road wheel pads are vulcanised rubber intended to resist wear and tear for long durations.

Photo: Soucy Defense

An M113 in Afghanistan fitted with Soucy CRT: Traditionally, the M113 runs on single-pin tracks.

For larger, heavier vehicles, tracks with a greater load-carrying capacity are required. With an increased surface area, the double-pin track is suited to armour such as MBTs and larger SP artillery. Track shoes are referred to as links, comprising two link elements – similar to single-pin shoes – and two integral circular pins. End connectors join the pins of adjacent tracks to create the whole double-pin track assembly, together with a third connector at the centre of the pins and link. The end connectors engage the sprocket wheel. The central connector, which incorporates a horn, guides the track centrally along the road wheels.
Rubber bushes and vulcanised pads play similar roles as performed in single-pin steel/rubber track systems and are chemically similar in their make-up. That said, heavier vehicles and often more demanding operational performance requirements put heavier vehicle tracks through greater stresses and forces, with potentially increased wear on every element of the assembly.

Author

Tim Guest is a defence and aerospace journalist and a former officer in the Royal Artillery. In the 1980s he was responsible for a major UK MoD track evaluation trial, resulting in the replacement of in-use American tracks with a new and more efficient Diehl Remscheid (now DST) track across the whole Royal Artillery M109 fleet.

While the above paints an overall picture of traditional track, the efficiency and performance of a track system is evaluated by such factors as the noise and vibration effects the track directly generates, along with fuel consumption and maintenance hours required to keep the track serviceable and a vehicle roadworthy. Now, a closer look at Composite Rubber Track (CRT).

CRT on Show

One of the most innovative developments in track technology in recent years, CRT, was on display at Eurosatory this year. Soucy Defense, which has pioneered CRT systems over the past 28 years, currently providing 20 nations in Europe, North America and Asia with track from its portfolio of solutions for 15 different Armoured Vehicle (AV) platforms that range in Gross Vehicle Weight (GVW) from 4 tonnes to 42 tonnes, highlighted its latest rubber band track systems in Paris. In partnership with FFG Flensburg, a lightweight track was on display fitted to an upgraded FFG German Army WIESEL Armoured Weapons Carrier. The WIESEL has a requirement for lightweight armour, though offering a high degree of ballistic protection without hindering manoeuvrability. Soucy's track, with its continuously cased rubber band structure, reinforced with a range of composite materials and steel cord and weighing up to 50% less than comparable steel track, therefore enables the extra protection to be carried and has been adapted for the Wiesel 1 to suit its exacting weight requirements. Other vehicles currently fitted with Soucy CRT include: CV90 (GVW 35 tonnes), LEOPARD 1 (GVW 46 tonnes), FFG G5 (GVW 25 tonnes), M113 A2 (GVW1 3 tonnes), BVS10 (GVW 16 tonnes), and WARRIOR (GVW 32 tonnes). The company told European Security & Defence (ESD) that its tracks have been operationally fielded in Afghanistan and Iraq, making their product the only operationally fielded rubber track on the market.

CRT External Profile

CRT Internal Profile

M113 Drive Sprocket

BVS10 Drive Sprocket

Collapsible Tensioner

Idler Wheel

Standard Natural Rubber

Soucyprene™ Rubber

Photo: Soucy Defense

Photo: Soucy Defense

BRONCO vehicles fitted with Soucy CRT. Usually, heavier vehicles require double-pin tracks with an increased surface area for a greater load-carrying capacity.

Advantages of CRT

CRT provides armoured vehicles not only with increased durability over conventional Steel Tracks (ST), but, more specifically, with around a 70% reduction in vibration, according to Soucy, which also has the effect of extending the service life of ammunition, electronics and onboard sensors. Using CRT also reduces Whole Body Vibration (WBV), so that crew members experience less physical fatigue and maintain greater operational awareness. In terms of noise reduction, CRT

DARPA's RWT Programme

As part of a Defence Advanced Research Projects Agency (DARPA) programme called Ground X-Vehicle Technologies, or GXV-T, and in collaboration with Carnegie Mellon University's National Robotics Engineering Center (CMU NREC), a breakthrough in enhancing ground vehicle movement across rough terrain was announced earlier this year. Tyres that turn into compact triangular tracks in a matter of seconds and while a vehicle remains in motion make up the Reconfigurable Wheel Track (RWT) programme, where a round road wheel becomes a triangular track in order to increase surface area

Photos: DARPA

contact with terrain, thereby lowering vehicle ground pressure and offering improved traction. The RWT system was trialed on a HUMVEE in May at the Aberdeen Proving Grounds. A DARPA statement said: "wheels permit fast travel on hard surfaces while tracks perform better on soft surfaces. A team from CMU NREC demonstrated shape-shifting wheel-track mechanisms that transition from a round wheel to a triangular track and back again while the vehicle is on the move, for instant improvements to tactical mobility and manoeuvrability on diverse terrains". Carnegie Mellon said that "in testing to date, vehicles equipped with the reconfigurable wheel-track have achieved 50 miles an hour in wheel mode and almost 30 mph in track mode. The device has transformed from wheel mode to track mode at speeds as high as 25 mph and from track mode to wheel mode at speeds of around 12 mph." The future can expect to see this innovation develop further and be adapted for larger wheeled armour.

reduces this by up to 13.5dB, improving the efficiency of communications, stealth and crew health and safety. Fuel savings have also been notable; comparison trials held at the end of 2017 by the UK MoD's Armoured Trials and Development Unit (ATDU) showed a 30% fuel saving on a Warrior IFV. Being up to 50% lighter than ST, using CRT has also allowed end users to add mission-critical equipment to armoured vehicle platforms, as in the case of the WIESEL and its ballistic protection. The track also delivers a reduced braking distance, as much as 30%, dependent, of course, on variables such as vehicle mass, acceleration and velocity. And for crews whose every spare moment is crucial to their effectiveness in battle, CRT requires almost 'no maintenance' other than visual inspection.

Technology in Profile

CRT comprises a continuously cased rubber band structure, reinforced with a range of composite materials and steel cord arranged longitudinally and laterally. It is supplied as a complete continuous track that is generally driven by an internal drive sprocket in military applications. The track is assembled in a precise sequence giving it the strength it requires. Also incorporated within the CRT are carbon nanotubes, which are used for their exceptional strength and stiffness, along with their good thermal properties, which allow for better heat dissipation, to prevent hot spots or premature track failure.

To accommodate the diverse weight classification portfolio of CRT-integrated armoured vehicles, when Soucy provides track it also provides other elements of the running gear like the sprockets; the sprocket that is provided to accompany the CRT, however, will depend on the vehicle weight. The company's Ultra High Molecular Weight Polyethylene (UHMW-PE) sprocket suits lighter armour, for example. This very tough material has the highest impact strength of any thermoplastic currently made and is highly resistant to abrasion. For heavier vehicles, the company provides a Full Cast Iron (FCI) sprocket, which can handle the additional forces placed on it by bigger platforms. Both sprockets use an open design that prevents the risk of clogging from dirt, mud and snow.

Steel track – Vehicle Range		
322 mi	25% Road	81 mi
239 mi	75% Cross-country	179 mi
		260 mi (1.3 mile/gallon)

CRT – Vehicle Range		
384 mi	25% Road	96 mi
314 mi	75% Cross-country	236 mi
		332 mi (1.66 mile/gallon)

As the longitudinal stiffness of CRT is higher than ST, Soucy has designed a Collapsible Tensioner (CT) designed to collapse at a pre-set tension should an ingress of rocks and debris occur between the tracks, sprocket, or idler wheel. This prevents any damage to these other components. During normal operation, the tensioner would act as a grease track adjuster. Once the pre-set limit is reached, however, the tensioner collapses temporarily and acts as a spring until the track tension decreases sufficiently for the tensioner to return to its original set position. The idler wheel, (made of austempered ductile iron, highly resistant to wear), along with the CT, provides tension to the CRT and also keeps

the track aligned. Like the sprockets, the idler wheel's open design prevents clogging with debris.

CRT's Rubber

One important material used to make CRT is, of course, rubber, and the track's rubber compounds represent roughly half the track weight. The system comprises more than 12 distinct rubber compounds, each with different mechanical properties. One compound is Soucyprene; it has a wear rate 20 times less than conventional, natural rubber compounds.

Using CRT in military AV applications presents a number of challenges, not least of which are the extremely heavy weights of most AVs and the need to meet extreme survivability levels. This survivability criterion makes for an engineering dilemma, presenting the need for a compound which is versatile enough to avoid abrasion, cutting and chipping, but which has a core structure strong enough to survive and absorb blast, whilst meeting all the complicated processes involved in vulcanisation. In line with this, Soucy's CRT has been tested to survive blast damage at STANAG level 3. Corresponding ST, according to Soucy, fragments in most cases at STANAG level 1.

In the unlikely event of a CRT rupture with the Soucy track, the company provides a limp-home solution called the Battle Damage Repair (BDR) kit; this allows CRT to be temporarily repaired in order for the vehicle to manoeuvre. Using the BDR kit only enables the vehicle to travel 100 km at 40 kph, unlike track repair on a conventional ST, which enables the vehicle to be up and running as normal.

CRT Future

Since the official validation of its 39-tonne product line, Soucy has also been developing new and improved compounds to support the development of rubber track technology for vehicles in the 50-tonne category. As for future customers, in Poland, HSW, (which developed the 26-tonne BORSUK IFV for the Polish Army), will be testing Soucy CRT against ST starting in the early Winter of 2019. The BORSUK programme features many different configurations for which Soucy's CRT will be adapted, with full production for BORSUK CRT slated from 2021, if confirmed. At the end of 2017, the UK's ATDU trialled Soucy CRT on BAE's 32-tonne WARRIOR vehicle, in a 5,000-km evaluation. The official trial report stated that throughout, there were no requirements for track maintenance, as track components and running gear did not require changing.

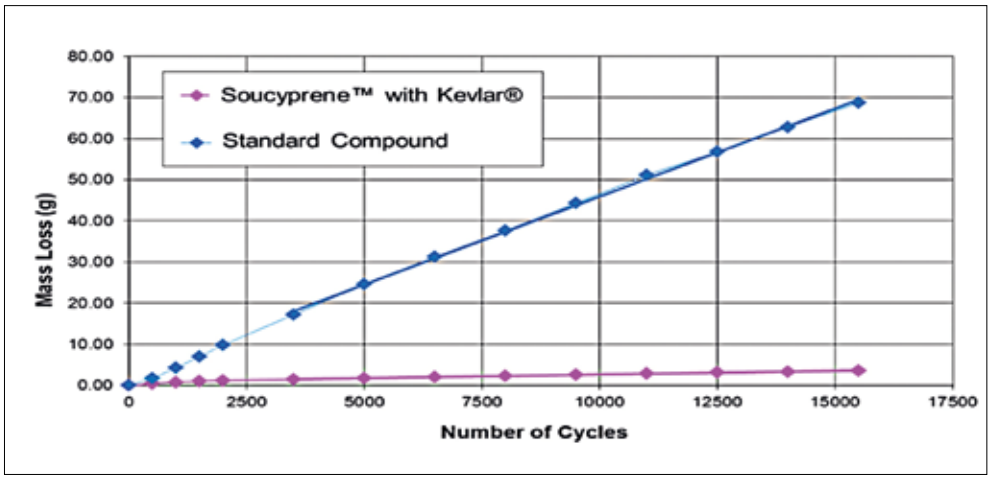
Photo: Soucy Defense

An ATDU 4 fitted with Soucy CRT in a neutral turn sequence.

Warrior CRT Trial

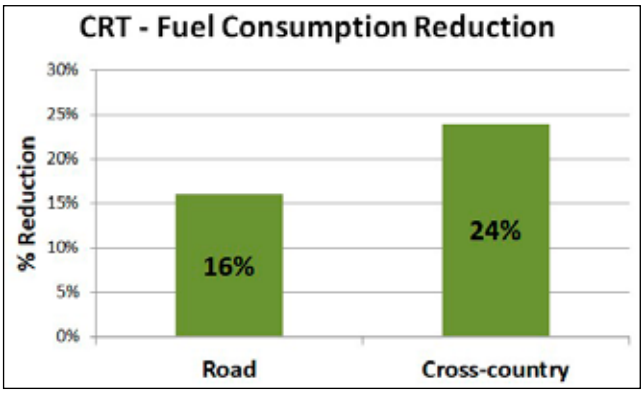
In August this year, the results were announced of last year's CRT track trial on the UK's WARRIOR IFV. ATDU conducted a private venture trial on behalf of Soucy Defense, sponsored by the Head of Capability – Ground Manoeuvre, with the trial aim to build UK MoD confidence in CRT technology by validating manufacturer performance claims, so that CRT could be given due consideration in future AV programmes. The trial, from September to December 2017, involved the WARRIOR variant 510.

Amongst many positives, the trial report stated on the maintenance side, so critical to crew morale and performance, that maintenance of the CRT system "is simple and mostly requires a visual inspection, saving a combined total of 415 hours for level 1 and 2 maintainers (one vehicle for 3,000 miles). Daily maintenance procedures only require a visual inspection of running gear components, with after-use inspection of the complete track carried out by slowly reversing the vehicle". It added that, "the CRT does not stretch – no need for re-tightening or removing a track link". The report also noted that no shoe pad replacement is required using CRT and road wheel replacement is three times less than with ST systems. In its conclusion, the report stated that the CRT system was operated for 3,107 miles during this intensive 10-week test on the WARRIOR IFV Variant 510, with several benefits over in-service ST demonstrated. These included CRT 1) having direct weight savings of 3,306 lb representing an overall 5% GVW reduction; 2) increasing the vehicle's average range by 28%. Also, 3) overall noise using CRT was reduced by 57%, and 4) average vibration levels were reduced by 42%. The Warrior was also said to have 5) an improved Vehicle Cone Index – its ability to traverse soft-soil terrain – and 6) a Mobility Index 24% better than when using ST.



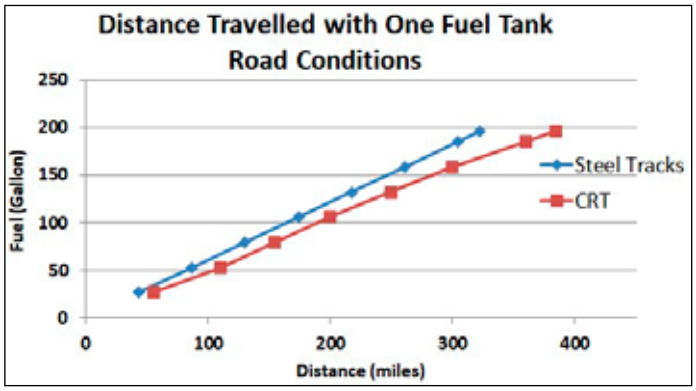
The chart shows laboratory abrasion test results demonstrating the 20-fold reduction in wear rate of Soucyprene™ relative to conventional natural rubber compounds used on steel track pads.

The report concluded that the trial had validated Soucy's "claimed benefits (based upon a wider fleet in service with NATO nations) including reliability, durability, N&V (Noise and Vibration), automotive performance, much reduced maintenance time and fuel efficiency". It added that, "Confidence in CRT technology has thus grown significantly and the trial has identified several possible exploitation opportunities in

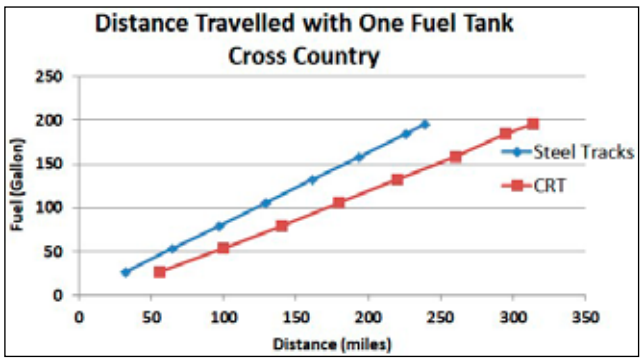


Source: CRT WARRIOR Trial Results / 2018 NDIA Symposium

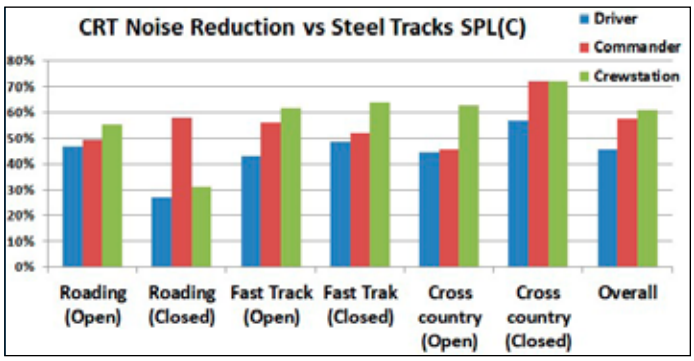
Fuel Consumption Reduction



Vehicle Range – Road conditions



Vehicle Range – Cross country



CRT – Sound Pressure Level Reduction

the current and future UK AFV fleet where CRT should deliver programme efficiencies (time and cost) and enhanced capability to the user. There is evidence that the noise and vibration produced by having CRT fitted is significantly reduced, which will have a genuine effect on the health of our soldiers".

Track Innovations with German Pedigree

An article on latest track developments would not be complete without mention of Diehl Service Tracks (DST), acquired by Krauss-Maffei Wegmann at the end of 2014. This is the only German track manufacturer for military vehicles. The company has equipped all the Bundeswehr's tracked vehicles and latest innovations include segmented rubber band tracks and light-weight tracks for the German infantry's PUMA combat vehicle. DST delivers tracks, road wheels, idler wheels and sprockets, with its track systems – of which there are around 100 different kinds – in use the world over on vehicles, including: the LEOPARD 1 and 2 MBT; MARDER, PUMA, PIZARRO and ASCOD AIFVs; M113 family of APCs; and SP field artillery systems like the M109 and PzH 2000.

Its iDeal System Track (iDST) and iDeal Lightweight Track (iDLT), together with double-pin track technology, help reduce torsion forces and increase service life. The iDLT is a lightweight design, with corresponding weight reduction allowing such vehicle modifications as increased armour protection and, thereby, improved crew safety. DST has also developed its innovative iDeal Band Track (iDBT) system to reduce weight, noise and vibration, thereby improving crew comfort. This system has a patented segmentation system that incorporates a connector. The company says that compared to an endless band track, it enables the crew to handle and replace individual track segments easily in almost any location.

In 1982, when the UK's 2nd Field Regiment RA trialled a double-pin Diehl track in a head-to-head evaluation against the incumbent US track for its M109s, two crews, working round the clock over many months to conduct the 3,000-mile test, could hardly wait at the end of the trial for the UK MoD to make its decision to replace the US tracks and adopt the German system. The Diehl tracks had proven themselves hands down, requiring considerably less maintenance, producing much less noise and vibration, all leading to happier crews who delighted in helping Diehl win the substantial contract. ■

Photo: Soucy Defense

A BAE Systems 35 tonne CV90 on Soucy CR

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Vehicle and Crew Protection

Tamir Eshel

Survivability is an essential component of military effectiveness. Military forces have long invested in platform armouring and personal protection to increase the survivability of combat forces, while also improving lethality to exceed the opponent's capabilities.

Traditionally, the more technologically advanced a nation is, the better its troops are protected. However, recent conflicts have shown that opposing forces – regular, paramilitary and guerrilla forces – have improved their level of personal protection. These conflicts have also revealed gaps in vehicle protection when it comes to improvised weapons and operational techniques that have exploited vulnerabilities in combat vehicles.

Generally, survivability theory eyes three levels of protection – mission continuity, platform protection, and personal survivability. On dismounted operations, mission capability, plus platform and personal survival relate to the individual soldier and aim to preserve combat capability and agility, so that hits are avoided rather than contained. In mounted operations, vehicle protection takes the shape of an onion, where the outer layers relate to the mission and the inner layers protect the vehicle and its occupants.

Photo: via author

Syrian armoured vehicles caught in an ambush in 2013

Photo: Amsafe Bridport

The TARIAN RPG net is designed to reduce vulnerability to RPGs.

Human-Centric Protection

For the individual soldier, effective survivability is determined by his ability to accomplish the mission – establishing contact with the enemy, maintaining agility and concealment – and not by carrying the best means of protection. In dismounted operations, the soldier is exposed mainly to direct fire, as well as fragments and debris from nearby explosions. Sharp instincts, experience and training are the main factors contributing to survival. Therefore, modern combat suits are designed as ergonomic load-bearing assemblies integrated with protective elements that allow soldiers to carry basic loads such as ammunition, communications equipment, energy, food and water. Ballistic head, eye and ear protection has to maintain these vital functions, along with ballistic inserts integrated into the vest to protect the torso and groin. This flexible approach ensures maximum functional flexibility and mobility with minimal strain.

Eyesight and hearing are two human senses that are easily affected by radiation, pressure, aerosols and physical impact. With eye protection a special concern, ballistic eye protection should be used to safeguard the eyes from fast debris, shrapnel and aerosol spray as well as from laser radiation. Current laser filters are effective against lasers operating in a single band. Future filters should utilise advanced active materials and ultrafast shutters to block lasers in multiple bands, including very fast,

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high-power blinding pulses that would penetrate through vision blocks and blind human eyesight and sensor vision. Some of those active materials would be able to quickly adapt to block only the threat wavelength, leaving the rest of the spectrum intact.

Hearing protection is equally important. Protecting hearing in combat requires advanced earplugs that both attenuate harmful noise levels yet facilitate voice communications and situational awareness in environments of high ambient noise, such as in tracked vehicles or self-propelled guns, where occupants are exposed to continuous noise levels higher than those sustainable by a human. New hearing protection aids have other advantages, particularly in special operations, as they enable the ultra-sensitive 'whisper mode', which allows communications below audible levels.

Crew protection, survivability, and mission readiness are not just about bolting layers of armour onto a truck. Optimising a vehicle for life-threatening missions requires a full system engineering approach to integrate every element of the vehicle.

Man is the softest and weakest element on a protected platform. Therefore the crew needs additional protective means to survive a violent, close-range engagement. From mine and IED attacks to a skirmish or an ambush involving RPG threats, small arms fire or even rocks, incendiary bombs and suffocating smoke, there are many eventualities that can prove dangerous for unprotected occupants.

Precision fire may be used against vehicles and exposed crews. These include guided missiles launched from long ranges, or snipers firing from medium and short range. Other threats aim to maim the platform, by damaging the engine and driveline, tracks or wheels and causing a "mobility kill". As the vehicle is stopped in its place, it draws other vehicles to assist, all becoming more predictable and vulnerable to attack.

Snipers use heavy-calibre rifles – also known as "anti-materiel rifles" – to take out essential elements on protected vehicles, including cameras and remote-controlled weapons by hitting the weak spots that would cripple those vehicles and deteriorate their combat capability. These threats are most potent against vehicles that are exposed and stationary.

Protecting the Platform

Threat levels are defined by the NATO standard STANAG 4569 Volume 1. Each level in that protocol addresses kinetic, fragmentation and blast effects. Level 1 is the basic, referring to 5.56x45 and 7.62x51

Photo: Rheinmetall

The KF41 LYNX from Rheinmetall uses modular armour in response to high threat levels.

NATO ball fired from a distance of 30 metres and fragments from 155mm rounds exploding 100 metres away. Armour at this level should also defeat grenades and small anti-personnel mines detonated under the vehicle.

STANAG 4569 Level 2 refers to 7.62x39 AP rounds fired from 30 metres and 155mm artillery exploding 80 metres away. It should also defeat 6 kg of high explosives activated under the wheel or track and the belly. Armour designed to withstand Level 3 threats, which up until now has been the highest level of basic armour used on wheeled combat vehicles, should defeat 7.62x51 armour-piercing projectiles fired from 30 metres and artillery fragments from 155mm projectiles exploding 60 metres away. Mine protection at this level addresses threats with an 8 kg explosive charge.

Vehicles conforming to these levels often use armoured capsules made of steel that offer the most affordable protection against single and multiple hits. This design also provides a solid base for add-on protection, when anticipating a higher threat. However, at these levels, steel armour becomes heavy and remains vulnerable to other armour-piercing techniques, primarily shaped charges. Using lighter and stronger composites and ceramic materials delivers better protection at a lower specific weight, though at a higher cost. Most applications require a combination of those materials, as none offers complete protection against all threats. Future armour solutions are likely to use hybrid materials as part of the base armour that will integrate ceramics, composites and metals into thinner and lighter matrices offering higher protection at a lower weight. Ultrahigh Molecular Weight Polyethylene (UHMWPE) is currently used to provide ultralight personal protection and vehicular armour, offering higher ballistic efficiency at a lower weight.

Photo: via author

A destroyed US Army M1 ABRAMS MBT after a direct hit in Iraq

Future armour applications would also benefit from the large-scale synthesis of graphene nanotubes. Weaving in a three-dimensional layout of future composite materials will enable the mass production of materials offering new structural efficiencies, reinforcement and damage tolerance to deliver a high level of protection at lower weight and cost. Implementing such a 3D architecture requires multiphysics and mathematical models to predict the behaviour of each material and protective structure under attack. As a result, such lightweight mate-

Photo: Plasan

A curtain-shaped spall liner designed by Plasan

Photo: Plasan

Different types of add-on armour and anti-RPG protection developed by Plasan

rials are expected to increase soldier and vehicle protection with zero impact on effectiveness and performance.

Ballistic protection against threats higher than Level 3 requires the use of heavier armour solutions that are often too expensive for general purpose and utility vehicles. For most applications, the use of modular add-on armour is a useful way to address new threats as they appear on the battlefield. These include high-explosive and armour-piercing rounds from medium-calibre 14.5–30mm guns and 155mm artillery rounds exploding 10 metres away, as defined by STANAG 4569 Vol .1 level 4, 5 and 6.

Such armour often comes in tiles fitted to the base armour using attachment methods standardised by the user. A modular approach enables users to quickly upgrade the vehicle's armour as they encounter new threats. Given the vehicle's load carrying capacity, a modular protection system can be optimised to meet a combination of threats. The use of advanced materials that include unique elements such as reactive armour, anti-RPG networks or active protection can provide protection against most threats. The modular design also offers a practical way to repair the armour in the field. The roof of a vehicle is quite vulnerable to attack by relatively light threats such as bombs and grenades, so it should get appropriate protection. For this purpose, "porcupine" shaped cover mats are used, with or without a ceramic layer, to improve roof protection and prevent a direct contact of the threat with the roof's thin metal surface.

Windows and sights are also vulnerable and require transparent ceramic armour to increase the resistance of ballistically protected windows and lenses and prevent penetration and damage to electro-optical (EO) assemblies.

A Modular Approach

Armour modules are designed to defeat different threats – kinetic, shaped charges, or IEDs. Modular armour was introduced in the 1980s by the Israel Defense Forces (IDF), addressing an urgent requirement to upgrade tank base armour against shaped charge threats. These warheads were massively used by Arab armies during the Yom Kippur war in RPGs and anti-tank guided missiles. The Israelis opted to add an outer 'skin' that incorporated a matrix of reactive armour tiles that covered the base armour, each tile encapsulating a small sheet explosive in a sandwich of steel plates. When subjected to a shaped charge attack such a module would explode and dissipate the shaped charge's plasma jet before it hits the tank's steel armour. Soon after the introduction of reactive armour, missile and ammunition manufacturers adopted countermeasures in the shape of a probe that would trigger the armour prematurely, thus exposing the base armour to direct attack. Utilising the modular design the armour was modified quickly to meet those countermeasures. By the next round, shaped charge threats added a small precursor in tandem to the main charge, to activate the reactive armour. Active protection systems (APS) evolved to counter this new threat. These include the Israeli TROPHY and IRON FIST and the Russian AFGANIT, which developed as a stand-off APS with the German ADS, and the Ukrainian ZASLON offering close-in defence.

Add-on armour is also employed to protect against specific threats, such as RPGs. These anti-tank weapons are common with irregular forces. RPG threats are often handled by slat armour and nets attached to all the sides of medium protected vehicles. When used on heavy combat vehicles such as main battle tanks and infantry fighting vehicles, slat armour is often used to protect only the most vulnerable parts,

such as the ammunition storage in the turret bustle, the engine compartment and the sprocket wheel in the rear.

Multi-Functional Armour

All those protection capabilities are integrated into a holistic protection system combining passive, reactive and active protection. Such systems require real-time sensing and vehicle intelligence to enable protection suites to adapt to specific threats, and operational situations.

The use of multifunctional armour (MFA) is part of this new approach. MFA comprises structural and armour elements that enhance system efficiency and performance while maintaining the levels of protection necessary to meet current and future threats.

An example of MFA is Plasan's SMART ARMOUR that comprises sensors embedded in the armour tiles to constantly monitor the armour health and integrity and assess the vehicle's overall protection. Weighing only 200 grammes per square metre of armour, SMART ARMOUR enables the crew to identify vulnerable areas around the vehicle in real time, where protection has been compromised or degraded due to combat damage or operational use. Integrated with the vehicle's electronics and battle management system (BMS) via standard NGVA protocol, SMART ARMOUR depicts the vehicle's protective shield in a graphical view on the battle management display. Such a display draws the crew's attention to where an enemy attack could possibly come from and recommends tactical manoeuvres such as seeking cover from buildings or other vehicles, evaluating combat damage and selecting appropriate ammunition.

Other types of MFA employ nanocomposites and gel inserted in structural elements, to act as ballistic protection and energy storage combined. Elements composed of such armour would embed high-performance ballistic films, dielectrics, and graphene-based electrodes to form structural batteries and supercapacitors that bear the load of the platform and store electrical energy at the same time. Such energy storage is required to activate futuristic "electric armour," a new way to stop kinetic and chemical energy threats as they pass through the armour. Future armour packages developed this way save about 10% of the weight while maintaining the same protection performance.

Future multifunctional armour, such as BAE Systems' "Adaptive armour" also enables camouflage and concealment of the platform, by using polymeric materials and adaptive microfluidic surface appliqués to manage optical or thermal properties. Applied as the outer layer of the armoured vehicles, such "skins" have the potential to manage the visual and thermal signature of the vehicle, blending it into the surrounding scene.

Occupant-Centric Survivability

No armour is invincible; vehicle armour ultimately fails if it is exposed to a constant threat. Therefore, vehicle survivability design should consider such events, contain the damage and minimise the chance of human injury under such conditions. Measures including spall liners, blast mitigation design, explosion, and fire suppression are

Photo: Tamir Eshel

Turret of an ASCOD 2 AJAX showing add-on armour and optronics protection

some of these means, along with emergency escape pathways, air filtration, insensitive explosives and propellants, fire retardant ammunition storage, and clothing, along with non-flammable fluids and lubricants, improving the survivability of humans in such circumstances.

Spall liners provide armoured combat vehicles an important "last barrier' between an overmatching threat and the crew. This critical survival measure consists of composite materials that protect the crew by absorbing most of the spalling and fragments released by penetration of the armour. Spall liners are attached to the inside walls and floor. It can be installed in the field, attached either directly to the inner armour wall or as an overhanging "folding curtain" that maintains access to critical equipment with full mission functionality.

The numerous technologies used for blast protection include blast seats, floor designs, restraints, active blast hulls, hull-shaping, and forging techniques. In the case of an explosion, the floor caves into the crew compartment and turns into a devastating surface that must be isolated from the crew. Attaching the upper floor layer to the walls, rather than the belly, is one way of mitigating much of the blast effect away from the soldiers inside.

Multi-layered blast protection is another of these techniques. By employing a spaced armour design that enables controlled deformation of the underbody, the vehicle can survive mine or IED explosions with a deformed but intact capsule. Under such blast conditions the vehicle is exposed to ultra-high accelerations, way above the human endurance level. Utilising a V-shaped belly to deflect the blast sideways, or a double- or triple-level blast-attenuating floor, or even active counterblasts to eliminate the load are part of the solution. Blast attenuating floors and seats would channel the blast further away from the crew.

Photo: via author

A destroyed Syrian T90: note the spent reactive armour tiles.

For individual protection, energy attenuating seats absorb and reduce the transfer of kinetic energy resulting from explosions to the human body. Such seats often come with energy-attenuating footrests and headrests that further reduce up to 70% of the forces induced by a mine or IED affecting the lower legs.

Fire hazards remain even after a vehicle survives penetration or a blast event. Fire protection and suppression are designed to deal with such risks, minimise the risk of uncontrolled eruption of fire of flammable liquids or a sympathetic cook-off of propellant and ammunition that would result in a catastrophic fire inside the fighting compartments. Multi-zone fire detection systems with various means of suppression would provide the crew with the critical time they need to respond either by extinguishing the fire or by escaping.

Live ammunition, particularly propelling charges, is particularly hazardous when exposed to an overmatching threat penetrating the fighting compartment. When stored ready to fire in a magazine, the probability of igniting such propelling charges is particularly high, posing the greatest risk to crew survival. A sustained high-temperature environment would also pose a possible sympathetic cook-off risk to other munitions stored inside the crew compartment.

The storage of ammunition in ballistically protected, fire-retardant cells reduces the risk but does not eliminate it. The development of insensitive energetic materials (fuels and warheads) or the separation of the ammunition by a firewall outside the crew cell or the complete removal of humans from the turret contributes to the survivability of the vehicle.

Different means of protection are required to operate in the presence of chemical, biological, radiological and nuclear (CBRN) threats. While such threats are relevant only in a total war, modern CBRN systems also provide air filtration, clearing dust and smoke to maintain normal operation inside vehicles even when insurgents try choking the crew by blocking the vehicle's air inlets using smoke and fire.

As armoured vehicles become heavier and more protected, modular armour strategies are necessary to maintain transportability and air deployability. Eventually, with the availability of unmanned combat platforms, humans could be removed entirely from some platforms, eliminating the weakest element in the system. Such manned–unmanned vehicle teams, along with innovative signature management, agility and protection, will enable soldiers to shape the future battlefield, avoid detection and deliver effects with the highest impact on the enemy while avoiding most of the threats. ■

Heavy Armament for Medium and Light Armoured Vehicles

Sidney E. Dean

Survivability and operational effectiveness of armoured vehicles depend on a number of factors, including protection, mobility and armament.

There is inherently a trade-off between these factors. Armour and armament add weight and bulk, at the expense of speed and agility. Every chassis also has an overall weight limit. For these reasons, the combination of heavy armour and heavy weapons has normally been restricted to large-framed vehicles such as Main Battle Tanks (MBTs). Another reason to limit weapon size on medium and light armoured vehicles is the impact of weapon recoil. This reflects concerns for long-term damage to the chassis, as well as the stability of a lighter vehicle when firing a heavy gun.

Having said this, there remains a fairly broad spectrum of weapons options for medium and light armoured vehicles. The choice of weapons suite will depend largely on the vehicle's primary mission. Light tanks and other Armoured Fighting Vehicles (AFVs) will require heavier weapons than Armoured Personnel Carriers (APCs) and scout vehicles, which will mostly fire in self-defence or in support of their dismounted passengers. Overall, there is a trend toward more powerful armament on medium and light armoured vehicles. This reflects various factors. Many nations cannot afford the investment in heavy MBTs – or can afford only a limited number – but perceive the need for increased firepower to thwart current or potential threats. Placing heavier weapons on more lightly armoured vehicles strengthens offensive capacity; the limited armour on these vehicles is compensated by reliance on mobility to improve the odds of battlefield survival. Strategic or tactical considerations may motivate even some wealthier nations to favour investments in lighter vehicles which can be quickly airlifted to conflict zones, but which feature potent combat capabilities. Finally, improvements in materials and defensive systems such as appliqué and reactive armour now require that more powerful weapons be mounted on middle-grade combat vehicles as a counterbalance.

Photo: Oshkosh Defense

A JLTV prototype mounting a JAVELIN ATGM

Author

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Armament Options

In addition to light and heavy machine guns, these vehicles can mount heavier weapons drawn from the three categories listed below:

Grenade Launchers

Automatic grenade launchers or AGLs (most commonly in 40mm) provide an indirect fire capability with effective ranges averaging circa 1,500 meters and maximum ranges in excess of 2,000 metres. Rate of fire varies from as little as 215 rounds per minute (the SB LAG 40 produced by Spain's Empresa Nacional Santa Barbara and mounted on the Brazilian Marine Corps' PIRHANA IIIC APCs) to 500 rpm (such as Singapore's STK 40 AGL which can be integrated on an armoured vehicle's ringmount or remotely operated weapon station). High-explosive fragmentation grenades are the most frequently deployed munitions. Fuse options include point detonation and air burst. Optical and infrared sights are common, but a few AGLs – such as the Heckler & Koch GMG – feature reflex sights. While grenades individually have a smaller charge than cannon shells, the very high rate of fire makes AGLs highly effective, especially against dismounted infantry and against thin-skinned or lightly armoured vehicles and structures (saturation fire). On the negative side, muzzle velocity averages less than 250 metres per second, significantly slower than other weapon types. This can reduce effectiveness against moving targets.

Photo: CMI Groupe

The COCKERILL 3000 family of turrets can accommodate guns between 25mm and 105mm. Displayed here are the 30mm and 105mm versions.

Cannons

Cannons ranging from 20mm to 105mm are commonly carried. Light tanks and medium-armoured AFVs generally feature a turret-mounted main gun. Light Armoured Vehicles (LAVs) are more likely to carry a ring-mounted main weapon; increasingly the LAV's man-crewed weapons station is being replaced by a remotely-operated weapons station (RWS). Weapons calibre varies widely depending on a vehicle's construction, weight and primary mission. Light tanks are designed to engage enemy armoured vehicles and require significant firepower. They generally carry up to a 105mm main gun. However, several manufacturers including Leonardo (HITFACT 105/120) now offer turrets designed specifically for light tanks/medium AFVs and which can be fitted with either 105mm or 120mm low-recoil guns. The turrets themselves are smaller than those of MBTs and utilise combinations of ballistic aluminium, steel plates and composites to reduce weight while providing equivalent protection to heavier turrets. Mounting low-recoil guns permit firing on the move without endangering vehicle stability or excessively stressing vehicle frame integrity. The CENTAURO II 8x8 Mobile Gun System produced by Iveco Fiat/Oto Melara is equipped with the HITFACT. Intended primarily as a tank-destroyer, it carries the 120mm smoothbore cannon and can match the firepower of an MBT. The CENTAURO also illustrates one serious drawback of mounting large-calibre weapons on smaller vehicles. While MBTs (with a weight range between 55 and 70+ tonnes) typically carry 40–50 rounds of 120mm ammunition, the 27-tonne CENTAURO's capacity is limited to nine rounds.

Medium-armoured AFVs intended for support roles – including Infantry Fighting Vehicles – will frequently carry smaller turret guns, usually autocannons ranging from 20mm to 50mm, although larger guns are also seen. Autocannon ammunition variants include solid shot, high-energy fragmentation, incendiary, and sabot. Current trends favour larger calibres for newly developed vehicles, and even for in-service vehicles undergoing refit. This trend reflects two factors: improved power trains and strengthened chassis capable of carrying the extra weight of larger weapons, and improvements in (opponent) armour which require more powerful weapons to be fielded to compensate. Many LAVs are optionally equipped with 20mm to 35mm autocannons. Another major trend is toward modularity, with turrets or mounts capable of supporting a range of weapons. CMI Defence's COCKERILL 3000 series turret is one of the most versatile, capable of accommodating anything from a 25mm autocannon to a 105mm main gun.

Photo: via author

A Heckler & Koch GMG automatic grenade launcher mounted on a German Army FENNEK light armoured reconnaissance vehicle

Missiles

Missiles and rockets can be mounted on turrets, telescopic masts or remote weapon stations, either as primary or additional heavy armament. While a wide range of munitions is available, anti-tank guided missiles mounted alongside gun turrets are the most prevalent. A significant current development is Kongsberg's upgrade of its PROTECTOR remote weapon systems to accept JAVELIN anti-tank missiles. During testing in 2016, PROTECTOR-mounted JAVELINs were able to hit targets as far as 4,200 metres distant. Kongsberg cites 18,000 PROTECTORs of various configurations – including the CROWS I and II of the US armed forces – in service on medium and light vehicles in eighteen nations. In addition to externally mounted Anti-Tank Guided Missiles (ATGMs), several AFVs outfitted with large-calibre ordnance are capable of firing specially prepared guided missiles through their main gun. These include the NORINCO ZTQ/VT-5 tracked light tank (105mm) presented in China in 2017, and the NORINCO ST-1 8x8 wheeled tank destroyer unveiled in 2014. Both Chinese AFVs mount the rifled ST1 105mm cannon capable of firing laser-guided ATGMs with a range of 5,200 metres and the capacity to penetrate 700-millimetre armour. These missiles can also be deployed against low-flying helicopters.

In addition to mounting general purpose weapons, some armoured vehicles are outfitted as mortar carriers or mobile air defence platforms, but these specialised combat support vehicles are beyond the purview of this review. A brief discussion of various armoured vehicles currently in development or introduced into service over the past decade will illustrate current weapon suite developments.

Light Tanks and Medium-Weight AFVs

United States

In December 2018, the US Army narrowed the competition to develop the Mobile Protected Firepower (MPF) light

tank down to two proposals. The MPF is intended to escort and provide heavy fire support to light infantry units, and it requires a large-calibre main gun. BAE is presenting an updated version of the 24-tonne M8 BUFORD armoured gun system, equipped with a 105mm cannon. Competitor General Dynamics Land Systems (GDLS) is offering the 28-tonne GRIFFIN II. This system pairs the chassis of the British AJAX armoured scout vehicle with a downscaled variant of the M1A2 ABRAMS MBT's turret. This enables the GRIFFIN II to mount a 120mm cannon. Both guns are capable of firing the gamut of tank munitions in their respective calibres, enabling them to engage a broad set of targets including personnel, hardened structures, and armoured vehicles up to and including MBTs. However, while the 120mm gun can engage MBTs head on, the BUFORD's smaller weapon fires for effect against the enemy flank and rear only.

Europe

In 2013, Poland's OBRUM and BAE Systems presented the PL-01 concept as a proposal for a new fire support vehicle for the Polish Army. The tracked chassis is based on the Hägglunds Combat Vehicle 90. Unlike the Swedish CV90 (which carries a 30mm, 35mm or 40mm main gun), the 35-ton PL-01 design features a large unmanned turret with either a 105mm rifled or 120mm smoothbore cannon. Barrel elevation encompasses an arc from +20 to -10 degrees. The munitions magazine and autoloading unit are integrated inside the turret. The gun meshes seamlessly into the turret, providing a streamlined silhouette for a reduced radar signature. An optional 40mm AGL– which would negate any radar "stealth" factor – is shown mounted on an RWS atop the turret. Gunner sights, an active protection system, laser warning sensors and a panoramic surveillance system with 350-degree coverage are embedded into the turret. While eventual development and production of this futuristic concept design – which incorporates thermal signature neutralisation and radar absorbent materials – remains highly uncertain, many elements are likely to flow into future ACVs in many nations.

Russia

The Russian armed forces are currently testing the new SPRUT SDM-1 amphibious light tank/tank destroyer produced by the Volgograd Tractor Plant. In line with the traditional Russian preference for large-calibre weapons, the 18-tonne vehicle features the same fully stabilised 125mm smoothbore cannon mounted on the T-72 and T-90 tank families. It also includes some fire-control technology adopted from the T-90MS MBT. According to statements by the TASS news agency, the SDM-1's firepower is equivalent to an MBT and almost on par with that of the T-90MS. The vehicle can carry forty rounds. The autoloading 2A75 main gun can fire seven rounds per minute. In addition to conventional tank munitions with an effective range in excess of 2,000 metres, the cannon can fire ATGMs with a reported effective range of 5,000 metres against MBTs equipped with reactive armour. The ATGMs can also engage low-flying helicopters.

Photo: US Army

An Infantry Carrier Vehicle Dragoon (ICVD) mounting a JAVELIN missile (CROWS-J) during the ICVD/Common Remote Weapons Station Operational Test at the Joint Manoeuvre Readiness Centre (JMRC), Hohenfels, Germany.

Photo: General Dynamics.

The UK's AJAX Infantry Fighting Vehicle will feature the CTAS weapon system, including a 40mm autocannon firing cased telescopic ammunition.

Asia

The 26 tonne Mitsubishi Type 16 manoeuvre combat vehicle (MCV) is currently being fielded with the Japanese Army's rapid reaction forces. Armed with a 105mm gun built by Japan Steel Works, the 8x8 wheeled vehicle is primarily intended to support light, mobile forces as a tank destroyer in lieu of MBTs. High-energy rounds can engage dismounted or unarmoured forces. The vehicle can be airlifted or delivered via landing craft, providing firepower to defend or retake smaller islands.

India's TATA Motors illustrates an alternate approach to mobile fire support. The 8x8 KESTREL Amphibious AFV introduced in prototype in 2014 is slightly heavier than the Type 16, but is configured with a 30mm main gun. A 40mm AGL can be mounted as a secondary weapon. Two Anti-Tank Guided Missiles (ATGMs) mounted outside the Kongsberg PROTECTOR MCT-30R turret provide a limited capacity for engaging heavy targets including MBTs. The KESTREL can carry up to ten soldiers or marines in the rear compartment, categorising it as an infantry fighting vehicle (IFV).

IFVs and Support Vehicles

Overall, Infantry Fighting Vehicles, Armoured Personnel Carriers and similar medium-weight armoured vehicles show a broad spectrum of armament, again with a trend toward heavier calibres.

United States

This trend is illustrated by the US Army's 2016 decision to conduct a "lethality upgrade" of the STRYKER Infantry Combat Vehicles assigned to the 2nd Cavalry Regiment stationed in Germany. The CROWS-mounted 12.7mm machine gun carried on most STRYKERs was replaced with a Kongsberg PROTECTOR MCT-30 turret mounting a 30mm autocannon on 83 vehicles. These upgunned STRYKERs, designated DRAGOON, can now effectively engage soft and moderately armoured vehicles including Russian BMP IFVs. An additional 86 STRYKERs of the 2nd CR are being equipped with Kongsberg's new CROWS III weapons mount. The CROWS III (also known as the CROWS-J) can be armed with JAVELIN anti-tank missiles capable of destroying MBTs. The new weapons and associated equipment will increase vehicle weight by approximately two tonnes or ten percent, with no significant impact on mobility. The upgrades reflect concern over a lack of permanently stationed US Army firepower in the face of the looming Russian threat in Europe. Similar concerns exist regarding threats in northeast Asia. Beginning in 2020, the army plans to equip an additional 240 STRYKERs of an as yet unidentified brigade with the CROWS-J.

Photo: Polish MoD

Mock-up of the OBRUM PL-01 fire support vehicle proposed for the Polish Army

Europe

The CV90 Mk IV IFV introduced by BAE/Hägglunds in 2017 exemplifies the broad range of armament options and the demand for flexibility made on today's AFVs. The Mk IV weighs 37 tonnes, two tonnes more than the preceding Mk III, and features a more powerful engine and transmission. This permits an even greater choice of weaponry and payload on the new D-series turrets. Customers can choose between four different autocannon configurations in calibres between 30mm and 50mm, or opt for a 120mm main gun. Pods for turret-mounted ATGMs are also available. Overall the Mk IV's ordnance options retain the CV90's position as one of the world's most versatile AFVs, in terms of both arsenal and mission profile.

NEXTER has developed a series of new AFVs for the French Army. These include the 28-ton 6x6 multi-role armoured vehicle GRIFFON VBMR (Véhicule Blindé Multi-Rôles), the 25-tonne infantry fighting vehicle VBCI (Véhicule Blindé de Combat d'Infanterie), and the JAGUAR EBRC (Engin Blindé de Reconnaissance et de Combat) reconnaissance AFV. The GRIFFON carries the lightest armament with a remotely operated, roof-mounted 40mm AGL. The VBCI fielded in 2009 with the French Army has a manned turret with a 25mm GIAT M811 autocannon; in 2015, NEXTER introduced the export-variant VBCI 2, armed optionally with either a manned turret with a 40mm CTAS autocannon and two turret-mounted MMP ATGMs or an unmanned turret with a 30mm gun. The JAGUAR, which is expected to enter service in 2020, is equipped with the same turret and 40mm gun/MMP configuration as the VBCI 2. The CTAS (Cased Telescopic Armament System includes not only the weapon but the mount, controller, and ammunition handling system. It is produced by a BAE/NEXTER joint venture, and has also been procured for the British AJAX and WARRIOR armoured vehicles. CTAS is the world's first operational autocannon system to fire cased telescoped ammunition, which encases the projectile and propellant in a singular tube; this system delivers significantly more explosive power than conventional munitions of the same calibre. Options include point detonating rounds against armoured or hardened targets, and airburst rounds against soft or airborne targets. The gun barrel can be elevated to 45 degrees, enabling engagement of light aircraft, helicopters and UAVs.

Germany's 38-tonne PUMA IFV is another prime example of new combat vehicles featuring significantly enhanced armament vis-a-vis the vehicles they are replacing. The Bundeswehr's MARDER IFV introduced in the 1970s – and currently being phased out – comes with a turret-mounted 20mm automatic weapon and the option to mount a MILAN ATGM launcher on the turret. The successor PUMA IFV currently being introduced mounts a much more powerful belt-fed Rheinmetall/Mauser Mk-30-2 ABM (Air Burst Munition capable) 30mm main gun. An even more powerful 40mm gun was rejected for two reasons: the German Army wanted to avoid further weight gain on the

Photo: Artem Tkachenko

The SPRUT SDM-1 light tank/tank destroyer is capable of conducting amphibious landings and being airdropped. The 125mm cannon can fire regular tank shells and ATGMs.

vehicle, and, given the space constraints of the unmanned turret, the 30mm weapon more rounds to be carried. The 30mm gun is augmented by a turret-mounted SPIKE LR missile launcher with two projectiles capable of engaging MBTs and other hardened targets at a range of 4,000 metres. Finally, a 76mm grenade launcher with six rounds is mounted at the back of the vehicle, primarily as a self-defence weapon against targets within 400 metres.

Photo: JGSDF

The Mitsubishi Type 16 Manoeuvre Combat Vehicle provides anti-tank capabilities to Japan's Rapid Reaction Forces.

Russia

The 35-tonne URAL IFV introduced by Uralvagonzavod as a prototype in 2013 utilises the chassis of the French 8x8 VCBI, but it mounts a Russian 57mm autocannon developed by Petrel. This autoloading BM-57 gun has a rate of fire of 120 rpm and a maximum range of six kilometres. It is capable of engaging light armoured and soft targets including dismounted or exposed personnel. Both armour piercing and high-energy rounds can be carried, with 100 ready in the turret and another 100 in the rear compartment.

The BMP 3M presented in 2011 as a state-of-the-art upgrade to the BMP family presents much heavier firepower, even though its 18-tonne weight is only half that of the Ural IFV. The semiautomatic 100mm 2A70 main gun, mounted on a two-man turret, retains the calibre of the previous BMP 3's weapon, but with upgraded lethality. The 2A70 fires high-explosive fragmentation shells at a rate of eight per minute; the cannon tube also fires 9M117M1 laser-guided ATGMs with a tandem warhead designed to defeat reactive armour. The ATGMs have an effective range of 5.5 kilometres. Mounted coaxially with the main gun is the 30mm 2A72 autocannon capable of engaging ground and air targets at ranges up to 2,000 and 4,000 metres, respectively. The 2A72 munitions load includes armour-piercing and incendiary rounds.

By contrast, the newly developed 40 tonne ARMATA T-15 IFV will feature smaller-calibre main guns, mounting either the BUMERANG-BM remote weapons turret with a 2A42 30mm autogun or a remote turret with a 57mm gun. In either case, the guns will be augmented by four ATAKA ATGMs. Designed to work in tandem with the ARMATA MBT, the T-15 has no need for a heavier main gun of its own.

Light Armoured Vehicles

The trend to up-gun Light Armoured Vehicles is also easily recognised, whereby the need to balance mobility and combat power is perhaps more obvious with the LAVs than with medium-weight AFVs. By definition, LAVsare not expected to engage heavy vehicles, but they must be capable of protecting themselves from other light- to medium-armoured AFVs as well as against infantry and light aerial targets including UAVs.

The first of approximately 60,000 Joint Light Tactical Vehicles (JLTVs) produced by Oshkosh Defence are currently being fielded to the US ground forces. Armament carried will depend upon vehicle variant and mission requirements, but options will include the Orbital ATK M230LF 30mm chain gun, as well as TOW and JAVELIN missiles, all mounted on an RWS.

This armament level is generally the heaviest found on LAVs such as the 10+ tonne JLTV. Larger weapons would risk reducing the mobility which is the LAV's greatest asset. Additional weight would also increase fuel consumption. Finally, the smaller chassis of an LAV has less room to mount larger weapons or larger calibre ammunition. Another example of a typical LAV load-out is found on the seven-tonne HAWKEI 4x4 Light Protected Vehicle developed by Thales Australia to replace the Australian Army's LAND ROVERs. The HAWKEI's RWS optionally accommodates a 30mm gun or a 40mm AGL, as well as a selection of guided rockets or missiles.

Even very light armoured vehicles are increasing firepower in the face of increasingly well-armed opponents, even in so-called low-intensity conflicts. The General Dynamics FLYER 72 Advanced Light Strike Vehicle weighs a baseline 2,000 kg, but it can be optionally armoured. In the strike configuration, the vehicle can mount a wide array of weapons, including a 40mm AGL, a Northrop Grumman M230FL 30mm autocannon optimised for light vehicles (200 rpm rate of fire, 850 m/s muzzle velocity), or anti-tank missiles. US Special Operations Command procured the Flyer 72 in 2013 to provide commandos with a highly mobile but lethal reconnaissance and strike vehicle.

Iran's 14-tonne AQAREB 8x8 wheeled fire support/reconnaissance vehicle illustrates the opposite end of the LAV spectrum. Introduced in 2015, it carries a 90mm main gun in a 350-degree traversing turret. The gun is heavy for a light AFV, and it represents the rare upper limit for this category of vehicle. The indigenously developed AQAREB is patterned after the Soviet/Russian BTR-60 which it replaces, but the BTR's largest weapon was a 14.5mm heavy machine gun. ■

Photo: Rheinmetall

The BOXER IFV variant is equipped with the Rheinmetall LANCE 30mm two-man turret, which features a new modular design.

When Time Counts

Armoured Ambulance Requirements in Europe

Paolo Valpolini

MEDEVAC must be available 24 hours a day, in any weather, on any terrain and in any scenario. Helicopters have become a preferred platform for MEDEVAC. However, it is not always possible to create a landing zone near the scene of the incident. In this case, the casualty must be moved by ground assets.

The mission of medical support in military operations is to support the mission by preserving manpower and life and minimising the remaining physical and mental disabilities. Adequate medical assistance makes an important contribution to the protection of the armed forces and morale by preventing disease, quickly evacuating and treating the sick, wounded and injured, and reintegrating as many people as possible into the service. This statement comes from the NATO AJP 4.10 (A) Allied Joint Medical Support Doctrine, where "rapid evacuation" is one of the key elements and the one referring to this article. As with the MC 326/2 NATP, entitled "Principles and Policies of Operational Medical Support" MEDEVAC (Medical Evacuation), the transfer of patients under medical supervision to the Medical Treatment Facilities (MTFs) is an integral part of the treatment continuum. NATO AJMedP-2, Allied Joint Doctrine for Medical Evacuation, further explains the continuum concept: "Evacuation of casualties is a fundamental aspect of medical care. Movement of casualties is not only the transport to a suitable MTF, but is also part of a continuum of patient treatment and care and thus a medical responsibility. At no point in the chain of evacuation must the level of care be reduced below that received at the previous MTF."

MEDEVAC must be available 24 hours a day, in any weather, on any terrain and in any scenario, as long as it is compatible with the current situation, the NATO document continues. In order to cope with the "Golden Hour" or "Platinum Half an Hour", helicopters have become the preferred plat-

Photo: Patria

Designed and produced by Patria of Finland, the AMV – here in the ambulance version – is now produced in other countries such as Poland. The Polish Army acquired the Rosomak-WEM, the local MEDEVAC version.

Photo: Bundeswehr

A legacy vehicle, the Tpz1 FUCHS is still in service in the German Army; such ambulances have been brought up to the A4 standard but are no longer used in high-risk scenarios.

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form for MEDEVAC missions. However, it is not always possible to create a landing zone near the scene of the accident. In this case, the casualty must be moved by ground assets. "Forward MEDEVAC takes care of transporting patients from the wound to the first MTF. This is required by operational circumstances to meet clinical timelines, and therefore, increasingly conducted by rotary assets in forward areas . . . Forward MEDEVAC needs to be configured to meet similar force protection levels as the forces in the area they are required to enter." Off-road capability and protection required by front-line medical vehicles are clearly stated.

Photo: GDELS

The EAGLE is the lightest armoured ambulance fielded by the German Army; it allows light infantry units to be supported when operating in constricted terrain.

Forward Ground MEDEVAC Vehicles

STANAG 2872 AmedP-1.14: "Medical Design Requirements for Military Motor Ambulances" states, "Ambulances are the most common type of ground evacuation transportation assets. Within the range of ambulances available, there is considerable variation in terms of respective capabilities and patient capacity. At the top of the scale are advanced support units, staffed with trained personnel who can provide resuscitative care, administer basic drugs, and begin administration of intravenous fluids in addition to providing basic first aid. Others, usually a greater number, are equipped for basic life support only. Medical ambulances for forward ground MEDEVAC should have the same passive protection status as the combat vehicles that they are supposed to accompany in battle and operations. This usually includes armoured protection and light individual weapons for self-protection, within the regulations of the International Law."

While the Red Cross or the Red Crescent should protect ambulances and medical personnel on the field, in recent operations such as those in Afghanistan, the Red Cross quickly became a convenient target for for RPG gunners; many units removed the medical sign from their vehicle to avoid it becoming a crosshair. It is sad to say, but new ambulance vehicles consequently do not have the Red Cross sign painted on their sides and top, but are equipped with removable signs.

Photo: Austrian Army

An Austrian Army PANDUR 6x6 in the ambulance version

Vehicle Categories

AMedP -1.14 provides a categorisation system for military motor ambulances based on medical capability, vehicle protection level and vehicle terrain capabilities. There are four types of ambulances:

Type A – transport ambulance, designed and equipped for the transport of patients who are not expected to become emergency patients; **Type B** – multifunction ambulance, optimised to deliver Primary Health Care (PHC) and MEDEVAC; **Type C** – emergency ambulance, primarily designed and equipped for the Specialist MEDEVAC, for the full spectrum of trauma and other medical emergencies, up to consultant-led care; and finally **Type D** – mobile intensive care ambulance, primarily designed and equipped for Specialist MEDEVAC, able to provide in-transit care for high and medium dependency ill or injured patients.

Within those types of ambulances data on terrain capability and vehicle protection against KE, mines and IEDs are added. All types must feature sufficient space for access to the patient during transit, mountings for infusion fluids, a secure seat for use by a medical attendant carrying out procedures while in transit, and appropriate means to load and unload stretchers. Moreover, the overall interior noise level should not exceed 85 dB. Many other medical systems are required for all types of medical problems, such as automated or semi-automated external defibrillators. Type A ambulances lack only a few of the systems offered by the other three types, which offer, for example, vital signs monitoring, bag valve mask and chest seal dressing.

Heavyweights

What does the market offers in terms of ambulances? Starting from the heavyweights, these include both tracked and wheeled vehicles, although the former are less and less common. All of them are derivatives of infantry fighting vehicles or armoured personnel carriers, some with a heightened roof to allow more head space for medical personnel. The British Army is currently still operating the SAMARITAN, a derivative of the CVR(T) family, which is being replaced by the AJAX, based upon GDELS ASCOD 2. However, the ambulance version is forecasted only in a possible Block 2 that is currently not yet financed. While in the past many armies equipped with APCs such as the M113 deployed ambulance versions of that tracked vehicle, not many are currently fielding the equivalent derived from modern IFVs such as the German PUMA, the Swedish CV90, the Austro-Spanish ASCOD, the Italian DARDO, although the family concept was maintained and most brochures show such a version. The higher cost of IFVs versus old APCs and the decline of tracks versus wheels in asymmetric conflicts led to a shift toward wheeled vehicles. FFG of Germany developed a variant of the M113 known as the M113 G4, which features an extended hull with six road wheels instead of five, improved suspension, allowing a gross vehicle weight (GVW) of 18 tonnes, with 2 tonnes of growth potential, and raised roof to increase the internal volume. In ambulance configuration, it features a main stretcher and a secondary stretcher that can be folded up to make space available for seats for up to three seated patients. The same company developed a new tracked vehicle known as G5 PMMC (Protected Mission Module Carrier) designed for a rapid role change; this allows potential customers to reduce the number of vehicles, quickly re-roling them according to requirements. This configuration draws on the design of the G4 ambulance. As for the inner height, FFG is ready to adapt the vehicle to customer needs; if the customer chooses to reduce the mine protection level, the decoupled walking floor can be removed, increasing the inner height by about 20 cm, while the roof can be raised, the maximum height obtainable being 1.75 metres. The G5 ambulance crew includes one driver, one commander, one doctor and two paramedics. The vehicle, which also features six road wheels, is fitted with rubber tracks which reduce noise considerably, both outside and inside by about 13.5 dB, but also vibrations by 70%, which were definitely a problem for conventional tracked MEDEVAC vehicles. As for cross-country mobility, tracks still maintain an edge, but 8x8 vehicles are closing the gap in most situations, and some countries, such as France, have given up tracked IFVs

Company	Iveco DV	Iveco DV	ACMAT	ACMAT	Nexter	Nexter	ARTEC	Rheinmetall	GDELS	STK
Model	LMV	VTMM	BASTION	BASTION HM	VBCI	TITUS	BOXER	SURVIVOR R	EAGLE IV BAT	BRONCO
Gross weight [t]	7.1	18	12	14.5	30	27	35	16	9.5	16
Configuration	4x4	4x4	4x4	4x4	8x8	6x6	8x8	4x4	4x4	Rubber tracks
Protection level	n.a.	n.a.	3, 2a/b	3, 2a/b	4, 4a/b	4, 4a/b	4, 4a/b	3, 3a/b	n.a	n.a.
Length [m]	5.275	7.2	6.0	6.3	8	7.8	8.33	6.5	5.4	8.6
Width [m]	2.050	2.53	2.2	2.3	2.98	2.55	2.99	2.5	2.27	2.3
Height [m]	2.345	3.1	2.4	2.6	2.3	2.73	2.94	2.95	2.5	2.2
Inner height [m]	1.3	1.7	n.a.	n.a.	1.7	1.7	1.85	1.6	n.a.	n.a.
Range [km]	500	700	1,400	1,400	750	700	1,050	800	700	400
Medical crew	1	2	1	1	1	1	2	2	1	2
Injured (seated)	2	0	-	6	3	3	7	6	-	9
Injured (stretcher/ seated)	1/2	0/2	-	2/3	1/3	2/3	2/3	2/3	-	2/4
Injured (stretcher)	1	2	2	-	2	2	3	2	1	4

Photo: KMW

The GFF4 in the ambulance version was developed by KMW and is based on an Iveco TRAKKER chassis fitted with a heavily protected cell.

Company	FFG	GDELS	GDELS	KMW	KMW	KMW	Patria	Rheinmetall	RTD	BAE Systems	Thales
Model	G5	PIRANHA IIIC	DURO IIIP	GFF4 Ambulance	DINGO 2	DINGO 2 HD	AMV	FUCHS 2	VAB Mk III	BV206S7 AMB	BUSH-MASTER
Gross weight [t]	26.5	19.4	13.5	25	12.5	14.5	32	23.5	20	7.1	15.4
Configuration	Rubber tracks	8x8	6x6	6x6	4x4	4x4	8x8	6x6	6x6	Rubber tracks	4x4
Protection level	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	5, 4a/b	4	n.a.	n.a.	n.a.
Length [m]	6.42	7.77	6.75	7.95	6.8	6.6	7.9	6.8	7.3	6.9	7.18
Width [m]	3.06	2.72	2.2	2.53	2.39	2.39	2.8	3.04	2.65	2.02	2.48
Height [m]	2.95	2.93	3.15	3.08	2.5	2.7	2.7	2.54	2.5	2.1	2.65
Inner height [m]	max 1.75	n.a.	n.a.	n.a.	1.35	1.63	n.a.	1.35	n.a.	n.a.	n.a.
Range [km]	1,000	600	600	700	1,000	800	600-800	700	800	370	800
Medical crew	3	2	2	-	2	2	2	2	2	1	1
Injured (seated)	3 / 6	-	3	-	4	4	-	3	8	3	4
Injured (stretcher/ seated)	1/3	1/3	2/3	-	-	-	3/4	possible	2/4	1/3	1/4
Injured (stretcher)	2	2	2	-	3	2	-	2	4	2	2

and now deploy only 8x8 vehicles within mechanised infantry formations.

In the heavy segment, Germany is currently fielding the BOXER sgSanKfz (schweres geschütztes Sanitätskraftfahrzeug) 8x8 vehicle, heavily protected and with a good casualty transport capability, but with limited mobility in some areas due to its size and weight as shown in the Afghan theatre. Germany acquired 72 ambulance vehicles, while The Netherlands bought 52 of them, both armies having selected the BOXER for combat support and combat service support missions. Another 8x8 vehicle produced also in ambulance version is Patria's AMV. To date, the only customer that has deployed the ambulance version seems to be Poland, which acquired the Rosomak-WEM (Wóz Ewakuacji Medycznej, Medical Evacuation Vehicle). The Rosomak WEM features a raised roof, about 40 cm higher than the combat version, and 24 such vehicles have been acquired by the Polish Army. The two aforementioned 8x8 vehicles, as well as others, such as the NEXTER VBCI, STK Terrex 3, General Dynamics PIRANHA 5, LAV 6.0 and LAV 700, were offered to the UK for its MIV (Mechanised Infantry Vehicle) requirement, which includes also an MIV-A (Ambulance) version, although no numbers have yet been provided. The UK MoD announced the selection of BOXER in April 2018. All those vehicles can be made available in MEDEVAC version, although not all of them have already been produced in such a version. Besides the MIV programme, another that calls for 8x8 ambulances is the Australian Land 400 Phase 2, with 15 such vehicles being part of the current requirement. Although the French Army did not acquire the VBCI in the ambulance version, NEXTER developed a kit that allows a combat vehicle to be quickly transformed into a casualty extraction vehicle capable of carrying at least one stretcher.

Medium Vehilcles

Moving towards lighter vehicles, most MRAPs can be fitted as ambulances. NEXTER is proposing its TITUS in the ambulance version. This 26-tonne vehicle on a TATRA swinging arm chassis provides high mobility at a reduced cost when compared to fully independent suspension vehicles. Some armies are moving towards 6x6 vehicles. This is the case with France, whose new GRIFFON will also be available in MEDEVAC configuration. The order should include 196 vehicles in that version, though not much is known about the layout of the ambulance version. Arquus (former Renault Trucks Defense) is proposing its VAB Mk III 6x6 also in the ambulance version. Germany should still have in service numerous 22.5-tonneTransportpanzer FUCHS vehicles in the KrKw (Krankenkraftwagen) configuration. It can carry a medical soldier and four stretchers, or two stretchers and four sitting wounded. FUCHS ambulances have been upgraded to the TPz 1A4 standard; they should not be used anymore in high-risk scenarios. Rheinmetall is offering its FUCHS 2 as an armoured ambulance vehicle. Austria deploys the PANDUR 6x6 in ambulance version with a higher roof, which brings its inner height up to 1.83 metres. The vehicle can be quickly reconfigured in three different ways, transporting either four stretchers, two stretchers and three seated casualties, or six seated casualties. As for Brazil, the Iveco GUARANI 6x6 in the ambulance version will be capable of carrying one doctor, one paramedic, two stretchers and four seated casualties. No indications on the number of ambulance versions among the 1,580 vehicles ordered in late November 2016 were provided. Germany, KMW developed a 6x6 armoured vehicle based on an Iveco TRAKKER chassis to answer the GFF4 requirement, which was for a medium-weight, highly protected class 4 wheeled armoured vehicle. With a 25-tonne GVW and a considerable protected space, a KMW vehicle known as GRIZZLY is a spacious ambulance vehicle with a high level of protection, but the programme, at least for Level 4 vehicles, seems to have been moved to the right. The GFF4 ambulance layout is

very flexible, and with four crew members, two of them medical, it can carry two intensive care casualties, or two low care and one intensive, or three seated and two low care; with a crew limited to two members, the GFF4 can carry up to four seated and four low care casualties. The Bundeswehr fields another type of 6x6 protected ambulance, the DURO IIIP or YAK, as it was known when produced by Mowag and Rheinmetall prior the acquisition of Mowag by GDELS. Also in service with the Danish Army, the German Army ambulance is based on the high rooftop version, while the Danish one is based on the standard version that does not allow medical personnel to work in the stand-up position. A total of 31 "Mobile Medical Team" vehicles were produced for Germany, while Denmark acquired 29 such vehicles. This said, the German military is seeking a medium ambulance vehicle to fill the gap between the aforementioned BOXER and the much lighter EAGLE IV. Known as "mittleres geschütztes Sanitätsfahrzeug" the programme is believed to become subject to RfPs shortly. Germany is shifting from a three-member crew to one made of four elements, to include a driver, one doctor and two paramedics, one of them also acting as vehicle commander. According to available information the programme should lead to the acquisition of around 70 armoured ambulances.

Photo: KMW

Austrian Army DINGO 2 vehicles; the ambulance adopted was adapted for the transportation of NBC-contaminated casualties. Note the heightened roof.

Light Vehicles

Switching to 4x4 vehicles, the Italian Army adopted the ORSO (BEAR), the military name of the Iveco DV VTMM (Veicolo Tattico Medio Multiruolo, multirole medium tactical vehicle). It is the Italian counterpart to the KMW GRIZZLY, with Italy aiming at a lighter vehicle, in the 18 tonnes range. The army acquired a first batch of 16 vehicles, which are deployed within Role 3 and Role 2 field hospitals. The ORSO in the ambulance configuration carries two casualties on stretchers, one of them in critical condition, the medical crew consisting of one doctor and one paramedic.

A "germanised" version of this 4x4 is currently being offered by KMW for the German contract. The Munich-based company portfolio also contains a lighter 4x4, based on the DINGO 2 with an 11-cubic-metre protected volume. Ten vehicles are in service with the Belgian Army, their data corresponding to those in the table. Furthermore, an Emergency Vehicle for isolation, treatment and transportation of contaminated casualties has also been developed, its protected volume being increased by 2 cubic metres thanks to an increase in height, its inner height growing from 1.4 to 1.64 metres. Three such vehicles were produced for the Austrian Army, which fields them in its NBC emergency response teams. In this configuration, the DINGO 2 carries one doctor, one medic, and two lightly injured patients, or one severe casualty. An ambulance version based on the most recent DINGO HD is also available, two reclining casualties being carried in this vehicle. Rheinmetall is proposing its 16-tonne SURVIVOR R in ambulance version, which was exhibited at DSEI 2015, while Thales Australia's portfolio includes an ambulance version of the Bushmaster that was adopted by the Australian Army. In 2007, Spain launched a UOR for acquiring 180 RG-31 NYALA 4x4 MRAPs from then BAE Systems Land Systems OMC, 10 of them in the ambulance version, eight of which deployed to Afghanistan. In that configuration, the 17-tonne vehicle is fitted with a complete suite of medical equipment (including a defibrillator, vital signs monitoring system, ventilator, and so on) and can host two seated casualties and one on a stretcher. The limited height between the casualty and the vehicle roof proved to be a problem for the medical team, lessons learned calling for treatment outside the vehicle, the casualty being loaded once stabilised.

The same problem should be true for all smaller vehicles. Italy fields a medical version of the Iveco DV LMV; in the army this is defined as CASEVAC, being aimed only at casualties' first aid and monitoring. It can host one severe casualty and one light casualty, with one paramedic to assist them. This type of vehicle, based on the long wheelbase version of the LMV, should be deployed within all combat units; however, for the time being, only a limited number of vehicles has been acquired in this version. In 2010, the German Bundeswehr acquired the EAGLE IV BAT (Beweglicher Arzttrupp), which hosts a crew of three, including a doctor, a paramedic, and a single casualty on a stretcher. It can provide intensive care thanks to the full medical equipment suite.

Tracked Vehicles

When high mobility and sufficient protection are required, many armies deploy medical versions of tracked off-road vehicles, such as the BAE Systems BV-206S or BvS10 BEOWULF, or the BRONCO by Singapore Technologies Kinetics (STK). The fully articulated two units make them a 4x4 tracked vehicle and ensure maximum mobility, with low ground pressure enabling movements on very soft terrain. The rubber tracks also reduce noise and vibrations. The rear wagon has considerable room and can thus easily be turned in a medical support vehicle. In Afghanistan, the British Army deployed the VIKING, a BvS10 fitted with cage armour, and then acquired the WARTHOG, a heavily up-armoured version of the BRONCO. Germany, Sweden and other countries deploy the smaller and older BV-206S in ambulance version. ■

Breaking the Trail

Armoured Engineer Vehicles

David Saw

Armour and mechanised forces have unsurpassed battlefield mobility, but to be able to operate across all types of terrain they will need the assistance of specialist vehicles. These vehicles, often based on the chassis of tanks and other armoured vehicles, have the mobility to follow mechanised forces wherever they might travel.

Added to which, the capability that these specialist vehicles provide is absolutely essential to the effective conduct of operations.

Right from the very beginning of the tank era, it was clear that tanks would have to be designed to cope with the battlefield conditions that were to be found in France. The tanks would have to operate in a devastated landscape, surmount obstacles and cross trenches. Once the tanks were used operationally, it soon became apparent that they would need assistance and this led to the development of additional systems that could be fitted to the tanks and to specialist variants of the tank.

Despite being designed to operate in the battlefield conditions of France, there were often times when tanks would become stuck in trenches or shell holes. This led to the use of the unditching beam – this was a heavy oak beam with steel plates on the ends that was mounted on rails on top of the tank. When needed, the crew would get on the tank roof and attach the beam to the tracks, the driver would put the vehicle into gear and the beam would go under the tank and provide enough grip for the tank to exit the hole.

The unditching beam was a regular feature of the early tanks. Then there was another evolution in obstacle crossing in the form of the fascine. This was a large bundle of wooden logs bound with chains and carried above the nose of the tank with the release lever in the crew compartment. The tank advances to the edge of the trench or other similar obstacle, drops the fascine to fill the gap and travels onward. The fascine would later become part of the specialist armoury of obstacle crossing solutions for armoured engineers

A lighter alternative to the fascine known as the crib, which could be reused, was deployed operationally in 1918, but did not have the longevity of the fascine. A tank with a crane attachment was used initially for logistics support and then for repair/recovery applications, the first bridge-laying tanks were introduced; then came a tank with a mine roller system for mine clearance. Another mine clearance device was the mine-lifting tank; here a crane was mounted on the front of the tank, and attached to this was a very large electromagnet that was used to lift the mine or unexploded ordnance.

Photo: Crown copyright

The BAE Systems TROJAN AVRE is an armoured engineer vehicle based on the CHALLENGER 2 chassis. The vehicle is used for minefield breaching – note the mine plough – and obstacle clearance, and also carries a fascine for passage through obstacles.

In the two years after that tank entered combat at Flers in 1916, a range of specialist vehicles had been developed, some successfully, others not so much. These were the forerunners of today's Armoured Engineer Vehicle (AEV), Armoured Recovery Vehicle (ARV) and Armoured Vehicle Launched Bridge (AVLB).

The Second Generation

The roles and capabilities of specialist armour systems would inevitably grow over the years, in tandem with the performance characteristics of tanks and other armoured vehicles. Change continues in this armoured vehicle sector, for example as the combat weights of tanks have grown over the years that has required that ARVs develop the ability to recover and repair vehicles in the 60- to 70-tonne plus range. The

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Photo: US Marine Corps

A pair of M88A2 HERCULES ARV systems of the US Marine Corps on exercise at Camp Lejeune. The M88A2 is the third generation of this ARV family to enter US service and was developed to recover the M1 ABRAMS, which was beyond the capabilities of the earlier M88A1. Now an M88A3 variant is being proposed to cope with even heavier M1 tank variants.

same capability growth was necessary for bridging systems, with AVLBs being modified to cope with increased load capacity requirements.

What has become readily apparent in terms of specialist armour is its flexibility; these systems are not just confined to being used in support of armoured forces. The British Army did not take any main battle tanks to Afghanistan, but it did take its TROJAN Armoured Vehicle Royal Engineers (AVRE) to provide an AEV capability; TROJAN is based on the CHALLENGER 2 tank chassis. The system was transported to Afghanistan in 2009 and was used on major operations in 2010.

The TROJAN provides an awful lot of engineering capability. After all, this vehicle weighs in at over 60 tonnes. Obstacle clearance and obstacle creation are obvious missions for this AEV. In the context of operations in Afghanistan, TROJAN was used for mine clearance/minefield breaching and counter-IED missions. The use of specialist armour in asymmetric conflicts is increasingly common; an example of this is the PUMA AEV of the Israel Defence Forces (IDF). The vehicle is based on the chassis of the CENTURION tank and is designed to transport IDF combat engineers with high levels of protection through heavily contested terrain. The vehicle is also equipped with systems for minefield breaching and counter-IED missions.

Operational experience in Iraq and Afghanistan was the driving force behind the fielding of a multitude of dedicated route clearance, counter-IED systems and technologies. This led to the development of counter-IED capabilities such as the British TALISMAN system based on wheeled armoured vehicles. Considering the level of the IED threat in Afghanistan and the need to keep communications routes open, it was simply impractical to utilise full-specification AEV systems for the counter-IED missions. With the emphasis on asymmetric conflicts being less intense than before, much of the equipment that came into service for Afghanistan is either being put into storage or is destined for disposal. The danger of this approach is that IED and mine threats are likely to become more, rather than less, common into the future, indicating that full-specification AEV systems will be in high demand and most probably overtasked in future conflicts.

Photo: DVIDS

The M60 AVLB deploying its MLC 70 class bridge in Afghanistan. The AVLB is based on the M60A1 chassis, which caused a problem when the M1 ABRAMS came into service, as the AVLB could not keep up with the faster tank. The M60 AVLB remains in US service, as the planned full replacement programme in the shape of the WOLVERINE system never took place.

New Capability

One negative facet as regards specialist armour is the fact that many operators do not have the required level of assets or have not invested in improving existing assets. Unfortunately, these issues are usually only discovered when it becomes necessary to utilise specialist assets, as is reflected by experience in Ukraine.

The Ukrainian Army has been involved in military operations against Russian-supported separatist groups and the Russian military in the Donbas region of Eastern Ukraine since March 2014. Military operations in the Donbas were characterised by high-intensity mechanised combat, with both sides using large numbers of tanks and other armoured vehicles. One of the lessons learned from these operations was the need to have repair and recovery vehicles on hand to remove damaged or inoperable armour from the battlefield so it could be repaired and put back into action. It would appear that the Ukrainian Army found itself short of ARV assets and therefore turned to the Ukrainian defence industry to provide new capabilities. In April 2018, the Kharkiv Morozov Design Bureau (KMDB), a UkrOboronProm company, an-

Photo: DRS

The US only purchased 44 WOLVERINE AVLB systems based on the M1 ABRAMS. These will now be replaced, as will the M60 AVLB, by the JOINT ASSAULT BRIDGE (JAB). Leonardo DRS were awarded a contract, worth up to US$400M, for the new JAB system in August 2016. The JAB is based on the ABRAMS chassis and 273 are required initially.

nounced the ATLET ARV system was entering production. ATLET has a combat weight of 46 tonnes and is capable of recovering and towing a main battle tank. The system also mounts a 25-tonne crane unit allowing it to remove a tank powerpack or turret as required. The Royal Thai Army (RTA) has ordered two ATLET ARV systems to support its T-84 OPLOT tank fleet acquired from the Ukraine. Ukraine has had a single T-84 based ARV in service for some time, but the new ATLET will provide a significant boost to the Ukrainian ARV fleet both in terms of numbers and capabilities

Elsewhere in Ukraine, the Lviv Armour Vehicle Factory (LAVF), also a UkrOboronProm company, announced at the end of September 2018 that its LEV ARV system had completed state testing and was ready to enter production. Based on the T-72 chassis, the LEV has a combat weight of 41 tonnes and would be used to provide ARV capabilities to armoured units equipped with T-72 tanks, as well as supporting lighter armour. In 2017, LAVF delivered 72 upgraded T-72B/B1 tanks to the Ukrainian Army; prior to that, the Ukrainian T-72 fleet had been in store.

Reflecting Needs

The Ukraine is not alone in seeking to upgrade its ARV capabilities. In December 2018, Rheinmetall announced that it had received a €30M order to increase the capabilities of the Bundeswehr BERGEPANZER 3 (BPz3) ARV fleet, with 69 vehicles to be upgraded between 2019 and 2024. The vehicles will be fitted with new battlefield recovery equipment (GFB) and a Universal Transport Platform (UTP). Previously, four BPz3 vehicles that were deployed on the ISAF mission in Afghanistan were upgraded to this new configuration, as were two BPz3 vehicles that were operated by the Canadian Forces in Afghanistan.

The BPz3 upgrade programme moves the recovery equipment from the front to the back of the vehicle, which will allow tanks and other armour to be recovered and removed from the battle area more rapidly, with the ARV able to operate in forward gear. The UTP will be fitted to the rear of the BPz3, providing rapid access to equipment necessary for the vehicle recovery task.

The US Army has an interesting story to tell in terms of its primary ARV asset, the original version of which was developed in the 1950s. This was the M88; it was based on the M48A2 chassis, but used some M60 components and had a petrol engine. Total M88 orders amounted to 1,075 vehicles, with service entry in 1961 and production complete in 1964. In the 1970s, an enhanced ARV was required and this led to an upgraded version of the M88 in the form of the M88A1 that featured a diesel engine and increased performance. Initially, existing M88s were upgraded to the M88A1 configuration, with first units delivered in 1977 and the upgrade programme complete in 1982. Then over 1,900 more M88A1s were built, with production complete in 1989.

The problem for the US Army was that the M1 ABRAMS tank was becoming increasingly difficult for the M88A1 to recover. Indeed, for recovery to be certain, it needed two M88A1s to do the job. In 1986, the US Army started work on an improved M88A1, but it was unable to secure funding for a new ARV. It was only in 1991 that it was able to start work on a new ARV programme that led to the M88A2 HERCULES that entered service in 1997; this saw the procurement of new vehicles and the upgrade of existing M88A1 assets. The US Army has in excess of 500 M88A2s and the US Marine Corps has 75; some 21 other countries operate the M88A1 and the M88A2.

Since the arrival of the M88A2 on the scene, the combat weight of the M1 ABRAMS has continued to rise and this has led to a situation where the M88A2 is becoming unable to perform a Single Vehicle Recovery (SVR) of the tank, exactly the same situation as happened with the M88A1 in the 1980s. BAE Systems has now developed the M88A3 to overcome these issues, with the vehicle featuring a new engine and transmission, as well as an improved suspension and track system. The aim is to be able to upgrade existing vehicles to the M88A3 configuration, but at this point the new vehicle is not an officially sponsored programme.

Photo: KMDB

The Kharkiv Morozov Design Bureau (KMDB) announced the ATLET ARV system was entering production. It is designed to provide the Ukrainian Army with an ARV capable of recovering its heaviest tanks. An ATLET variant will be exported to Thailand to support their OPLOT tank fleet.

Polish Programmes

Poland has developed a comprehensive specialist armour capability to support both its own forces and export customers. One customer for Polish equipment was Malaysia, who decided to form an armoured regiment with the acquisition of the Bumar Labedy PT-91M tank. In March 2002, Malaysia ordered 48 PT-91M tanks, six WZT-4 ARVs, three MID-M AEVs and five PMC-LEGUAN AVLBs. Polish industry has been very active in the specialist armour sector over the years, starting with the WZT-2 ARV based on the T-55 hull. Poland acquired some 600 of these and India acquired 196. When the T-72 entered Polish service this created a requirement for a new ARV, resulting in the WZT-3 BIZON. Poland purchased a limited number, while then-Yugoslavia purchased some and then produced the vehicle under licence, including 15 exported to Kuwait.

When Poland introduced the PT-91 tank, a more powerful domestic development of the T-72, into service, that created a requirement for a new ARV, which led to the WZT-3M. The new ARV used the PZL WOLA S12U diesel engine of the PT-91, but otherwise was much the same as the earlier WZT-3. Poland purchased nine new WZT-3Ms and then upgraded its 20 WZT-3s to the new WZT-3M standard. The largest WZT-3M user is India, placing an order for 44 in 1999 and then a second order for 80 in April 2002. Deliveries of the system commenced in 2001 to support the Indian T-72 and T-90 tank fleets. Then, in 2005, India returned to place a major order for 228 WZT-3M ARVs, with this being followed in 2011 by a decision to build the vehicle under licence in India with 204 ARVs required. To support the PT-91 fleet, Poland also developed the MID AEV based on the PT-91 hull with eight vehicles acquired. The MID-M is a variant developed to meet Malaysian requirements. The AVLB purchased by Malaysia has a somewhat different background. The Polish Army had intended to develop an AVLB system to support the PT-91 to be known as the PMC, but in the end the programme was not progressed. The solution for the Malaysian AVLB requirement was based on the work done for the PMC with the addition of an MLC 60 class bridge in the form of the KMW LEGUAN system.

Photo: LAVF

At the end of September 2018, the Lviv Armour Vehicle Factory (LAVF) announced that its LEV ARV system had completed state testing and was ready to enter production. Based on the T-72 tank chassis, the LEV system would be an ideal complement to the 72 T-72B/B1 tanks that LAVF had upgraded for the Ukrainian Army.

The LEGUAN is one of the most widely utilised bridging systems, both in AVLB and truck-mounted variants, and is also available in different lengths. Belgium, Chile, Greece and Norway use it on the LEOPARD 1 chassis, with Finland using it on the LEOPARD 2 chassis and Spain on the M47/M60 chassis. The Netherlands, Norway and Singapore use a variant mounted on a MAN 8x8 truck, while Finland uses a version mounted on a SISU 10x10 truck.

Bridging

The possession of an effective AVLB capability is undoubtedly essential to support armoured operations on the modern battlefield. We have previously mentioned the British Army AEV system in the form of the TROJAN AVRE, but they also have an AVLB capability that is also based on the CHALLENGER 2 chassis; this is known as the TITAN. This AVLB can carry a 26-metre No 10 bridge or two 13.5-metre No 12 bridges. It should be noted that the British Army ARV capability, the CRARRV, 80 of which were originally purchased, is actually based on the older CHALLENGER 1 hull.

In America the US Army is in the midst of the acquisition of a new AVLB capability. Initially they had been using an MLC 70 class AVLB, at first on the M60 and later on an M60A1 chassis; the problem was that these systems could not keep up with the M1 ABRAMS, and so an ABRAMS AVLB solution was necessary. This led to the development of the M104 WOLVERINE by General Dynamics Land Systems, which integrated the M1 chassis with an MLC 70 class 26-metre LEGUAN bridge. First deliveries were in 2003, and the US Army received a total of only 44 M104s; originally the intention had been to order over 400 M104s and totally replace the M60 AVLBs. The M104 arrived at a point when the US Army was not really that interested in acquiring an expensive and heavy AVLB. They then came to the conclusion that the M104 bridge took too long to deploy and that the system as a whole was too complicated. This set the scene for a new programme called the Joint Assault Bridge (JAB). On 23 August 2016, DRS Sustainment Systems, a Leonardo company, announced that it had been awarded an indefinite delivery, indefinite quantity contract worth up to US$400M to build the new JAB system. Mounted on an M1 hull, the JAB is an MLC class 85 scissor bridge that can be set up within three minutes; it will replace both the WOLVERINE and the M60 AVLB.

The JAB programme is ongoing; in November 2018, DRS was awarded a US$17.2M contract modification to the existing JAB contract. As matters stand at present the US Army JAB programme will cover up to 273 AVLB systems with deliveries to be completed by mid-2024. The total US Army AVLB requirement calls for the acquisition of 337 JAB systems.

It is clear that specialist armour variants make an important contribution to modern military operations. What is less obvious is why there is often a reluctance to invest in such capabilities. The experience of the US Army is instructive in this regard, where a situation has developed where its standard M88A2 ARV cannot easily recover the latest variants of the M1 ABRAMS tank and where it was dissatisfied with its AVLB options. At least these difficulties are being resolved or options to resolve them are being developed. For other operators, the key is to have the appropriate numbers of AEVs, ARVs, AVLBs and other specialist vehicles in their inventory, this remains a truly sensible investment. ■

The Turkish Armoured Vehicles Industry: Current Developments

Korhan Özkilinc

The Turkish arms industry has made amazing progress in recent years. In the near future, Turkey will modernise its entire armoured vehicle fleet.

In October 1999, the German Parliament debated whether Germany should deliver 1,000 LEOPARD 2 A5 tanks to NATO partner Turkey. The debate put the red-green coalition government to a test; Chancellor Gerhard Schröder wanted to push the business forward, but Foreign Minister Joschka Fischer was against it. The likelihood was high that Turkey would opt for the LEOPARD 2 A5, because the Turkish armed forces held its predecessor models LEOPARD 1 A1 and LEOPARD 1 A3 in high esteem. Of these, 397 were delivered to Turkey in 1988, and in 2005 Turkey received 298 LEOPARD 2 A4 tanks and another 56 in 2007. Additionally, the Turks wanted to buy 200 FUCHS 6x6 APCs and licence-produce another 1,800 FUCHS units in Turkey.

Although Turkey had received a single LEOPARD 2 A5 model for testing purposes, the political situation in Berlin was not transparent for Ankara, which is why the Turkish Government decided in 2007 to stop importing tanks from abroad and instead to develop and produce its own MBT. In 2008, Turkey signed a contract with the South Korean company Hyundai Rotem to licence-produce the K2 BLACK PANTHER. In November 2012, the Turkish company OTOKAR as general contractor presented a modified first prototype of the Turkish MBT ALTAY to the public. In spring 2018, due to disagreements between OTOKAR and SSB (Presidency of the Defence Industry), the Turkish company BMC was charged with renegotiating the series production of the MBT ALTAY. On 9 November 2018, the Turkish Ministry of Defence announced that the contract for the production of the first 250 MBT ALTAYs had been awarded to BMC.

BMC will produce the MBT ALTAY in three delivery phases: In delivery phase T1, 40 MBT ALTAYs based on the last prototype will be delivered to the land forces; a first delivery is scheduled for mid 2020. In addition, the ALTAY will receive the AKKOR active protection system from ASELSAN and new reactive armour from ROKETSAN. In the T2 delivery phase, 210 MBTs will be delivered with new features, such as better protection systems, laser-capable ammunition and situational awareness. The Turkish company STM has developed a new Tactical Field Command Control Information System (TANKOM) which will be used here. It is highly likely that the first 250 tanks in T1 and T2 will be equipped with a German MTU engine and a German Renk transmission, but SSB has a fallback option if delivery from Germany is not permitted. Anyway, in order for Turkey to be able to export the MBT ALTAY in the future, it has to build the engine and transmission itself. According to recent statements by SSB President Prof. Dr. Ismail Demir, a domestically developed Turkish engine is expected for 2022. In June 2018, the BMC subsidiary BMC POWER developed a six-cylinder diesel in-line engine with a displacement of 12.8 litres and around 600 hp. The know-how will also be of use in the development of the future MBT ALTAY, for which SSB has placed a development order. At the end of delivery phase T3 there will be an all-new MBT ALTAY; the ALTAY will receive an unmanned tower with a fully automatic loading system. The shape and weight of the tank will also shrink and create additional operating capabilities. Development is planned for 2023-2025, which is quite a challenge for the Turkish armoured vehicle industry, as new technologies are used and new development strategies are pursued. The Russian competitor MBT T-14 ARMATA with an unmanned turret and the KURGANETS-25 will not be produced in series until further notice; when announcing the decision in late December 2018, Russian Deputy Defence Minister Yuri Ivanovich did not give any reasons.

Photo: Korhan Özkilinc

The TULPAR Light Tank developed by OTOKAR is Turkey's latest development.

Photo: Otokar

Turkey has heavily invested in developing a domestic Main Battle Tank named ALTAY.

Photo: Otokar

The procurement of the ALTAY has been delayed by several years.

In November 2018 at the Land Systems Seminar in Ankara, Ahmet Raci Yalcin, Head of the Land Platforms Department, made important remarks during his presentation on the future strategy of MBT ALTAY. Following the first deliveries of 250 MBT ALTAYs, SSB will also focus on complementary strategies; future medium and light battle tank projects will use the MBT ALTAY as a development platform. Moreover, Turkey wants to set up a "Centre of Technological Developments for Land Platforms (CTDL)" modelled on the German WTD 41, a centre of technological competence of the German MoD. In order for the Turkish land platform strategy to be successful, efforts are being made to consolidate the entire value chain. In December 2018, President Recep Tayyip Erdogan decreed to lease the "First Main Service and Engineering Command (MSEC)" of the Turkish Army for 25 years. It is expected that the ALTAY will be produced here, which would provide BMC with high-quality engineering services and equipment in one fell swoop; the BMC building being built near the MSEC might then become the CTDL.

The lease of the MSEC raises some questions. Turkey has produced 250 pieces of the T-155 FIRTINA main seats here at the premises. On 14 December, the Turkish Army contracted ASELSAN with a new fire control system worth US$195M to be used by MSEC. Most likely, this order is for the future T-155 FIRTINA II and would be sufficient for a tranche of 150 new units. The question, then, is who will build the next generation T-155 FIRTINA II. This development is a good example of how to turn a good customer into a serious competitor for the Western defence industry.

Modernising the Old Battle Tanks

The procurement of the Turkish MBT ALTAY has been delayed by several years while the security situation in the region, especially in Syria and Iraq, has deteriorated. This is why the Turkish Government has been forced to modernise its obsolete tank inventory. Over the last fifty years, Turkey has mainly bought German and US second-handtanks, but this poses enormous challenges in terms of repair and logistics, making the Turkish armed forces dependent on foreign services. The weaknesses of Turkey's outdated tanks became apparent during the military operations "Euphrates Shield" and "Olive Branch" in Northern Syria, where at least five dozen tanks were destroyed in asymmetric warfare. The July 2016 military coup exacerbated the plight of the Turkish Army when many experienced officers were arrested or dismissed from service and experienced tank crews were suddenly absent, but this weakness has been significantly mitigated.

At the moment, Turkey is pursuing three different modernisation projects, which will now be discussed.

For its loyalty during the Gulf War, Turkey received about 1,000 used M60 PATTON tanks from the US, most of which are disposed of today. In 2010, Turkey still had about 170 PATTON tanks, which were upgraded to the M60T version by ASELSAN and MKE in cooperation with Israel. For "Operation Euphrates Shield" ASELSAN recently upgraded 139 M60Ts with an additional system so that the tank can initiate effective countermeasures against CORNET anti-tank rockets. After successfully passing the tests, integration centres were set up at five sites in northern Iraq where the upgrades were carried out. Two integration centres are located in Cobanbey and Cildiroba near the city of Kilis, directly on the border with Syria. A third integration centre is in Silopi in the Sirnak district near the border with Syria and Iraq, another in Iskenderun on the eastern Mediterranean coast and the last integration centre is in northern Iraq. The upgrade includes a laser warning system, a 12.7mm SARP tower, a 360-degree situational awareness system and position detection. In addition, the tank received the ZASLON Active Protection System (APS) from Microtech, a subcontractor of the Ukrainian company UkrOboronProm, and 40 tanks received the AKKOR PULAT APS, which was developed in cooperation with ASELSAN and TÜBITAK SAGE.

The second modernisation project relates to the M60A3 tanks and is carried out by ROKETSAN. It includes installing external protection systems and a SARP Remote Controlled Stabilised Gun System, a power distribution unit, a tank laser protection system, and all-round visibility.

The third project concerns the LEOPARD 2 A4 tanks, which are obsolete but still form the backbone of the Turkish Army. The contract was awarded to BMC and ASELSAN as subcontractors, because ASELSAN has a lot of experience with the LEOPARD 2 NG upgrade. The main purpose of the contract for BMC is to acquire additional expertise for series production of the ALTAY tank.

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Photo: FNSS

Turkey will procure 260 armoured anti-tank vehicles from FNSS.

Modern Turkish Medium Tanks

The two heavyweights in medium tanks are the TULPAR Light Tank, produced by OTOKAR, and the KAPLAN MT of FNSS. They differ in weight by about 7 tonnes, but they have the same weapon platform and are well suited to asymmetric warfare in complex terrain. They can take on special tasks and act as the backbone of the infantry. With these two tanks, the Turkish tank industry will be able to hold its own on the international market.

KAPLAN MT/HARIMAU

In May 2015, Turkey and Indonesia agreed to jointly develop a Modern Medium Weight Tank (MMWT) prototype in only 36 months. FNSS represents the Turkish side and PT Pindad the Indonesian side; the tank is called "TIGER" in both national languages. A first prototype – a state-of-the-art technology platform with superior firepower – was presented at Indo Defence Expo 2016. Thanks to its innovative design and ballistic protection, the tank will hold its own in the markets of the future. Of course, the experiences of the FNSS product line KAPLAN 10, KAPLAN 20 and KAPLAN 30 Light Tanks were incorporated into this project. At IDEF 2017 in Istanbul, KAPLAN MT attracted considerable attention. On 5 September 2018, it was officially announced that the tank had passed qualification tests in Indonesia with distinction – the Mobility Test Rig (MTR) and the Firing Test Rig (FTR) – and is about to go into series production.

The armoured tracked vehicle with a crew of three is 6.95 m long and 3.36 m wide and weighs 30-35 tonnes depending on the version. A new-generation Caterpillar C13 diesel engine with 711 hp with a fully automatic electronically controlled Allison/Caterpillar X300 transmission enables the tank to travel at speeds up to 78 km/h with a range of 450 km. It can also cross a 2 m ditch and 0.9 m vertical obstacles and a gradient of 60% or a side gradient of 30%. The KAPLAN owes its advanced mobility to its six-wheel anti-shock suspension system, which is based on torsion bar springs with double locked chains which provide optimum performance both in urban terrain and off-road. Modular armour designed to STANAG 4569 Level 4 is used as fuselage protection, and it can be raised to Level 5 if needed. The substructure of the tank has a V-fuselage that can withstand a 10 kg anti-tank mine. The turret is a Belgian CMI COCKERILL 3105 model with a 105mm high-pressure gun with high direct fire capability that can fire projectiles like HEP-T, HE4 TP2 or TPCSDS-T.

The turret has an autoloader; it can rotate electronically and mechanically through 360 degrees. Both the KAPLAN and the TULPAR have a battlefield management and laser warning system, and they are also equipped with an IFF system, a Hunter Killer system for target selection and an Auto Target Locking system. Indonesia has

Photo: FNSS

The KAPLAN is a joint development of the Turkish FNSS and the Indonesian PT Pindad.

ordered 44 tanks, with delivery to begin in 2019. The HARIMAU tank is well suited to a country with many islands, as the tank can be easily deployed with transport planes. The Indonesian market alone has a need for up to 400 HARIMAU tanks.
The Turkish Army also wants to order the KAPLAN MT to supplement the MBT ALTAY, and Bangladesh, Brunei and the Philippines have already expressed interest. FNSS is expected to meet the high expectations in Southeast Asia; Malaysia has already produced 257 GEMPITA wheeled tanks based on the PARS II 8x8. Today, FNSS has become a successful global company with foreign orders worth almost US$3Bn.

The TULPAR Winged Horse

In Turkish mythology, Tulpar is a winged horse, and the TULPAR Light Tank developed by OTOKAR and unveiled at Eurosatory 2018 is the latest member of the TULPAR family. It is 7.23 m long and 3.45 m wide and has a weight of 42 tonnes. Due to its modular platform, the tank can be adapted to different deployment requirements. Despite its ingenious design and low signature, it masters rough terrain and its agility makes it suitable for asymmetric warfare. The high-tech tank is operated by a crew of three. The latest technology provides sophisticated protection and firepower as well as NBC protection.
The tank is powered by a Scania DSI 16-litre eight-cylinder V8 720 hp (530 kW) turbocharged diesel engine and offers a top speed of 70 km/h and a maximum range of around 600 km on the road. The vehicle can overcome gradients of up to 60% and side gradients of up to 40%.
The TULPAR features advanced mobility from its seven-wheel anti-shock suspension system, based on torsion bar springs with double, fixed chains, offering optimum performance on different terrains. It is equipped with a CMI COCKERILL 3105 turret with STANAG 4569 Level 5 ballistic protection. The main weapon is a 105mm high pressure gun capable of firing all types of NATO ammunition, plus a second 7.62mm weapon or a 12.7mm MG. The GLATGM Gun-Launched Anti-Tank Guided Missile)increases the effective range of firepower up to 5 km and for some missile types up to 8 km and is therefore capable of engaging moving targets, including low-flying helicopters. OTOKAR has used the know-how from the MBT ALTAY project for the development of the TULPAR. Turkey is holding talks with five countries on the export of the tank.

Photo: Korhan Özkilinc

The PUSAT 4x4 developed by TÜMOSAN is a 12-tonne vehicle with a 5.2-litre 250 hp diesel engine.

Photo: Otokar

Turkey plans to procure almost 3,000 armoured vehicles, and Otokar's ARMA 8x8 is under consideration.

Photo: Simta

In 2008, Turkey signed a contract with the South Korean company Hyundai Rotem to licence-produce the K2 BLACK PANTHER MBT.

Current Procurements

This year at IDEF 2019, the Turkish industry will present many new armoured vehicles with enormous performance growth. The ZAHA armoured amphibious attack vehicle is particularly noteworthy. The 30-tonne vehicle with six wheels and crawler tracks reaches 70 km/h on the road and two additional water jets accelerate the vehicle to 13 km/h in the water. The development contract was signed between FNSS and SSB on 7 March 2017 and provides for the production of 27 vehicles (23 transporters, two command and control vehicles and two recovery vehicles).

Another vehicle that has been under development by TÜMOSAN for several years and presented at IDEF 2019 is the National Integrated Tactical Wheeled Vehicle, PUSAT. The PUSAT 4x4 is a 12-tonne vehicle with a 5.2-litre 250 hp diesel engine. Engine, transmission and system architecture also stem from the same developer. The nose of the vehicle has been kept short, allowing better visibility for the driver and moving the vehicle's centre of gravity to the middle for better off-road capability.

In the next few years, Turkey will procure several thousand armoured vehicles. This is a great challenge for domestic companies and a great opportunity for foreign suppliers to do business in Turkey.

- There are plans to procure 2,962 6x6 and 8x8 armoured vehicles in 52 versions for the New Generation Armoured Vehicle project. The PARS III from FNSS and ARMA from OTOKAR are under consideration.
- It is planned to procure 100 6x6 and 8x8 special tactical wheeled tanks from FNSS in the following versions: 30 command vehicles, 45 reconnaissance vehicles, 15 radar and 5 NBC protection vehicles as well as an additional 5 vehicles for the gendarmerie.
- For the transport of tanks, containers and rescue teams, 476 8x8, 10x10 and 12x12 trucks were ordered in the following quantities: 134 tank transporters, 65 container transporters and 277 rescue vehicles. BMC and KOLUMAN OTOMOTIV will build the vehicles based on a Mercedes-Benz chassis. KOLUMAN recently presented a heavy armoured truck in the presence of Minister Mustafa Varank of the Ministry of Industry and Technology.
- FNSS will supply 260 anti-tank vehicles, 184 of them based on the KAPLAN 10 and 76 based on the PARS 4x4. Delivery will start this year and should be completed by 2021.
- A total of 713 VURAN Tactical Wheeled Armoured Vehicles manufactured by BMC are to be procured for the fight against terrorism and homeland security – 512 of them for the army, 200 for the gendarmerie and one for the coast guard.
- BMC has supplied 230 KIRPI II Tactical Wheeled Armoured Vehicles. A follow-on order of 329 additional vehicles for the army and 200 for the gendarmerie is currently under consideration.
- The army will procure 84 combat zone fuel tankers from BMC – 17 for helicopters and 67 for land platforms.
- The Turkish police will receive 180 EJDER YALCIN III Tactical Wheeled Vehicles and the gendarmerie 100 (Project 1).
- The procurement of another 337 Tactical Wheeled Vehicles (Project 2) for the police and the gendarmerie is currently being processed; 240 units have been delivered so far.

Photo: Katmerciler

The HIZIR 4x4 tactical wheeled armoured vehicle for up to nine crew members is designed and optimised for high performance under extreme operating conditions in both rural and urban areas. The vehicle has a high level of ballistic and anti-mine protection. The platform is agile, dynamic, versatile, low-maintenance and easy to maintain and is available in various configurations such as combat vehicle, command vehicle, CBRN vehicle, weapon carrier (easy integration of different weapon systems), rescue vehicle, border security vehicle, reconnaissance vehicle.

Conclusion

Over the last five years, the Turkish armoured vehicle industry has made significant progress in terms of innovation, modularity, adaptability and market penetration. This success is the result not only of the performance of the system manufacturers BMC, FNSS, OTOKAR and Co, but also of the Turkish suppliers and their accomplishments in research and development. Of course, the large number of system manufacturers in Turkey has significantly increased the competitive pressure in the country. When developing new components, care is taken to ensure that the components are reusable; these are to be used not only for land platforms, but also for ship platforms. Here are some examples of Turkish technology developments:

Three Turkish companies have developed three different railguns on their own initiative: ASELSAN developed the TUFAN Railgun, a consortium of companies the SAHI209 Railgun and TÜBITAK SAGE the SAPAN Railgun. In the category of direct energy weapons ASELSAN has developed a laser weapon for 4x4 light wheeled armoured vehicles.

Photo: Korhan Özkilinc

Engine and transmission of the PUSAT are domestic developments.

In cooperation with Turkish SMEs, ASELSAN has developed the innovative mortar system ALKAR – an autonomous, soft-recoil 120mm mortar mounted on a 4x4 light armoured wheeled vehicle. The mortar has a range of 1,500 m to 8,000 m; its recoil force below 25 tonnes is rather low compared to Western models.

And another example: ASELSAN and FNSS developed the KORKUT air defence gun for the ACV-30 armoured combat vehicle, which is also integrated on maritime platforms.

The technological progress of the Turkish defence industry reinforces the increasing military strength of NATO partner Turkey and can also play a role in the developing Framework Nation Concept of European security policy. As a leading power in the Middle East, Turkey is able to substantiate its geopolitical influence with an advanced armaments technology. It may sound ironic, but it is only a question of perspective: Turkey is the anchor of stability for the Western hemisphere. ■

Special Protected Vehicles

André Forkert

For some years, and in view of the growing threat of terrorism, the German military and police authorities have been improving the level of protection of their equipment.

The private sector is also demanding more and more weapons, and many people are investing in additional protection. The trend towards a higher level of protection for protected vehicles started with the Afghanistan missions. Up until recently, the German police avoided such a step and stressed that they did not want to use military-style vehicles on German streets. Here, too, a change of mind has taken place. The police first acquired vehicles with military-grade protection for the peace-keeping mission in Afghanistan; ten MOWAG EAGLE IV vehicles were purchased between 2011 and 2014. After returning from Afghanistan and having undergone the necessary conversions, these vehicles are now replacing the "Sonderwagen 4" (SW 4) previously used at Munich, Frankfurt, Berlin and Stuttgart airports.

Photo: GDELS-MOWAG

A GDELS-MOWAG EAGLE IV of the Zurich Police Department, Switzerland. The German Federal Police is using the same vehicle.

Mobile Protection for the Police

In 2015, the then Interior Minister of Rhineland-Palatinate said: "In principle, we must ensure equality of arms", a statement which led to the introduction of new protective vests, helmets, assault rifles and protected vehicles.

The most recent police procurement contracts concerned the SURVIVOR R 4x4 manufactured by Rheinmetall MAN Military Vehicles (RMMV). To date, this vehicle has been deployed by the police and SpecOps Command (SEK) of Hamburg, Saxony and North Rhine-Westphalia. The vehicle is based on the HMV SURVIVOR I manufactured by the Austrian company Achleitner, which designed the car for the Viennese COBRA task force. The state of Brandenburg has been using the Achleitner SURVIVOR HMV since 2017. The SURVIVOR R's monocoque cabin offers a mix of mobility, protection up to STANAG 4569 Level 3 and a payload in the 15-tonne vehicle class, and it comes with a large interior (for a crew of up to ten), a de-escalating appearance and extras such as levelling blade, carrier for tear gas or fog grenades, NBC protective ventilation system or a fire extinguishing system. A modular weapon station can be integrated on request.

Photo: André Forkert

Rheinmetall MAN Military Vehicles' SURVIVOR R 4x4

The Federal Police uses the GDELS EAGLE IV. A joint venture between RMMV and Krauss-Maffei Wegmann (KMW) has proposed a vehicle for the tender of a new multi-purpose vehicle (AMPV), which has not yet established itself in the military or police sector.

Author

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KMW is also trying to gain a foothold in the market with a police version of the DINGO 2 off-roader (ATF). Since 2009, the Federal Police has been using two DINGOs, which were procured for Afghanistan at the time.

Blurred Boundaries

In addition to these highly prominent vehicles, military, police and private security contractors often choose more inconspicuous vehicles. There are two types of vehicles: lightly armoured patrol vehicles (LAPV) and special vehicles on civilian platforms.
The LAPVs are used as support vehicles for heads of state and government. The Bundeswehr uses ENOK 6.1 LAPVs for the military police and the Sonderkommando (KSK). Based on the Mercedes-Benz G-Class and available in various versions, they are the result of a joint venture between Mercedes-Benz, Magna Steyr and ACS Armoured Car Systems. ACS in Aichach, Bavaria, is responsible for the design of all protective elements and final assembly.
The ENOK LAPV 6.1 is a further development of its predecessor LAPV 5.4; the latest development stage is the ENOK 6.2; the number denotes the permissible total weight and indicates the higher payload

Photo: RMMV

Rheinmetall MAN Military Vehicles' SURVIVOR R 4x4 of the Dresden Special Operations Command (SEK)

(>1 tonne) of the 6.2 version. In addition, the portal axle provides greater off-road mobility. The compact dimensions with a vehicle width of 190 cm – about 40 cm narrower than an IVECO LMV or an EAGLE – ensure high agility during police operations in urban environments. In addition, the ENOK's appearance is less conspicuous, which can be of decisive importance, and its high protection level makes for an efficient support vehicle with a crew of up to six and a high operational range. ENOKs can be upgraded with a remote-controlled weapon station such as KMW's FLW 100 or a machine gun in the turret.
With the ENOK, ACS has repeatedly demonstrated its competence as a general contractor and system integrator. Working closely with Mercedes-Benz ensures worldwide logistics supply. In addition to the German armed forces, the German Federal Police and, most recently, the Bavarian State Police

also use ENOK. At major trade fairs around the world and at the Mercedes-Benz Defence Vehicles Experience Days, the ENOK attracts considerable national and international attention from military and police customers. With its 4+2 seats, the ENOK is at the lower end of ACS' vehicle portfolio; thus far, there is no vehicle in the weight range of up to 8 tonnes and 6+2 seats. The vehicle should still be small enough to be used in urban terrain, and ACS is currently designing a modular prototype.

Civil Appearance

Ballistic protection or the integration of modular weapon stations are only two aspects of protection. Inconspicuousness is another one. Those who can hide in the urban jungle and do not stand out as a worthwhile target have done quite a lot to protect themselves. What is more, non-governmental organisations (NGOs) or civilians often do not want to be confused with the police or military, which is why protected civilian vehicles are a frequent choice. There are many suppliers of such vehicles, with often large differences in quality. Due to their low-key appearance, government agencies also rely on such vehicles today, the most popular platforms being the Mercedes-Benz G-Class or the Toyota LAND CRUISER.

The Brandenburg family business STOOF International GmbH offers protected vehicles based on both models. The company also offers armoured limousines and trucks and money transporters. STOOF's flagship is the Toyota Land Cruiser 200 TROJAN, which is certified according to the 1999 BRV (Bullet Resistant Vehicles) Class VR (Vehicle Resistance) 6. This specification as well as its requirements, classification, and test procedures are released by Beschussamt Ulm – a state-run live-fire testing facility for protected vehicles and bullet-resistant vehicles. In addition to being fired at with small arms fire, a short-distance blasting with an explosive equivalent of 15 kg TNT is also part of the test, which the TROJAN successfully passed.

The German armed forces use these vehicles for foreign deployments where no large contingents are available, such as in Lebanon. Other owners of larger fleets are the EU and GSG 9. Since demand for such vehicles is volatile, STOOF International offers a pooling solution: they operate a pool of protected vehicles in Brandenburg which are always available and can be shipped or air-transported worldwide at short notice if required. The United Nations (UN) is the most prominent user of this service.

Photo: André Forkert

A police version of the Achleitner HMV SURVIVOR I

Photo: FIN Police

A Mercedes-Benz G280 CDI LAPV 5.4 ENOK armoured vehicle of the Helsinki Police Department. The vehicle was designed and built by ACS; Mercedes-Benz is the prime contractor in Finland for this project.

Photo: André Forkert

A protected Mercedes-Benz SPRINTER 6x6 designed by Carl Friedrich GmbH for Police Special Forces operations.

WELP Group has a similar portfolio. Whether off-roaders, transport vehicles or pick-ups, all of these vehicles can be armoured and customised according to user requirements. WELP's managing director Roland Gerschewski points out that the demands and requirements from state authorities have become more diverse – gun ports, various communication systems, emergency exits, protected roof openings, electric footboards, voice and light systems, shields or monitoring and location systems are in demand. The Saxon state police recently procured seven WELP Toyota LAND CRUISER V8, and the police of Brandenburg and Baden-Wuerttemberg are using similar vehicles, naming neither the contractor nor the model.

Transport Vehicles

The company Carl Friedrich GmbH offers a wide range of larger vehicles for fire brigades, rescue services and police as well as (anti-riot) water cannon vehicles and special vehicles. In addition there are the models Mercedes-Benz G, ML and GL, Toyota LAND CRUISER 100/105, Land Rover DEFENDER or VW TOUAREG as TUAREX – of course, all in a protected version. One size larger is the Mercedes-Benz SPRINTER GUARD with a reinforced chassis with all-wheel drive and powerful brakes. Its protection class corresponds to VPAM 9 and the permissible total weight is 8 tonnes.

Hartmann Spezialkarosserien GmbH from Alsfeld offers safety-related vehicle upgrades for companies and authorities, which includes vehicle protection and armouring, as well as the integration of surveillance technology, X-ray scanners and sensitive security technology. Hartmann also offers a "screening vehicle" as a mobile security platform with X-ray technology based on the SPRINTER, for example for securing major events. With the SPRINTER SHIELD, Achleitner also offers a protected vehicle in this class.

As a supplier, Oberaigner offers the SPRINTER with a 4x4 and 6x6 chassis; with this proprietary all-wheel drive and commercial-off-the-shelf (COTS) technology from Mercedes-Benz, the SPRINTER is equipped for every application.

The German Federal Police has procured several armoured Mercedes-Benz SPRINTERs for their "Evidence Retention and Arrest Units Plus" without naming the contractor.

Protection as a System

However, protection does not end with ballistic protection alone, it must continue with the subsystems. Here, too, the requirements for technology and expertise are becoming ever more complex. The most obvious are certainly the communication systems, which include satellite telephones in addition to a two-way voice function – in order not to have to open any windows or doors – or, according to Barrett Communications, tactical or civilian HF radios with high bandwidth as standard equipment. Jammers have also become standard equipment in vehicles, but they must not interfere with the vehicle's communication channels.

The diversity of threats, especially in asymmetric warfare scenarios, poses particular challenges to electronic protection functions. To improve vehicle protection while driving, lighweight multifunction devices are required that integrate previously separate tasks into a single system. Intelligence systems that detect and evaluate enemy radio traffic can also generate targeted interference signals for defined frequencies. In the past, this required special equipment and lots of electricity and storage space.

Photo: DIEHL

DIEHL's HPEMcarStop

For this purpose, the German sensor company HENSOLDT has developed its ultra-fast SMART jammer, which identifies radio signals that are to detonate roadside bombs and IEDs. It then sends real-time interfering signals precisely tuned to the enemy's frequency band, interrupting the link between the enemy operator and the bomb. This Vehicle Protection Jammer is used by NATO and Middle Eastern military and security forces.

Photo: Hensoldt

Hensoldt's SMART responsive jamming technology on a Mercedes-Benz G-Class.

Thanks to new digital receiver and signal processing technology, the system achieves response times of well under one millisecond. Up to 1.5 million threat signals in all major frequency bands can be detected and blocked at any second. Compared to conventional "barrage" interference, HENSOLDT's jammer focuses the output power on the specific frequency of the ignition signal instead of being distributed over the entire frequency range. As a result, less energy is required and the disturbance effect is increased. In addition, interference to the radio communications of friendly forces is reduced to ensure reliable command and control.

The HPEMcarStop from DIEHL Defence is a non-violent system for selectively stopping vehicles in dynamic scenarios. The system consists of a powerful HPEM (High-Power Electromagnetic) source, which is integrated into an agile carrier platform. DIEHL uses a Jeep GRAND CHEROKEE SRT8 as a platform, but the system can be installed in any other large trunk. The systems fully integrated into the vehicle body, making it indistinguishable from a regular Jeep. In contrast to conventional mechanical stop methods, HPEM only interferes with the vehicle's electronics, which does not damage the target vehicle or persons. HPEMcarStop technology has proven its reliability in tests with more than 60 different vehicle types from different international manufacturers. The HPEMcarStop is used for special applications and the protection of major events.

In order to achieve best results, the target vehicles must be irradiated from the front. A vehicle approaching from behind or attempting to overtake the HPEMcarStop is exposed to radiation that leads to failure of the engine control electronics. The driver can easily trigger the stop effect via a simple user interface. A strong electromagnetic field will short-circuit the target engine, bringing the vehicle to a standstill without physical damage. Target vehicles can later be restarted. According to DIEHL, the operating range of HPEMcarStop is 3–15 m, depending on the target vehicle. The system has a maximum operating time of 3 minutes. Another advantage of HPEMcarStop is its disturbing effect on all types of car bombs with electronic ignitions.

Nowadays, (electronic) counter-drone systems are another protection requirement. Currently only stationary systems are in use. But HPEM might also be a solution for the future. Currently, DIEHL cooperates with ESG to design such systems.

Active protective systems (APS) are currently only found on larger combat vehicles. For the future, they could also be an option for smaller 4x4 vehicles, but weight will have to come down. Possible systems could be from Rheinmetall Active Protection GmbH or Rafael with its TROPHY LITE series.

Night Vision

An important protective aspect is nighttime operation, which may involve the use of night vision goggles, permanently installed night vision or thermal imaging systems, and driving without lighting. IR lighting is most commonly used to provide maximum visibility with minimum illumination. In the future, the Bundeswehr will only be allowed to install IR lighting systems that comply with the 95030 armament standard (VG standard); the standard is still in the implementation process.

That is why Rainer Diederich GmbH has upgraded its vehicle IR light, which is used in the Bundeswehr IVECO Trakker vehicles. It has an IR spectrum of 880 nm and can display all daylight functions (driving and brake lights, indicators, and so on). The user can also programme a self-coded SOS signal or use the lamp as a friend or foe (IFF) identifier when mounted on the vehicle roof, for example. The IR light has a magnetic base and can be placed anywhere in the vehicle. In addition, the light can be removed from the vehicle and used with a rechargeable battery as a torch light to indicate the position to aircraft, for example. Soon, another upgrade will be available which will combine all functions – IR indicator or IR brake light combined with white light (high and low beam) – in a single casing. ■

"The only way to achieve the goal is through true industrial cooperation"

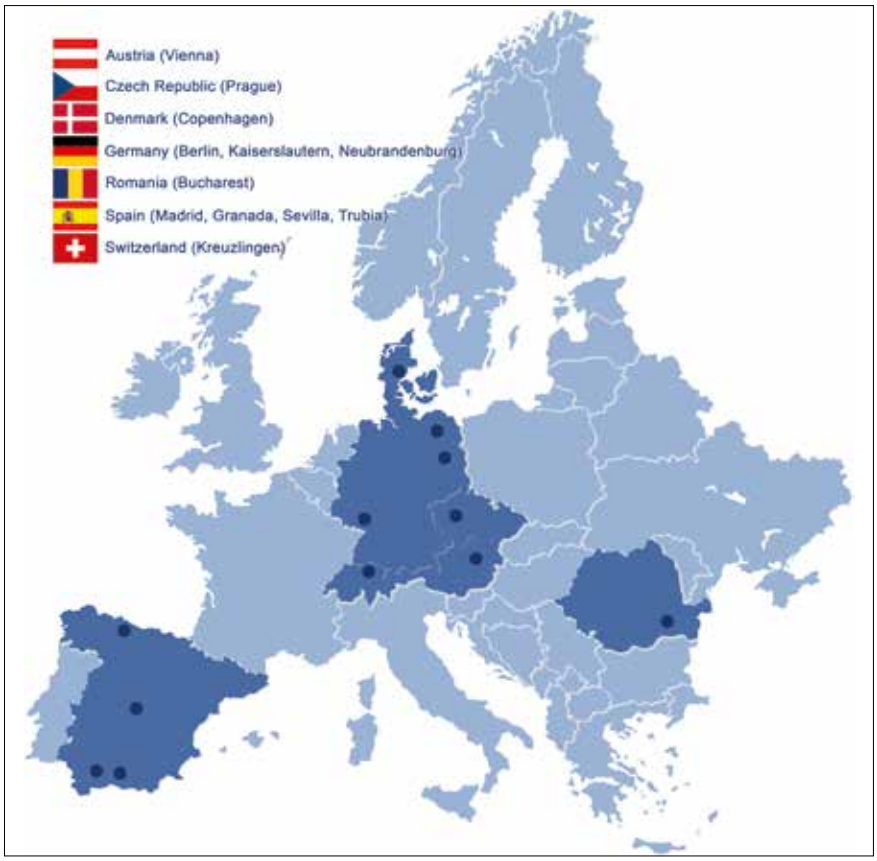
Interview with Thomas A. Kauffmann,
Vice President International Business & Services at GDELS

With numerous programmes ongoing throughout Europe, General Dynamics European Land Systems (GDELS) is among the major industrial players in European land defence. In this interview, Thomas Kauffmann considers the company's current status and looks at perspectives.

ESD: Can you elaborate on the organisational structure of General Dynamics in general and the geographical distribution of GDELS' facilities in particular? To what extent can this kind of organisation support the generation of synergies within the group?

Kauffmann: General Dynamics (GD) is a US based defence corporation with approximately 100,000 employees divided into five business groups: Aerospace (Gulfstream and Jet Aviation), Marine Systems (Electric Boat, NASSCO, Bath Iron Works), Information Technology, Mission Systems and Combat Systems. General Dynamics European Land Systems (GDELS) along with General Dynamics Land Systems and General Dynamics Ordnance Tactical Systems are the business units that form Combat Systems, which encompasses all of GD's activities in land defence.

GD's management model is a decentralised approach where business units like GDELS are responsible for their own company strategy and future business. With approximately 2200 highly skilled employees, GDELS conducts its business through operating sites and presences in Austria, Czech Republic, Denmark, Germany, Romania, Spain and Switzerland. As an indigenous European multi-national organisation, our company's strength lies in our ability to capitalise on our multicultural diversity including different mentalities, background and education. Our cross-border teamwork and cooperation at all levels of our company is a key component to GDELS's success and a skillset we have systematically developed over the years. As one of the leading land systems suppliers in Europe, we are convinced that true cooperation among the players in the defence industry, both large and small, is the only way to improve military interoperability between NATO coalition forces and to achieve the European Defence Agen-



Photos/Graphic: GDELS

The GDELS locations in Europe

ASCOD MMBT (Medium Main Battle Tank, left) and ASCOD IFV with the unmanned UT30MK2 turret

cy's political vision of "fostering defence cooperation". GDELS, unlike many others, has demonstrated experience as a team player both internally and externally.

ESD: GDELS has developed a dedicated strategy for the participation of local industries in export markets. Can you explain the principles of that strategy?

Kauffmann: Industrial cooperation through active and sustainable participation of local industry partners in our projects and products is our main approach to business and to supporting our customers. This cooperation does not focus on licence manufacturing arrangements for our products, which are limited to individual projects. Instead, it is about developing sustainable industrial capabilities in a customer country and maintaining a collaborative network across the countries in Europe. One way to achieve this is to team with competitive, reliable and qualified local business partners for a specific project. It is the initial or first phase. These partners then become members of General Dynamic's global supply chain, where they can also benefit from export opportunities and relationships with other GD business units. Another example is our technology partnership with small to medium sized companies where we assist with market innovation. It is important to note, that a collaborative business strategy requires more than Powerpoint charts during the marketing phase. It is the result of a consistent and well defined company, product development and sales strategy. For example our ASCOD tracked vehicle family, which is built on a "common base platform" to assure commonality and logistic benefits among allied countries. The open vehicle architecture allows flexible integration of different components, subsystems and mission modules. This design approach enables and eases on the one hand cross-border/country cooperation and on the other hand allows rapid and affordable technology insertions over a product's lifetime – an indispensable advantage in a world of rapidly progressing digitisation. We are convinced that our customers will appreciate the open architecture that will allow for more affordable midlife upgrades of the vehicle.

To deliver our products on cost, quality and schedule in a collaborative environment including technology transfer remains key. In order to do so, you need an experienced team, which believes in and lives up to good and professional cooperation and teamwork.

ESD: To what extent are you prepared to actually transfer technology to third parties? How do you respond to the increasing international demand for ITAR-free technology?

Kauffmann: The level of transfer of technology depends on the size of the project, the customer preferred partnership model, customer and legal requirements like arms export regulations and many other things. In our business approach any "Transfer of Technology" involves a multi-step process to mitigate programmatic and management risks. With regard to ITAR, it does not play a more important or crucial role for GDELS than for any other European or international defence companies. GDELS's indigenous technology base is here in Europe and will remain so, another added benefit of the GD decentralised business model.

ESD: To what extent could your export approach be implemented in the scope of the PIRANHA programme in Denmark and the EAGLE programme in Germany? What are the perspectives for Romanian companies to be involved in the local PIRANHA programme?

Kauffmann: I would like take a step back and answer these questions a bit more globally as I think the concept and rationale behind our approach in these programmes is important. As pointed out, years ago we established good and professional cooperation and industrial participation as a key element in our business approach. From our past experience, local national content and industrial participation represents a legitimate requirement of governments that spend public

The ambulance version of the EAGLE V is a contender in the scope of the German mgSanKfz medium medical vehicle requirement.

money. This is particularly true for countries that do not possess their own comprehensive and modern defence industry capabilities. Our approach has the potential to be a macro-economic stimulus for the local industries. As a transatlantic and European partner, but also being part of a global corporation, GDELS can leverage and contribute to this local stimulus significantly. As a result, our business strategy is comprised of a combination of economic, political and technological elements. A fourth "soft" element remains even more important for GDELS - the ability to successfully manage such an international programme on cost, quality and schedule – without these core competencies the above described approach will not work.

Austria has awarded GDELS a contract for 34 PANDUR 6x6 EVO APCs. The contract considers an option for additional vehicles in the scope of a second batch.

The BIBER Armoured Vehicle Launched Bridge (AVLB) is in service with the armies of Australia, Canada, Chile, Denmark, Germany, Italy, The Netherlands and Poland.

ESD: GDELS is currently working on an order for 34 PANDUR 6x6 vehicles for the Austrian Army. What can you tell us about the design of the vehicles and local industrial partnerships?

Kauffmann: We are very pleased that the Austrian Army has awarded us another PANDUR 6x6 contract as it illustrates the high confidence and satisfaction the user has in our products. In terms of manoeuvrability, survivability and payload, the new PANDUR 6x6 Evo is one of the most capable vehicles available today in the market. The 6x6 the vehicle has unmatched compact dimension, which was very important for the Austrian Army operating the system in narrow environments. From a timing perspective, we have executed the programme from preliminary design reviews to first delivery of qualified and certified vehicles in less than 18 months. More than 190 Austrian companies are involved in the PANDUR "Made in Austria" project. Last but not least, we are exactly on schedule, quality and cost!

ESD: Are there plans for expansion? Are there any countries where GDELS aims at strengthening its presence? If so, against what background?

Kauffmann: GDELS has a long history in Europe with unique industrial landmarks from our heritage. As an example, our operating site in Seville, Spain, where we are currently executing one of the largest and most modern tracked vehicle programmes worldwide, was founded in 1540, almost 500 years ago, to produce armaments and cannon systems for the Spanish Empire.

Being present in seven European home markets, GDELS as a land system supplier has one of the largest footprints across Europe. Thus, we are uniquely positioned to be a European and transatlantic partner with our customers and other European defence companies, especially in Eastern Europe.

In furtherance of our European commitment and footprint, we recently decided to consolidate and grow our presence in Germany. For decades GDELS has successfully supplied the German Army with our vehicle and bridge-systems like the vehicle EAGLE, the bridge and ferry system M3 or the FSB and tank bridge BEAVER (BIBER). Germany with its location in the centre of Europe remains a major defence market for us. We have recently established a new holding company in Berlin, GDELS-Deutschland, which will manage all our in-country activities in Germany under one umbrella. In addition, we have acquired the maintenance and service provider FWW Fahrzeugwerk located in Neubrandenburg. FWW is a respected and qualified partner for the German Army with significant growth potential to maintain the Army's legacy vehicle fleet. Along with new vehicle procurements, we believe that maintenance and services will become more and more crucial for our German customer.

More than 11,000 PIRANHA AFVs are in global service. The picture shows the version currently on order to the Danish armed forces.

In summary, GDELS today employs approximately 2400 employees in Europe, with 600 in Germany. Our company is a reliable and trusted business partner for more than 4500 suppliers, small and medium companies included. As a transatlantic corporation, GD is committed to Europe and that commitment will not waiver.

ESD: How do you envision the highly competitive market for combat vehicles in the medium term? Is stronger industrial cooperation a sound objective? If so, does that apply for the prime contractors, too? What can you win, what can you lose?

Kauffmann: I am personally convinced that strong, transparent and fair competition drives innovation and technology and is in the best interest of the customer. Protectionism whatever "colour" does not help, but instead it damages and hinders. If we seriously consider our customers' objective to strengthen interoperability among NATO and EU coalition members, the only way to achieve this goal is through true industrial cooperation among all companies in the defence industry, both large and small. What exactly industrial cooperation looks like is dependent upon the customer country's objectives, but each business partner should contribute with its strength and a potential OEM or prime contractor need to have a core expertise in cooperating successfully with others.

The Interview was conducted by Jürgen Hensel.

Brake Upgrades for Armoured Vehicles

(ck) Alcon Components Ltd, a UK-based brake and clutch company, has announced an order intake milestone of over 5,000 brake upgrade kits delivered to the civilian and military armoured and specialist vehicle sector. Alcon are offering a 25% discount for any new enquiry for trial brake upgrade kits, received before 28 February 2019. Alcon brake kits are available for many armoured and specialist SUVs, including Ford's F550- and F150-based RAPTOR and RANGER platforms; Chevrolet's SUBURBAN and SUBURBAN HD; GM's GMT K2-based platforms TAHOE and ESCALADE; Toyota's LC 200, LC78-79 and HILUX; Mercedes' SPRINTER; and VW's AMAROC and CRAFTER. All these armoured vehicles have significantly increased Gross Vehicle Weight, often by more than 30%. Alcon offers brake upgrades for armoured modifications and other special vehicles where standard braking systems are not up to the task.

500 VT4 for French Army

(ck) In mid-December 2018, the French Army took delivery of its 500th VT4 vehicle. Thanks to this delivery, the delivery targets for 2018 have been met. Designed for liaison and command, the VT4

Photo: Arquus

is a light vehicle which has been delivered to the French Army since 1 October 2018. The French MoD announced the VT4 programme in December 2016: it will cover a total of 3,700 vehicles produced in the ARQUUS plant that has been located in Saint Nazaire since December 2017. The VT4 programme aims at militarising a 4x4 civilian base vehicle, adding several new references which focus on mobility, ergonomics, resistance and military equipment integration. The delivery of the Standard 2 version of the VT4 will start as early as the beginning of 2019. The order for the 2nd tier, which consists of 1,200 Standard 2 vehicles with 350 more modifications, was signed on 7 September 2018 by the French procurement authority, the DGA.

LEOPARD for Hungary

(ck) NATO and EU member state, Hungary, will modernise its land forces. As part of this modernisation process, Hungary has signed a contract with the German defence tech-

Photo: KMW

nology company Krauss-Maffei Wegmann (KMW) for the procurement of 44 new LEOPARD 2 A7+ battle tanks and 24 new PzH 2000 howitzers. In addition, Hungary will procure 12 used LEOPARD 2 A4 main battle tanks from KMW's stock for training purposes. The project is also intended to increase interoperability between the European armed forces. Hungarian Defence Minister Tibor Benkő stressed that the agreement would strengthen cooperation between the German and Hungarian armed forces.

IRON FIST for BRADLEYs

(ck) The US Army has given the go-ahead for General Dynamics Ordnance and Tactical Systems (GD-OTS), in cooperation with Elbit Systems and IMI, to move forward with Phase II of their IRON FIST LIGHT (IFL) Active Protection System (APS). The low size and weight, easy integration and versatile performance make IFL well suited for the BRADLEY combat vehicle. IRON FIST LIGHT uses independent optical sensors, tracking radar, launchers and countermeasure munitions to defeat threats at a safe distance from the defended combat vehicles. The system provides 360-degree protection coverage for close-range scenarios in both open terrain and urban environments. The US Army urgently wants to field active protection capabilities.

Software-Defined Radars for IRON FIST

(ck) RADA Electronic Industries Ltd, a manufacturer of tactical land radars for force and border protection, will provide its radars for the IRON FIST LIGHT (IFL) system to be fitted

Photo: RADA

on US Army BRADLEY Fighting Vehicles. RADA's software defined radars identify and precisely track incoming threats from any direction, in real time. The system then intercepts the threat by launching a small warhead and activating it at a safe distance from the protected platform at a precisely calculated moment, defeating the threat through a shock-wave effect. In phase II of the IFL for BRADLEY project, RADA expects to receive near-term orders for the supply of radars for qualification testing. The current plan is to equip one US Army Brigade of BRADLEY armoured vehicles. This phase is expected to continue into the years 2020 and 2021.

TROPHY APS for US Army

(ck) The US Army and the US Marine Corps have contracted Leonardo DRS and Rafael to deliver the TROPHY Active Protection System (APS) under a contract with a total value of US$79.6M. This brings the total funded value of the programme to over US$200M. TROPHY provides protection against anti-armour rocket and missile threats, while at the same time locating and reporting the origin

Photo: Rafael

of hostile fire for immediate response. The DRS and Rafael teams demonstrated a new, lighter "TROPHY VPS" variant on a BRADLEY Fighting Vehicle in Israel in August 2018. Those teams will also be participating in the Army's STRYKER Expedited APS demonstration "rodeo" in February 2019.

Upgrades for Armoured Recovery Vehicles

(ck) In response to altered operational requirements, Rheinmetall will upgrade the German Army's fleet of BERGEPANZER 3 (BPz3) armoured recovery vehicles. From 2019 to 2024, 69 of Germany's BPz3 vehicles will be fitted with battlefield recovery equipment and universal transport platforms. The order is worth around €30M. The battlefield recovery equipment will be relocated from the front of the vehicle to the back in order to safely tow disabled combat vehicles like the LEOPARD 2 in forward drive, removing them from the battlefield at high speed. Furthermore, the rear of the modified

BPz3s will be fitted with a transport platform for carrying equipment for recovering other vehicles. Four BPz3s have already been upgraded for the ISAF mission in Afghanistan. Two other vehicles, previously deployed by the Canadian Army in Afghanistan, have already received the same upgrade.

Photo: Bundeswehr

Texelis Management Board Acquires Majority Stake in Company

(ck) With the support of institutional investors the Texelis management team has acquired the majority shareholding of Texelis Group. Based in Limoges, Texelis specialises in developing and producing drivetrains, including axles, and power transmission systems for heavy vehicles including trains, trams, armoured vehicles and heavy trucks. Over the last few years the company strategy has focussed on diversifying its customer base with major manufacturers such as Siemens, Bombardier, Volvo and Nexter. Amongst recent successes, the Group is supplying mobility systems for the Siemens NEOVAL people mover and the SERVAL 4x4 armoured vehicle for the French Direction Générale de l'Armement (DGA). Texelis employs 350 people and reported revenues of €110M in 2018, a threefold increase since 2015, when the new strategy was adopted.

New Iveco Military Vehicle

(ck) Iveco Defence Vehicles has presented a new unprotected or slightly protected multi-purpose vehicle at EDEX 2018. The new Military Utility Vehicle (MUV) 4x4 builds on the company's experience with light vehicles. The robust and mobile MUV benefits from the use of many commercial components, which reduces the logistical effort. It is available in three GVW versions up to seven tonnes and designed for a maximum payload of four tonnes. The vehicle is armoured and has a modular load handling system. The van and crew cabin configurations (single and double cab) can accommodate a maximum of 14+2 persons with equipment. The MUV can be equipped with engines with EURO VI 175 hp technology or EURO III 146 hp, 175 hp or 197 hp technology; they all are designed for use in demanding environments including extreme temperatures from -32°C to +49°C. They can be coupled with either an FPT Industrial six-speed manual gearbox or an eight-speed automatic transmission with torque converter. The 4×4 permanent drive with front/rear lockable differential and PTO transfer case and independent torsion spring suspension provide balanced off-road mobility, handling and reliability.

Photo: Iveco Defence Vehicles

Preview

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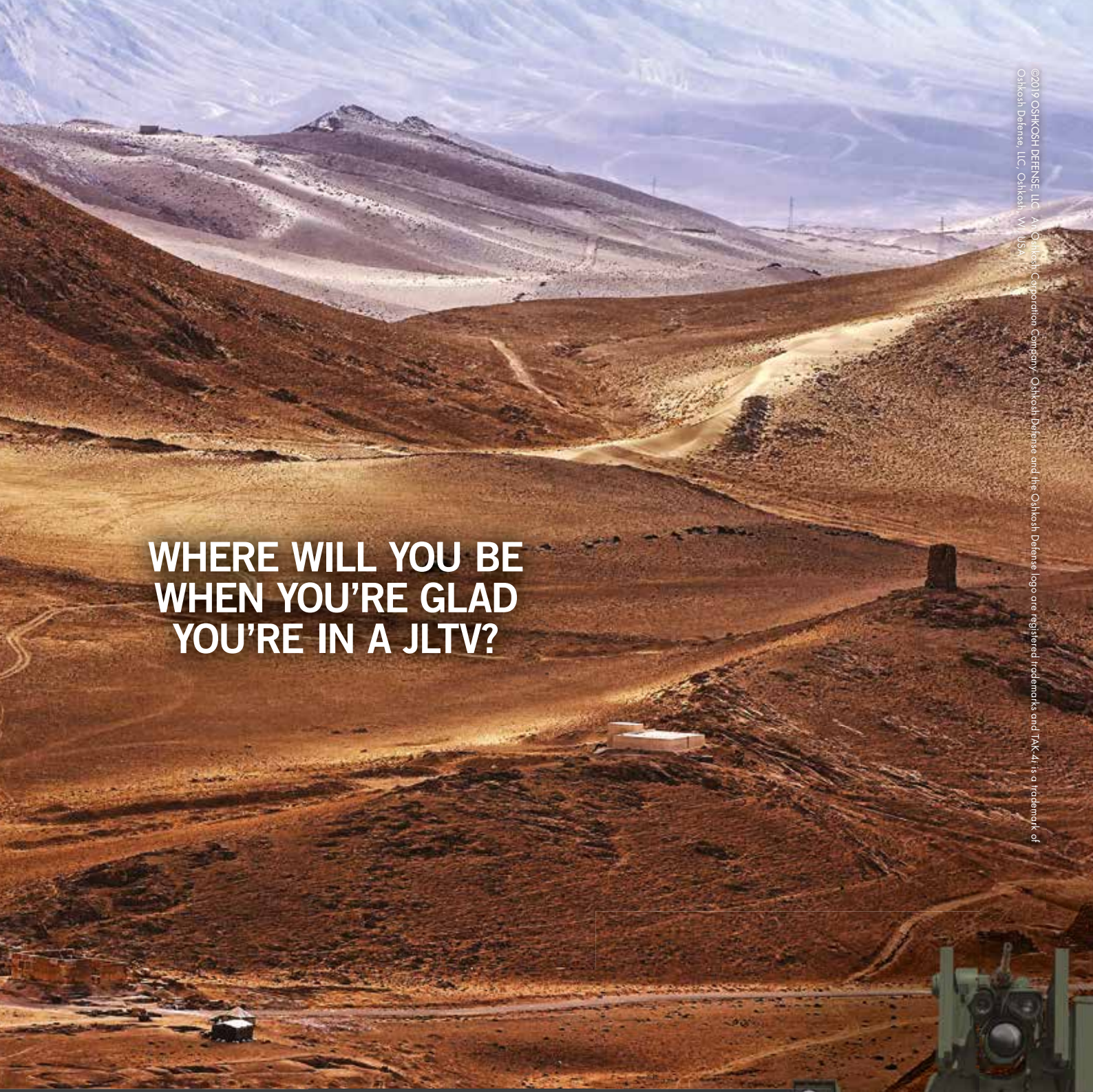

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