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Future Directions for Armoured Fighting Vehicles

Armoured fighting vehicle (AFV) acquisitions, including those for MBTs, IFVs, and Combat Reconnaissance Vehicles (CRV), are moving forward in every region of the world. These include development of new systems, modernisation and upgrade of existing systems, and purchase of surplus AFVs by armies transitioning their armoured force structure. MT looks at these many efforts, of which there are some common directions in both the requirements issued by the military issued and the responses made by industry.

The impetus behind the activity is a combination of evolving threats, new capabilities offered by technology, and increased comfort with and expectations for these technologies. Broadly speaking the common paths encompass armament, situational awareness and survivability. These are, in fact, connected solutions to addressing demands for increased lethality, combat effectiveness and efficiency and solder protection, with each contributing to achieving each of the others. This represents a crossing of traditional design boundaries, with a move towards a holistic approach to addressing the capabilities and challenges of the AFV.

Armament

There has always been a desire to increase the firepower of combat vehicles. However, for the AFV, unlike, for example the MBT or specialty fighting vehicles like the tank destroyer, there is a stronger tension between weapon size and its other required capabilities. Carrying larger calibre auto-cannon in the past required a manned turret to provide adequate mounting and ammunition storage and feed. A sighting system suitable to allow use of the range and accuracy required a gunner and, if concurrent target detection was desired, also a commander. This meant either a one- or two-man station. Crewed turrets required protection, took up roof area, and had 'baskets' that occupy interior space. These add weight and reduce interior capacity. So a decision to 'up-gun' a fighting vehicle required careful consideration of the design and tactical implications.

As a result, larger armaments were generally restricted to reconnaissance vehicles, which did not need to carry many soldiers, and designated IFV, which had a smaller dismounted infantry section. The IFV itself is recognition of the need to accept a balance. It required an uneasy compromise between optimising for dismounted combat or mounted

The STRYKER Infantry Carrier Vehicle, following in the tradition of the M113 APC, was fielded with a .50 calibRE M2 heavy machine gun, albeit mounted in an RWS, serving well in Iraq. Shown here in Mosul with RPG Bar Armour.
(Photo: US Army)

Some MBT, like the Russian T90MS, feature an RWS to replace the open mount commander's hatch weapon. The T90MS RWS appears to be aimed by the commander's panoramic sight. (Photo: AI)

action. Being smaller, the infantry section lost tactical capability for separate manoeuver, so IFV unit tactics reflect the close support of the vehicle and dismounted infantry. Accepting this troop vs gun calibre trade-off has allowed IFV to carry 25, 30, 35, and even 40mm auto-cannon.

A technical innovation altering this design dynamic is the refinement of the remote weapon station (RWS). The latest RWS take advantage of advances in electro-optics and video cameras to mount larger weapons without previous constraints. The RWS is external to the vehicle with the operator positioned remotely from the station, usually inside the vehicle hull. With the gun and ammunition external and sighting accomplished via high resolution cameras mounted with the guns, the interior space claims are limited to the gunner's display panels and station controls. There is no need to penetrate the hull, offering mounting flexibility with regard to location on the roof.

The first successful RWS mounted heavy machine guns. Kongsberg's PROTECTOR achieved particular success with its adoption for the US Army STRYKER M1126 Infantry Carrier from General Dynamics. Benefits of the RWS include its significantly lower weight compared with a manned turret and the ability to provide target engagement with the gunner fully protected. Disadvantages have included limited situation awareness and target detection, and the need to leave protection to reload.

Advances in RWS design are allowing AFV to gain the benefits of a remote armament with larger calibre guns. The début in 2009 of the PUMA IFV from PSM, a joint venture of Krauss-Maffei Wegmann (KMW) and Rheinmetall to replace the German Army's MARDER with an unmanned 30mm LANCE turret, was viewed at the time by some as somewhat unusual. Yet today in the Australian Land 400 competition unmanned turreted vehicles are candidates. In addition, the US Army, in an accelerated development by General Dynamics Land Systems, is fielding an upgrade of STRYKERs to the 30mm Medium Caliber Remote Weapon Station (MCRWS) for its 2nd Cavalry.

The RWS is reaching beyond its application as a primary weapon station for AFV and is now also being introduced as a supplemental weapon. This was first seen on MBT with the US Army's M1A1 TUSK (Tank Urban Survival Kit) developed for improved capability in Iraq's urban areas. TUSK includes the ability for the commander to operate his .50 heavy machine gun from inside the vehicle. This was later updated to fitting the PROTECTOR RWS on the turret roof.

The latest Russian and Ukrainian MBT integrate the RWS into the MBT. The T90MS, for instance, has a 7.62mm machine gun RWS behind the commander's hatch. Introducing the additional RWS increases the crew work load, demands that can be met through training and well-tuned crew drill. The trend toward the RWS as a supplemental armament is now also evident in the IFV. The new Norwegian CV9035 AFV has an RWS on the turret roof. This PROTECTOR RWS can mount either the .50 machine gun or an Automatic Grenade Launcher, and has been seen with a 7.62mm MAG58.

Survivability

Protection, once synonymous with armour, is now simply one aspect of the tools for assuring system (and soldier) survivability. Many militaries are less ready to trade-off personnel safety. Dan Lindell, CV90 Platform Manager at BAE Systems Hägglunds, shared with MT, *"The art lies in achieving the best balance ... Survivability is the most important factor, though this must not be at the expense of mobility, which is a big part of force protection."*

A case can be made for alternate protection, as occurred when confronting the IED in Iraq. The effort focused on both protecting against them and detecting and neutralising them. The result was not only traditional up-armouring but also widespread fitting of IED jammers that would overcome radio command detonation links, something new for ground vehicles but a practice used on combat aircraft for decades. The RPG threat there also saw add-on protection systems like BAE Systems' BAR ARMOUR, introduced in Iraq. The penalty was its weight which was addressed by QinetiQ's Q-Net, which is 40-60% lighter.

While priority has trended toward preventing penetration, a spokesperson for Armatec, a major Canadian armour/survivability firm, stated: *"There is a new emphasis on 'holistic survivability.'"*

This includes eliminating or reducing factors like behind armour spall, blast, secondary effects and even flying objects which increase the lethality of a hit. These reflect designs that not only defeat threats but mitigate post-hit destructive factors, enhancing both crew and vehicle survivability. SAIC's work in the Survivability Upgrade to the US Marines AAV-7 (Assault Amphibious Vehicle) is an example. The AAV-7, despite its Enhanced Appliqué Armor Kits (EAAK), proved in Iraq to be vulnerable to RPG volley attacks and IED. This was exacerbated by secondary explosions of loose ammunition and fuel that resulted in catastrophic destruction of vehicles.

Under a recent USMC contract, SAIC comprehensively addressed the AAV-7 vulnerabilities. IED and mine resistance was added through belly armour, blast resistant seating, relocating and armouring fuel cells, an interior bonded spall liner, exterior armour panels and reconfiguring interior stowage. Many of these solutions were provided by Armatec. SAIC went further by also increasing the engine power, beefing up the suspension and even improving the vehicle's water performance through new

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hydro jets and better trim. This reflects that broad 'system view,' in which automotive performance is integral to overall survivability.

The German Army's new PUMA IFV (and now proposed for the Australian Land 400) takes another approach to crew protection. It moves the commander and gunner into the hull, substituting an unmanned 30mm LANCE turret for the traditional crewed turret. This allows focusing armour and survivability enhancements on the chassis, containing the crew and troops. It relies primarily on data from cameras, sensors and video displays for surveillance and target acquisition. This might be seen as a drawback to being 'head-out;' but a strong case can be made that this is already largely the case when taking advantage of current sensor cueing and hunter-killer sighting systems. Still, old ways change slowly and it is revealing that in the Combat Reconnaissance Phase of Land 400 every candidate vehicle offered a two-man turret.

Survivability Through Detection Systems

AFV survivability is, due to new technologies, going beyond passive measures to those that counter threats by defeating their targeting. These utilise targeting detection sensors to alert the operator if an enemy is initiating an engagement. One such system uses laser warning receivers which sense laser energy from a rangefinder, guided projectile or missile tracker/designator. On detecting the signal the system immediately determines its direction, announces this to the crew and can automatically or when initiated orients the vehicle weapon toward the threat and launches smoke. This obscures the targeted vehicle from the enemy gunner and interrupts the link of a guided projectile while allowing rapid counter-fire.

Other responsive counter-measures are acoustic gunshot detection systems like the Raytheon BOOMERANG III. They detect the fired shot, alert the operator and identify the direction and distance to the shooter. The latest systems, such as QinetiQ North America's EARS, are barely visible on the vehicle. They provide both direction and the GPS physical location of the shooter. This information can be distributed to the entire unit, to higher command and supporting firing units that can thus engage. Another is Rheinmetall Defense Electronics' Acoustic Shooter Locating System. It automatically trains an RWS weapon on to the detected target, allowing immediate and effective return fire. The interconnection between AFV enhances the capabilities of individual on-board sensors and their value is magnified through instantaneous distribution. This faculty is a major component of expanding situational awareness and its new potential capability. Another use of sensors is in 'soft-defeat' systems like that on the Ukrainian OPLOT MBT. Its VARTA optronic countermeasures system uses an IR jammer designed TO DECEIVE incoming missiles and guided weapon trackers. The system is integrated with laser warning sensors and aerosol smoke launchers. Optronic jammers have been favoured by Russian AFV developers and featured as early as their Afghanistan conflict.

Combat Proven Acoustic Multi-Mission Vector Sensor Technology for Radically Increased Survivability

(Photo: Microflown AVISA)

Armed forces rely to an increasing degree on technical superiority over their opponents. This puts extra pressure on procurement officers, as they need to incorporate relative superiority factors into the development and procurement process while keeping a weather eye on the domestic and global defence and security markets for products that are proven, reliable and which meet current needs. Microflown AVISA takes all that into account in constantly improving its already fielded, lightweight, fast and easy to deploy sniper and mortar localisation system.

Contemporary military operational success is no longer measured in large, decisive single battles but in smaller encounters with even smaller margins of error between success and failure. This has led governments to capitalise more resources in new and enhanced capabilities. Today, manufacturers are required to design, develop and bring to the market well optimised systems which deliver end-users the required capability to meet and also counter future threats.

Microflown AVISA's Acoustic Multi-Mission Sensor (AMMS) is one of those innovative systems that can make a difference. It has been fielded with diverse NATO and non-NATO countries and has become a real-game changer in bringing 'ears to the battlefield.'

The Microflown transducer is the first and only acoustic sensor that uses acoustic particle velocity, instead of sound pressure, for measuring the origin of any sound. Due to its intrinsic broad band capabilities this single system can be used to detect, classify and localise all genres of audible threat. Combined with low size, weight and power, the AMMS is a true multi-threat detection system. Further, the innovative sensing units allow for accurate threat localisation with considerable performance in difficult terrain and extreme environmental conditions, handling temperatures from -20 to +50°C, including desert conditions. Based on user feedback, the system has shown steady performance which compares favourably to other acoustic systems in the market.

Furthermore, the latest results have defined once again that the system can perform and support multi-shooting scenarios. In a recent demonstration the AMMS light-weight, fast and easily deployable sensor system was set up in a mountain valley terrain, which included six shooters. Calibres from 5.56-12.7mm were fired in a mix of single shots and bursts. This represents an excessive challenge for acoustic systems and currently no available system is able to perform well in such a scenario, according to the company.

However, the AMMS system proved the opposite and showed outstanding localisation results, performing without reportable fault, as shown in the accompanying illustrations. Each single sensor performed without false alarm or missed detection.

A significant aspect of the AMMS system is that it is very flexible to use and can be employed in a highly mobile environment, as it is fast to deploy and redeploy. It takes just a few minutes by a single soldier on foot to deploy or redeploy a single system. In addition, it can also be used to protect fixed bases.

As well as its ability to detect small arms fire (i.e. snipers), the AMMS system can also locate indirect fire coming from rockets, artillery and mortars (RAM), well beyond the line of sight. The system provides fast, near real-time, localization, allowing for timely counter-measures and responses to be made rapidly when under attack. Having such a good situational awareness allows the end-user to take fast decisions which are time- and cost-effective and will ultimately save lives.

Benefits of Using the AMMS System

The AMMS system enables armed forces to locate snipers or mortars, in mountainous or valley terrain, with a really light-weight system. Enemy action is constrained by knowledge that an attack will produce instant and accurately directed counter-measures. This leads to a lesser requirement for ammunition expenditure by friendly forces, contributing to the system's cost-effectiveness.

All this comes with minimal logistic impact. A full system consists of five AMMS (i.e. Sensor Posts) and one Command Post. Using the system requires just one day of training. A complete system weighs only 32kg, including standard batteries. Furthermore, the ability to initiate counter-measures with lower ammunition expenditure drastically simplifies the logistics requirements. The system has a recording function, allowing for detailed analysis and providing input for an after action report.

The "Survivability Upgrade" of the USMC AAV-7 is an example of a comprehensive effort that includes both protection and performance improvements. (Photo: USMC)

They are reported to be included in several of their new AFV as well. On the other hand, optronic jamming has not gained much acceptance with western AFV. Current detection systems are largely reactive in that they respond to an enemy action – a sniper firing or a gunner initiating an engagement. However a good sniper or gun crew requires only one shot to kill. Industry experts suggest the next step will be for technologies that pre-emptively locate and confirm a hostile threat. This allows AFV to take action to counter the threat on the vehicle's own terms, not the enemy's, before they are engaged.

Active Protection Systems

Another survivability system aims for a hard kill, targeting the incoming threat projectile. These Active Protection Systems (APS), as typified by Rafael's TROPHY, automatically detect a projectile aimed at the host vehicle, assess the threat and actively respond to disable or destroy it before it can hit. They can be a defence against both hand-held (i.e. RPG) and guided anti-tank missiles. A Raytheon APS, called QUICK KILL, according to company officials, *"uses a multi-mission fire control radar to detect and track multiple incoming threats. It then employs a vertically launched hard-kill countermeasure to disrupt or destroy the threat."* Although no NATO Army has yet deployed APS, the Israeli Army began to fit TROPHY to its MERKAVA MBT in 2009 and is pursing broader fielding and development of improved systems. Russia has also developed and made limited deployment of the DROZD-2 and ARENA APS, primarily on MBT.

Although Rafael has introduced a TROPHY LV for lighter combat vehicles, the APS remains primarily used on MBT, principally due to concerns over APS potential to cause casualties to dismounted infantry. In fact, the Israelis have modified their tactics to have infantry follow their tanks at a safer distance. This has caused concern over the resulting effectiveness of close tank-infantry coordination and support. The US Army will be evaluating the APS in 2017. However, as Maj.Gen. David Bassett, Program Executive Office for US Army Ground Combat Systems shared with MT: *"Fitting APS is not simply an 'add-on' - it can require a substantial integration effort and employment considerations."*

Still the Army is also looking at an interim fielding as early as 2020.

What is well recognised is that no single system can assure the survival of the AFV and its occupants. A combination of armour, hit effects mitigation, and attack response technology systems are essential. Rheinmetall Chempro, in collaboration with IBD Deisenroth Engineering, has developed and demonstrated the Advanced Modular Armor Protection system that uses innovative material combinations to get more protection with less weight. It also combines various passive armour suites with an active defence system from ADS. The system can be configured for light to heavy AFVs with detector sensor-directed energy countermeasure modules placed around the vehicle. A company spokesperson indicated that, *"it engages at 10m and does not use a ballistic kill. Thus, it is safe for surrounding infantry but this means that vehicle armour is needed to protect against (the) impact of remaining target fragments."*

An often overlooked tool for enhancing survivability is signature management, commonly also referred to as camouflage. Despite increasingly

Active Protection Systems like the Raytheon QUICK KILL have shown they can detect, assess, respond and destroy an incoming projectile or missile, often in milliseconds. Their drawback has been in the potential for collateral casualties to accompanying infantry and civilians. (Photo: Raytheon)

◁ *The Australian Land 400 program will replace both the Combat Reconnaissance and Close Combat Vehicles. A number of candidates, including the BAE Systems AMX-35 CRV shown, are offering the same turret for both applications. (Photo: BAE Systems)*

capable target acquisition sensors, it remains true that, "what cannot be seen cannot be hit." So, systems like Saab Barracuda's Modular Camouflage System aim to conceal by blending with the surroundings' visual, thermal, radar, and other spectral cues. Though it may not make the AFV "invisible," it has been demonstrated to reduce detection ranges and complicate the enemy's targeting process sufficiently for the friendly vehicle to gain an advantage. Current technology and design approaches can reduce the signature of AFV sufficiently to begin to mitigate many of the advantages of thermal imaging sights, radar, and passive homing sensors.

Situational Awareness and Distributed Data

Perhaps the most impressive advances for AFV and those that portend the highest advantages are digital. The perpetual limitation for combat vehicles – of knowing their immediate surroundings – are being corrected through fitting peripheral video cameras. Michael Mohawk, Vice President for Sales at Sekai Electronics, told MT that the company's AFV systems, *"combine panoramic CCD cameras with software that allows a virtual view of every aspect of the vehicle and the area around it. Even 'seeing' under the vehicle or through it."*

Panoramic stabilised multi-spectral sight systems, once found only on the highest end MBT, are now increasingly viewed as mission essential for any close combat and reconnaissance vehicle. Their observation and target detection on the move can be coupled with automatic target detection that alert crews to possible threats. Most panoramic sights, like the Thales ORION and Rheinmetall Electronics SEOSS, are independent and directed by an operator who detects and identifies targets. However, advances in continuously scanning systems, both infrared rotating and staring arrays, suggest this could be automated in future systems. Electro Optic Industries and Rheinmetall are among those firms that have successfully demonstrated automatic target detection capabilities.

Of equal value to the gathering of images is the ability to distribute these images from any sensor to any position in the vehicle. This is not limited to visuals, but can include any sensor or tactical data and maps. Sharing images and information integrated all soldiers inside the AFV into the combat team, allowing them the ability to more effectively understand what is happening and respond.

This new data distribution ability is even more revolutionary when coupled with advanced digital communication. It allows information intrinsic to each vehicle and that of other unit vehicles and higher headquarters to be shared. This offers the capacity for not just each unit and vehicle but every soldier to have access to intelligence on friendly and enemy dispositions. Having this tactical and operational information in hand improves the possibility for small unit leaders to take the initiative with actions that support the larger mission objectives. The greatest value is not the information itself but the actions that it facilitates to gain the upper hand tactically.

There is a cumulative impact of distributive networking, both within individual AFV and within the tactical unit. The network broadcasting of data allows any on-board sensor to transmit its alerts and threat details to other AFV in the unit. Survivability (and combat effectiveness) thus becomes a team function, not a one-on-one contest. With every AFV sharing, for example, a detector cue, each crew can orient and respond with sound knowledge of the situation and enemy even before being able to view it directly.

The next step in turning this information into a valuable game changer is leveraging multiple distributed sensor data sets with advanced processing. The objective is to use the combination to reliably deliver effective, accurate fire on threat targets, including the incorporation of additional sensor platforms like tactical UAV and forward signals intelligence. A response could ideally be made in minutes if not seconds, not only by organic on-board weapons but by supporting arms, including indirect fire. An opponent's awareness of the certainly of such a response would provide a dominating edge, an overwhelming tactical advantage and a dominating physiological overmatch.

Moving Forward – It's All in the Integration

As capable as each improvement has been in the separate areas of armament, survivability and situational awareness, it is the integration of the elements between them that is making the greatest contribution to AFV combat effectiveness. Even more challenging is the potential to extend this integration to sensors and platforms that are not even located on the vehicle itself, such as tactical UAV, offering the potential for significant extension of battlefield awareness and combat effectiveness. Recognition of this has already been seen in the development of sixth generation combat aircraft: It is the future direction for the AFV as well.

The latest version of the CV90, the -35N, is an evolution of the first design incorporating digital networking, improved suspension, lighter armour, mine protection, perimeter cameras, a panoramic sight and an RWS. It has been selected by the Norwegian Army as their new IFV. (Photo: Norwegian MOD)