Time for Shifting Gears?

Giat VBCI

Had anyone dared predict, only a few years ago, that the main battle tank would no longer be regarded as the focal point of the mechanised armed forces in the Western World, that very same person would have been looked upon as a serious psychiatric case. The facts are clear today, though: the main battle tank market has simply plummeted.

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Indeed, back in 1989, no one would have been able to fathom the extent to which the fall of the Berlin Wall would change the world. Apart from a few exceptions, main battle tank manufacturers are now focusing all their efforts on medium and long-term solutions to keep recently sold models up to the job for at least another 20 – or even 40 – years. In a strange twist of events, a number of those solutions are also being trimmed to equip what have become their business rivals on the market, the light armoured vehicles. Good thing for some of the main battle tank manufacturers if they are also into the light armoured vehicle business. Yet, the established armoured vehicle manufacturers now have to carry out heavy lobbying campaigns to prevent their respective governments from looking too closely at alternative foreign solutions.

However, one should never forget the errors of the past. «It'll never happen again» can always happen again, as indeed it repeatedly has. So the dilemma for both manufacturers and governments is to work out how technologies can be kept alive on the backburner, «just in case». The golden years of state-owned arsenals are gone and buried, and manufacturers need to make a profit to survive. On the other hand, governments have this pernicious tendency to believe that private manufacturers can invest ad infinitum in future technologies and theoretical concept studies. The ideal solution, of course, would be for individual governments to finance such research work and order only a few limited batches of such vehicles that could be ushered into mass production should an urgent need arise. But just by reading those lines, no doubt some will immediately hear the sound of «subsidies in disguise!» wringing their ears. A modus vivendi should, and could, be found. As usual, the solution is in the hands of the politicians, but the latter are seldom present to stick the pieces back together when trouble eventually hits the fan.

Light Armoured Vehicles Er, Light?

The idea behind the creation of the so-called light armoured vehicle was primarily to enable soldiers to follow the main battle tank on the battlefield. For this reason, they generally tended to be tracked, because as 'followers' they had to operate on fields totally broken up by the Tanks. Hasn't this changed...

There are two aspects in the recent evolution of the armoured fighting vehicle: the tracks and the wheels. While the latter still have a penalty in terms of footprint (in other words the pressure they impart on the ground in kilograms per square metre) progress made in tyre technology, drive techniques and suspension systems are making them increasingly attractive. The tracked vehicle, on the other hand, still remains more efficient in extreme terrain, such as snow and marsh. Because of their lower footprint, they also offered a preferred solution to carry heavier turrets. Why offered? Because, as we shall see, the wheeled vehicle is now closing the gap, very quickly.

General Technology – Track

The tracked vehicle still has its attraction. Contrary to a widespread belief, its design looks more complicated than its wheeled

Swan song for the Boxer? Up to recently promised a bright future with some 2000 units at stake, the vehicle is still tri-national in its development and trials phase, but will it survive as a bi-national programme even after a fat-burning diet? (Armada/EHB)

counterpart, but in fact is not. A tracked vehicle can very much be regarded as a 2 × 10 or a 2 × 12 truck rolling on articulated steel carpet, only that it continuously picks the carpet up at the end of the run and reinserts it under the front wheels. The drive thus consists of a couple of half-shafts running out of the differential to drive two sprockets. The only added subtlety is the differential inverter to enable the sprockets to turn in opposite directions to steer the vehicle (as a matter of fact, and to be more accurate, to allow both sprockets to turn in the same direction when one looks from the side of the vehicle; indeed, when a vehicle moves forward, the left wheels turn counter-clockwise, while the right turn clockwise!).

The main disadvantage of the track could be attributed to its weight and to the wear of its articulations. But there is more. The excessive wear factor seems to belong to the past now, since some manufacturers, like Diehl in Germany for example, have devised systems that can run for several thousand miles before needing readjustment or replacement. The track, however, must run on nice, fat rubber pads not only to avoid totally wrecking the surface they run on, but also to provide increased adherence when on a hard metalled surface, otherwise not only will the vehicle simply glide sideways and off a road at high speeds, but it will also find it very difficult to sharply stop or turn. The rubber pads are the Achilles' heel of the track; they are constantly under shearing forces whenever a turn is taken, which gives them a propensity to part company with the vehicle particularly when the separation forces are their peak, i.e. when they reach the apex of the curve at the rear and get catapulted up in the air. If this happens in an urban environment and hurts someone – and it has happened – even a 'liberator' vehicle can instantly become very unpopular. An alternative exists: rubber. However, this type of track can only be fitted to the lighter types of vehicles, although companies like William Cook will undoubtedly, one day, come up with a solution where the heavy tanks will not crush and chew up its own rubber tracks.

«In the armed forces, as anywhere else in today's world, speed has become of prime importance..»

In the armed forces, as anywhere else in today's world, speed has become of prime importance. For an armoured vehicle, this means moving fast on road as well as off. While the track generally has an edge in such terrain, it does have a problem in extreme conditions, because it is not expandable or stretchable. Ideally this facility would be needed to enable all the road wheels to remain in contact with the ground to better distribute the weights over as large as possible a surface. When a vehicle finds itself in a situation whereby only the track portions under the front and rear sprockets are in contact with the ground not only does the track find itself under considerable stress, but its two ends also have to cope with the entire traction duty. An ideal solution, but which still belongs to fiction, would be to find a hydraulic tensioner/loosener that would automatically, and therefore constantly, adjust the track tension according to the travel any given road wheel would require to drop down to maintain contact, or conversely, allow that wheel to move upwards and allow the other ones to remain in contact with the ground. Did we say fiction? Yes, but did say "still", as some constructors are known to work on the problem posed by long-stroke suspensions on tracked vehicles – either heavy or light.

General Technology – Wheel

The wheeled armoured vehicle has always had a tendency to look simpler, like a mere big lorry protected by metal plates, and it certainly lacked the macho image of the tank. But this tendency is now winding down. Under the skin, a wheeled vehicle is a lot subtler than its appearance would suggest. To be truly cross-country capable, it

A Hummer à la Iveco, the MLV will be built under licence by Alvis for the British Army, which has confirmed its selection for 486 units. It has a total gross weight of 7000 kg (of which 1200 kg payload), a choice of 3.2 and 3.5-metre wheelbase and 185 hp from an Iveco F1C common rail Euro III diesel. (Iveco)

Britain's Future Rapid Effect System encompasses a wide variety of roles and variants, and could include 40 mm telescoped ammunition gun turrets and air defence missile launchers, down to the basic armoured troop carriers. (Alvis)

has to be all-wheel driven. This means that power has to be transmitted front, middle and rear through as many differentials as there are axles. Since the idea is to guarantee as much permanent contact to all wheels and the surface as is feasible, an independent suspension is required; because nature has this peculiarity of seldom dispensing the same configuration on both sides of the vehicle. Such a layout in turn requires one pair of universal joints on both sides of the centreline as well as triangulated struts, although torsion bar designs allow the simpler use of trailing arms.

To justify the exploitation of independent suspension to the full, a long stroke, or suspension travel, is required. Here too, phenomenal advances in tyres and shock absorbers have come to the rescue, while hydro-pneumatic systems, a domain pioneered by the French, particularly with the AMX 10RC, are now deemed to offer an ideal answer. Because there is no panacea: a long-stroke suspension tends to be softer, which is quite positive to go over large obstacles and therefore run at lower speeds, but as soon as the surface irons itself out and speed increases, a softly suspended wheel will soon start bouncing about like a pea on a drum and toss the vehicle over its roof. This is hardly a caricature, it has happened – and more often than one might think. Hydro-pneumatic suspensions offer a remarkable flexibility in that they are adjustable to suit the prevailing road conditions. On certain vehicles, like some of the latest Piranhas or the good old AMX 10RC already mentioned, all wheels are independently adjustable, to the extent that when running transversely across a slope, the uphill-side wheels can be retracted and the downhill side extended. Such a feature might be looked upon as an extravagant luxury on ordinary fighting vehicles but certainly a praised one for a driver who feels the rocking movement imparted by a heavy turret up behind his shoulders.

Comes the steering point. As seen above, the tracked vehicle steers by applying a differential torque to the left and right, causing the vehicle to spin around its centre. On a wheeled vehicle, as we all know, the wheels have to be wrenched sideways. This has two drawbacks: they 'bite' inside the cabin, and for proper steering capabilities with a multiple wheeled vehicle, more than one axle will have to be steerable – which takes even more space away from the cabin. The author can testify that on a greasy terrain, the behaviour of a two-axle steered Piranha 6 × 6 versus a single-steered axle Piranha 6 × 6 simply bears no comparison. While the first will gently obey to the slightest inputs on the steering wheel, the second will require a far more determined action to get the front wheels to overcome the in-line resistance of the other two axles. In fact, the vehicle feels like it has a heavy understeer bias.

Returning to the issue of internal cabin space stolen away by the wheels, there are two solutions that allow one to limit the intrusion. One must distribute the steering effort to all corner wheels - in other words, to apply normal steering to the front and opposite steering to the rear. The other is to add differential torque steering to the normal steering when circumstances require a tight turning circle. Giat had applied the technique to its Vextra demonstrator a few years ago. The system simply cuts in when the steering wheel reaches the left or right stops.

The Light Armoured Vehicle Market

Having briefly analysed the pros and cons of wheels versus tracks, let us turn to the success of the 'light' formula, and its evolution. Light, though, may not always be appropriate. Military vehicles, in a way reminiscent with the automobile, have had a tendency to put on weight: a 1970s Golf almost looks Polo-sized compared with the current Golf model and the same could be said of the post-oil crisis American compacts and today's range.

The current range of 20 tonners owe much of their growth to the reduced loss of interest for the main battle tank. However, bigger can also become too big. The three-nation Boxer is a good example of this governmental mismanagement. The official roll-out of the first two prototypes took place in Munich on 12 December 2002, only to see the programme stabbed in its back in July by Britain's decision to pull out on the grounds that, after all, 27 tonnes was way too heavy. The irony is that much of the excess weight was due to the fact that Britain had demanded a serious roof armoured protection to protect the vehicle from top attack (which, given the performance of current top attack weapons, amounts pretty much to wishful thinking). According to an Alvis Vickers official met at the DSEi exhibition in September 2003, the manufacture of the twelve planned prototypes shall continue since all three nations were committed to the development phase. Under what form, though? Indeed, both the Dutch and the Germans – if they want to save the programme – will have to find ways of seriously cutting down both development and production costs. The Dutch planned to replace all its existing light armoured vehicles (including its ageing M113s) with 384 Boxers, while Germany was expected to acquire up to 1000 units. Britain, on the other hand, wanted 775 to replace its FV430s, Saxons and CVR(T)s.

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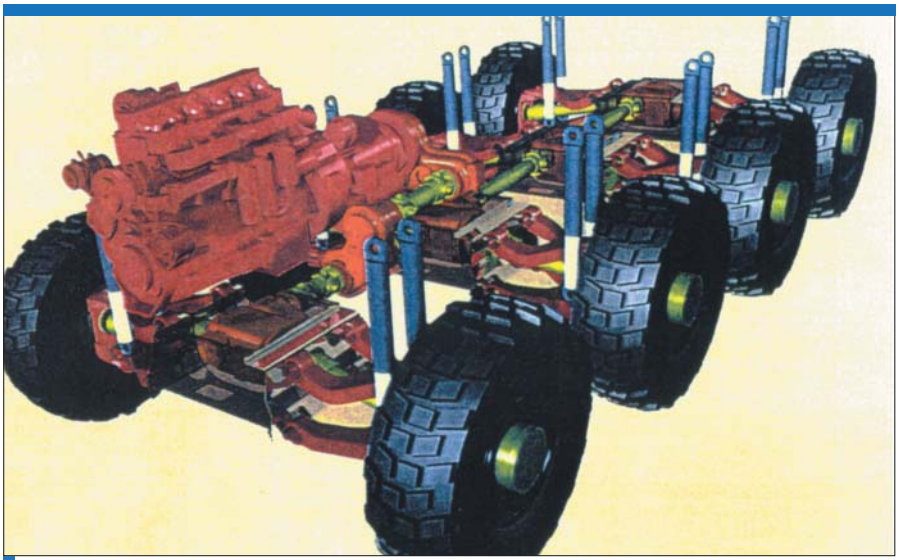
In a somewhat odd move, the British Ministry of Defence announced during DSEi in September 2003 that part of



The VBCI has an independent hydropneumatic suspension which enables it to jam up a wheel that has suffered damage on a mine. Its 550 hp engine affords it a road speed of 100 km/h. (Renault)

these will be replaced by a much lighter set of wheels, the Italian Multiple Purposed Light Vehicle. Designed by Iveco, the vehicle will be built under license by Alvis Vickers as part of the 'future Command and Liaison Vehicle programme'. «The [£ 200 million] contract for the 486 vehicles still has to be signed, but production will start next year or so,» said Alvis Vickers at the time of the DSEi exhibition. In a more size-for-size replacement, though, it is more likely that the big Boxer gap will be filled by the Fres.

There is no doubt that the money saved on the industrialisation and procurement of the Boxer by the United Kingdom will help push ahead the Future Rapid Effect System. Also known as Fres, this project follows yet another defunct project – the Anglo-American Tracer. While it is still a paper project, the Fres was scheduled to enter service in 2007. One can now safely speculate that this will not happen before 2010 at the earliest. The idea is to build, and initially procure, some 1500 vehicles with a service weight of between 17 and 24 tonnes depending on its armament and versions (there could be up to 15 or 16 if one includes engineer and demining versions). At time of writing, important definition discussions were underway, so any description of the Fres can only be speculative. One can safely predict, however, that should the project metamorphose itself into a programme, prime contractorship would be entrusted to Alvis Vickers. Traces of the former alliance with the United States would appear to survive with General Dynamics handling the assessment phase (although the Americans will not acquire the Fres; this appears to be a cross-feeding of information between the British vehicle development and the work being carried out on the Future Combat System in the United States).

Raytheon, for example, is offering an open architecture-based reconnaissance, surveillance and target acquisition system using a Thales radar and an Alvis-built pylon. Much of the technology would be derived from the know-how acquired by Raytheon in the context of a $ two million Future Combat System study contract awarded by the US Army to continue with the development of this automatic target acquisition system. Raytheon, a company official recently told Armada, has invested $ four million of its own money on top of that.

The Patria AMV seen here is representative of one of the versions ordered by Poland and sports a 30 mm Oto Melara Hitfist turret. (Patria)

VBCI: In France, developments in the field of light armoured vehicles are going apace, in total contrast with the tremendous downsizing trouble Giat has to face following the crash of the tank market and the severe procurement cuts in the French Leclerc orders. A complete restructuring of the company is underway with plans to gradually establish a new company under the name of Giat Systèmes headquartered in the centre-east city of Roanne, with a subsidiary known as Giat Munitions. In total contrast with both the above and with the troubled Boxer programme (which in total irony included France in its initial stages), the initial phase of the VBCI programme appears to be as steady as a locomotive on rails with the development and the firm order for the production of a first batch of 65 units, including 54 Dragar-equipped infantry fighting vehicles and eleven command posts.

Ultimately, some 700 VBCIs will be produced, including 150 VPC command posts and 550 VCI infantry fighting vehicles. The latter category could eventually include a number of variations, although the prime, basic vehicle will be equipped with a 25 mm Dragar turret developed by Giat. The whole idea behind the VBCI is to replace the tracked AMX 10P (760 units in France) and, up to a certain point, the wheeled VAB. The first VBCIs are scheduled for 2006 and, pending formal receipt of additional orders, deliveries to the French Army would throttle up to a rate of 100 vehicles per year until 2013.

In addition to the Dragar turret, the 25.6-tonne combat weight VCI will be equipped with a laser rangefinder and a thermal sight, a rear Infrared countermeasure system as well as a Sit information system terminal based on the Finders developed for the United Arab Emirates Leclercs. Thus equipped, the VCI will seat eight infantrymen in addition to the driver, the commander (seated behind the driver) and gunner. Interestingly, the commander will have the ability to take over full control of the turret.

A first prototype representative of the VBCI with a Dragar turret is expected to be rolled out in April or May 2004. This will be followed by another two vehicles that will be delivered to the DGA, which will test them for about a year. Giat will also deliver a naked, but armour-equipped, hull for ballistic testing.

The VBCI family was being developed and was to be marketed by Satory MV, a joint venture between Giat and Renault Trucks Défense, the latter being more essentially involved with the entire power chain. The hull is very much in line with Giat's philosophy on modular design, being made of welded aluminium – therefore a relatively light structure which has excellent spall protection properties, tough composite spall lining

Like most vehicles of its generation, the Piranha IV features easily replaceable armour plates. It is seen here with a 25 mm Bushmaster gun turret. (Mowag)

The photograph at left shows that the Stryker cannot really be rushed into, or out of, a C-130 as there is precious little space if any for the loadmaster to run about it. The gun is on a folding mount and is here seen in its stowed position. The right picture displays reality with the weapon system erect. (General Dynamics Land Systems)

can be added if needed – to not only allow the emplacement of armour 'a la carte' (titanium-based in this instance), but also to easily enable a user to upgrade (at depot level) the vehicle's protection as new and more effective armour is developed. A perfect example of this progress is now given with the last 92 Leclercs to be delivered to the French Army. The VBCI will, of course, be aero-transportable in a Military Airbus A400M. Giat says that the vehicle could receive additional reactive armour to improve protection against RPG7s.

The overall concept of the VBCI, however, will enable the vehicle to accept a total load of 28 tonnes (some sources mention 32 tonnes, but a Giat official told Armada that this was not likely to happen in the foreseeable future), which leaves a comfortable margin for future expansion, one of which could be the 40 mm telescoped round turret developed by CTA (a Giat and BAE Systems RO joint venture). A 105 TML is certainly in the realm of possibilities, while a 120 mm smooth bore turret would really push the vehicle into its weight limitations – the aforementioned 32 tonnes.

The reason why we use the past tense in the sentence referring to Satory MV stems from the fact that both Giat and Renault announced on 25 September 2003 that this marketing structure had been shut down and the marketing responsibilities for the light armoured vehicles redistributed. Giat now carries prime contractorship for the VBCI as well as for the AMX 10P and the AMX 10 RC, and will be responsible to Renault for the production of the hull and weapons suite of the VAB. Renault's responsibilities are a complete mirror figure of this, and involve the marketing leadership of the VAB and production of the entire powertrain for all vehicles.

AMV: Another new wheeled vehicle to have recently scored a resounding export success is the Patria 8 × 8 AMV. Initially developed to meet the requirement of the Finnish Armed Forces, it was selected and then ordered by the Polish land forces. The order for no less than 690 vehicles was placed on 20 December 2002. Ten per cent of these will be built and delivered by Patria, while the remainder of the vehicles will be licence produced by the Military Mechanical Works in Siemianowice, and 313 of these will carry an Oto Melara 30 mm Hitfist turret.

In Finland, the development of the AMV was very much linked or paired with that of the Amos twin-barrel mortar turret, also developed by Patria (Vammas), but in cooperation with Hägglunds (which subsequently came under the control of Alvis). Finland ordered 24 of these turrets, to the tune of € 100 million, which are scheduled for delivery between 2006 and 2009. To wrap up on the subject of the Amos, the turret was also short listed as one of the candidates to equip the mortar version of the American Future Combat System. In this particular case, Patria Hägglunds sold a technology license to AAI in January 2003.

Returning to the vehicle itself, another batch of AMVs – approximately 100 this time, but equipped with a 30 mm canon turret – became the focal point of a memorandum of intent signed by the Finnish Defence Forces in March 2004. The Finnish Army has ordered the first pair of vehicles about two years ago and they were delivered in 2003 for testing purposes.

The AMV perfectly fits in the current trend for wheeled vehicles: 25 tonnes fully loaded, independent hydro-pneumatic suspension (ride height control on option), road speed of 100 km/hour and adaptability to a variety of turrets. A Patria brochure even shows an illustration of an AMV in 'Light Mobile Gun' guise.

Piranha: Born in Mowag's workshops on the peaceful Swiss shores of lake Constance, the Piranha family not only expanded both across the Channel at Alvis' and the Atlantic at General Motors' where it became known as the LAV (and since came under the fold of General Dynamics, of course), but also went through no less than three generations. Strictly speaking, though, the Piranha IV is more than an extra generation, it is a new breed altogether and is much larger than even its similarly wheeled predecessor. This vehicle is in fact pretty much in the league of the Boxer, Terrex and VBCI 25 tonners and the sole prototype, shown at the 2001 DSEi exhibition in London, even looked like a finished, definitive product (a second prototype was in the final stages of assembly at time of writing). The vehicle was designed from the outset to offer a high degree of

In the upper range of the Stryker Spectrum is the Mobile Gun System, pictured here demonstration that it can cope with soft sand. (General Dynamics Land Systems)

The open vee shape of the outer floor of the Singapore Technologies Kinetics Terrex is particularly noticeable from the front. The swivelling twin propellers at the back testify to the floating abilities of this steel monster. (STK)

protection to its occupants (against 14.5 mm all round, 25 mm sabot frontal arc and eight kilo mines underneath) and to be integrated within a battlefield management network.

At the last DSEi exhibition in September 2003, the Mowag IV was displayed with a two-man General Dynamics turret mounting a stabilised 25 mm Bushmaster canon. The vehicle is far from being underpowered with 544 hp (400 kW) on tap from its MTU, which means that it too could see some tank calibre land on its roof if needed. The seven-gear ZF-Ecomat auto gearbox dispenses the power to the eight wheels, which are independently linked to the body through a semi-active hydro-pneumatic suspension with independent control on each wheel. Both the front axles steer, but for on-a-penny turns a differential steering system cuts in.

Stryker: Initially known as the IAV for Interim Armoured Vehicle, the Stryker is based on an LAVIII, in other words, a Piranha III 8 × 8. The intention was to provide the Interim Brigade Combat Teams with a family of rapidly deployable vehicles. This was obviously not to the liking of 'certain people' who sparked of a hot campaign against the vehicle's alleged poor protection. The campaign has been going on for virtually two years and even culminated with a circular anonymously distributed at the 2003 DSEi exhibition entitled «The Stryker RPG 7 Armor Desaster» (typo included). However, these people are obviously unaware of the fact that RPG 7s have managed to defeat even heavier armour, as the Russian Army can testify. One cannot have ones' cake and eat it; it is as simple as that. If one genuinely wants a C-130 transportable vehicle, there are obvious limitations in weight and size. There is a word for this and it is known as compromise. Furthermore, the vehicle must be taken as an interim measure, as its former designation stipulates. Nevertheless, United Defense was indeed awarded a contract to develop an RPG 7-proof appliqué ceramic armour which should be tested by February 2004. In the meantime, the US Army has developed a grid array that mounts around the vehicle to set off the warheads before they hit the vehicles.

Some 2131 Strykers are to be produced in a number of variants, from the basic troop transport to the 105 mm Mobile Gun System based on the first cannon that originally equipped the Abrams tank. Particularly aimed at urban warfare, the Stryker has a range of 300 km and a dash speed of about 100 km/h, but still retains the central tyre pressure adjustment system to adapt the vehicle to prevailing driving conditions. The final weight/true C-130 Ro-Ro performance/dimensions data will only be established once the Strykers are fully equipped with their new armour.

Currently, the basic Infantry Carrier Vehicle has an appliqué armour produced by IBD Deisenroth protecting its eleven occupants (including crew of two) against 14.5 mm rounds and artillery fragments, weighs in the region of 19 tonnes and mounts a remotely controlled .50 cal Mk 2 machine gun or a 40 mm Mk 19 grenade launcher. A most important feature of the Stryker are the FBCB2 communications which enables all vehicles to receive and provide position and heading text and data as well as terrain mapping and intelligence data (friendly forces and enemy locations).

European GDLS Centre

The General Dynamics European Land Combat Systems office was set up in Vienna by General Dynamics in October 2003 to centralise the marketing activities of the American company's subsidiaries in Europe. These include Mowag in Switzerland, General Dynamics Santa Barbara Sistemas in Spain and Steyr in Austria.

Terrex: A relative newcomer in the wheeled fighting vehicle arena is the Terrex from Singapore Technologies Kinetics. Unveiled to the public in prototype form during the 2001 DSEi exhibition it belongs to the heavier category of light tanks, rubbing shoulders with the Piranha IV and the VBCI. Weighing 17.5 in its basic configuration (but down to 13 tonnes naked and dry), it could be up-armed with a 120 mm howitzer turret, according to its manufacturers, which would bring it into the region of 25 tonnes. Press releases even show a drawing of a 155 mm howitzer turret. The Terrex is a modular development in that, except for its hull, it makes use of readily developed components. For instance, the entire independent coil spring and double wishbone suspension is from Timoney (Ireland) and offers a generous +150 and –250 mm stroke while power is delivered by a 400 kW Caterpillar C9 diesel through an Allison autoshifter, although an MTU Europack could be fitted on customer's request. Like its counterparts, it has a double floor (the lower slightly V-shaped) to increase protection against mines. Singapore Technologies told Armada that it could withstand a blast from a 12 kg trinitrotoluene charge. Possibly one of the most remarkable features of the Terrex is its modular roof design, which enables it to receive a variety of configurations, one of which being a twin-hatch enabling the vehicle to be converted to a mortar carrier. The hull features sturdy frames to guarantee rigidity.

The Terrex is still under development and testing, but most interestingly the Singaporean company has recently signed a memorandum with Otokar from Turkey to develop another 8 × 8 based on the Terrex.

Pandur: Now under development at Steyr in Austria is the Pandur II. Basically identical to the original Pandur of which 285 6

The Steyr Pandur family is now venturing into the 8 × 8 world. The prototype of the Pandur II (there is no first-generation eight wheeled Pandur) is here seen undergoing trials in Austria. (Steyr)

The Arzamas BTR-80 has been exported to several countries, like Turkey for example, which are outside of the normal Russian sphere of influence, and to the United Arab Emirates as seen on this picture where it mounts a formidable KBP Kluiver turret combining missiles and a 30 mm 2A72 gun. (Armada/EHB)

× 6s have been sold since its introduction in 1996, the Pandur II incorporates a digital engine and gearbox management system to make the vehicle compliant to new environmental regulations. Currently, three vehicles are being submitted for tests in view of customer trial. Steyr is also working on improved floor protection against mines and on a Node digital system which will facilitate the integration of identification friend-or-foe and battlefield management systems. The real novelty in the Pandur II range is the introduction of an 8 × 8, which did not exist in the first generation.

BTR-80: Now the standard 8 × 8 in the Russian army, the BTR-80 is looking at the export market. To this end, its manufacturer Arzamas based in Nizhni Novgorod is offering a model powered by an American Cummins 6CTA-250 diesel driving an eight-gear ZF9S-75 in lieu of the original 191kW Kamaz. Whatever the set of pistons, the vehicle can travel over a range of between 600 and 800 km/h on a 290-litre tank of diesel. An innumerable amount of versions are available (command post, recovery, ambulance and so forth) but powerful turrets can be mounted like the KBP Kluiver or the Nona SVK 120 mm mortar. Breech fed, the system includes an autoloader and can even fire western rounds.

CV90: The Hägglunds CV90 has been with us for a number of years now, but probably is the most advanced tracked infantry fighting vehicle readily available in the Western World. Now an Alvis Hägglunds product, the Swedish vehicle was engineered with all the care that usually goes into an aircraft, which is hardly surprising since its main designer had previously been an aeronautical engineer with Saab. It incorporates a number of clever features. For instance, the engine bay was designed in such a way as to allow quick removal of the engine, with only eleven points to be disconnected. The engine itself slides into a fitting very much inspired from ski binders as explained to Armada by the designer himself. Then great care was given to infrared stealthiness: the engine compartment hatch, for instance, also acts as the air intake; in other words it is double-skinned, the intake slats being in the upper portion and the air sucked downwards through the panel to reach the air filter so as too keep the 'lid' as cool as possible. Likewise, the engine radiators are in the rear, but the plumbing is shielded within a duct that is also ventilated.

Although a tracked vehicle, the CV90 drives as easily as a large (right, very large) road vehicle. It can receive all manner of turrets. In the upper range, there is the Patria Hägglunds Amos twin-barrel 120 mm system, which was ordered by the Swedish Army. A prototype also featured a Giat TML 105 gun and even a Ruag 120 mm Compact Tank Gun, complete with battlefield management system, three independent sights and defensive aid suite including laser, radar and missile approach warners as well as a multi-spectral aerosol dispenser. This particular vehicle is known as the CV90120-T. Now being developed is a CV90 Mk III with a more powerful Scania diesel, improved armour (which probably explains the need for the extra horses) and an ATK 35-50 mm gun.

Since the delivery of the first of 509 CV9040s developed in conjunction with Bofors to the Swedish Army in 1 November 1993, the CV90 has done rather well for itself. The last vehicle was delivered to the Swedish Army on 24 September 2002, but the service has since ordered another batch of 40 to carry the Amos turret. Finland has ordered 47, Norway 104 (CV9030 – 30 mm Hägglunds turret with Bushmaster II) and Switzerland 186 (CV9030, of which 32 are command posts). Currently the CV90 is fighting on two new fronts: Netherlands, where there is a requirement for about 200 and Greece where a contract for 150 vehicles is to be won.

BV206/BvS10: Yet another Swedish product from Örnsköldsvik that has been around for a while, the BV206 has constantly been kept up to date by Alvis Hägglunds to the extent that the latest development, launched in 1998, had to be renamed. Known as the BvS10 the tandem tracked vehicle has been developed on company funds to offer increased power (250 horsepower – 186.5 kW), an automatic six-gear cog job, improved protection against 7.62 armour-piercing rounds and a higher road speed. The BvS10 typically tips the scales at 3100 kg (850 front and 2250 kg aft), but this depends of course on the customer's desired configuration. It seats four in front and ten in the rear cabin, and can swim at five kilometres per hour. It already has a customer, the British Royal Marines, which ordered ten on 9 March 2000. Known as the Viking there, the first unit was delivered on 1 July 2003.

The latest version of the BV206, however, remains in production and is still being marketed. So much so, in fact, that the Italian Esercito ordered 112 units to the tune of £ 40 million on 9 October 2003. To be delivered between 2004 and 2007, these add to the approximately 11,000 BV206 series sold to 40 countries worldwide. Italy, which is actually expected to acquire a second batch of 77 is also spending some £ 5.7 million on the upgrade of 40 of its 100 older BV206s (the first 60 have already been modernised under an earlier contract. Other recent exports include Germany which acquired 31 BV206Ss on 7 March 2002 for its medevac and its airborne units (but the final requirement there is said to be

The Stalker from Minotor returned to Idex in 2003 to provide a rather dynamic display of its agility. Its unusual speed for a tracked vehicle and its stealth capability are not its sole characteristics: apart from a sophisticated fire control and weapons suite, it also features a system that records and transmits video data from its sensors to a command post. (Armada/YL)

for some 200 vehicles), Spain which parted with £ 2.8 million to purchase of ten units on 20 October 2001 and France ordered twelve on 22 June 2000.

Bronco: Now keeping company with the Swedish BV series, but in a much heavier category, is the Singapore Technologies Bronco, which started life as the ATTC when it was unveiled to the public in 2000. With a gross weight of 15 tonnes, it probably needs the extra 100 hp from its turbocharged 350 hp (261 kW) Caterpillar to propel it to 60 km/h on its moulded rubber tracks. It carries 16 troops; slip six in the front car and ten in the rear. Normally, articulated vehicles like the BV206 and the Bronco are totally deprived of any steering capacity if the two cars are separated, since they turn by virtue of powerful actuators that push the cars into a < or > configuration as seen from the top. Singapore Technologies is now working on a differential transmission that would enable the vehicle to steer its way around once unhooked. The Bronco is now in service with the Singapore Armed Forces.

Stalker 2T: Jointly developed by Minotor with a number of other Belarusian and Russian companies, the Stalker is not only new, but also looks futuristic to the extent that it could have been designed somewhere near Maranello had it been finished in signal red. Designed as a light tank, its systems are highly automated and it boasts stealthy features, which probably makes it the most advanced Eastern armoured fighting vehicle on offer. Making its first international appearance at Idex in 2001, the Stalker weapons suite includes a fully stabilised KBP 2A42 30 mm cannon with a 7.62 mm coaxial machine gun, two retractable launchers each able to fire two KBM Igla air-to-air or two KBP Shturm anti-armour missiles plus a 30 mm automatic grenade launcher. The fire control system can handle simultaneous engagement of two targets with different weapons and, in addition to a laser and infrared warner, it also features a rear-looking television camera. The 27.4 tonne vehicle looks fast and it is: 96 km/h, courtesy of no less than a 620 kW producer. The Belarus army was at a time said to be interested to acquire a first batch of 30 Stalkers, but no announcements have been made public on the subject.

Further Down the Road

Turning to vehicles that are further down the road, mention must be made here of the American Future Combat System, the French EBRC, the Swedish SEP and SD2 and work being carried out by United Defense on the FCS-W.

One would be tempted to say that, naturally, the current focusing point of research is on electric propulsion. However, the battle is far from being won and, as testified by one of Armada's faithful readers in the United States, Donald R. Kennedy, who has been involved in defence design since 1948, has started quite a while ago: «The power train technique known as hybrid technology for combat vehicles originated in a system concept that I did for the US Armor Association in 1962. They had sponsored an international contest seeking ideas for the future. My concept was done in considerable detail and was for a future light tank weighing only 10 tons. It featured a series hybrid propulsion system, namely a gas turbine main engine that drove brushless alternators to generate electricity that fed motors in every wheel set. Each hub was the stator, the wheel the rotor. This was a wheel/track Christie-type system with a rubber band track. Loss of track converted the vehicle to a multiple wheel, electrically steered vehicle. The remaining technical challenge was to employ lightweight materials to minimize unsprung weight».

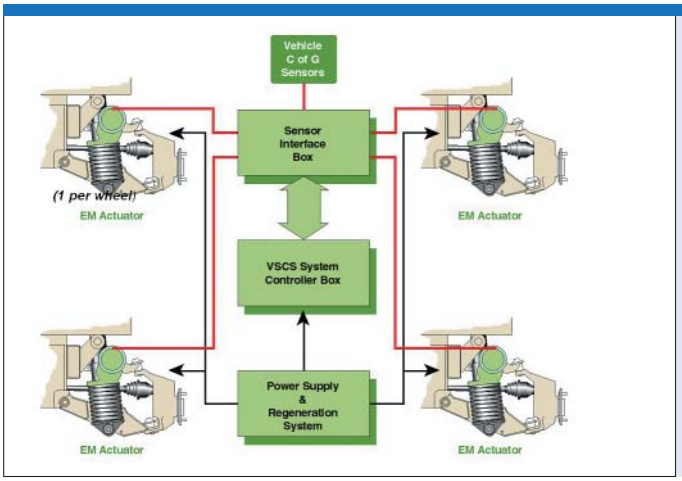
Minimising unsprung weight is something that obsessed even Ettore Bugatti, who, in the early 1930s, invented a light alloy wheel into which the brake drums were embedded to save weight and dissipate brake-generated heat. However, apart from the weight (the heavier the weight, the stronger the shock absorbers and the higher the heat needing to be dissipated, from the absorbers this time), the other challenge is to develop materials for both the stator and the rotor that will not simply shatter as the wheels are kicked upwards at every obstacle. As we can see from another section of Kennedy's letter, the idea of the 'plastic tank' on which Qinetiq has been working on for a while is not new either: «The vehicle armour was mainly composite materials, 50 millimetres of fibreglass as the inside hull, that was surrounded by a thin eight-millimetre shell of maraging steel with the 150 to 200 mm space between the two hull pieces housing things and materials we would use, such as fuel (multifuel), crew tools and personal gear, miscellaneous items whose loss would not render the system vulnerable to combat loss, etc […] there were many other features, and many of those have subsequently shown up in the designs of newer vehicles […] a composite material for the inner hull and turret was selected to minimize spall from those weapons that defeated the armour. I was to later introduce Kevlar based composites in the US for spall suppression liners. Needless to say I was delighted with the hybrid systems described in the article *Beyond Leaf Springs*» (see Armada 4/2003, p. 22).

«Minimising unsprung weight is something that obsessed even Ettore Bugatti, who… invented a light alloy wheel into which the brake drums were embedded to save weight and dissipate brake-generated heat.»

Active Suspension

The ability to traverse terrain at high speed is a major factor in determining the combat survivability of armoured Fighting vehicles. For any given terrain, the higher the vehicle speed, the greater the shocks which must be handled by the vehicle's suspension system, and inevitably, the rougher the ride for the crew and for the motors that they will eventually house.

Traditional passive suspension systems use springs, torsion bars, or similar devices to absorb the energy from the



This diagram shows the principle components of Northrop Grumman's Ecass. (Northrop Grumman)

www.armada.ch A Selection of Main Battle Tanks

General Dynamics LS Abrams M1A2

4	67.6	120 mm	16.11	1.54 [kg/sq cm]	manual

1102.4 kW Textron Lycoming AGT1500

Crew Sights
Driver – Gunner – Commander
D 3 periscopes
G DRS IR two-axis
C Raytheon thermal CITV

combat weight 69,540 | 1665 litres

Iveco Fiat-Oto Melara Ariete

4	65	120 mm	17.40	not specified	manual

937 kW Fiat V12 MTCA

Crew Sights
D 3 p/scopes, 1 intensifier
G thermal
C Sfim SP-T-694

54,000 | *1200 litres

Vickers Challenger 2

4	59	120 mm	14.00	0.90 [kg/sq cm]	manual

880 kW Perkins Condor V12

Crew Sights
D day + imaging IR
G stabilised thermal
C stabilised thermal

64,000 | 1590 litres

Hyundai K1A1

4	65	120 mm	16.15	0.88 [kg/sq cm]	manual

880 kW MB 871-Ka-5501 V8

Crew Sights
D not specified
G Raytheon day + IR
C day + infrared

54,500 | 1130 litres

Giat Industries Leclerc Emat

3	72	120 mm	19.50	0.90 [kg/sq cm]	auto

1102 kW Wärtsilä V8X

Crew Sights
D 3 p/scopes i-intens
G HL60, IR, day + TV
C HL70, i-intens, dual mag

56,500 | 1300 litres

Giat Industries Leclerc Export

3	72	120 mm	19.50	0.90 [kg/sq cm]	auto

1102 kW MTU 883 V12

Crew Sights
D 3 p/scopes i-intens
G HL60 Athos IR, day + TV
C HL80, IR, dual magnif

56,500 | 1300 litres

www.armada.ch

Al Faris / Al Fahd

1+11 | 90 | up to 105 mm | undisclosed | 14.00 | variable | 294 kW Deutz 10 cyl

Crew Sights
Driver – Gunner – Commander
D optional
G optional
C optional

21,000 | 500 litres

Patria AMV

1+9 | 100 | 2 x 120 mm | undisclosed | 14-24 | auto (mortar) | 360 kW Scania DI 12

Crew Sights
D 3 p/scopes optnl night
G Soptac x8 day/night
C TJN2-71 day/night

15,880 | 525 litres

Artec Boxer

2+8 | 100+ | 12.7 MG | not specified | 33 (max) | not applicable | 530 kW MTU

Crew Sights
D not defined
G not defined
C not defined

28,500 | undisclosed

JSC Arzamaz BTR-80A

3+7 | 90 | 30 + 7.62 | 2.03 [kg/sq cm] | 13.00 | dual feed | 191 kW Kamaz 7403

Crew Sights
D optional
G day 1PZ9 night TPN3-42
C not specified

14,550 | 300 litres

JSC Arzamaz BTR-90

3 | 100 | 30 KBP 2A42 | not specified | 17.90 | dual feed | 368 kW 2B-06-2C

Crew Sights
D periscope
G BPKZ-42
C 1P-13

20,920 | *400 litres

Steyr-Daimler-Puch Pandur II 6 x 6

2 (basic) | 100 | up to 30 mm | variable | 17 or 19.50 | variable | 265 or 302 kW

Crew Sights
D periscope
G depends on turret
C not applicable

15,000 | 295 litres

Steyr-Daimler-Puch Pandur II 8 × 8

2 (basic) | 100 | up to 105 mm | variable | 15.00 | variable | 302 kW

Crew Sights
D periscope
G depends on turret
C not applicable

20,000 | 287 litres

Mowag Piranha III 10 × 10

4 | 100 | up to 105 mm | 460 [kPa] | 14.50 | semi-auto | 261 kW Detroit 6V53TA

Crew Sights
D interchangeable
G thermal 2M336
C HL 69 light-intensifier

20,000 | 400 litres

A Selection of Armoured Fighting Vehicles

Mowag Piranha IV Basic

2 crew

100 km/h

up to 105 mm gun/turret

481 [kPa] footprint

16.60 power/weight

variable weapon load

400 kW 544 MTU Powerplant

25,000 combat weight

Crew Sights
Driver – Gunner – Commander

D day/night

G depends on turret

C BMS option

400 litres fuel capacity

Textron M & LS Stryker

2+9 crew

98 km/h

40 mm Mk 2 gun/turret

undisclosed footprint

17.00 power/weight

N/A weapon load

268 kW Caterpillar Powerplant

17,237 combat weight

Crew Sights

D 3 periscopes +

G as required

C as required

302 litres fuel capacity

ST Kinetics Terrex

2 or 3 crew

120 km/h

up to 105 mm gun/turret

undisclosed footprint

12.00 power/weight

variable weapon load

298 kW Caterpillar C9 Powerplant

25,000 combat weight

Crew Sights

D 3 periscopes

G depends on turret

C depends on turret

*400 litres fuel capacity

Rheinmetall TPZ1 Fox

4 crew

96 km/h

20, TS-15 gun/turret

undisclosed footprint

13.80 power/weight

not specified weapon load

235 kW Powerplant

17,000 combat weight

Crew Sights

D not applicable

G Steinheil LZL2000

C not applicable

*300 litres fuel capacity

Giat VAB Dragar

2 crew

110 km/h

25 mm gun/turret

undisclosed footprint

15.80 power/weight

dual feed weapon load

219 kW Renault MIDR 062045 Powerplant

13,800 combat weight

Crew Sights

D optional

G day 7x, light-intens 4x

C not applicable

300 litres fuel capacity

Giat VBCI

3+8 crew

100+ km/h

25 mm Dragar gun/turret

undisclosed footprint

18.00 power/weight

dual feed weapon load

405 kW Renault Powerplant

25,000 combat weight

Crew Sights

D day/night

G day/night

C day/night

450 litres fuel capacity

Patria Vehicles XA-200

2+10 crew

95 km/h

up to 90 mm gun/turret

undisclosed footprint

10.00 power/weight

variable weapon load

202 kW 6-cyl Valmet Powerplant

22,000 combat weight

Crew Sights

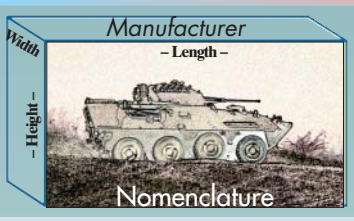
D not available

G not available

C not available

280 litres fuel capacity

Manufacturer Nomenclature



crew

speed km/h

gun/turret

footprint

power/weight

weapon load

Powerplant

combat weight

Crew Sights

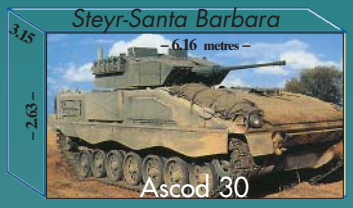
D driver

G gunner

C commander

fuel capacity

Steyr-Santa Barbara



4

70

30 mm Mk 30

166 [kPa]

15.48

dual

441 kW
MTU 8V 183
TE22 8 V-90

28,500

Crew Sights
Driver – Gunner – Commander

D 3 periscopes
G day/night
C relay from gunner

860 litres

ST Kinetics

3

70

25 mm

0.62 [kg/sq cm]

16.11

not applicable

355 kW
DDC 6V92TA

20,500

Crew Sights

D 3 periscopes
G thermal
C relay from gunner

*600 litres

Kurganmashzavod

3+7

70

100, 2A70

0.60 [kg/sq cm]

19.70

auto/semi

373 kW
UTD-29M

18,700

Crew Sights

D 5 periscopes
G 1K13-2 day/night
C 1PZ-10 day/night

*450 litres

United Defense

3+7

61

25 mm

0.73 [kg/sq cm]

14.75

belt

447 kW
Cummins
VTA-903T

29,940

Crew Sights

D undisclosed
G 2nd-gen infrared
C CIV

620 litres

Hägglunds/Ruag LS

4

70

120 mm

50 [kPa]

19.80

semi-auto

445 kW
Scania DS14

25,000

Crew Sights

D not specified
G Utaas
C Lemur

840 litres

Minotor

3+1

95

30 + 7.62/miss

0.62 [kg/sq cm]

22.55

not applicable

620 kW

27,500

Crew Sights

D 3 peris + rear TV camera
G multi-chan. surv/sights
C multi-chan. surv/sights

undisclosed

Rheinmetall

3+7

73

25 mm, KBA

72.7 [kPa]

20.00

not specified

MTU

29,500

Crew Sights

D light intensifier
G thermal
C Kollsman thermal

700 litres

GKN Defence

3+7

75

30 mm

0.74 [kg/sq cm]

15.90

dual

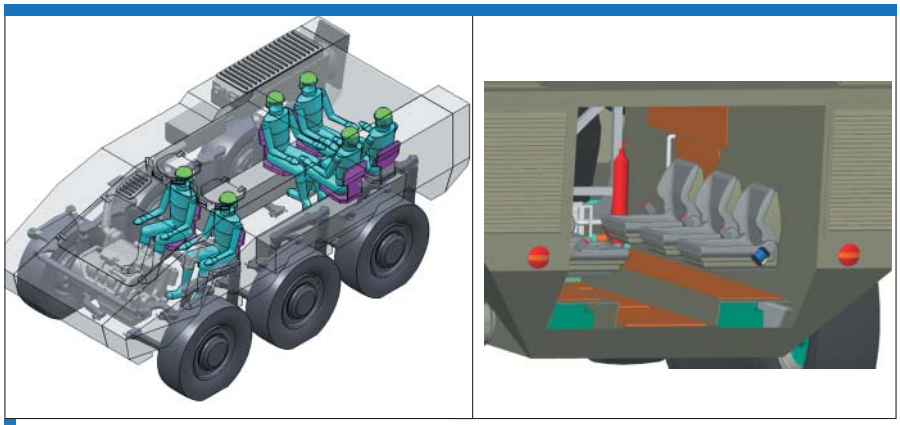
485 kW
Perkins Condor

30,400

Crew Sights

D periscope +
G Raytheon flir
C relay from gunner

not disclosed



These computer-generated pictures illustrate the general layout of the 6 × 6 electrically driven EBRC (at left) as well as the suspended seat arrangement for the rear passengers. (Giat)

wheels or road wheels, but Northrop Grumman is currently testing an Electronically Controlled Active Suspension System (Ecass) which offers a two to threefold increase in the ride limiting speed compared with that of vehicles fitted with conventional suspensions.

The Ecass replaces conventional hydraulic shock absorbers with high-bandwidth electromechanical actuators that are controlled to impart a near constant force acting between the vehicle body and tires. These actuators are installed at each wheel location. They do not eliminate conventional suspension springs – the latter are still used to support vehicle static weight, thereby reducing actuator size and power requirements. The system can be used on wheeled and tracked vehicles alike. Displacement sensors and an accelerometer are located on the vehicle chassis at each wheel location, the moving part of each wheel's suspension system also has a positional sensor, while longitudinal and lateral accelerometers are located near the vehicle centre of gravity. A controller running patented proprietary algorithms uses these sensors to continuously monitor vehicle motion, and commands the actuators as required to maintain optimal orientation of the vehicle body.

During recent Tardec-funded tests at Yuma Proving Grounds, Army Hummers with Ecass were reported as having a threefold increase in cross-country speed (both steady state and dash) with a simultaneous five to tenfold improvement in platform stability. An increase in speed of two or three times over off-road terrain enables increased tempo of battle for the combat force. Faster recoil management after weapons firing and increased cross-country mobility improves shoot and scoot capability, thus reducing mission times and increasing survivability

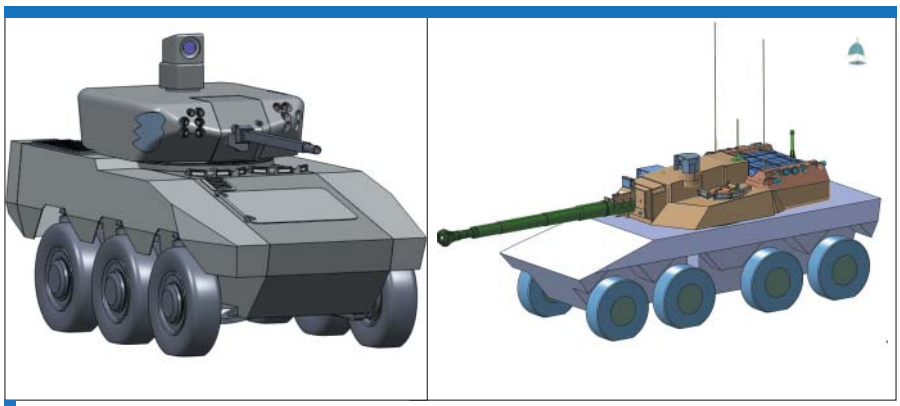
Improved vehicle stabilisation also minimises the time between weapon firings, increases speed for firing on the move and improves the effectiveness of sensors and fire control systems. As with a semi-active hydro-pneumatic suspension, the Ecass can also be used to raise or lower the vehicle (which can be quite useful when the loading height into an aircraft is critical) or level it on uneven terrain. This allows a weapons platform to use greater range of launch sites, and speeds set-up time

In off-road conditions, an Ecass reduces vehicle vibration, pitch and roll six to eight times, says Northrop Grumman, and thereby cuts down crew stress and fatigue and improves soldier efficiency. It also reduces vehicle and electronics failure rates and life cycle costs.

EBRC: In France, Giat is currently under contract with the DGA (defence procurement agency) to determine what could emerge in the next decades. The company, like, inter alia, United Defense and Hägglunds, is investigating the possibilities of using a (largely) common hull for both wheeled and tracked vehicles – although the tracked version appears to have taken a second priority lately, even if the only scaled down model produced to date represented a tracked vehicle. The company is to produce and deliver one vehicle – a 6 × 6 demonstrator – with electric drive and, of course, hydro-pneumatic suspension, which could eventually be of the active type. According to Giat, it should be rolled out during the first half of 2005.

Sep Technical Particulars

	Sep Track	Sep Wheel
Combat weight	13.50 tonnes	13.50 tonnes
Maximum speed	85 km/h	100 km/h
Dimensions (L x W x H)	5.6 x 2.9 x 1.8 m	5.7 x 2.9 x 1.9 m
Load capacity universal load carrier	6.0 tonnes	6.0 tonnes
Load capacity personnel transport	4.5 tonnes	4.5 tonnes
Role volume	8 + 2 m^3	8 + 2 m^3



While a standard configuration of the combat version of the EBRC will carry the 40 mm CTA turret seen on the left (although specific modular armour could well change the shape of what is seen here), an 8 × 8 version could carry something even more substantial, such as a 120 mm turret, an obvious option being a Leclerc's derivative – the T 21 – although other possibilities exist. (Giat)

Sep: Hägglunds has been involved in the studies of a new-generation vehicle since 1996 and has since been awarded several contracts from the FMV to carry on development work, the latest contract to the tune of £ 8.9 million being as recent as 2003. A first running platform has been undergoing trial since 2000. Like other studies pursuing similar aims, the Swedish effort looks into the possibilities of using a common platform for wheels and tracks, but unlike France, predominance appears to be in favour of the track. Designated Sep for Spitterskyddad EnhetsPlatform (Modular Armoured Tactical System in Swedish). The project seems to be in a pretty advanced stage since the latest contract to (now) Alvis Hägglunds not only covers engineering studies, but also the manufacture and delivery of test rigs and another tracked Sep.

The parameters ruling the development of the Sep are:

- ► Low system cost
- ► Low signature
- ► High mobility
- ► High flexibility
- ► High reliability
- ► Extremely high load capacity (weight/volume) in relation to vehicle weight/volume into a system for the future armed forces.

A Selection of Main Battle Tanks

armada©

Krauss-Maffei Wegmann Leopard 2A5

Crew	4
Combat range	72
Main gun	120 mm
Gun stabilisation	8.9 [N/sq cm]
Turret traverse	18.40
Gun elevation	manual
Engine	1100 kW MTU MB 873-Ka 501
Crew Sights	Driver – Gunner – Commander
D	Phillips day/night
G	STN Emes 15
C	Zeiss Peri R17A
Weight	59,700
Fuel	1200 litres

Krauss-Maffei Wegmann Leopard 2A6

Crew	4
Combat range	72
Main gun	120 mm L55
Gun stabilisation	8.9 [N/sq cm]
Turret traverse	18.35
Gun elevation	manual
Engine	1100 kW MTU MB 873-Ka 501
Crew Sights	
D	Phillips day/night
G	STN Emes 15
C	Zeiss Peri R17A
Weight	59,900
Fuel	1200 litres

Israel Military Industries Merkava Mk 4

Crew	4
Combat range	60
Main gun	120 mm MG251
Gun stabilisation	1.00 [kg/sq cm]
Turret traverse	13.5/16.5
Gun elevation	manual
Engine	1119 kW GD883 + Renk RK325
Crew Sights	
D	not specified
G	2-axis stab, x12 IR + TV
C	x4.8 & x12, IR + TV
Weight	65,000
Fuel	1400 litres

Uralvagonzavod T72M1M

Crew	3
Combat range	65
Main gun	125 mm 2A46M
Gun stabilisation	90 [kPa]
Turret traverse	45.00
Gun elevation	auto
Engine	735 kW V-92S2
Crew Sights	
D	not specified
G	2-axis stab, x12 IR + TV
C	x4.8 & x12, IR + TV
Weight	65,000
Fuel	1400 litres

Omsk ZTM T-80U

Crew	3
Combat range	70
Main gun	125 mm
Gun stabilisation	0.92 [kg/sq cm]
Turret traverse	20.00
Gun elevation	auto
Engine	919 kW GTD-1250 turbine
Crew Sights	
D	not specified
G	Buran-PA day/night
C	PNK-4S day/night
Weight	46,000
Fuel	1090 litres

Uralvagonzavod T-90S

Crew	3
Combat range	65
Main gun	125 mm
Gun stabilisation	0.91 [kg/sq cm]
Turret traverse	13.00
Gun elevation	auto
Engine	736 kW B92C2 V12
Crew Sights	
D	periscope
G	1A43/TO1-K01 thermal
C	PNK-S
Weight	46,500
Fuel	1200 litres

*All data direct from manufacturers except author-estimated fuel figures marked with **

The last line is of particular interest, as it de facto implies an electric drive to clear space normally taken away by mechanical drives.

FCS: United Defense and GDLS are now under contract to jointly develop demonstrator vehicles with a view to establishing a viable platform for the Future Combat System. Two prototypes have been built and were displayed at the 2002 Ausa exhibition in Washington. Both vehicles have hybrid propulsion but take slightly differing paths; as the tracked platform, known as FCS-T, uses a diesel engine with lithium batteries while the wheeled ship – the FCS-W – is animated by a 400 hp Honeywell turbine feeding more conventional lead batteries via a United Defense generator. According to UDLP, the turbine option has resulted in a 60 per cent space saving. As in some of the other contemporary developments, use is made of aluminium in the construction of the hull to combine the lightness afforded by this material together with the toughness of other protective material such as titanium, composites and ceramics, while keeping weight and size trim for C-130 compatibility. Basically, as Armada was told by a United Defense official, "this is a 17-tonne frame on which you add three tonnes of armour or gun". Suspension is from Timoney and, as befits modern vehicles, is ride control. No firm Army decision has yet been made on the choice between track and wheel. This should have been decided this year, but is likely to slip into 2004.

The FCS variants are, of course, intended to fulfil a number of missions depending on the variation on the theme, and these included a so-called "Nlos-C" – read here a BAE 777 equipped carrier. A prototype has already been built and fired its first shot during the second half of 2003.

A demonstrator of a tracked Alvis Hägglunds Sep is already running. The Sep study looks into the possibilities offered by modern materials and developmental propulsion systems to create a single hull able to receive either wheels or tracks (inset). A further element of commonality regards the weapons and vetronics. (Alvis Hägglunds)

Two media for the same purpose: A decision on whether the Future Combat System will be wheeled or tracked still has to be made. (United Defense)

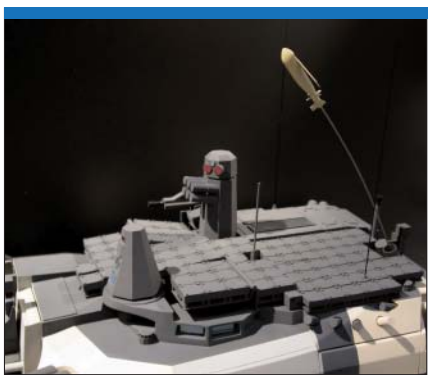
Don't Touch Me!

Traditional armour – and one can now consider that explosive reactive armour has become a traditional type – has reached its limits against the current performance of anti-armour warheads. The Russians, more particularly, have been very active in finding solutions following some pretty dramatic experiences in Chechnya. One has to admit that they have pioneered the development of active defences.

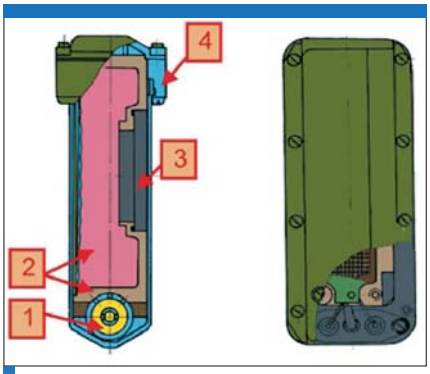
Active protection systems are intended to detect incoming anti-tank rounds or missiles, then engage these in their final moments of flight by firing some form of counter-munition. They are intended to provide protection to armoured vehicles that equals or exceeds that of traditional armour, but at a fraction of the weight.

The first active-armour system to enter service was the Russian Drozd, which was fielded in the late 1980's. As originally fielded, The Drozd provided only a 60-degree frontal protection, but the follow-on Arena E system from Konstruktorskoye Byuro Mashinostroyenia, better know as KBM, provides all-round protection against both direct-fire and top-attack guided or unguided missiles.

In the Arena E system, a multi-function millimetre-wave radar detects the incoming threat and triggers one of an array of protective ammunitions housed in silos arranged around the turret. This counter-munition detonates a few meters ahead of the target, generating a directed field of fragments. The Arena E covers an arc of 135 degrees left and right of the turret from the centreline, in other words, a total arc of 270 degrees. Having the silo crown on the turret rather than around the vehicle offers the advantage of redundancy in the (improbable) event of a double attack against the very same spot on the vehicle. Indeed should protection in a given arc been used, the turret can be trained a few degrees to bring a fresh counter-warhead in line with the incoming threat. Needless to say given the extremely short reactions required (0.07 second), the system is fully automated. While the Arena E is able to deal a death blow to all manner of unguided rockets and missiles – including top attack types like the Bill 2 and oblique attack types like the Javelin or the Gill – it cannot cut the way to almost vertically-fired explosively forged projectile warheads such as the Franco-Swedish Bonus or the German Smart. However, the system could usefully and relatively easily be redesigned to protect air-defence aerials against anti-radiation missiles.



Speculative impression of the Leclerc's future turret with the Spatem warhead killer. (Giat)



The Arena E munition is propelled out of its silo at an oblique angle. This cross-view drawing reveals: 1- the propellant charge; 2- the explosive element; 3- the proximity fuze; 4- the container. (KBM)

A typical Arena E weighs approximately 1000 kilograms and can thus be mounted on the larger light armoured vehicle types.

The Arena E counter-munition is launched on a rising trajectory and detonates above its target; its destructive fragments thus strike the shaped-charge warhead at a high angle, so impact mostly on the outer part of the charge. Other systems under development fire their splinters ahead of the incoming threat, so will damage both the cavity and the liner of the shaped charge.

Tests conducted by the French German Research Institute of Saint-Louis have assessed the effects of fragmentation attacks on shaped charges. Impacts close to the liner region caused test warheads to lose more than 70 per cent of their penetration power. Fragment trajectories which do not cross the liner or which just touch the basis of the liner reduce performance by less than 60 per cent.

Shaped charges are sensitive to perturbation during the jet formation phase. Small objects placed in the liner cavity often have little effect on the jet tip velocity, but have dramatic effects on the jet quality. Tests conducted by the Swiss Defence Procurement Agency have shown that the most efficient way to destroy the shaped charge effect is to introduce some low-density material with embedded metallic spheres into the cavity of the shaped charge. The jet-formation process is completely perturbed; the charge only produces a cloud of liner material fragments having no penetration capability against a steel target.

As a matter of fact, the problem of the deterioration of the shaped charge effect is now being seriously investigated by some manufacturers as it has been clearly established that there is an interaction between the front and rear charges in tandem-charge warheads, the shock wave of the first disturbing the effect of the second.

This trials photo shows the experimental engagement of a Milan wire-guided anti-tank missile by an Awiss counter-munition. (Diehl)

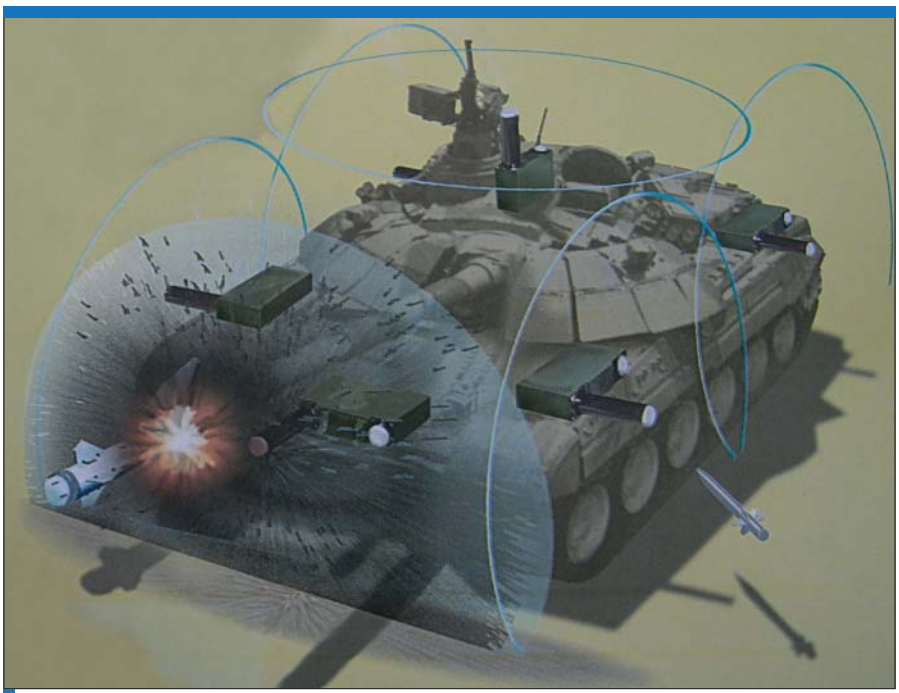
The Ukrainian Ukrinmash organisation is now marketing the new Zaslon active defence system, which is intended to protect stationary and mobile vehicles from all types of anti-tank weapons, including those using diving trajectories.

It consists of a threat-detection radar, control panel, and a number of defensive modules which detonate to destroy an incoming threat.

The radar sensor offers coverage of plus or minus 150 to 180 degrees in azimuth and from –6 to +20 degrees in elevation. The counter-munition modules can deal with threats flying at speeds from 70 to more than 1200 m/sec.

Total system weight depends on protection level required and is typically between 50 and 130 kg. Power consumption is a maximum of 200 Watts.

The US Army Tank-Automotive Research, Development, and Engineering Center (Tardec) leads the Army Active Protection Program, with technology development efforts provided by the US Army Research Laboratory (ARL), the US Army Armament Research, Development, and Engineering Center (Ardec) and industry.



The Ukrainian Ukrinmash organisation is now marketing the new Zaslon active defence system, which is intended to counter all types of anti-tank weapons, including those using diving trajectories. (Ukrinmash)

The problems to defeating chemical energy threats (also referred to as CE), such as anti-tank missiles and RPG projectiles, are eclipsed by the challenges of detecting kinetic energy threats. These are high-speed threats, so must be detected at longer ranges than chemical energy weapons, and tracked at higher data rates. They may have to be intercepted closer to the vehicle, and any impact of their remains must be handled by the vehicle's conventional armour. Advanced concepts featuring lightweight high-strength materials are being investigated to deal with this debris-defeat problem.

A passive infrared tracking sensor has already demonstrated the ability to accurately track kinetic projectiles at range rates and data rates at or near the programme requirements, says the Army Research Laboratory. Subscale experiments with momentum transfer armour, radial shaped-charge warhead and multiple EFP warhead counter-munitions have demonstrated the technology needed to intercept kinetic threats. In addition to counter-munitions, active-protection systems will also use jammers, decoys, and traditional obscurants.

In August 2003, United Defense announced that a combat vehicle fitted with an Integrated Army Active Protection System (Iaaps) had defeated live threats while travelling at 20 miles per hour. During the test, the Iaaps success-

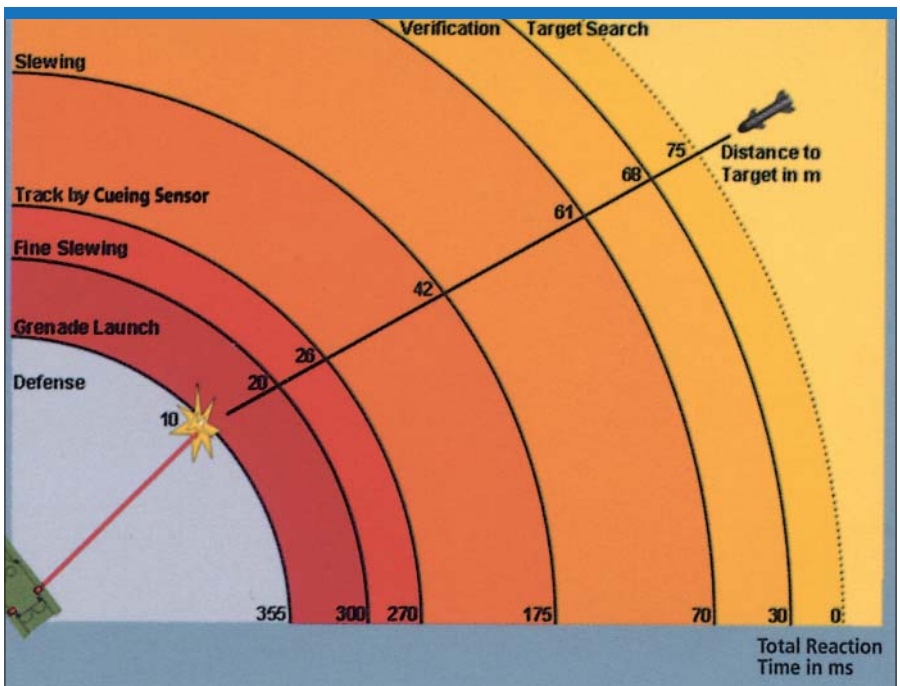
Currently being developed by Ruag Munition in Switzerland in 65 and 72 mm calibre guises, the Crad grenades are fired from vehicle smoke pot launchers from a range of 40 metres and are fuzed to fire down a hail of over 1000 steel balls from a height of seven metres on their descent phase. The highest density of balls remains within a 120-degree cone. (Armada/EHB)

fully defended the moving vehicle against live anti-tank guided missiles by using a combination of a Northrop Grumman 'hard kill' active-protection system and a BAE Systems 'soft kill' electronic jammer able to handle more than one threat concurrently.

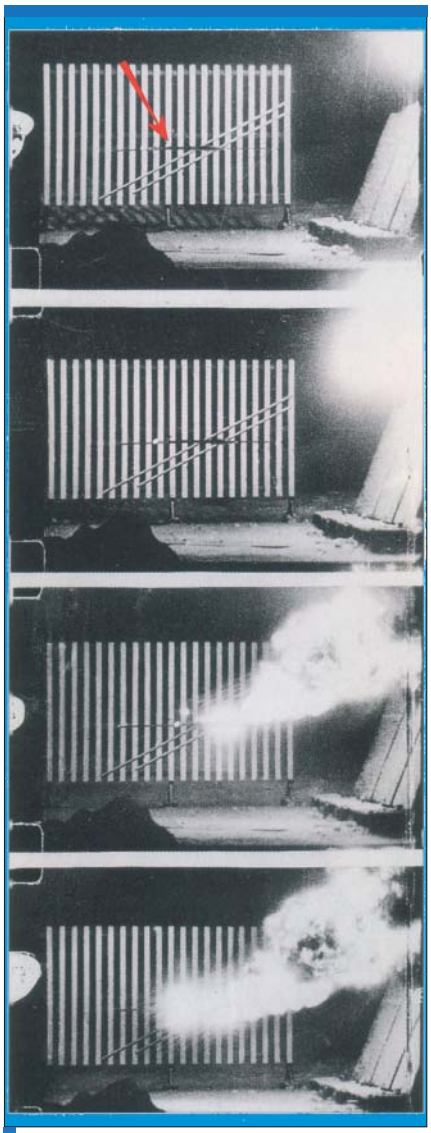
The trial followed twelve months of successful stationary Iaaps testing in which the system had repeatedly defeated a wide range of threats. It successfully stopped the threats, and sustained no damage, while demonstrating both a self-defence capability and the ability to provide a limited degree of area protection that could be used to defend nearby vehicles. In the spring of 2003, it demonstrated the first simultaneous defeat of two live threats.

The Iaaps shows the technological feasibility of equipping Future Combat System vehicles with an integrated self-defence suite of sensors, processors and countermeasures. «The survivability of 20-tonne Future Combat System vehicle platforms will be highly reliant on active protection, combined with advanced lightweight armour, to defeat the most lethal anti-armour threats,» says Mark Middione, the Iaaps programme manager at United Defense. «Our successful stationary and on-the-move Iaaps test results continue to place the system on track for FCS increment 1.»

The Iaaps programme is being conducted as a US Army Tacom Integrated Army Active Protection Science and Technology Objective. It will continue through fiscal year 2005 and will demonstrate the defeat of incoming threats while the vehicle is moving cross-country at tactical speeds. Future developments will include the incorporation of an active-protection counter-munition able to deal with hardened threats and large-calibre, long-rod penetrators.



As this diagram of an Awiss engagement shows, an active protection system has only tens of milliseconds in which to detect and defeat an anti-tank missile. (Diehl)



This succession of high-speed film stills detail the operation of the Arena E, which can handle projectiles approaching at speeds of up to 700 metres per second. (KBM)

Similar projects are also underway in Europe. The Diehl Awiss is an active protection system that is light enough to be used on all light and heavily armoured air deployable vehicles. Its use would allow the weight of armour carried by future vehicles to be reduced, minimising vehicle all-up weight and allowing air transportation. The Awiss uses a Ka-band radar sensor to detect incoming threats. These would be handed off to one of the system's launch units, each of which carries an Integrated Cueing Sensor and three counter-munitions. The total weight of a complete system with two launchers, which would be able to provide all-round coverage would be 400 kg.

System reaction time would be less than 400 ms, and the launchers would be able to slew through 90 degrees in less than 140 ms. A trailing wire between the launcher and the counter-munition serves as a command link to initiate detonation at the optimum moment.

Software development is still under way, says the company, but hardware tests have already been carried out, including the engagement of a Milan missile.

Grenades

An alternative way of protecting oneself against shoulder-fired weapons is perhaps to ensure that they never leave their tube. Ruag has recently developed a grenade the warhead of which is based on that of the Mapam mortar round (see the "What's Up" article in the Armada magazine to which this supplement belongs). Basically, the Mapam is a bomb designed to radially scatter a high density of steel balls over a very precise range. The same technique has been adopted for the Crad (Close Range Active Defence), a grenade launched from existing (or additional) smoke grenade launchers, only these grenades throw a conical shower of steel balls down onto anyone displaying hostile intentions – like, say, aiming an RPG7 at one's vehicle.

The Awiss would use a triple-barrelled launcher to fire a counter-munition able to defeat incoming threats. (Armada/DR)

Stealth

Another way of avoiding hits from the enemy is to remain as inconspicuous as possible, to the naked eye or to the heat sensor – or even better, to both.

Reductions in signature will reduce the range at which an armoured fighting vehicle can be detected by surveillance sensors on the seeker heads of 'smart' anti-tank missiles or munitions. The top deck of the powerplant compartment is a strong source of infrared energy, making armoured vehicles vulnerable to top-attack heat-seeking weapons.

According to the Kharkiv Morozov Machine Building Design Bureau, modifications devised by its engineers can reduce the thermal signature of the T-84 tank by a factor of between 5-7, the radar signature by a factor of 3 to 5, and the visual signature by a factor of 1.5.

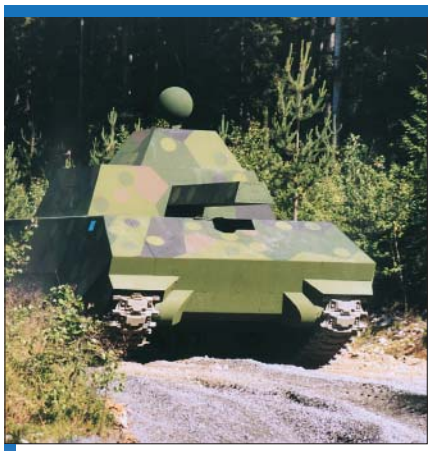
Schemes being offered by the Bureau to reduce the infrared output of the power pack compartment include adding thermal insulation to the top deck , and ventilating it with cool air. Giat's Démonstrateur Furtif à Chenille – an AMX-30-based stealth demonstrator vehicle – takes this concept a stage further. The vehicle has a double-skin construction within which cooling air is circulated.

«...hysteresis losses in rubber components such as tires and rubber-bushed and rubber-padded tracks all generate heat energy. »

The running gear and suspension system are other sources of unwanted IR energy. As we have seen in paragraphs concerning suspension, shock absorbers create heat as they absorb mechanical energy, while hysteresis losses in rubber components such as tires and rubber-bushed and rubber-padded tracks all generate heat energy. Side skirts can be used to cover much of the running gear and suspension, screening these components from infrared and radar-based sensors.

Giat's AMX 30-based Démonstrateur Furtif à Chenille has tested various signature-reduction measures, including air-cooling of the hull surfaces, visual camouflage and side skirts for the suspension. (Giat)

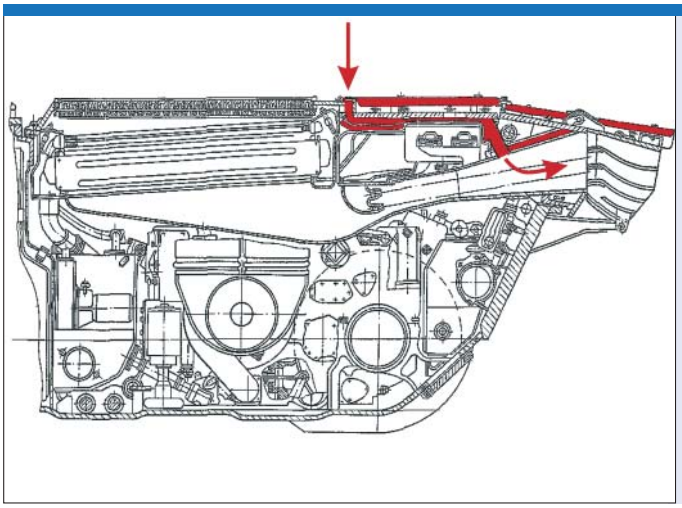
By covering the running gear of the T-84 with a skirt, Kharkiv Morozov engineers have reduced the infrared and radar signature of the vehicle. (Kharkiv Morozov)



Sweden, through its TD2 demonstrator, is studying the possibilities offered by stealth technologies. (Hägglunds)

This approach was taken on the Démonstrateur Furtif à Chenille, and has been proposed for the T-84. It will be interesting to see, in this respect, how manufacturers will cope with the heat generated by motor-equipped wheels when hybrid propulsion comes of age.

The Swedish FMV, for its part, has taken delivery of a stealth demonstrator built by a group including Alvis Hägglunds (platform), Bofors Defence (turret and weapons), Saab Barracuda (camouflage and surface treatment) and SaabTech (sensors).



By circulating cool air through the upper surfaces of the T-84 engine bay, the tank's designers say they can reduce the vehicle's IR signature, making it less vulnerable to heat-seeking missiles. A similar concept was adopted for the Hägglunds CV90. (Kharkiv Morozov)

Keep'em Running

It is clearly impossible to list all the upgrade programmes offered for armoured vehicles here – a full issue of Armada simply wouldn't suffice. Some are well known and have been extensively described in recent issues of Armada, but others, perhaps less known or publicised, are worthy of a few words in this context.

A good and recent example of a tank that many would have forgotten is the Centurion, or rather the Olifant, as it is known in South Africa, where it is to be given a new lease on life. Indeed, South Africa has recently awarded a $ 17 million contract to Alvis OMC to upgrade a number of Olifant 1Bs. The nation has between 167 and 172 30-year-old Olifants, but the exact number of vehicles still in running order is not known.

The upgrade mainly concerns the engines, the gun control system and the targeting suite. The engine upgrade is somewhat unusual in that it involves turning the basic diesels into turbodiesels. This is achieved by fitting four turbochargers with intercoolers, low-compression rate pistons with new blow-by suppressing rings (to prevent compression blast from reaching the sump) and silicon carbide cylinder liners. As a result the power leaps upwards by 15 per cent to 1040 horsepower. The gun actuators are more modestly being replaced with indigenously-developed DC type motors, while, apart from the fitting of an automatic tracking system, the exact nature of the improvement made to the target designation, fire control system and sights remained unclear at time of writing. This puts an end to a replacement programme in which the contenders had been the Challenger 2E, the Leclerc and the T-80U.

«Another type that looks as though it will never die is the T-72...»

Another type that looks as though it will never die is the T-72, which, once upon a time, impersonated terror for the Western World. The type was deemed totally superseded, but given the huge numbers built (about 10,000), there appears to be an unlimited reservoir to (re)produce some rather capable sets of tracks.

The Uralvagonzavod T-72M1M is an example of a thorough modernisation programme that largely draws on lessons learned during the development of the T-90 (itself a redesigned T-72, which was originally known, first as the Objekt

The new generation of improved Uralvagonzavod T-72M1s will most probably remain around for quite some time. (Armada/YL)

Almost a forgotten sight, the South African Centurion-based Olifant is to receive a serious steroidal treatment to allow it to continue kicking up dirt in the years to come. (Armada/EHB)

188, then as the T-72BU). The table on the preceeding page summarises the improvements.

Naturally, the T-72 can be further improved with the KBM Arena E projectile and missile interceptor, which can be seen on the preceeding page.

In Jordan, the King Abdullah II Design and Development Bureau (KADDB) has fitted the Ruag smoothbore gun onto a Challenger 1 turret. Ruag also offers the same gun as part of its Phoenix upgrade package for the M60 tank. The L50 CTG is a drop-in replacement for the M68 with only a few minor modifications to the cra-

Parameters	T-72MI	T-72MI M
Weight	43	45
Engine diesel	573kW V-46-6	735 kW V-92S2 or 617kW V-84MS
Power-to-weight ratio, hp/t	18.1	22.2 (735kW engine)/18.6 (617kW engine)
Average speed on dirt road, km/h	35 to 40	40-45
Maximum seed on highway, km/h	60	65
Main gun	125 mm smoothbore 2A46	125 mm smoothbore gun 2A46M;
Automatic loading gear	Provides stowage of artillery shells	Adds missiles
Guided weapon system	No	9K119, on the move, day and at night
Gunner's night sight	TPN1-49-23	Combined optical, thermal and laser channel (missile), 2-axis stab
Identification range metres	600 (active)	3000 to 3500 thermal imaging
Gunner's day sight	TPDK-1	Combined optical, thermal and laser channel (missile) TPDK-1 twin sight
Commander's sight	TKN-3 , day/night	PNK-4M, day/night, elevation stabilised
Identification range (m) day	2000	4000
Identification range (m) night	300	1200
Ballistic computer	No	Digital
Weapon stabilizer	Two-axis with electrohydraulic drive	Two-axis electromech. drive azimuth and electrohydraulic elevation
Autotracking	No	Yes
Improvement of protection level of frontal projections against APDS Heat shells	1/1	1.25/1.8
Smoke-generating system	902A	Smoke-generating system of TshU-1 complex, automatic, ensures protection against antitank means with laser guidance and rangefinding system
Electromagnetic protection system	No	Against mines
Navigation equipment	GPK-59	Satellite navigation equipment
Fire fighting equipment	3ZTz11-3	3ZTz13-1 automatic quick-acting

dle. Reportedly, it can fire all current and planned Nato 120 mm smoothbore ammunition types.

KADDB is also developing the Falcon reduced-silhouette turret. a unit which offers a minimal silhouette allowing correspondingly higher levels of protection to be achieved for the same mass of armour. It is armed with a Ruag Land Systems 120 mm smoothbore L50 Compact Tank Gun (CTG) and an FHL Claverham autoloader. The latter is fitted in the turret bustle, which incorporates a blow-out panel.

The project is being tackled by KADDB win conjunction with Ruag Land Systems, the Mechanology Design Bureau and IST Dynamics of South Africa, with assistance from various European defence companies. The turret structure was designed and developed in collaboration with the Mechanology Design Bureau. Surveillance, target acquisition and situational awareness systems have been sourced from 4-Sight Optronics and from Thales, while the ballistic fire control systems and autotrackers are supplied by IST Dynamics. Curtiss-Wright provides the gun positioning and stabilisation systems; the turret power management and distribution systems were developed and supplied by CLS Systems.

The Falcon, a cocktail of western and eastern technologies mixed in Jordan under the auspices of King Abdul Design and Development Bureau. (Armada/EHB)

Unconventional Armour

Advanced ERA concepts are expected to cope with new-generation threats. The US Army Laboratory (ARL) is studying several promising concepts.

Not all current armour concepts will make it to market, but the following is a sampling of what is on the drawing boards.

Slera: Self-Limiting Explosively Reactive Armor provides comparable performance to traditional ERA, but has reduced effects on vehicle structures. Although still based on explosive materials, these types are less energetic that those used in existing ERA, and could be classified as passive materials by Nato. For this reason, Slera may be a more viable long-term solution, but for the moment it remains an elusive unproven technology.

Nera: Non-Energetic Reactive Armor is a proven technology that is passive (and thus easy on vehicle structures), so will be easy to integrate with vehicles. Effective against chemical energy munitions such as shaped charge warheads, the versions tested to date are not effective against kinetic energy threats. However, ARL believes that future designs will have the potential of defeating medium-calibre kinetic rounds.

«Not all current armour concepts will make it to market...»

Smart Armor: a novel reactive armour technology that integrates sensors and microprocessors within the armour envelope. The sensors determine the location and velocity of the projectile or plasma-jet impact, and microprocessors then determine the optimum time to initiate the reactive armour. The latter will use insensitive energetic materials and initiators for increased safety.

Momentum Transfer Armor: an advanced reactive armour technology that defeats kinetic energy threats by explosively launching small bars in a direction perpendicular to the penetration path of a threat projectile. These are intended to defeat the attacking weapons through fracture, deflection and rotation. Still unproven in combat, the Momentum Transfer Armor poses practical chal-

Rafael is one of many manufacturers worldwide to have designed and developed explosively reactive armour modules that are suitable for use on lighter armoured combat vehicles (Rafael).

Modular armour designs like this Piranha not only enable vehicles to be re-fitted with fresh armour after a hit, but also newly developed protection to be mounted as the armouring techniques evolve. (Mowag)

lenges, such as minimising the weight of the explosive for an optimum defeat mechanism and achieving consistent robustness against a wide range of threats.

Electromagnetic armour: electromagnetic armour is designed to counter the plasma jet created by shaped charge warheads. It consists of two plates between which there is a potential of several thousand volts. When the plasma jet from the exploding warhead breaks through the first plate, it is exposed to the high voltage, and effectively dispersed to the point where its remaining effects can be absorbed by the vehicle's armoured hull. In January 2001, the US Army Tank-Automotive & Armaments Command awarded Science Application International (SAIC) a $ two million payment under a contract worth a total of $ 8.03 million for the design, fabrication and test of an electromagnetic armour test bed. Work was due to be completed by 30 January 2004. Given the power of modern anti-tank weapons, there seems little chance that the proposed FCS vehicle could survive a direct hit. The Block I vehicle is likely to be armoured only against small arms and heavy machine-gun fire, and against fragments from bursting artillery shells, though ERA will probably be used to cope with weapons such as rocket-propelled grenades. For the Block I vehicles, some form of ceramic armour will probably be used, but electromagnetic armour could be used in the Block 2 vehicles as this technology can be matured in time. One organisation outside of the USA that is known to have made significant progress in electromagnetic armour is the British Defence Science & Technology Laboratory (DSTL), which has already successfully demonstrated an experimental system mounted on an armoured personnel carrier.

Rafael has also recently developed a new generation of reactive add-on armour. This system is considered by the company to be effective against modern shaped charge warheads. The reactive elements contain a novel insensitive, low rate explosive that does not detonate or burn when hit by any projectile or fragment. The system (the name of which has been withheld) has been adapted and applied, the company reports, to several combat vehicles.

In October 2003, the US Army released an announcement that Rafael and General Dynamics ATP launched an upgraded version of a reactive add-on system for the M2 Bradley.

A lighter hybrid version of Rafael's system has been adapted to the M113 APC, the LAV III and the Stryker. This modular system combines reactive and passive elements to defeat both advanced shaped-charge threats, including RPG-7 at 360°, and 14.5 mm armored piercing bullets and high speed 155 mm artillery KE projectile fragments.

After a good day out and with fewer personnel to do the job nowadays, how about using a Moby Tank tank washing system before parking for the night? Under a French Defence Ministry contract, Frutiger has developed a washing station which, under the worst conditions, cleans 90 per cent of the mud collected by jeeps and tanks alike within twelve minutes, even after mudcakes have dried solid. To conserve water, the system uses a separator cistern and recycles the liquid, which a traditional hose and hand wash does not. (Frutiger)

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