



The IMI Iron Fist is intended to defeat both chemical and kinetic energy threats

**Although the Soviet Union fitted the Drozd hard-kill active protection system to its tanks in the early 1980s (see Armada 4/2005) it is the post-Cold War emphasis on lighter armoured fighting vehicles for rapid strategic deployment, and the asymmetrical characterisation of conflicts that has given new impetus to the development of active protection systems.**

### Ian Kemp

Threats cover a broad spectrum from chemical energy (CE) weapons such as rocket propelled grenades (RPG) fired at point-blank range to kinetic energy (KE) projectiles such as long-rod penetrators fired from high-velocity tank guns several kilometres away, as well as top-attack weapons. An Active Protection System (APS) must detect and track an incoming threat, calculate the timing of the response and launch a soft- or hard-kill defence. To be successful this must be done within a second or less, in all weather and visibility conditions and with minimal risk of collateral damage to nearby personnel and vehicles.

Active protection systems are divided into two categories:

- ▶ countermeasures or 'soft-kill' systems which are intended to confuse and divert threats by using signature reduction measures such as obscurants, jammers and decoys

- ▶ Active or 'hard-kill' systems designed to intercept an incoming missile or projectile before it impacts the vehicle.

The US Army through its Future Combat Systems (FCS) project, and the British Army through its Future Rapids Effects Project (Fres), was hoping to field new vehicles that would weigh less, i.e. one-third the weight of an M1A2 tank, than the vehicles they would replace yet still provide the same if not better levels of protection. This will be achieved by a holistic approach to survivability that combines better situational awareness, improved lethality, signature reduction, active protection and advanced light-weight armour.

### Quick Kill

The Future Combat Systems lead systems integrator, Boeing and its partner Science Applications International Cor-

poration (SAIC), announced on 3 March 2006 that it had selected Raytheon's Network Centric Systems division to develop an active system for the vehicle. Raytheon launched the development of the Quick Kill using its own money and after only six months, destroyed an RPG launched at less than 50 metres during a test on 7 February 2007 at the New Mex-

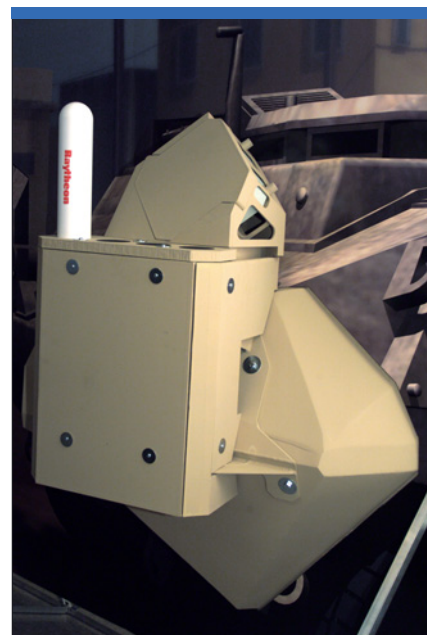
**«An Active Protection System (APS) must detect and track an incoming threat, calculate the timing of the response and launch a soft- or hard-kill defence.»**

ico Institute of Mining and Technology's test centre near Socorro. Following Raytheon's selection a trade study of several alternative concepts selected the company's Quick Kill vertical launch system for further development.

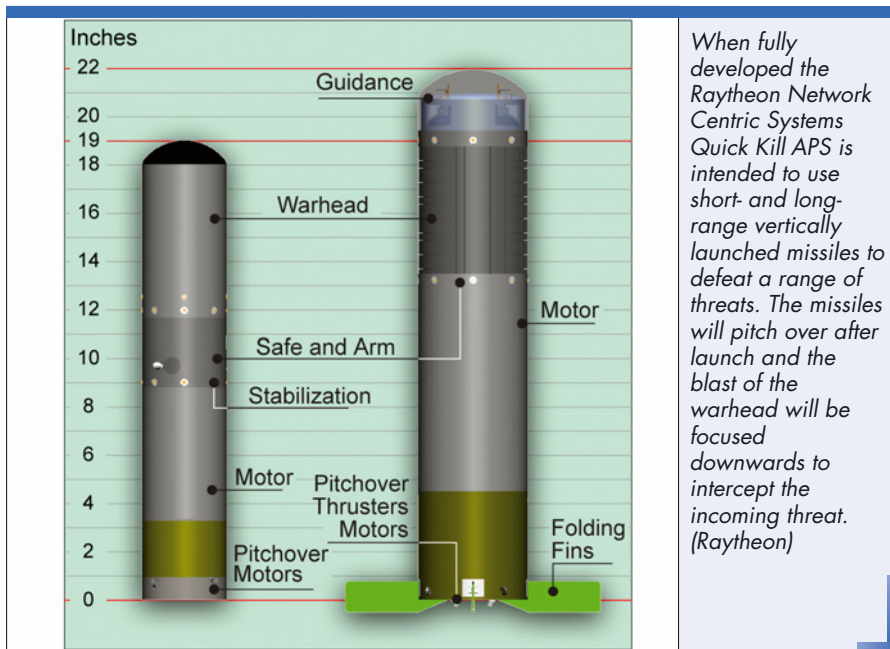
BAE Systems, which is the 'hit avoidance integrator' within the programme, subsequently awarded Raytheon a phased contract worth up to \$70 million to develop the hard-kill APS for FCS Manned Ground Vehicles (MGV). Hard-kill elements are expected to counter rockets, missiles, high-explosive anti-tank rounds, tank-fired kinetic energy rounds and top attack munitions.

The Quick Kill is integrated with the Multi-function Radio Frequency System (MFRFS), which Raytheon Network Centric Systems is developing as the common radar for FCS manned ground vehicles under a four-year, \$118 million contract awarded in mid-2004. In mid-May 2007 Raytheon announced the

delivery of the first two MFRFS radars for the Quick Kill project. The electronically-scanned, solid-state phased array radar system can detect and track the 'full spectrum of threats' and supports a number of radio frequency functions including surveillance, high-band secure communication and combat identification. The MFRFS alerts the Quick Kill launch system that the vehicle is under attack by anti-armour weapons, computes the threat's speed and trajectory, determines an intercept point and cues the Quick Kill missile to counter-attack. The system uses a vertical soft launch technique that eliminates concussion to the vehicle and its crew. Raytheon engineers selected this approach because a single launcher, typically loaded with eight to 16 missiles, is able to defeat threats through a full 360° hemisphere. The 51-cm-long missile pitches over after launch, and then accelerates to the point of intercept and fires its focused blast warhead downward to destroy the incoming threat in mid-air.



Raytheon Network Centric Systems is developing installations of its Quick Kill APS to integrate with legacy vehicles, beginning with the US Army's Stryker family and the eight manned variants of the Future Combat System. (Raytheon)



This angle of attack is intended to minimize the risk of collateral damage. Quick Kill can track and counter-attack 'several' threats simultaneously. The Quick Kill system weighs less than 136 kg.

Work will be conducted in three phases. The overarching first phase, from March 2006 to September 2011, is an engineering effort to develop a robust APS architecture. The second phase, from June 2006 through September 2009, is a risk-reduction effort to develop the APS for integration in vehicles now in service such as the General Dynamics Land Systems 8 x 8 Stryker and the BAE Systems M2/M3 Bradley. Production integration could occur in «the late 2008 timeframe». The third phase, from January 2007 to September 2011, will culminate with the complete APS solution, hardware and support for the first incremental delivery of FCS manned ground vehicles.

### Trophy

Some critics have questioned the army's rejection of the Israeli Trophy system, which is the result of a ten-year collaborative development project between Rafael Armament Development Authority and Israel Aircraft Industries/Elta that was funded by the Israeli Ministry of Defence. The Office of Force Transformation (OFT), within the US Department of Defense, selected the Trophy for installation onto the Stryker-based Full Spectrum Effects Platform being developed under Project Sheriff. The Trophy was integrated into a Sheriff vehicle late in 2005 and during trials in February 2006 simultaneously shot down two incoming rocket-propelled grenades. Despite this success, when the OFT handed management of the Sheriff project to the US Army the service decided not to continue with the Trophy integration.

The Trophy was first shown publicly in March 2005. The Israel Defense Forces claim that the Trophy can defeat, «all

types of Heat threats including all known types of the anti-tank guided missiles and anti-tank rockets». According to Rafael the performance of Trophy is not degraded when the vehicle is in motion, by weather conditions or in close and urban terrain. With a total weight of less than 454 kg the Trophy system can be integrated into light, medium and heavy platforms. Rafael states that 'several hundred' tests have been carried out with prototypes. Prototype Trophy systems have been installed on a Merkava Mk 3, one of the three Strykers that the US government shipped to Israel for evaluation in 2004 and more recently on one of the IDF's newest tanks, the Merkava Mk 4. Rafael will supply three fully integrated Trophy systems on Merkava Mk 4s in July and these will be followed by production line systems by February 2008.

The Trophy has two main components: a threat detection and tracking subsystem, and a hard-kill subsystem. The threat detection system consists of several sensors, including four flat-panel radars, positioned around the vehicle to provide complete coverage. When a threat is identified the optimal intercept point is automatically calculated, the countermeasures assembly is opened and an interceptor is launched which forms a 'beam' of frag-

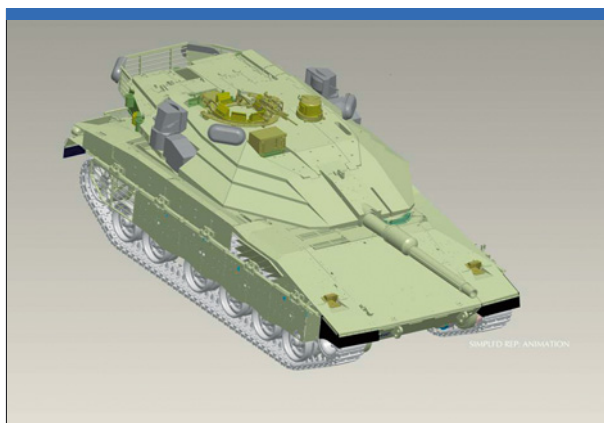
ments to intercept the threat at a range of 10 to 30 metres from the vehicle. A munition will only be launched when the tracking sensors confirm a missile or rocket is a threat to the vehicle. According to Rafael the system can defeat «several threats from each direction arriving simultaneously». The Trophy is designed to pose a low risk of collateral damage with computer simulations indicating that the risk to nearby personnel is less than one per cent. The Trophy has an automatic reload facility.

General Dynamics and Rafael responded to a US Marine Corps request for information issued in July 2005 proposing that the Trophy be installed in the corps' fleet of more than 700 GDLS Light Armored Vehicles. The corps' requirement is expected to increase following the order for 130 new LAV A2s. Although Rafael will not specify other potential export customers for the system it has confirmed to Armada, «the Trophy will be integrated on several European vehicles and tested during 2007». Work on enhancing the Trophy to defeat KE threats is now at Technology Readiness Level 3 or 4, according to Rafael.

Last September Major General Jeffrey Sorenson, the US Army's deputy for acquisition, defended the service's selection of the Quick Kill by claiming that the Trophy was not yet a mature system: «The Israelis have been working on the Trophy system for ten or eleven years yet no Israeli Merkava tanks carried it. If this thing was ready to go, my question would be, why wasn't it on the particular tanks that went into Lebanon?» In the aftermath of the recent war in Lebanon some Israeli officers claimed the crews of the lost Merkavas were the victims of the 'money kills' theory, as the Israeli government delayed in funding the deployment of the Trophy. With more money now available for defence the IDF has given priority to the fielding of an active protection system.

### Iron Fist

Israel Military Industries unveiled its new Iron Fist system (see title picture) in mid-2006 which is intended to be mounted on a wide range of platforms from light utility vehicles to main battle tanks. It is designed to protect against rocket-propelled grenades, anti-tank missiles



Following the 2006 Lebanon War senior Israel Defence Force officers said that priority would be given to installing the Rafael Trophy on the army's Merkava Mk 4 tanks. According to unofficial sources, a prototype installation should be completed by mid-year. (Rafael)



*The Rafael Trophy successfully demonstrated its ability to defeat RPGs during trials in the US in February 2006 mounted on a Stryker Full Spectrum Effects Platform for the US Office of Force Transformation. The US Army decided not to continue with integration of Trophy when it assumed management of Project Sheriff. (Rafael)*

and tank rounds equipped with shaped charge warheads, and also kinetic energy threats such as armour piercing tank rounds. The Iron Fist uses a radar sensor developed by IAI-Elta and an optional passive infrared detector developed by Elbit's Elisra. These sensors detect potential threats and measure distance and trajectory, allowing the control unit to calculate an engagement solution. An interceptor is then launched which destroys or disrupts the incoming threat without detonating its warhead. The entire engagement sequence takes less than one second. IMI has conducted extensive testing of the system mounted on stationary and moving M113 armoured personnel carriers and operational evaluations by the IDF should begin in mid-2007.

### Traps

To protect lightly armoured vehicles such as the Humvee from RPG attack Textron Systems unveiled its Tactical RPG Airbag Protection System (Traps) at the AUSA meeting in Washington in October 2006. The product was added to the company's portfolio with the acquisition of Innovative Survivability Technologies by Textron in July 2006. The Traps employs a simple radar derived from a police speed gun and a modified commercial airbag system which can be used to protect not only vehicles but also guard posts and other installations. When an incoming threat is detected by the radar the system processor triggers one of the downward-firing airbags, which are mounted in boxes either side of the vehicle's roof. The bag inflates within 30 milliseconds and absorbs the RPG, which is defused by an unspecified countermeasure. During trials conducted in April 2006 the system was shown to be effective against several combinations of RPG-7 warheads and fuzes as well as tandem warhead RPGs. The Quick Reaction Contract Office within the Office of the Secretary of Defense provided \$ 3.5 million to fund the project in 2005 and Congress added a further \$ three million into the FY07 defence budget. Further developments include boxes with two airbags to defeat a second threat and configurations for larger platforms such as the Stryker.

### Muss

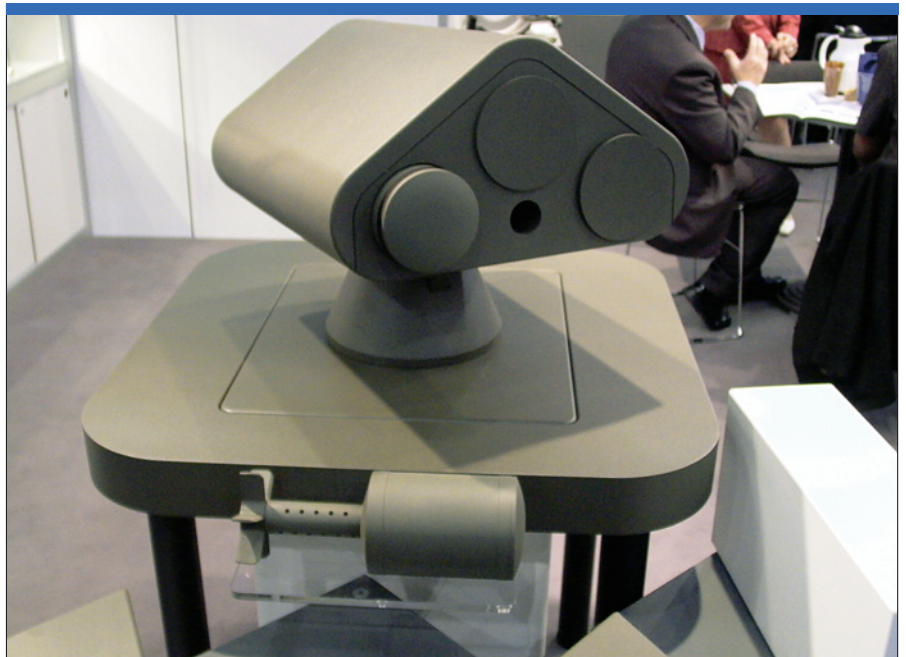
The German Army is relying upon a high level of armour and an active protection

system to protect its new Puma infantry fighting vehicle. The Puma technology demonstrator was rolled out in Kassel on 20 December 2005 by PSM, a 50:50 joint venture between Rheinmetall and Krauss-Maffei Wegmann, and was subsequently followed by five pre-production vehicles. Eads Defence Electronics and KMW are working on a € 21 million contract for the final development, integration, testing and qualification of the Multifunction Self-protection System (Muss) on the five pre-production Pumas. Since 1997 the German BWB defence procurement agency has funded the development of Muss. Later this year the German government is expected to approve the purchase of 410 Pumas, worth roughly € 3.05 billion, for delivery from 2009. A production contract to fit the entire fleet with the Muss is expected to be worth up to € 200 million.

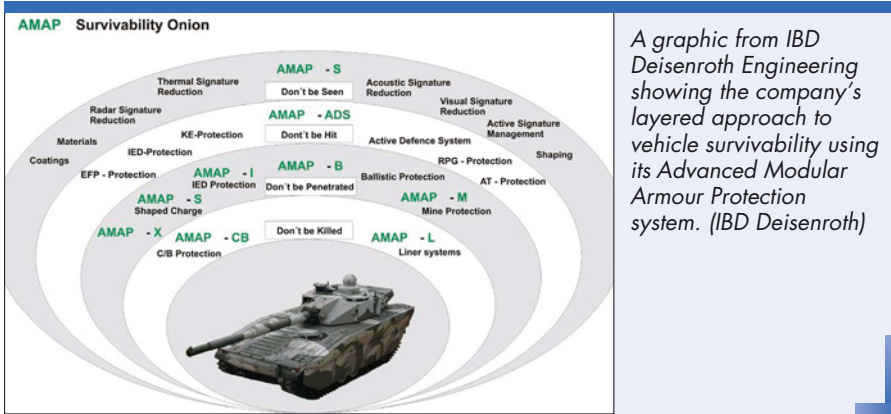
When a threat is detected, the system responds within 1 to 1.5 seconds, activating a smoke screen or directing an infrared jamming signal toward the launching platform. During trials in 2003 a prototype Muss installed in a Leopard 2A5 tank successfully countered various missile threats. Four Missile/Laser Threat

Alerting System (Miltas) units will be installed on the Puma's turret and linked to an active IR jammer and a 76 mm grenade launcher. The Muss provides protection in 360° azimuth and 70° elevation and can counter four threats simultaneously. Each sensor covers an arc of 95 × 70°, with a resolution of +/- 1.5°. The sensors employ UV missile launch signature and laser detectors. The 76 mm Maske multi-spectral smoke grenade, produced by Rheinmetall Waffe Munition's Buck Neue Technologien, is based on a bi-modular concept that incorporates a rapid-reaction jamming module producing intense over-radiation utilising proven decoy technology and a long duration module producing visual and IR screening smoke. Rheinmetall's Maske multi-spectral smoke grenade is also available in 66 mm and 81 mm calibres.

Eads and KMW are together working on a Muss Compact design for installation on KMW's Fennek 4 × 4 armoured reconnaissance vehicle, the Boxer 8 × 8 APC and the Leopard 2. The system, which has a target weight of 130 kg, includes a mast unit with four Miltas sensor and the IR jammer unit, and eight 76 mm grenade launchers.



*Germany's Diehl has demonstrated the ability of its Awiss to defeat RPGs and other chemical energy threats, such as the Milan missile. The Awiss grenade is designed to intercept the incoming threat about ten metres from the vehicle. A typical installation would consist of two launchers. (Diehl)*



A graphic from IBD Deisenroth Engineering showing the company's layered approach to vehicle survivability using its Advanced Modular Armour Protection system. (IBD Deisenroth)

needed beneath the armour to install the system. The company is proposing that the Awiss be fitted to the Leopard, the Puma and other high value vehicles.

### Crad

Ruag is proposing a cost effective hard-kill solution using its Close-Range Active Defence (Crad) munitions launched from the standard smoke grenade launchers fitted to most AFVs to deal with anti-tank weapon operators. The Crad draws on the controlled fragmentation technology used in Ruag's 60 and 81-mm Mapam (Mortar Anti-Personnel Anti-Material) bombs. The munition is launched to a range of 35 metres where it detonates creating a cloud of more than 1000 0.3-gram metal fragments. The launchers could be linked to a threat detection system of the customer's choosing. Most armoured fighting vehicles have two smoke grenade launchers fitted either on the front of the hull or on the

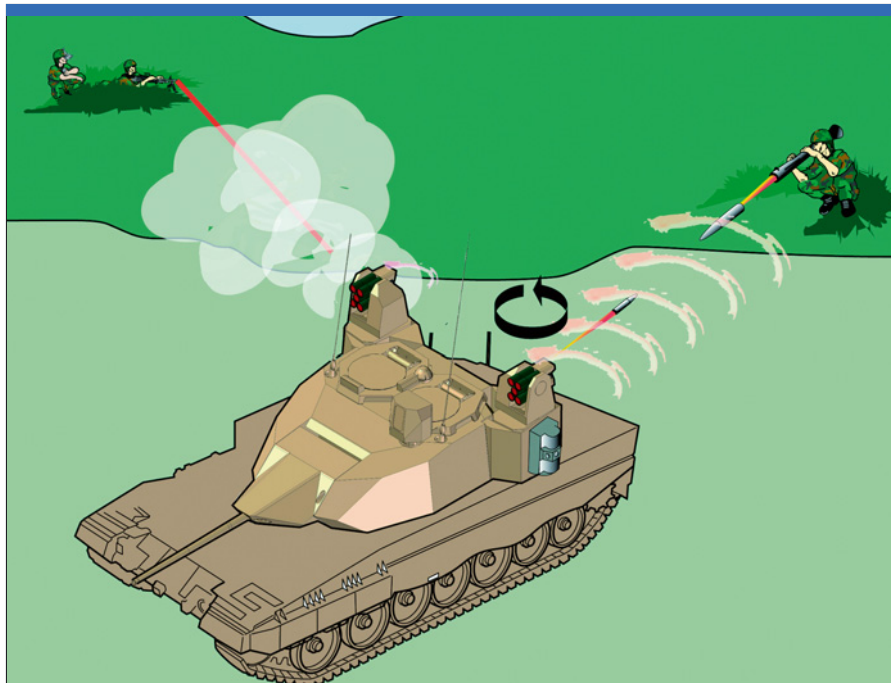
### Mass

For installation on light vehicles such as the German Army Dingo, Fennek, Mungo, Wiesel and Wolf, Rheinmetall Waffe Munition has developed the Light Vehicle Protection System, using technology derived from its rotating Mass (Multi-Ammunition Softkill System) naval protection system. The system consists of a horizontally trainable launcher with three 'magazines' each of five launchers that can be mounted on a vehicle's roof or rollover bar. The loaded launcher weighs 15 kg. The manually triggered launcher fires 40 mm grenades that are designed to burst 32 metres from the vehicle and create a 30 metres x 3 metres smoke screen effective in the visual and near-IR spectrums as well as temporarily blinding systems that operate in the medium- and distant-IR spectrums. Red phosphorus smoke, CS smoke, flashbang and practice grenades are available.

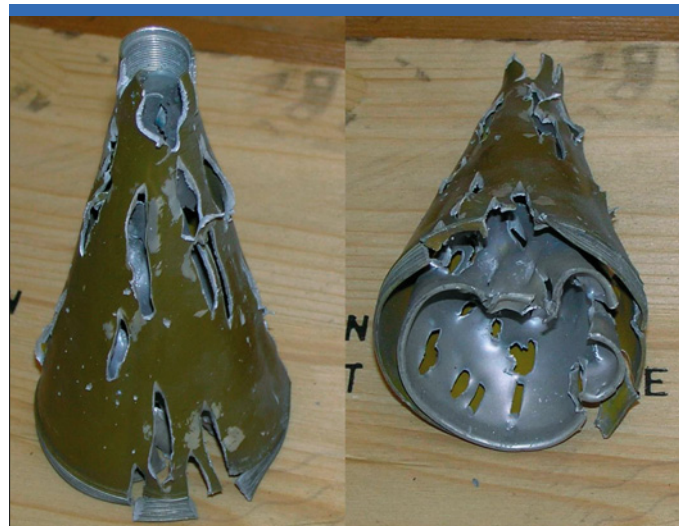
detects incoming threats at a range of 75 metres and launches a three-kg grenade to intercept the threat ten metres from the vehicle. The entire sequence takes 355 milliseconds. The complete system weighs 400 kg and extends 40 cm above the armour; a further 40 cm clearance is

### Awiss

Diehl BGT Defence has developed a hard kill system for installation in light and heavy vehicles to defeat RPGs and other CE munitions. It is also capable of reducing the penetration of KE warheads. The Awiss (Abstandswirksames Schutzsystem) consists of a search-and-track Ka-band radar linked to a launch unit with sensor and two launchers that provide 360° coverage. The system



The Leds 150 reacts in a fraction of a second to launch a Mongoose counter-weapon, but the resultant collateral damage area is restricted to an eleven-degree cone around the axis of the intercepting round. (Saab)



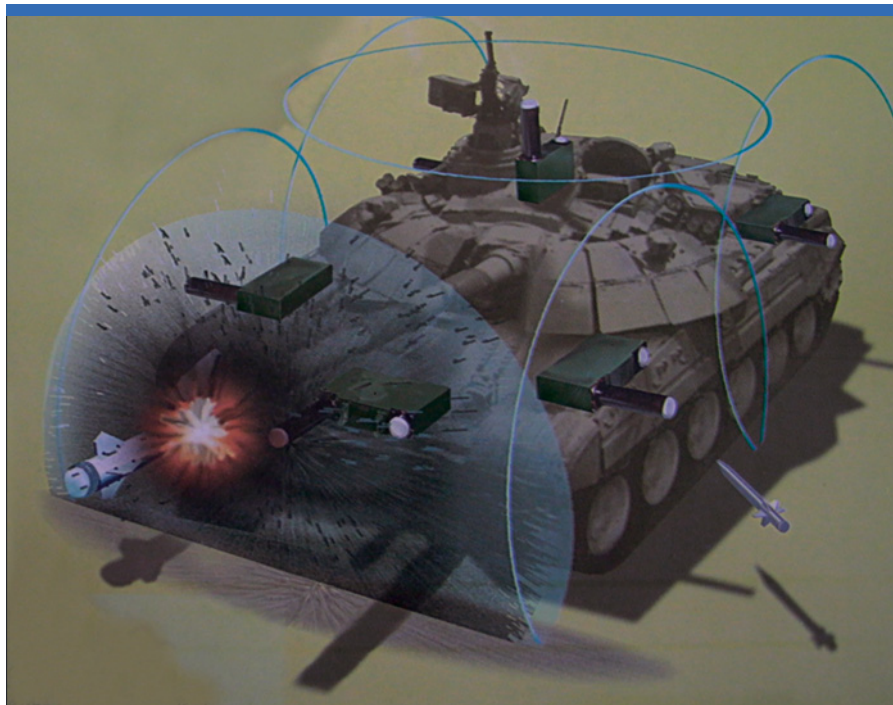
The Oto Melara Scudo uses an outer tier of interceptors and an inner tier of active tiles to spray thousands of tungsten balls in the path of the incoming threats such as these RPG warheads. (Oto Melara)

front or sides of the turret to cover the frontal arc; coverage could be extended by fitting additional launchers to cover the rear arc.

### Amap

The Advanced Modular Armour Protection-Active Defence System from ADS/IBD Deisenroth Engineering is a component of the German company's Advanced Modular Armour Protection (Amap) system, which includes vehicle liners, advanced armour, APS and signature management.

At Eurosatory 2006 BAE Systems Hägglunds displayed a CV-90120 light tank fitted with an Amap which is being evaluated by Sweden's Defence Materiel Administration. Italy's Iveco Defence



As is the case of most systems reviewed here, very little is disclosed regarding either deployment or technical information. In the Ukraine, the Zaslon was launched on the market some four years ago by the Microtech Base Center for Critical Technologies. This drawing appears to show that it is also able to cope with top-attack weapons. (Armada archive)

Vehicles Division announced in early May that the system had been integrated in the company's 4 × 4 LMV and subjected to live ballistic testing witnessed by representatives of 'several' governments. The LMV, which has been bought by the armies of Italy, Norway and Britain, is fitted with a modular armour package developed by IBD Deisenroth. It demonstrated its ability to provide all-round protection against multiple threats, including RPG-7s, fired at close range. According to Deisenroth serial production of the Amap will begin 'by 2008 at the latest'.

### Scudo

The Italian Ministry of Defence and Oto Melara launched the development of the Scudo (shield) in 2002 with each providing 50% of the funding. Reflecting its experience in developing naval point-defence systems the company has developed a two-tier approach. The outer tier is based on active continuous-wave X-band radar and two traversable launchers with either two or four cells. Two options are being considered for the radar installation: either installing several elements in a rotating mast or installing several elements in fixed locations around the vehicle. If the control system determines there is sufficient time one or two 70-mm interceptor rockets would be launched in the path of the incoming threat. Detonated by a 'smart' proximity fuse the munitions would shower thousand of tungsten balls in the path of the incoming warhead. If the threat were to be an RPG or a similar weapon launched at short range it would be engaged by the

inner tier, which consists of explosive tiles that discharge thousands of tungsten balls. Oto Melara intends to complete development work so that a prototype installation will be available for testing in 2008. The Italian Army has also indicated that it is planning to evaluate Rafael's Trophy and IMP's Iron Fist.

### Leds, Soft to Hard

Saab Avitronics, a division of Saab Grintek Defence, is actively marketing its Leds-150. The Land Electronic Defence Systems (Leds) is the result of a co-operative effort between several South African companies including Denel Dynamics, Bellingan Engineering Devel-



The Israel Military Industries hard-kill Iron Fist is competing in Israel against the Rafael system Trophy, but is claimed to be lighter and thus adaptable to smaller vehicles. Like Saab's solution, it appears to use blast effect to crush the incoming warhead rather than detonate it or achieve a direct hit-to-kill. (Israel Military Industries)

opment (Bed), Kreon Technology and Kuehl Tech. The first stage of this modular system to appear was the Leds-50, which consists of an Active Defence Controller, four LWS-300 sensors to provide 360° azimuth protection and one LWS-500 sensor to provide full hemispherical coverage. The system alerts the crew when their vehicle is being leased by a rangefinder, designator, beam-riding missile or laser dazzler. The Leds-50 is in production to equip the 184 CV9035 Mk IIIs ordered by the Netherlands. The Leds-100, introduced in 2004, provides a soft-kill capability by combining the Leds-50 with twin six-tube High Speed Directed Launchers (HSDL), developed by Bed and Kreon Technology.

When set to automatic mode the controller will activate the deployment of multi-spectral smoke from the launchers. One or more Lacroix Galix 13 multi-spectral smoke grenades are able to produce a 'fully effective screen in less than 800 ms' 40 to 50 metres from the vehicle. At the IDEX 2007 exhibition in March 2007 the Leds-100 was displayed on an M60 tank modernised by Jordan's Kaddb.

In October or November 2007 Saab Avitronics plans to demonstrate the new hard-kill Leds-150 installed on a Mowag Piranha in Switzerland. The Leds-150 launches Denel Dynamics Mongoose 1 interceptor munition from the HSDL to intercept ATGMs and RPGs fired as close as 20 metres from the vehicle. The incoming threat is typically destroyed by a perpendicular blast from the Mongoose-1 at ranges between 6 and 25 metres from the vehicle. The company hopes to have the Leds-150 ready for serial production in early 2009. The next phase will be the introduction of the Leds-200, which is intended to defeat threats such as top-attack munitions fitted with multi-band seekers. Through an array of sprinklers around the vehicle, an active signature management subsystem dispenses a polymer-based foam, developed locally by Kuehl Tec, that changes the vehicle's signature within one second so that a multi-band seeker breaks lock. The Asm can also defeat IR and radio frequency detectors and be manually initiated to extinguish petrol bombs that are thrown onto the vehicle.

The product of the final phase, the Leds-300, is intended to defeat KE and stand-off munitions using a 'steerable' derivative of the Mongoose optimised to intercept these threats at least 150 metres away from the vehicle. A prototype interceptor had successfully defeated 105 mm kinetic energy penetrators in three trials conducted prior to IDEX and officials are confident that the Leds-300 will be a viable system by 2010. Industry sources have suggested that the Leds could be selected for the South African Army's Hoefyster infantry combat vehicle project, which involves the local production of 264 Modular Combat Vehicles based on Patria's 8 × 8 Armoured Modular Vehicle. The first of these will be delivered in mid-2012. □