The Merkava Mk 4 — Israel's Newest MBT Enters Service

by Lieutenant Colonel David Eshel, IDF, Retired

During a ceremony in June 2002, the Israel Defence Force (IDF) unveiled its new member of the Merkava family, the Mk 4 Main Battle Tank (MBT).

The new tank, a fourth generation development of the 1979 Mk 1, which saw its first combat action during the 1982 Lebanon Campaign, includes new design concepts, which rate it among the best in the world for survivability and firepower.

According to the "father of the Merkava," retired Major General Israel Tal, who, for over 30 years, has been the driving power of this revolutionary tank design concept, "The Merkava Mk 4 being a fourth generation combat-proven vehicle, represents a quantum leap forward in modern tank design in all its parameters, protection, firepower, mobility, and combat control."

Improved Firepower

The Merkava Mk 4 mounts a new, locally produced, 120mm smoothbore gun, designed to sustain higher internal ballistic pressures and generate superior muzzle velocity, which is specified for advanced kinetic energy munitions. The new main armament can fire all types of 120mm ammunition, including APFDS-FS kinetic rounds, high-explosive antitank (HEAT) munitions, antipersonnel/antimaterial ammunition (APAM), as well as the latest Israel Aircraft Industries-developed, gun-barrel launched, laser-homing antitank (LAHAT) missile. The loader can feed the breech from a fully automated, fireproof revolving magazine, accommodating up to 10 ready rounds, and delivering four types of automatic ammunition for selection. The semiautomatic loading system is electrically operated and ready-round selection is controlled by a microprocessor.

The new Merkava Mk 4 design eliminates the loader's hatch, improving the loader's position to serve the gun breech while in a sitting position. A TV monitor screen, instead of the traditional optics, improves external observation. The loader also operates the 60mm mortar tubes from inside the tank. This weapons system fires HE and illumination rounds.

The tank is equipped with a modern fire control system, which includes computerized ballistic calculations and compensations for climatic changes, and internal pressure shock resulting in barrel distortion also effectively controlled by the video thermal sleeve. Special sensors monitor the precise gradient changes close to the firing sequence in the barrel line-of-sight, which can distort the ballistic angle.

Loading the breech during cross-country movement can affect crew safety. As in most tanks, the gun is stabilized in elevation and traverses during movement, but the barrel changes its elevation angle in relation to the inclined turret level. To prevent this, a new system was introduced, which locks the barrel during the loading process in a specified elevation angle for easy loading sequence, then regains its former stabilized position after the loading process is completed.

Other improvements to the Mk 4 include a dual axis gunner's sight and dual axis stabilized commander's panoramic sight, both equipped with an advanced forward-looking infrared and TV screen for day and night observation channels that contributes substantially to en-

hanced first-hit probability, surpassing the former Merkava Mk 3 (Baz) version, which already achieved remarkable gunnery standards.

A second-generation automatic tracking system (ATS), which locks on target at several kilometers range, automatically tracks moving ground targets and low-flying helicopter targets. The gunner's sight is locked onto its designated target throughout the firing sequence, irrespectively of any evasive action the target attempts when aware that it is coming under attack. The ATS is based on video output from either a TV camera (daylight channel) or thermal imaging camera (night channel).

Firing-on-the-move is conducted with an ultra-fast gun stabilizing electric turret drive system, which enables locking the sight while moving over rough cross-country terrain. An instantaneous smoke self-screening system is mounted either side of the turret.

New Tank Ammunition Used in Merkava Mk 4 Gunnery

The LAHAT round, designed by Israel Aircraft Industries, was developed to the IDF armor corps' specification. Using the semi-active laser homing guidance method, LAHAT can be designated by the firing tank crew or through external designation from ground, mobile, or airborne observers.

Firing the round requires minimal exposure in the firing position, and can be directed through the commander's sight by only maintaining LOS during missile flight, when "turret-down." The missile's trajectory can be preselected for either top attack (tank) or direct attack (helicopter) engagement. The missile uses a tandem warhead, which can defeat modern armor and reactive panels.

Another round to be introduced in Merkava is the APAM munition. Already in use with the former Merkava tanks that mount the 105mm main gun, a 120mm smoothbore version is soon to be included in the Merkava Mk 4 model. The APAM constitutes an ultimate solution to the growing threat to tanks, especially in urban warfare, where tank-killer squads lurk with modern lethal antitank weapons. The new round uses the proven concept of antipersonnel munitions based on controlled fragmentation. It deploys submunition shrapnel at defined intervals, covering a wide lethal area against soft targets. Each fragment is shaped to have enough kinetic energy to penetrate conventional body armor, or other materials.

Protection and Survivability

The principles on which the Merkava family was designed are maintained in the Mk 4, namely, enhancing crew protection and maximum survivability in high-intensity, fire-saturated combat. The emphasis on "combat" is necessary to clarify the recent terrorist incidents in the Gaza Strip, where two Merkava Mk 3 tanks were blown up, in separate attacks, by massive explosive charges, surpassing 100 kg each.

Against an explosive force of such magnitude ripping into its underbelly, none of the Merkava models, nor any other tank in the world, are designed to remain intact without compromising mobility, through abnormal weight additions, to its protective armor suit.

Designed for modern combat operations, top priority in the Mk 4 was given to enhanced protection against third or fourth generation antitank guided weapons, with special emphasis on top-attack, terminal-guided missiles. The revolutionary concept of placing the power pack in front was maintained.

To achieve maximum protection of the upper turret, the loader's hatch was eliminated in the Mk 4 design. This enables a full extent of the modular armor protective suit on the turret top without compromising the additional hatch, which had so far remained a conceptual hindrance based on the lack of alternative observation systems. This problem has now been solved.

For full perimeter defense, the Merkava Mk 4 is fitted with a latest state-of-the-art Amcoram LWS-2 laser warning system, its sensors capable of detecting incoming missiles soon after launch. The threat warning display is installed at the tank commander's station. Although details are classified, the Mk 4 is believed to be protected by a new type of hybrid armor, which can be conformed from modular elements to match specific threats. Another classified item is an advanced active full perimeter defense system incorporated with the LWS.

Enhanced survivability against fire hazards is gained through the all-electric turret-control system, which eliminates all remaining hydraulic fluid. An advanced version of the automatic fire suppression system is installed. The crew is also protected against nuclear, chemical, and biological warfare by a central high positive pressure system in the fighting compartment, also providing individual air conditioning (micro-cooling) designed for sustained combat under adverse climatic conditions.

Battle Management and Control Systems

The Merkava Mk 4 uses a new integrated battle management system (BMS) designed by Elbit Systems, which provides rapid communications networking between the tactical tank commander and his subordinate units. It enables the commander to plan missions, navigate, and continuously update situational awareness. The system also records data for operational debriefing by using the tank's Vectop digital data recorder. This records and restores sight images and observation data collected during missions. This data can be shared with other elements, using the same network with the BMS, to report enemy targets. Such a concept is rapidly becoming an essential part of the new digitized land forces integrated battlefield concept, combining armor, antitank, and combat helicopters in combined task force operations.

Each member in the Merkava Mk 4 crew has an individual flat-panel color display at his station, showing the status of systems related to his specific task. The tank gunner and commander can also monitor the respective sight images on their individual display screen. The tank commander can use his map display to navigate, orientate, and control his subunits.

Optronics Equipment for All-Around Observation

The design concept of the Merkava Mk 4 version was also based on combat experience, including high-risk close combat in urban environment, which, in contrast to desert warfare in open terrain, is extremely hazardous to tank crews observing targets from open hatches, which was traditional in the IDF's armor corps doctrine. Thus, top priority was placed in the design of a new concept, which affords continuous combat with closed hatches to all crewmembers, without impairing their full perimeter observation, at close and long ranges.

The Vectop Tank Sight System (TSS) integrates an array of video cameras installed in different positions around the tank to enable the crew to cover "dead zones" in the tank's surroundings. An array of four cameras provides complete peripheral coverage (360 degrees), and the top of the tank, including re-

verse movement, which the driver can monitor without impaired vision.

For protection against enemy fire, all the outboard cameras are imbedded in armored cases outside the tank. They provide high-resolution pictures to monitors installed in the driver's position and fighting compartment crew positions.

The optronics provide full and clear vision for the tank commander to operate under closed hatches, using an advanced panoramic sight for all-round observation. The turret machine gun can also be operated from under armor by being mounted on a circular revolving ring for automatic traverse. The commander's sight has override to the gunner's sight while data is being continuously relayed in both directions. All sights are day/night stabilized, rendering the commander's hunter/killer capability.

Propulsion and Mobility

The Merkava Mk 4 is powered by a new 1500 hp diesel engine, which improves its mobility substantially, compared to the former models, which were powered by 900 and 1200 hp respectively (Mk 1/2 and Mk 3).

The General Dynamics GD833, co-produced in the United States by GDLS and MTU (which also powers the French GIAT Leclerc), is a liquid-cooled, direct-injection engine, and paired with the Renk RK325 automatic transmission, comprises the Merkava Mk 4 power pack. It offers the best power-to-weight ratio at such weight levels (65 tons). A computer connected to the driver's panel and to the transmission system controls the engine. Field tests covered over 10,000 km in rough terrain successfully.

An auxiliary engine provides power when the tank is on "silent watch" for battery recharging and night observation, with full systems operating while the main engine is shut down.

One of the unique advantages of the entire Merkava family is its remarkable cross-country capability through its specially designed suspension system. This is typified by a powerful spring and rotary coil-spring design, differing from the double spring system used in previous Merkava Mk 1 and Mk 2 models. The Merkava Mk 3 Baz suspension is optimized for fast ride over extremely difficult terrain, like the basalt rock strewn Golan Heights.

With vertical road wheel travel of up to 600mm in diameter, the crew is given a softer ride, which reduces fatigue. The suspension meets the stringent requirements of 60 km-per-hour in rough country and reduces the impact on its crew thanks to the excellent absorption capability of the suspension system, which never surpasses g-1. In comparison tests with other vehicles undergoing the same criteria, when speed approached g-9, crewmembers suffered injuries and system malfunctions. In the Merkava Mk 3, at twice that speed, on the same test bed conditions, the g-force never exceeded g-1!

Although details are still classified, the Merkava Mk 4 suspension system also underwent additional improvement, which, combined with the new power-to-weight ratio, could even surpass the data of the Mk 3.

Retired Lieutenant Colonel David Eshel, Israel Defence Force, is a freelance journalist and serves as a defense analyst for several military journals. Following his brief service with the British Forces during World War II, he became one of the founding members if the Israeli Armoured Corps and served as a career officer with the IDF for 26 years. Educated at the French Cavalry School at Saumur, he later held various command and staff assignments and fought in all of the Arab-Israeli wars, including the 1973 conflict, when he served as the Armoured Corps' chief of signals.