M48 tanks of the Bundeswehr's 35th Panzer Brigade move into position during NATO maneuvers near Grafenwoehr in 1970.

Battle Tanks for the Bundeswehr

Modern German Tank Development, 1956-2000

by Rolf Hilmes

This article will give *ARMOR* readers an overview of the Bundeswehr's development of main battle tanks since World War II. It will cover Germany's initiation of its own MBT development, beginning in 1956; the introduction of the two new tank series that resulted, the Leopard 1 and Leopard 2; and some details of the test bed projects and studies completed during this period.

Introduction

The Bundeswehr obtained its first series of tanks from the U.S. in January 1956. They were M47s, and while their performance was not the best, these 1,100 tanks provided German tank crews with solid, basic tactical skills in the Bundeswehr's early days.

The M47s boasted modern suspensions and automatic transmissions, which contributed to a substantially easier driver's operation. But their disadvantages were considerable. They consumed enormous amounts of fuel, about .33 miles per gallon on the road, and this could double when driving in difficult terrain. Handling was not the best, nor were the optical components in the turret, in particular the optical range finder, which led to frequent difficulties.

For the U.S. Army, the M47 was an interim solution, and the U.S. fielded the M48 beginning in 1953. But a delivery of this MBT to friendly states was not possible before 1958, when the first of 1,462 M48 tanks were delivered to the German Army. The M48 was more reliable than the M47 and exceeded the earlier tank in all parameters of firepower, mobility, and protection. The M48 had a crew of four, compared to five on the M47, so there was a relatively spacious compartment for crew and components. There was also room for growth: its 90mm cannon was easily replaced with the NATO-standard L68 105mm gun in 1978. Germany even explored putting a 120mm smoothbore cannon on the M48!

This tank remained in service with the Bundeswehr until 1993, and in a way, it is still in service. Some M48 hulls have been converted into Keiler mine-clearing vehicles.

A Joint Project Fails

Because U.S. tanks did not fulfill all German requirements, specific national requirements for a future main battle tank were established by the chief of staff of the German Army in 1956.

German objections to the U.S. MBTs were that they were too heavy, too bulky, and too high. Beyond that, German industry wanted to be in a position to carry on independent development and production of MBTs on a long-term basis.

Military requirements initially called for an MBT of 30 metric tons, and the tank was to be developed jointly with France. Later, when Italy agreed to the same military requirements, optimists spoke of a "European standard tank." It was agreed that France and Germany would build their own prototypes, but the arrangement broke down, and by the time testing of the two tanks began in 1963, the joint tank development agreement had clearly failed. The French went on to build the AMX 30 and the Germans the Leopard 1.

The Leopard 1 Project

From a technical point of view, the development and testing of the Leopard 1 was a very successful project for Germany. The high reliability and the low operation and support costs of the Leopard 1, in comparison to other MBTs of that time, were essentially based on very systematic development, careful component selection, and extensive testing of both the components and the system. When compared to U.S. battle tanks of the same period, the Leopard 1 possessed a number of advantages:

- Higher weapon efficiency, better combat surveillance, and situational awareness for the commander due to the tank's panoramic sight
- More favorable task distribution within the crew
- Higher tactical and operational mobility
- Improved stream-crossing mobility and easier transportability
- Lower vulnerability and greater endurance due to its diesel engine
- The inclusion, for the first time, of an NBC protection and ventilating system
- Acceptable ergonomics for the crew
- An overall higher reliability and life expectancy of the entire system.

An M47 demonstrates its mobility in a 1958 exercise by Panzer Battalion 64.

But the Leopard clearly had less ballistic protection than the M48.

The Leopard 1 also stood its ground well in international comparisons with the other main battle tanks of the '60s: its firepower was equal and its mobility outstanding, surpassing all the other MBTs in both road and cross-country driving. Its protection was below average, although it was better than the protection of the AMX 30. The decision for less ballistic protection was based on the idea that mobility was a part of survivability.

A very efficient and functional family of vehicles was developed in the '70s on the platform of the Leopard 1. The availability of an extensive system environment, including training aids and simulators, etc., as well as an efficient logistics system in German industry, helped this vehicle become an international success. The Leopard 1 finally became the European standard tank!

Between 1965 and 1976, the German Army procured 2,437 Leopards. Today, the Bundeswehr tank force includes 727 Leopard 1A5s; the rest have been sold. Within the next few years, some Leopard 1s will be modified to become artillery observer vehicles to accompany our new howitzer, the Panzerhaubitze 2000, but after a service life of over 30 years, and given its outdated armor protection, it will no longer be employed as a main battle tank in the Bundeswehr. Nevertheless, other countries — including Australia, Belgium, Canada, Denmark, Greece, Italy, Norway, Turkey, Brazil, and Chile — will continue to use Leopard 1s, with various different updates, in their armor forces.

The MBT 70/Kpz 70 Project

Both the M60 in the U.S. Army and the M48 in the Bundeswehr were scheduled for replacement in the early '70s. This expectation led the U.S. and Germany to begin joint development of a new battle tank for their armed forces in the MBT 70/Kpz 70 project. Both nations agreed on joint military requirements and later on a joint vehicle design, which was a great improvement on the earlier German-French MBT-project. The main characteristics of the MBT 70 were:

- A 152mm weapon system that could fire both guided missiles (the Shillelagh) and conventional ammunition
- A three-man crew with the driver in the turret
- An automatic loader for the main weapon
- A 20mm automatic cannon as secondary weapon, capable of independent laying
- Stabilized optics
- A retractable, extendable night vision device, based on low-light intensifier technology
- Radiation shielding of the crew compartment
- An 1,100 kW engine
- Hydro-pneumatic suspension with adjustable level control
- Air conditioning and NBC protection
- Spaced armor in the front of turret and hull.

Tests began in 1967. Not surprisingly, given the project's high performance specifications and the associated development risks, nearly all components had substantial deficiencies, with components either under-performing or failing reliability standards. The Germans spent nearly $410 million in development costs until mid-1969, and fielding of the vehicle was not yet in sight. It

At left, a Leopard 1 leaps over an obstacle in a mobility demonstration at Munster by PzLehr Brigade 93.

became obvious that the complexity of the MBT 70 would lead to immense O&S costs and that the total system could not have been used effectively by a conscript army. Competition between the industries of both nations intensified with the development of individual components, but by the end of 1969, the bilateral development was terminated. Some progress had been made, and both partners had gotten to the prototype development stage before the program was halted. Germany would never reach this stage again with any other joint MBT project.

From MBT 70 to the Leopard 2

After termination of the MBT 70 program, Germany worked to keep the basic concept alive by simplifying and reducing development risks. They dropped the idea of putting the driver in the turret, in a capsule that always faced forward even when the turret traversed. This feature proved to be disorienting to the driver, and was dropped in favor of a more conventional 4-man crew arrangement, with the driver in the hull. By 1971, developers finally succeeded with a tank concept, which had originated in 1968 in the "Keiler Study."

The first prototype of the Leopard 2 tank was completed in 1972, equipped with a 105mm smoothbore gun. From 1972 to 1975, there were 17 prototypes developed to test various kinds of equipment. Some variants used torsion bar suspensions, some hydro-pneumatic; some mounted 105mm guns, others the 120mm smoothbore. After analyzing the results of the 1973 Yom Kippur War, the maximum weight limit of the new tank was raised from MLC 50 (approx. 47.5 tons) to MLC 60 (approx. 55.4 tons). Starting in 1975, the hull and turret were again completely revised and the front and side areas of the combat compartment were equipped with special armor sections. This resulted in the so-called Leopard 2 AV. After a development time of over seven years, at a cost of about $325 million, Leopard 2 was ready for fielding. The German Army procured 2,125 Leopard 2s from 1979-1992.

As with the Leopard 1, systematic development and intensive technical and user tests led, in the long run, to a highly sophisticated product. The Leopard 2 represents an overall optimal system in terms of efficiency, performance, size, and weight. Remarkably, in all international competitions, the Leopard 2 proved a winner when competing against other international tanks, resulting in its adoption by Switzerland, Sweden, and (probably) Greece. Almost 20 years after the delivery of the first full-production vehicles, another version with more sophisticated equipment and high performance armor protection was designed and built for Sweden.

New production is also intended for Spain, while refurbished Leopard 2s are used by Austria and Denmark. Presently, seven nations use this weapon system.

Since 1984, there have been various product improvements. In 1995, the Leopard 2A5 version began production. A total of 350 vehicles will get the following improvements:

- Additional protection at the turret front and sides
- A liner in the crew compartment
- A new driver's hatch with better ballistic protection
- An electric turret drive
- A new commander's periscope sight with day-night channel
- A TV camera aimed backward to help the driver reverse the vehicle.

Last July, an agreement was reached to bring 350 vehicles up to Leopard 2A6 configuration from 2001-2005. Features of this version are:

- A new gun with a longer barrel (+ 1300 mm)
- New kinetic energy ammunition (LKE 2).

These modifications increase the muzzle energy from 10 megajoules to 13.5 MJ, and muzzle velocity from 1,650 m/sec to 1,750 m/sec.

Besides the official improvements for the Bundeswehr, the German tank industry, and specifically the prime contractor, Krauss-Maffei-Wegmann, is improving the Leopard 2 as a private venture. A demonstrator vehicle is being built with a cooling system for the crew compartment and an auxiliary power unit. A second demonstrator will be built with the Euro-Power Pack (a 1,250 kW diesel), improved mine-protection, and possibly a new ammunition storage arrangement in the rear of the turret.

A Joint British-German Project

In 1969, four years after the fielding of the MBT Leopard 1, the German Army's Chief of Staff began pondering its termination. The Leopard 1 was scheduled to be replaced by a new MBT in the mid-1980s.

There were similar considerations in the UK concerning their Chieftain MBT. Therefore, at the beginning of the '70s, negotiations took place with the British to develop joint tactical requirements of a future MBT 80/KPz 3. Nationally, the tactical requirements for a Leopard 1 successor were issued in April 1972, calling for a procurement of 2,180 MBTs, beginning in 1985.

Similar to the French-German attempt to build a standard tank, each nation drafted independent concepts to meet

Some Experimental Concepts

Above, an MBT 70 prototype "kneels" in a demonstration of its unusual variable height suspension.

At left, the VT 1-2 prototype, a turretless casemate tank with two 120mm cannons mounted in the hull, undergoes testing at Munster.

At lower left, a model of the flat turret technology, which included a roof hatch which could go up at the rear to allow the gun to depress. This feature permitted a flatter turret and lower vehicle height, while saving weight.

the tactical requirements. The German team suggested some interesting but very sophisticated concepts in 1973, including a turreted tank, a casemate tank with armament in the hull, and an externally-mounted gun concept). Demonstrators were also tested in 1973 that included the testing of a casemate tank with two cannons in the hull (VT 1-1 and VT 1-2).

In 1974, during the evaluation of the submitted concepts, none met the requirements, especially the requirements for protection, weight, logistics support, and costs. These problems could not be solved, and the German-British tank program was terminated in 1977. The UK insisted on a turreted concept for a future tank design (which later became the Challenger program), while Germany did not see a significant improvement in a turreted concept compared to the Leopard 2 then under development.

Innovative Turret Concepts

Between 1976 and 1978, Germany began an intensive search of battle tank concepts with externally mounted guns. From the technical point of view, there were hopes that this design would provide better protection than Leopard 2 within the upper weight limit of MLC 60. The studies were also accompanied by advanced technology demonstrators, VTS-1 and VTF.

However, there were serious doubts about the external gun concept. The hull station lacked the 360-degree visibility for the commander found in the TC's position in a turreted tank. This created substantial command and control problems. The external mount also increased the probability of a firepower kill. Correction of malfunctions on the weapon would not be possible from under armor, hence combat could no longer be carried out in an emergency. The weapon itself had limited traverse of +/-60 degrees. And finally, there was no reasonable adaptation for an anti-aircraft machine gun.

At the end of 1977, considerations focused on the low profile turret concept of Wegmann. A moveable hatch in the turret roof allowed a flatter turret design, reducing the height of the turret about 30 percent, which achieved the necessary weight reduction. In studies at the end of 1978, different variants of the low profile turret concept were examined with front- and rear-driven hull concepts (FT mod. 1 - 4).

Another Joint Project Fails

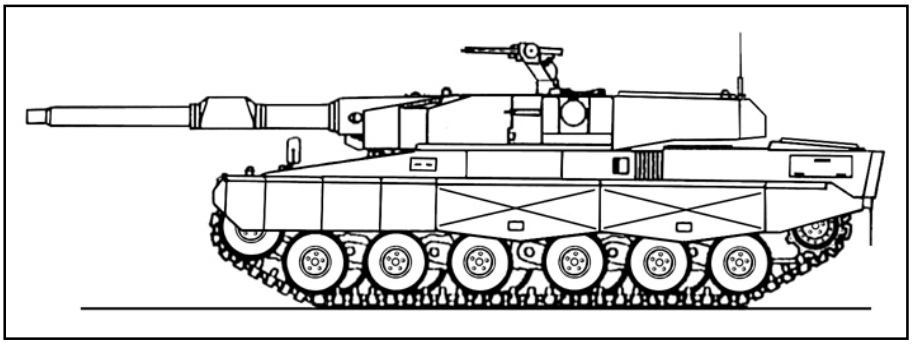
The studies of the low profile turret concepts coincided with the beginning of another French-German tank program (MBT 90), which had the goal of fielding a new tank as successor to MBT Leopard 1 and the French AMX 30, with fielding beginning in the 1990s. Both nations were well aware of the lessons learned from the failure of the earlier joint program. This time, the program was structured carefully and a goal set to reach a joint agreement on important basic requirements before detailing technical problems or building prototypes.

In the first phase, joint resolutions were to be achieved in regard to:

- Military requirements for the future main battle tank
- Harmonizing governmental and industrial organization for the joint project
- Timely planning, as well as allocation of the work package and the funding
- The necessary procedures (e.g. evaluation; type of contract, reimbursement of costs etc.)

Above, a prototype of the Leopard 2A6, with its longer gun tube, seen here at the 1998 Eurosatory arms show.

The drawing below is a proposal that incorporated the flat turret and the Euro-Power Pack, which reduces the length of the chassis about three feet with commensurate advantages in weight reduction.



- Proceedings for possible international cooperation and regulation of export questions
- A joint basic MBT concept.

In the course of the project, cooperation problems arose and their solutions were obviously extraordinarily difficult. France insisted on a weight of MLC 50 (approx. 48 tons) as upper weight limit. And due to budgetary reasons, France also insisted on a 1991 date for first unit fielding. On the other hand, Germany's procurement budget was tied to the Kampfwagen 90, and sufficient funding was not available before 1996. From the German point of view, there was no significant advance in chassis technology compared to that of the MBT Leopard 2. Therefore, Germany decided in 1980 to use the newly developed low profile turret on a Leopard 2 chassis, an idea that, understandably, drew no approval from the French partner, who had done a lot of work to develop a tank chassis with new technology. Disagreements also arose over the allocation of work between the two countries, the planned single-source production of important components, and the handling of the export rights. At the end of 1982, it was obvious that the second attempt at a French-German joint MBT had failed once again.

Upgrading the Leopard 2

In 1983, it was clear to the German Army that within the time frame of the intended introduction period of a future MBT, i.e., 1996, there were no new technologies that couldn't be transferred into upgrades of the Leopard 2. Therefore, new studies in the mid-'80s primarily targeted enhancement of the Leopard 2. The Leopard 2A5, as well as the Swedish version (Strv 122), are based essentially on the results of these studies completed in 1986.

In 1984, the date for the first unit to be equipped with a new MBT was postponed to 1999 due to budget constraints. As a result, the MOD took a new approach in the MBT program and requested the development of a new tactical requirement. Until the end of 1988, industry worked on the definition of new tactical requirements for the Panzerkampfwagen 2000 (PzKW 2000). Contrary to earlier practices, the Army was now ready to accept innovative technologies for the PzKW 2000. The constantly increasing demand for protection within the given weight limit of MLC 60 could only be realized with a space-optimized tank concept, e.g., an externally mounted gun. Remarkably, the Army was also ready to accept a two-man crew (with two-man alternate crew) after an appropriate field test showed positive results. Other substantial characteristics of the PzKW 2000 were:

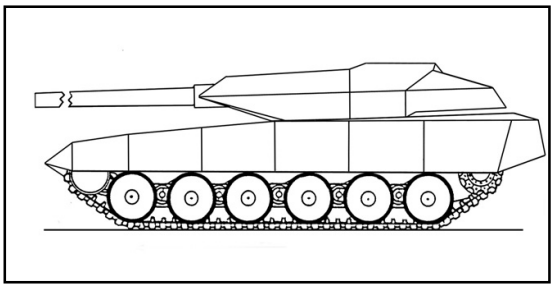
- A large-caliber powder gun, possibly 140 mm
- A digital fire control system with modular structure
- A 2nd generation FLIR and CO_2 laser rangefinder
- Multi-sensor technology for automatic target engagement
- An integrated command, control, and information system (IFIS) with digital data communication
- A digital bus system for the entire vehicle
- Realization of an effective overall protective concept.

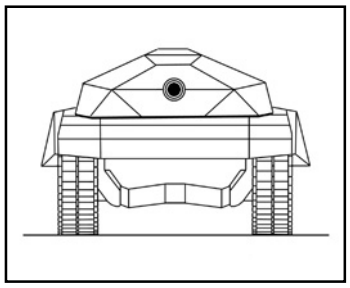
Compared to the Leopard 2, firepower, as well as survivability, was planned to be significantly increased with the PzKW 2000. But before the project could be added to the German Armed Forces plan of 1989, it was cancelled, like numerous other projects of the KW 90 program, because of the political changes in Europe and the reunification of Germany. There was also a dramatic shortage of funds and a change of priorities in defense planning. As the '90s began, this changed political situation led to a 50 percent reduction in the Armor branch of the German Army.

Looking to the future, and based on the complexity and the necessary development efforts for a future MBT, a development time of approximately 10-15 years is still expected. A replacement for the Leopard 2 is now envisioned in the time frame of 2015 and beyond, requiring immediate development activities.

Into the Future

Mission statements and operational requirements for a future tank family have been compiled since 1997. They were accepted into armament planning under the specification "New Armored





Platforms" (*Neue Gepanzerte Plattformen* = NGP), which is intended to result in development of the following armored vehicles:

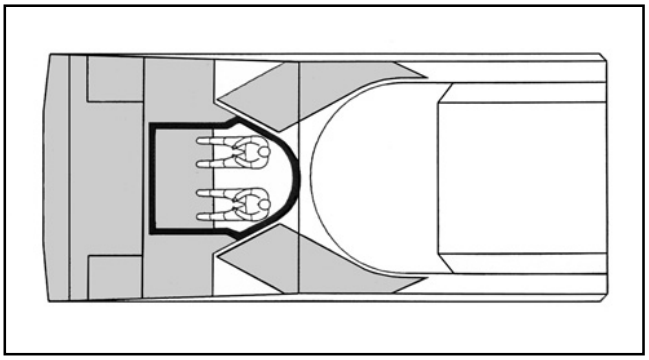
- A platform to fight heavy ground targets (i.e., MBTs)
- A platform to fight the remaining target spectrum with the capability to incorporate a dismounting component (i.e., mechanized infantry fighting vehicles)
- A platform for combat support tasks, i.e., antiaircraft vehicle, mortar vehicle.

With a proposed introduction date of somewhere in the 2008-2025 time frame, the employment of innovative component technologies is necessary for the NGP in important areas. Appropriate preliminary investigations and proofs of feasibility were introduced, including the production of the testbed "EGS" (*Experimentalwanne Gesamtschutz*). The EGS also incorporates a compact 2-man crew compartment. Further investigations will explore a 2-man crew compartment with sophisticated ergonomics and a comprehensive total protection system incorporating signature reduction and the use of defensive aids suites. New tank armament is being considered, either a 140mm high-velocity powder gun or a 120mm electro-thermal-chemical gun (ETC). It would incorporate a sensor package for reconnaissance, surveillance, and target acquisition; a sophisticated C^4ISR system; digital system architecture; and an electric drive system.

Based on past experience, it is unclear whether the development of the new MBT should be carried out as a national program or together with a partner. Today, the development of a future mechanized infantry fighting vehicle is top priority. The IFV is planned for fielding about 2009, but before this will happen, many political, technical, and economical difficulties must be solved.

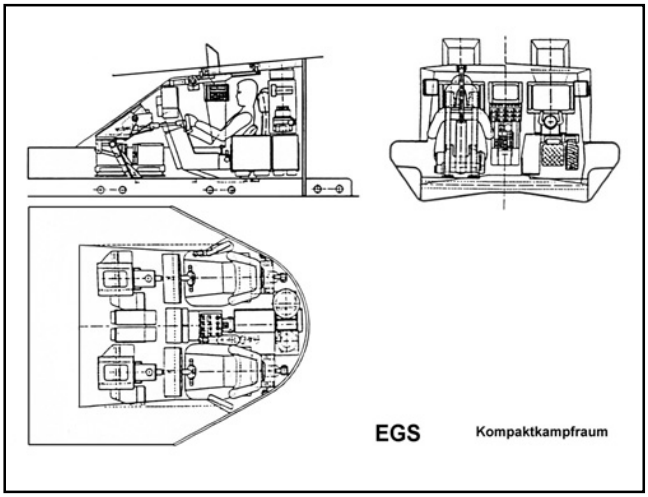
A future MBT must differ in important combat effectiveness parameters and operation characteristics from the Leopard 2. This will require the employment of future-oriented technologies, especially in the areas of armament, drive components, survivability, and C^2. It is obvious that these stringent requirements have serious impacts on development and engineering. It remains to be seen whether reasonable solutions for these difficult problems will be found in the coming years so that the German Armored Force will be equipped with an efficient main combat system to challenge the future threats and tasks expected.

Into the Future?



The "EGS" concept tank has a two-member crew, located deep in the hull, which permits a weight of about 48 tons. This would be augmented with defensive aids, signature reduction technologies, and either a 140mm conventional gun or a 120-mm electro-thermal-chemical gun incorporating new technology.

The tank, proposed for use in the 2008-2025 time frame, would also benefit from emerging technologies in its sensor package, a digital system architecture, and electric drive.



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