PROFILE

AFV WEAPONS

56

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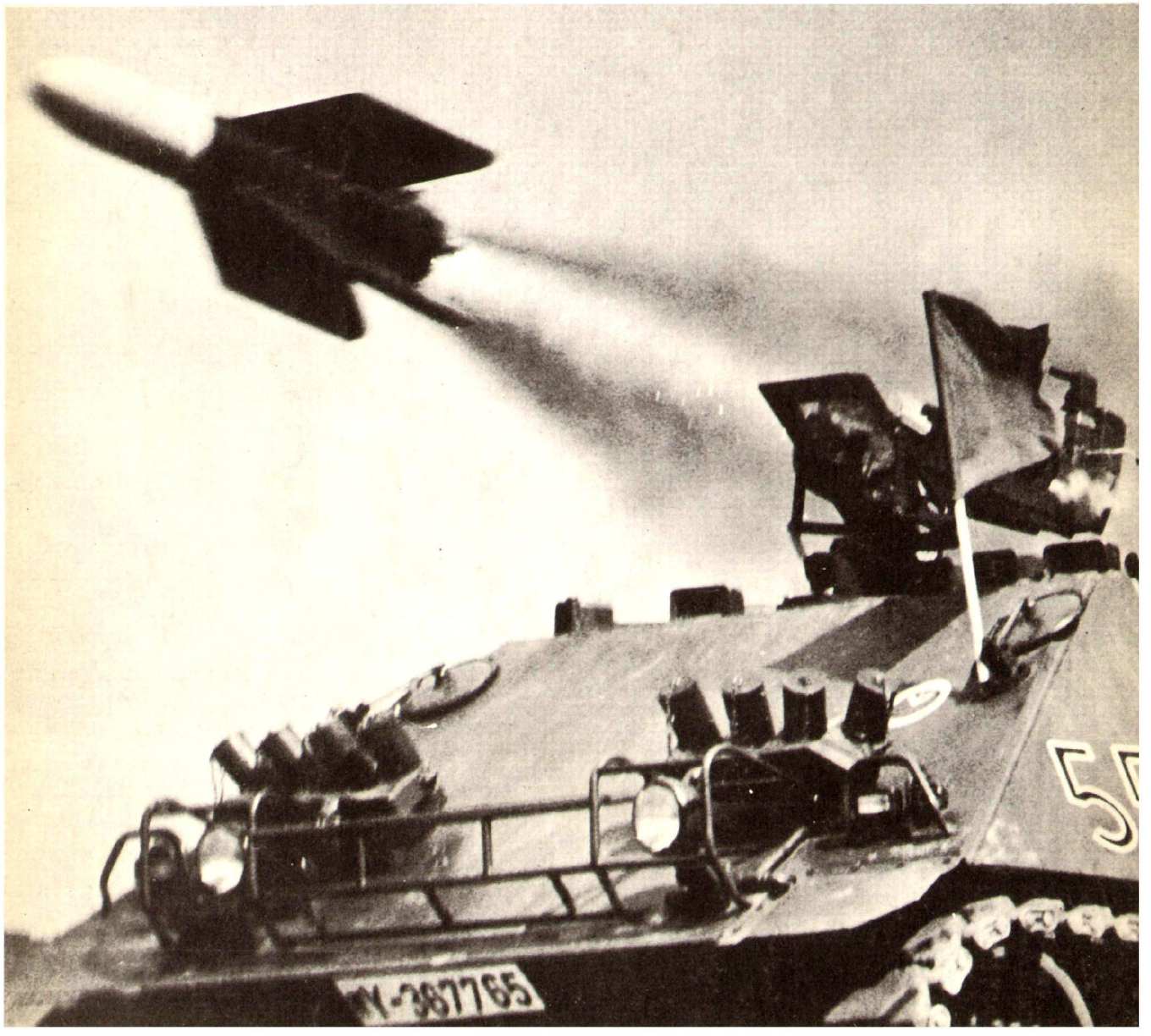
Missile Armed Armoured Vehicles

by R. M. Ogorkiewicz



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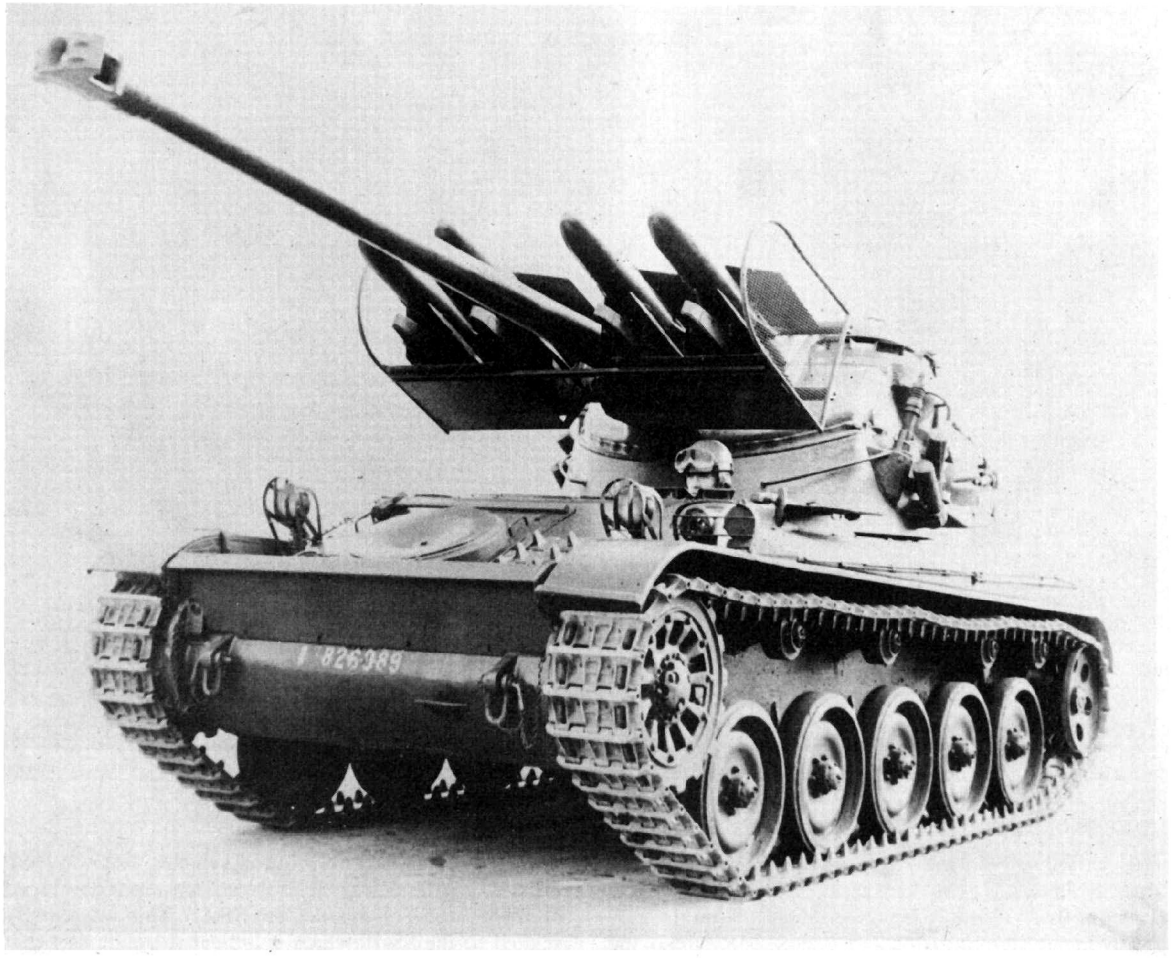


French AMX-13 light tank with SS-11 missiles, the pioneer missile-armed armoured vehicle. (French Army)

Missile Armed Armoured Vehicles

by R. M. Ogorkiewicz

The development of guided missiles has often been claimed to spell the doom of tanks. The reason for such claims is twofold. One is the fact that the warheads of anti-tank guided missiles are capable of perforating the thickest tank armour. The other is the belief that tanks' armour made them virtually invulnerable and that their effectiveness was based on this. From these two premises it is inevitable to come to pessimistic conclusions about the future of tanks, since their armour can be defeated by anti-tank guided missiles.

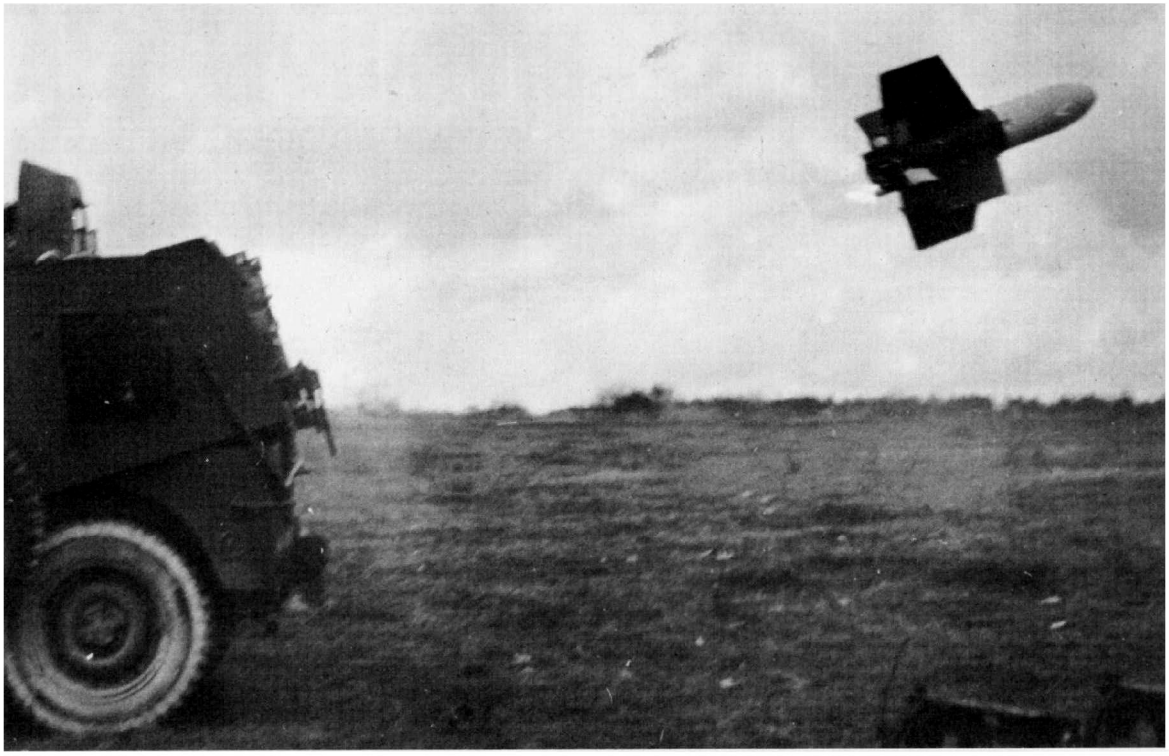
Armour protection is not, however, the only or even principal attribute of tanks. What is far more important is their ability to make weapons mounted in them more mobile and therefore more effective. In other words, tanks are essentially mobile ground weapon platforms and as such they do not depend for their usefulness on being invulnerable, which they have never been anyway.

Moreover, anti-tank guided missile systems need to be mounted in armoured vehicles to have an adequate degree of battlefield mobility, just as guns have had to be mounted in tanks. Thus, instead of putting an end to them, guided missiles have created an additional need for tanks, or tank-like vehicles, and their development has led to several new types of missile-armed armoured vehicles.

FIRST ANTI-TANK GUIDED MISSILES

The development of anti-tank guided missiles began in Germany during World War II. Its first outcome was the X-7, a slow, 90 m/s missile with a two-stage solid propellant rocket motor which was guided to a range of 1,200 metres by signals transmitted through a trailing wire link. It had a 140 mm diameter body with a shaped-charge warhead and its mass was 9 kg.

The basic features of the X-7 were derived from an earlier, wire-guided, air-to-air missile, the X-4 whose development began in 1943 and which successfully flew for the first time in September 1944. Work on the X-7



Nord-Aviation SS-10, the first anti-tank guided missile to go into service, fired from a jeep. (Aerospatiale)

itself started in 1944 and it was about to be produced in quantity in 1945 when Germany was overrun by the armies of the Western Allies and the Soviet Union.

However, after the war, in 1946, the development of the X-7 type of missile was taken up in France, at what was then the Arsenal de l'Aéronautique and later the Societé Nationale de Constructions Aéronautiques Nord-Aviation. It bore fruit six years later in the production of the SS-10 which became the first operational anti-tank guided missile in the world.

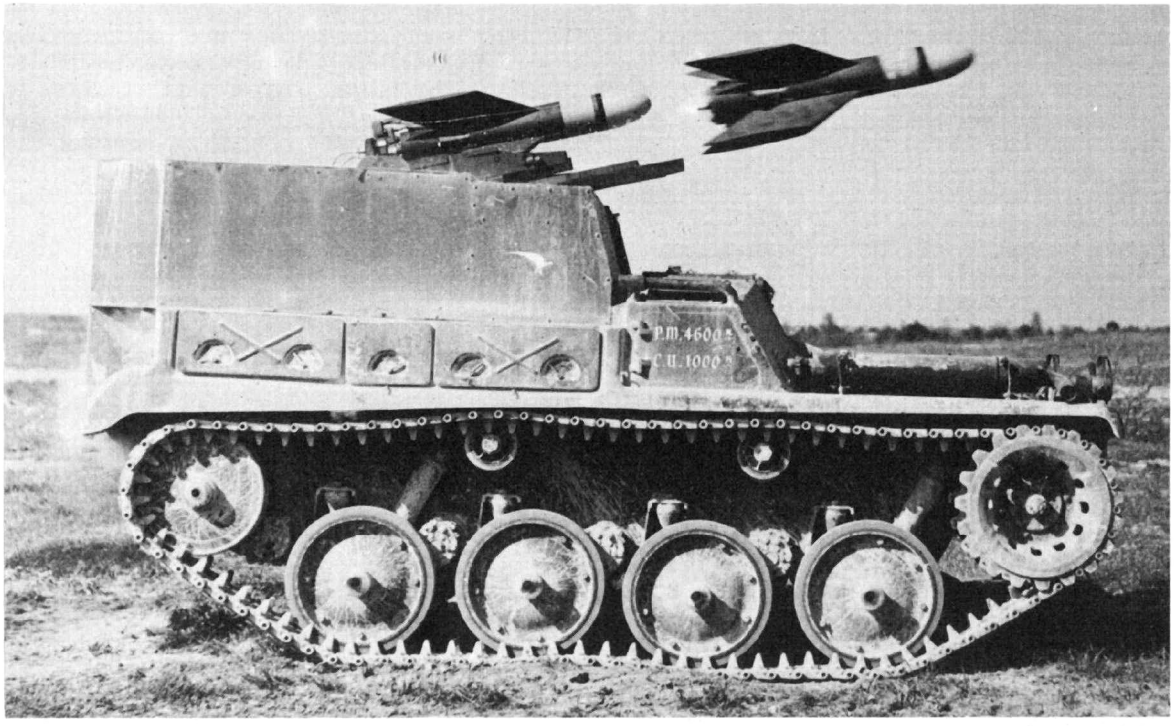
Like its German forerunner, the SS-10 was a solid fuel propelled rocket with relatively large wings because of its low, 80 m/s flight speed. It was guided through a trailing twin-wire link by signals generated at a control box with a small joystick used by its operator to align it with the target and thereby make it fly along his line of sight. The missile had a range of 1,600 metres and was fitted with a 164mm diameter shaped-charge warhead which could penetrate 400mm of armour. This meant that the SS-10 could perforate the armour of any contemporary tank. At the same time its mass of 15 kg made it light enough to be an infantry anti-tank weapon. As a result it attracted considerable attention and when it began to be produced in 1952 for the French forces the U.S. Army also ordered several hundred for trials and eventually, in 1957, adopted it as its first anti-tank guided missile. By then the SS-10 had also been ordered by the armies of Israel, Sweden and Western Germany and its success is attested by the fact that by the time its production came to an end in 1963 no less than 29,850 had been made.

The SS-10 was normally fired from launcher cases placed on the ground or from jeeps. It was also tried on slow-flying aircraft and helicopters but it was not adopted for use in them or in armoured vehicles. For use from ground and aerial vehicles Nord-Aviation developed another *Sol-à*-Sol missile, the SS-11. This was closely related to the SS-10 which is indicated by the fact that it was designated Nord 5210 while the operational version of the earlier missile was designated Nord 5203. However, it had a higher, 120 m/s flight speed and a longer, 3,000 metre range. Its shaped charge warhead had the same, 164 mm diameter as that of the SS-10 but it was heavier and more effective, being able to penetrate 600 mm of armour. It was inevitably heavier than the SS-10, having a mass of 29.9 kg, and it cost more – 1,500 U.S. dollars, in fact, compared with 970 dollars for the SS-10. Nevertheless, it proved even more successful than the SS-10, being adopted by the armed forces of some twenty different countries and its production exceeded 120,000 missiles.

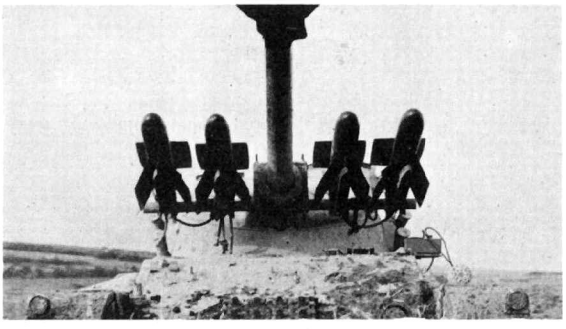
ORIGINAL ARMOURED VEHICLE INSTALLATIONS

The SS-11 became operational with the French forces in 1956 and soon after its appearance it began to be installed in armoured vehicles. One of its earliest installations was in a light Hotchkiss armoured carrier which did not, however, proceed beyond the experimental stage and the carrier itself was not adopted by the French Army although in a somewhat modified form it was produced for the German Army's reconnaissance units as the SPz 22-2. Instead, the French Army decided to mount the SS-11 on the AMX-13 light tank.

The AMX-13 was originally developed as a light, air transportable tank but when it was produced during the fifties the French forces had no transport aircraft



An early Nord-Aviation SS-11 fired from an experimental Hotchkiss armoured carrier. (Aerospatiale)



An early installation of SS-11 missiles on the AMX-13 light tank. (Aerospatiale)

Service version of AMX-13 with SS-11 missiles. (French Army)

capable of carrying it, nor was there a real need for air transportable tanks. On the other hand there was a very real need for anti-tank vehicles which the AMX-13 was partly able to meet. However, the armour piercing performance and range of its 75 mm were limited and it was logical to turn it into a more effective tank destroyer by arming it with SS-11 missiles. In fact, the AMX-13 with SS-11 missiles were considered so effective as long-range tank destroyers that the organization of French armoured forces adopted in 1959 included a squadron of twelve of them not only in each four squadron regiment of AMX-13 light tanks but also in each battle tank regiment.

Nevertheless, the installation of the SS-11 on the AMX-13 was of a makeshift nature with the missiles mounted on the front of the turret, two on each side of the gun. The missiles were therefore vulnerable to damage by bullets and shell fragments and even to being struck by branches of trees. The size of the missiles and in particular the span of their fins together with the very limited amount of room inside the AMX-13 made an external installation unavoidable and limited the number of missiles to four per vehicle. But, for all this, the mounting of the SS-11 on the AMX-13 represented the first successful example of the installation of guided missiles in a tank. It also provided a model, however

An SS-11 fired from an AMX-13. (Aerospatiale) (Note: A photograph of an SS-11 missile being fired from a Panhard AML—light armoured car—with H.90 turret appears in the *Profile* on Panhard Armoured Cars by R. M. Ogorkiewicz, as does a photograph of a Panhard AML with ENTAC missiles.)

Soviet BRDM with three Snapper missiles.

Soviet BMP-76 infantry combat vehicle with a Sagger missile above its 76 mm gun.

primitive, of the use of missiles and guns as complementary rather than alternative forms of tank armament.

Since the SS-11 were mounted on the AMX-13, several other anti-tank guided missiles have been mounted externally on armoured vehicles and, inevitably, their installations have incorporated a number of improvements. One example of this was the installation of four ENTAC missiles on the Panhard AML, a light four-wheeled armoured car armed in its original form with a 60 mm mortar and two 7.5 mm machine-guns. The missiles were mounted on a SAMO 1160 launcher located at the back of the AML's turret, which offered them a fair degree of protection, and they only moved from behind the turret for firing: this was done by the electrically operated launcher sliding one pair of missiles sideways to each side of the turret. The installation of the ENTAC on the AML was not, however, adopted and it has only been adopted on one armoured vehicle, the AMX-VTT armoured personnel carrier of the Belgian Army, in spite of being produced in numbers which rivalled those of the SS-11. The ENTAC, whose name is an acronym for *Engin Téléguidé Antichars*, has been in fact a direct successor to the SS-10 and has similar general characteristics. However, it has a longer, 2,000 metre range and its 150 mm diameter warhead can penetrate 650 mm of armour.

More recently the SS-11 has also been mounted on the Panhard AML with the H.90 turret but in this case the installation represented no advance on the original AMX-13 version and it has not been adopted.

In the early sixties a different type of anti-tank guided missile installation appeared when the Soviet Army began to mount its first generation missiles on the BRDM, a four-wheeled amphibious reconnaissance vehicle. The first of these anti-tank guided missiles, or PTURS, was one given the NATO code name "Snapper". It appeared on the BRDM in 1962 mounted on a three-missile launcher which was raised for firing from within the vehicle where the missiles were fully covered, the overhead covers being swung to the sides to allow the launcher to rise into its firing position. The next, "Swatter", missile was mounted on the BRDM in a very

SS-11 missile fired from a Jagdpanzer Rakete, or JPz 3-3.
(German Army)

similar way, except that there were four instead of three missiles on the launcher. The third, "Sagger", missile has been much more compact so that six could be mounted on the launcher and the cover over the launcher compartment rose with it into the firing position. In addition to the BRDM the "Sagger" has also been mounted on the BMP-76, an amphibious infantry combat vehicle which can carry one ready-to-fire missile above its turret mounted 76 mm gun.

The most advanced of the installations of the first-generation anti-tank guided missiles on armoured vehicles consisted of the SS-11 mounted in the *Jagdpanzer Rakete*, or JPz 3-3, a turretless tank destroyer developed by the German Army from the basis of the HS-30 tracked armoured personnel carrier. This low silhouette vehicle carries its missiles under armour and they are brought out for firing one by one by two retractable launching posts. The JPz 3-3 has also been provided with a tall periscope so that under suitable circumstances it can take up a firing position behind cover with nothing more than the head of the periscope and one of the missiles showing above it.

The JPz 3-3 was developed during the early sixties and has been followed since by a very similar *Jagdpanzer*

Rakete based on the chassis of the *Marder* armoured personnel carrier. The SS-11 missiles are mounted in it in much the same way as in the JPz 3-3 but its automotive characteristics and protection are considerably better than those of the earlier vehicle.

SHORTCOMINGS OF FIRST GENERATION MISSILES

The installation of guided missiles on armoured vehicles created a new category of tank destroyers which could be relatively light and yet could carry very powerful armament. They opened, therefore, the possibility of a considerable increase in the strategic and to some extent also in the tactical mobility of armoured forces, particularly by eliminating the need for very heavy gun tanks which were developed to support the standard battle tanks by destroying enemy tanks at long range.

However, the first generation missiles have suffered from a number of serious disadvantages. The principal one has been their dependence on the performance of their human controllers. They are, in effect, miniature rocket-propelled aircraft and as such have to be piloted, by remote control, to their targets. They require, therefore, a high degree of skill on the part of their controllers whose training is very expensive because it requires practice firing of missiles as well as the use of simulators. Moreover, they demand a very high degree of concentration during their flight to the target which may last 20 seconds and this is not easy to achieve under battlefield conditions. In consequence, the chances of scoring hits with the first generation missiles are considerably lower on the battlefield than they are at peacetime demonstrations, where hit probabilities of 90 per cent have been achieved. It is not surprising, therefore, that their employment has not proved particularly successful.

Anti-tank guided missiles were first used on the battlefield in 1965 during the fighting between India and Pakistan. They were Cobra first generation missiles very similar in principle to the SS-10 and the Entac but developed in Germany by Messerschmitt-Bolkow-Blohm GmbH and used by the Pakistani troops against Indian tanks, without much success however. It was widely reported nine years earlier that SS-10 were used by the Israeli troops when they defeated the Egyptian forces in the Sinai in 1956 but this was untrue even though SS-10 were in the Israeli Army inventory at the time. Some use was made by the Israeli forces of SS-11 missiles and by the Egyptian forces of Soviet anti-tank guided missiles during the Six Day Arab-Israeli War of 1967 but again neither side could claim any particular success.

VIGILANT AND SWINGFIRE

Some of the shortcomings of the first generation missiles were alleviated in those produced in Britain. Anti-tank guided missiles were taken up by the British Army later and with less enthusiasm than by the French forces and their development was hampered at first by scepticism about the effectiveness of their shaped-charge warheads. In fact, the first British missile to come into service, in 1962, the clumsy, Australian-developed Malkara, did not have a shaped-charge warhead but a heavy, 200 mm diameter squash head warhead.

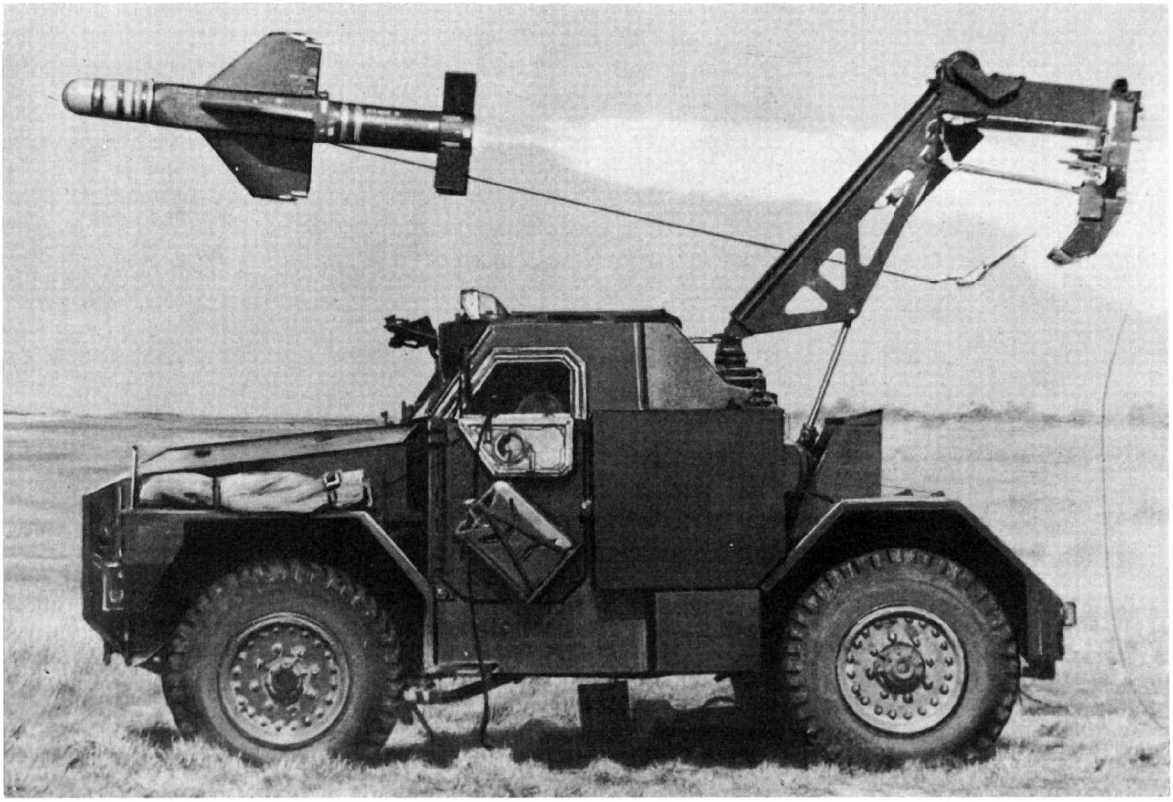
The second anti-tank missile adopted by the British Army was, however, much more successful. Its development was initiated in 1956 by Vickers-Armstrong (Aircraft) Ltd. as a private venture and it was only in 1961 that the British Army ordered some for trials, although subsequently it was adopted on a considerable scale. Originally called Vickers Type 891, the missile has since become known as the Vigilant, an acronym for Visually Guided Infantry Light Anti-Tank weapon. Most of its characteristics are similar to those of other first generation missiles, its mass with a 130 mm diameter shaped charge warhead being 15.5 kg, flight speed 140 m/s and range 1,500 metres. It has, however, an advantage over other manually guided missiles in having an autopilot which implies a velocity, instead of an acceleration, control system and simplifies the operator's task of guiding it along his line of sight. Inevitably, the autopilot control system of the Vigilant made it more expensive to produce. Thus, its original price was 1,400 dollars compared with the contemporary price of about 430 dollars for the cheapest of the first generation missiles, the Cobra.

A control system very similar to that of the Vigilant was incorporated in the third anti-tank missile developed in Britain, the Swingfire. In several other respects, however, the Swingfire is greatly superior to the Vigilant: it has a more powerful warhead with a diameter of about 150 mm, a flight speed of 185 m/s and a range of 4,000 metres. In contrast to earlier manually guided missiles, the Swingfire is also gathered after launch into its operator's field of view, close to his line of sight to the target, by an automatic programme generator built into its ground control equipment. In consequence, the minimum range at which it can be used to engage targets is 150 metres, compared with more than 300 for the SS-11, for instance.

All three British missiles have been mounted in armoured vehicles. The first, the Malkara, was mounted in the F.V.1620 Hornet launcher which was developed from the basis of the F.V.1601, the 1-ton armoured 4 × 4 Humber truck. The Hornet could carry four missiles, two ready-to-fire on a hydraulically-controlled launcher arm and two more, partly disassembled, under the launcher arm. It was operated by a crew of three and fully laden it weighed 5.7 tonnes, which not only made it possible to transport it by air but also to drop it by parachute. It was, consequently, earmarked for use in support of airborne operations by units of the Strategic Reserve when battle tanks could not be brought in. However, this meant that its use was confined to the one air portable squadron of the Royal Armoured Corps which was attached to the Parachute Brigade. Moreover, only a few years after it was introduced into service it was withdrawn.

The airborne role of the Hornet was taken over by the Ferret scout car armed with Vigilant missiles. Although the Vigilant was originally developed for use by the infantry it was tried in 1960 on a Ferret Mark 2 scout car and by 1962 it was adopted by the Royal Armoured Corps for its armoured car regiments, to strengthen their anti-tank capabilities. As a result, one of the two Ferrets in each armoured car troop of these regiments was fitted by the mid-sixties with Vigilant missiles and so were half the Ferrets which formed the equipment of the air portable squadron.

The Ferret with the Vigilants was given the designation F.V.703 and when it was adopted by the Royal Armoured Corps it became the Mark 2/6. It was essentially a Mark 2 fitted with a Vigilant container-cum-launcher on each side of its turret which retained its



Malkara fired from a Hornet. (MVEE—CCR)

Hornet launcher vehicle with two Malkaras on its launcher arm and one stowed below it. (The Engineer)

Vigilant guided missiles mounted on the turret of a Ferret Mark 2/6 scout car. (MVEE—CCR)

Ferret Mark 2 with Vigilant anti-tank guided missiles. (BIS—CCR)

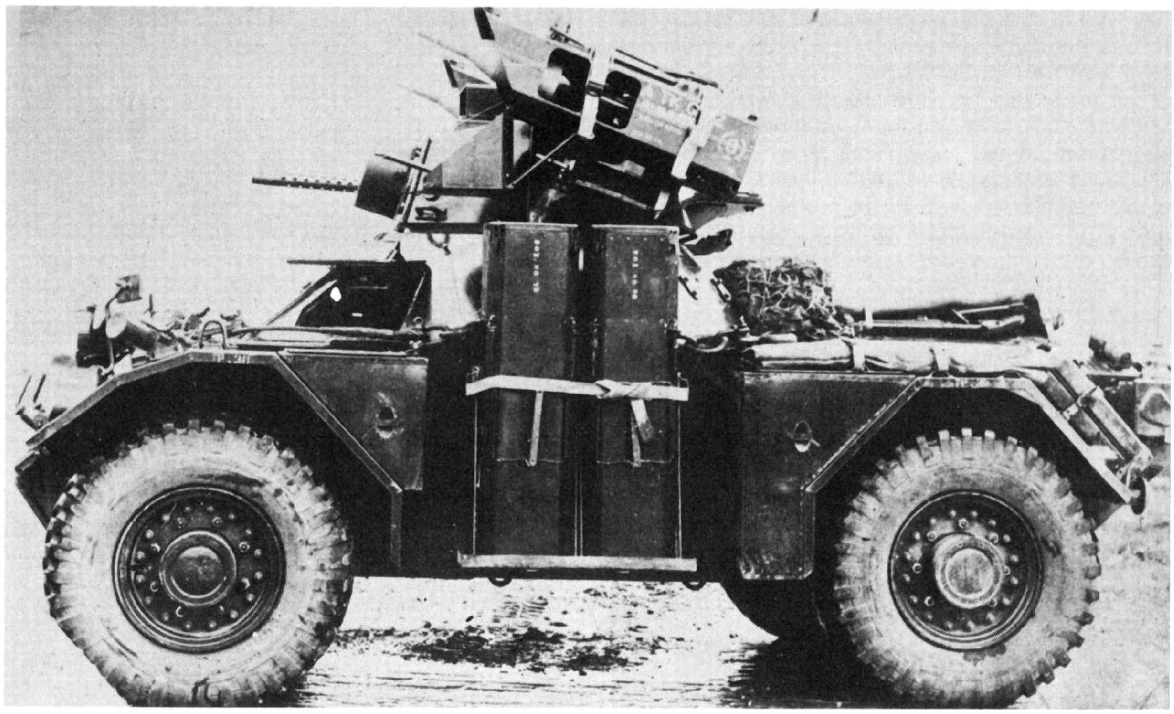
Swingfire guided missile. (British Aircraft Corpn.)

.30 in. Browning machine-gun but gained additional sighting equipment. In addition to the two ready-to-fire missiles two more Vigilant containers were mounted on the left of the hull, in place of the spare wheel.

Although it is effective, the Mark 2/6 has been only a makeshift for a properly designed missile version of the Ferret the development of which started in 1962. The new model consists essentially of the improved, "big-wheeled" Mark 4 version of the Ferret with a larger turret whose design started in January 1963. Instead of the steel armour used on all the earlier Ferrets, the turret of the new, missile-armed Mark 5 was welded from aluminium alloy extrusions and plates and it became the first British fighting vehicle with aluminium armour.

The turret of the Mark 5, or F.V.712, holds four ready-to-fire Swingfire missiles in pairs on either side of the gunner. The missile launching boxes are elevated for firing but otherwise the missiles are fully protected by armour, which represents a considerable advance on the Mark 2/6. In addition to the turret mounted missiles, two more can be stowed on the hull and the turret is also fitted with a 7.62 mm machine-gun. At one time the production of several hundred was contemplated but only a small number of the Mark 5 was actually built, the first coming into service with the British Army in 1968.

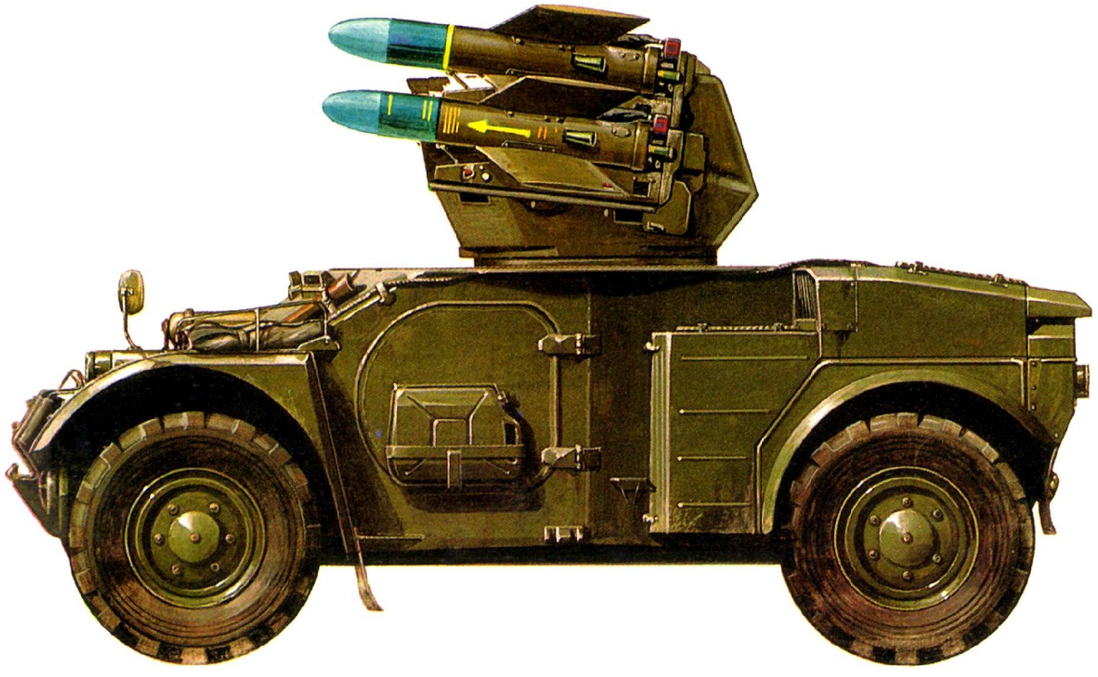
The reason why the Mark 5 was not produced in quantity was a switch by the British Army in the mid-sixties from its well-founded practice of using wheeled reconnaissance vehicles to the development of tracked reconnaissance vehicles. The latter have taken the form of the CVR(T), or Combat Vehicle Reconnaissance, Tracked, and include the Striker anti-tank guided weapon vehicle with Swingfire missiles as well as the basic Scorpion gun vehicle. Originally it was thought that the Striker, or F.V.702, would have the same turret as the Ferret Mark 5 but the Striker has been developed into a turretless vehicle with five ready-to-fire missiles in

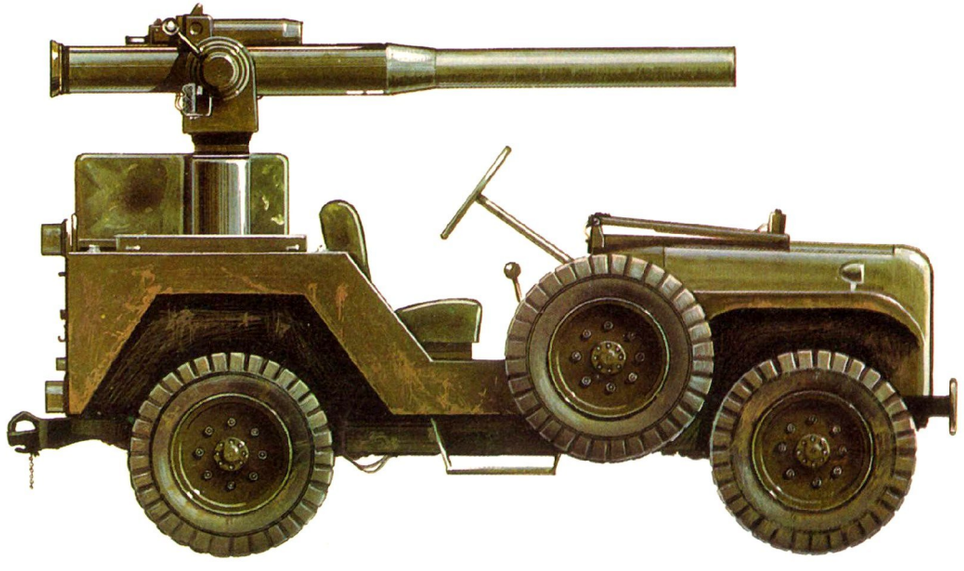


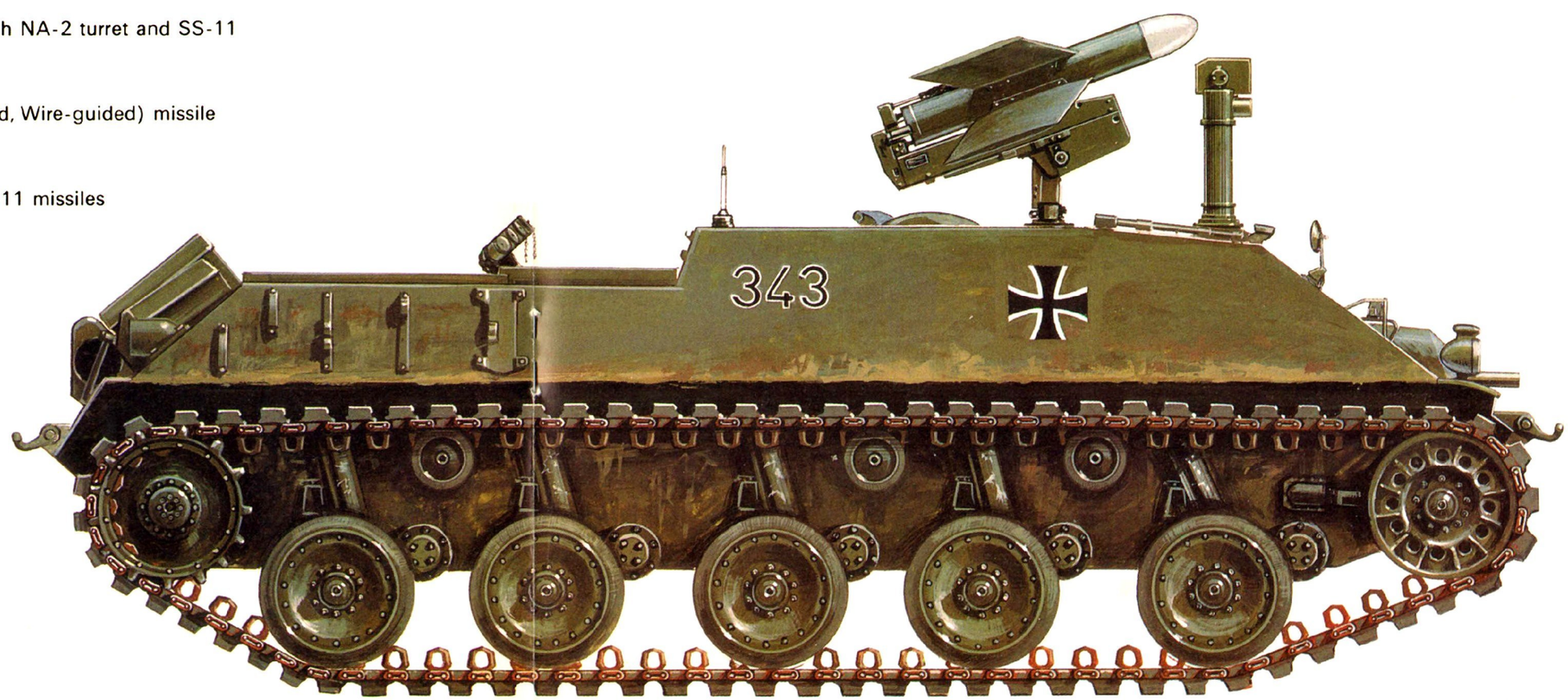
Two "reload" Vigilant guided missiles were carried on the left of the Ferret's hull in place of the spare wheel. (MVEE—CCR)

Prototype of Ferret Mark 5 with all four of its launcher boxes elevated for firing. (Alvis)

Prototype of Striker guided weapon vehicle with its five-Swingfire container elevated for firing. (Alvis)







Three missile-armed vehicles

Above left:
French Panhard A.M.L. (Automitrailleuse Legère) with NA-2 turret and SS-11 missiles

Above right:
United States TOW (Tube-launched, Optically-tracked, Wire-guided) missile launcher mounted on a jeep

Bottom right:
German Jagdpanzer Rakete (Neu) M-1966 with SS-11 missiles

Rear view of Striker guided weapon vehicle. (Alvis)

Early version of the FV 438 Swingfire launcher vehicle. (British Aircraft Corps.) (Note: Photographs of Swingfire being fired from a service version of the FV 438 launcher vehicle appear in the Profile on The FV 432 Series.)

an armoured container which can be elevated but not traversed. In addition, the Striker carries five more missiles in the hull. Its crew consists of three men, one of whom, the commander, mans a cupola with a 7.62 mm machine-gun. Fully laden the Striker weighs 8.2 tonnes and this together with its very compact dimensions makes it easily air transportable. In fact, two Strikers can be carried in such standard military transport aircraft as the Lockheed C.130 Hercules.

The first Striker was completed in prototype form in February 1972. When it is produced in quantity it will act as a complement to the Scorpion in the reconnaissance regiments of the Royal Armoured Corps by providing them with a long-range anti-tank capability and it has also been adopted by the Belgian Army as its anti-tank guided missile launcher.

In the meantime the British Army had acquired another tracked launcher for the Swingfire. This is the F.V.438, a 12.5 tonner developed from the F.V.432 armoured personnel carrier by fitting it with a fixed turret with two launching boxes and a tall periscope. The launching boxes are elevated for firing and can be reloaded from inside the vehicle which carries a total of 14 missiles. The crew of the F.V.438 normally consists of three men, including the driver, who are not only protected from small arms fire and shell splinters by its armour but also from radioactive dust and airborne chemical agents by the crew compartment being slightly pressurised and provided with an air-filtration system, as well as a heater or an air conditioning unit to suit climatic conditions.

The F.V.438 came into service in 1969 with the armoured regiments of the Royal Armoured Corps. Each regiment has a guided weapons troop with six F.V.438 which can engage targets beyond the effective range of its Chieftain battle tanks and thereby improve still further its capability against enemy armoured units.

In addition to the Ferret, Striker and F.V.438, the Swingfire has also been experimentally installed by its manufacturers, the Guided Weapons Division of the British Aircraft Corporation, on several other armoured vehicles. These include the Saladin armoured car and the Saracen armoured personnel carrier and the Centurion, Vickers and M47 battle tanks each of which has been fitted with two Swingfire launcher boxes on either side of its turret. The experimental installation of the Swingfire on battle tanks indicates clearly how their long range anti-tank capabilities can be significantly increased without altering their basic design or degrading their performance at short ranges where guns are much more cost-effective.

Like the Hornet and the Ferret Mark 2/6, all the installations of the Swingfire on armoured vehicles have retained the ability to fire the missile not only from the vehicle but also, through a cable link, from a position away from it – up to 50 metres away in the case of the Ferret Mark 5 and 100 metres in that of the F.V.438 and the Striker. This means that the missile operator can take up a concealed position with his separated sight away from the vehicle which can therefore be completely hidden and thereby immune to direct fire. However, on leaving the vehicle the operator loses the protection of its armour and the launcher vehicle effectively loses its mobility until the operator rejoins it.

AUTOMATIC GUIDANCE

Although the Swingfire is a second generation missile and is programmed to fly on to the operator's line of sight it still has to be guided by him all the way to the target like all the first generation missiles. In consequence its hit probability is still very dependent on the skill of its human controller who requires a considerable amount of training and the expensive firing of several missiles to acquire and retain the necessary level of proficiency. It is not surprising, therefore, that manual guidance has been abandoned in the development of other second generation anti-tank guided missiles in favour of automatic guidance.

The first step towards anti-tank guided missiles with automatic guidance was represented by the development by Nord-Aviation of the *Télécommande Automatique*, or T.C.A., for the SS-11. This was developed as early as 1962 and was based on the use of an infra-red sensor to track the missile and measure its deviations from the operator's line of sight, the error signals being fed into an electronic computer which sends out commands through the wire link to steer the missile within a 1 metre radius of the line of sight. In consequence, the T.C.A. simplifies the operator's task to placing the cross-hairs of his sight on the target and keeping them on it during the missile's flight. The elimination of the operator from the missile guidance loop greatly simplifies his training and reduces its cost, although, inevitably, the sight, infra-red tracker

Saladin Mark 2 with Swingfire; two missiles are "ready-to-fire" on the sides of the turret, two are in containers on the rear wheelguards. (Alvis)

Mock-up Swingfire installation on an M47 medium tank. (British Aircraft Corpn.)

Harpon system consisting of SS-11 missiles with automatic guidance on an AMX-13: the missile tracker can be seen on top of the turret. (Aerospatiale)

and command electronics increase the cost of the missile installation.

The T.C.A. was combined with an improved version of the SS-11, the SS-11 B1, and mounted on the AMX-13. The combination was called the Harpon missile system and was adopted in 1970 by the French Army as a successor to the AMX-13 with earlier SS-11 missiles and manual guidance. The Harpon did, however, retain the manual mode of operation as an alternative to the automatic guidance mode, which was thought to be desirable for engaging targets at very long range, and the change from one mode to the other can be made even during a missile's flight simply by means of a switch.

In addition to the AMX-13, the T.C.A. was also installed in a special one-man NA-2 turret developed by Nord-Aviation for mounting on light armoured vehicles. Originally the NA-2 turret was designed to have one SS-11 on each side and in that form it was experimentally mounted on the *Engin Légèr de Combat*, or E.L.C. a very light experimental two-man combat vehicle designed to mount either two 30 mm automatic cannon or an automatically loaded 90 mm anti-tank gun. The second version of the NA-2 has been developed to mount four SS-11 and two 7.62 mm machine-guns. As an alternative, the pair of SS-11 launchers on either side of the turret can be replaced by a single launcher for the much more powerful SS-12 "artillery" missile and a mixed installation of this kind was demonstrated with an NA-2 turret mounted on a Panhard AML light armoured car.

The use of T.C.A. with SS-11 missiles represents a major step forward in the development of anti-tank guided missile systems but automatic guidance has become even more effective when applied to more advanced missiles. This has been shown by the HOT missile system developed since 1963 by Nord-Aviation (now Aérospatiale) in collaboration with Messerschmitt-Bolkow-Blohm GmbH, of Ottobrunn-Munich, to a Franco-German requirement for a long-range anti-tank weapon suitable for installation in armoured vehicles.

In principle, the guidance system of the HOT is similar to the T.C.A. used with the SS-11 B1 but the missile has a considerably higher flight speed and this accounts for its name which is an acronym for *Haut subsonique – Optiquement Téléguidé*. Its flight speed is, in fact, 260 m/s compared with 160 m/s for the SS-11 B1, which means a significantly shorter time of flight to the target, and it also

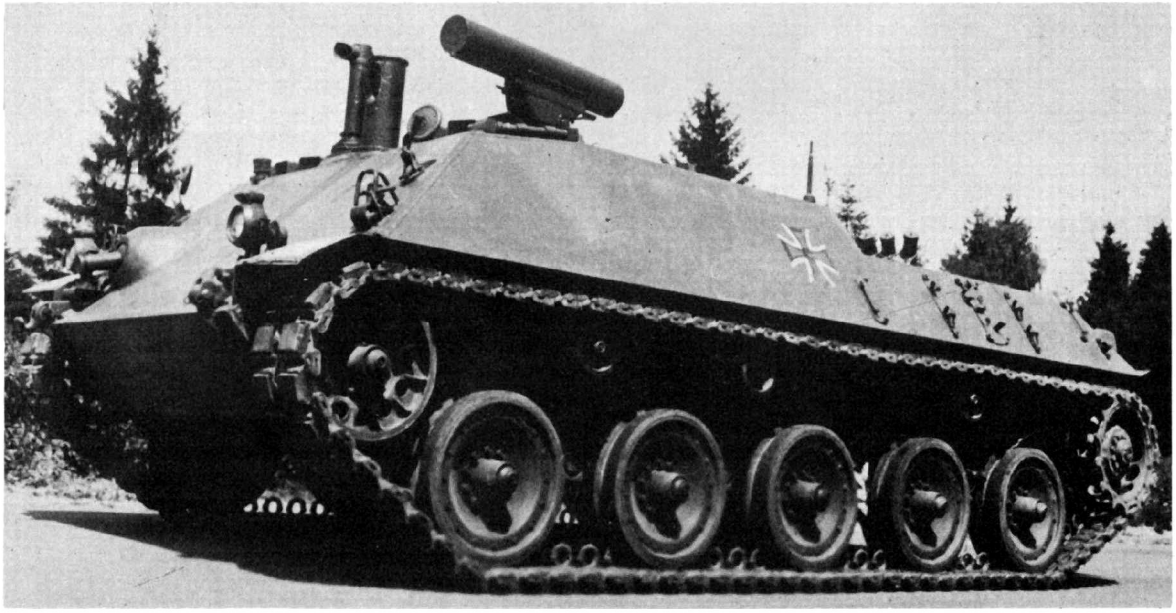
SS-11 fired from a NA-2 turret mounted on an Engin Léger de Combat. (Aerospatiale) (Note: A photograph of the NA-2 turret with one SS-12 and two SS-11 missiles on a Panhard AML appears in the *Profile* on Panhard Armoured Cars.)

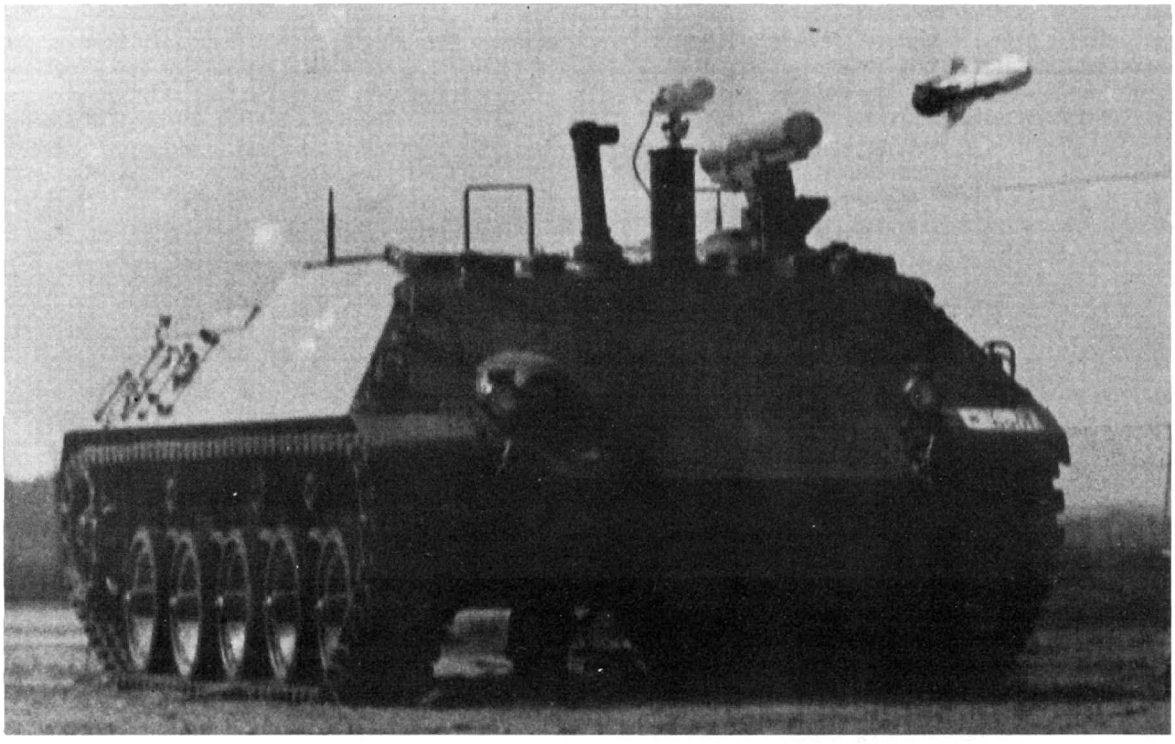
has a longer range of 4,000 metres, compared with 3,000 of the SS-11. Its overall length of 1.3 m is only marginally more than that of the SS-11 but in contrast to the SS-11 which has fixed fins with a span of 500 mm the HOT has folding fins and can be fired from a 176 mm diameter tube. As a result of its much smaller width the HOT can be much more easily installed in armoured vehicles and because it is fired from a tube it can engage targets as close as 75 m. It is also lighter, its mass being 22 kg compared with SS-11's 30 kg, but although its shaped charge warhead has a somewhat smaller diameter of 136 mm it can penetrate steel armour to a depth of 800 mm.

The two original armoured vehicle installations of the HOT have been the same as those of the SS-11, namely on the AMX-13 and the new *Jagdpanzer Rakete* based on the same chassis as the *Jagdpanzer Kanone*, or JPz 4-5. In the case of the AMX-13 it has been mounted in launchers on either side of the turret, each of the two launchers containing three missiles. In the case of the *Jagdpanzer Rakete* the missiles are stowed within the vehicle and are brought out from under armour by two hydraulically operated launcher arms each coupled to a cylindrical magazine containing eight ready-to-fire missiles. Altogether about 30 HOT missiles can be carried in the *Jagdpanzer*, which makes it comparable in terms of the number of rounds to battle tanks and very different from most other missile-armed vehicles, or even from its original form with SS-11 missiles of which it can only accommodate 14. The *Jagdpanzer* is manned by a crew of three which includes the commander, driver and missile operator. The operator is provided with a tall periscope

Triple HOT launchers on an AMX-13. (Messerschmitt-Bölkow-Blohm)

Second model of the Jagdpanzer Rakete with a HOT missile elevated into its firing position. (Messerschmitt-Bölkow-Blohm)





HOT fired from Jagdpanzer Rakete. (Aerospatiale)

TOW fired from a jeep-mounted launcher. (Hughes Aircraft Co.)

TOW launcher mounted on top of an M113 armoured personnel carrier. (Hughes Aircraft Co.)

so that he can fire missiles from behind cover with nothing more of the vehicle showing above it than the head of the periscope and one of the launcher tubes.

Another second generation missile with automatic command guidance is the TOW developed in the United States by the Hughes Aircraft Company. The TOW, whose name is an acronym for Tube-launched, Optically-tracked, Wire-guided, is very similar in principle to the HOT but has a slightly smaller, 127 mm diameter warhead and its maximum range is less, being 3,000 metres. In fact, originally the TOW was developed to have a range of only 2,000 metres, as it was only intended to be an infantry anti-tank weapon. As such it has been designed to be fired from a ground-mounted tripod or from a simple mount on top of the M113 armoured personnel carrier. The crew of the TOW are, therefore, exposed to bullets and shell fragments while firing it but there is no fundamental reason why it should not be mounted as effectively as the HOT.

The development of the TOW started in 1962 and in 1968 it was adopted by the U.S. Army, which ordered it as a replacement for its 106 mm recoilless guns as well as the earlier SS-11 and Entac missiles. It received its baptism of fire in Vietnam in 1972, when it was successfully fired from the ground and from helicopters against North Vietnamese T-54 medium tanks as well as other ground targets.

SHILLELAGH AND SHERIDAN ARAAV

A concomitant of the fact that no efficient armoured vehicle installation had been developed for the TOW was the earlier development for the U.S. Army of another second generation guided missile specially for tanks. This was the MGM-51A Shillelagh whose development was started in 1958 by the Aeronutronics Division of Philco-Ford Corporation. Even earlier, in 1956, the U.S. Army had experimented with the installation of the XSSM-A-23 Dart guided missile on the contemporary M59 armoured personnel carrier. However, the Dart, which was developed by a subsidiary of the Curtis-Wright Corporation, was as clumsy as the British-Australian Malkara and the U.S. Army did not, very rightly, adopt it.

The Shillelagh was originally developed for installation in the Armoured Reconnaissance/Airborne Assault Vehicle, or ARAAV, which subsequently became the M551 Sheridan. This was intended to replace both the M41 light tank and the 90 mm M56 self-propelled anti-tank gun produced specially for airborne forces. In consequence the ARAAV had to be armed with a weapon highly effective against battle tanks as well as being relatively light and mobile. These difficult requirements were met by mounting in it a 152 mm gun/launcher which would enable it to engage tanks at long range with Shillelagh missiles and various targets at short range with more conventional projectiles.

The Shillelagh missiles fired from the gun/launcher of the Sheridan ARAAV have an automatic command to line of sight guidance system similar to those of the HOT and TOW but instead of the trailing wire link of the other missiles they have an infra-red link. The elimination of the wire link was essential to firing the Shillelagh out of the same gun tube as conventional projectiles, which made its armament more versatile. At the same time it enables its missiles not only to be stowed but also fired from under armour, which makes them less vulnerable. However, because the Shillelagh is fired from a gun/launcher, the Sheridan must at least expose its turret to engage targets, in contrast to the *Jagdpanzer Rakete*, for instance, which need not expose itself at all to fire its missiles. Moreover, because the warhead of the Shillelagh had to be relatively large, the calibre of the Sheridan's XM81 gun/launcher is larger than necessary for a general-purpose gun. Nevertheless, the number of rounds that the Sheridan can carry is 19 in addition to 10 missiles.

The conventional rounds of the Sheridan are unusual in having combustible cases which were introduced to save weight and to eliminate the problem of case disposal which exists with normal brass cartridge cases. However, the combustible cases proved very troublesome because they did not burn completely when a round was fired, thus leaving a dangerous, smouldering residue in the gun which could ignite the case of a subsequently loaded round. Troubles with the combustible cases were aggravated by their absorption of moisture which was overcome by the provision of nylon bags for the rounds but the bags have to be removed by the crew before each round is loaded and in general the combustible cases proved to be the most serious problem in the development of the Sheridan.

Development of the Sheridan actually started in 1959 and trials of its prototypes in 1962. In spite of difficulties, the U.S. Army awarded a production contract in April 1965 to the General Motors Corporation which completed the first production vehicle in June 1966 at the Cleveland Tank Plant originally operated by its Cadillac Division and later by the Allison Division. But continuing troubles, mainly with its conventional ammunition, delayed the issue of the Sheridan to the troops which did not take place until 1968, by which time several hundred had been produced. Even then the shortcomings of the Sheridan's armament had not been completely overcome but in spite of it the U.S. Army sent 64 Sheridans to Vietnam in January 1969, to test them under battlefield conditions. The Sheridans sent to Vietnam were, however, stripped of their missile systems since there was no need at the time for anti-tank weapons as powerful as the Shillelagh.

Without its missiles the Sheridan is a fairly conventional light tank of 15.8 tonnes. Its layout is orthodox and its crew of four the same as that of contemporary battle tanks with which it compares closely in size but inevitably not in armour protection. The armour of its hull consists of 7039 aluminium alloy plates which are superior to the 5083 plates of the first generation aluminium-armoured vehicles, such as the M113 armoured personnel carrier, but it is still relatively light. So is the steel armour of the turret which is also poorly shaped from the point of view of ballistic protection as it has undercut sides. On the credit side, the 6V53T General Motors turbo-charged two-stroke diesel of 300 b.h.p. gives the Sheridan a power-to-weight ratio of almost 20 b.h.p. per tonne and its light weight combined with its large size results in a nominal ground pressure of only 0.48 kg/cm^2, which is only half that of some battle tanks and makes for good off the road mobility. Moreover, it is fitted with a collapsible flotation screen so that it can cross water obstacles unaided. It is also light enough to be carried in standard military transport aircraft, such as the C.130 Hercules from which it has also been successfully dropped by parachute.

Shillelagh missile. (Philco-Ford Corpn.)

However, the best feature of the Sheridan is undoubtedly its ability to fire Shillelagh missiles and it is noteworthy mainly because of this and because it is the first tank ever to be designed with guided missiles as its primary armament. But, in spite of being specifically designed to fire Shillelagh missiles, the Sheridan is not the most effective way of deploying such powerful, long-range missiles because it is relatively vulnerable, having neither the armour of battle tanks nor the low silhouette of missile launcher vehicles. Thus the use of the Sheridan has been confined to the armoured reconnaissance units of the U.S. Army and its production came to an end in 1970 when 1,662 had been produced.

M60A2 BATTLE TANK

The last of the Shillelaghs was produced at about the same time, in March 1971, even though the Sheridan was not the only tank to be armed with them. In fact, when the U.S. Army started the development of the Shillelagh in 1958–59, its planners envisioned that guided missiles will be the primary anti-tank weapon of all future tanks and the Sheridan was merely the first step towards implementing this vision. But in 1963–64, before a new missile-armed battle tank could be developed, the U.S. Army decided that it could and needed to improve its tank strength more quickly by rearming some of its M60A1 battle tanks with the 152 mm gun/launcher which had been developed for the Sheridan. The gun/launcher was to be mounted in a new turret but otherwise the rearmed M60A1E1 was to be much the same as the M60A1. It was thought, therefore, that the introduction of a missile firing battle tank in the form of the M60A1E1 could be accomplished not only quickly but also economically, particularly as the 105 mm gun turrets removed from the M60A1s could be used to modernise part of the stock of M48 tanks which were armed with 90 mm guns.

Unfortunately, the development of the M60A1E1 was rushed, which was bound to lead to trouble. Thus, the first prototype was completed in September 1965 but the installation of the new turret did not prove as easy as expected and considerable redesign was necessary. Moreover, as with the Sheridan, there was trouble with the gun/launcher due to the combustible cartridge cases of its conventional ammunition. Nevertheless, production orders were awarded in 1966 to the Chrysler Corporation which operates the battle tank plant in Detroit, where all the M60s have been produced.

The first order was for the production of 243 turrets for the M60A1E1 and the second for 300 M60A1E2, which was identical with the M60A1E1 but was produced from scratch instead of being made out of an M60A1. The 300 M60A1E2 were built by December 1968 but because of troubles, particularly with the turret stabilization system which had not been cured, they were unusable and remained in storage until 1971, as did the additional turrets. It was only then that the failings of the M60A1E2

Shillelagh fired from a M551 Sheridan. (Philco-Ford Corpn.)

were overcome and 210 were ordered to be reworked for issue to the troops as the M60A2 battle tank.

Thus, the development of the world's first missile-armed battle tank was badly delayed, though not by its missile system which has given it a significant advantage over other battle tanks whenever engagements can take place at long range. Under other conditions the Shillelagh is less of an asset and the conventional projectiles of the M60A2 only offer a reasonably high hit probability at short ranges because they are inevitably fired with a low muzzle velocity out of its short barrelled gun/launcher. The turret of the M60A2 also leaves much to be desired. Admittedly, its novel configuration gives it a small frontal area and good ballistic protection from attack from the front but it is cramped and surmounted by a monstrous commander's machine gun cupola which gives it the very doubtful distinction of being the world's highest battle tank.

M60A1E2 battle tank with 152 mm gun/launcher. (Chrysler Corpn.)

U.S.-German MBT-70 with a long-barrelled 152 mm gun/launcher. (U.S. Army)

MBT-70/XM-803

The U.S. Army's requirement for a missile firing battle tank, to which the M60A2 was only an interim answer, was going to be met by the MBT-70. The development of this "Main Battle Tank for the Seventies" dates from August 1963, when the defence ministers of the United States of America and the Federal Republic of Germany agreed on a joint development programme of a single battle tank for the U.S. and German armies. The military characteristics which provided the basis for the design of the MBT-70 were established jointly with the aid of an extensive, computer-based study carried out by the Lockheed Missiles and Space Company. The design and development contracts were awarded in 1964 to General Motors and a consortium of German firms; the basic design was approved by both countries in March 1965 but no decision was taken at that stage regarding a number of alternative components. Instead, each country proceeded to develop its own version and to build prototypes. The first was completed in the United States in July 1967 at the Cleveland tank plant and by 1969 six prototypes were built in each of the two countries.

The MBT-70 looked like a conventional battle tank but in fact it represented a major departure from traditional practice in having all three members of its crew located in its turret. The turret had a radiological liner and the crew was concentrated in it for protection against radiation produced by nuclear explosions, but this concentration of the crew in the turret made it necessary to provide the driver with a counter-rotating capsule so that he would always face in the direction of motion of the tank no matter which way the turret was turned. The need for a fourth crew member was eliminated by the installation of an automatic loader. The MBT-70 also incorporated various other advanced features. These included an adjustable hydro-pneumatic suspension and diesel engines which gave it a power-to-weight ratio of as much as 31 b.h.p. per tonne, in spite of its weight being 47 tonnes instead of the 45 tonnes originally planned. The U.S. built vehicles were powered by the Teledyne Continental air-cooled variable compression ratio AVCR-1100 which developed 1,475 b.h.p. and the German vehicles were powered by a more conventional water-cooled Daimler-Benz MB-873 diesel of 1,500 b.h.p.

However, the most important and controversial feature of the MBT-70 was its main armament. This consisted of the 152 mm XM150 gun/launcher which was very similar to the XM81 gun/launcher of the Sheridan and the M60A1E1 but had a considerably longer barrel and was capable, therefore, of firing not only Shillelagh missiles and medium velocity high explosive projectiles but also high velocity armour piercing shot – APFSDS, or Armour-Piercing, Fin-Stabilised, Discarding-Sabot shot.

The provision of APFSDS ammunition for the gun/launcher of the MBT-70 answered the criticism levelled at the original, XM81 gun/launcher that the projectiles as well as the missiles fired from it rely on shaped charges for their armour-piercing performance, which means that tanks armed with it absolve the enemy of the need to protect himself against attack by high velocity shot and makes it possible for him to achieve a higher degree of protection.

Nevertheless, the German Army remained critical of the 152 mm gun/launcher and proceeded to develop more conventional 120 mm guns for its version of the MBT-70. One of the main points against the 152 mm gun/launcher was its calibre which was larger than necessary to achieve satisfactory performance with high velocity projectiles. The other point was doubts about the cost/effectiveness of the Shillelagh at typical battle ranges. In fact, the cost of the Shillelagh, like that of the HOT and the TOW, has been in the region of 3,000 dollars which is equivalent to the cost of about twenty rounds of conventional tank gun ammunition.

Moreover, the complexity of the whole tank and the extravagant management of its development made costs rise rapidly. Initially the cost of the development was put at 40 million dollars for each country but by the time the 12 prototypes were built it had risen to 303 million dollars, or ten times what other contemporary tanks cost to develop, and the development was far from

U.S. XM803, the "austere" version of the MBT-70 battle tank.
(U.S. Army)

being complete. Estimates of what the MBT-70 would cost to produce were equally high. For instance, in 1967, when the first prototype appeared, the cost per tank was put at 600,000 dollars. This was more than twice the cost of the M60A1, or other contemporary tanks, but in 1969 the cost rose to between 750,000 and 850,000 dollars and some pessimistic estimates put it as high as one million dollars. It is not surprising, therefore, that in 1968 the U.S. Congress began to question the cost of the MBT-70 and by the end of 1969 forced the U.S. Army to try to modify the tank so that it would cost 585,000 dollars. At the same time Germany withdrew from the joint development programme.

For a year or so the U.S. Army continued to work on an "austere" version of the MBT-70, which was called XM803. However, it failed to bring its cost down to the figure stipulated by Congress and the XM803 continued to suffer from trouble with its components, including its AVCR-1100 engine in spite of it being derated to 1250 b.h.p., and ammunition. In consequence, in 1971 Congress rightly refused to provide funds for further development of the MBT-70/XM803 and in 1972 the U.S. Army started working on a new battle tank.

LATEST MISSILE DEVELOPMENTS

While the U.S. Army was developing the Shillelagh for tanks, the French Army was working on a somewhat similar missile system called the ACRA – an acronym for *Anti-Char Rapide Autopropulsé* – which is also intended for installation in tanks and other armoured vehicles. As its name implies, the ACRA missile has a high flight speed, even higher than that of the HOT. It is, in fact, supersonic and can reach targets at its maximum range of about 3,000 metres in 7 seconds whereas HOT requires 12 seconds to cover the same distance and SS-11 about 20 seconds.

Another important consequence of the high speed of the ACRA missile is that it can be fired at the rate of 3 to 4 rounds per minute. This is significantly faster than the rate of fire possible with earlier missile systems although it is still only half that of conventional tank guns with manual loading and only a quarter of that of the Swedish S-tank which has an automatic loading system for its 105 mm gun.

The high speed of the ACRA has been made possible by the elimination of the trailing wire link used by other missiles, except the Shillelagh. Like the Shillelagh, the ACRA is fired from a gun which can also fire more conventional projectiles. The gun has a calibre of 142 mm, which makes it slightly smaller than the gun/launcher of the Shillelagh system. What is more important, however, is that the ACRA missile and its complementary projectile both have brass cases so that they can be handled like conventional tank gun ammunition and create none of the problems which bedevilled the development of the U.S. 152 mm gun/launchers. Moreover, the brass cases make it possible for the 142 mm gun to have a conventional semi-automatic breech block instead of the special, electrically operated screw-type breech mechanism of the U.S. 152 mm gun/launcher. The gun of the ACRA system has a longer barrel than the XM81 gun/launcher but unlike the XM150 gun/launcher it has not been provided with high velocity armour piercing projectiles.

The most interesting feature of the ACRA is its guidance system which uses a receiver in the missile to make it follow an infra-red beam emitted from a laser aligned with the gunner's line of sight. In other words, the ACRA missile is a beam rider and its infra-red guidance system is practically impossible to jam while its operator only has to keep the centre of his sight on the target, like the operators of missiles with automatic command guidance.

The ACRA weapon system has been developed by the Direction Technique des Armements Terrestres (DTAT) with one of its own establishments, the Atelier de Construction de Puteaux which was responsible for the development of the ENTAC, as the prime contractor. It has been mounted in the AMX 10M, a turretless assault gun type of vehicle developed from the AMX 10P armoured personnel carrier and it has also been considered for installation in a special turret mounted on the AMX 30 battle tank chassis.

Another and much more recent development is that of guided missiles with semi-active terminal homing and laser target illumination. Such missiles would home on the energy emitted by laser target designators and reflected from the target and they should have a much higher hit probability at long ranges than missiles with line of sight command guidance only. Semi-active terminal homing would also make it possible to aim missiles, or designate targets for them, from one vehicle and to launch them from another. This would bring advantages on occasions but would also lead to all sorts of additional operational problems.

The next stage in the development is likely to be missiles with passive target homing. Missiles of this type would probably home on the thermal signature of opposing armoured vehicles and would make it possible to increase significantly the rate of fire and, what is more, to engage armoured vehicles hiding behind cover. However, they are bound to cost even more than missiles with laser-assisted semi-active homing, which are already at least twice as expensive as the missiles with automatic command guidance.

Acknowledgements

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FORTHCOMING TITLES:

45 Vickers Main Battle Tank
(publication delayed).

55 German Self-Propelled Weapons
by Peter Chamberlain and H. L. Doyle.
An illustrated guide to all the SP weapons used by the Germans in World War II.

57 SdKfz 250 and 251
by Walter Spielberger and P. Chamberlain
German Schützenpanzerwagen of World War II.

58 French Infantry Tanks: Part I (Chars 2C, D and B)
by Major James Bingham, Royal Tank Regiment
The tanks included in Part I of the two French Infantry Tanks Profiles, in which Major Bingham completes the story of French tanks from 1919 to 1940 begun in his Profile of French cavalry tanks (AFV/WEAPONS 36), are: Heavy tanks – 1A, 1B, 1C ("significant only as the prototypes for . . . ") 2C ("a formidable weapon for its time"); Medium tanks – D1 and D2 ("the Renault Chars D, together with a few Chars B, were the only new tanks to be issued to the French infantry between the end of World War I and 1935 when rearmament started"), B ("the Char B1 bis became the principal French medium tank in 1940 . . . a sophisticated tank with some technically advanced features, but its very complexity was a disadvantage in manufacture and maintenance, whilst its layout and demands on the crew hindered an efficient use of its weapons in battle"), AMX 38 ("it was not used in action"), and the post-war ARL 44. The Profile includes a full description of the famous Char B.

59 French Infantry Tanks: Part II (including R 35 and FCM 36)
by Major James Bingham
The tanks included in Part II are the French Infantry Light Tanks: Renault FT, Renault NC, Renault R 35 ("the most numerous light infantry tank in service in 1940"), FCM 36, and Renault R 40 (AMX 40). A full description of the R 35 is included.
Major Bingham concludes this Profile with a critical examination of the French use of tanks, not only in direct support of infantry but in armoured formations, whose development, limitations and demise in action he recounts ("Within a period of three weeks the entire armoured force had been presented for destruction or neutralisation, successively and in detail").
The Profile also includes tables showing the comparative details of French infantry tanks and the deployment of French AFVs in European Operations May–June 1940.

FUTURE TITLES WILL INCLUDE:

Elefant and Maus (+E-100)
by Walter Spielberger and John Milsom
Elefant was the conversion of the original Porsche Tiger tank design into a self-propelled tank destroyer. "It turned out to be a technically most complicated and unreliable vehicle. This is said despite the fact that your author was engaged as design engineer on this project and that he participated actively in the action in Russia described at the beginning of this *Profile*."
Maus the largest armoured fighting vehicle ever built, was the culmination of Porsche technical development in the Tiger field. E-100 was the Maus's rival.

Commando and Twister Armored Cars
by Christopher F. Foss
The multi-mission Commando and the revolutionary Lockheed Twister XM-808.

AMX-30
by R. M. Ogorkiewicz
France's Main Battle Tank.

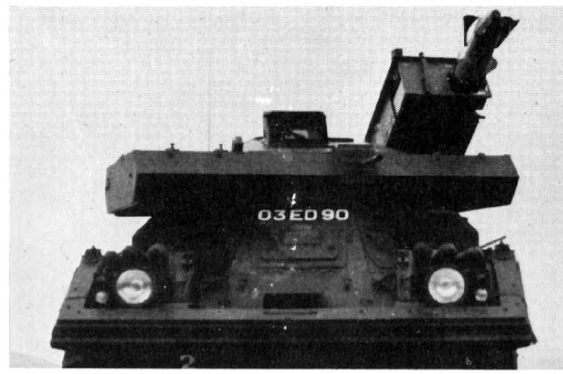
French Armoured Cars
by Major James Bingham
The story of French armoured cars from before World War I until the end of World War II.

PT-76
by Christopher F. Foss
The Russian amphibious light tank and its many variants.

The Twenty-Five Pounder
by Colonel Farrerly, R.A.
The history of the British Army's famous field gun.

To give pictorial completeness to the survey of missile armed armoured vehicles in this *Profile*, the following pictures which have already appeared in earlier *Profiles* are repeated.

Three-quarter left rear view of FV438 firing Swingfire missile.
(British Aircraft Corporation (Guided Weapons Division)



Ferret Mark 5 with a Swingfire missile emerging out of its container/launcher. (British Aircraft Corp.)

A.M.L. with HE.60 turret and S.A.M.O. 1160 launcher with ENTAC anti-tank guided missiles.

A.M.L. with NA-2 turret mounting two SS-11 and one SS-12 missiles.

A.M.L. with H.90 turret and SS-11 missiles one of which has just been launched.