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NEXT GENERATION MAIN BATTLE TANK. PART I: UPGRADING THE "PAN" TANKS

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ABSTRACT

Modern MBTs (Main Battle Tanks) last more than 30 years. During this period, they will be periodically upgraded in any aspect except the basic structure. Even the main armor is becoming an upgraded accessory that depends on the nature of the threat. The main armament may be also changed or upgraded. The huge electronic equipment is the most upgraded part. The crew compartment may be upgraded in internal armor (for example for spalling), interfaces (optics, displays, commands), safety and protection devices (fire detection and suppression, ejection seats..). This continuous upgrade process should be included in the design of new vehicle, than can be modular for these mid-life upgrades. The vehicle is designed by adding items to the crew compartment and to the mobilization system. As an example, this first part introduces a few options to retrofit the ARIETE MBT. The retrofit cannot be reduced to engine and armor upgrade. A reasoned step approach is outlined in this paper. The first minimal step is based on an active armor and an HMD (Helmet Mounted Display) visual system. The weight increase is compensated by reducing road wheels weight. A second step increases firepower by installing on the main turret an automated turret with an automatic small cannon and a machinegun. The weight increase is compensated by limiting the internal ammunition storage of the main cannon to the anti-tank ones. A third step converts the turret internal ammunition storage into an automatic reloading system. In this way, the crew is reduced from 4 to 3. A fourth step increases crew safety by relocating the driver in the turret and by installing ejection seats. Solutions to reduce ground pressure and to increase the effective "power" available by replacing the final-drives and adding two electric motors on the front sprockets are also briefly examined. It is also highly advisable to add an APU (Auxiliary Power Unit) to reduce IR (infrared) signature, improve main engine life and reduce maintenance.

Keywords: MBT, updated, power, automated turret, ARIETE.

INTRODUCTION

Modern Main Battle Tanks (MBT) last more than 30 years. During this period, they will be completely refurbished in any aspect except the basic structure. Even armor is an add-on accessory that depends on the nature of the threat. The vehicle is a crew compartment with the mobilization system (powerpack+track-assembly). Modules are added to this system to obtain the required performance. The armaments with its main weapon, the automatic loader and the secondary weapons will not remain the same through the life of the new vehicle. New technologies for the main weapon like the EM (ElectroMagnetic in its different versions) may replace the more traditional unit. However, the new tank costs may be too huge even for world super powers. An important upgrade to furtherly prolong existing MBT life should be considered. Just to make an example, this first part introduces a few steps to retrofit the ARIETE MBT.

HISTORICAL BACKGROUND OF THE "PAN" TANK"

In WWII, the German ended with the Jagdpanzer (tank hunter or tank destroyer) Hetzer, which costed one tenth of the Tiger II and had a production rate of 200 units per month, limited by the cannon availability. The production rate of the Tiger I was 56 units, while the Tiger II was produced in 30 per month. The Panther, the most successful German tank of the period, topped with 250 per month. Still very few when compared to the T34-1,200 tanks per month figure. The nimble Hetzer was a Romanian concept, installed on a Skoda chassis and refined by the German experience. The Hetzer did not have a turret, it had a nimble shape and a 105mm cannon (final version) that can defeat any tank of the period. The crew was reduced from 5 of the bigger brothers to 4 due to limited room inside the vehicle. It could be operated "closed hatch only". A remotely controlled MG42 completed the firepower. Far were the times in which the German tanks would not engage enemy armored forces but would draw them into an ambush with PaKs (Panzer Abwehr Kanone - anti-tank cannon) and heavy artillery or would call the Stukas to destroy them. In October 1941, Guderian asked for T34: it was not a joke, the diesel powered, sloped armor tank was far superior that any other German design. The situation would not change with the vertical armor, gasoline powered Tiger I, whose only advantage was the very good 88 cannon, a well-known T-34 killer. The Panther was slightly better, but the fragile transmission, the slowly rotating turret and the gasoline engine kept the advantage on the T34 side. Finally, the Tiger II had sloped armor, but the fragile propulsion system made this tank unreliable. German tank design were not conceived for mass production and the production never reached the T34 levels. At the end of the war, only the Hetzer, produced in Skoda with minimal costs could keep the support to the German Army. Meanwhile, the Soviet had lost the touch and ended the war with the JS2 "Stalin" disaster. The Stalin had a large

122mm cannon with only 28 rounds, heavy armor and transmission problems. As most Russian tanks of the period, it should be operated "open hatch" with great risks for the crew. The only available firepower for ground troop support were the nimble machine guns on the turret with about 1,000 rounds. On the allied side the British Centurion was coming. With its huge 105 cannon, the low ground pressure and the downrated Merlin gasoline engine it was an extremely mobile design. Just to make a classification, the T34, the Panther and the Centurion were Main Battle Tanks or Medium Tanks. The Tigers and the Stalin were Heavy Tanks. The nimble Hetzer was a tank destroyer. In the eastern front, tank battles were common, while on the western front the Allied air and artillery superiority allowed the destruction of most German tank by rockets and artillery. In both fronts, tanks were used to direct artillery support and armor protection for ground troops. Only mobility and shallow shapes were available to reduce tank vulnerability to shaped charges. After WWII a big confusion followed. The US introduced the very good M47 Patton tank: diesel powered, sloped armor, low ground pressure, mass-produced. It was a true Main Battle Tank. Its successor, the M60, lacked of mobility being a Heavy Tank but had the very good 105 cannon, versatile and powerful. This cannon defeated the Arab tanks in the famous tank battle of the Yom Kippur war, where the IAF (Israel Air Force) had been temporarily defeated by the AA (Anti Aircraft) Arab weaponry. A few Israeli tanks were able to stop a massive Arab tank offensive, due to the lack of elevation of the Arab cannons, the poor quality of T55 cannon rounds and the lack of artillery support. Surprisingly, the Israeli tanks operated with open hatches. The lack of penetration capability of Russian cannons was also a decisive factor during the Iraq-Iran war, were the British-made Chieftains outgunned and out-armored the Russian tanks. The fact that the Iran US-made attack helicopters destroyed most of the Iraq tanks was often downplayed. Meanwhile, statistics were available about the 6-days war, in which heavy tanks had suffered far less causalities than medium ones. The fact that the high-speed 6-days war left most heavy tanks out of the fight was not included in most reports. The unacceptable vulnerability of tanks to shaped charges became clear after the Vietnam War. In the late seventies, several solutions of armors against shaped charges becomes available. These armors had to be added to armor plates to offer this type of protection. With the German-US project that brought to the development of the Leopard II and the Abrams tanks, the "pan tank" was born. A basic light armor was retained and the additional specialized armor was added. The shallow shape made this tank very low above the terrain and very large. From this concept came the "pan" surname. During the development of this tank, the Russian introduced the 125mm 2A46M smooth bore cannon with APFSDS (Armor Piercing Fin Stabilized Discarding Sabot) rounds that could defeat most western armors. The arrival of this new round revolutionized the "pan tank" specifications, by replacing the original 105 mm with the smooth bore 120mm that, for long years, could only fire about 40 APFSDS rounds. The armor was also reinforced. Since power required goes with ground pressure squared, much larger engines were required. The Abrams used a gas turbine, which was a funny choice for ground vehicles. In fact, air-cooled gas turbines are poor performer at partial loads and need massive air filters. MTU developed a new engine for the new German tank. The new "pan tanks" that were initially medium tanks with improved armor, became JagdPanzer (Tank destroyer) Heavy Tanks. Their firepower for ground troop protection was limited to just machine guns. The Israelis with the Merkava installed a mortar and designed and HE (High Explosive) shell for the 120 mm smooth bore. Yet, the new HE shell is far less effective than the 105 cannon one and much more expensive. Still, the "pan tank" has only 40 rounds available inside the vehicle. In WWII terms, the "pan tank" passed from the T34 to the Stalin. Remember that the best German Jagdpanzer was the nimble Hetzer and not the massive Tiger II. A capability to hit helicopter was also added to the big cannon, again reducing the ammunition availability. Since the firepower is so reduced, the "pan tank" has to get closer when it is used for ground troop support. For this reason, its vulnerability increases. Additional amour and equipment has to be added for this and other reasons. The "pan tank" became underpowered since the power required goes with the square of the ground pressure. A 20% increase in weight requires 44% more power. This concept is purely theoretical since the track will be much more stressed, with reduced reliability and increased wear. In most cases, the weight increase would impair off-road performance to the point that hard soil is required. The path of the "pan tank" becomes foreseeable with all the risks connected. In addition, the increased power would require larger powerpacks and more fuel, adding further weight. Another major problem is that with the hatch closed only the machine gun coaxial with the main cannon can be used. Imagine using this tank in areas with limited room of maneuver where the cannon cannot be rotated. In a few pan tanks an automated turret with a machine gun was added to avoid "open hatch" operations. In this condition, the risk for the crew is enormous. In addition, IED protection is highly impaired by open hatch operations. At the end, the "pan tank" became a poor jagdpanzer and a poor ground support tank with limited mobility and firepower. New concepts or a major update is required.

HISTORICAL BACKGROUND OF THE ARIETE MBT

At the beginning of the eighties, Oto Melara was producing the last batches of the German-designed Leopard I. The Leopard I was a traditional post-WWII MBT, with a better cast-armor, the good 105 cannon with several different warheads and the traditional torsion bar suspension system. Its weak points were the limited number of rounds of the main cannon, the lack of a secondary heavy weapon and the hydraulically operated turret, which retained flammable hydraulic fluid inside the crew compartment. Its strong points were the good maneuverability given by the very good suspension and track system, the reliable diesel engines and the ease of

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maintenance. The traditional armor could not protect the crew against shaped charges and the last generation cannon warheads could defeat even the frontal armor. Starting from this good design, OTO designed the OF40, with a better quality armor and the possibility to upgrade the two 7.62 machineguns to 12.7 ones. A more efficient 105 cannon with improved rounds was also installed. The OF40 was lighter, better armored, more maneuverable and it had more firepower. Protection against shaped charges was still not available. A fully electric turret was considered in the early stages of the project, but was discarded due to the lack of the necessary knowledge. Meanwhile, Russia, Germany, United States and UK were designing new battle tanks able to protect the crew from new generation shaped charges and anti-tank rounds. At the end of the eighties, the Italian Army needed a substitute of the Leopard I. The German Leopard II was considered, but was discarded due to several reasons. The main one was the excessive cost of the German license fee. The Leopard II design was also considered flawed by the lack of floor protection against mines. In addition, the Leopard II armor, at the time a non-explosive reactive armor, was not considered at the level of the Chobam-type one. Finally, the two nimble 7.62 machine guns were considered insufficient for ground troop support. The lack of firepower was deepened by the lack of explosive warheads for the 120mm smooth bore cannon. Therefore, a brand new design was considered. An OTO Melara 105 cannon and a coaxial Oerlikon KBA 25mm composed the main armament. A remote controlled 12.7 machinegun was to be installed on the turret, along with another back-up 7.62 machinegun. The tank was designed to protect the crew against multiple 14.5mm hits on all sides. Additional, improved Chobham armor should be installed in the front and lateral sides of hull and turret. A non-explosive armor was to be installed in the floor and the suspension should be hydropneumatic to save room for the floor armor and to allow larger main cannon elevation. A second, export, version was also considered with an MTU engine instead of the original IVECO one and a torsion bar suspension to reduce costs and maintenance. The design ground pressure was 0.83 daN/cm^2 with a maximum allowable for further developments of 1 daN/cm^2. The engine was installed on the rear to reduce track wear and to allow a better escape for the driver. Spring-loaded ejection seats were also considered. An additional APU was to be installed on the frontal armor. Afterwards the 120mm was imposed and the remotely controlled 12.7 cannon were eliminated. There was not enough room for the 25mm coaxial automatic cannon that was replaced by a 7.62mm machine gun. The export version was never developed. Ariete weak points are linked to its history.

ARIETE MINIMAL UPDATE

It is possible to reduce the MBT weight by replacing road wheels and wheel arms. The original wheels are made with thick steel laminates that works in bending. It is possible to replace them with box-welded steel wheels (50% weight saving) or box-welded aluminum-alloy-steel wheels (70% weight saving) or titanium-alloy-CFRP (Carbon Fiber Reinforced Plastic) with up to 90% weight saving. The replacement of the steel laminate with an advanced titanium alloy is possible but the weight savings are limited to 25%. The advantage of the boxed structure is the presence of rays that work in traction (see Figure-1).

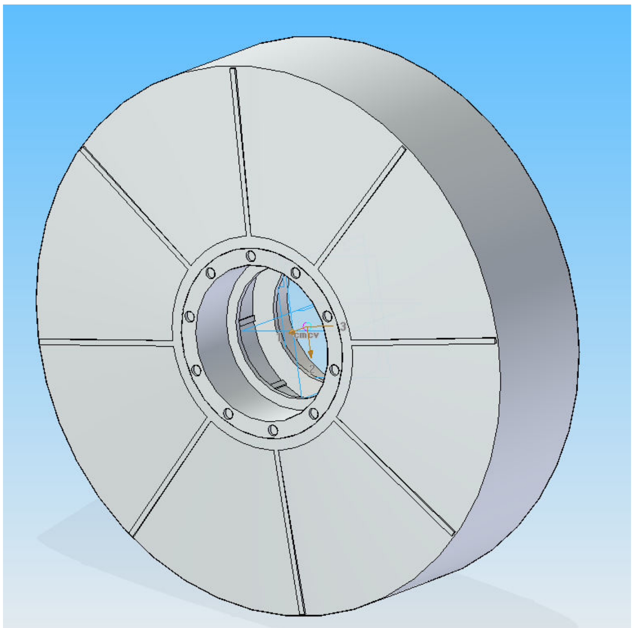

Figure-1. The patented, box-welded wheel without the steel protections and the rubber band.

It is possible to improve the armor with commercially available hard-kill measures that physically affects the incoming missiles by means of either blast and fragment action. These active systems may also works against incoming warheads. This will reduce the problem of the lack of multiple hit capability of modern advanced armors. The only main shortcoming is the necessity to operate "closed-hatch-only" and to keep ground forces at safety distance from the MBT. The "closed hatch operation" requires the introduction of see-through devices. The least invasive ones are HMDs (Helmet-Mounted Display) that generate an image that enables the crew to 'see through' the vehicle's armor. The HMD provides day-and-night 360° situational awareness, helping the crew overcome inherent visibility limitations, while improving mission efficiency and safety. These devices can be very small and they make it possible to see also the interior of the vehicle and the other crewmembers. These systems may also provide relevant symbology and C^4I^2 data (Command, Control, Communications, Computers, Intelligence, and Interoperability). The minimum relevant data available is the presence of hot spots of fire in the background. It is also possible to utilize pre-loaded terrain, obstacle and navigation information, combined with smart, intuitive symbology. By presenting the crew with an intuitive image of the relevant part of the world outside the vehicle, HMD relieves the crew of the mental load of having to interpret data from multiple devices, reducing fatigue and improving situational

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awareness. This system may be modular and redundant to reduce installation problems, increase reliability and facilitate maintenance. In this way, with minimal efforts, the ARIETE weapon system can be updated. However, the basic lack of firepower remains intact. To further improve the tank protection it is necessary to install an APU (Auxiliary Power Unit). A 50kW diesel APU on the frontal armor adds about 130 kg. The APU can be protected from 14.5 fire with an additional 50 kg. Therefore, the total would then be 180 kg. Another option is to install a small turbine 10kg-25kg APU inside the engine compartment. Unfortunately, this APU would have a very limited efficiency (less than 10%) and its infrared image is much larger than the diesel one. A modern common rail diesel has an efficiency far higher than 40%. The additional APU would not only reduce the tank IR signature, fuel consumption and main power system wear, but would also facilitate cold starting and allow a start-and-stop main engine management similar to the one of modern cars.

ARIETE FIREPOWER UPDATE AND CREW REDUCTION

After the replacement of the OTO 105 mm main cannon with the OTO 120mm smooth bore one, the firepower for ground troop support of the tank relied on a very limited number of not-very-efficient and extremely expensive HE (High Explosive) rounds and two nimble 7.62 machine-guns. Only one of them can be operated “closed hatch” being coaxial with the main cannon. If the turret cannot rotate for lack of room and the hatch are closed, the tank firepower is available on a very limited angle. The lack of range of the 7.62 machine-guns compels the crew to get close to enemy ground forces with increased danger of effective enemy fire. The best solution to these problems comes from remotely controlled automatic weapons like the one installed on the roof of the turret of the WWII Hetzer. With modern technology, it is possible to install an automatic turret weighting less than 100kg with a caliber up to the 14.5x114. If armor has to be installed to protect the turret against small weapon fire (as it was done on the Hetzer) the weight remains well under 150kg. The automatic turret is stabilized and is controlled by a gaming-like pad with a small monitor, by the gunner or the commander. The monitor can be integrated in the HMD. The weapon aim can be zeroed to a selected position depicted on the HMD or the turret can follow the HMD like in attack helicopters. However, experience demonstrated that a 30mm or, better, a 40mm cannon is much more effective. The 25mm proved to be too small for most ground targets. The weight of a 40mm automatic turret with 100 rounds can be less than 400kg or 450kg with the armor. The 40mm has a large choice of 0.5 kg warheads and a fire rate from 100 to 200 rpm. The availability of electronically controlled HE rounds makes it an ideal choice for light targets up to helicopters and light armored vehicles. The short barrel version of the 40mm cannon provides protection even in urban environment. In this way, the number of 120mm rounds carried inside the tank can be reduced from 42 to 11 APDSFS shells, saving about 830kg. The hull storage can be eliminated and the rounds inside the turret compartment can be better protected against secondary explosions. In alternative, a very simple automatic loading system like the OTO Palmaria one can be installed. In this way, the crew can be reduced to three. A secondary 7.62 machine gun with 1,200 rounds (the same number of the Hetzer) would add only 55kg and it can be installed on the side of the 40mm cannon.

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Table-1. Ground pressure and other data of several armored vehicles.

Armored Vehicle	HP/t	Ground pressure (daN/cm^2)	W (ton)	L (cm)	B (cm)
M113	20.4	0.6	10.4	267	38
Centurion	15.3	0.73	42.5	271	61
Stalin	13	0.81	46	436	65
KV1	13.8	0.77	43.5	65	433
T34A	16.18	0.64	26	372	55
PIII (1940)	15.4	1.01	19.5	286	36
Sherman M4	13.2	0.96	30.3	373.4	42.1
Cromwell	21.4	1.05	28	373.4	35.6
Tiger I	12.1	0.97	57	361	72.5
Panther	15.6	0.9	44.8	392	66
Hetzer	10	0.76	16	300	35
Leopard 2	24.1	0.83	55.1	525	64
AMX-56 Leclerc	27.2	0.9	54.5	432	63.5
Challenger2	19.2	0.9	62.5	479	65
Merkava	23	0.96	60	478	64
Abrams	24.5	1.08	67.7	457.5	64
Ariete	26	0.9	54	460.2	65

ARIETE ARMOR UPDATE

A major improvement of the main armor may be required even after the previous updates. This will increase the survivability of the tank against direct hits from large cannons and from advanced shaped charges. The main problem in this case is the weight increase. The most common error is to increase engine power. Even if IVECO succeeds in improving engine power without increasing weight, the off-road performance of the tank will be hugely affected by an increase in tank weight due to the added armor. Most “pan tanks” are extremely overweight due to the continuous addition of equipment to the existing tank. In most cases, a 30% increase of track shoe width is the only practical solution from the technical point of view. In this way, the original design ground pressure is restored. The track is stronger and larger wheels will distribute the load on the steel path. Unfortunately, this solution has several shortcomings. The most important one is the increase of vehicle width that makes transportation on wheel or on rail very difficult. A patch can partially solve this problem. The Ariete track system, composed by sprockets, return rollers, front drive wheel, road wheels and arms is extremely sturdy, being the torsion bar the weak component. Unfortunately, the track itself is not so sturdy, with failure probability and durability greatly challenged by the increase in stress even on hard roads. A larger power with increased torque would probably be problematic for the track. Another important factor is the amount of power needed on soft grounds that goes with the cubic power of the ground pressure in wet mud and with the square of the ground pressure on wet sand. In fact, the track floats on the terrain more like a ship or a motorboat than a wheeled car. Equation (1) summarizes the increase or reduction of the Power required on wet sand by varying the GP (Ground Pressure).

$$P_{wet\_sand} = \left(\frac{GP_{new}}{GP_{original}} \right)^2 P_{original} \tag{1}$$

Equation (2) summarizes the variation of the Power required on wet mud by varying the ground pressure.

$$P_{wet\_mud} = \left(\frac{GP_{new}}{GP_{original}} \right)^3 P_{original} \tag{2}$$

The problem with mud is that its performance varies with the water content. When the track passes on the wet soil, the water is squeezed away. A second pass will find a more solid soil and the tank will float better. Table-1 summarizes the ground pressure of a few tanks. It should be kept in mind that the true tank weight is a classified information and the values available in literature are mostly underestimated even for historical armored vehicles. It is then necessary to reduce the ground pressure of the Ariete. Numerous attempts were made to "reduce ground pressure and improve flotation" of several tanks. The most practical was the one used on the Sherman A1 tank. In the Sherman, "duckbill" Extended End Connectors (EEC) were retrofitted to the outside edge of the tracks (Figure-2). 100,000 EEC connectors for 630 tanks arrived in Britain by the end of September 1944. The production ended in April 1945 with over 1.8 million units. The increase of track shoe width (B) was of up to 25%. The EEC approach does not follow directly the rule of equations (1) and (2). In fact, the road wheel does not directly support the extension. However, the crew can install it on site, without much work, in 1-hour time. In this way, the portability of the tank on roads and railways does not change. In the case of the Sherman, the equivalent area improvement was about 10%. Therefore, the Sherman A1 equipped of EECs would have an equivalent power increase from the original 350 HP to 423 HP in wet sand, up to 466 HP in wet mud. Therefore, an Ariete equipped with a similar EEC will have an equivalent power of 1,537 HP (wet sand) and 1,690 HP (wet mud) from the original 1,270HP. The increased stress on the track pins can be reduced by modifying the track shoe and changing the pin material. In addition, the rubber bushing can be easily improved from the original 30 years old design.

Figure-2. Last generation EEC track extensions on the Sherman A1 tank.

The tank can be transported on road or on rail without EEC. The EEC can be applied in 1 hour time directly on site by the tank crew or by the maintenance people. Probably a new design for the track system will be necessary. However, with all the improvements in materials and technologies of the last 30 years, it would be welcome in any case.

ARIETE "POWER" INCREASE OPTIONS

If it is compulsory to increase engine power, several options are available. In ground vehicles, talking about power is always misleading. Today, when customers ask for more power for their vehicle, the best option is to change the turbocharger with a smaller one [1-17]. The small turbocharger will increase the airflow at low rpm with and correspondent increase in torque. The modern computer controlled engines can be easily remapped for the new configuration. If the engine/gearbox is sturdy enough, the torque is increased and the maximum torque is met at lower rpm. The maximum power is reduced, but usually the drivers, even the professional ones, have the impression of a more "powerful" engine. Even in naturally aspirated Formula 1 engines, the 10-cylinder-units with their higher torque at lower rpm were capable of better performance than the much more powerful V12-5-valve ones. The Ariete was designed to reach 70 km/h. Other, very mobile MBTs, like the Centurion and the M47, had much lower top speeds of 36 km/h and 48 km/h respectively. Even the Merkava IV, which is not a masterpiece in off-road operations, reaches "only" 55 km/h. In most tanks, the engine is installed as a "power-pack" that includes engine, transmission and cooling system. The power pack is interfaced to the sprockets through splines, torsion shafts and a final reduction drives. The variation of the top speed can be done simply by increasing the transmission ratio of final reduction drives. A reduction of the maximum speed of the Ariete from 70 to 50 km/h means increasing the torque of 40% (3).

$$T_{new} = \left(\frac{V_{original}}{V_{new}} \right) T_{original} \tag{3}$$

The variation in performance will be similar to an increase of power of 40%. The Ariete would have an "equivalent power" of 1,770 HP (4) instead of the original 1,270 HP.

$$P_{equivalent} = \left(\frac{T_{new}}{T_{original}} \right) P_{original} \tag{4}$$

This would allow a theoretical increase in weight even on very wet mud of 11% (5).

$$W_{wet\_mud} = \sqrt[3]{\frac{P_{equivalent}}{P_{original}}} W_{original} \tag{5}$$

On wet sand, the allowable weight increase would be 30% (6).

$$W_{wet\_sand} = \sqrt{\frac{P_{equivalent}}{P_{original}}} W_{original} \tag{6}$$

A reasonable weight increase would be 20%. Before proceeding in this way, the track system should be verified. Another viable solution is to add two electric motors on the idle sprocket. This solution would also reduce track wear. Two small 150kW-each (200HP) water-cooled electric motors can be coupled to the front sprockets, with a total weight increase of about 200 kg. A lithium-ion 85 kWh battery pack weighs 540 kg [18-28]. This battery would guarantee 8 min of full-power-continuous-operation to limp back "home" or to move the tank for maintenance or transportation. "Silent" low-IR-signature operations are also possible with tactical advantages. Another viable option is to substitute the IVECO engine with the very small MTU 883-500, the first version of the Leopard 2. This purely mechanical engine can be easily updated to 1,500HP and, with a few corrections, is very reliable. Its maintenance is extremely limited and it can be manufactured under license from MTU. Newer, more performing versions of this engine require huge maintenance.

ARIETE INCREASED CREW SAFETY

During the early stages of the conceptual design, a purely mechanical ejection seat was proposed. This system did not increase the amount of hazardous material inside the crew compartment being a simple spring loaded device able to open the hatch and to position the crewmember with the torso well outside the hull. A simple thrust from arms or legs would allow the crewman to climb out of the tank. The study of this system should be available in OTO archive. In any case, a new updated version can be requested to the Authors. This ejection seat works for all the crewmembers except for the driver. In a reduced crew configuration, the driver can be positioned in the turret. Even if the turret is far from a safe position for crew in battle tanks (see figures 3 and 4), it is possible to increase the armor locally.

Figure-3. The turret-hull connection is always a weak point in tanks.

Figure-4. A turret diplaced far away from the hull by an IED.

The remote control of the tank drive can be easily installed in modern drive systems and it allows the tank commander to drive the tank in emergency.

CONCLUSIONS

Updating a modern battle tank is far from being a very simple process that can be resolved by adding power and armor. Care should be taken to introduce the most cost-effective solutions. This paper introduces a reasoned update of the Ariete MBT subdivided in steps. The first step is minimal and introduces an active armor system and an HMD based improved "see through" visual system. The weight increase can be compensated by far-lighter road wheel of new conception. A second step introduces a secondary automated turret with a 30-40mm cannon to increase the firepower for ground troop support and urban warfare. In this case, the limitation of the internal ammunition storage to the anti-tank rounds will reduce the overall tank weight. A third step converts the turret internal ammunition storage into an automatic reloading system. In this way, the crew is reduced from 4 to 3. A fourth step increases crew safety to relocating the driver in the turret and by installing ejection seats. Ejection seat will also allow the use of seat-belts that is compulsory for crew safety in case of a modern cannon direct hit. Solutions to reduce ground pressure and to increase the effective "power" available by replacing the final-drives and adding two electric motors on the front sprockets were also briefly examined.

SYMBOLS

Symbol	Description	Unit
W	Vehicle mass	ton
L	Track length on ground (track width)	m
B	track shoe width	m
Pwet_sand	Power required on wet sand	HP
GPoriginal	Today Ground pressure	daN/m2
GPnew	New Ground pressure	daN/m2
Poriginal	Today engine power	HP
Pwet_mud	Power required on wet mud	HP
Toriginal	Today torque on sprockets	Nm
Tnew	New torque on sprockets	Nm
Voriginal	Today maximum design speed	km/h
Vnew	New maximum design speed	km/h
Pequivalent	Equivalent engine power	HP
Wwet_mud	Allowable vehicle mass on wet mud	ton
Voriginal	Today vehicle mas	ton
Wwet_sand	Allowable vehicle mass on wet sand	ton

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