VOL. 15, NO. 15, AUGUST 2020 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

NEXT GENERATION MAIN BATTLE TANK. PART III: AN AIR TRANSPORTABLE, UPGRADABLE AND FLEXIBLEWEAPON SYSTEM INTEGRATED IN THE FUTURE WARFARE

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ABSTRACT

With a foreseen life of more than 30 years, the future Main Battle Tanks (MBT) will face continuous upgrades in and will challenge ever-changing threats. The armament, the armor, the information and the communication suite will be upgraded/changed depending on the scenario and on the technology available. Like in moder cars, the huge hardware/software/sensors is the most changing package. This continuous upgrade should be included in the design of new vehicle, than should be conceived more as a modular, vehicle family than as a single vehicle. The new battle tank is closer to a car platform that is the base for a family of vehicles, in which a major revision of any single model should be performed every two years. The old option-less approach like the Ford T model, which remained in production from 1908 to 1927, belongs to the past. A very desirable requirement would be to host the new vehicle in the bay of the latest C130 for rapid deployment. Even if it is time to update the venerable C130 to something newer and more capable, the basic concept remains. The always-growing 100-ton pan-tank approach is becoming obsolete, along with the idea to add hardware to improve firepower, protection and battlefield effectiveness. This third part introduces a few concepts to design a new MBT or better, a new MBT family, in which a modular concept makes it possible to adapt the vehicle to a specific scenario and to update it with ease. Flexibility and update capability are the new key words. The old concept of the mobile bunker with tracks should be substituted by a hierarchical protection system. This approach is inherited from the attack helicopters. The best-protected part of the tank should be a very small crew compartment. It should be completely separated from the weapon compartment with the main and secondary armaments equipped with automatic loading systems. The NBC (Nuclear Bacteriological Chemical) air filtering system can then be reduced to serve only the humans. The crew should travel secured by safety belts and should be equipped with ejection seats. Air-bag should be considered to reduce the shock of a direct hit from APFSDS penetrator or other high energy threats. These seats are conceptually different from aircraft ones since they will assure a simple exit from the tank, not a true ejection. A multiengine-multimotor approach may be used for traction with two or more powered sprockets. The small powerpacks will occupy less room inside the vehicle. A drive by wire system with an enhanced stability and direction system should be implemented. The ground pressure should be kept well under 900 kPa. Tracks should be narrow and long to reduce power requirements. Only the frontal arc of the MBT should be protected with passive "direct kill" armor. The remaining part of the vehicle should rely on hard-kill active systems except for "light" automatic fire. Since armor is an accessory, it should be added to the basic MBT structure. The "adding" from the outside approach should be extended to as many items as possible to simplify maintenance, equipment and update. The basic vehicle structure is closer to the frame of an F1 car with all the parts and accessories added to it. Similarly to F1 racing cars, it can be made with lightweight materials and aircraft technologies, like Carbon Fiber Reinforced Plastic or aluminum alloy monocoque structure. Finally, an on-board electronic diagnosis system should be implemented to simplify maintenance and increase availability and reliability.

Keywords: new generation MBT, modular, upgradable, automated turret.

INTRODUCTION

It is estimated that there are more than 100,000 battle tanks currently in service across the globe. It is unknown how many of them are still serviceable. More than 15,000 of these are “modern” pan-tanks with different upgrades packages. The largest part are M1 Abrams. A very commercially successful tank is the Leopard 2 with 4,800 distributed in the armies of Germany, Switzerland, Canada, Australia, Norway, Holland, Finland, Sweden, Spain, Greece, Turkey, Singapore and Chile. Japan has 340 Type 90s tanks, plus 200 Type 10. South Korea Army has about 1,000 K1 tanks. Israel may still have around 1,000 Merkavas of various marks serviceable. Italy has 200 Arietes and France has 400 Leclercs. Britain owns 250 Challenger 2s. All these tanks are nominally "Main Battle Tanks" but they became Heavy Tanks: a completely different weapon system. Their update is possible but with limited results due to the more than 30 years old design concept. This paper focuses on a revolutionary new vehicle design that is the key of the future Main Battle Tank. Old and new concepts are mixed up in this new design. The new Main Battle Tank should be an industrial product. This means that it should be mass produced. A typical example of this mass-production concept is the Russian T34, that required 5 times less work than German WWII Panther. Therefore, with the same industrial effort and in the same time the Red Army could deploy five T34 against a single Panther. The T34 was more agile and

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more reliable but slightly inferior in cannon and armor in respect of the Panther. The confrontation between five T34s against a single Panther was no match. Another important issue is the logistics. Fuel, tracks, spare parts should be supplied as much as possible on the field. No specialized maintenance should be required. Tank availability in the battlefield is the concept. Napoleon put great focus on this point, no award or career was guaranteed to the absent men in his Army. Presence on field was fundamental. It should be clear that component durability is not as important as the ease of substitution. If a powerpack can be replaced in half an hour, its durability is important from an economical and logistical point of view, but it is not fundamental. If replacement requires specialized operators or should be trimmed in a specialized maintenance site, part durability becomes extremely important. Another important point in this electronic world is the modularity and the strategy in item substitution. Generally, in modern vehicles, a diagnostic system is installed in the vehicle. It is called OBD (On Board Diagnosis). As the ODB light turns on, the vehicle necessitates maintenance. If the failure is a generic data-bus or wiring failure, it means that the true nature of the warning is unclear to the diagnosis system. In other words, the diagnosis detected a failure, but it is unable to find what actually has failed. In this case, the maintenance is performed by substituting the most probable candidates, until the diagnosis light turns off. To avoid this long procedure, it is necessary that the electronic subsystems are located in single boxes with their own diagnosis system. In this way the item can then be replaced as a whole on the field. This approach gives also the advantage that the single block can be upgraded without affecting the maintenance plan of the vehicle. This is particularly important in the electronic-hardware world, were components have an average production-life of a year. It is normal that customers want leap-ahead results with agreed timeline for the huge amount of money required. The leap-ahead approach means that new technologies are to be used. Customer and suppliers identify the most promising technologies and then invest into them to obtaining leap-ahead results. Unfortunately, because of the ambitious timeline and technical uncertainties, cost increases and schedule slippage are common. Consequently, instead of identifying which technologies to invest in, the more relevant problem is to manage uncertainty to maximize the benefits of technological innovation. In other words, it is important to have back-up solutions to make the development of the new design robust. This leads directly to a modular approach, where each module that has one or more back-up solutions. Each module will face competing technologies up to prototype stage where a winner can be found. Therefore, it is convenient to defer production decisions up to when a working all-around prototype is tested. Still, each part or modulus should be designed for production and a commercial offer for the production will be used for cost-effectiveness evaluations. The performances of a Main Battle Tank can be summarized in four groups: reliability, lethality, survivability, and mobility. The reliability is not truly a group, since affects all the systems in a different way. For example, in a single engine powerpack, engine failure means a complete loss. Therefore, engine reliability is critical for traditional battle tanks. If electric motors are added to the free sprockets, it is still possible to limp home on a battery. Even with the motorized sprockets in the mobilization system, a track failure means again tank immobilization and probable complete loss. Therefore, from the reliability point of view, it is convenient to motorize two or more wheels as in the old BT-7 Betka. However, a full mechanical seizure of a motorized wheel would again bring to a complete failure. Therefore, reliability evaluation should be performed on the weapon system as a whole. The same happens with the maintenance or field-availability evaluation. In modern weapons, numbers should be evaluated in "fighting hours" instead of number of units.

LETHALITY AND FIREPOWER

The fundamental mission of the (MBT) is to close with and impair the enemy. Ground troop support is the main task, giving mobile artillery support and protection to the infantry. Impairing enemy tanks is not a main task. For this purpose, it is more convenient to use anti-tank aircraft or heavy artillery. Ambush with anti-tanks weapons and mines can be used for this task. The one-to-one tank-to-tank combat "Battle of Kursk style" is not very convenient. The practical possibility to outgun the enemy Tank is not so obvious. It happened in wars like the first Iraq war, where the Iraqis did not have updated cannons and ammunition or in the Yom-Kippur war (Battle of the Valley of Tears), where the Syrian tanks did not have enough elevation to kill the Israeli ones. However, it is not common and it is not convenient. Remember the last part of WWII where the tiny Hetzer, with its low profile and 75mm PAK cannon, scored huge successes against the massive JS2 122mm Stalin tank. On these days, "pan tanks" use 3-tons cannons to deliver an enormous amount of kinetic energy (or a very large high-explosive squash head) against enemy tanks. These conventional tank cannons are fueled by solid propellants that produce pressures in excess of 700 MPa to propel projectiles at very high velocity. The tremendous friction that bore surfaces must endure along with the extremely high pressures, temperatures reduces cannon life to less than 1,000 rounds, in most cases few hundreds. The enormous rounds are usually stored inside the crew compartment ready for use by the loader. Fire-blast resistant materials to increase crew survivability protect them. The size of the rounds and the protection system reduces the available storage to 40 units. Not all of them are anti-tank shells, since the 120mm cannon should also be used for ground troop support. New recent studies indicate that only 140mm cannon will be able to defeat that new generation of armor. This will require an automated loading system and an even smaller ammunition storage. Other options include chemical energy (CE) weapons and new generation kinetic energy (KE) weapons with velocity exceeding Mach 3 derived by electrical energy or a combination of electrical energy and conventional propellant. The CE and the rail-gun are not

VOL. 15, NO. 15, AUGUST 2020 ISSN 1819-6608
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mature for MBT use. For this reason, designers are currently thinking to turn to Anti-Tank Guided Missiles (ATGMs) as an alternative to the cannon. ATGMs head employ complex shaped-charges and from top attack strategy to defeat modern armor. AGTMs use self-propelled missiles, with a no-recoil lightweight launcher. Modern large "fire and forget" ATGMs can penetrate even the most advanced armors and missile improvements do no need for major changes on the launching platform itself. Unfortunately, because of the larger missile components, ATGMs require more stowage space reducing the number of rounds to 10 even with the missile-in-a-box approach where the stowed missiles would be vertically loaded in a container. Electromagnetic (EM) guns and electro-thermal-chemical (ETC) both offer tremendous potential for lethality improvements and they may reach technological maturity in the next 30 years. Nonetheless, there are significant hurdles to overcome before the concept can be reliably applied armored vehicles and they may require a complete different turret design. For this reason, it is convenient to design a fully automated main turret with integrated ammunition storage for the future MBT. In this way, the hull and the turret module are completely separated with greater flexibility and updatability. A slip ring will complete the interface between the hull and the turret. A secondary automated turret with smaller cannon (up to 40 mm), a small machine gun and an anti-aircraft missile launcher may be installed on the main turret. A set of sensors dedicated to the weapons can complete the "turret design". To reduce the tank profile it is also possible to avoid a rotating main turret and to install the cannon in a fixed mount. This operation would not require a complete redesign of the MBT, being the turret physically separated from the hull. In the case of transportability requirement on the current or on the future C130 airplane, the 120mm cannon with its 3 t weight and the enormous barrel length would exceed the C130 capability. The top mounted turret(s) solution allows assembling a "special" version with a smaller main turret with smaller cannon. 60mm ultrafast cannon retains good penetration capability in close combat, while being much lighter and shorter. It is also possible to eliminate the main turret and to install only the secondary turret with the 40mm cannon and hundreds of rounds. This solution is ideal for urban warfare and for ground troop assistance. A small number of ATGMs would keep the anti-tank capability if required. In fact, long antitank cannon are not suitable for combat in small room where the turret rotation can be impaired by the long cannon. The turret(s) replacement can be conceived as a depot operation to adapt the same hull to different scenarios. In addition, the two turrets solution, with the primary slip ring between the hull and the main turret and the secondary slip ring between the main and the secondary turret, improves the reliability of the tank. In fact, in case of failure of one of the turrets, at least one is still operational. Redundancy can be built in the slip rings to improve their reliability. This robust design approach, coupled with a built-in independent diagnosis capability, would improve the robustness of the tank design. In fact, with the addition of a machine gun coaxial to the main cannon, the firepower of the new tank will be the same of the actual "pan-tank" even with a completely failed secondary turret. The availability of modern, lightweight automated turrets revolutionize the future tank design.

SURVIVABILITY AND WEIGHT

The continuous horserace between penetration capability and armor has been continuous without one holding the lead, at least nominally, for very long. For sure, each improvement in both protection levels and shell penetration capabilities resulted an increase in resultant vehicle weight. Improved armament systems lead to subsequent improvements in armor. Both sides claimed for weight increase. The solution to mobility problems has been the installation of bigger engines, larger drivetrains, and heavier suspension systems to accommodate the incremental weight. In many cases, with the increase of ground pressure, the mobility improvement has been negligible or even negative. In fact, mobility goes with third power of ground pressure. For sure, this succession of improvements has resulted in the 70 t monsters we have on the battlefield today. In a few cases, the weight, a restricted data, exceeds 100 ton. Even with this precedent, with modern technology, it is perfectly possible to design a new vehicle less than one-third the Abrams weight that could rival it. In fact, it is important to consider that more than thirty years ago, the tanks were designed in a conventional way. A basic steel armor, brazed or cast, protected the crew from small caliber cannons, usually up to the Russian 14.5 (NATO STANAG 4569 threat 2 or 3). This monocoque structure holds all the structural loads and has the attachment for everything: power pack, suspensions, turret bearings. On this basic structure, which is made of steel, the specialized armor is installed, mainly on the front and in sides. This basic structure is heavy, being an armored monocoque. It is said that 70% of the Abrams weight is made by steel. For this reason a few paper were written to replace the steel with titanium alloy, which is perfectly possible except for the weaponry and the tracks. Titanium has a density of 4,430 kg/m^3 (Grade 5), while steel has a density of 7,800 kg/m^3. If you take away from a 66.8 ton tank, the cannon assembly (3 ton), the light weapons (500kg) and the tracks (5 ton), the remaining weight is 58 ton of which 40.6 ton (70%) are due to steel. By using titanium, just for its lower density, the weight saving would be 17.5 ton. This means that the "titanium tank" would weigh less than 50 ton. If you use RP (Reinforced Plastics) with various types of fiber to obtain optimum properties for the specific tasks, the saving would be 30t and the plastic tank would weight 36.8t. It is still more than the 20t target for the C130, but far less than the original. Probably a new generation wide-body C130 would be able to carry the "plastic tank". In any case, the "plastic" and the "titanium" tank would require a complete redesign of the vehicle. Therefore, designing a new generation of MBTs is convenient and the 20 t tank is probably possible. Table-1 shows a weight breakdown of a few US armored vehicles. Table-2 shows the theoretical weight obtained by replacing the steel with

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titanium GR5 and RP (when applicable). The aluminum alloy parts have been replaced by RP also. The savings are huge for the MBT due to the massive use of steel in the vehicle.

Table-1. Weight fractions of a few armored vehicles (%).

	LAV	AGS	M2A2	M1A2
Hull	**30**	**23**	**46**	**28**
Suspension	21	18	17	17.7
Power Plant	14	16	10	8
Auxiliary	6	5	3	3
Turret	12	26	13	35
Ammunitions	4	5	3	2.7
On vehicle equipment	3	2	3	2
Fuel	2	3	2	3
Crew	8	2	3	0.6
Total	100	100	100	100

Table-2. Theoretical weights (t) of a few armored vehicles replacing most steel parts with titanium GR5 or RP and aluminum alloy with RP.

Weight	LAV	AGS	M2A2	M1A2
Original (t)	14.4	20.2	35.7	68.3
RP (t)	7.5	13.9	17.2	26.6
Save RP (%)	47.8	31	51	55
Titanium (t)	10.5	17.4	33	44.5
Save Titanium (%)	27.2	13.6	7	44.4

Crew survivability is the most significant challenge for designers of MBTs, due to the continuously improving of modern anti-tank systems. For this reason, it is essential to reduce the crew to a minimum. Currently a crew of two is feasible. Historically the tanks has been designed as mobile bunkers. The confined space is surrounded by armors, with tracks, additional weapons and optics outside, almost everything else inside. The armor was an integral part of hull and turret. In the "pan tank" generation, the main armor is added. As armor technology became more sophisticated, the "integral part" of the armor has grown thinner. During the Vietnam War, the concept of "scope specific armor" has been proven in the attack helicopter. In this aerial vehicle, the mass is fundamental. Ceramic or titanium alloy armor plates were added following a well defined hierarchy. In the case of the tank, table 3 (for a 5-crew tank) defines this hierarchy.

Table-3. Protection priority.

Item	Priority
Driver	1
Commander	2
Loader	3
Gunner	4
Radio Operator	5
Vehicle Mobility or Limp Home Capability	6
Fuel	7
Fight Ability with secondary armament	8
Minimal communication equipment	9
Fight Ability	10
Short range sensors	11
Long range sensors	12
Ammunition main cannon	13
Ammunition secondary weapons	14

It is essential to reduce the crew compartment to the smallest possible. A crew compartment composed by the Commander, the Gunner and the Driver was considered the minimum possible. With modern technology, it is possible to eliminate the driver. The main problem is the workload that may be excessive for a two-man crew. For this reason, a modular, detachable crew compartment can be added to the rear of the tank. The position on the rear is due to survivability and escape. A fully armored module makes it possible to have a two or a 3-man crew. In addition, an "automation" module to convert the MBT into an UMBT (Unmanned MBT) can replace the crew-module. In this case, it would be possible to use mixed platoon of UMBTs and MBTs having the same performances and with the same appearance with obvious improvements on the vulnerability of the personnel. Fiber optics and limp home solutions can be adopted to improve the limp home capability of the new tank in case of multiple failures. A small crew module would also reduce the cost and weight of the NBC (Nuclear Biological Chemical) and AC (Air Conditioning) systems. BTs (Battle Tank) have become increasingly vulnerable to a wide range of threats, ranging from improved shaped charge warheads with top-attack capability, APFSDS (Armor Piercing Fin Stabilized Discarding Sabot), smart mines, and chemical weapons. Modern APFSDSs and ATGMs can significantly damage even the most new generation main battle tanks. Therefore, a 20-ton MBT may protect the crew, but the FCS (Fight Combat System) would not survive a direct hit. In fact, the survivability concept has changed. Armored vehicle design should include tradeoffs. A future increase in the crew survivability package must compete with all of the other subsystems or modules for its share of the total design weight. Therefore, an increase in the

VOL. 15, NO. 15, AUGUST 2020 ISSN 1819-6608
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weight of one subsystem means a commensurate reduction of the remaining components. FCSs incorporate survivability, armament, propulsion, and drive train components. The design challenge is to develop an effective crew module within available weight and size constraints. In July 1999, the US ASB (Army Science Board) conducted a study titled "Full Spectrum Protection for 2025-Era Ground Combat Vehicles" in which they determined that it is reasonable to allocate approximately from 5 up to 9 tons for the crew compartment on the future, 20-ton, C130-compatible MBT. A good design strategy would be to allocate 5 ton to the crew module, foreseeing a growth up to 10 ton. Unfortunately, even the most advanced armor systems will not provide the desired levels of all-around crew protection within those weight constraints. Only a frontal small area of about $1m^2$ can be protected against all the threats while the remaining surfaces of the crew module would protect against lesser threats. This frontal area protection can be subdivided into the armors of other sections of the FCS. In any case, it is important to focus on the fact that, pieces of track, wheels, engines, gearboxes and other technical components would be "transparent" to APDSFS penetrators. For example, the 120mm KEW-A2 uses a M=8.6 kg tungsten penetrator fired at a muzzle velocity V of 1,740 m/s (5 Mach). Its energy KE (Kinetic Energy) is represented by equation (1).

$$KE = \frac{1}{2}M\ V^2 = 13MJ \quad (1)$$

This is approximately equivalent to a 20-ton FCS slamming into a stationary vehicle at about 130 km/h. A new 140mm cannon would have a longer and heavier penetrator, while keeping the same speed. If new steels become available, it will be possible to increase also the speed, due to the larger propellant mass. With actual steels, a 140mm will deliver an amount of energy represented by equation (2).

$$KE_{140} = \frac{1}{2}M\left(\frac{140}{120}\right)^3\ V^2 = 20.7MJ \quad (2)$$

Therefore, the new 140mm cannon will deliver KE_{140}=20.7MJ penetrators in the near future. This energy amount will probably increase, with the new steels that would become available in the future (3).

$$KE_{140} = \frac{1}{2}M\left(\frac{140}{120}\right)^3\left(V\left(\frac{140}{120}\right)^3\right)^2 = 52MJ \quad (3)$$

Therefore, a new 140mm cannon with improved steel would probably deliver KE_{140}=52MJ penetrators in the future. A new, advanced armor may prevent the direct penetration. Unfortunately, the energy absorbed by the armor is only a fraction and the impact shock will cause severe internal vehicle damage, even if the vehicle does not capsize. Therefore, the crew should be strapped to safety belts and airbags should be included in the design to avoid incapacitation. In addition, the crew module may be installed on the vehicle body with dampers. The impact energy of the jet of intensely hot plasma of a shaped charge weapons has penetration pressures up to 1 TPa. KE and CE (Chemical Energy - shaped charge) weapons require different armors. At the risk of oversimplification, KE projectiles are defeated by slowing, turning and breaking up the penetrator. Slowing is usually accomplished by putting ceramic armor in the path. Standoff sloped layers achieve turning so that the penetrator hits the basal armor broadside. In addition, most KE projectiles are brittle and using standoff sheets composed of very hard materials causes the penetrator to shatter upon impact. Since the impact energy is huge, all the armored vehicles require a very strong hull and turret structure. This structure will also accommodate the suspension system, the power-pack and the armament. Traditionally, vehicle hulls are constructed of 20-50 mm ultra-high-strength steel or aluminum alloy, which protect the crew from NATO STANAG 4569 threat 2 to 4. On "pan tank" an additional armor is selectively added to protect the crew against KE cannon and CE threats. Alternative solutions include RA (Reactive Armors) and active protection systems that are effective against KE and CE threats. RA, ERA (Explosive RA) and AERA (Active ERA) can be simplified into a sandwich of two metal plates with a core of explosive (ERA) or inert energetic materiel (RA). In traditional ERA armor, because of its extremely high velocity, the tip of the shaped charge jet typically penetrates both plates before they begin to move. Therefore, the vehicle basal armor should be thick enough to stop the tip before it enters the protected area. In AERA (Active ERA) systems, that are effective also against KE projectiles, a sensor detonates the armor before the arrival of the projectile. In this case, the basal armor should be strong enough to absorb the shock induced on the rear plate by the huge armor detonation. Therefore, the basic structure should be thick and sturdy enough to withstand the energy transfer from the additional armor. In addition, it should be easy to replace the additional, specialized armor on the basal plates. Electromagnetic armor concept is back to the 1970s without any known practical applications. The first operational APS (Active Protection Systems) was developed by the Soviet Union and was designed to provide protection against ATGMs. It scored 80-percent success against RPGs in the Soviet-Afghan War (1979-1989). Active protection systems are essentially defensive systems designed to destroy or deviate incoming anti-armor threats by utilizing sensors and counter-munitions. The APS could provide excellent protection within certain ranges for KE penetrators at distances larger than 500 m, while for CE heat it may be as little as a few tens of meters. The advantage of APS is that the vehicle is not interested by any impact; the main disadvantages are cost, reliability and countermeasures. Table-4 shows the capacity of the C130 cargo bay.

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Table-4. Loockeed C130J cargo bay.

Length (m)	**12.5**
Height (m)	2.74
Width (m)	3.48
Load (t)	20

A WWII T34 tank can be transported on the C130 for size LxWxH=6.75x3x2.45 (m) but its weight is excessive even for the Mark I (26 t). By building the T34 fully with RP it is possible to reduce the weight down to about 8t. Therefore, even with the additional armor, it is possible to design an MBT under the 20t. Even with the longer 120/L55 cannon (6.28 m) the length of the new MBT would stay inside the C130J bay. Unfortunately, the overall weight of the 120mm cannon with breech, damping and insulation is huge (3t) and it may be difficult to design an MBT within the 20t along with the armor. As back-up a solution, it is possible to design a "lightweight" version of the new MBT with only the APS as specialized armor. Another alternative is to adopt a multiple turret "bolt on" design with the possibility to choose different turrets for the same hull. This latter solution is to be preferred being more flexible.

MOBILITY AND POWER

One of the most contentious issues is whether the primary platform should be tracked or wheeled. Wheeled armored vehicles are still under development; however, the poor cross-country performance and the vulnerability make the wheeled vehicle impractical. In terms of survivability, tracked vehicles offer also a lower silhouette. However, with increasing ground pressures, the pan-tanks are usable only on hard soil. In this situation, the advantage of tracks is reduced. In many papers, trafficability is confused with mobility, which are similar but different concepts. In the early 70's, D. Rowland (RARDE - Royal Armament Research and Development Establishment, UK) introduced the MMP method for assessing the capacity of land to overcome the load of tracked vehicles (4).

$$MMP = \frac{1.26W}{2nb(td)^{0.5}} \quad (4)$$

Where $\boldsymbol{W}$ is the vehicle weight (kN); $\boldsymbol{b}$ is the track width (m); $\boldsymbol{n}$ is the number of road wheels; $\boldsymbol{d}$ is road wheels diameter (m) and $\boldsymbol{t}$ it the track pitch (m). The interest of the MMP equation stands in the fact that it was shown that MMP are numbers are well correlated with RCI (Rating Cone Index) (5).

$$RCI = 0.83MMP \quad (5)$$

This means that the capacity of the land for a single crossing of the terrain is 83% of MMP. MMP equation shows that, for trafficability, it is convenient to have long tracks with large wheels. However, it should be kept in mind that longer tracks reduce the capability of the tracked vehicle to turn; in other terms, they reduce the maneuverability. Equation (4) has many variables inside that are linked together: pitch $\boldsymbol{t}$ is linked to $\boldsymbol{d}$, which is linked to $\boldsymbol{n}$ which is linked to $\boldsymbol{b}$. These constraints correlate directly equation for with GP (Ground Pressure) that remains the main parameter for maneuverability. Most tracked vehicles utilize torsion bars that fits under the vehicle floorboards. Unfortunately, they require a flat floor and it is not possible to adjust vehicle height. In addition, the room under the floorboard is precious for armor and a shaped floor is better against blast. Therefore, hydropneumatic suspensions are an obliged choice. The propulsion is relatively easy to implement, given the low vehicle weight. A dual drive system with two modern, electronically controlled, automotive-derived, 300HP diesel engines equipped with automatic gearboxes, make it possible to have a very light and slim propulsion system. Engines as small as 2.2 liters are up to the task [1-6]. These engines, installed on the sides, can drive through the reduction-drives the rear sprockets. A back-up, emergency system can be implemented with electric motors and an APU with battery. This latter is essential for silent operations. The powerpacks are so small that it is still possible to install a crew compartment between the engines with a 2/3-men-crew armored module. Rear an upper escape/access complete the rear of the tank. The crew compartment can be installed on the main RP hull with shock-absorbers, and escape-seats can equip the module. The conversion between the manned version and the unmanned one can be performed by merely substituting the crew module [7-22].

NEW MBT CONFIGURATION

Positioning the crew compartment and the power packs on the rear makes it natural to position the turret in the front of the tank behind the frontal armor. A cavity can be designed in the hull to allow the elevation of the very large cannon. Elevation can be also improved by using the hydropneumatic suspensions. Ammunitions for the main cannon, for the coaxial weapon and for the secondary turret are all stored in the turret, with a further separation from the crew. In this way, turrets and weapons are add-on bolted on the hull. Also the specialized and continuously update armor is bolted on the main RP hull. A low profile antitank version with fixed turret completes the family of MBTs-UMBTs based on the same hull.

CONCLUSIONS

In this paper, it was demonstrated that it is possible and it is convenient to develop a new MBT-UMBT family. It is possible to carry the new vehicle in the 20t C130J bay. These achievements are possible by using a RP (Reiforced Plastic) basic hull structure with composite plates to achieve a basic protection at NATO STANAG 4569 threat 3 or 4. The small MBT can then be equipped with additional specialized armor for CE and KE shells. The automation of the driving system makes it possible to reduce the crew to two men with the possibility to add third crewmember. The crew compartment should have its own additional armor and it is positioned between the two small powerpacks that energize the rear sprockets. The crew should travel secured by safety belts and should have ejection seats. Air-bag should be considered to reduce the shock of a direct hit from APFSDS penetrators or other high energy threats. Access/escape hatches should be provided in the upper part and in the rear. A floor access is welcome but it is difficult to implement. The fully-bolted-on weapon system is positioned on the top of the hull behind the front plate. A large cannon main turret can be installed along with a secondary one with small machine guns and AA devices. Both turrets are fully automated and carry their own ammunition storage. In alternative, a smaller turret with a smaller cannon can replace the main one. In fact, it is dubious that, with a large main cannon, it is still possible to fulfil the 20t requirement. From Authors calculation, the weight reaches 22t. Finally, a fixed turret can be bolted in place of the previous ones in order to assemble an antitank vehicle. The RP basic hull approach with bolted armor and turrets makes it possible to assemble a family of MBTs capable of different tasks and to be upgraded to new technologies by replacing instead of adding. Finally, an “automation module” to transform the MBT into an UMBT (Unmanned MBT) may replace the crew compartment. A larger C130 with improved wings may be developed for the transportation of the new MBT with the full 120-140mm cannon.

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