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Article *in* Defence Science Journal · June 2017

DOI: 10.14429/dsj.67.11426

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Defence Science Journal, Vol. 67, No. 4, July 2017, pp. 343-353, DOI : 10.14429/dsj.67.11426

Design Configuration of a Generation Next Main Battle Tank for Future Combat

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ABSTRACT

The future combat scenario will undergo a sea change as compared to the conventional and un-conventional warfare employed by the traditional armies and non-state actors. In such a scenario, the main battle tank which serves as a game changer during these conflicts has to face the dilemma whether its design should be either evolutionary or revolutionary. To determine the basis of selecting the right type of design based on the above, the broad parameters that define the configuration namely number of crew, weight, armament system, survivability, operating range, transportability, tactical mobility, trafficability, intelligence - surveillance - target acquisition - reconnaissance (ISTAR), system modularity and theatre of operation have been considered. Taking these parameters into account, this study evaluates both the evolutionary and revolutionary design configurations for a generation next main battle tank. Finally, from the outcome of this study it is observed that the revolutionary design approach not only fares better compared to the evolutionary approach, but also possess ease of adaptiveness as an universal combat weapon platform.

Keywords: Future combat; Threat scenario; Configuration; Firepower; Survivability; Mobility; Modularity; Adaptability

NOMENCLATURE

A_{shoe}	Area of the track shoe in mm^2
b	Track width in mm
D	Draw bar pull in N
d	Road wheel diameter in mm
e	Projected area of track plate/bp in mm^2
G	Penetration resistance gradient
l	Nominal length of track on ground in mm
m	Number of wheel stations per track
n	Number of road wheels
p	Track pitch in mm
RCI	Rating cone index in N/mm^2
x_i	Distance between front idler to CG
x_f	Distance between sprocket to CG
W	Gross vehicle weight in N

1. INTRODUCTION

Main battle tank (MBT) Forms the backbone of the mechanised forces for any conventional army. Traditionally these platforms were designed keeping in mind the conventional warfare philosophy or the iron triangle of firepower, mobility and protection. Such an iron triangle underwent minor changes with the introduction of un-conventional warfare by non-state actors post[1] 9/11. Hence, the conventional design philosophy based on contemporary threat scenario needs to be modified or incorporated with fresh threats in order to extrapolate it as a future combat scenario. One such future combat scenario is as shown in Fig. 1. This threat scenario forms the baseline for arriving at the configuration for the generation next main battle tank (GNMBT). However, the dilemma facing designers of such GNMBT is whether to arrive at a configuration which is evolutionary or revolutionary in nature.

An evolutionary approach per se is an extension of an existing platform with add-ons or technology upgrades so that contemporary threats are addressed. Examples for such an approach include Arjun (Mk-I and Mk-II), Challenger (1,2 and TES), M1 Abrahms (A1 and A2), Leopard 2 (A1 to A7+) etc. On the other hand, the alternate approach includes arriving at an altogether new configuration which not only addresses the future threats but also truly revolutionary in configuration and design.

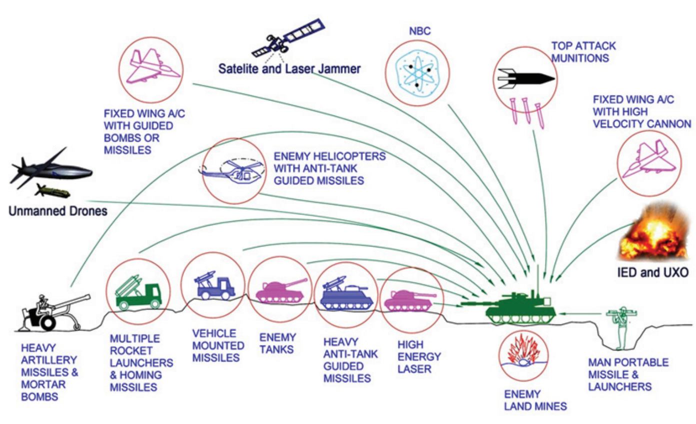

Figure 1. Future threat scenario for the battlefield.

Received : 18 March 2017, Revised : 24 May 2017
Accepted : 26 May 2017, Online published : 27 June 2017

The traditional solution for such dilemmas has always been to go with the evolutionary approach since it reduces the logistical echelon and acquisition cost for the services. However, the technical advantages that accrue due to the revolutionary approach has very limited basis in literature which forms the core of this study.

2. PARAMETERS

Although a number of major and minor parameters are used to arrive at the configuration of a MBT, only those critical parameters that have a major bearing on the configuration alone have been considered. In addition, for each parameter its relevance, variation, advantages, limitations etc., have also been discussed in detail.

2.1 Number of Crew

The number of crew plays a vital role on the final configuration. Apart from an unmanned MBT, options exist for one, two, three and four crew combination. To decide on the right number of crew, various parameters such as internal volume, weight, crew comfort, ergonomics, endurance, redundancy and reaction time are considered. It is worth noting that as the number of crew reduces from four to two as shown in Fig. 2, the overall weight reduces as the amount of protection required is reduced[2]. However, on the flipside the crew endurance (72 h - 96 h), reaction time and redundancy reduces as their workload increases thus affecting combat effectiveness.

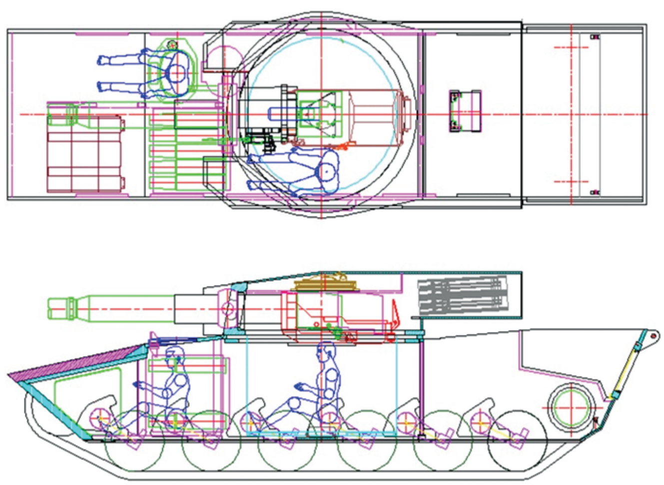

Figure 2. Typical two men crew configuration.

2.2 Weight of MBT

Weight of the MBT means combat weight i.e., max weight at multi-mission conditions. Whereas in the evolutionary approach, the configuration and design is top-down, the bottom-up approach works well for the revolutionary approach as weight is the final deciding factor as shown in Fig. 3.

Combat weight has a huge bearing on both strategic mobility and agility. Future global requirements are expected to be in the range of 45 to 50 ton class taking into account even high altitude operations. However, as the multi-mission protection and mobility requirement increase for the GNMBT, designing within the weight limits is challenging.

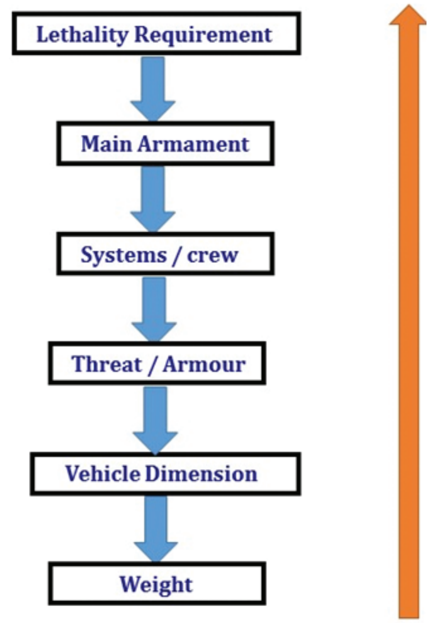

Figure 3. Evolutionary and revolutionary design approach.

2.3 Armament System

The overall effect of the armament system on the configuration of GNMBT is as shown in Fig. 4.

From the above, it is inferred that the armament system affects not only the turret configuration but also the hull configuration thereby deciding the final GNMBT configuration. Further, it is stated that as the recoil length increases with higher caliber, the adoption of certain technologies such as concentric or adaptive recoil along with ammunition of lesser length leads to decreased turret width. Also, it is to be noted that as the variety in ammunition increases due to mission requirements, the dimensions need to be same to achieve uniformity in configuration. In addition, by shifting or lowering the trunnion pivot coupled with adoption of ammunition autoloader for higher rate of fire (ROF) and crew location in the hull, the overall height of the GNMBT can be substantially reduced thereby aiding tactical survivability.

Although the effect of the above parameters are well documented for a conventional armament system, the same for un-conventional gun system also need exploration. In

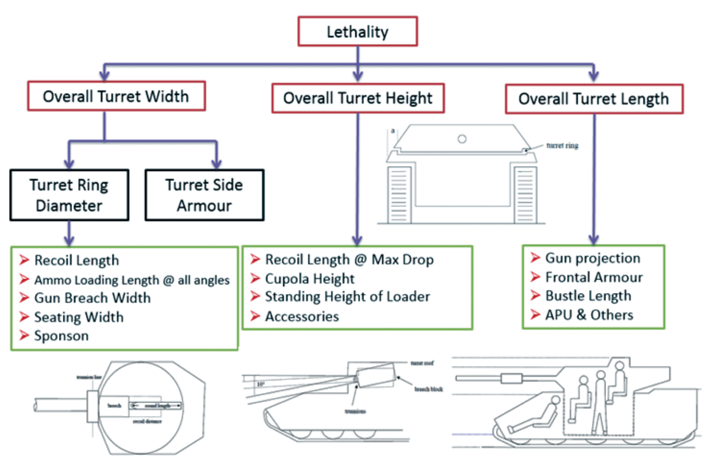

Figure 4. Effect of armament system on configuration[3].

this regard, first let us consider the liquid propellant gun (LPG) system. Such a system can be either monopropellant or bipropellant type where the propellant is injected into the chamber behind the projectile prior to or during the combustion. The ignition to all burnt stage of a typical bulk loaded LPG is as shown in Fig. 5.

For such LPG system, a cursory look at the internal ballistic cycle indicates increased muzzle velocity for lower pressures, higher range, higher ROF, infinite zoning, soft ride for sensitive munitions and lesser weight as compared to conventional solid propellant gun system[5]. Such LPG systems have been extensively trial evaluated in USA under two programs namely BRL program and Crusader program. Whereas the BRL program conducted studies with 25, 30 and 105 mm caliber guns, the Crusader program carried out trials with 155 mm artillery gun for which the pressure-time history recorded is as shown in Fig. 6. One such similar program was also conducted by the Ernst-Mach Institute of Germany with a 28 mm caliber gun.

Secondly, let us consider the electro-thermal (ET) gun system where the projectile gains momentum through a low molecular weight propellant that converts into a plasma when charged by a high voltage electrode as shown in Fig. 7.

Such a system was built and extensively trial evaluated both by US-Israel JV and UK by general dynamics (105 mm) and United Industries (120 mm), respectively. During these trials, it was observed that breech pressures could be sustained for the entire ballistic cycle with greater projectile energy for the same gun tube as used by a conventional system as shown in Fig. 8.

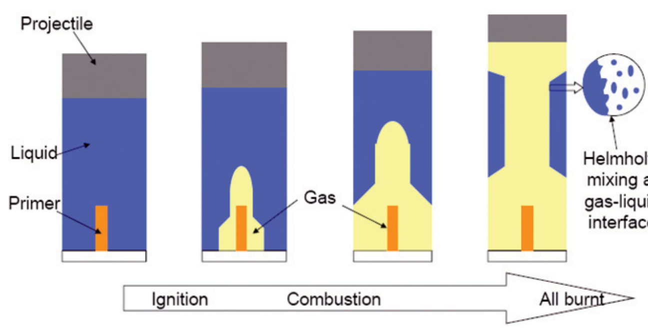

Figure 5. Ignition cycle for bulk loaded LPG system[4].

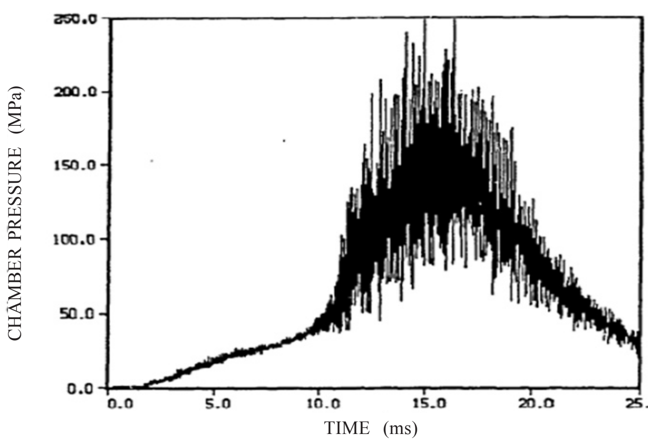

Figure 6. Pressure-time history Crusader gun system[6].

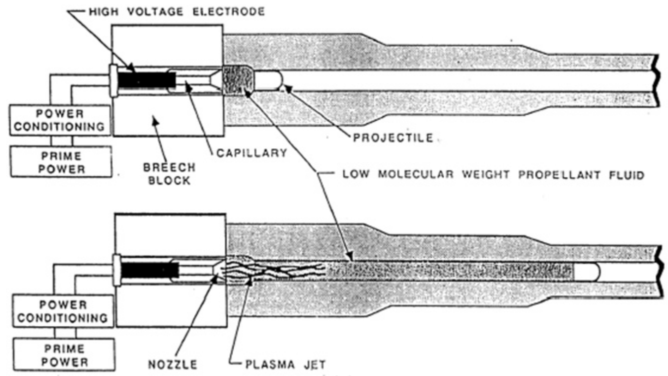

Figure 7. Electro-thermal gun system.

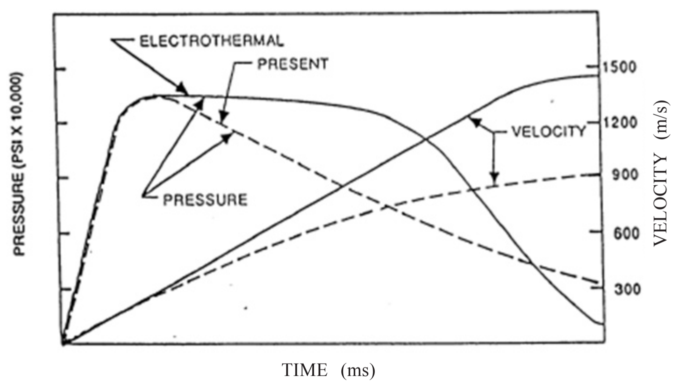

Figure 8. Pressure and velocity-time history for general dynamics gun system[7].

Finally, let us consider the electromagnetic (EM) gun system whereby the projectile is accelerated due to the Lorentz force generated between two rails as shown in Fig. 9.

Although many programs exist, the most successful EM gun program is the BAE hypervelocity gun program for US Navy where a projectile delivered 32 MJ of energy recently at Mach 7.4 with a range greater than 50 km[8]. To evaluate the feasibility of both conventional and un-conventional gun system for GNMBT a comparison of various parameters is carried out as shown in Table 1.

From the comparison, it is observed that LPG, ET and EM systems are superior both in terms of lethality and efficiency compared to conventional armament systems. Similarly, these systems offer lower smoke and flash in addition to ignition delay, muzzle velocity and charge temperature control.

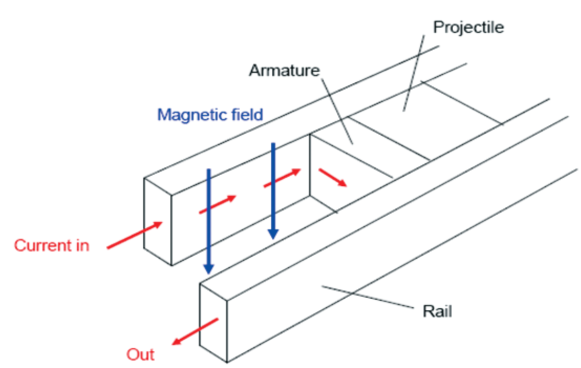

Figure 9. Typical EM Gun system working principle.

Table 1. Comparison of conventional and un-conventional gun systems for GNMBT

Parameters	Conv.	LPG	ET	EM
Calibre in mm	120	155	120	80
Accuracy in mil	≤0.3	-- (CEP)	≤0.3	≤0.3
Rate of fire in rounds/ min	8-10	8-10	8-10	6-8
Muzzle velocity in m/s	≤1900	≤2500	≤2600	≤2600
Gun efficiency in %	~ 33	~ 50	~ 50	~ 50
Weight in t	3.80	4.30	4.20	5.30
Volume in m^3	1.80	3.40	2.60	4.00
Power consumption	Very Low	Low	High	Very High
Stowage efficiency	Low	High	High	High
Fuel pre-ignition	No	Yes	Yes	No fuel
Pressure oscillations	No	Yes	No	No
Ignition delay control	No	No	Yes	No ignition
Muzzle velocity control	No	Yes	Yes	Yes
Charge temp control	No	No	Yes	No charge
Smoke and flash	High	Very Low	Low	No smoke
Residuals	Low	High	Low	No residue

However, the weight, volume, power consumption and safety issues for the un-conventional gun systems are higher compared to conventional gun system. If un-conventional systems are adopted, then the premium internal volume in the tank will be consumed which leads to further weight spiral and transportability issues. Hence, holistically considering all these issues it is preferable to consider the conventional armament system for GNMBT unless miniarisation and weight reduction is attempted in the future.

2.4 Survivability

Survivability or protection requirements contribute mainly to the weight and volume requirements. For a typical MBT, the armour alone contributes directly to 46 per cent of the weight and indirectly to 50 per cent of overall volume as shown in Fig. 10.

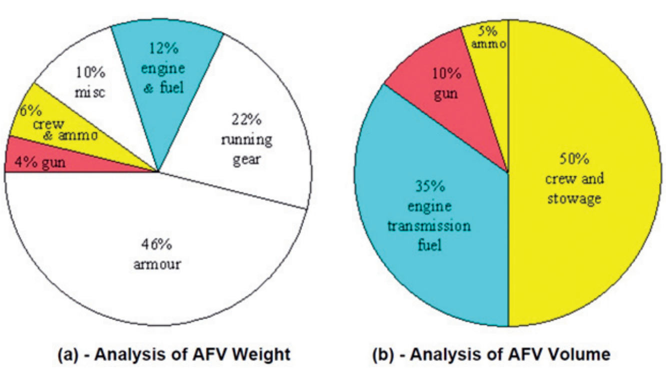

Figure 10. Effect of armour on weight and volume[9].

However, as future requirements such as GNMBT target the weight class of 45-50 ton, conventional design philosophy of evolutionary MBTs using Whittaker's theory of directional probability of variation (DPV) on frontal 60° arc do not suffice. Hence, for revolutionary design philosophy 360° protection or super Whittaker along with belly protection seems to be the only solution due to emergence of myriad threats as shown in Fig. 11.

For the threat profile shown below, the survivability solution has to be holistic i.e. a combination of various protection solutions namely passive, semi-active and active as aptly described in the survivability onion philosophy as shown in Fig. 12.

From the survivability onion, it is observed that the last line of defence in the MBT consists of body armour, spall liners, insensitive munitions and energy absorbing seats with harnesses. The next line of defence consists of passive armour which forms the bulk of mass and volume as shown in Fig. 12. So, to prevent penetration by adversary projectiles the evolutionary approach is to induce the concept of equivalent protection factor (EPF) or sloping along with add-on steel armours, composite armours with ceramic plates and explosive reactive armour (ERA).

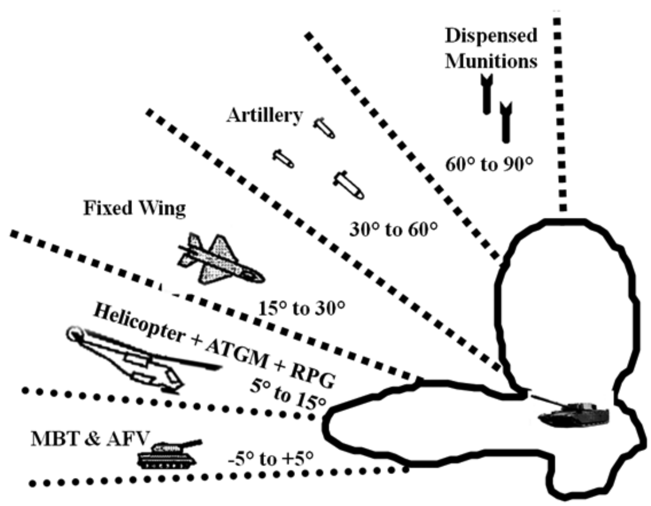

Figure 11. Super Whittaker threat profile[10].

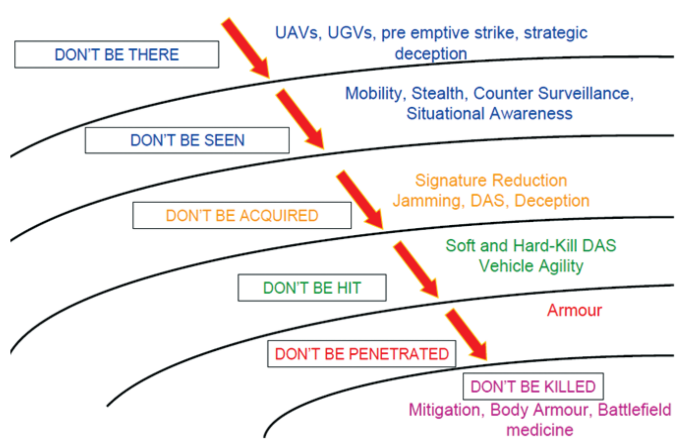

Figure 12. Survivability onion[11].

However, for the revolutionary approach newer materials like ultra-high hardness armour steel i.e. steels with hardness greater than 600 BHN than the current 300-500 BHN shall be explored. This aids in the reduction of plate thickness used in the fabrication, thereby providing much needed weight saving. In addition, non-ferrous armours such as titanium and aluminium armour, perforated steel armour, sapphire glass armour, hybrid and non-explosive ERA and bulge armour may also be explored in non-critical areas i.e. below bustle, cover plates etc. along with EPF to achieve higher protection. However, this methodology becomes redundant in terms of weight if not augmented with signature management techniques and active protection system as discussed.

Signature management techniques involve the adoption of multi-spectral camouflage which is capable of covering the entire spectrum of sensors as shown in Table 2. In addition, thermal management in the form of exhaust configuration by sloping it upwards along with cold air blending has the potential to reduce signature[12]. Another approach is to blend kerosene or diesel fuel to the exhaust that creates a thick smoke around the vehicle along with the existing smoke grenades capable of creating an anti-thermal anti-laser smoke. Further, certain paints such as TAN 686 are capable of reflecting radiation of upto 85 per cent and cool the exterior by 15 °C thereby reducing thermal signature.

However, the entire gamut of signature management techniques discussed above which involve careful design and configuration can be obviated by the adoption of technologies such as adaptive camouflage similar to the one proposed by BAE Systems, UK. This technology not only reduces the visual and IR signature but also camouflages the AFV visual signature into a less protected or civilian vehicle as shown in Fig. 13.

Active protection system (APS) for MBTs are currently capable of defeating targets such as anti-tank guided missile (ATGM), rocket propelled grenade (RPG) and a host of other chemical energy and kinetic energy ammunition. These targets are destroyed either by an explosively formed projectile (EFP) or grenade at a stand-off of more than 30 m to prevent secondary damage[14]. However, when comparing protection to weight ratio for a 360° horizontal and 180° vertical envelope APS fares better than the combined passive and reactive armour.

Table 2. Sensor wavelength spectrum

Sensors	Wavelength
Battlefield radar	16.66-37.5 mm, 8.57 mm
Thermal imagers	3-5 micron, 8-12 micron
Laser range finders	0.4-14 micron
Laser target designators	0.4-14 micron
Seeker heads of missiles	3.19 mm

Finally, for GNMBT which is likely to operate in an intense urban mission with threats namely improvised explosive device (IED), unexploded ordinance (UXO), RPG, ATGM, blast and EFP mines, technologies such as urban survival kit, medium appliques, drag plates, tow plates, jammer, spoofer, laser dazzler and electronic countermeasures in addition to the above help overcome all the above threats.

2.5 Operating Range

Operating range or cruising range is not only a mandatory war tactic requirement but also dictates the amount of fuel carried by the MBT. This affects the configuration as it imposes both weight and volume based constraints. Hence, the only differentiating parameter between the evolutionary and revolutionary approach lies in the reduction of overall fuel capacity which is a function of fuel consumption based on an on-road to off-road ratio.

2.6 Transportability

Transportability implies the ability to carry out logistics through a variety of platform namely road, rail and air for rapid deployment. For the road transport, the challenges are tank transporter, self-movement on tracks and load capacity of civilian bridges. However, for rail transport the constraining parameter is the over dimensioned consignment (ODC) which consists of three classes namely A, B and C for Indian Railways as shown in Fig. 14. Of these three classes, it is prudent to choose class A, as unhindered movement is ensured on all lines which results in least possible time during deployment.

In addition, for air transport the same type of ODC exists which is platform specific. In this regard, the ODC of C-17 Globemaster available with the Indian Air Force is as shown in Fig. 15. Finally, when evaluating both the evolutionary and revolutionary design, the composite parameter of road, rail and air transport should be considered together for better transportability.

Figure 13. Adaptive camouflage[13].

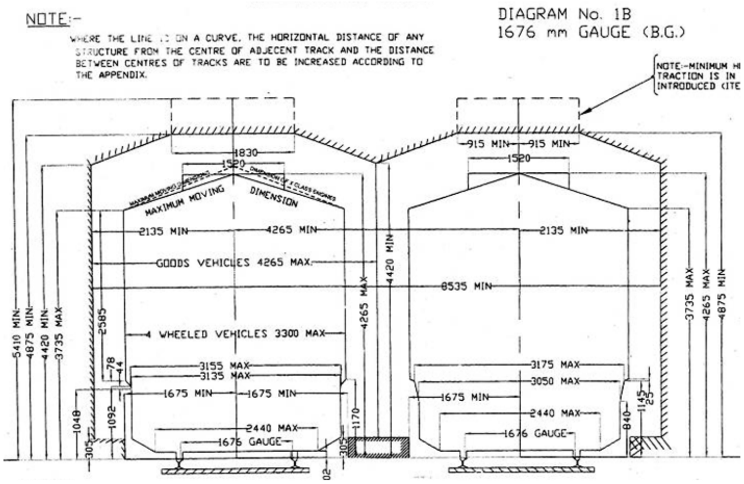

Figure 14. Indian railways ODC Class profile[15].

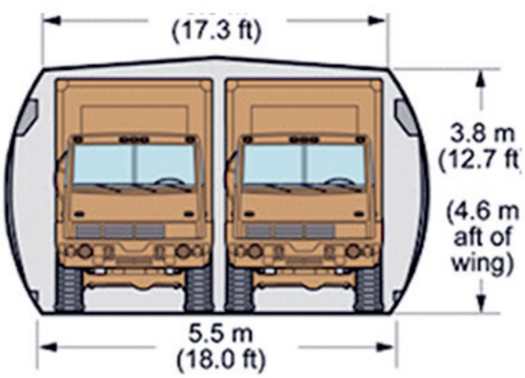

Figure 15. C-17 globemaster ODC profile[16].

2.7 Tactical Mobility

Tactical mobility implies a mixture of road, cross country and track movement. It also includes some water wading or fording capability. Tactical mobility is further broken down into two parameters namely terrain accessibility and agility which are discussed in detail as fallows:

Terrain accessibility is a function of gross weight, nominal ground pressure (NGP), mean maximum pressure (MMP), length, width, track type, trench crossing, gradient and climb (including side slope) and fording capability[17]. Among these parameters, NGP is the ratio of vehicle weight to contact area and it reflects the average pressure exerted by the vehicle on the soil as per Eqn (1). On the other hand, MMP represents the average of the peak pressures that occur under each road wheel which is calculated as per the Eqn (2).

$$NGP_T = \frac{W}{2bl} \tag{1}$$

$$MMP_T = \frac{1.26W}{2mbe\sqrt{pd}} \tag{2}$$

When comparing both NGP and MMP as shown in Fig. 16, it is observed that MMP is a more accurate method to predict cross-county performance of the MBT[18]. Hence, while comparing two MBTs with the same NGP the one with the lower MMP will have better performance over soft ground.

Another factor that decides tactical mobility is the trench crossing capability. For a MBT as shown in Fig. 17, this is a geometrical parameter which depends on the number of road wheels, distance between the CG and track tensioner, CG and sprocket centre and road wheel diameter given in Eqn (3) for a MBT with even number of wheels.

$$Max\,trench\,width \le L\left(\frac{0.5n-1}{n-1}\right) + 0.5(x_i - x_f) + 0.2d \tag{3}$$

With regard to the step climbing capability, the maximum step height achievable is a function of the ratio of vehicle mass centre from the axis of the front road wheel to the length of track on ground (a/L) and suspension/track deflection at centre wheel station. In case, the mass centre cannot reach a position directly above the step it results in overturning as shown in Fig. 18.

With respect to agility, it depends upon the power available at the drive sprocket (a function of gross engine output and losses due to transmission and other elements) in relation to the vehicle weight and the flexibility of the transmission, steering and suspension systems. Also, agility reflects the capability of the vehicle in the following circumstances.

- Acceleration at different terrains
- Radius of turn at different speeds at various terrains
- Responsiveness of the transmission to engine loads
- Dynamic response of the hull to the transient shock loads imposed by rapid movement over rough terrain (The maximum usable speed across terrain).

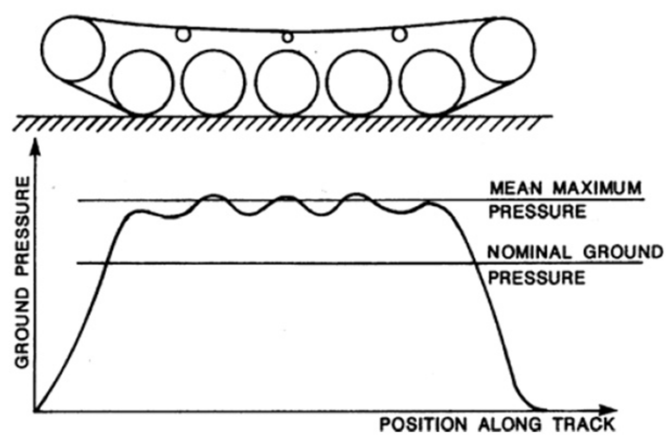

Figure 16. NGP and MMP comparison.

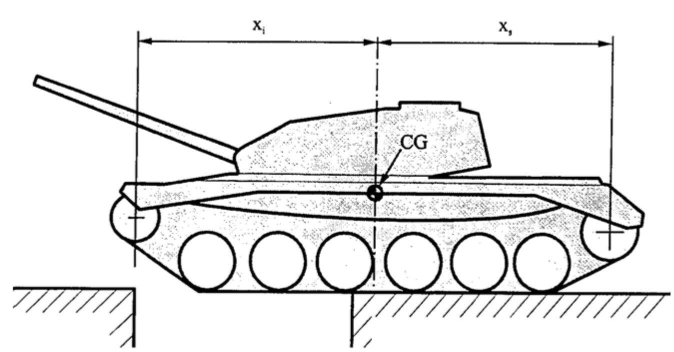

Figure 17. Trench crossing capability of MBT.

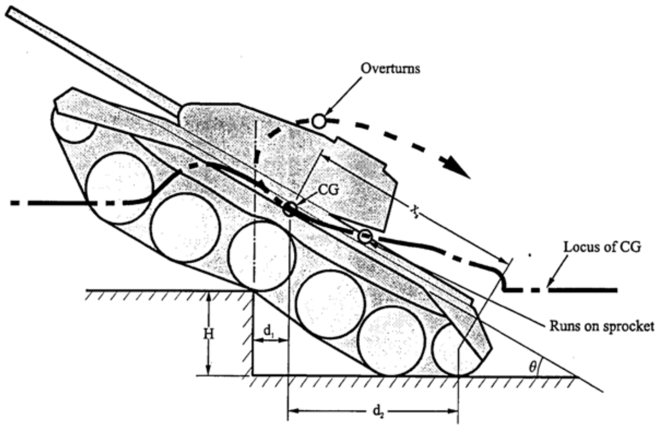

Figure 18. Step climbing capability.

Finally, while comparing the evolutionary and revolutionary design a composite parameter be evolved that accounts for all the above factors to achieve better tactical mobility.

2.8 Trafficability

Trafficability refers to the ability of the vehicle to traverse a range of terrains such as hard, soft, sand, marsh etc. which is a combination of basic soils namely clay, silt, sand and gravel. Whereas, hard terrain mobility is achieved with ease, the critical parameter that differentiates tracked vehicles is soft ground mobility which is a vehicle characteristic[19]. Several parameters have been developed to achieve this, which can be classified into two heads namely mobility characteristic parameters and mobility limit parameters.

Mobility characteristic parameters depend only on vehicle specification and does not depend upon the type of soil on which it operates, whereas mobility limit parameters are designed to indicate the minimum strength of soil on which the vehicle is expected to remain mobile. Although various methods have been proposed in literature, the well accepted methods that are experimentally validated are as given in Table 3.

Of the above, VCI is a methodology based on mobility index along with the other parameters such as weight and track dimensions. Whereas VCI for a clay type soil is given in Eqn (4) with MI given in Eqns (5) and (6), for an organic soil this is estimated as given in Eqn (7).

Table 3. Mobility characteristics system (trafficability)

Mobility system	Soil types	Observation
NGP	--	Over simplistic
MMP	--	Basically sound
Vehicle cone index (VCI)	Clay	Sound if measured in field
Vehicle limit Cone index (VLCI)	Clay	Needs further validation
Mobility numeric	Clay and sand	Empirical-Plethora of equations
Excess soil strength	Clay	Depends on VCI
NATO reference mobility model (NRMM)	Clay and sand	Uses VCI and mobility numeric

$$VCI_T = (48.258 + 1.379 MI_T) - \frac{270.245}{MI_T + 5.6} \ (kpa) \text{ for one pass} \quad (4)$$

$$MI_T = \left[\frac{CPF \cdot WF}{TE \cdot GF} + WLF - CF\right] EF \cdot TRF \quad (5)$$

$$WLF \text{ (Wheel load factor)} = \frac{\text{Gross vehicle weight}}{22.07\, N\, A_{shoe}} \quad (6)$$

$$VCI_{TMK} = 89.622 + 0.43 \frac{W}{2(b+l)} (kpa) \text{ for one pass} \quad (7)$$

In Eqn (5), contact pressure factor (CPF) is the ratio of gross weight (kg) to area of track (m^2). In addition, the weight factor is 1.8 for MBTs, track factor (TF) is 0.01 times the track width (m), grouser factor (GF) is 1.1, clearance factor is ground clearance (m)/10, engine factor and transmission factor is 1.0, respectively[20]. Similarly, the VLCI, mobility numeric, excess soil strength and NRMM is given below from Eqns (8)-(10), respectively.

$$VLCI_T = \frac{1.63W}{2mbe\sqrt{pd}} \quad (8)$$

$$\pi_{ct} = 11.25 \left[\frac{0.145 RCI}{MMP}\right]^{0.72} \quad (9)$$

$$\frac{D}{W} = 0.6512633 - \frac{4.90683}{RCI - VCI + 7.285463} + 0.02224646 \quad (10)$$

Hence, while arriving at the optimum configuration for both the evolutionary and revolutionary approach, that design which offer superior trafficability as per the above parameters be chosen.

2.9 Intelligence Surveillance Target Acquisition and Reconnaissance

Intelligence surveillance target acquisition and reconnaissance (ISTAR) is an advanced multi-dimensional and configurable decision support set of tools, adaptable to all command levels, from national HQ to battlefield commanders[21]. It assists in achieving intelligence dominance for the net-centric battlefield by providing decision makers (commander in MBT) with a real-time situation picture of the theatre as shown in Fig. 19.

In reality, this network centric approach in a MBT involves the following systems and sensors as given fallows:

- Battlefield management system (BMS)
- Software defined radio (SDR)
- Automated target tracker (ATT)
- Commanders panoramic sight (CPS)
- Gunners main sight (GMS)
- Laser target designator (LTD)
- Laser range finder (LRF)
- Laser warning and countermeasure system (LWCS)
- Drivers sight with thermal imager (TI)
- Combat identification of friend or foe (CIFF)

Hence, while comparing the evolutionary and revolutionary approach, the emphasis would be on integration of all the above technologies along with their respective volume, weight and power requirements.

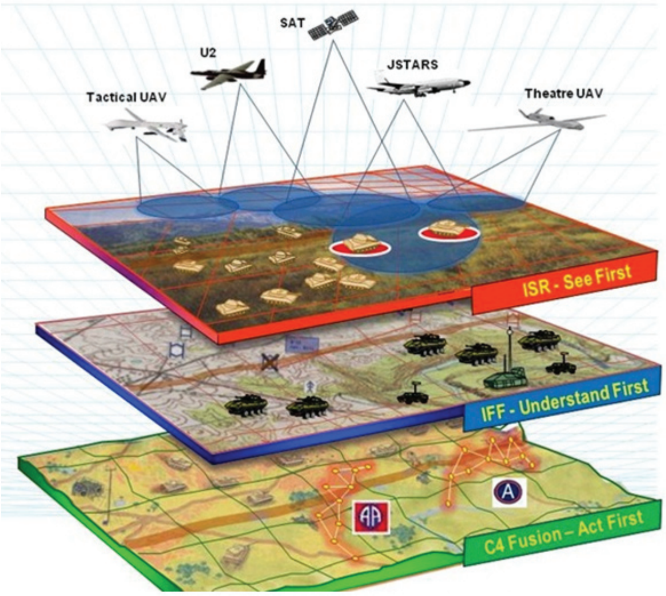

Figure 19. ISTAR configuration.

2.10 System Modularity

System modularity is a function of combat mission as MBTs for future have to undertake a variety of missions such as limited skirmish, urban warfare, high altitude engagement etc. During such missions, the weapon platform should be so configurable that modules be fitted based on requirements as shown in Fig. 20 for the frontal armour. In this regard, the revolutionary design is capable of better modularity whereas the evolutionary design lacks modularity due to fabrication constraints and only add-ons are possible which increase weight thereby reducing mobility.

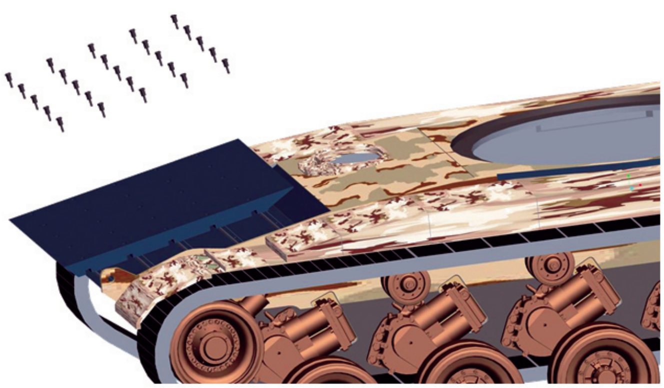

Figure 20. Modular frontal armour.

2.11 Theatre of Operation

The future MBT should be capable of operating in a variety of terrains and ambient conditions. These terrains include hard ground (small pebbles, medium size boulders, shallow shale and salt over layer), clay/loam, sand, marsh (with and without vegetation) and combination of snow and boulders. These types of terrains are available in the Indian sub-continent extending from J&K, Punjab, Rajasthan, Gujarat to NE region. Coupled with these terrains, the adverse effect of temperature and air density at high altitudes pose additional challenges. Whereas the challenges in deserts and plains are well documented, scarce information exists on the challenges experienced at high altitude deployment of MBTs.

At high altitudes, extreme temperature (sub-zero), logistical challenges (>30° gradient), high power requirement (air density less than 50 per cent compared to mean sea level) and material failure are some of the major challenges encountered. Hence, while evaluating the evolutionary and revolutionary design, the emphasis should be on operating the MBT across all the theatres of operation.

3. FINALISED CONFIGURATION

The revolutionary design configuration that is used for comparison with a evolutionary design is as shown in Fig. 21.

This revolutionary design consists of a three men crew configuration located in the frontal portion of the hull which has maximum protection. By doing so, the amount of passive, composite and reactive armour protection required for the crew on the turret is reduced. Also, by providing active protection system (APS) the protection levels can be further downgraded. This design also caters to a modular armour in the frontal hull which can be upgraded or downgraded based on mission. Thus by combining crew configuration, APS and modular armour, a substantial weight reduction is achievable.

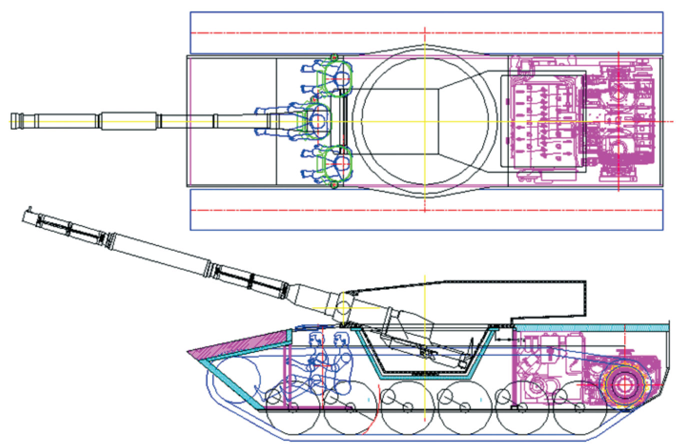

Figure 21. Revolutionary design configuration.

The pit mounted revolutionary configuration houses a conventional smooth bore gun with a bustle autoloader that provides the required lethality. Such a configuration also enables crew isolation from the ammunition along with space for housing other systems such as ISTAR. In such a configuration, the under armour fuel capacity can also be augmented thus increasing cruising range.

The input and output data for evaluating tactical mobility and trafficability are as shown in Tables 4 and 5, respectively. From this, it is observed that the revolutionary design with least NGP and MMP coupled with higher power to weight ratio is capable of achieving superior terrain accessibility and agility.

Comparing the trafficability parameters it is observed that the VCI, MI, VCI_{TMK} and VLCI are lesser whereas mobility numeric and NRMM are higher implying that the revolutionary design has low soft soil sinkage and higher trafficability across a range of terrains namely hard, clay, soft sand, marsh etc. On the transportability front, both the configurations have road, rail (ODC Class A) and air transportability (C-17).

Table 4. Inputs for tactical mobility and Trafficability

Parameter	Evolutionary	Revolutionary
Mass in kg	54380	41000
Engine power kW	735.8	864.5
No of wheels	6	6
Track width in m	0.580	0.630
Wheel dia in m	0.660	0.810
Track pitch in m	0.164	0.184
Length of track on ground in m	4.212	4.5
Ground clearance in m	0.404	0.500
Contact pressure factor	15.83	10.28
Weight factor	1.8	1.8
Transmission factor	1.05	1
Grouser factor	1	1
Wheel load factor	13.55	8.38
Clearance factor	1.59	1.97
Engine factor	1	1
Track factor	0.228	0.283
RCI in kN/m^2	689.476	689.476

Finally, the revolutionary design also has the flexibility for turret interchangeability based on mission i.e. for high-altitude warfare the heavy turret be replaced with a light turret (i.e. 105 instead of 120 mm) thus enabling higher mobility. This type of configuration ensures that different platforms such as self propelled (SP) howitzer, heavy infantry combat vehicle (ICV), bridge layer tank (BLT) etc, can be easily adopted with ease and flexibility thus serving as a perfect universal combat weapon platform as shown in Fig. 22.

Table 5. Tactical mobility and trafficability comparison

Parameter	Evolutionary	Revolutionary
NGP in kN/m^2	109.18	70.94
MMP in kN/m^2	293.54	173.64
Trench Width m	2.027	2.16
P/W ratio kW/kg	13.53	21.86
VCI (one pass) in kN/m^2	244.45	156.92
MI	143.59	81.06
VCI_{TMK} in kN/m^2	226.547	186.06
VLCI in kN/m^2	379.75	224.63
Mobility numeric π_{ct}	186.47	272.14
D/W	0.60	0.62

4. CONCLUSIONS

The dilemma that exists in the mind of designers and users that whether it is better to choose an evolutionary or revolutionary design configuration for a generation next MBT is addressed in detail. The different parameters to be considered for comparison are also elaborated along with their significance. On comparing both the configurations, it is observed that although similarities exist with respect to armament system, ammunition autoloader and transportability, they differ vastly with respect to survivability, cruising range, ISTAR, tactical mobility, trafficability and ease of adaptability.

The revolutionary design as compared to the evolutionary design conforms to integrated survivability but with minimum armour. This pit mounted configuration not only provides higher cruising range but also enough space for packaging ISTAR systems. In addition, the revolutionary design caters to

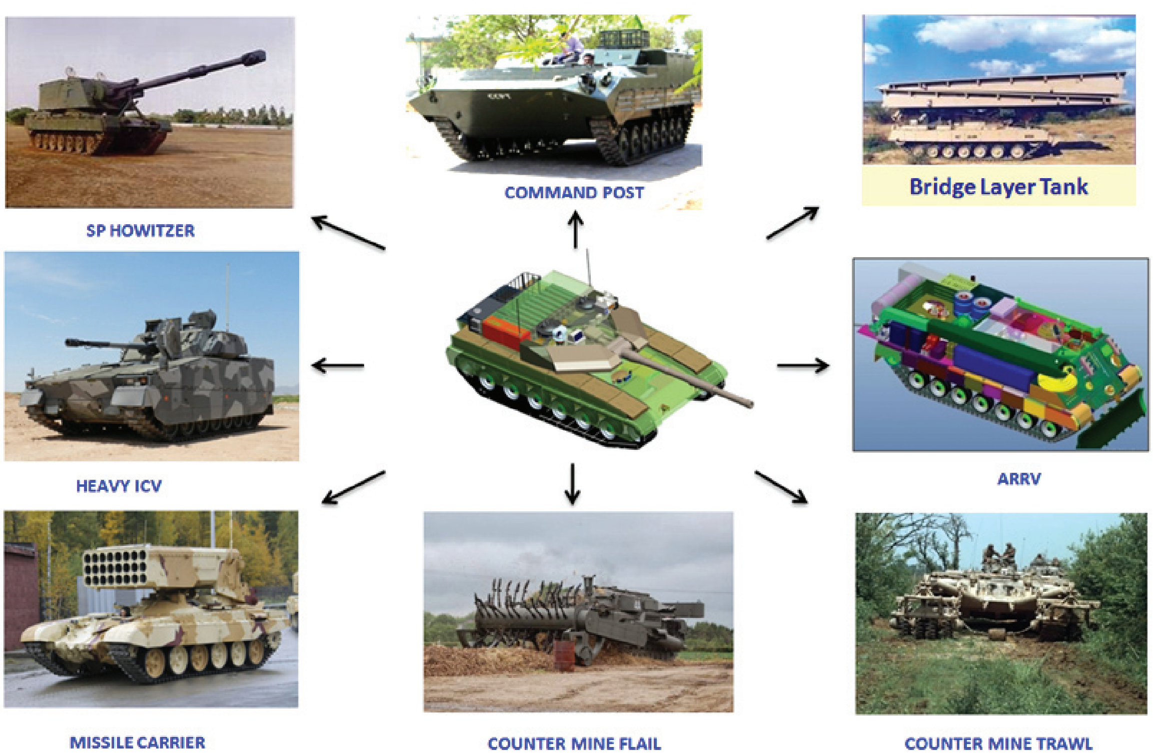

Figure 22. Universal combat weapon platform concept.

superior terrain accessibility, agility and soft soil trafficability that translates it into a weapon platform capable of superior mobility in a variety of terrains. Finally, this configuration is capable of adapting itself with ease into a universal combat weapon platform for executing multi-mission requirements of the users.

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His contribution in this study include revolutionary MBT configuration, universal combat weapon platform and overall guidance.