

CONCEPT DESIGN OF SPECIAL VEHICLE FOR INDIAN MILITARY

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Abstract

Light specialist combat vehicles are required for the Military for a quick response to the attacks with effective 1) Maneuverability, 2) Survivability and 3) Combat. While focusing on to Indian defence scenario, the battle zones are moved from conventional to unconventional like terrorist attacks, border incursion and jungle warfare which highlights the requirement of an agile compact transportation medium for reconnaissance activities along with the border patrolling and counter attacks. The combat vehicle must be able to meet military requirements such as engine power efficiency, better internal space, more lethal force, armour protection, more ammunition storage, latest communication facilities, multipurpose utilities and remote weapon stations.

The requirement of a vehicle for Indian defence forces in future is studied from the analysis of various defence agencies. The opportunity gap is analysed with the existing defence vehicles in India along with the International defence vehicle market. The product design specification is generated with the help of QFD matrix and customer voice isolated from the military personnel's across various army wings. The requirements of the transportation from army location to combat zone has been analysed thoroughly along with the ergonomics data to reach overall packaging dimension of the vehicle. The concepts has been generated based on the PDS and customer voice like integrating sharable platform for various weapon stations, addition of communication facilities to line up with the battle command control and multi-purpose activities like border patrol, recce operations and quick attacks. Selected concept is justified with the exterior and internal defence vehicle features and a mock up model visualization.

It is observed that the design features of the vehicle can meet the requirements of Indian Army and protect the interest of the country against the future threats.

Keywords: Indian Military, Special Purpose Vehicle, Concept Design, Mock up model

Nomenclature

Mm	Millimetre
L	Litre
Kg	Kilogram

Abbreviations

CRPF	Central Reserve Police Force
DRDO	Defence Research and Development Organisation
HVAC	Heat, Ventilation and Air Conditioning System
IDF	Israeli Defence Force
IED	Improvised Explosive Device
JLTV	Joint Light Tactical Vehicle
L-ATV	Light Combat Tactical All-Terrain Vehicle
LOS	Line of Sight
MRAP	Mine Resistant Ambush Protection
NATO	The North Atlantic Treaty Organisation
NSG	National Security Guard
PDS	Product Design Specification
QFD	Quality Function Deployment
RPG	Rocket Propelled Grenade
RCWS	Remote Controlled Weapon Station
SUV	Sport Utility Vehicle

travel on a proper balance between protection and manoeuvrability during this age of economic imbalance.

We can assume that the ability to operate on difficult terrain in extreme climates should be one of the factors taken into account when designing and procuring armoured vehicles. Officers in the field have other options to consider, when it comes to terrain because routes and strategies can be altered to accommodate the easiest, safest and most effective path. But they cannot mitigate the effect of an IED blast or cannot prevent an RPG strike on the vehicle wall. Suggestion from Brigadier General C.P. Mohanty, North Kivu Brigade Commander, United Nation Peacekeeping force from India is a key solution to the issues addressed above. According to him, protection can be offset by mobility. To achieve a better protection, light armoured vehicles with high power-to-weight ratios and high mobility is the most highlighted solution available [1]. Considering this, the requirements for the armoured vehicles to protect against directed energy attacks is not a final solution. But IED, terrain conditions, RPG are still problem for the defence vehicle design. So the design needs to be developed on focusing the armour protection with better mobility and lethality.

1. INTRODUCTION

Requirements for the light armoured vehicle over the next decade will concentrated on terms like modular, mobile and adaptable. The demand for light armoured vehicles will outrun all other variants, and it shows the fact that the supply chain and end-user must

2. BACKGROUND THEORY

The biggest step in the defence market is to analyse the new market especially on the developing countries. India started spending a great deal on defence and security over the next decade as it seeks to establish a

world class and robust national security infrastructure. Various factors like terrorism, border incursions and guerrilla wars from separatist groups are some of the key factors that make India highlighted by most of the defence analysts in the defence survey as the country with the greatest potential for growth [1].

The support and reconnaissance vehicles are no longer to be just backup vehicles – but they will enter the mainstream of the Army and will need to be up-armoured as a result of their increased multi-role capacity. Fig.1 highlights the demand for light armoured vehicles in the future: Modular, mobile and adaptable according to the defence analytical organizations. Figure 1 shows the statistics of preferred armoured vehicle among defense organizations globally [1].

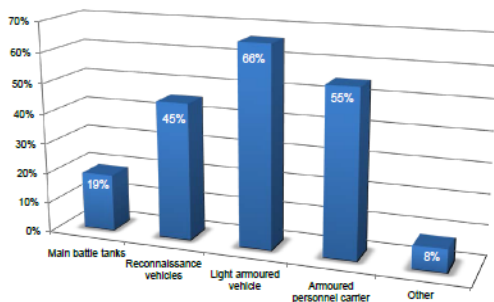


Fig. 1 Demand of various armoured vehicles by 2022 [1]

According to the Military, the future army operations will range from peacekeeping to irregular warfare and the major combat operations against a well-equipped armoured force. The different types of combat put different demands on combat vehicles, particularly the types of weapons that may be fired at the vehicle and the direction from which they strike the vehicle. The emphasis of peacekeeping is on safe guarding the local population with minimal collateral damage, including damage to road infrastructure from the movement of heavy vehicles, in particular, vehicles with tracks. Because threat possess is minimal in peacekeeping missions, trucks and light vehicles are often sufficient, but a good combat vehicle may be more useful [2].

3. LITERATURE SURVEY

A literature survey is conducted to understand the about the Indian Defence Scenario and the threat to current and future forces. Also study includes the armour protection required and consideration for future light armoured vehicles.

3.1 Summary of Literature Review

The design requirement for a military combat vehicle for Indian environmental includes manoeuvrability and survivability, Off-road efficiency, Stealth design, Compact size without compromising the interior features like munitions storage, protection, comfort, communication equipment, etc. and more lethal force. Additional to all these feature the vehicle must follow with European norms B7 which is a defence criterion in present auto market for Indian Military.

4. DATA COLLECTION, ANALYSIS AND PDS

Product study and market study have been conducted for data collection. Different kinds of existing Indian defence vehicles, International vehicles and defence personals from various wings of Army were considered for data collection. Data collected through these primary research methods has been analyzed and utilized for deriving QFD and PDS.

4.1 Customer Identification

The customers identified are Indian Army, CRPF, NSG, Marcos, Border Security Forces and various commando units shown in Figure 2.



Fig. 2 Indian Armed Forces [3]

Some of the basic requirements of Armed forces are:

- Better engine power
- More ammunition
- Compact size with enough interior space
- Modern communication facilities
- Camouflage
- Easy transportation
- Hull Shaping for IED protection
- Integrated weapon station facility
- 4-8 crew capacity

4.2 Indian Light Armoured Defence Vehicles

Some of the generally used light specialist defence vehicles along with the specification shown in Figure 3 used in various army wings.

Maruthi Gypsy is a four-wheel-drive vehicle based on the long wheelbase of Suzuki Jimny SJ40/410 series. The vehicle is capable of carrying 6 passengers. Mahindra XDB 550 is a 4x4 drive jeep using in Indian military. XDB jeep is the replacement for Nissan based Jonga of Indian Army. Good riding on mountain and desert terrains with a good seating capacity of 6 crews made XDB 550 jeep as a standard vehicle for many army divisions.

Mahindra bolero striker is a multi-utility vehicle which is using in Indian army and is made on Bolero invader platform which can be equipped with weapon station and rocket launchers. Mahindra Rakshak is a cost effective solution for security forces deployed in counter-insurgency and anti-militancy operations. An optional light machine gun comes with a protection shield in the front, providing a firing range of 120 degrees. Rakshak is joint solution made by Mahindra and Plasan Industries, Israel.



Fig. 3 Indian Light Armoured Defence Vehicles [4, 5]

Tata LSV or light specialist vehicle is an all-wheel drive (4X4), multi-purpose, all-terrain vehicle developed by Tata in collaboration with DRDO. Tata LSV – QDMCT (Quick Deployment Mobile Communication Terminal) is a shelter based, self-contained vehicle mounted communication system. Sherpa is the recently received bullet-proof vehicle for NSG which is capable of undertaking specialized operation against terrorists and hijackers. The Sherpa Light family of 4x4 tactical and light armoured vehicles is designed to provide light forces by supporting with the best mobility and payload compromise of its category.

4.3 International Light Armoured Vehicles

Some of the International light armoured vehicles are considered for the bench marking are shown in the Figure 4. Gaz 2975 Tiger is a Russian high-mobility multipurpose military vehicle, manufactured by Military Industrial Company LLC (GAZ Group division) [6]. Independent torsion suspension, telescopic shock absorbers and regulated-pressure tires ensure exceptional off-road ability, top speed of 90 km/h over rough terrain and up to 150 km/h on the normal road. The High Mobility Multipurpose Wheeled Vehicle (HMMWV), generally known as Humvee, is a four-wheel drive military automobile produced by AM General primarily used by US armed forces. The HMMWV was designed primarily for personnel and light cargo transport behind front lines [7].

Plasan Sand Cat a composite armored vehicle designed by Plasan Industries of Israel. The armored body of the vehicle utilizes a combination of armoured steel, ceramics, and composites to provide a field replaceable modular armor package at various threat levels. The interior can accommodate an open stretcher also [8]. LATV is a defence vehicle is made as a part of JLTV program to replace Humvee. This vehicle is equipped with an advanced crew protection system that provides MRAP (Mine resistant ambush protection) level protection with the ability to scale and evolve as operating environments change [9].

4.4 Data Study

Understanding the needs of the customer is necessary before designing any product. Customer needs are identified by data study from user experiences. Comparing to the olden days of strategies of product selection by providers is changed in to the

customers. The market differentiation is a requirement for designing a better product and to stay in the competition.



Fig. 4 Foreign Defence Vehicles [6-9]

For this research paper, a brief customer interaction has been performed with the army personnel to understand their opinions about the vehicles. According to the Indian army personnel, the main issues facing from the current vehicles are less armour protection, less comfort, lack of remote weapon and no proper protection guard around the gunner. The requirements from reconnaissance are more focused on the lack of communication system required on small armoured vehicles and the compactness of the vehicle. Also other concerns raised are mobility of the vehicle, less comfort and lack air conditioning facility.

4.5 Customer Voice and Corresponding Technical Voice

The customer voice is then correlated with the technical voice to convey the designers about the requirements by addressing similar requirements under a common category which will be taken care while in the process.

4.6 QFD Matrix

QFD matrix chart (Figure 5) is generated as shown in Table 1 to relate the user requirement with the different technical requirements. It also helps in relating between the customer voice and technical voice.

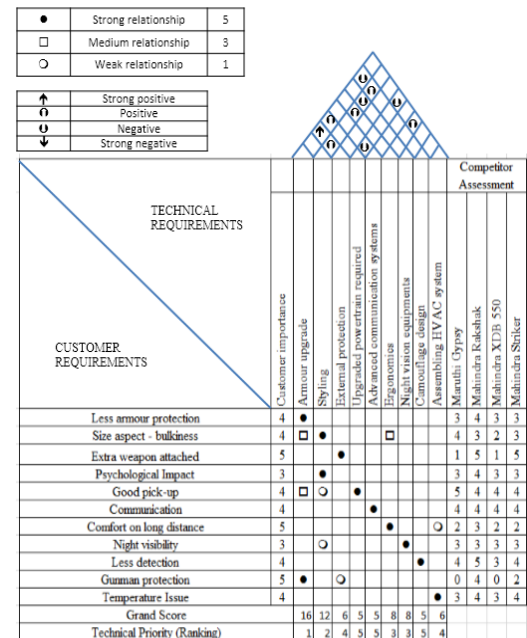


Figure 5. QFD Matrix Chart

Table 1. Customer Voice vs Technical Voice

Customer voice	Technical voice
Less armour protection	Armour upgrade
Size aspect - bulkiness	Styling
Extra weapon attached	External protection
Psychological Impact	Styling
Good pick-up	Upgraded powertrain required
Communication	Advanced communication systems
Comfort on long distance	Rigid design with comforts
Night visibility	Night vision equipment
Less detection	Camouflage design
Gunman protection	Armour upgrade
Temperature Issue	Assembling HVAC system

4.7 Product Design Specification (PDS)

The Product design specification as shown in Table 2 and 3 is generated after considering the QFD matrix and the research done. The PDS defines the specification and amenities to be considered while generating the concepts.

Table 2. PDS – Technical Specification

Length	5123 mm	
Height	2250 mm	
Width	2160 mm	
Overall height (includes gunner protection kit)	2800 mm	
Ground clearance	340 mm	
Wheel base	3100 mm	
Number of seats	4	
Wheel drive	4 x 4	
Engine	6.7 L Power Stroke V8	
Chassis	Ford F550 Super Duty	
Tires	285/70 R 19.5	
Colour	Military Green, Sand	
Transportation	Freight Train	
	Lockheed Hercules C130	
	Boeing C-17 Globemaster III	
	Ilyushin Il-76	
	CH-47F Chinook Helicopter	
	Mil-Mi-26	
Protection	IED Fragments	Optional up to STANAG 4
	Kinetics Energy	Optional up to STANAG 3(+)
	Mine Blast Protection	Optional up to STANAG 2a

4.8 Summary on Data Collection, Analysis and PDS

Through the data Collection, QFD and PDS it is concluded to design a vehicle achieving the purpose of

better protection, firing power with compact size without reducing the interior space.

Table 3. PDS – Optional Facilities

Communication facility
Gunner Protection Kit
Remote Controlled Weapon Station (RCWS)
Cargo/Storage Area (Non Armored): Open cargo bed
Fire Suppression Systems
Gun mounting hole on doors
Central Tire Inflation System (CTIS)
Run-Flat Tires
Trailer Hitch / Pintle
Rear View Camera
External Intercom System
ABS and Air Bag System
Air Conditioning System/Heater
Night vision equipment
Weapon mounting provision
Foldable stretcher for injured person
First Aid
Fog lamps

5. CONCEPT GENERATION AND SELECTION

The following Concepts were generated as per the PDS.

5.1 Concept – 1

The design was mainly focused on its aesthetic look along with the functionality. Also the design includes the packaging of the passengers in the vehicles. The concept shown in Figure 6 was generated more from a Jeep platform where the driver with co-passenger can share the front side and six passengers on rear side. Also a gun mounting is provided on top side for the combat situation. It can be operated from the back cab. The advantage of the vehicle is it can be used as an armoured personnel carrier. Also it can be used to carry two injured persons at a time. The main drawbacks of this design are the vehicle is more exposed through its big frontal windows and the rear single door delays the troop movement.



Fig. 6 Concept – 1 of Light Armoured Vehicle

5.2 Concept – 2

The concept shown in Figure 7 generated based on an SUV platform with higher ground clearance and detachable roof top for machine gun mounting. Addition to the four passengers, the vehicle can accommodate an injured passenger on its rear side. Also the vehicle can accommodate a remote weapon station and can be operated from the rear passenger seat. Concept is more focused on suiting the vehicle for multipurpose like reconnaissance, patrol tasks and combat situations.



Fig. 7 Concept – 2 of Light Armoured Vehicle

5.2 Concept – 3

The design of concept shown in Figure 8 is more focused on its aesthetic beauty as well concentrating on its military purpose. The vehicle can accommodate five passengers with two on front and two on middle compartment. And a third person can be accommodated in the rear cab. The area also can be used as ammunition storage or a cargo area. The vehicle is suitable for both manual weapon usages as well for a remote weapon station on the roof. One of the disadvantages is the vehicle not providing any exit for the rear cab passenger. The passenger should have to come out of vehicle by adjusting the middle cab seats. Also the vehicle lacks an aggressive look to promote a psychological impact over the enemy and the vehicle lacks a medical bay for injured persons.

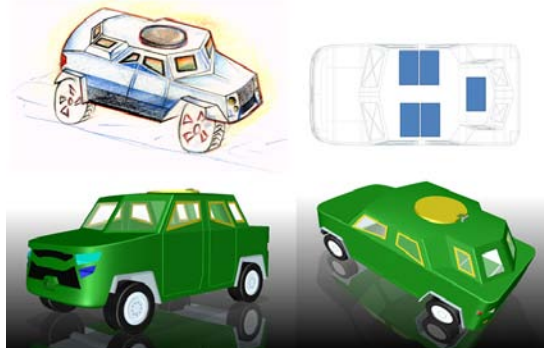


Fig. 8 Concept – 3 of Light Armoured Vehicle

5.2 Final Concept Selection

The concept was selected by using Ranking Method. By this each concept where given a particular rating for its Technical Requirement as shown in the Table 4. By this method Concept - 2 scored the highest and is selected as final concept.

Table 4. Concept Selection

Concept Rating	Concept 1	Concept 2	Concept 3
Packaging	8	8	6
Aesthetics	6	8	8
Ergonomics	7	8	8
Layout	7	9	7
Accessories	7	7	7
Shared Platform	6	8	7
Psychological Impact	8	7	6
Safety Aspects	7	8	7
Ground Clearance	9	9	8
Total	65	72	64

6. ANALYSIS, RENDERING AND MOCK-UP OF FINAL MODEL

6.1 Exterior Design Features

Based on the shared platform requirements, there are two variants have been designed for the selected light armoured vehicle - armoured vehicle with remote weapon station and manual gun mounted system as shown in Figure 9. In remote weapon station interior has to be modified in such a way that, it can accommodate extra computer and weapon control electronics system. Where in manual weapon system, the weapon is mounted on the roof of the vehicle which is caged in a transparent cell protected with glass windows for proper visibility and the remaining areas will be protected by armour shields. For this design, the vehicle roof needs to be penetrated. The gun man will be standing on the mid-console and controls the weapon system which is a turret mounted one and can be rotated 360°. Both the gun station can support MK19 Grenade Machine Gun, .50 Caliber M2 Machine Gun, M240B Machine Gun and M249 Squad Automatic Weapon. The remote weapon station design includes a laser dazzler to temporarily blind the enemy before opening the fire, additional cameras to analyze the enemies from all directions, and a laser point to mark objects with a visibility while attaching night vision equipment [10].



Fig. 9 Exterior Design Features

Besides the two configurations of weapon system, the vehicle is equipped with:

- 1) Deflector plate on bottom to give better protection from explosives.

- 2) Small side windows to offer maximum armour protection without compromising visibility.
- 3) Two piece front window design.
- 4) Detached rear view mirrors offset to the bonnet centre location for better visibility on both sides.
- 5) Gun mounting holes on the door below the side windows, so that the soldier can use them in case of emergencies with the protection of door armour.
- 6) Single door entry on back side for placing injured personnel.

6.2 Interior Design Features

The interior of the vehicle was designed to suit for the multipurpose requirements like combat activities, reconnaissance, border patrolling and also to work as a mobile command centre in case of emergencies. For this purpose the dashboard was incorporated with automobile gauges and external computer for connecting to the army mission centre. Also the centre console was extended from main dashboard to the end of B pillar seats which incorporated with GPS and provisions for mounting radio and other related accessories. HVAC systems are added to the dashboard-console system to provide better temperature while working on extreme environments.

The seats are ergonomically designed with push back facility and are adjustable for forward and backward movements incase seating posture adjusting. A remote weapon control station integrated with a computer and keyboard mounted behind the navigator seat and is controlled by the joystick assembled to the seat. The joystick integrated seat is provided with the hand rest for the better support of the arm.

The rear portion of the vehicle is customized with a raised platform holding a stretcher for an injured person with a medical kit for first aid. Next to the stretcher, mounting clips are provided to hold a Sniper rifle on the uplifted platform. The raised platform is integrated with an ammunition storage space in order to hold more weapons and ammo for long operations. All the 4 side doors are integrated with gun holding clips to position solidier guns while the vehicle in on movement. Detailed interior design features were shown in Figure 10.

6.3 Final Design Rendering

The Final Model was rendered as show in the Figure 11 to get a better perception.

6.4 Mock-up Model Development

The mock-up model of the final concept is made in 1:10 scale. Sun board was used for the creation of the mockup model. The board is bended and break as required and filled with the metal paste to cover the deformation areas as well as to gain the overall shape and strength. Model is made by splitting into three halves – The front half which is up to B-pillar, the rear portion covers the rest half and the gun man protection covers. Later the model parts are joined with glue and used multiple layers of surfacer and metal putty over the model. Over the finished surface, spray painting done. To get the styling features, stickers are used over the painted surface. Finally, lacquering done to get the

polished surface and desired texture surface quality. Figure 12 shows the operations involved in making the model.



Fig. 10 Interior Design Features

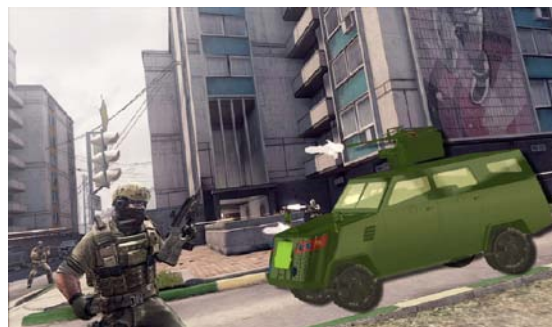


Fig. 11 Rendered Final Concept in Life Style



Fig. 12 Mock-Up Model

7. CONCLUSIONS

Design tools and methods are used effectively to achieve the requirements of the customers. Packaging

study and ergonomics analysis performed and also created a suitable interior space. For the visualization process, a mockup model has been created.

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