Designing an Electric Rickshaw

Product Design Project II

Submitted by:

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Guide:

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Submitted in partial fulfillment of the requirements of the degree of Master Of Design In Industrial Design

Industrial Design Centre

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Approval Sheet

Industrial Design Project II titled

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Project Guide :

Chairperson :

Internal Examiner :

External Examiner :

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1. Abstract

Auto rickshaw is one of the most commonly used mode of mass transportation. Due to its extensive usage there are few issues/ problems which is regularly faced by the passengers and drivers

The design approach adopted consisted of understanding the technologies, user requirements and identifying the specific problem areas and then coming up with insights for solving the above problems. Ergonomic study for improved comfort level, study of alternative fuels and technologies, travel requirements, drivers and passenger requirements were undertaken before developing the concepts.

No. Of concepts in the form of sketches and rough models were developed integrating the above mentioned factors and then the choice was made by comparing various features and giving appropriate rating to each feature.

The project work led to a product featuring increased leg room and head room due to the repositioning of various components and re-layout of the luggage space from back of the passenger seat to the front of it. This also led to increased space for ingress and egress. The rickshaw is powered by an electric motor and runs on batteries leading to negligible pollution and also reduced running costs. The styling of the rickshaw is unique with introduction of a new form. The interiors are improved with inclusion of dashboard and comfortable seating for both driver and passengers giving it a rich feel.

2. Project Aim

To design an auto rickshaw with contemporary styling and efficient power train

3. Scope of Project

The project deals with traversing through all aspects of designing resulting in a better product addressing most of the identified problem areas

4. Reason for Project

The reason for taking up of the project basically was to come up with a product to cope up with the rising fuel price and depleting fuel levels globally and also to keep in check with the increasing steel and other metal prices resulting in usage of alternative material in efficient manner

4. Introduction

An auto rickshaw is a three wheeled vehicle generally having a carrying capacity of three or sometimes six passengers. It is one of the basic forms of mode of transportation for passengers and also goods.

An auto rickshaw is a basically a motor powered rickshaw. Initially started as human powered carriage, where a runner pulls the two wheeled carriage.

The existence of hand pulled rickshaw goes back to 1707 as shown in the comic representation in the painting 'Les Deux Carrosses' by Claude Gilot. The earliest, most popular, usage though dates back to 1868 in Japan. In fact the term 'Rickshaw' derives from a Japanese word 'Jin-Riki-Sha' which means 'human-strength-vehicle'

The later version to come was the cycle coupled rickshaw or 'cycle rickshaw' which was more efficient and could travel at higher speeds than the earlier hand pulled ones.

. . .

Later on came the motor powered rickshaw popularly called ‘Auto Rickshaw’ or ‘tuk tuk’ as in the East Asian regions. These are rickshaws based on a scooter or a bike.

The first auto rickshaw was introduced in 1957 in India under B Achchraj Trading Corp which was based on the German three wheeler called ‘Hanseat’. This was basically a three wheeled rickshaw with the engine mounted on the front wheel steering system and was front wheel driven.

The current auto rickshaws are powered by small displacement engines with high torque output for maneuvering through the different road conditions at varying loads.

These run on petrol or diesel, and nowadays, also on CNG or LPG. The major concern, due to the usage of fossil fuels and the high volume usage in the developing nations, is the increase in air pollution and also higher running costs.

4.1.1Usage

Auto rickshaws are basically used in most of the developing nations where traffic is a major problem or in case where the roads are too narrow. These thus become one of the major mode of transportation.

These are generally used for passenger travelling on daily basis or also as a leisure travel as shown in the images. Also these are used for carrying the goods in small quantities.

Compared to most of the public transport system, for short distance travelling, these are the most efficient form of travelling. there are also chartered services provided at several cities and suburbs other than to carrying several children to schools.

4.2 Problem Definition

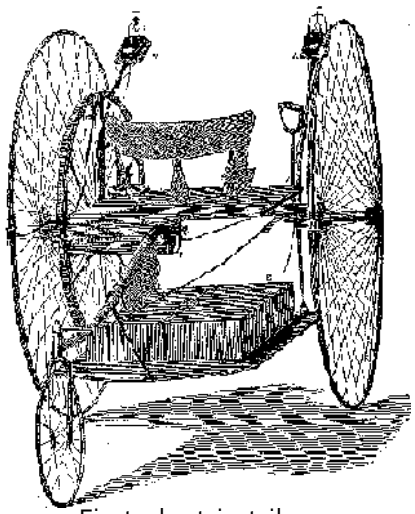
- The current rickshaws use fossil fuels which lead to air pollution and higher running costs. Also the availability of fossil fuel is a big concern due to its limited resource.

- The current rickshaws use steel and other metal parts due to which the design is not very rigid and also high on weight compared to NEV's.

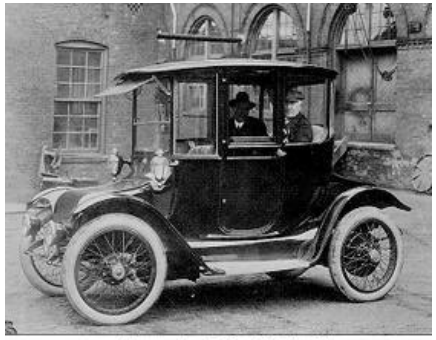
- The cabin space is also cramped if we consider higher percentile men leading to uncomfortable seating and driving positions.

- The power source of the current auto rickshaws are also not efficient from the point of view of noise and running costs

4.3 Electric Vehicles



First electric trike



An early Detroit Electric

History

The works on electric vehicles were started way back even before the introduction of the first commercial four wheeler the 'Ford Model T'. The initial works had started in 1835 by Thomas Davenport with introduction of small railway operated by miniature electric motor.

Later in 1838, Scotsman Robert Davidson built an electric locomotive attaining speeds of four miles per hour. But these used to run on normal non rechargeable batteries which seriously limited the total distance of travelling.

In 1859, Gaston Plante invented rechargeable lead-acid batteries which provided few more advantage to viability of the product. In 1888, F.M. Kimballs and P.W. Pratt from U.S. developed an electric car.

Anderson Electric Car Company started the production of the electric automobile 'Detroit Electric', powered by a rechargeable lead acid battery, began in 1907

GM ETV 1

GEM EV 4

Maini Reva

1960's saw growing interests in EV's for the growing concern on pollution. Several limited scale cars were introduced in the market. Later in 1970's the major concern got shifted towards the global energy crisis. This was the time when the development of sodium sulphur batteries took place and was the initiation of ETV-1 by the Chrysler in collaboration with GE.

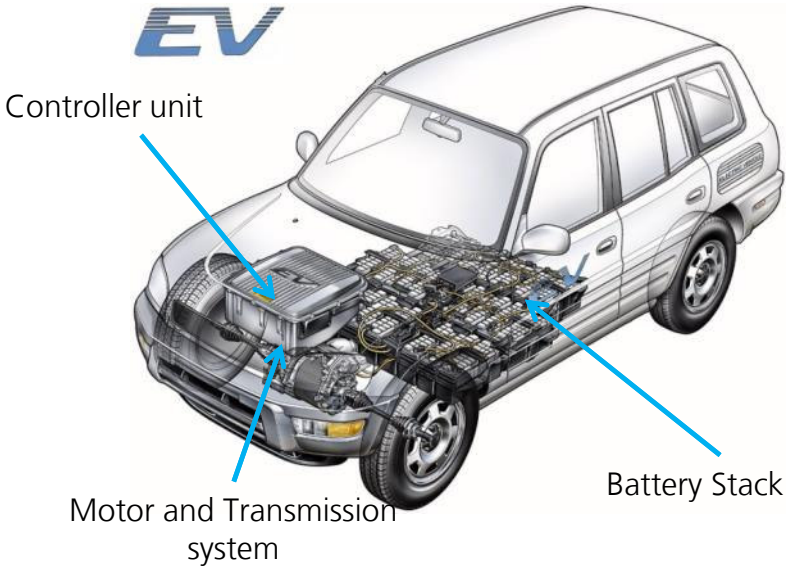
But in 1980's the EV demand slowed down due to plentiful oil supplies. But, later on, with the introduction of ZEV(Zero Emission Vehicle) Mandate by California and other major state in 1990's there was again an increase in demand. There were also introduction of several EV's but were available to the public only on lease.

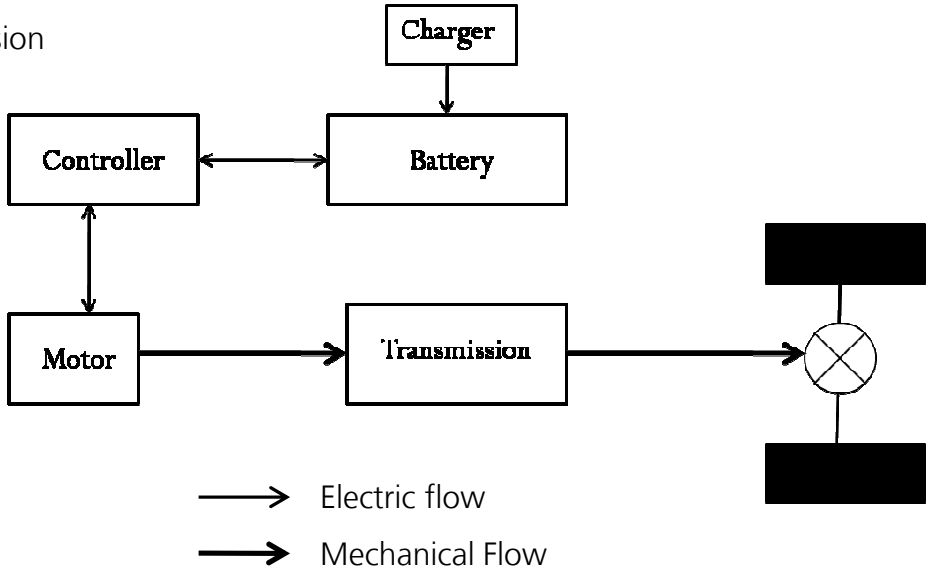
At the same time there were few small time companies like Maini, the Maini REVA and GEM with their EV4 which were introduced as small volume production vehicles, but later on commercialized the production of vehicles for the international markets

4.3.1 Components and Working

An EV generally consists of the following basic components
The basic components:

- Battery
- Motor
- Controller
- Charger
- Transmission





Battery:

Basically the main source of power for an EV. The energy stored in form of chemical energy is utilized for providing power. These are the rechargeable ones and can be of lead acid, Li-ion, Ni-Mh. etc

Motor:

The main element converting electric power to mechanical torque and providing motion to the vehicle

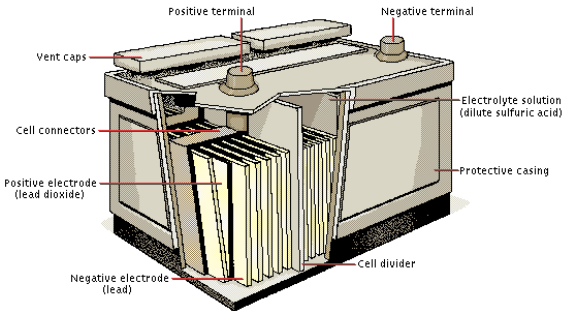
Controller:

The brain of the EV. The basic purpose of the controller, as the name suggests, is regulating flow of electricity from battery to motor

Charger:

The medium through which electric energy is stored in chemical form in the batteries

Motor and battery details



Types of batteries used in EV's

The batteries being the major power reserve in EVs are one of the most important components. These are of various types and basically provide the power through the chemical reaction, generally a reversible reaction, and they can be recharged. The various forms of batteries used in EVs are:

Lead Acid:

- The most commonly used rechargeable batteries for EVs.
- These are the cheapest form of medium for high capacity applications
- They have the ability to supply high surge currents
- These batteries have low energy-to-weight ratio
- These are very bulky

Lithium ion

- Best portable batteries due to high energy-to-weight ratio
- These batteries have compact dimensions and less weight which leads to its extensive usage in mobiles, laptops, etc and is venturing into EVs
- It can sustain high charge and discharge cycles
- Life cycle of the battery limited to 3- 4years irrespective of usage
- Should not be fully discharged

NiMH (nickel metal hydrate)

- Commonly used batteries in form of the rechargeable batteries
- Cheap and easily maintainable but have low energy-to-weight ratio

Types of motor

20kW hub mounted BLDC motor

The motors are the heart of the EVs and are the basic reason for enabling motion. There are a vast range of motors and a few most commonly used motors are as below:

Brushless DC motor:

- Higher efficiency, reliability, reduced noise, etc
- Requires no airflow due to natural conduction
- Casing of motor can be completely enclosed resulting in protection from dirt and other foreign matter

Hub mounted BLDC motor:

- Directly fitted onto the wheel of vehicle resulting in space saving
- Compact dimensions and clean feel to the vehicle

Inverted SR Motor:

- The inverted Switched Reluctance motors are very rugged
- It does not have magnets which makes it more reliable and also lighter in weight compared to others
- It provides high torques with excellent dynamic capability at very low end of the speed and also is with high speeds
- For a given input voltage range, the domain of speed, torque and efficiency of an SR drive system is the largest

4.3.2 Usage

The EVs, initially introduced in the mid 90's and early 00's, were basically used as experimental vehicles which were never sold to customers but leased out for a limited period. This made it very premium product and hence its usage was limited to very small packs of community.

But electric locomotives and trams were in existence right from the early twentieth century which used to run on the power cable network set up along the route. They were used for mass transportation for long or short distance travel

An attempt to make personal electric vehicles got initiated in the initial phase of 21st century with the first experiment being the Maini Reva and other small companies which later transformed into a global seller

GEM also started off with NEV's around 1998 which were very light weight open vehicles powered by batteries and were used for household or neighborhood travelling with a limited range of travel

Other applications as fleet of bus for city travel, trucks for short distance frequent start stop applications were also successfully implemented. But due to the limited range further implementation had been limited.

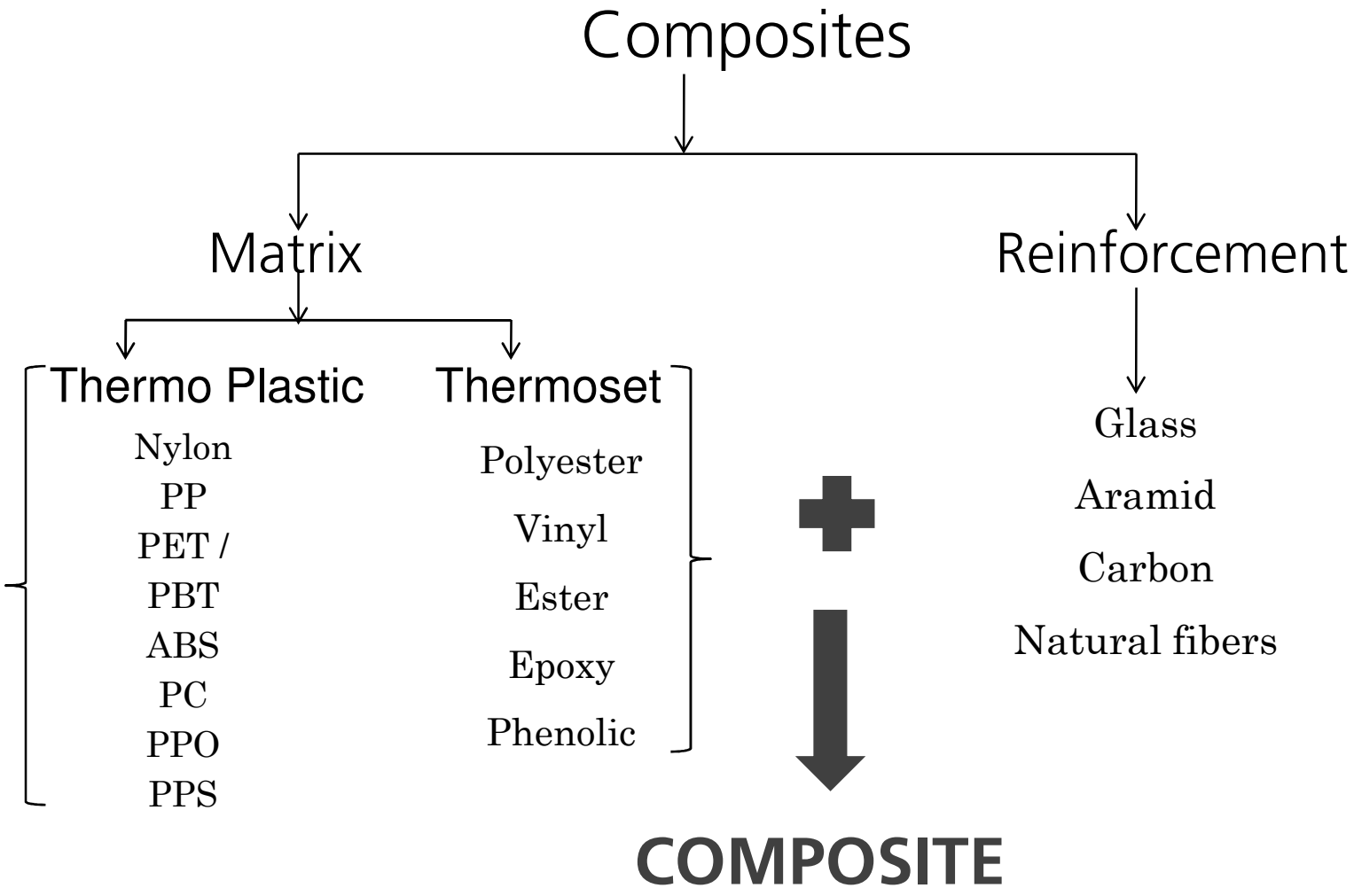
4.4 Materials

Inferences from the Internship project

The material to be used for the rickshaw is a composite material. For this my experience of the internship project came into play which was done under Mahindra Composites

Composites, as a material, are a special form of plastics where a combination of two or more materials such as fibre as a reinforcement, and matrix material as binder , resulting in a material with properties superior to that of the constituting materials. Generally heat and pressure are used to shape and cure the mixture to achieve a finished part. These materials require low amount of energy for manufacturing complicated shapes and thus resulting in reduction of overall processing cost

The matrix materials being used are general plastics, either thermoset as PE, vinyl ester, epoxy, etc or thermoplastics as PP, PET, ABS, PC, PPS, etc. which are mixed with resins as carbon, glass, aramid or natural fibres. Sometimes there is also addition of curing agents, also known as hardener, it acts as a catalyst and enhances in the curing process also hardening the final product. The generalized diagram is shown in the next page

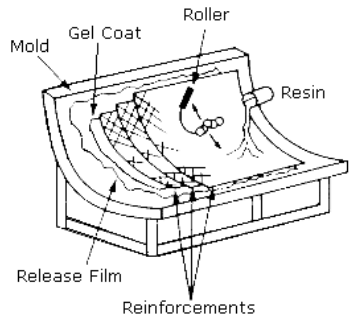

Composites
Matrix
Reinforcement
Thermo Plastic
Thermoset
Nylon
PP
PET /
PBT
ABS
PC
PPO
PPS
Polyester
Vinyl
Ester
Epoxy
Phenolic
Glass
Aramid
Carbon
Natural fibers
COMPOSITE

4.4.2. Types of processes

There are various composite manufacturing techniques depending upon the type of output and the type of quality required from the desired product. These manufacturing techniques are as follows:

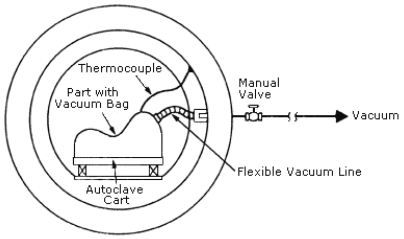
- Hand layup / spray up
- Vacuum bag / autoclave molding
- Compression molding
- Glass matt thermoplastic (GMT)
- Resin infusion molding (RIM)
- Resin transfer molding (RTM)
- Injection molding
- Filament winding
- Pultrusion
- Thermoforming

Few of the basic manufacturing techniques are explained as below.

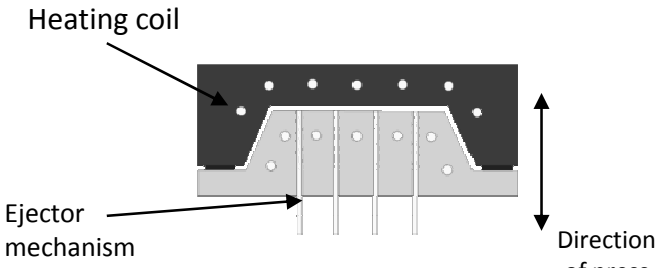


- Hand layup/ spray up: This is basically an open mould process where several layers of the resin and the binder. These layers are later pressurized using a roller for laying the layers properly over each other. Spray up method is similar to the hand layup process but the layering is done with the help of a spraying gun.

  This process results in single side finish products and the time required for getting the final product is high but requires less tooling cost. Due to the presence of direct exposure of the resin with humans these processes are not generally preferred. This process is preferred for small scale production or for general prototyping.

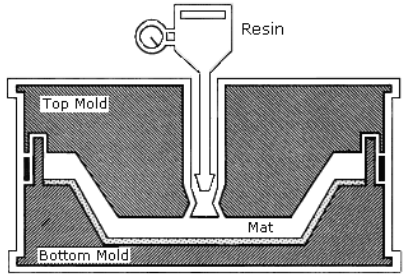


- Vacuum bag/ Autoclave molding: The process is carried in the presence of a vacuum. The layers are placed inside a plastic bag where the later vacuum is generated to shape the layers according to the mould. Later heat is applied for curing. The result of this process is high quality moldings without any air bubbles and good inner surface finish. Controlled curing conditions improve quality and consistency and also results into a more rapid cure with faster turn round of moulds

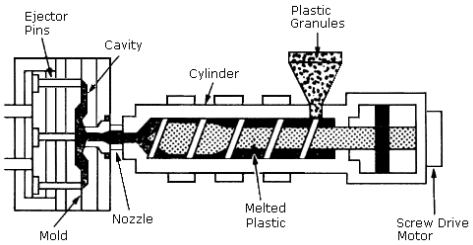


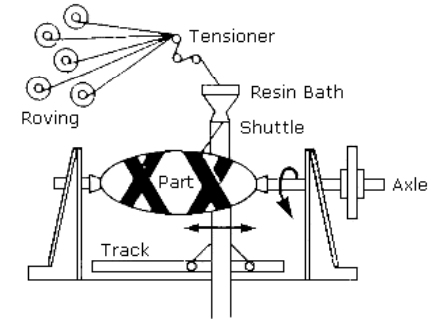
- Compression molding process: The process basically consists of applying pressure on to the raw materials. It requires metal mold due to the application of high pressure and thus the final product has both side good surface finish along with good strength.

  The raw material can be SMC or DMC which are placed over the mold and the press is closed later with the application of high pressure and temperature. The molds are heated to 140 to 160°C and pressures of 50 to 150 bars applied. Production rates of 200 parts per day possible with this process.



- Resin Transfer Molding(RTM): RTM process is preferred when parts with two smooth surfaces are required at low pressure. The basic reinforcement fibre is placed initially in the mold. The catalyzed resin mixture is pumped into the mold cavity which is later cured under heat and pressure basically to shorten the curing time. The process requires high energy consumption and high amount of ventilation. Also high quantity production is not possible in this process.





- Injection molding: The charge of the material is fed through the hopper into the cylinder. This charge is passed through a heated screw type barrel conveyer where the charge gets melted and later is passed into the mold through a nozzle.

  This process is best for large scale series production due to the possibility of automation of the process and high production rates. The temperature maintained for this process is around 160°C and the pressure maintained is around 150 to 200 bars.

- Filament winding: In this process continuous fibre reinforcement materials are drawn through a container of resin mixture and formed onto a rotating mandrel to achieve the desired shape. This is later cured in an oven. This process is generally preferred for producing high performance hollow symmetrical products.

4.4.3 Advantages of composites

The usage of composite materials and manufacturing techniques are advantages in various forms. These are explained as follows:

- Strength to weight ratio: Composites exhibit a higher strength to weight ratio than steel or aluminium and can be engineered to provide a wide range of tensile, flexural and impact strength properties. For example, a composite's strength per unit density is roughly two times that of aluminium and four times that of steel.

- Corrosion resistance: Composites are corrosion resistant to most chemicals, do not suffer from electrolysis and incorporate long-term benefits such as weather ability and UV stability.

- NVH compliance: The material provides internal damping to the vibrations moving along the fibres thus reducing the vibrations also has good noise transparency and also leads in reduction in harness.

- FST compliance: The material provides good fire resistant property with good compliance in smoke and toxicity thus satisfying the FST regulations.

- Surface finish: The product finally obtained can have high surface finish depending on the type and quality of the molds and working parameters making it possible to achieve near class-A surface finish with simple fabrications.

- Complex organic shapes: Due to the flexibility of the material and the method of manufacturing it, achieving complex organic shapes with good strength is easier.

- Components: Due to the flexibility in achieving organic shapes the no. of total components required for making the complex shapes reduces thus also reducing the time and cost of assembling

- Dent resistance: Due to the fibrous structure the material provides high amount of resistance to any force and preventing formation of dents.

4.5 Existing Products Data base

The existing product database basically consisted of collecting data and specification sheet for the products currently available in the Indian market.

The data collection was done by checking up the companies sales websites /. Main website. Few of them are also collected from the B2C type of websites.

Bajaj

Petrol	2 stroke,	145.45cc, 7bhp@5000 rpm, 12.1 Nm@3500rpm LWH 2625 1300 1710 GVW 277kg Fuel tank capacity 8L (main+reserve) Cost: Rs.90,039.00
	4 stroke,	173cc, 8.01bhp@5000rpm, 11.5Nm @ 4000 rpm LWH 2625 1300 1710 GVW 305kg Fuel tank capacity 8L (main+reserve) Cost: Rs.1,15,000
Diesel		416cc, 7.12 BHP @ 3000 rpm, 20 Nm @ 2200 rpm LWH 2625 1300 1710 GVW 350 Kg
LPG	4 stroke,	173cc, 6.94 BHP @ 5500 rpm ,10 Nm @ 3500 rpm LWH 2625 1300 1710 GVW 340 kg Fuel tank capacity 6.5L(LPG)+3L(petrol)
CNG	4 stroke,	173cc, 6.5 BHP @ 5000 rpm,9.33 Nm @ 3500 rpm LWH 2625 1300 1710 GVW 358 kg Fuel tank capacity 4L(CNG)+3L(petrol)

Lovson motors

Petrol 280	4 Stroke,	275 cc, 9 H.P. @4400 RPM, 19 NM @ 2800 RPM LWH 2800 1120 1885 GVW 435kg
Petrol 340	4 Stroke,	338 cc, 11 H.P. @4400 RPM, 23.7NM @ 2800 RPM LWH 2800 1120 1885 GVW 435kg
Diesel 360	4 stroke,	7.5 HP. @ 3600 RPM, 17Nm @ 2200 RPM LWH 2800 1120 1885 GVW 435kg
Petrol 280	4 Stroke,	275 cc, 9 H.P. @4400 RPM, 19 NM @ 2800 RPM LWH 2800 1270 1885 GVW 435kg
Petrol 340	4 Stroke,	338 cc, 11 H.P. @4400 RPM, 23.7NM @ 2800 RPM LWH 2800 1270 1885 GVW 435kg
Diesel 360	4 stroke,	7.5 HP. @ 3600 RPM, 17 Nm @ 2200 RPM LWH 2800 1270 1885 GVW 435kg

Goel tempo

Salani Petrol	4 Stroke, `	275 cc, 9 HP @ 4400 rpm, 16.0 Nm @ 2800 rpm LWH 3065 1395 1970 Kg
Salani Diesel	4 Stroke,	395 cc, 7.5 HP @ 3600 rpm, 16.7 Nm @ 2800 rpm LWH 3065 1395 1970
Salani CNG	4 Stroke,	275 cc, 9 HP @ 3600 rpm, 13 Nm @ 2800 rpm LWH 3065 1395 1970
Salani LPG	4 Stroke,	275 cc, 9 HP @ 3600 rpm, 13 Nm @ 2800 rpm LWH 3065 1395 1970

Atul motors

3+1 passenger	4 stroke (d),	395 cc, 8 hp @ 3600 r.p.m, 16.7 Nm @ 2000-2800 r.p.m
CNG Passenger	4 stroke,	275 cc, 7.7 hp @ 4400 r.p.m, 15 Nm @2800 r.p.m
LPG Passenger	4 stroke,	275 cc, 7.5 hp @ 4400 r.p.m, 14.7 ± 0.5 @ 2800 r.p.m
4+1 Passenger	4 stroke (d),	395 cc, 8 hp @ 3600 r.p.m, 16.7 Nm @ 2000-2800 r.p.m
6+1 Passenger	4 stroke (d),	395 cc, 8 hp @ 3600 r.p.m, 16.7 Nm @ 2000-2800 r.p.m

Force motors

Minidor Di	4 Stroke (d),	8.8bhp@3000rpm, 22Nm@2200rpm LWH 2764 1490 GVW 990kg
Minidor AR	4 Stroke (d),	499cc, 9.66bhp@3000rpm, 28Nm@2000rpm LWH 3325 1490 GVW 1350kg

Scooters India Ltd.

Vikram 450D	395 cc,	5.51KW@ 3600rpm 16.7Nm @ 2200-2800 rpm GVW 365 kg
Vikram 410G (CNG)		2Stroke 198 cc 9.8 BHP **@** 4800 rpm GVW 425kg

4.6 User Study

The user study was conducted to identify the various problems faced by the drivers and daily commuters while also identifying the reason for using it or not using it. The user study was also conducted to collect the essential parameters i.e., the mileage, running costs, etc. These data collected would lead into as essential inputs for designing the rickshaw.

4.6.1 Approach

The process considered for the user study was interviewing and observational analysis. A separate questionnaire was prepared for interviewing both drivers and passengers (both frequent and occasional users) also considering the issues from the pedestrian point of view.

In all 15 rickshaw drivers and 20 passengers were interviewed and the result was analyzed for the further implications in the project work.

4.6.2.Conclusion

The following are the essential parameters concluded by interviewing 15 rickshaw drivers. These are basically the inputs that are essential in finalizing or freezing up for the current project

Essential Parameters:

- Range of traverse generally covered:
- Maximum distance covered in one trip: 35km
- Average distance covered in a single trip: 1.5km
- Overall distance in one day: 75km (avg)

  100 km (Max)

- Running cost:
  - Average running cost for Bajaj RE petrol:
    - Average cost for the fuel consumed: Rs. 175/day
    - Average cost for maintenance: Rs 1500/month
  - Average running cost for Bajaj RE 4S CNG:
    - Average cost of fuel consumed: Rs 90/day
    - Average cost for maintenance: Rs 1500/month

4.6.3 Problems

The following are the most common problems unearthed after analyzing the user study. The problems are arranged according to the frequency of repetition

- Clutch and other small parts get wear off easily and generally result in high Engine failure or problem, a common problem faced almost two to three times a year causing high repair or replacing costs (5)
- No boot space while carrying lots of baggage (5)
- Noisy compartment, irritating engine vibrations (4)
- Rexin gets torn off or starts sagging after a period of time (4)
- Low roof height (3)
- Low illumination at night makes reading of meter very difficult (3)
- Colour of the vehicle causes problem in identification in the night if light does not work properly (3)
- Brakes generally wear out easily (3)
- Handle bar position too low (2)
- Low pulling power (2)
- Ingres and egress a problem (2)
- Polluted air gets in directly, no barrier provided (1)

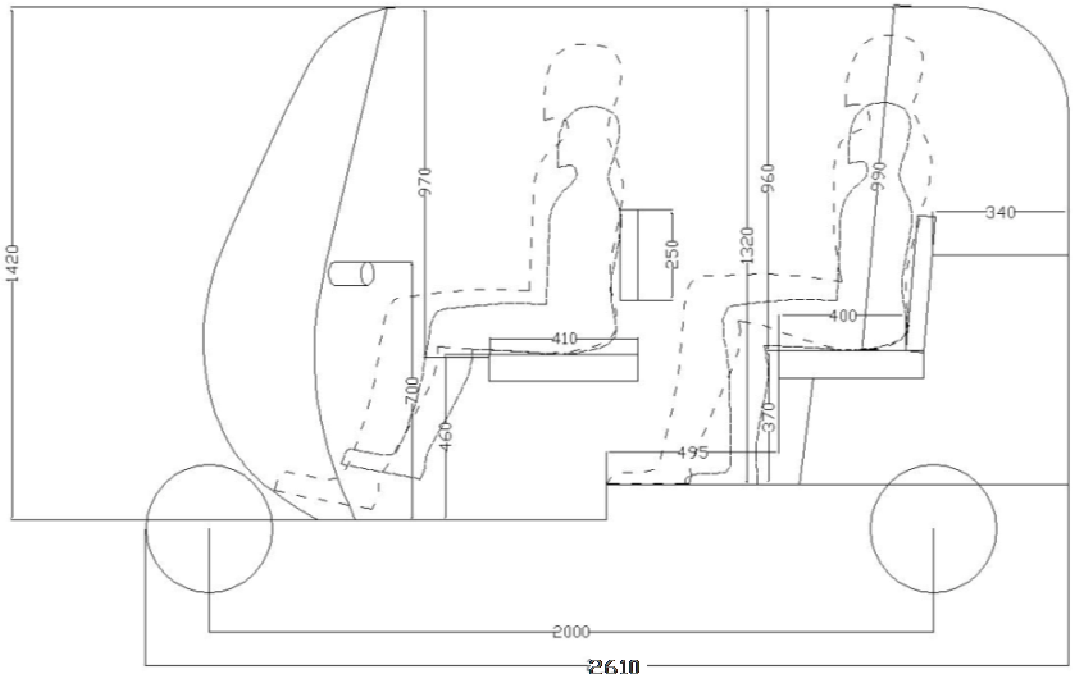
4.6.4 Design Insights

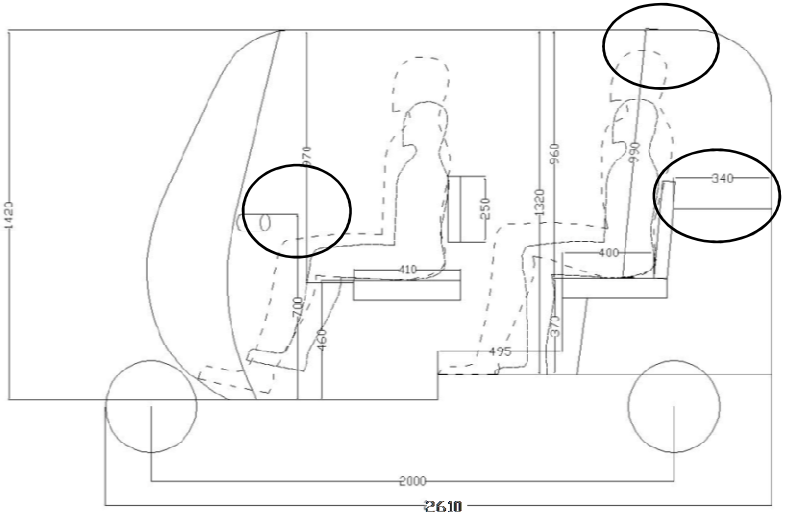
From the user studies, consisting of the interviewing and also observational analysis, the following insights were identified and are considered as the important points to be considered for the final product

- Design of vehicle looks clumsy hence it needs to be addressed
- Better utilization of space necessary for comfortable seating
- Luggage space repositioned from back to front for a secured feeling
- Rexin soft top should be replaced for a strong material to enhance overall rigidity and enhancing the look
- Front portion should be modified for better horizontal as well as vertical visibility range and for provision of ventilation for driver
- Rearranging all electrical and other equipments in drivers cabin for reducing visual clutter and providing comfortable seating area

4.7 Dimensional Data

To initiate with defining the packaging of the rickshaw some benchmarking needed to be done. This was required to understand the existing packaging and identify the problem areas and hence coming up with a new packaging/ schematic section. The current Bajaj RE series was benchmarked and the dimensional data, both exterior as well as interior, was taken into consideration. The diagram below shows the layout of the existing Bajaj RE rickshaw.





After considering the exterior packaging and interior layout, the following problems were identified other than the problems surfaced through the user study.

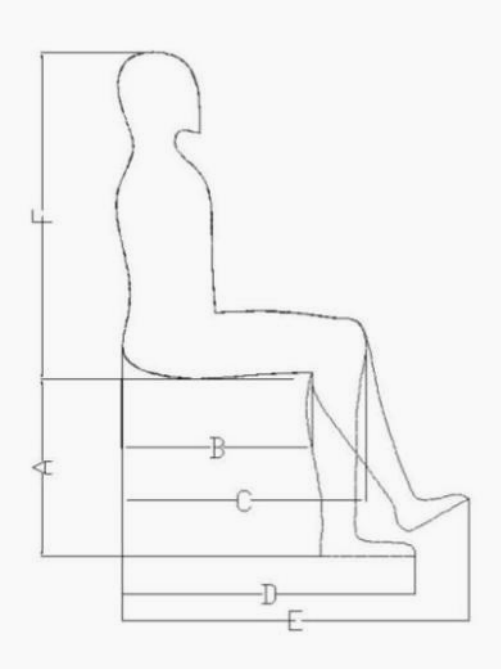
- The height of the roof had to be increased to accommodate the highest percentile person easily
- The luggage space had to be relocated for ease in access and also to reduce the length of the rickshaw
- The handle bar position had to be changed for ease in access and reach

5. Ergonomic Analysis

Ergonomic Data Sheet

To continue with refining the exterior packaging and layout of the rickshaw, the ergonomics of a human body had to be studied. This could help in understanding the minimum dimensional requirements and hence developing the interior layout.

The source for the ergonomic data was referred from 'Indian Anthropometric Dimensions' by Deb Kumar Chakrabarti



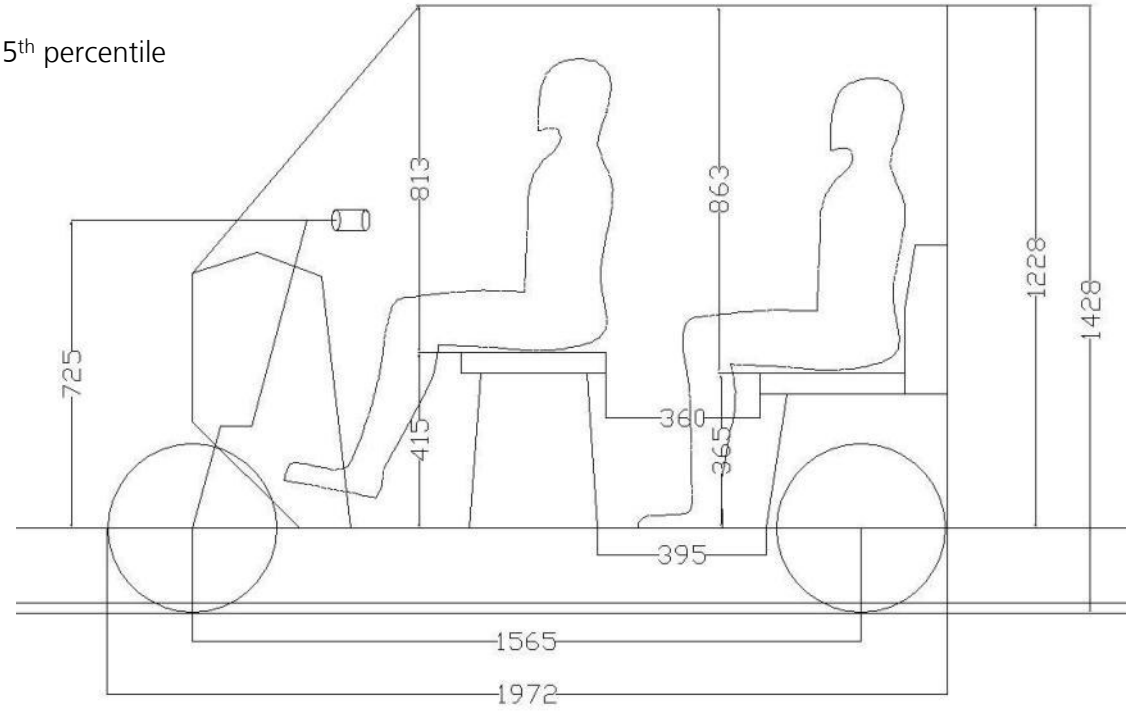
No	Nomenclature	5th %	50th %	95th %
1	A- popliteal	365	425	471
2	B- buttock to popliteal length	340	455	512
3	C- buttock to knee length	459	558	615
4	D- buttock to leg length	540	719	779
5	E- Buttock to leg length (extended)	719	923	1086
6	F- Erect seating height	713	837	905
7	G- Bi-deltoid	319	426	482

Indian Anthropometric Dimensions-Deb Kumar Chakrabarti

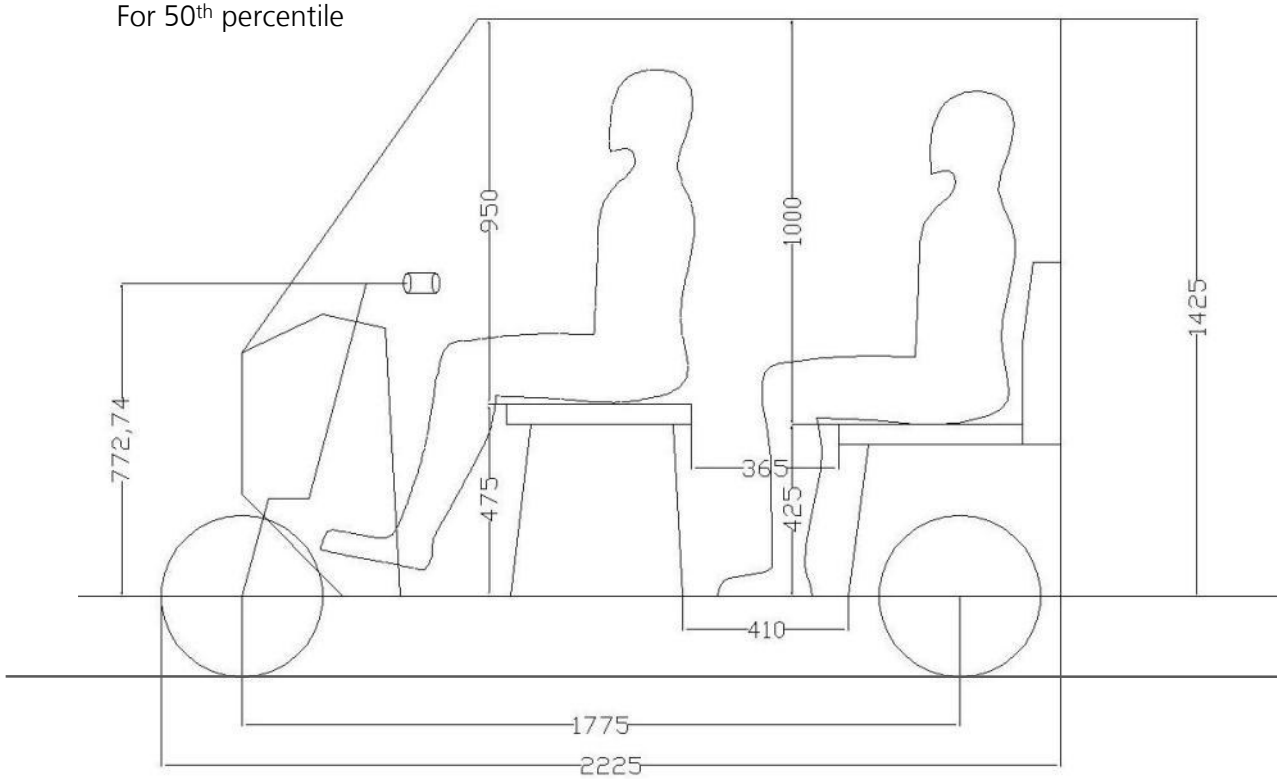
Schematic sections

To continue with the process of finalizing the schematic section for the new design, various layouts were made by considering various percentiles

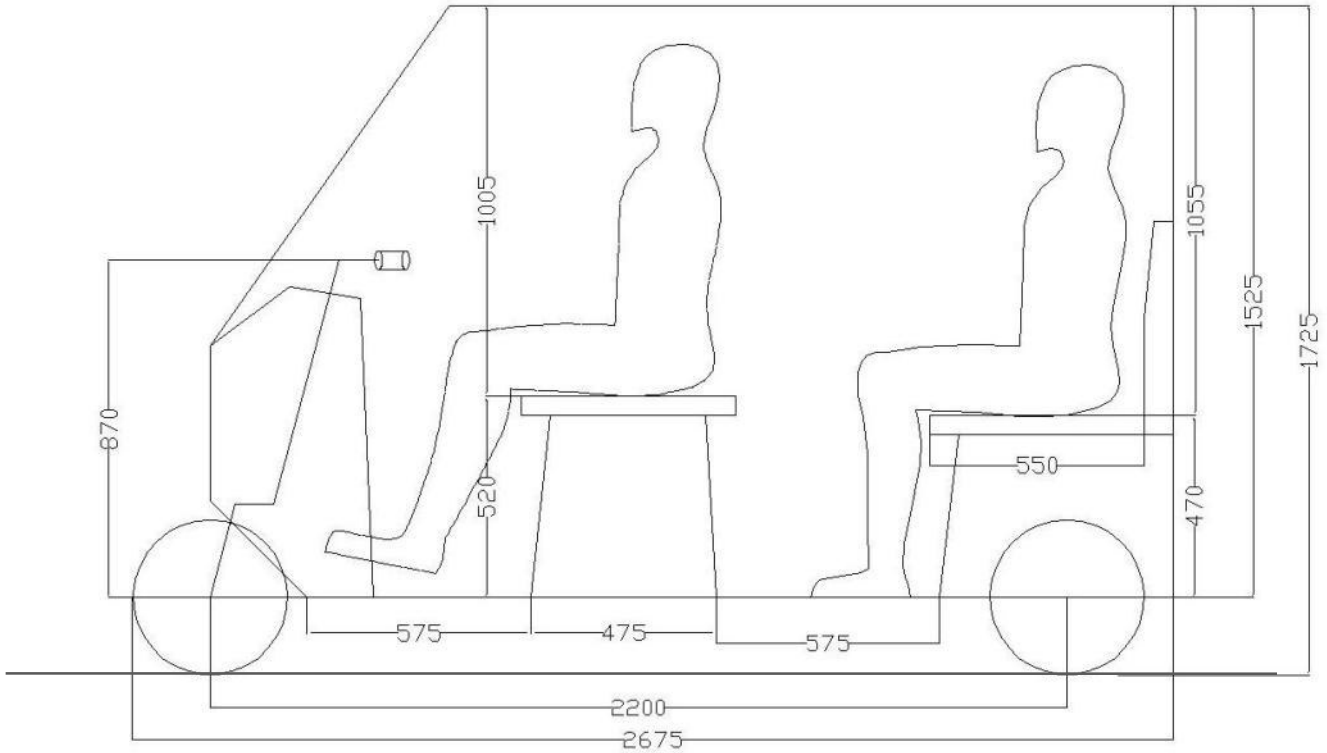
For 5th percentile



For 50th percentile

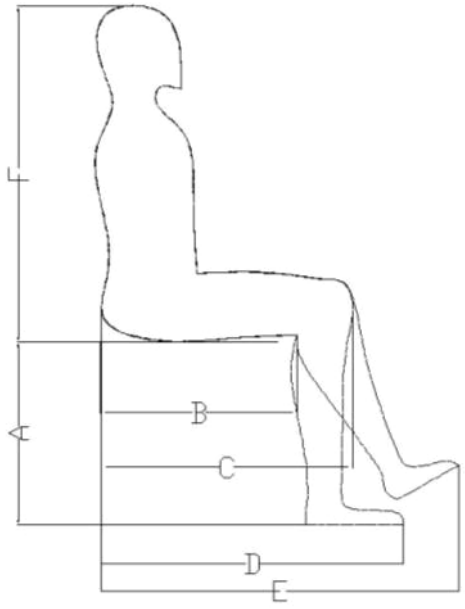


For 95th percentile



Finalized dimensional data sheet

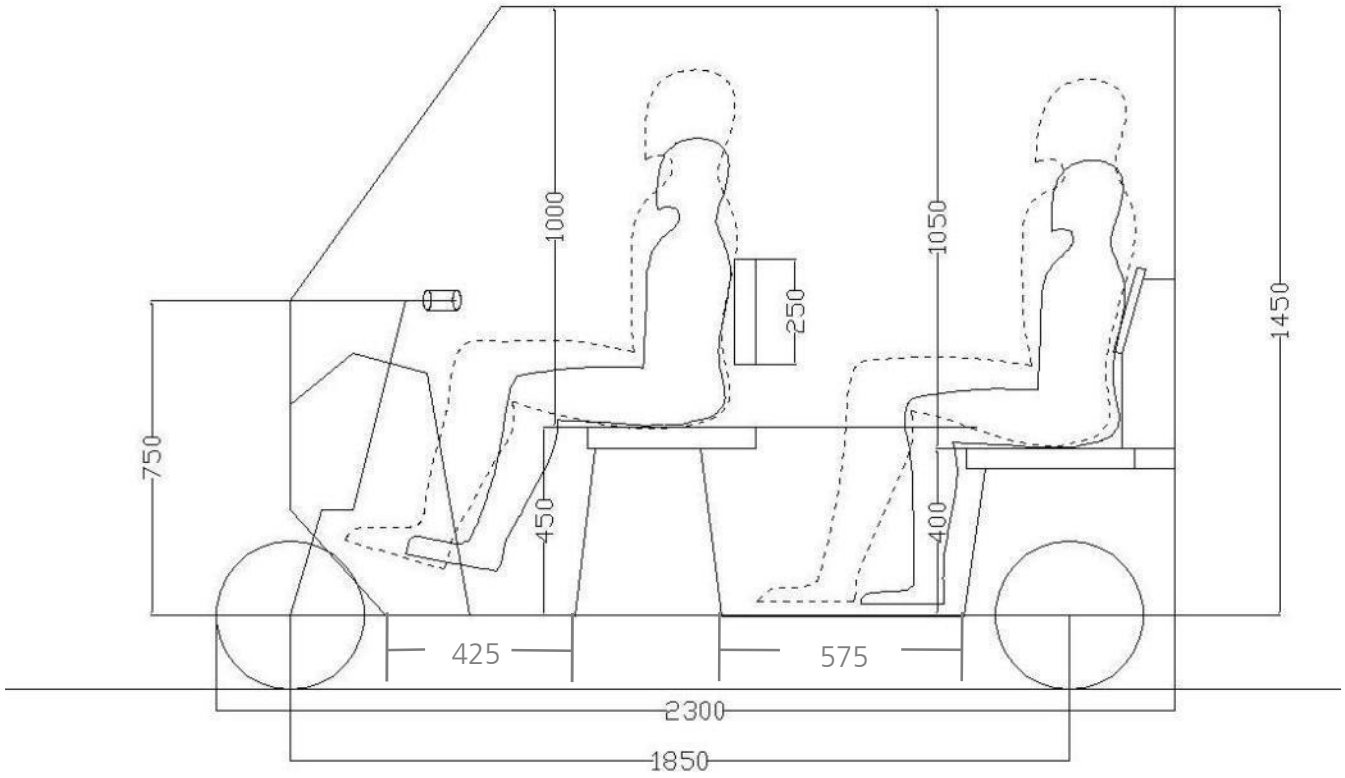
Now from the above generated three layouts optimal values for the various dimensional parameters were finalized. Below is the updated dimensional data sheet with optimal dimensions specified at the last column.



No	Nomenclature	5th %	50th %	95th %	Final
1	A- popliteal	365	425	471	400
2	B- buttock to popliteal length	340	455	512	400
3	C- buttock to knee length	459	558	615	615
4	D- buttock to leg length	540	719	779	779
5	E- Buttock to leg length (extended)	719	923	1086	950
6	F- Erect seating height	713	837	905	905
7	G- Bi-deltoid	319	426	482	482

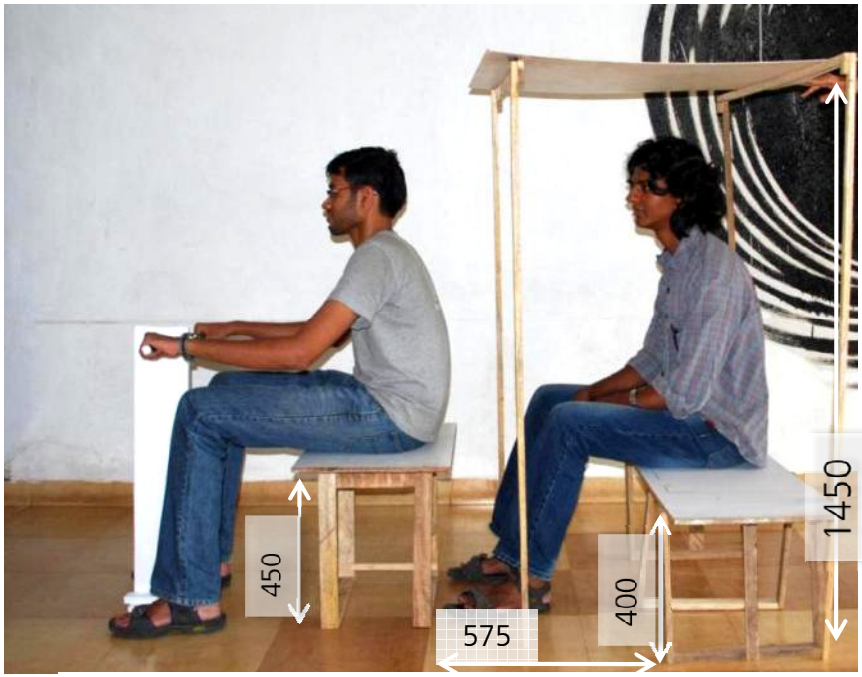
Finalized schematic section

The final layout was proposed on the lines of the optimized dimensional data and validated by placing the mannequins in 1:5 scale. The diagram shown below represents the final proposed layout but may get modified while considering styling of the vehicle



Space Exploration

To understand the proposed schematic section in a better manner and to experience the space a 1:1 sized test model was made and was checked up with different sized people.



1:1 Setup

6. Battery and motor calculations

Calculating the battery capacity and motor power requirements

After completion of the final schematic section next step was to decide upon the battery and motor specifications as the capacity of the battery and the power and torque requirements for the rickshaw

But for that few considerations had to be made in form of assumptions, these are listed down as below..

Requirements:

- Maximum power required for carrying the load
- Maximum torque
- Amperage rating for powering the motor for a defined period/ distance

Considerations

- The maximum load carried in form of passengers is considered 260kg (four person weighing 65kg)
- Maximum speed attained is limited to 50kmph and average speed is considered as 20kmph
- Considering maximum road climb 15°
- The battery will provide power supply for 50km/ continuous 1 hour of operation
- Considering a replaceable set of batteries cassette for continuous operation

Power and amperage calculations

First calculating the battery amperage and motor power, two conditions are taken into consideration.

In the initial case the total mass of the vehicle with the passengers and driver is considered 500 kg

Assumptions:

Case1

Total mass(M)	500kg
Maximum speed(V_{max})	50kmph
Average speed(V_{avg})	20kmph
Inclination angle(Ø)	15°
Voltage (Battery)	48V

Maximum power(P)= P_r+P_s

$P_r = MgV_{max}*0.036 = 2.45kW$

$P_s = Mg\sin Ø*V_{avg}*0.05 = .345kW$

Maximum power = 2.8kW ≈3kW

Ampere rating = P/V= 62.5Ah

In the second case, the total load was considered to be 600 kg and hence the following calculations were carried on.

Assumptions:

Case 2

Total mass(M)	600kg
Maximum speed(V_{max})	50kmph
Average speed(V_{avg})	20kmph
Inclination angle(Ø)	15°
Voltage (Battery)	48V

Maximum power(P)= P_r+P_s

$P_r = MgV_{max}*0.036 = 2.94kW$

$P_s = MgsinØ*V_{avg}*0.05 = .423kW$

Maximum power = 3.36kW ≈3.5kW

Ampere rating = P/V= 73Ah

Battery options

From the earlier calculated values for capacity of the battery, the following battery options can suit the requirements. The complete details of each option of battery set are put in the table below.

Battery	Configuration	Weight (Kg)		Dimension (mm)	Cost (Rs)		Remarks
		Single	Total	Single	Single	Total	
Lead Acid							
12v 35Ah	4 in series, 2 set in parallel (8 no.s in total)	13.15	105	195*130*183	4178	33424	Too heavy
12v 65Ah	4 in series	19.6	78.4	275*175*190	5810	23240	Suitable but a bit bulky
48v 35Ah	2 in parallel	25.85	51.7	178*202*406	-	-	Too big to be placed
Li-Ion							
3.8v 70Ah	13 in series	2.2	28.6	24*260*210	-	-	Higher no. of batteries required

From the above list the 12V 65Ah lead acid battery seems to be a good option considering the cost but is a bit on the bulkier side. The 3.8V 70Ah li-ion option seems to be the better option considering its weight and the size though have to use large no. of batteries.

Practical solution for current scenario

Optimal solution for the best performance

Motor requirements

Now to calculate the torque requirement for the vehicle to carry around the load. The table consists of all the values required for calculating the torque

Weight (kg)	Power(Kw)	RPM		Torque(Nm)	
		Min(20Kmph)	Max (50 Kmph)	Hi Speed(50Kmph)	Low speed(20Kmph)
500	3	265	665	43	90
600	3.5	265	665	50.41	115

Considering a 3kW motor providing a maximum torque of 90Nm

7. Basic rickshaw configuration

The configuration of the rickshaw is finalized from the point of view of the battery and motor specifications are considered

The battery set considered is a 3.8v, 70Ah Li-ion batteries, 13 no.s connected in series. The battery set is placed in a chamber below the passenger seat

The motor used is hub mounted Inverted Switched Reluctance motor positioned in the front wheel resulting in front wheel powered engine. The motor produces 3kW of power and a torque of 90N.m

Front wheel drive vehicle

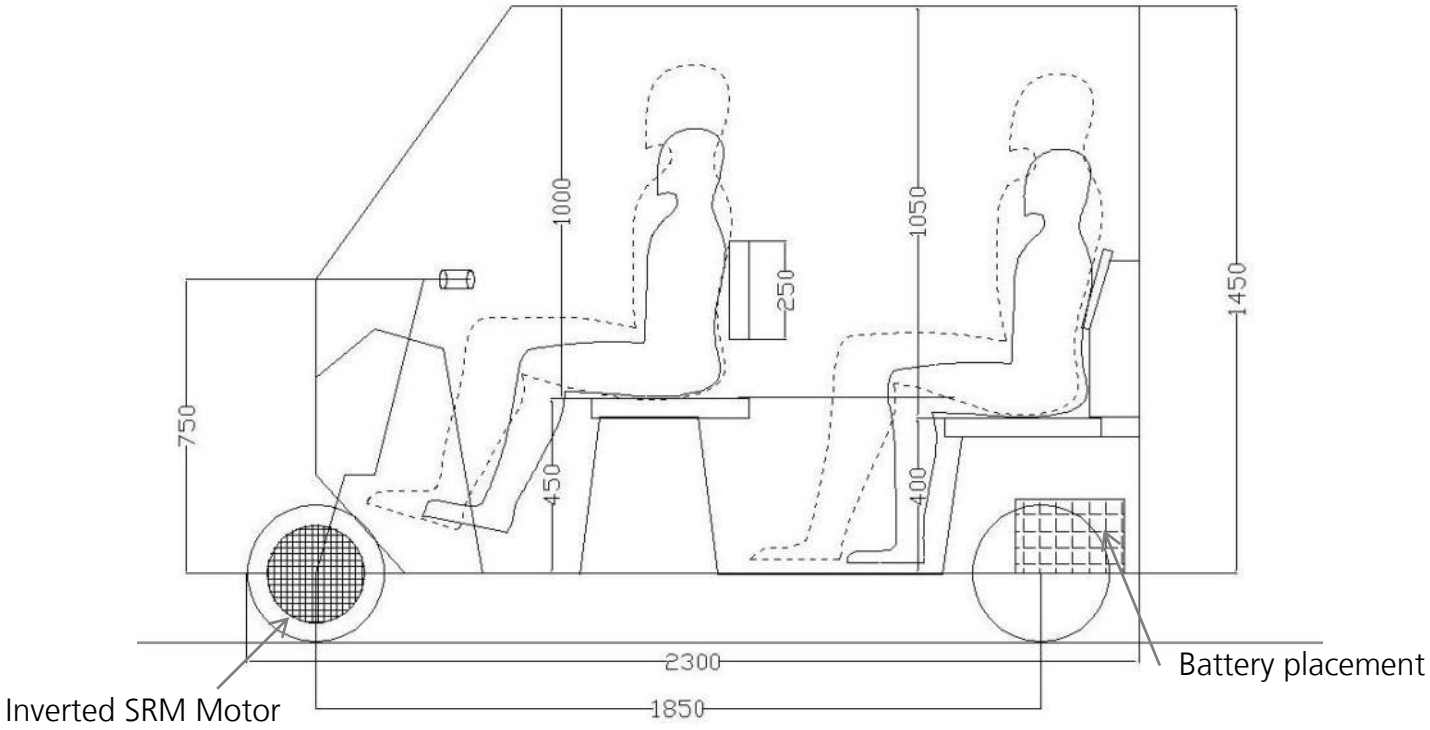
The motor of the rickshaw is positioned on the front to provide better distribution of load of vehicle since the batteries and passenger weight get concentrated at the rear portion of the rickshaw.

Advantages of front engine FWD:

- A front wheel drive vehicle has most of its weight on the front wheels, usually between 60% and 70%, so that it tends to go straight, just like an arrow where the weight is concentrated in the arrowhead.
- Placing the mass of the drive train over the driven wheels moves the centre of gravity farther forward than a comparable rear-wheel drive layout, improving traction and directional stability on wet, snowy, or icy surfaces.
- Causes under steering condition which can be easily controlled due to low power and speed

Proposed schematic section

The basic proposed layout of the rickshaw is as shown below with the placement details of the components as battery and motor shown



Length	2300mm
Breadth	1300mm
Height	1650mm
Wheelbase	1850mm
Battery area	800*300

8. Product Brief

Layout:

Front wheel mounted, Front wheel driven

Power Train:

Electric 3kW, 10" Inverted SR Motor

Power Source:

Electric, 13no.s, 3.8V 70Ah Li-ion batteries in series

Running cost:

Approximately Rs. .50/ Km

Overall Dimensions: (Subject to change according to styling)

L ~ 2300mm

B ~ 1300mm

H ~ 1650mm

WB ~ 1850mm

Styling Language:

The basic styling of the rickshaw should reflect the characteristics of electric vehicle and hence need to be more contemporary

9. Styling

Basic Styling Considerations

The next stage was to consider the styling of the rickshaw. Before starting with the styling of the vehicle few considerations related to the design had to be made.

The new design had to look contemporary and should be innovative as a form for a rickshaw. The vehicle body has to be of least weight for better performance considering the electric power source yet strong enough to sustain variable loads while traversing.

New design should not necessarily follow the basic characteristics of an auto rickshaw and preferably could be a monocoque structure

9.1 Semantic analysis

Characteristic features of an Auto Rickshaw

Now further starting off with the styling of the rickshaw few basic characteristic features of the rickshaw and EVs had to be identified. This was done under the small project taken under the semantics module. The various characteristic features of the rickshaw are as listed below:

- Three prominent wheels
- Prominent wheel arch
- Minimal body panels
- Simple layout of seating
- Exposed frame structure
- Rexin cover
- Open cabin
- Small tyre size
- Shape of the hood
- Prominent curving in at the corners

Characteristic features of an electric vehicle

- Organic shapes
- Compact size
- Minimal body panels and roomy cabin
- Bright colours

Characteristics of term ‘electric’

- Dynamic
- Sharp
- Vibrant
- Uncontrolled
- Aggressive
- Bright colour

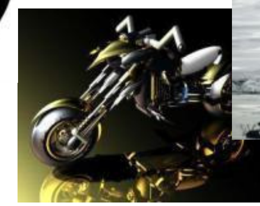
9.2 Defined attributes

For starting with the styling of the rickshaw few key attributes had to be fixed so that the styling of the vehicle could be validated on these points. The attributes were defined by keeping in mind what sort of final product was required. The attributes are as listed below:

- Futuristic- the design had to look something from the next generation as most of the EVs have a touch of future and look totally different from the other designs
- Organic- The design had to look organic as it is one of the major characteristic of an EV.
- Dynamic- The design had to look more dynamic as it is the feature of the term 'electric'
- Minimalistic- Since the EVs generally are very light vehicles and does not carry any form of an extra component other than the basic required ones the design also had to reflect it.
- Compact- The design had to be very compact not only to keep the weight of the vehicle minimal but also to make it look smaller than the current rickshaw.
- Airy space- One of the major characteristic of a rickshaw and also most of the EVs

9.3 Image Board













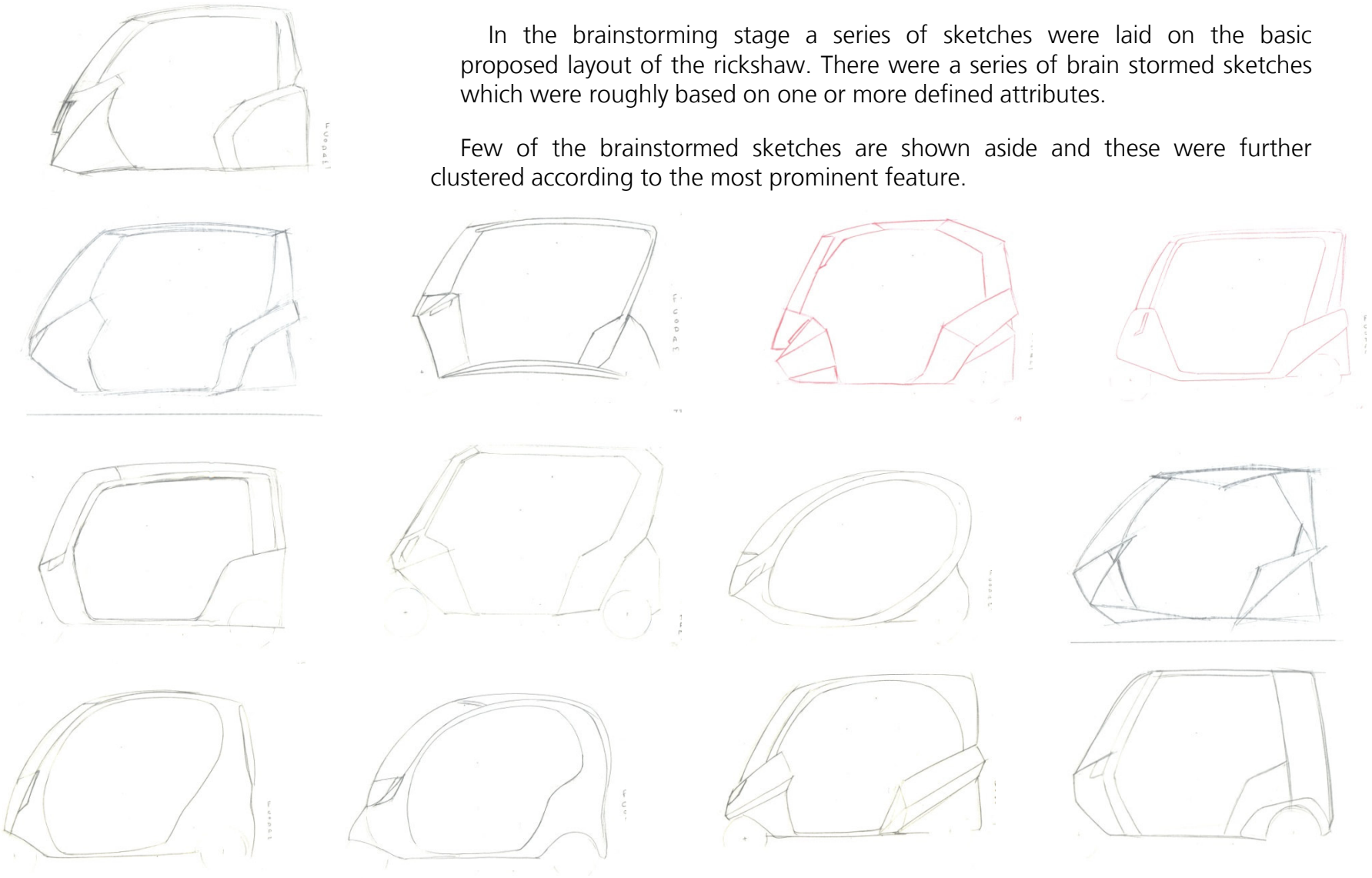




9.4 Brainstorming

In the brainstorming stage a series of sketches were laid on the basic proposed layout of the rickshaw. There were a series of brain stormed sketches which were roughly based on one or more defined attributes.

Few of the brainstormed sketches are shown aside and these were further clustered according to the most prominent feature.

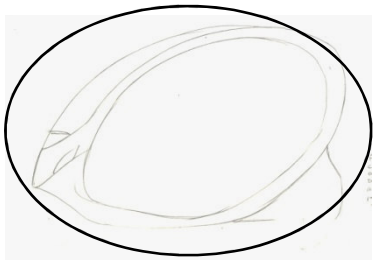


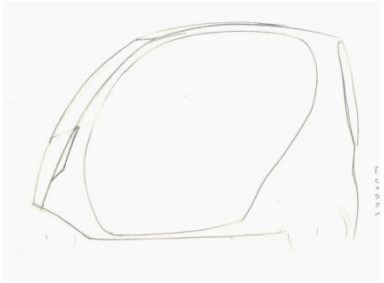
9.5 Clustering

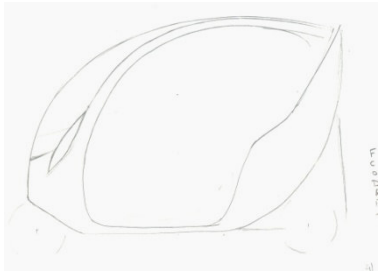
Cluster 1: Organic

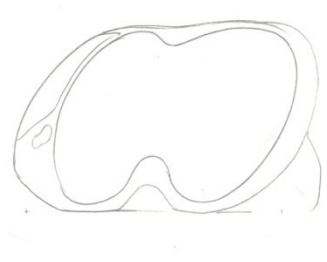
This cluster included designs which had a prominent essence of organicness. To understand the basic characteristics of 'organic' few examples were taken into considerations as shown besides

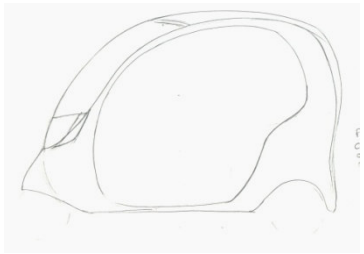
From the clustered sketches the encircled one had most prominent features of organic and hence was considered the representative of the cluster. the most prominent features making in more organic was the way each element gets blended onto the other.

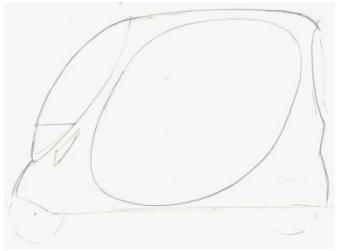


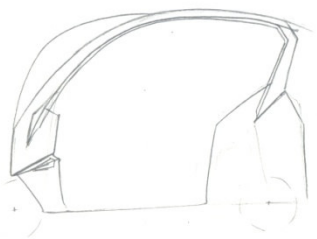


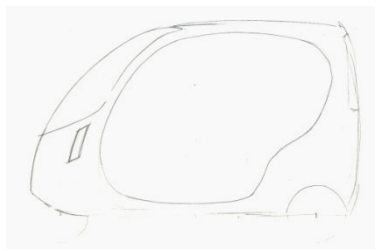








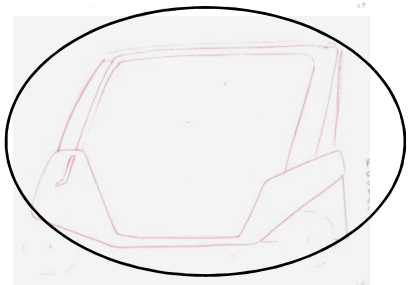




Cluster 2: Dynamic (Angular)

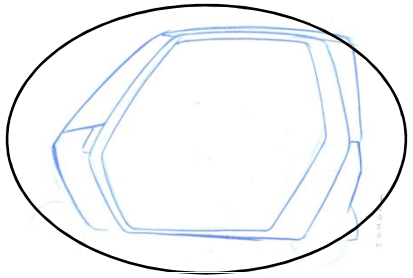
In this cluster the most dynamic designs were taken into consideration and ‘dynamic’ness was defined in the form of more angular design.

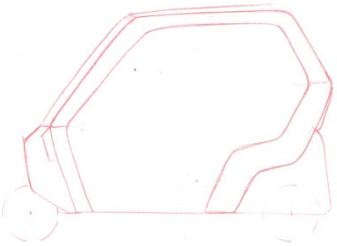
The encircled design was considered most dynamic design and this was considered as the representative of the cluster

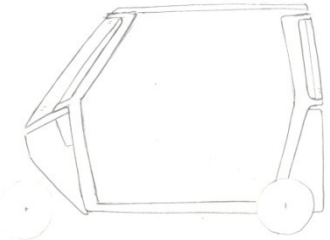


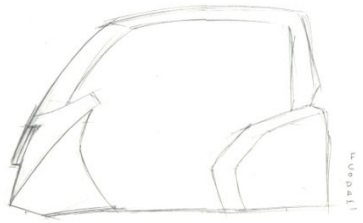
Cluster 3: Minimal

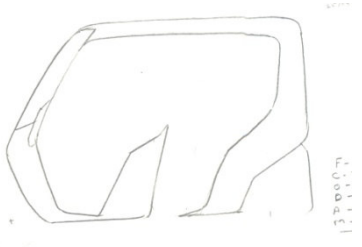
In this cluster, the body design is kept at minimal and most concepts had the frame structure as the major styling component

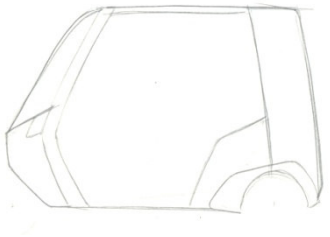






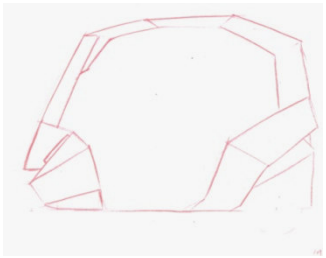


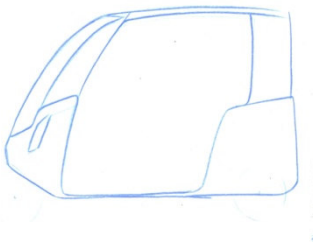


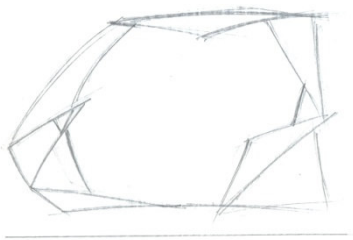


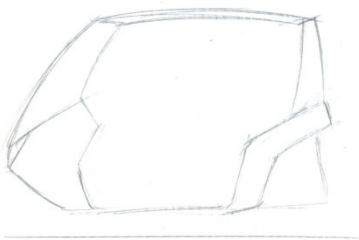
Cluster 4: Radical

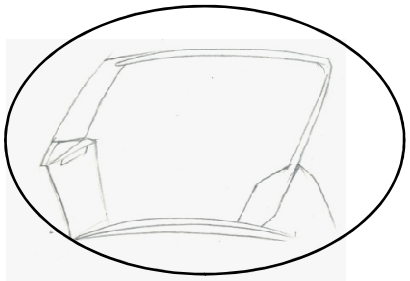
The last cluster consisted of all the ideas which were radical. Being radical is also a form of depicting futuristic design. The encircled concept had the most prominence of 'radical'ness and hence was considered the representative of the cluster

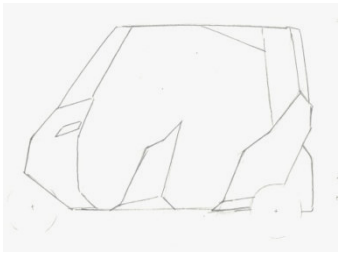






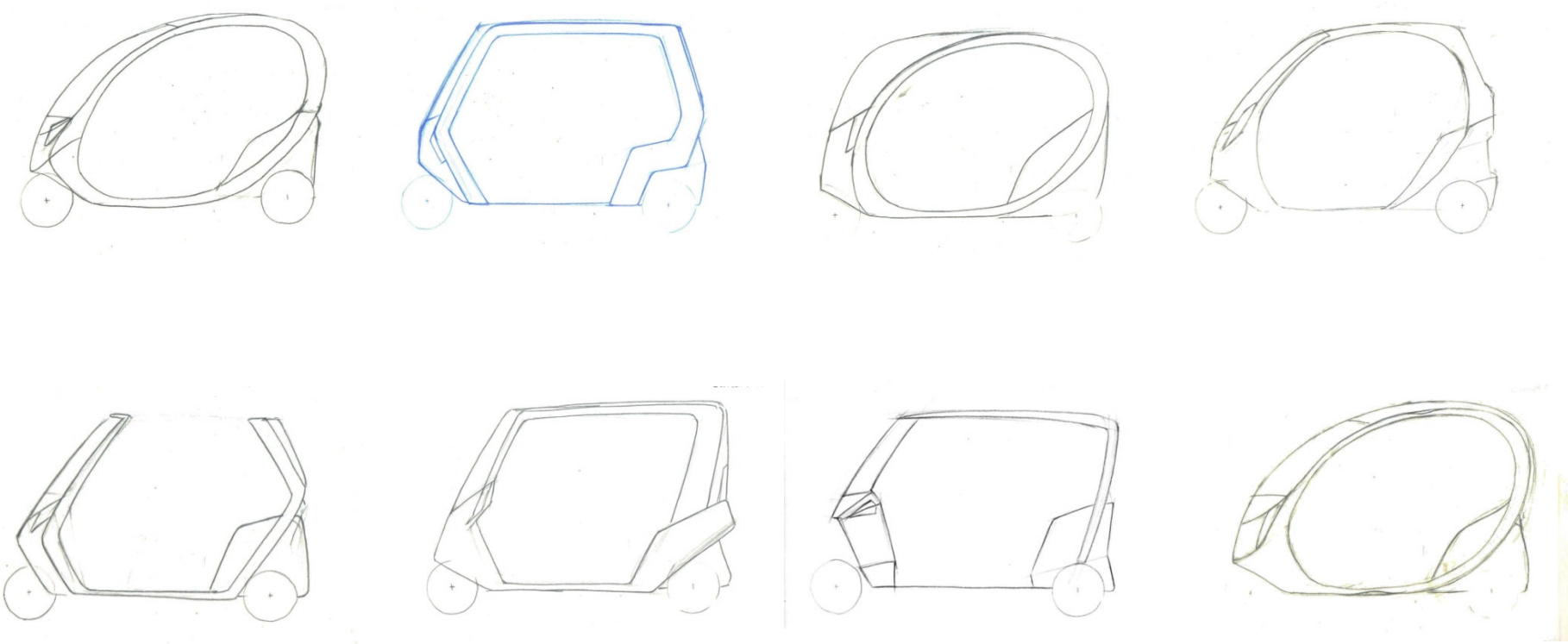






9.6 Concept Generation

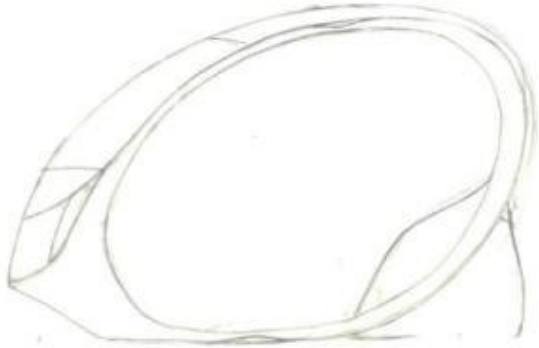
From the earlier generated cluster representatives new concepts were generated and these had the common essence of the other ideas generated. From the concepts developed they were shortlisted and were further worked upon for the initial rendering of the concept.



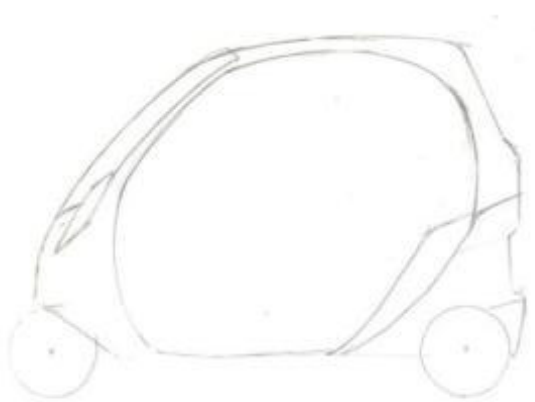
9.7 Concept Selection

The following concepts were short listed and this was done by rating each concept. The rating was done both by me as well as few of my batch mates.

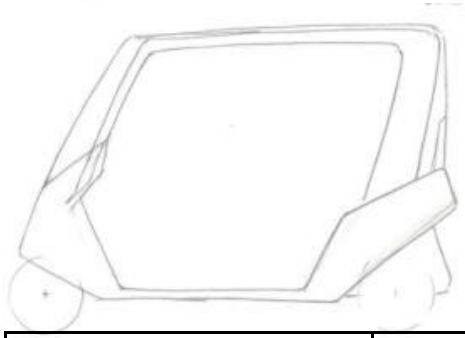
The basis of the rating was according to the features depicting the attributes defined. Each attribute was rated for five points.



Self rating	22(30)
Rating by others (8)	21



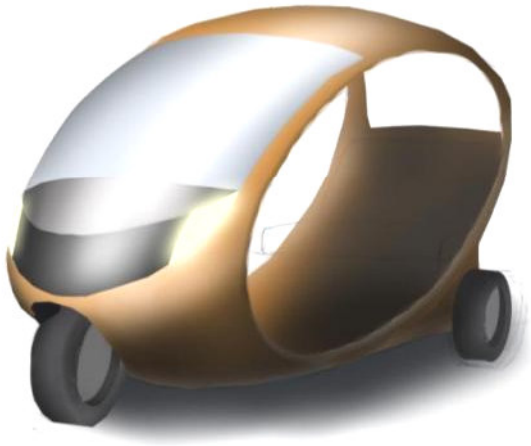
Self rating	22
Rating by others (8)	21

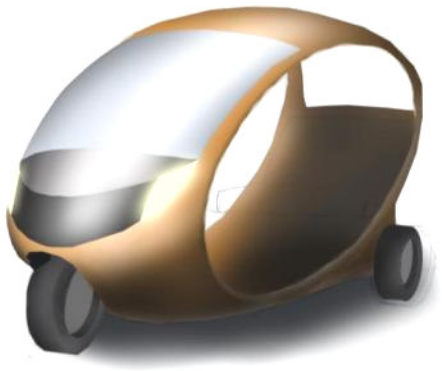


Self rating	22
Rating by others (8)	18

9.8 Concepts

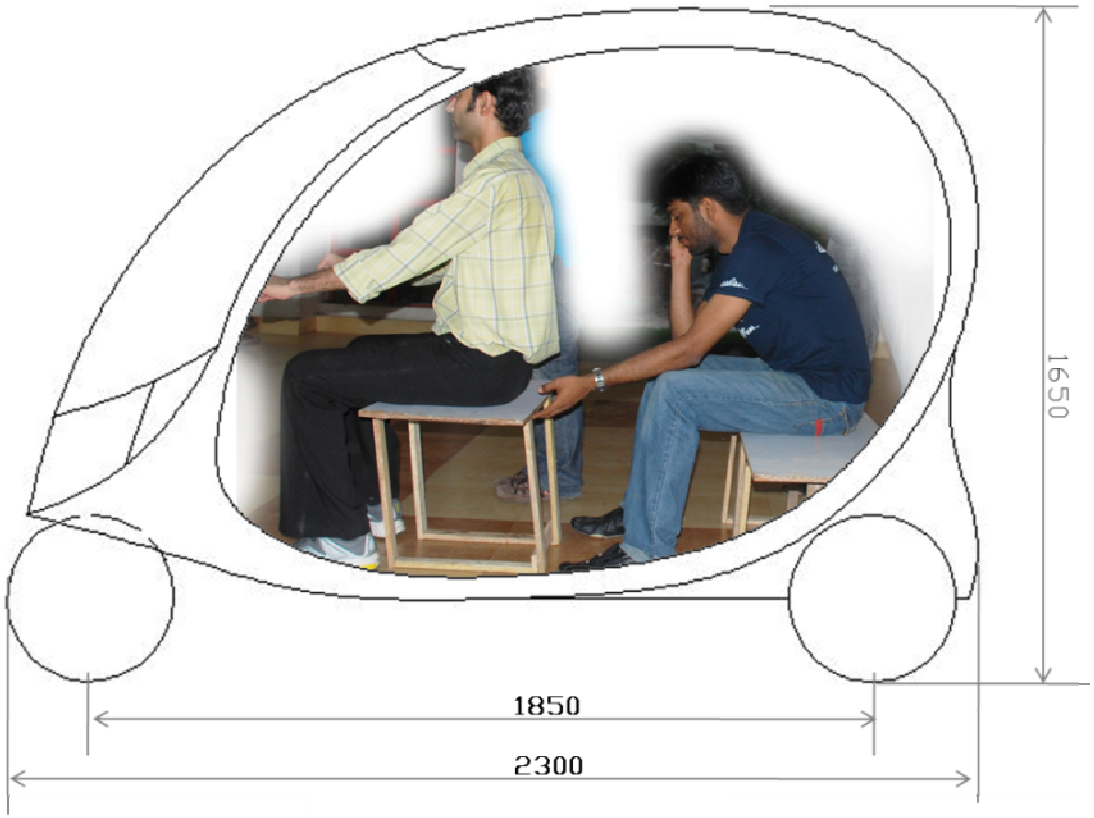
The following are the renderings of the concepts finalized. The first concept had the essence of ‘organic’ness to a greater extent while the third concept was much more of dynamic in form. The second concept on the other side has a mixture of both organic and ‘dynamic’ness

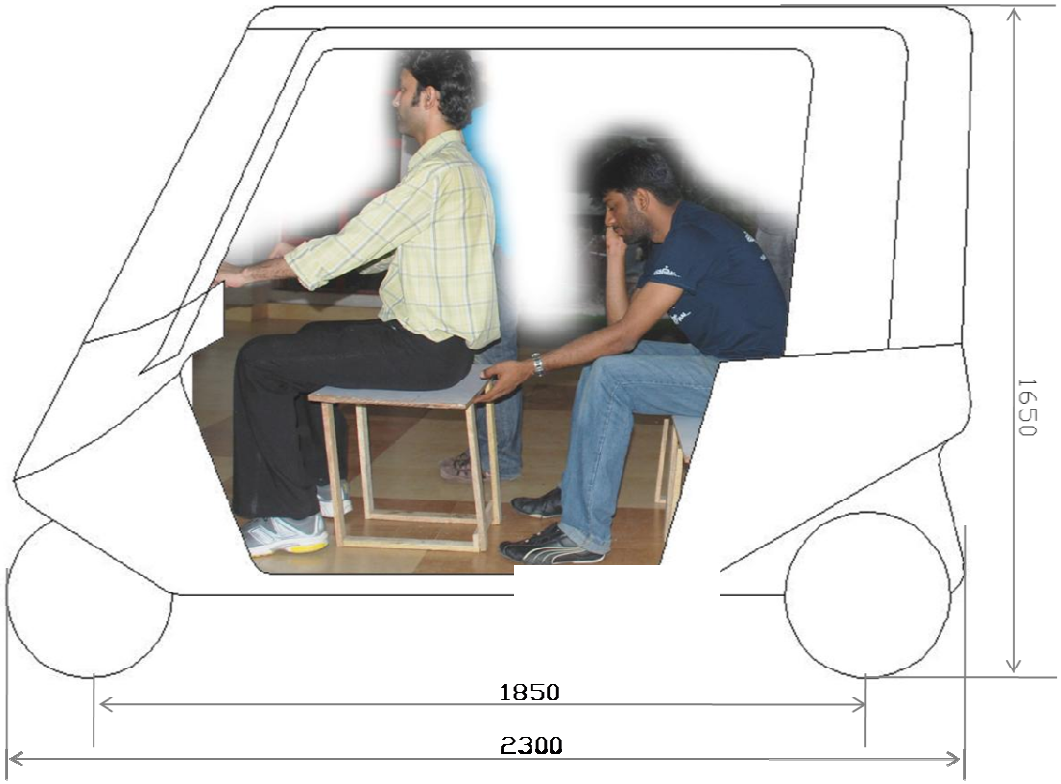


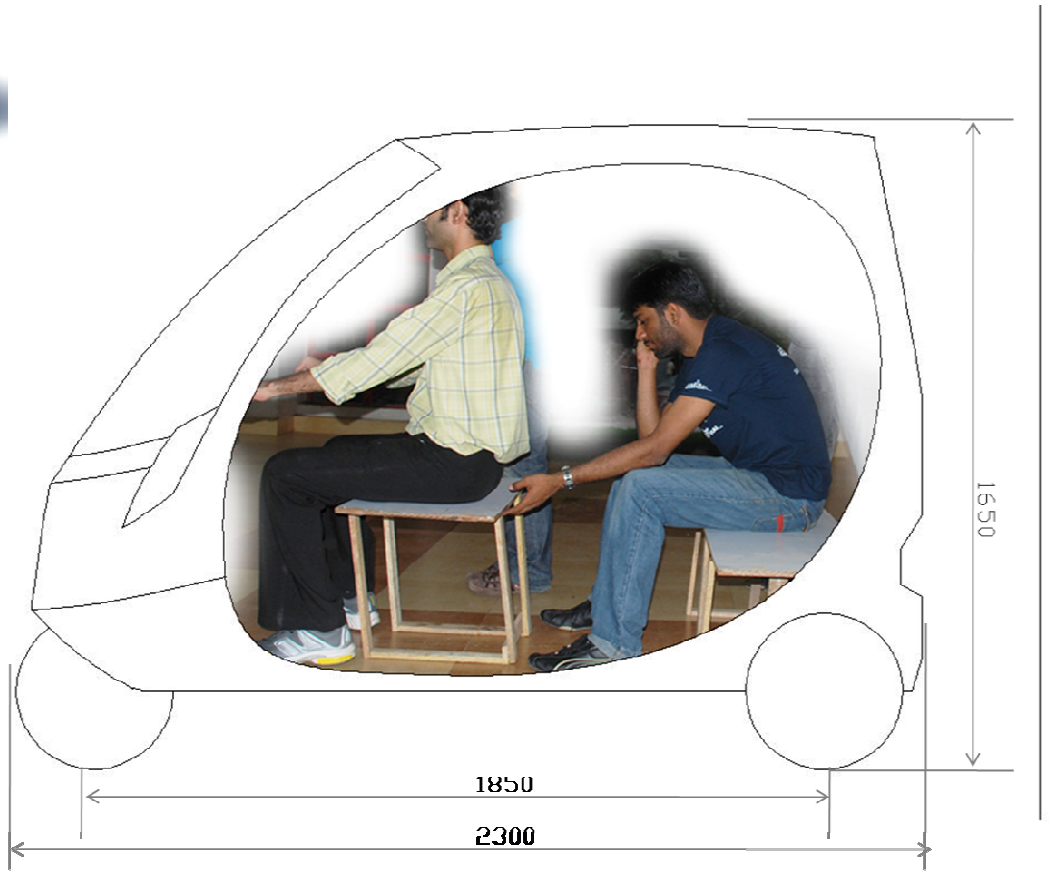


9.9 1:1 Realization

Now to exactly understand the actual concept at life size the draft of the concept was morphed with a scale image. This was done basically to understand the concept in a better way and also to understand if any problems existed



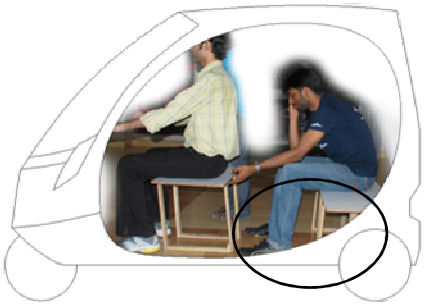

1650
1850
2300

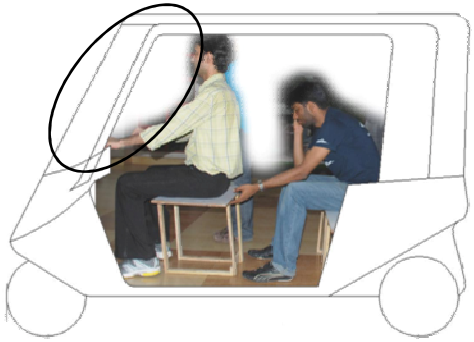

1550
1850
2300

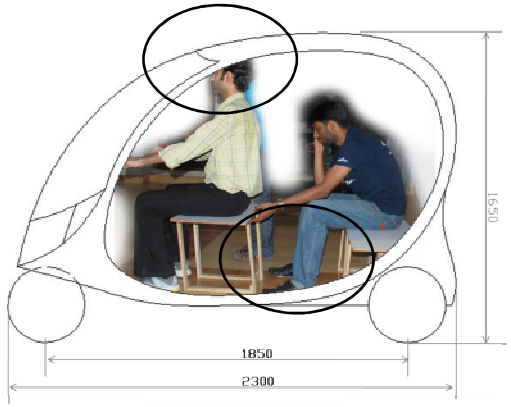
9.10 Problems

Few shortcomings got highlighted due to the 1:1 realization and these shortcomings are as listed below:

- The head clearance for driver was to be taken into consideration
- Obstructions especially during ingress and egress had to kept in check
- Styling of the concepts were almost similar
- Concepts reflected most of the existing rickshaw characteristics
- Concepts looked more bulky
- Driver facing the sun all the day

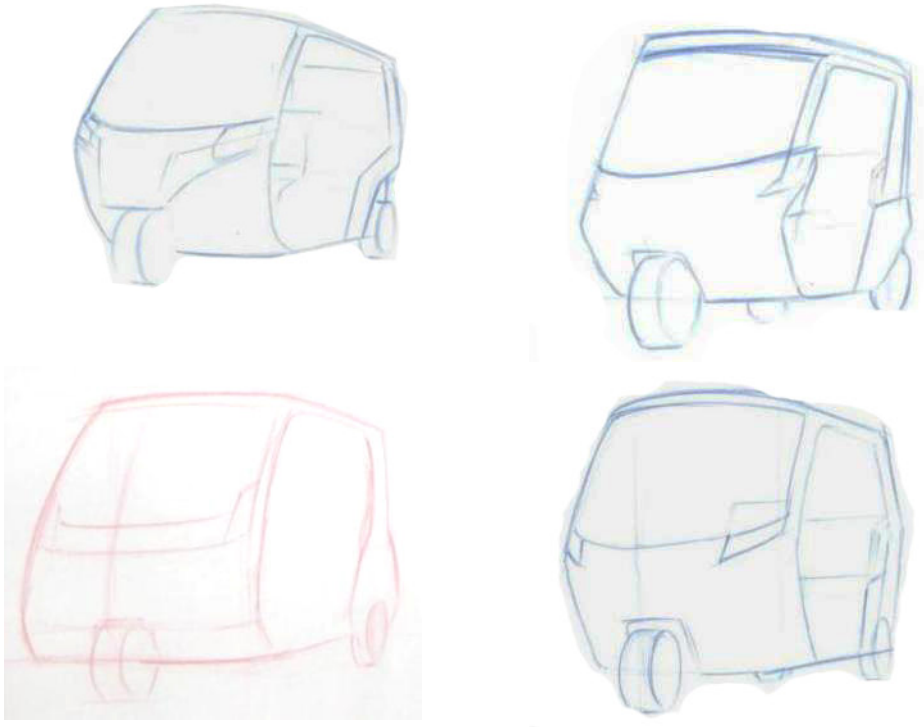






Reconsidering the styling

After the surfacing of the problems, the next step as usual was restyling the vehicle. Few concepts were developed with most of the earlier mentioned problems taken into account.



But still there were a few problems coming up as the basic components or rather the interior components of the vehicle were not yet defined

9.11 Designing the basic components

The basic components to be designed in the rickshaw are as listed below:
Components :

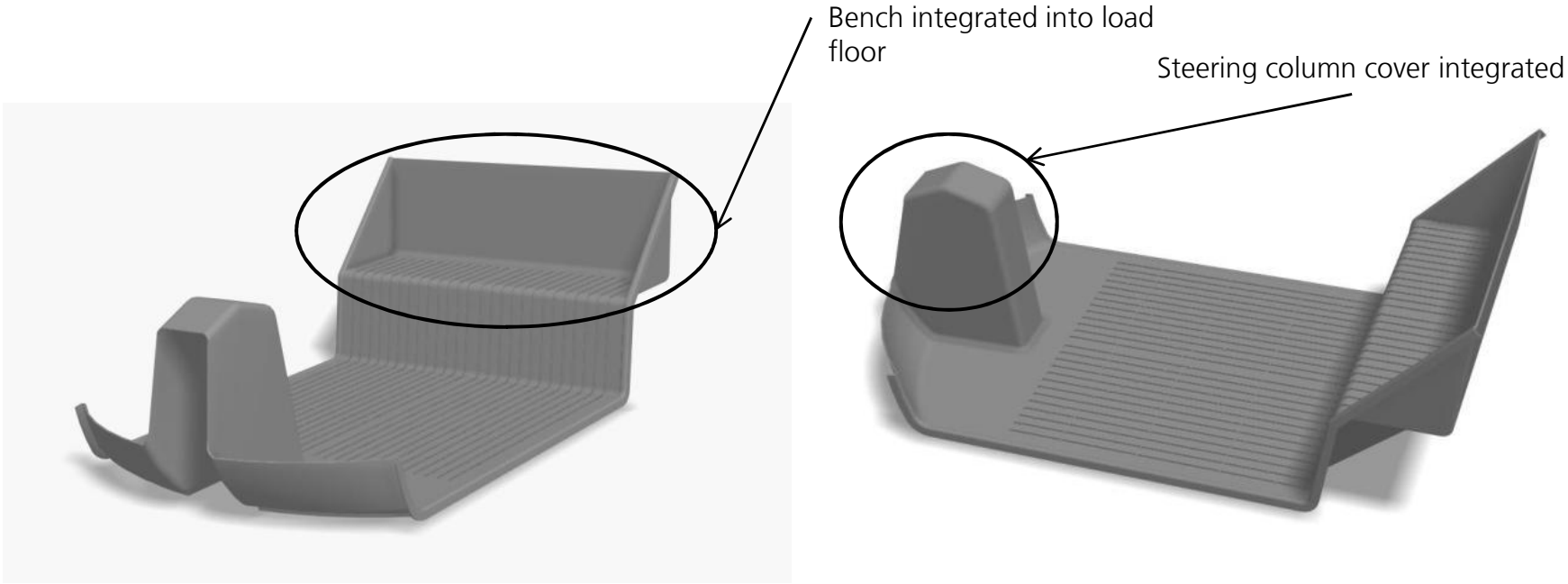
- Load floor: The base of the vehicle which forms the chassis for the vehicle
- Driver seat: The driver's seat is a stand alone component and had to be designed for better utility other than fulfilling the basic purpose of providing comfort to the driver
- Passenger seat: The passenger seat had to be designed is such a way to provide ample comfort to the passengers and also to, some extent, keep the overall weight of the vehicle minimal
- Grab bar: The grab bar is one of the essential components as it acts as a support to climb into the rickshaw and also acts as a barrier between the driver cabin and passenger cabin

9.11.1 Load Floor

As mentioned earlier the load floor has to act as a chassis for the vehicle hence it had to be strong enough to sustain most of the dynamic loads.

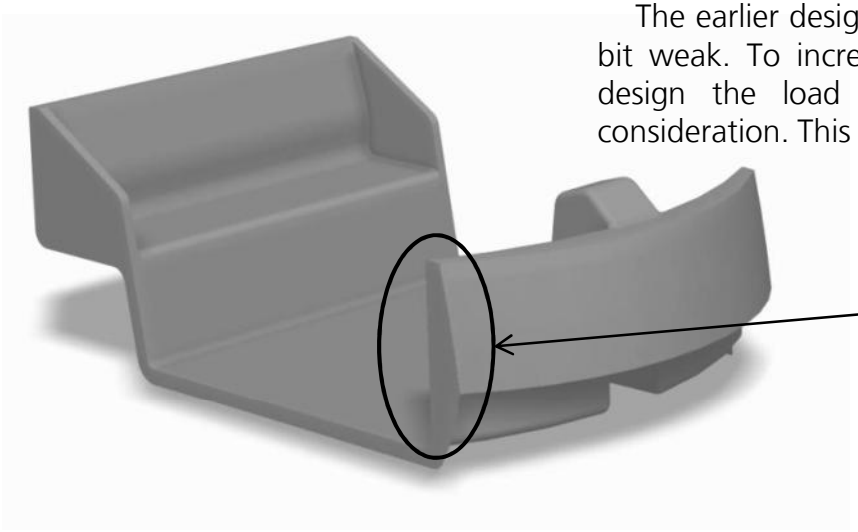
The main intention in designing the load floor was to integrate as much components as possible to make it strong and rigid.

In the design the steering column and the passenger seats are integrated together as shown below.

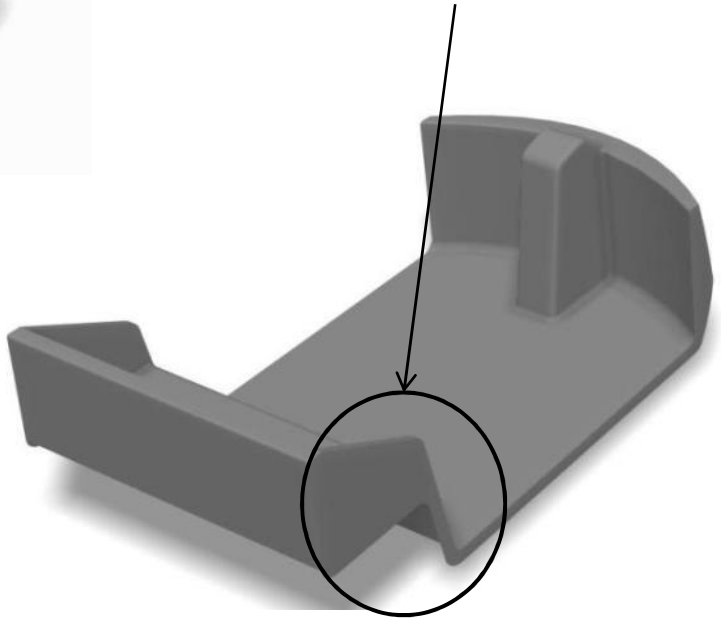


Load Floor

The earlier design of the load floor had a problem as it was visually a bit weak. To increase the visual as well as the actual rigidity of the design the load floor was redesigned with the box form into consideration. This led the load floor look more rigid than earlier



Basic structure converted to box form to enhance natural rigidity



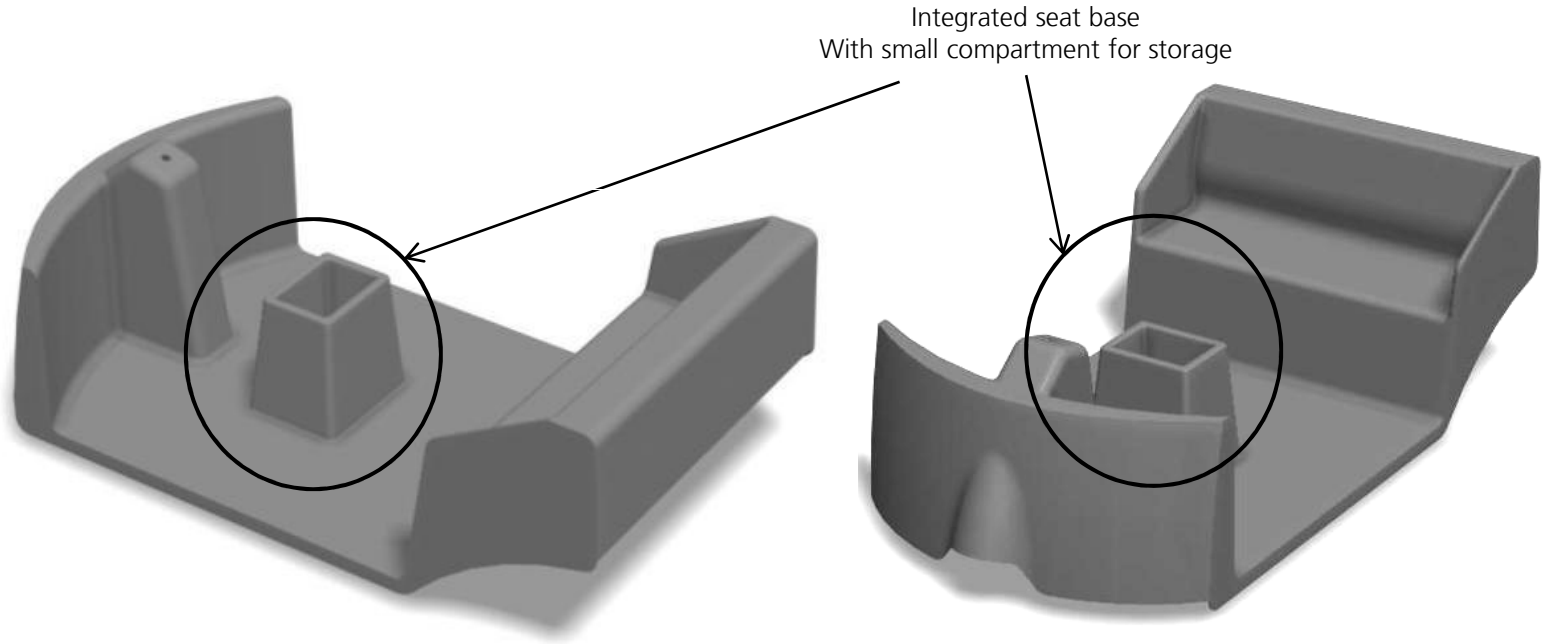
9.11.2 Driver seat and Grab rail design

In the driver's seat design the basic seat structure, support and strength was taken into consideration. The integration of the grab bar with the design was also taken into consideration with the placement of the luggage also being the priority of design

Modified load floor

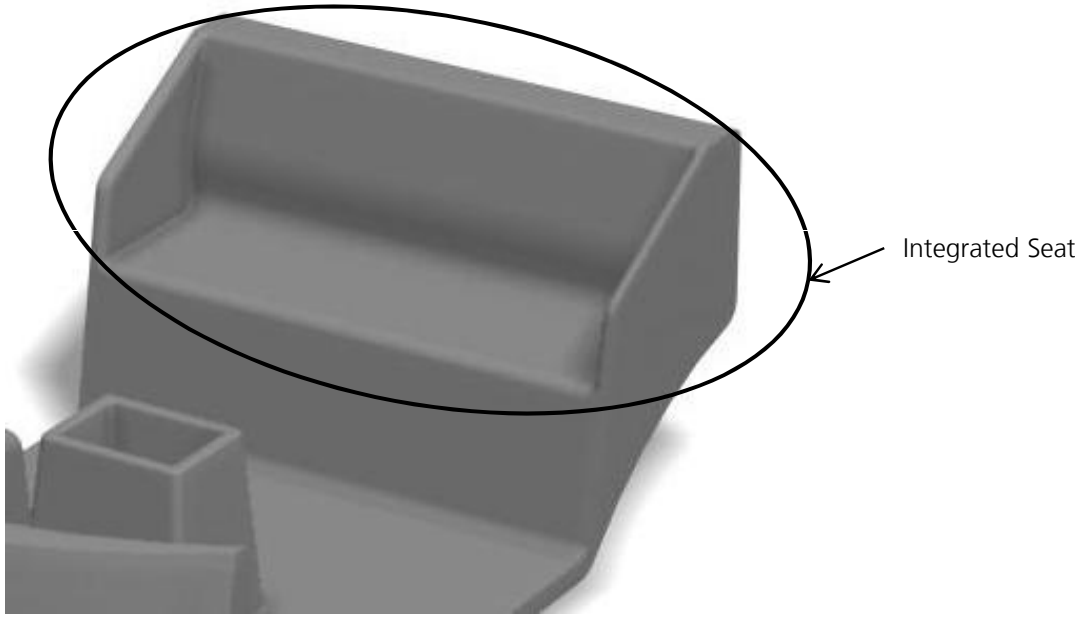
The driver seat design was reconsidered with integrating the base of seat with the load floor. This lead to increase in rigidity of the load floor and also reduction in parts to be assembled.

A parcel compartment provided below the seat which could accommodate any valuable or even the basic things like license and other papers.



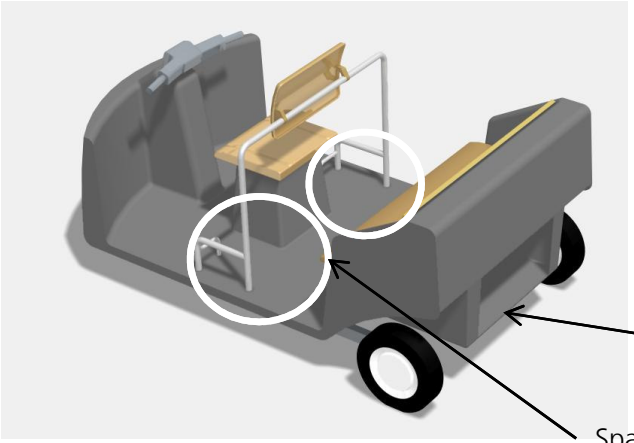
9.11.3 Passenger Seat

The Passenger seat is integrated with the load floor design as mentioned earlier. For back rest a profiled backrest area was provided in the load floor itself for comfortable seating and flexible cushion is directly placed on the profile.



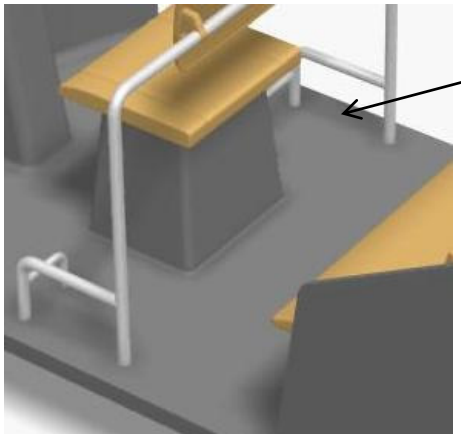
9.11.4 Final Layout

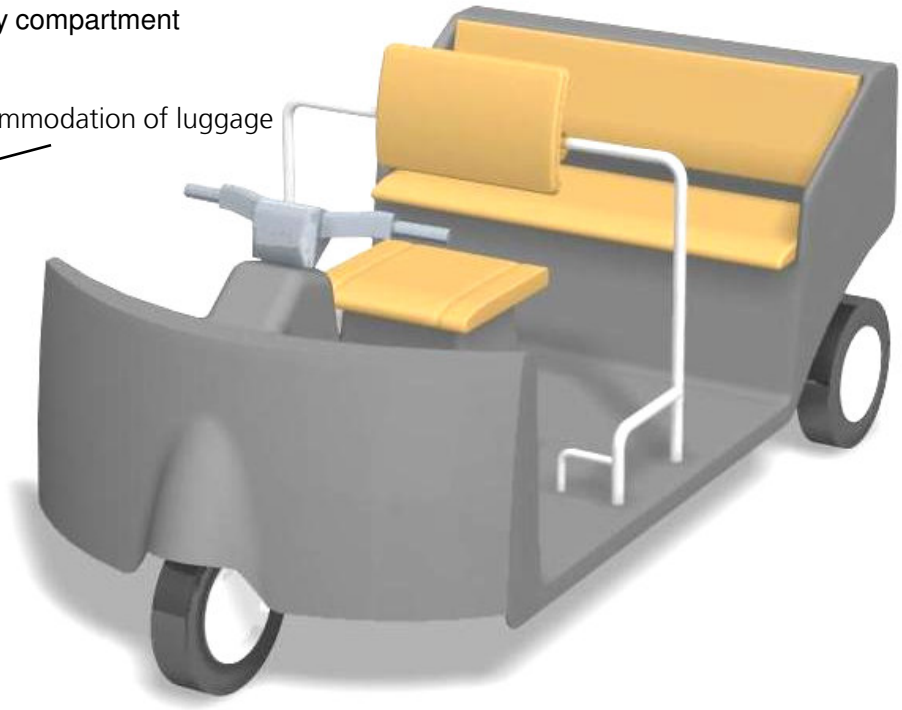
The proposed layout of the load floor, with all the base components placed at their positions, is as shown below. As you can see the grab bar not only acts as a support but also acts as a restrainer for the luggage to be kept besides the driver's seat. The battery compartment is placed below the passenger seat and the batteries, in stacked form, can be pulled out and kept for charging.



Battery compartment

Space for accommodation of luggage



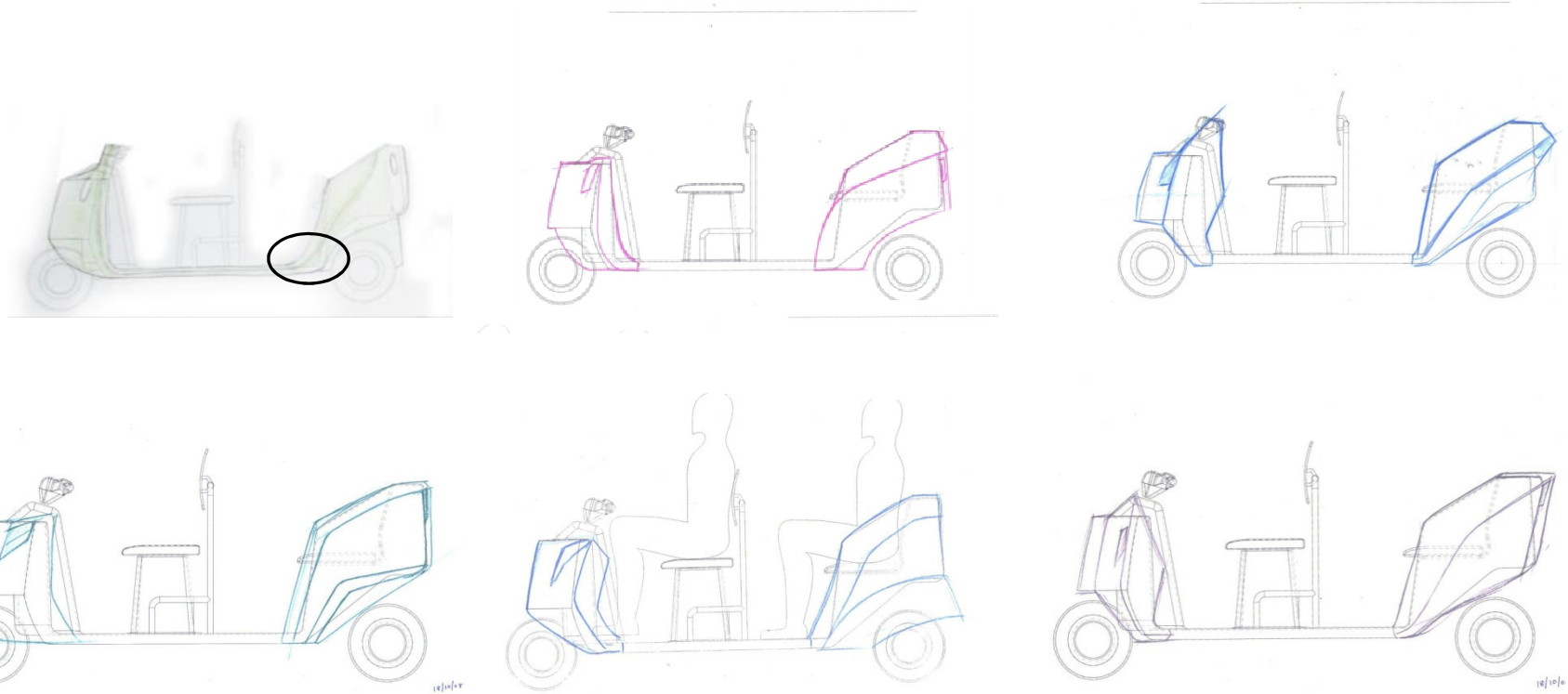


9.12 Exterior Re Styling

In this step, since all the basic dimensions were defined, the styling of the vehicle was reconsidered.

Other than the earlier image board a few more images were taken into consideration as the inspirations for the restyling of the vehicle. Few important features taken into considerations were the facets that are more prominent in any design of a vehicle had to be included in the new design.

For re styling the concepts only the lower portion of the design was taken into consideration for better concentrated work. Initially an important observation came into consideration i.e., the encircled portion led to be very narrow and caused a hindrance in the styling of the vehicle. Thus the length and wheelbase of the vehicle was increased by 150mm



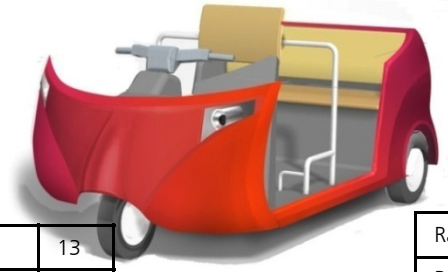
9.13 Concepts

Few of the earlier made sketched were converted into renderings, both Photoshop as well as hand renderings, basically to visualize the concept in s better manner.

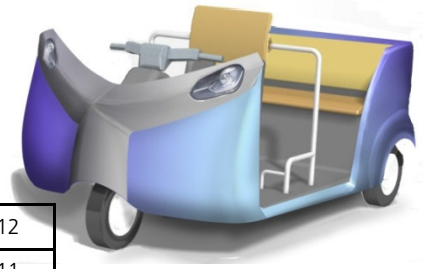
These were later evaluated under the attributes. The self rating of the concept was done as well as by few of my colleagues for validating

From all the concepts the last concept was taken into consideration as it had the most important feature of most of the modern vehicle design, the facets around the body, which made it look interesting and also unique.

Rating (Self)	12
Rating (others)	11

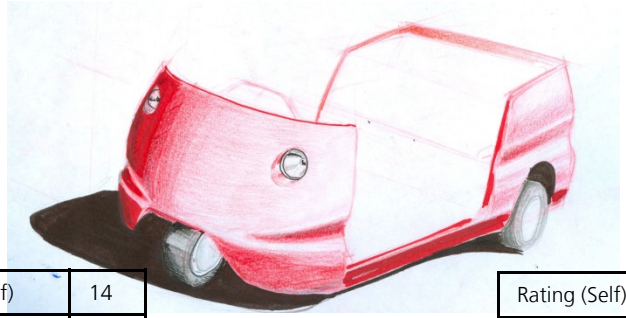


Rating (Self)	13
Rating (others)	11

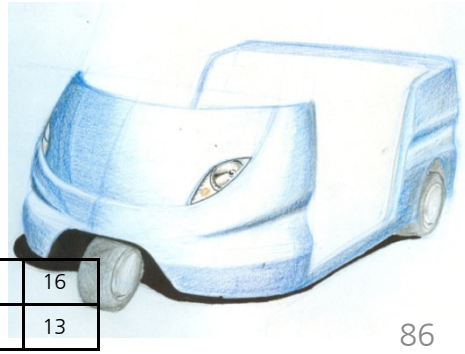


Rating (Self)	12
Rating (others)	11

Rating (Self)	10
Rating (others)	11



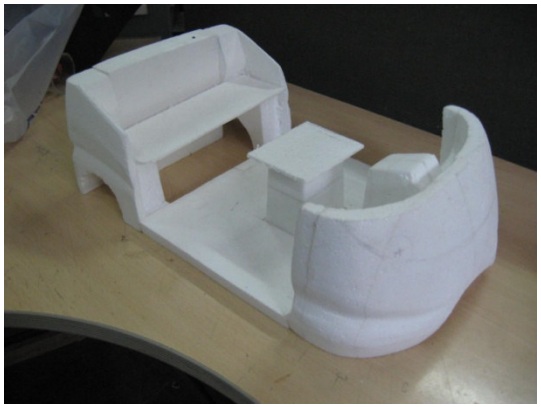
Rating (Self)	14
Rating (others)	12



Rating (Self)	16
Rating (others)	13

9.14 Selected Concept

The earlier selected concept was later on worked upon in Photoshop and few exploratory models were made basically to understand the inclusion of few design features on the front surface

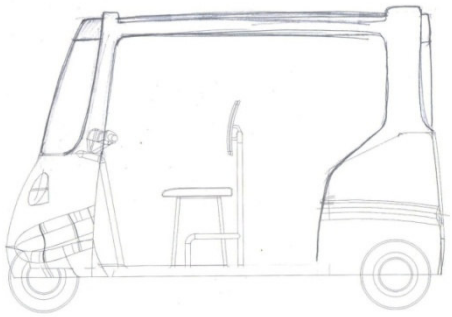


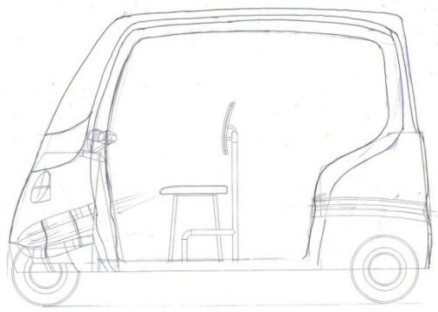
Later on these concepts had to be worked upon for the styling of the upper body. This basically consisted of making different options which could blend well with the lower portion

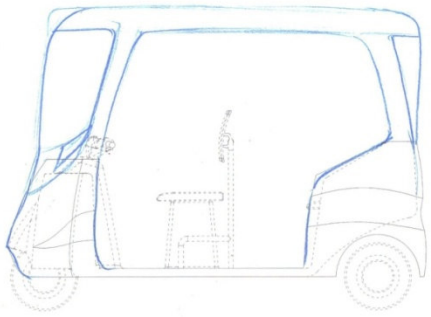
9.15 Complete styling of the vehicle

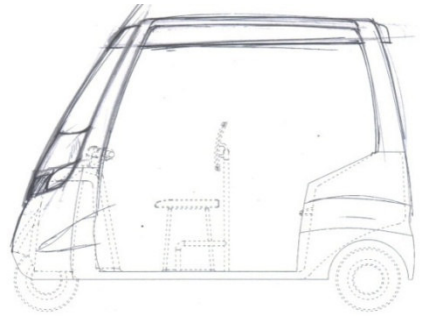
The following are the concepts developed on the basis of the earlier finalized lower body design. These concepts are made on the lines of the attributes as mentioned earlier and also carry a unique identity for an auto rickshaw.

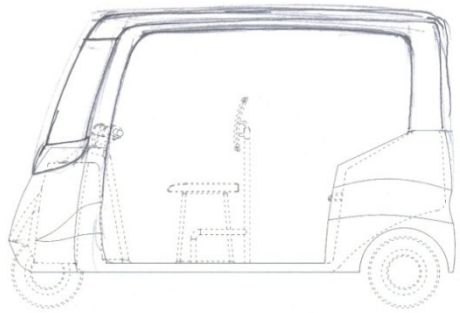
Based on them a few rendering were made to understand the concept and basically to realize them in a better way









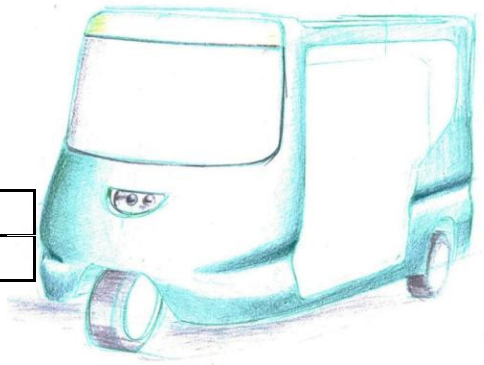


The following are the few selected renderings of the earlier defined concepts.

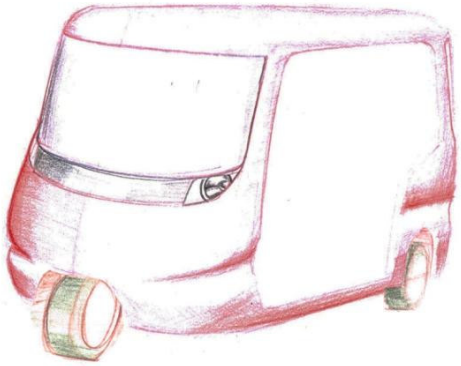
On the lines of these concepts, for better understanding, few exploratory models of the scale 1:5 were tried out in thermocol, while these concepts were rated according to the rendering.

Rating (Self)	14
Rating (others)	10

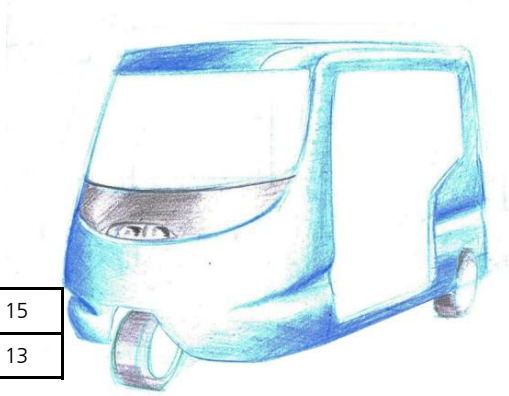
Rating (Self)	13
Rating (others)	11



Rating (Self)	13
Rating (others)	9



Rating (Self)	15
Rating (others)	13



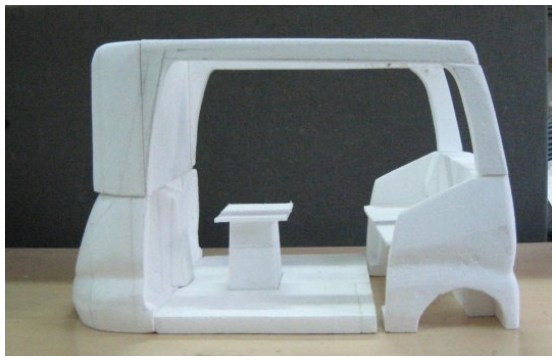
9.17 Mock up model

Various exploratory models of the concepts were made to understand the form in a better way at the same time experiencing it.

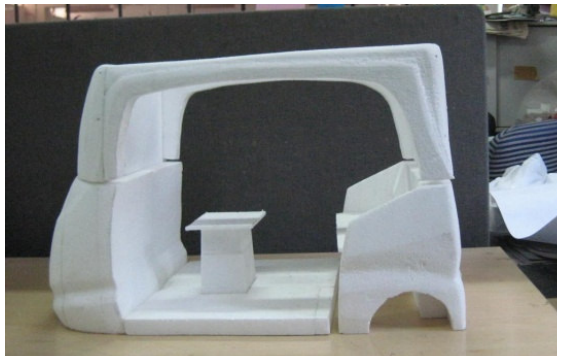
The images of the mock up models are shown in the next page

From all these exploratory models of the concepts the last models is selected as the final concept as it has all the other features as organic form due to the way the lines flow around the wind shield area and also around the lower portion including the front lower end where the wheel is going to be positioned Other than these points the angular positioning of the roof portion makes it much more dynamic and as if the whole of the design gets concentrated onto the front point.

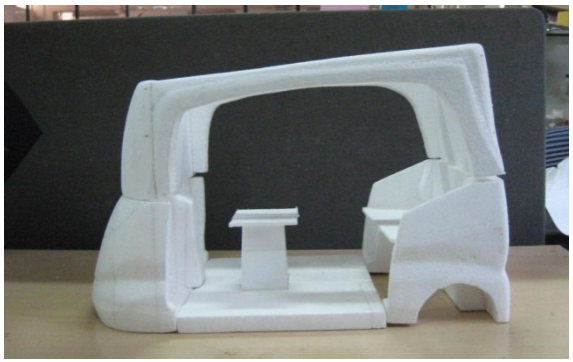
Option 1



Option 2



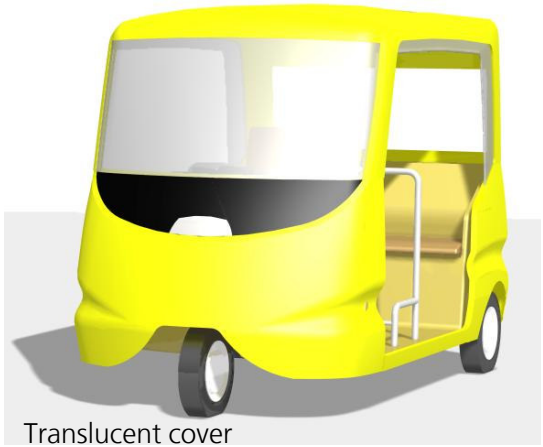
Option 3



The final concept

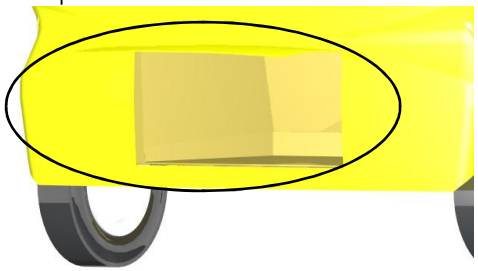
The finalized concept rendering is as shown below and has all the features of the attributes as organic, radical and futuristic. The lines in the front as well as the side panels follow an organic form. The design has a narrower upper portion and broadening lower portion as well as the whole form merges in to the front point making it fell dynamic.

Features like the headlamps, are unique with twin individual members placed in a single housing making the design interesting. The overall form of the vehicle does not carry the essence of the current rickshaw designs but have interesting facets, most prominent in the lower portion, making the design unique. The front of the rickshaw is more like the fairing of a motorbike hence making it look much more sleek.



Translucent cover

Battery compartment



The final proposed concept

Design:

The proposed concept is based on the lines of the attributes defined earlier and majorly is based on ‘organic’, ‘futuristic’ and ‘dynamic’.

The concept is based on the design insights mentioned earlier i.e., the luggage space has been relocated into the front besides the driver’s seat. The leg room and the roof height have been increased for comfortable seating for all sized people. For better illumination, the rear has large vertical glass and the side covers are kept minimal for increased natural illumination in day time.

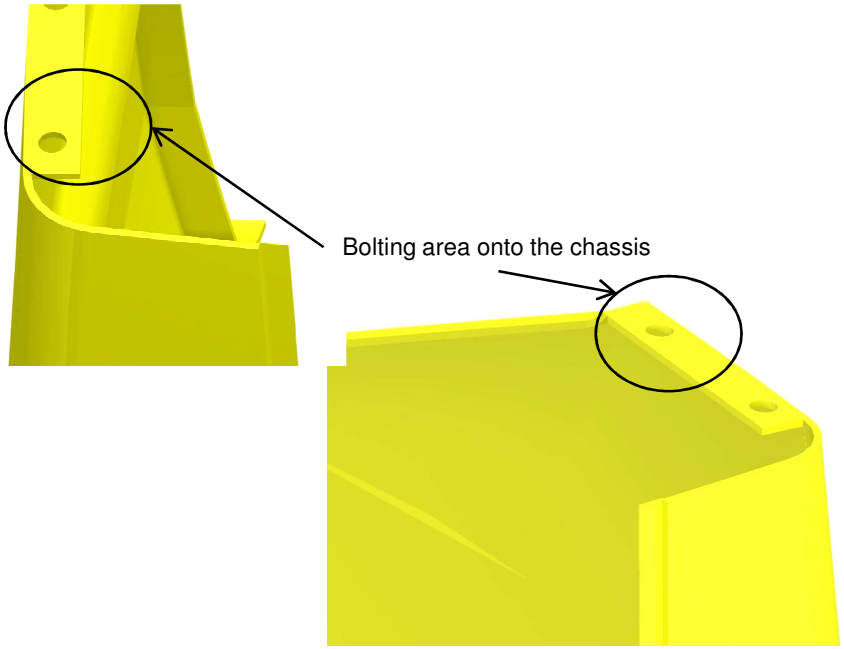
A translucent cover is provided around for enhancing the natural illumination and also acting as a barrier from sun and rain. The soft rexin roof has been replaced by low weight composite material so as to make it feel rigid as well as it is positioned in an inclined manner for enhancing dynamic nature of the design

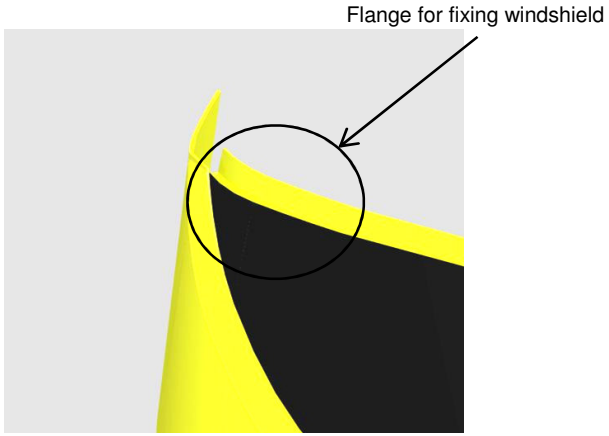
Mock up model

Material and manufacturing:

The material selected for the final product is smc and the components are manufactured under compression molding for better surface finish and good strength.

The whole vehicle(exterior panels) will be made in different pieces, suiting the manufacturing process, and are bonded, using special bonds used in composite materials. But at the major joining areas, the components are bolted to the chassis i.e., the front panel and the rear body panels

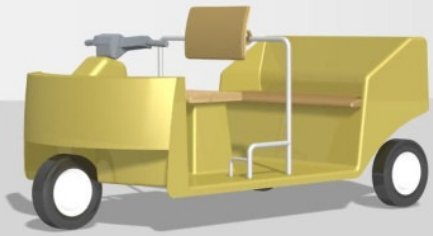




Stages of assembly

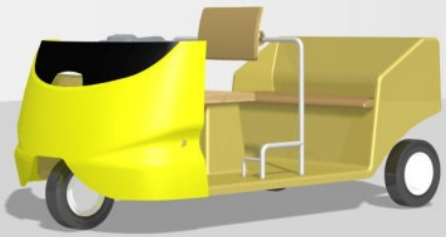
The different stages of assembly of the components of the rickshaw are as shown below

1



The basic chassis with interior components

2



Fixing of the front panel

3

Fixing of the rear side panels

4

Fixing of the rear panel

5

Bonding of the a pillars

6

Bonding of the rear pillars

7

Bonding of the roof

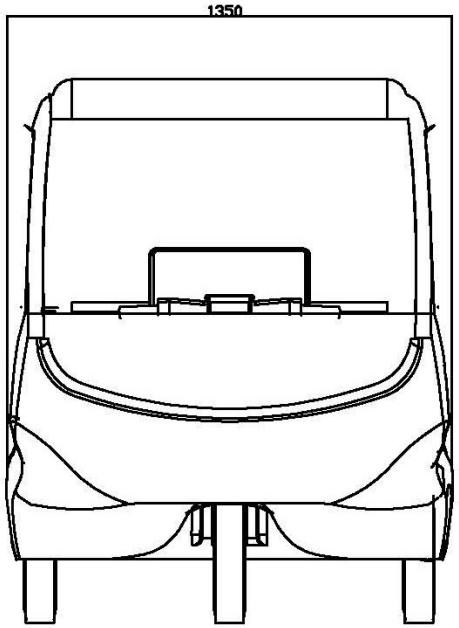
8

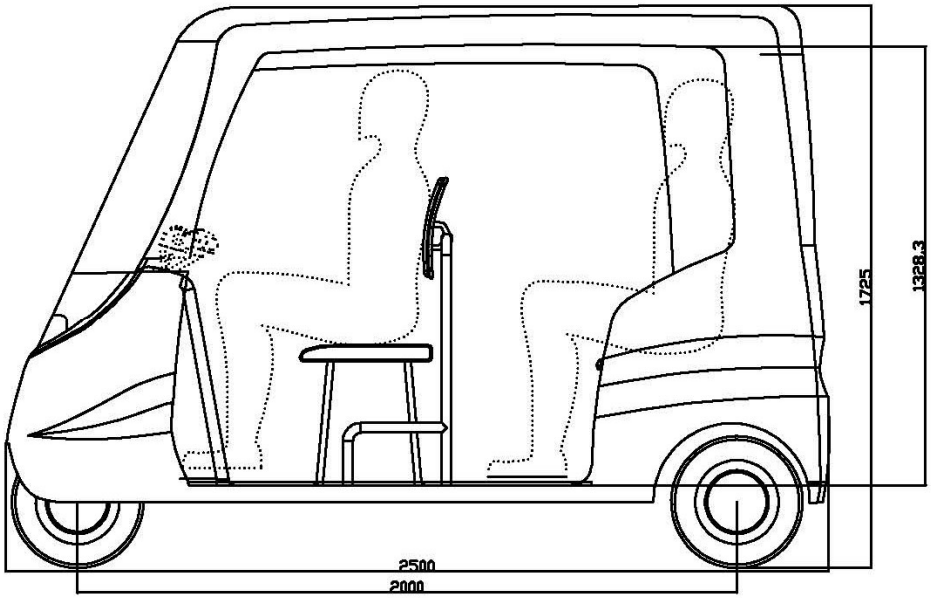
The final design with all panels fitted

The final drafted layout of the concept is as shown below.

As proposed earlier the dimensions are as follows:

L	2500mm
W	1350mm
H	1725mm
WB	2000mm





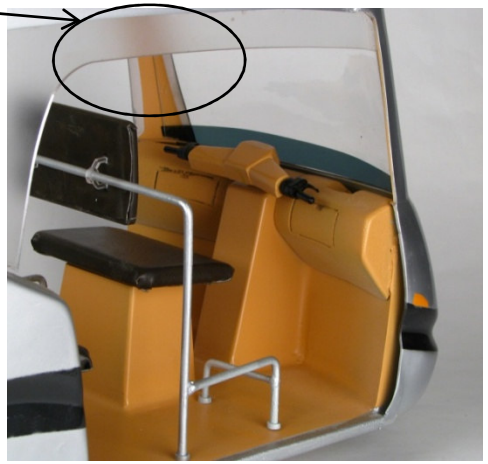
The form

The final form of the rickshaw is as shown aside. The final model was made in 1:5 scale. The colour selected for the model was silver and metallic black as it suites well in almost all environments due to the sober nature of the colour combination.

The interior is coloured in a shade of beige to show case the rich feel and comfort of the spacious interiors. This enables the rickshaw to be identified as a quality mode of transportation and not just any cheap mode of transportation.

The current design had a few shortcomings as the translucent sheet provided along the entrance could cause hindrance during ingress and egress for a tall passenger. This issue had to be solved and thus the modified design is as shown in the next page.

Translucent sheet causing hindrance

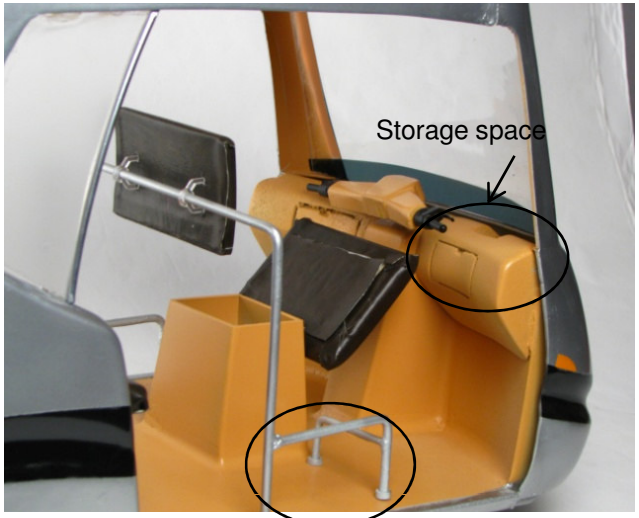


The final model ‘E-lax’

The modified design is as shown besides. The full translucent cover is replaced by just a cover near the rear seat bench to provide side support for the passenger while seated. A bent metal rod is provided to support the translucent cover and also to increase the visual strength of the cover portion.

The design features a compact headlamp to provide ample illumination in urban traffic and also to keep the consumption of battery charge minimal. The turn indicators and tail lamps are also compact and minimal.

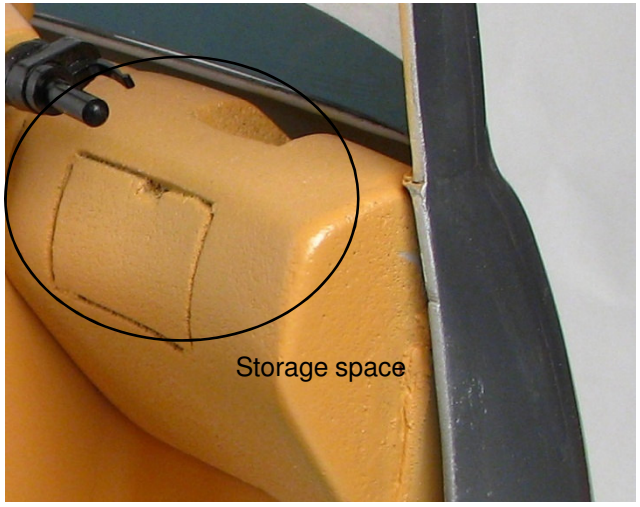
The interiors



The interior has loads of storage space for the driver as well as for passengers. The luggage space is relocated from rear to front. This provides the passengers with a sense of security about their luggage.

The driver has several closed storage boxes on the dashboard to accommodate important things i.e. documents, etc.,. Also there is a high volume compartment below the drivers' seat which can be accessed by lifting the seat.

The rickshaw is named 'E-lax' which is an acronym of 'Electric' and 'relax'. This is so because the USP of the vehicle is the abundance of comfort in form of physical space and rich feel due to innovative interiors for an auto rickshaw and also the least running cost due to electric power source



11. Appendix

User study form

For passengers

Name:

Situation when rickshaw preferred:

Frequency of usage:

Weather and usage relation:

Maximum distance traversed:

Any vehicle owned:

Reason for hiring a rickshaw:

Problems faced:

As a passenger:

As a pedestrian:

Suggestions:

For drivers

1. Name:
2. Place:
3. Distance of working area from home:
4. Vehicle using:
5. Period of usage:
6. Owner:
7. Total cost of the vehicle:
8. Running cost:
9. Mileage:
10. Average distance covered in a day:
11. Maximum and average distance of one trip:
12. Parking during non working hours:
13. Maintenance problems:
14. Effects of weather:
15. Mobile phone:
16. Rules(Union):
17. Luggage(Limit):
18. Problems faced:
19. Suggestions:

Date:

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