

DEP702  
M.DES PROJECT 2 REPORT

---

# DESIGNING AND BUILDING A BAMBOO E-RICKSHAW

---

Submitted by:

**Arka Hazra – 216390008**

Mobility and Vehicle Design

Guide:

**Prof. Nishant Sharma**

IDC School of Design

Indian Institute of Technology, Bombay

**IDC** School of Design  
अभिकल्प विद्यालय

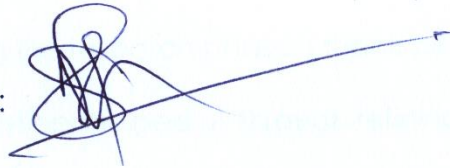



---


## APPROVAL SHEET

---

The Mobility and Vehicle Design project report entitled 'Designing and Building an E-rickshaw' by Arka Hazra is approved in partial fulfilment of the requirement for the Master's degree in Mobility and Vehicle Design.

Guide: 

Internal examiner:  15/12/22

External examiner: 

Date: 15/12/22

## DECLARATION

---

I hereby declare that this written submission represents my ideas and my own words and any reference have been properly and correctly credited. I also have adhered to all the principles of academic honesty and integrity and have tried my utmost not to falsify, manipulate or fabricate any information. Any resemblance is a mere coincidence Any violation of the above will be the cause of disciplinary action by the institute and can also provoke penal action from the sources from which proper permission has not been taken, or improperly cited.

Name: Arka Hazra  
Registration no.: 216390008  
Date: 28.11.2022  
Location: IDC school of design, IIT Bombay

Signature: 

## ACKNOWLEDGEMENT

---

I take this opportunity to express immense gratitude to Prof. Nishant Sharma for his constant guidance and supervision over the course of this project. His eagerness to build a full-scale working prototype has always kept me on my toes. A special thanks to all those who provided worthy opinions and insights during the research phase. I thank all my friends at IDC whose critiques and suggestions helped us through refining my direction. And last but not least, my parents always motivated me and kept reminding me how important this project is.

Arka Hazra  
216390008

Mobility and Vehicle Design  
IDC, IIT Bombay

---

## ABSTRACT

---

Last-mile travel is that part of a journey that involves the movement of goods or people from a certain point of a journey to their final destination. It is the last part of the travel where it is difficult for the primary mode of transport to reach the drop-off location. The package can range from goods to living passengers. In India, the last mile travel has majorly been man-pulled rickshaws and fossil fuel-based motor vehicles such as rickshaws, taxis, minivans and trucks. These vehicles are very convenient and practical, but the only drawback is that they pollute the environment. So, to put a check on the pollution levels a switch is slowly being made from fossil fuel-based vehicles to electric vehicles, in this case, that go-to vehicle is an **e-rickshaw**. The market for e-rickshaw in India is very limited and is only restricted to local brands and companies, with one option from Mahindra which is meant to transport passengers. These small companies source components from Indian and foreign origin vendors, assemble them and sell them via a dealership network. One prominent issue with these vehicles is that they don't have any standardization or regulation guiding their manufacturing. The only regulation it has is the I-CAT regulations. Which simply states the overall dimension and speed limit of the vehicle. This is perhaps to bring them under the government's radar, as they were being illegally imported as components and parts from China at a very cheap rate. The primary focus of this project is to create a local alternative that is easy to manufacture, sustainable and green and can generate employment. The project focuses on designing a vehicle that can be adapted for multiple use cases, prototyping, building testing and refining a full-scale working prototype using bamboo as the primary structural material.

# CONTENT

a) Approval sheet-----	i	b. Persona (rickshaw driver) -----	31
b) Declaration-----	ii	c. Persona (bamboo craftsmen) -----	32
c) Acknowledgement-----	iii	d. Design brief-----	33
d) Abstract-----	iv		
e) Introduction-----	01	4. TECHNICAL DETAIL	
f) Context-----	02	a. Indian anthropometric data-----	35
g) Objective-----	05	b. ICAT regulations-----	36
		c. Packaging layout-----	37
1. RESEARCH AND ANALYSIS		d. Final packaging-----	38
a. Understanding the need-----	07	e. Technical elevation-----	39
b. About-----	12	f. Seat dimension-----	40
c. Possible areas of intervention-----	13	g. Seat design-----	41
d. Scope and craftsmanship-----	15	h. Technical packaging-----	42
e. Bamboo communities in India-----	16		
f. Bamboo properties-----	17	5. CONCEPT DEVELOPMENT	
g. Scope and challenges-----	18	a. Inspiration Board-----	44
		b. Ideation-----	45
2. PRODUCT STUDIES		c. Initial concept-----	49
a. Exploded view-----	20		
b. Visual coherence-----	21	6. CONCEPT MODIFICATION-----	51
c. Usability action-----	22	7. RENDERS-----	62
d. Material used-----	24	8. CONVERSION TO AMBULANCE-----	67
e. Aesthetics-----	25	9. CONVERSION TO CARGO-----	72
f. Insights-----	26	10. FEATURE DETAILS-----	75
		11. PROTOTYPE BUILDING-----	78
3. USER STUDY		12. SCALE MODEL-----	87
a. Interviews-----	28	13. BIBLIOGRAPHY-----	88

---

## INTRODUCTION

---

The basic idea is to **explore the pros and cons of using bamboo as a structural material to build an e-rickshaw**. The vehicle will run with the help of an electric motor. The power source will be a Li-ion battery positioned in the vehicle's middle section under the passenger and driver's seats. Proper wiring is to be done for unrestricted flow of current. It will also be well insulated to prevent a shortage. The motor will be mounted on the differential along with the rest of the drive system such as the wheels, hubs and suspensions, so, this is why the rear section below the passenger's seat will majorly be made of metal pipes. Other than this the corners and junctions will also be made of metal pipes. The dashboard system and the battery electronic components will be conventional. The battery compartment will be housing two batteries. One that will power the motor and the other that will be charged by the principle of reverse/ active charging which will also be used as a standby battery. This **should increase the vehicle's effective range and reduce the user's range anxiety**.

Another aspect is, **why Li-ion battery?**

This is because Li-ion batteries can store a larger amount of current in a smaller package as compared to dry or wet cells. For this reason, they are also expensive, but this can be compensated for in the long run as the investment in battery replacement from the user's side drastically reduces. The vehicle will be aesthetically pleasing and it should be desirable because without these two factors the product will not sell and this idea will be a failure, but it will be a very good exploration.

---

## CONTEXT

---

**Article name:** Death trap or economic miracle? Rise of e-rickshaws show safety should go beyond cars

**Author:** Author: Kushan Mitra 21 August 2022 10:32 am IST

**Source:** The Print (Monday, 28<sup>th</sup> November 2022)

To picture the context, we need to understand the present situation of e-rickshaw in India. On one hand, according to the **Society of Indian Automobile Manufacturers (SIAM)**, only 1823 units were sold in July 2022. However, on the other hand, the **Federation of Automobile Dealers Associations, or FADA**, which uses registration data from the Ministry of Road Transport and Highways' VAHAN portal, said that 25,984 such vehicles—this is counting only passenger e-rickshaws—were sold and registered in India last month. Just for comparison, the same data from FADA shows that only 16,708 units of petrol-powered passenger three-wheelers were sold last year. There are four aspects according to this article namely,

1. **convenience**
2. **cost**
3. **safety** and
4. how is it **operated** in a day

**Convenience:**

1. The flat nature of the terrain
2. The dire need for local transport

**Cost:**

1. The cost of operation per trip in an e-rickshaw is way less than the same in a conventional rickshaw (Rs. 40 for an e-rickshaw in place of Rs. 100 for a regular petrol or diesel rickshaw)
2. The e-rickshaws charge a flat rate of Rs. 10 on their route
3. The unit cost of an e-rickshaw is also less than that of the conventional rickshaw

**Safety and appearance:**

1. Built from lightweight steel and plastic
2. It appears as if it is assembled and there is no coherence in the design

**Operation:**

1. Few times these vehicles are seen being driven on the arterial roads
2. Sometimes at night the driver drives it with the lights turned off just to eke out a little more range

**From this article, it can be derived** that the vehicle needs to have a motor that has more torque so that it can pull easily on an inclined plane, it has to be able to maintain the existing low cost of operation, it should be built more robust, and some regulatory restrictions such as not allowing the vehicle to run on arterial roads mandatory switching the headlight at night time should be imposed.

## OBJECTIVES

---

My objective in this project is

1. **To build a robust and stable vehicle using bamboo as the primary structural material.**
2. **To devise a way to reduce range anxiety.**
3. **To design a vehicle that is usable under multiple circumstances.**

# I. RESEARCH AND ANALYSIS

---

# 1. UNDERSTANDING THE NEED

---

## Current scenario

Presently in India, the last mile vehicles are majorly bikes, auto-rickshaws, cars, taxis, minivans and trucks. All these vehicles either run on petrol or diesel. Though they are practical and convenient, one major downside is that they run on **fossil fuels**, hence they **pollute**. Some of the vehicles are big in size, so, they create **traffic congestion**. Also, the number of **private vehicles** that run on Indian roads is huge. And most of these vehicles only **carry 1-2 passengers** at a time. So, this basically means the vehicle is being **underused**. These situations can be countered by:

- **Promoting public commuting** – this will **reduce congestion** on the roads because the personal commute will be less
- **Battery-powered commute** – this will control pollution and help manage it at its source.

## Why an e-rickshaw?

- **E- rickshaw** is a slow and small vehicle with a passenger capacity of three – four and a driver. So, it can travel through narrow roads and passages. This makes more sense compared to a car which is considerably bigger.
- The **size** of an e-rickshaw is adequate because it is neither big like a car nor small like a bike so it can neither block the way nor get into very small passages respectively.

- **A battery-powered vehicle** can be an alternative to this problem. But one might argue that producing electricity also creates pollution. Even then it is justified because then we know the source of the pollution, which is one single source, so it can be managed accordingly.

## What is a bamboo e-rickshaw?

A bamboo e-rickshaw is a battery-powered vehicle with a structure that is made of bamboo.

**The keyword here is bamboo.**

### Why a bamboo e-rickshaw?

The reason I want to use bamboo as a construction material for vehicles are as follows,

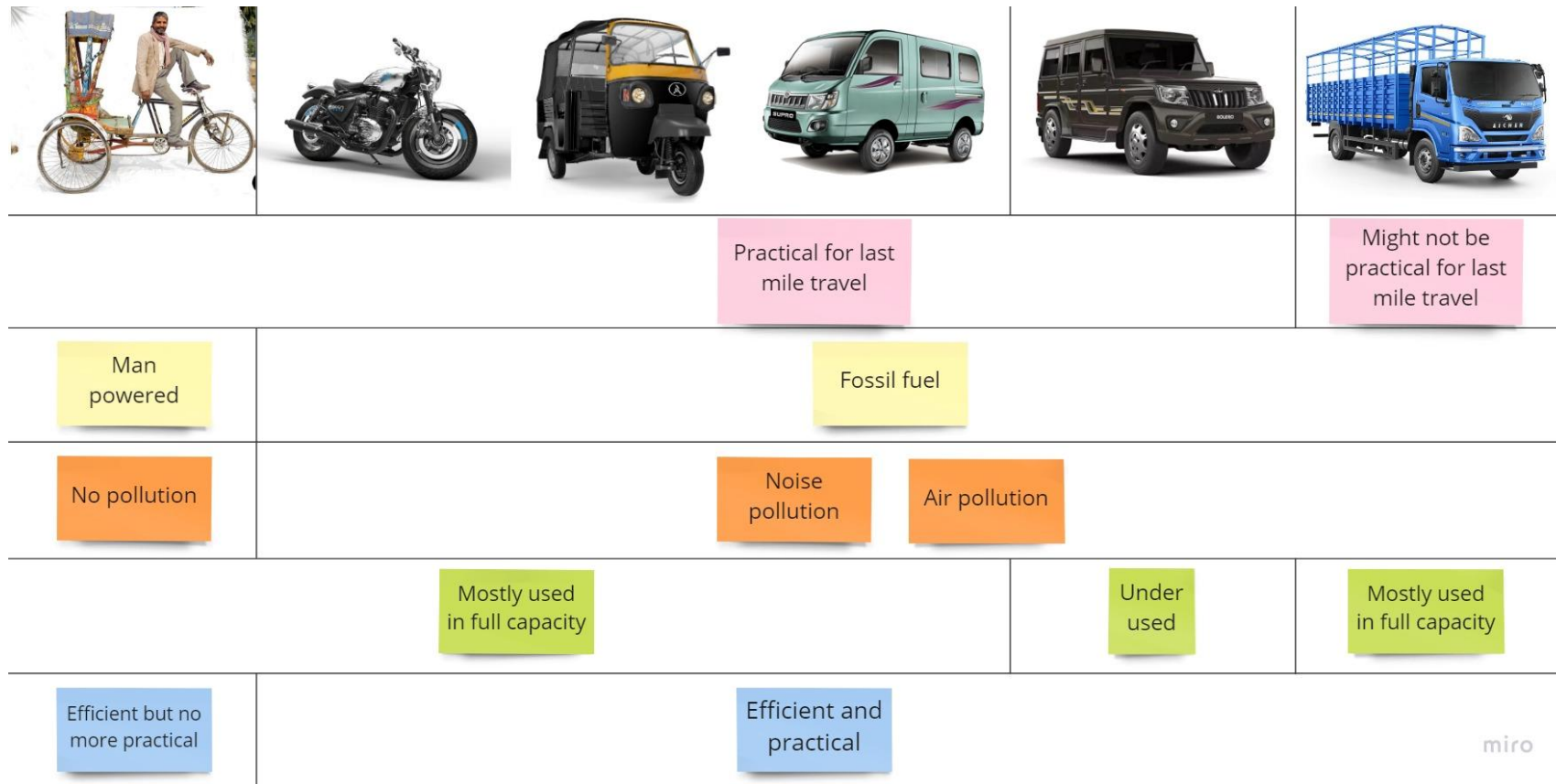
- it is sustainable as a material
- its processing has less carbon footprint directly or indirectly as compared to other alternative materials
- it is locally available
- it can be moulded and modified into desirable shapes
- it can be replaced easily with a fresh bamboo structure
- to include the bamboo communities in the mass manufacturing that will boost employment
- to explore new forms

- to explore the world of bamboo in automotive manufacturing
- to reduce the cost of production

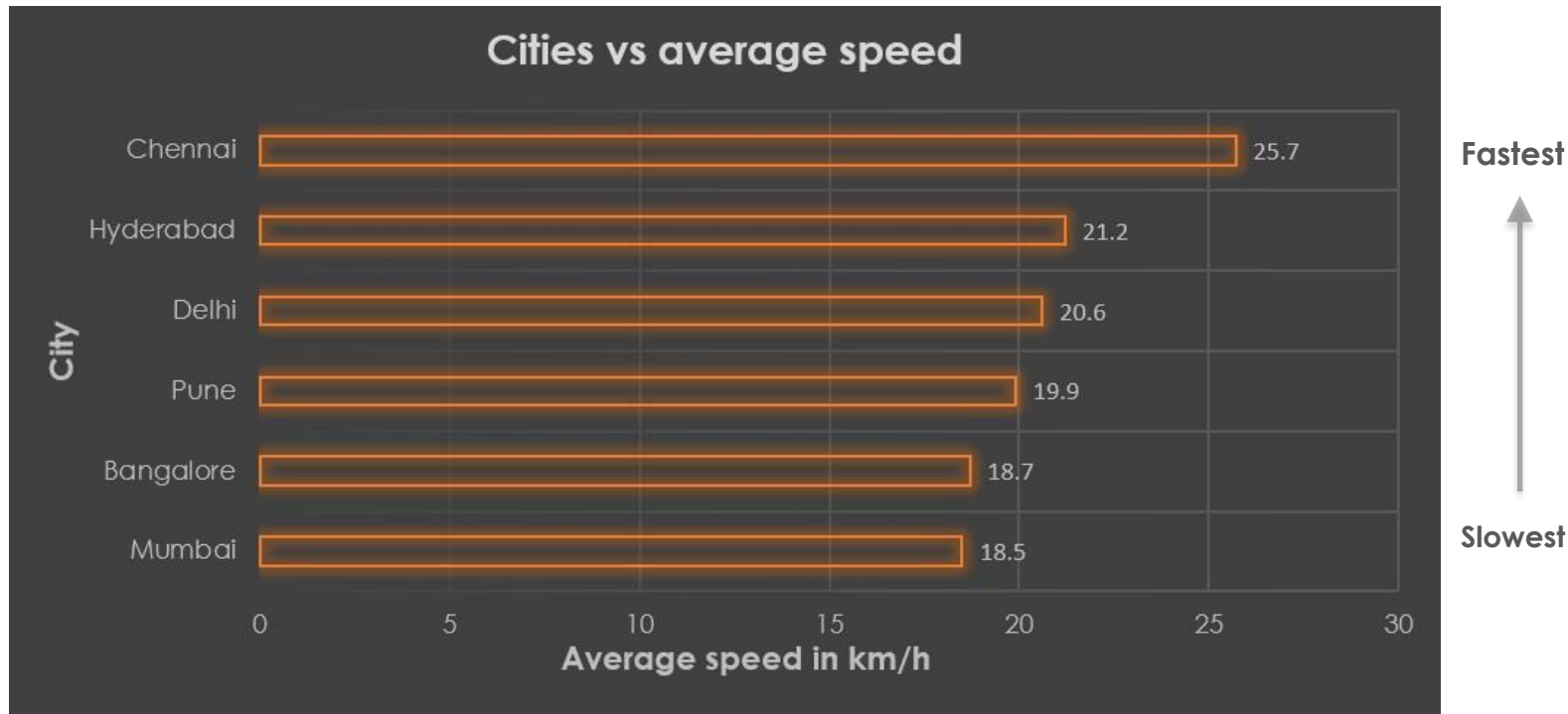
**Drawbacks of using bamboo:**

- Although bamboo is a green material that is widely available, people might be **sceptical** to use it in a vehicle. Because it is not easy to accept a material that is majorly used in furniture building and construction as a structural material for a vehicle. This limitation leads to making the structure **extra robust** and **strong**.
- Another drawback in the effect of climate. This can be avoided by treating the bamboo properly before using it.

**Figure – 1:** The chart shows how each category contributes to different factors associated with being sustainable and green



**Figure – 2:** The chart shows how the average traffic speed of each major city in India



Based on the above chart we can see that the vehicle categories mentioned earlier are underutilized. These numbers are taken during the commute hours in the respective places. **Slow speed** indicates that there is **a lot of application of the brake and clutch**. A repeated application of these means that the vehicle is **not running smoothly**, hence being underused. Only **1- 2 seats** in a car are filled at any time during peak hours which is around **25%** of the usable space, hence underused.

## 2. ABOUT

---

The project started as a 1st-semester project when we were introduced to the concept of last-mile travel by Prof. Nishant Sharma as an MD1 project. He explained to us the idea of Last mile travel and how is it important. As mentioned earlier, it is the means of transport where passengers go from a point where the primary means of transport ends to the destination doorstep. In India, there are many modes/ means to avail of this part of a trip, such as a taxi, auto-rickshaw, bikes, cars etc.

Being formally trained as an architect, I naturally had an inclination towards bamboo. So, it naturally occurred to me to try and use it in this project, and to explore the possibilities with this traditional material.

### 3. POSSIBLE AREAS OF IMPLEMENTATION

Here I have tried to explore the possible areas where this concept can be implemented and utilized to serve daily commuters.

Also, I have tried to figure out how my solution will cater to different segments of the demographics in **rural, urban and semi-urban areas** of India. To understand how this could be done we need to understand the problems related to each context.

Rural areas	Semi-urban areas	Urban areas
<ul style="list-style-type: none"> <li>• Less/ no traffic congestion</li> <li>• lack of basic public commute</li> <li>• Longer waiting time</li> <li>• Medical emergency</li> <li>• Personal commute</li> </ul>	<ul style="list-style-type: none"> <li>• Less/ no traffic congestion</li> <li>• lack of enough commute</li> <li>• Overloading of the vehicle</li> <li>• Longer waiting time</li> <li>• Personal commute</li> </ul>	<ul style="list-style-type: none"> <li>• Huge traffic congestion</li> <li>• They pollute the environment</li> <li>• Gridlock</li> <li>• Underused vehicles</li> </ul>
<p><b>The design can be implemented to improve all the above situations and reduce dependency on personal vehicles</b></p>		

Developing the solution that links all three areas together:

1. The **urban traffic scenario** can be improved by actively implementing the **bamboo e-rickshaw** which will be built by the **bamboo communities in the rural area**.

2. Similarly, the **semi-urban traffic scenario** can be improved by actively implementing the **bamboo e-rickshaw** which will be built by the **bamboo communities in the rural area**.
3. Building e-rickshaws in rural areas will generate employment for the bamboo community workers.

## 4. SCOPE FOR THE CRAFTSMEN

1. **Cultural flavour** - the rural bamboo workers can build these vehicles that reflect their style of work and the local art form.
2. **Income generation** - they will have employment throughout the years, increasing their income and improving their lifestyle.
3. **Round-the-year** work will be available for them.



# 5. BAMBOO COMMUNITIES IN INDIA

**o. SIKKIM (Jhokim)**

1. Arundinaria
2. Bambusa
3. Dendrocalamus
4. Melicope
5. Phyllostachya
6. Sasa
7. Sasa
8. Sasa
9. Sasa
10. Sasa



**u. UTTARHANDI (Duggam & Puzallati)**

1. Bambusa
2. Dendrocalamus
3. Sasa



**k. MEGHALAYA (Nongshingre & Umait)**

1. Bambusa
2. Bambusa
3. Bambusa
4. Bambusa
5. Bambusa
6. Bambusa
7. Bambusa
8. Bambusa
9. Bambusa
10. Bambusa



**l. TRIPURA (Zakhimogor)**

1. Bambusa
2. Bambusa
3. Bambusa
4. Bambusa
5. Bambusa
6. Bambusa
7. Bambusa
8. Bambusa
9. Bambusa
10. Bambusa



**EXISTING DESIGN**

**DENDROCALAMUS STRICTUS (Solid bamboo)**

Existing design can be incorporated



**e. UTTAR PRADESH (Kheong)**

1. Bambusa
2. Bambusa
3. Bambusa
4. Bambusa
5. Bambusa
6. Bambusa

**d. HIMACHAL PRADESH (Kangra)**

1. Bambusa
2. Bambusa
3. Bambusa
4. Bambusa
5. Bambusa
6. Bambusa



**m. ASSAM (Ho)**

1. Bambusa
2. Bambusa
3. Bambusa
4. Bambusa
5. Bambusa
6. Bambusa

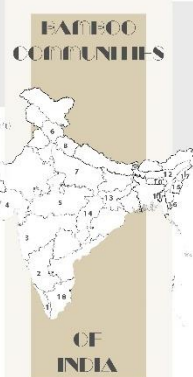
**EXISTING DESIGN**

**DENDROCALAMUS STRICTUS (Solid bamboo)**



**n. JHARKHAND (Dhagrad)**

1. Bambusa
2. Bambusa
3. Bambusa
4. Bambusa



**p. MADHYAPRADESH (BSP, Henc)**

1. Bambusa
2. Bambusa
3. Bambusa

**f. GUJARAT (Kanchhad)**

1. Bambusa
2. Bambusa



**EXISTING DESIGN**

**DENDROCALAMUS STRICTUS (Solid bamboo)**



**r. CHHATTISGARH (Durg)**

1. Bambusa
2. Bambusa



**EXISTING DESIGN**

**DENDROCALAMUS STRICTUS (Solid bamboo)**

Existing design can be incorporated



**q. MAHARASHTRA (Kheong)**

1. Bambusa
2. Bambusa
3. Bambusa

**s. MANIPUR (Chahoi)**

1. Bambusa
2. Bambusa
3. Bambusa
4. Bambusa



**t. MIZORAM (Shind)**

1. Bambusa
2. Bambusa



**EXISTING DESIGN**

**DENDROCALAMUS STRICTUS (Solid bamboo)**

Existing design can be incorporated



**h. KERALA (Puzallati)**

1. Bambusa
2. Bambusa
3. Bambusa

**v. NAGALAND (Chahoi)**

1. Bambusa
2. Bambusa
3. Bambusa



**i. KARNATAKA (Chahoi)**

1. Bambusa
2. Bambusa
3. Bambusa
4. Bambusa
5. Bambusa
6. Bambusa

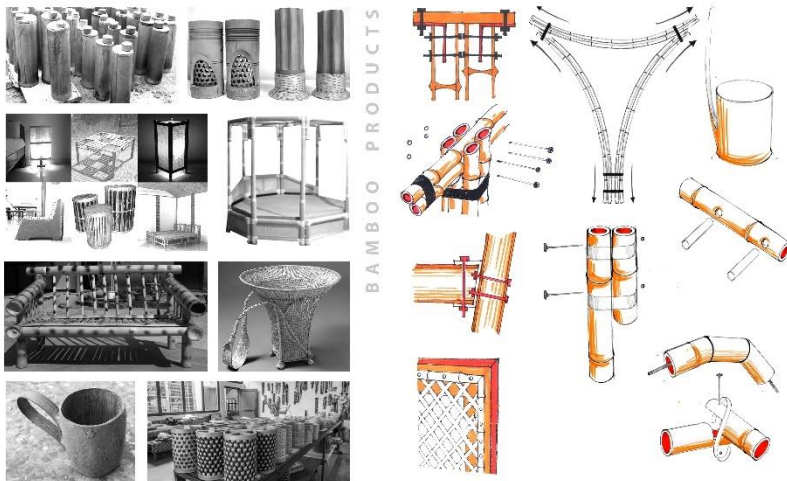


**EXISTING DESIGN**

**DENDROCALAMUS STRICTUS (Solid bamboo)**



## 6. BAMBOO PROPERTIES



BAMBOO PRODUCTS

BAMBOO JOINING

**PRODUCT TYPE**

All the products are static and stationary in nature, so they are not subjected to forces from multiple directions or from multiple directions but a dynamic product would experience. Therefore the joints that can damage the structure of the product is of the least.

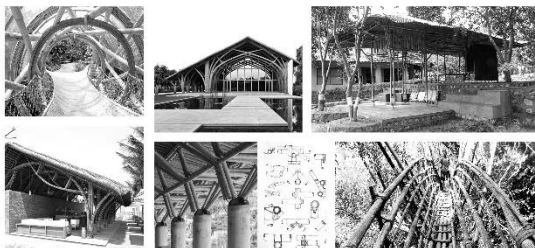
**ANALYSING THE PRODUCTS**

**a. Beels:**  
Full bamboo poles are not being used in any of the products because it is not easy to do so as the sections are difficult to handle a small form the outer surface of the belt. In case of the arches and the length is long enough to bend.

**b. Cuts & holes:**  
Whenever an other has cut to desired length or have been split to fit all as one whole pieces. Where there is a need to insert a split pole into a hole with a glue and wooden and the joint arrangement has been fixed from the outside.

**c. Joining:**  
1. Gluing  
2. Tying  
3. Cutting  
4. Inserting  
5. Knotting  
6. Reinforcement

**d. Material:**  
1. Bamboo  
2. Stone



---

## 7. SCOPE AND CHALLENGES

---

**SCOPE:** There are several scopes of the project that includes,

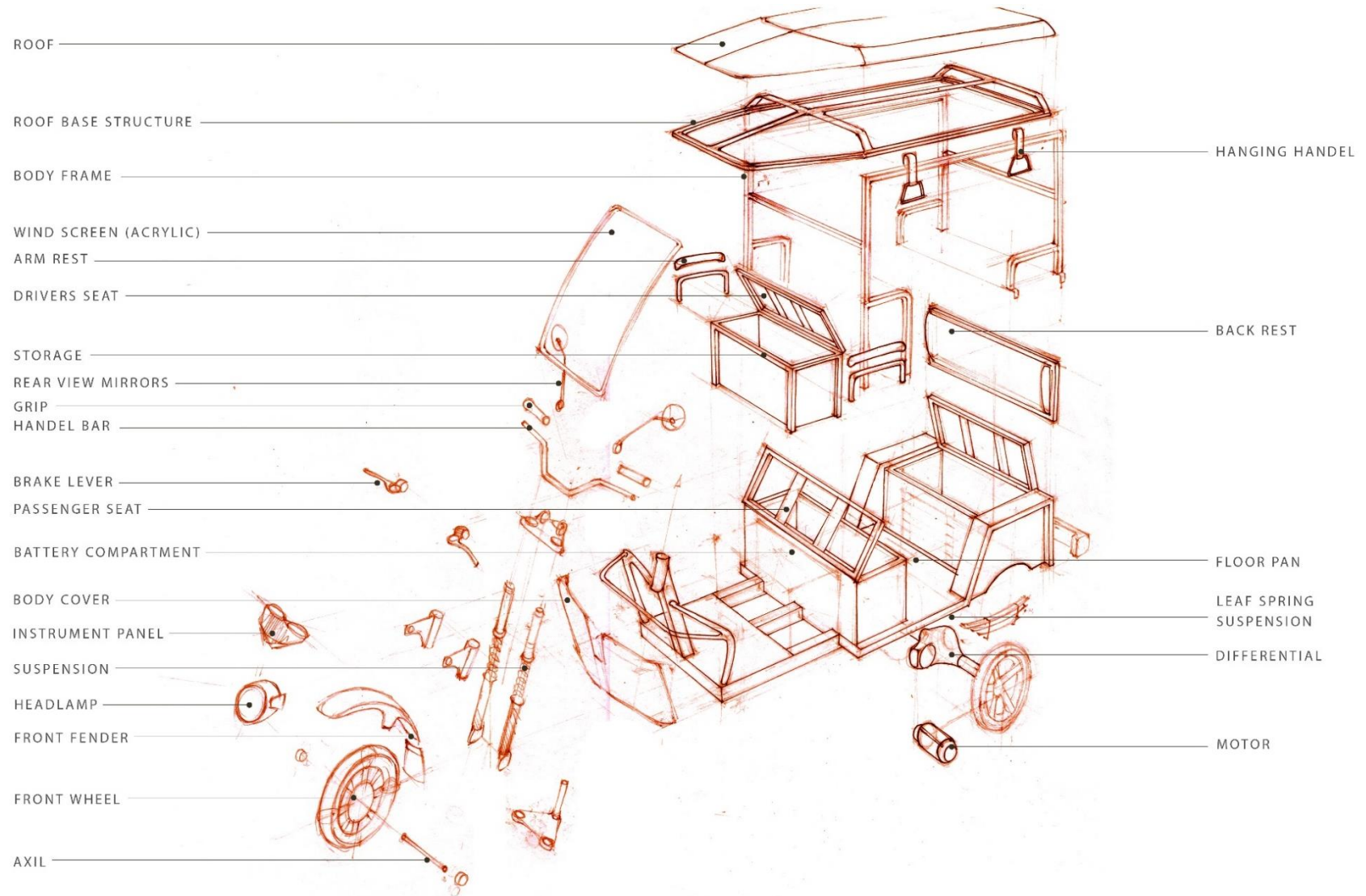
1. Building a **full-scale working prototype** of the vehicle
2. Preparing **variations** for different scenarios
3. Exploring the aspect of **bamboo as a structural material**
4. Exploring the aspect of **tool building** specific to bamboo vehicles
5. The possibility of **entrepreneurship** in bamboo vehicles
6. Building a bamboo **ecosystem** for vehicles
7. The design should follow the concept of **plug and play**
8. **Collaboration** between the community and institute

**CHALLENGES:** The associated challenges are as follows,

1. **Tool building** might be difficult and challenging
2. Bamboo **processing for vehicle** building might be difficult
3. Building an **ecosystem chain** might be difficult
4. The design should withstand the harsh road conditions
5. Completing the project in the available time frame

## II. PRODUCT STUDY

# 1. EXPLODED VIEW



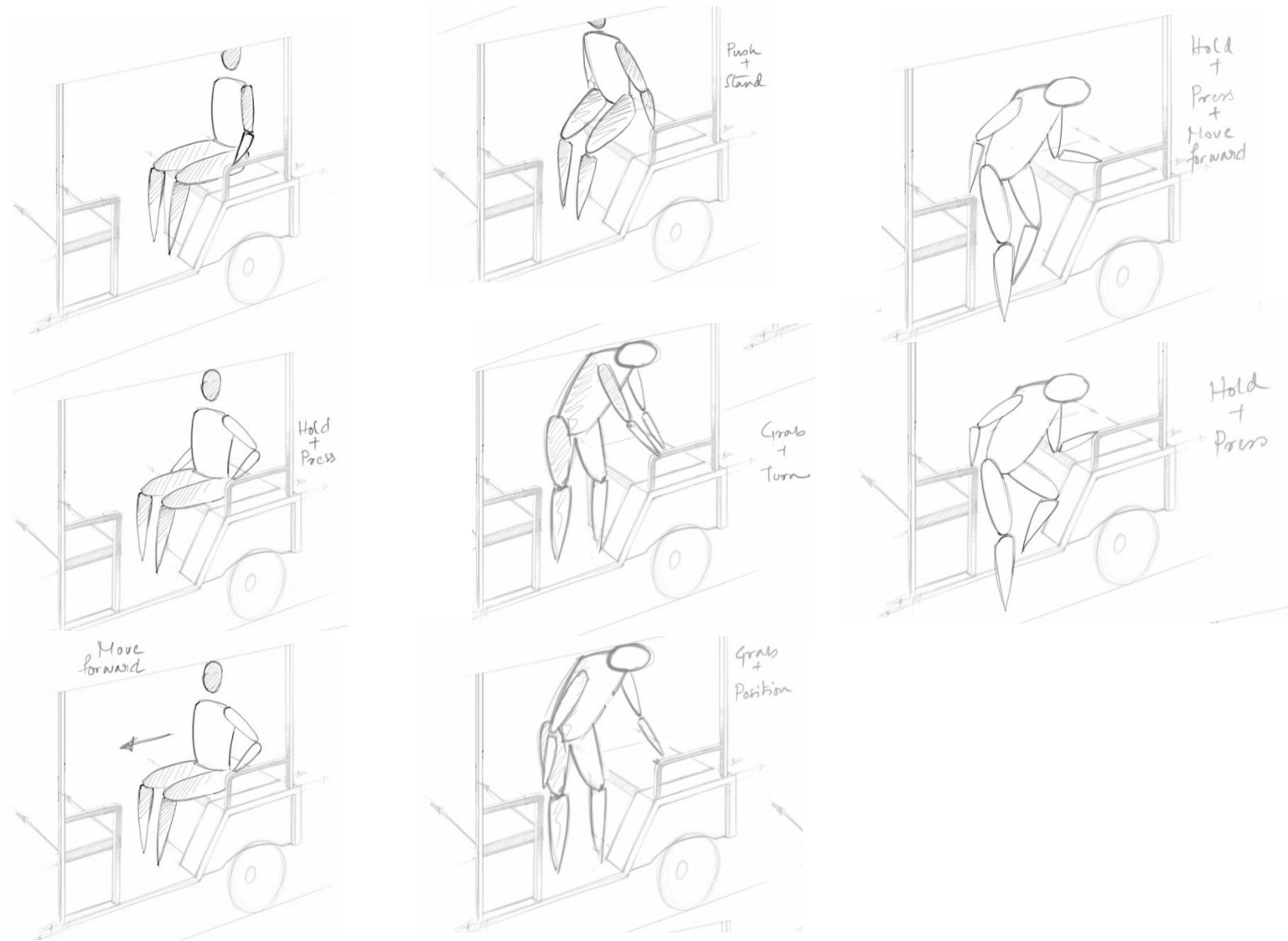
## 2. VISUAL COHERENCE

The adjacent images show that the existing product is not really designed. Because all the components do not have any visual similarity. The design language of each of these elements is different. They appear as if they are produced by different vendors and assembled at different places.

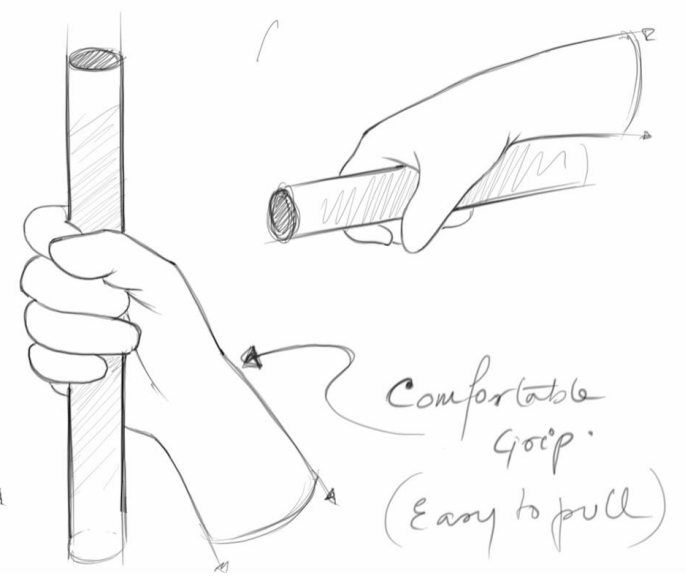


### 3. USABILITY ACTIONS

The action of egress is performed according to the following



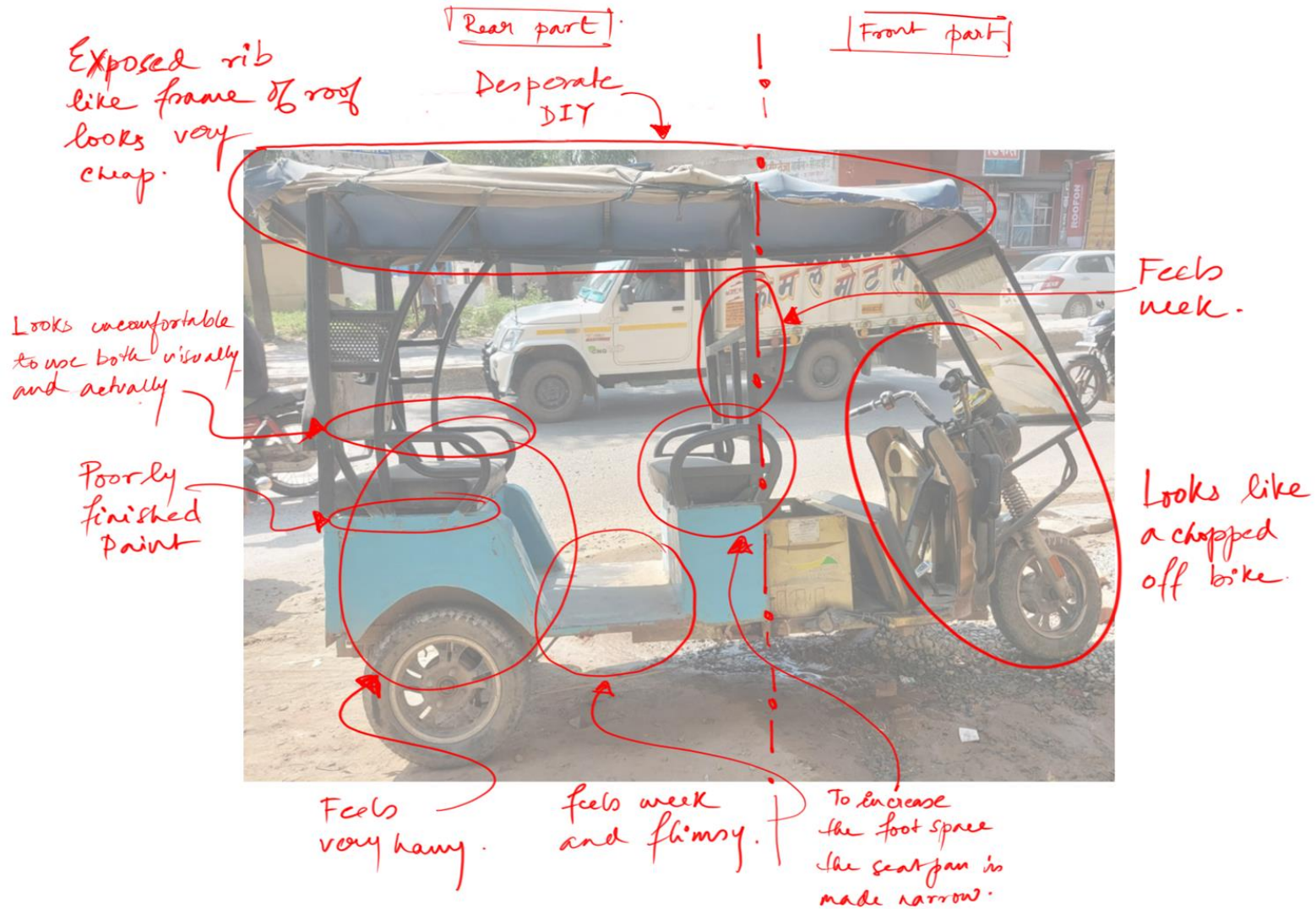
Which grip feels better and is more  
Comfortable for the user



## 4. MATERIALS USED



## 5. AESTHETICS



## 6. INSIGHTS

---

The above study shows the followings points

1. The vehicle is not designed as a whole
2. It is basically an assembly of parts from different sources
3. Ingress and egress are difficult for people of certain age groups because there are no defined handles or support
4. Reduced seat depth to allow increased knee space
5. There is no external charging port

## **III. USER STUDY**

---

# 1. INTERVIEWS

---

**Sample size** – is 24

1. **Driver** - 8 nos. (Male)
2. **Passenger** - 4 females (age 20-40), 2 females (age 40-60), 2 females (age 10), 4 males (50-70), 2malese (age 20-40), 2 males (10-15)
3. **Location** - Asansol, Kolkata, Durgapur. Alwar, Delhi, Faridabad
4. **Road conditions** - Asansol (rough and smooth), Kolkata (Mostly smooth), Durgapur (rough and smooth), Alwar (Rough & Smooth), Delhi (Mostly Smooth), Faridabad (Mostly Smooth)

## **User experience**

After having an informal discussion about a trip in an electric rickshaw with the above-mentioned sample size, the following are the observations that I noted.

These observations and experiences are most common and similar as all the samples were subjected to similar if not exact conditions.

- **Age group 40-70** (female and male) - 6nos.

Physical condition - None of them uses any walking aid

Three of the samples do morning walk on a regular basis

One female has a medical condition of spondylosis

- a. Difficulty / no difficulty during ingress and egress.
- b. Floor height is more than the normal stair riser height.
- c. Very little legroom.
- d. Luggage space is missing.
- e. Cannot withstand heavy jerks and hard braking.
- f. Seats are uncomfortable (meaning they are hard)
- g. Seating causes back pain (meaning upright seating posture)

- **Drivers' perspective**

Physical condition - None of them uses any walking aid

None of them does any exercise on a regular basis

None of them has any medical condition

Any brand (Mahindra e alfa, a big bull, Mayuri, Lohia, Jangid etc.)

- a. No difficulty during ingress and egress.
- b. Believes the vehicle is more reliable than other locally assembled brands
- c. Does not have an extra battery
- d. Cost is the primary concern:
  - On-road price - 1,42,000

- Price with interest - Rs. 1,54,000
- Down payment - Rs. 72,000
- EMI - Rs. 3,416 (Duration 24 months)
- Rs 250 / day maintenance at an average
- Average charging time
  - ❖ When new - 5 hrs. - 6 hrs. (6 - 7 units daily)
  - ❖ 5-6 months old - 8 hrs. - 10 hrs. (8 - 9 units daily)
  - ❖ 3-4 years old - 12-14 hrs. (10 -12 units daily)

- **Charging cost**

At Asansol

When new

Unit cost - Rs. 8 at an average

Daily charging cost -  $8 \times 7\text{hrs} = \text{Rs. } 56$

Weekly cost -  $56 \times 7 = \text{Rs. } 392$

Monthly cost -  $392 \times 4 = \text{Rs. } 1,568$

When 3 - 4 old

Unit cost - Rs. 8 at an average

Daily charging cost -  $8 \times 14\text{hrs} = \text{Rs. } 112$

Weekly cost -  $112 \times 7 = \text{Rs. } 784$

Monthly cost -  $784 \times 4 = \text{Rs. } 3,136$

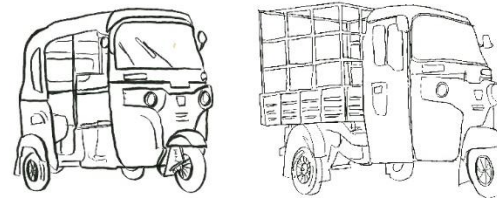
## 2. PERSONA (RICKSHAW DRIVER)



Rajan wants to become an independent Auto Rickshaw driver. He wants to purchase an Auto rickshaw that is

- AFFORDABLE
- CONVINIENT TO RIDE
- MAINTAINANCE

He compares these parameters when he is selecting the rickshaw  
He Realises:

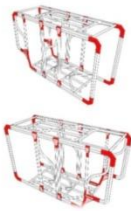


STANDARD FOSSIL FUEL RICKSHAW

- ✗ Fuel price High↑
- ✗ Difficult to maintain
- ✗ Undesirable aesthetics
- ✗ Less no. of seats
- ✗ Not meant for multiple uses

✓ MULTI PURPOSE USE

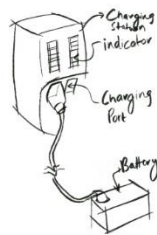
→ Seats can be arranged/folded to convert from passenger to Cargo load.



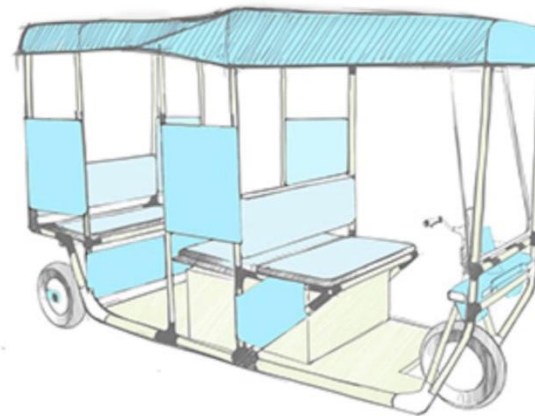
✓ SUBSCRIPTION MODEL

→ Replace body every 4-5 years by Service Provider

✓ CONVINIENT CHARGING PORT



→ Can charge from any electric Port




- ✓ LESS COSTLY THAN A STANDARD AUTO RICKSHAW
- ✓ ELECTRICITY POWERED So it is convinient to refuel.

BAMBOO E-RICKSHAW

Rajan decides to purchase the Bamboo e-Rickshaw.

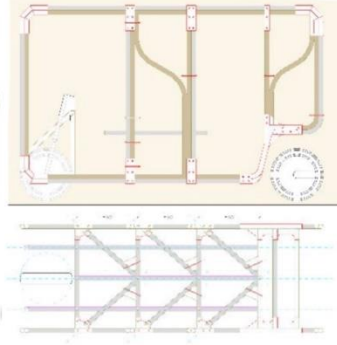
### 3. PERSONA (BAMBOO CRAFTSMEN)



PANKAJ & DEEPTI, bamboo artisans make & sell bamboo products for a living. They have done this their whole life.

They are looking for another source of income when bamboo Craft sales are not in demand.

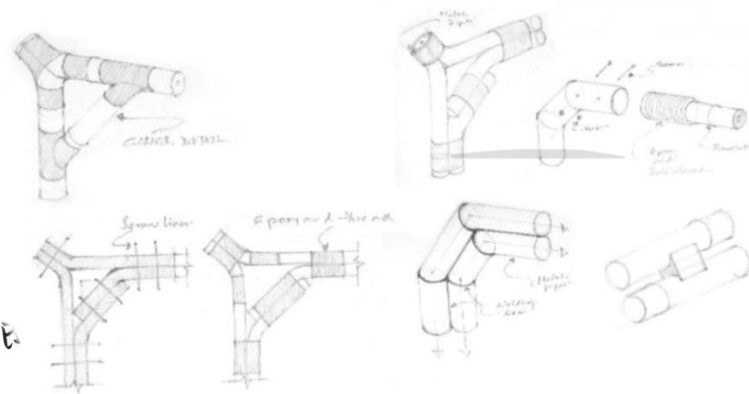
They come to know about a manufacturing company that makes AUTO-RICKSHAW OUT OF BAMBOO,



The company provides

① INCOME SOURCE FOR WHOLE YEAR

② EASY TO LEARN TECHNIQUES OF BAMBOO JOINERY & STRUCTURE



③ CONVENIENCE TO WORK FROM OR NEAR HOME

THEY ARE DELIGHTED BY THIS OPPORTUNITY & TAKE THE JOB IMMEDIATELY.

## 4. DESIGN BRIEF

---

**To design an e-rickshaw that is made of bamboo as a structural material and that serves as a multipurpose vehicle for rural and semi-urban areas.**

The idea is to design a vehicle that can be converted/ switched from one type to another by making very small change/s. This will bridge the gaps that are there in the rural and semi-urban areas in terms of public transportation, waiting time and the categories of vehicles available for the public. Doing the conversion from one type to another should be achievable through a minimum number of steps and in the least time possible because only then the concept will be viable.

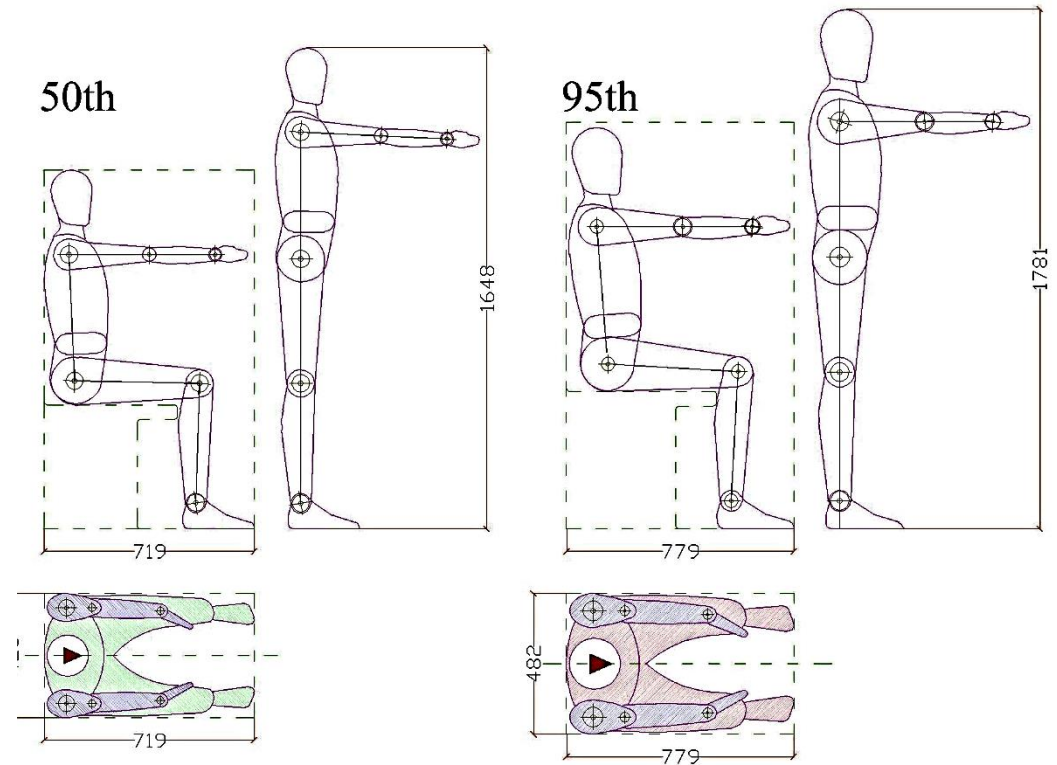
## **IV. TECHNICAL DETAILS**

# 1. INDIAN ANTHROPOMETRIC DATA

**Figure – 3:** The chart shows the dimensions for 50<sup>th</sup> and 95<sup>th</sup>-percentile humans

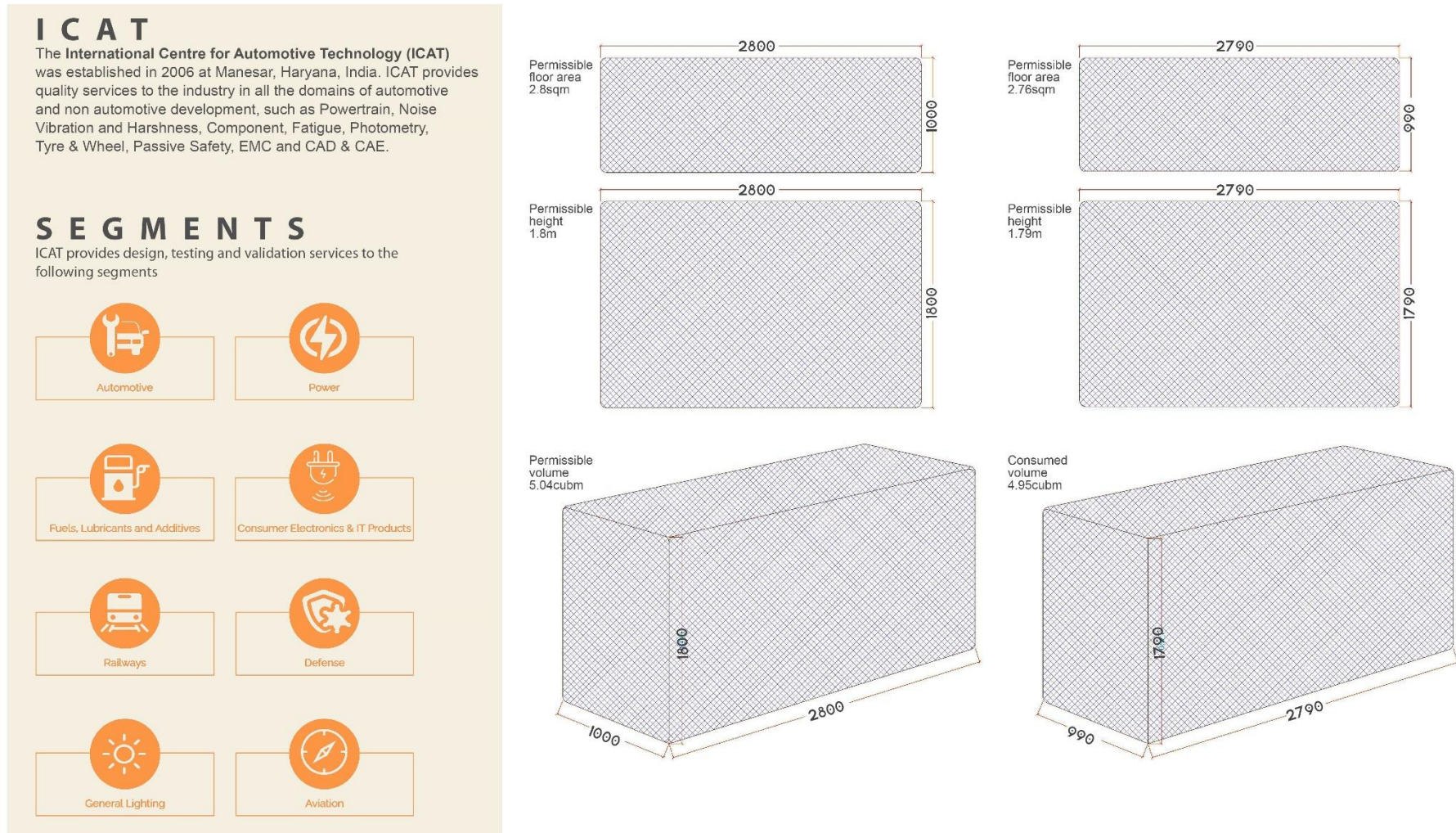
	MEASUREMENTS	PERCENTILE		REMARKS		TYPE
		50th	95th	FROM	TO	
<b>SEAT DIMENSION (PAN &amp; BACK REST)</b>						
1	Total height	1648mm	1781mm	Floor	Top of head	Height
2	Erect sitting	837mm	905mm	Seat pan	Top of head	Height
3	Cervical	616mm	670mm	Seat pan	Bottom of the part	Height
4	Eye level	738mm	805mm	Seat pan	Middle of eye	Height
5	Knee level	519mm	567mm	Floor level	Top of knee	Height
6	Elbow rest	213mm	270mm	Seat pan	Bottom of elbow	Height
7	Lower lumbar	101mm	156mm	Seat pan	Top of the part	Height
8	Upper lumbar	300mm	354mm	Seat pan		
9	Acromion	551mm	608mm	Seat pan		
10	Elbow to elbow closed	409mm	489mm	One side	Other side	Width
11	Hip (width)	331mm	405mm			
12	Bi-deltoid	426mm	482mm			
13	Buttock to popliteal	455mm	512mm	Buttock	Popliteal	Depth
14	Popliteal height	425mm	471mm	Floor level	Popliteal	Height
15	Buttock to front foot	719mm	779mm	Back	Front foot	Depth
<b>HEAD REST</b>						
1	Ear to ear	147mm	157mm	One side	Other side	Width
2	Head rest height	837-616	905-670	Cervical	Top of head	Height
		221mm	235mm			
		Average - 228mm				

**Figure – 4:** The diagram shows the dimensions as used



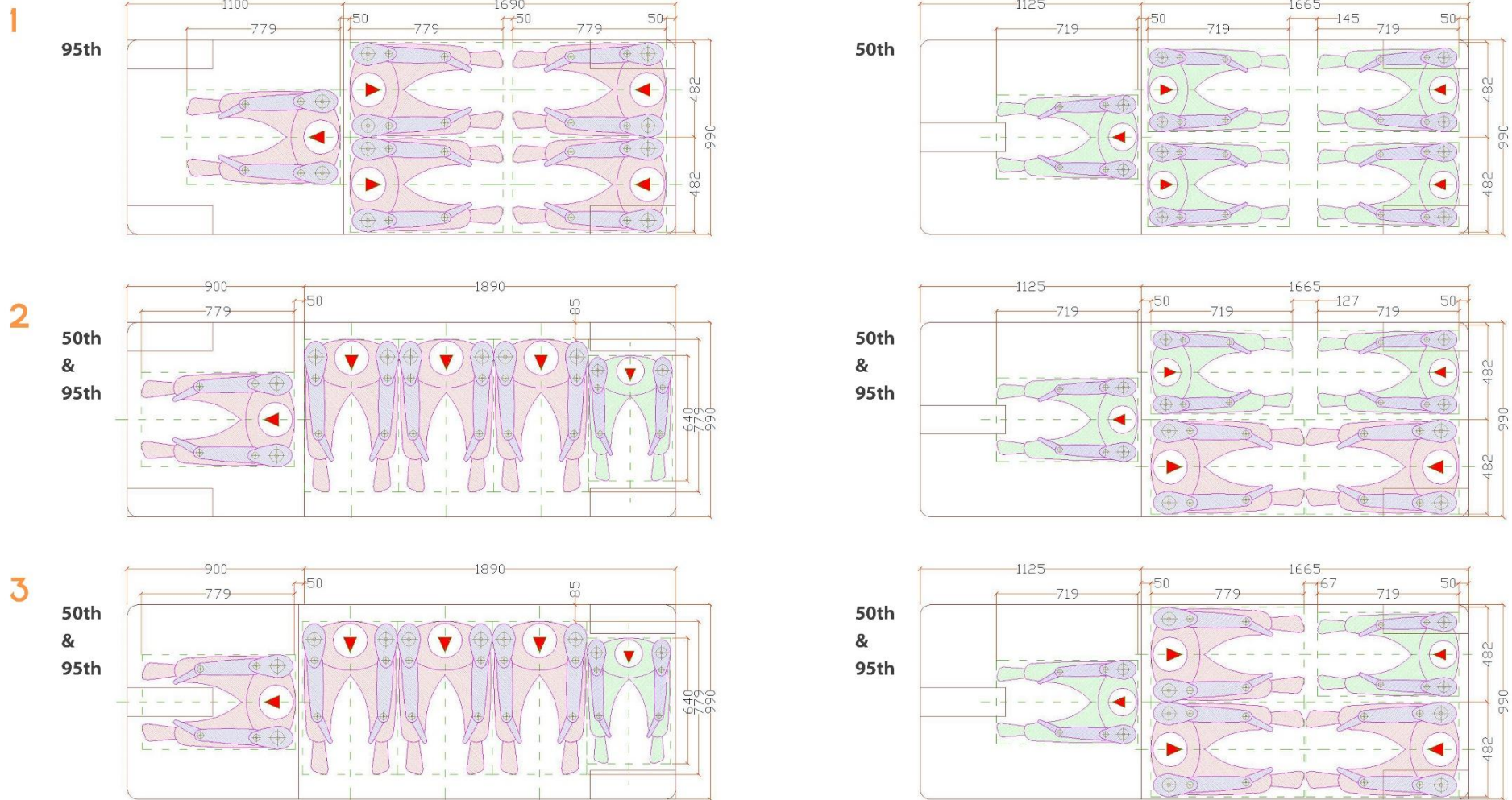
## 2. ICAT REGULATIONS

Figure – 5: The diagrams show the permissible and consumed volume of the designed vehicle



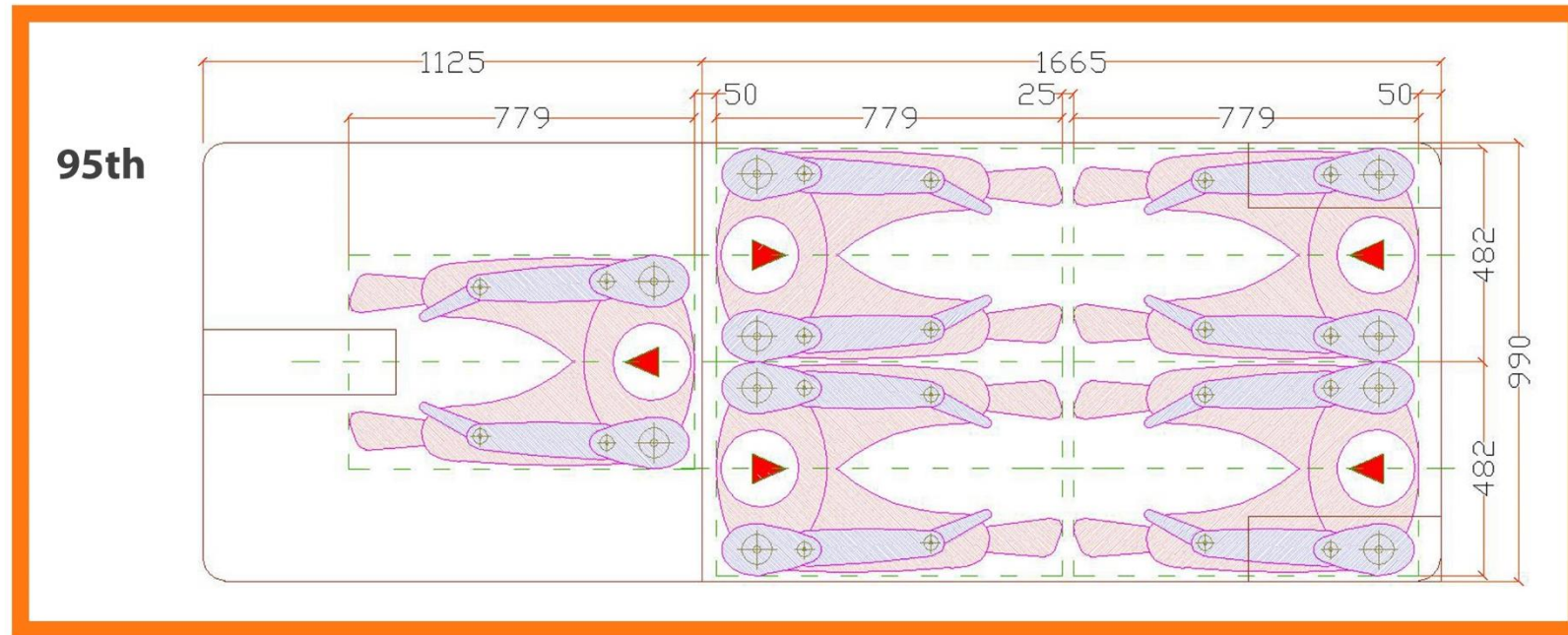
### 3. PACKAGING LAYOUT

Figure – 6: The diagrams show the combination of the percentile of passengers



## 4. FINAL PACKAGING

Figure – 7: The diagrams show the final packaging layout

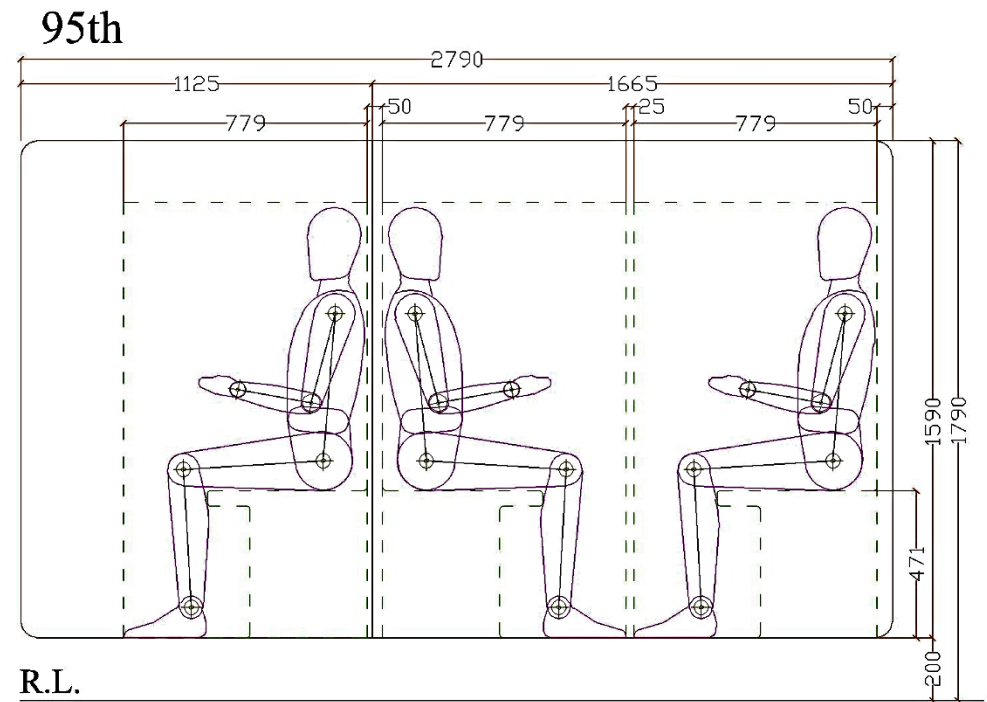
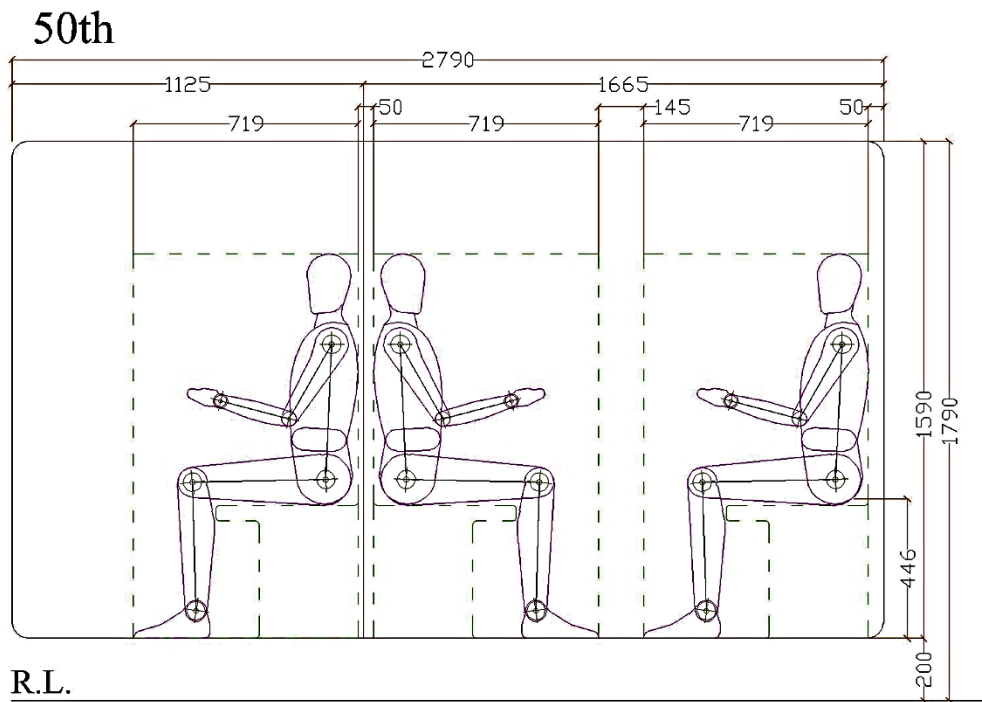


### Packaging layout

- A two-wheel front layout is not permitted by law for the category.
- Two-wheel front layout will increase the number of parts which will in turn increase the manufacturing cost missing the intended selling price.
- In the 2nd and layout, the driver's cabin space is very tight.
- In the 2nd and 3rd layouts the packaging is side by side leading to not all being of the same percentile group.
- In the 2nd and 3rd layouts the 50th percentile does not have enough legroom.

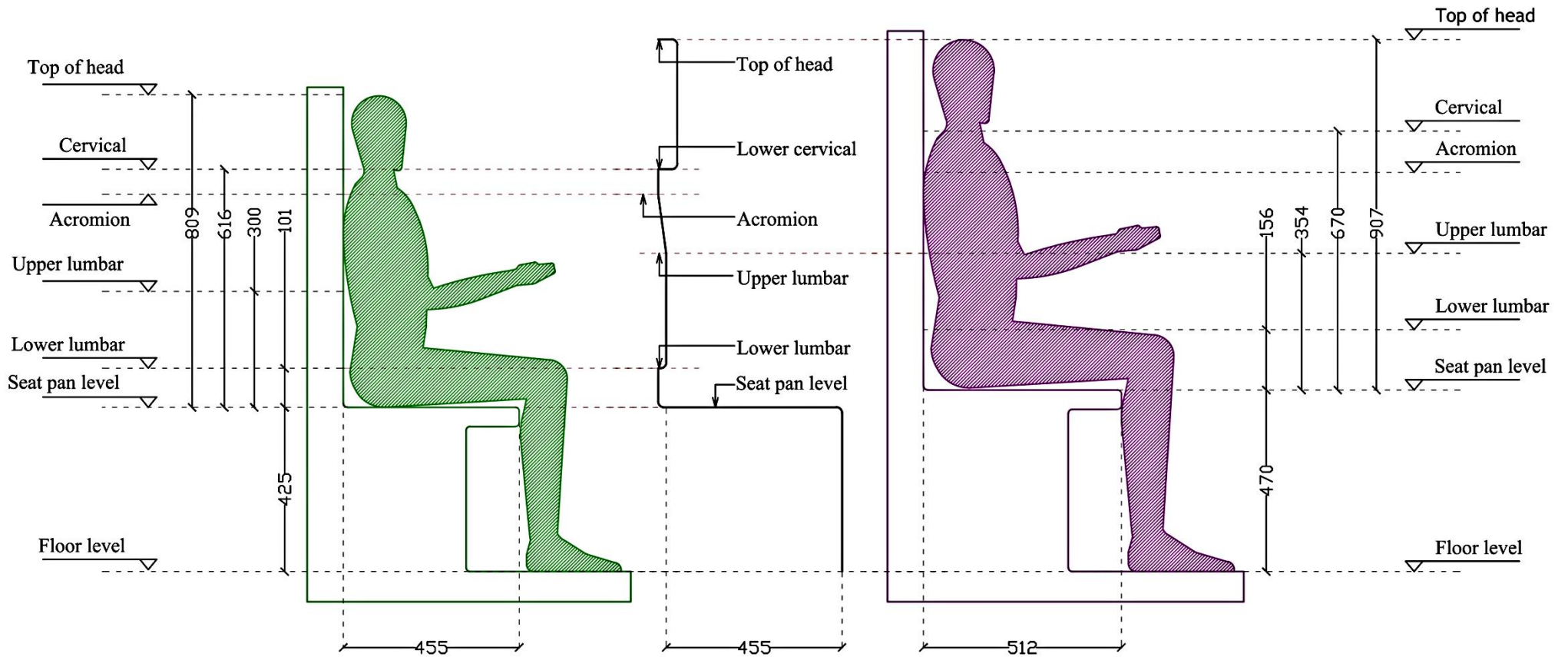
## 5. TECHNICAL ELEVATION

Figure – 8: The elevation



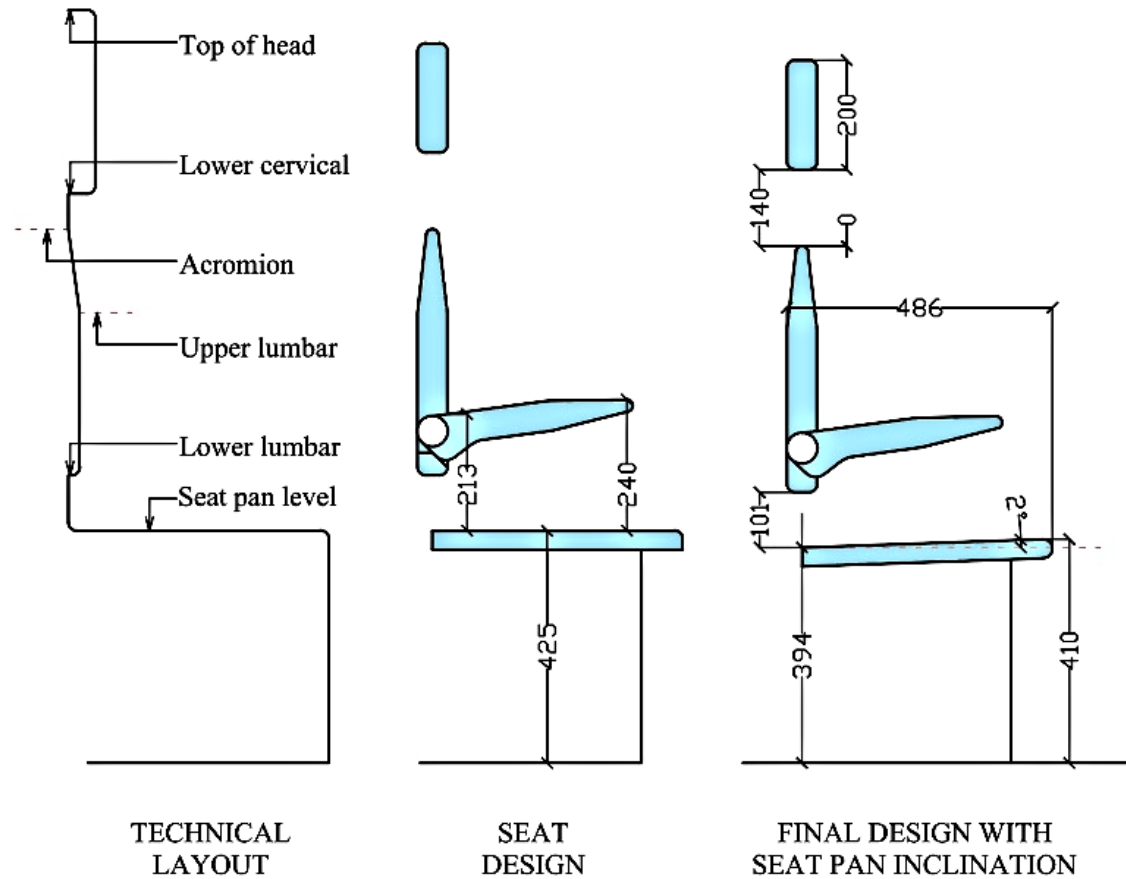
## 6. SEAT DIMENSIONS

Figure – 9: The anthropometrical dimensions of the seat



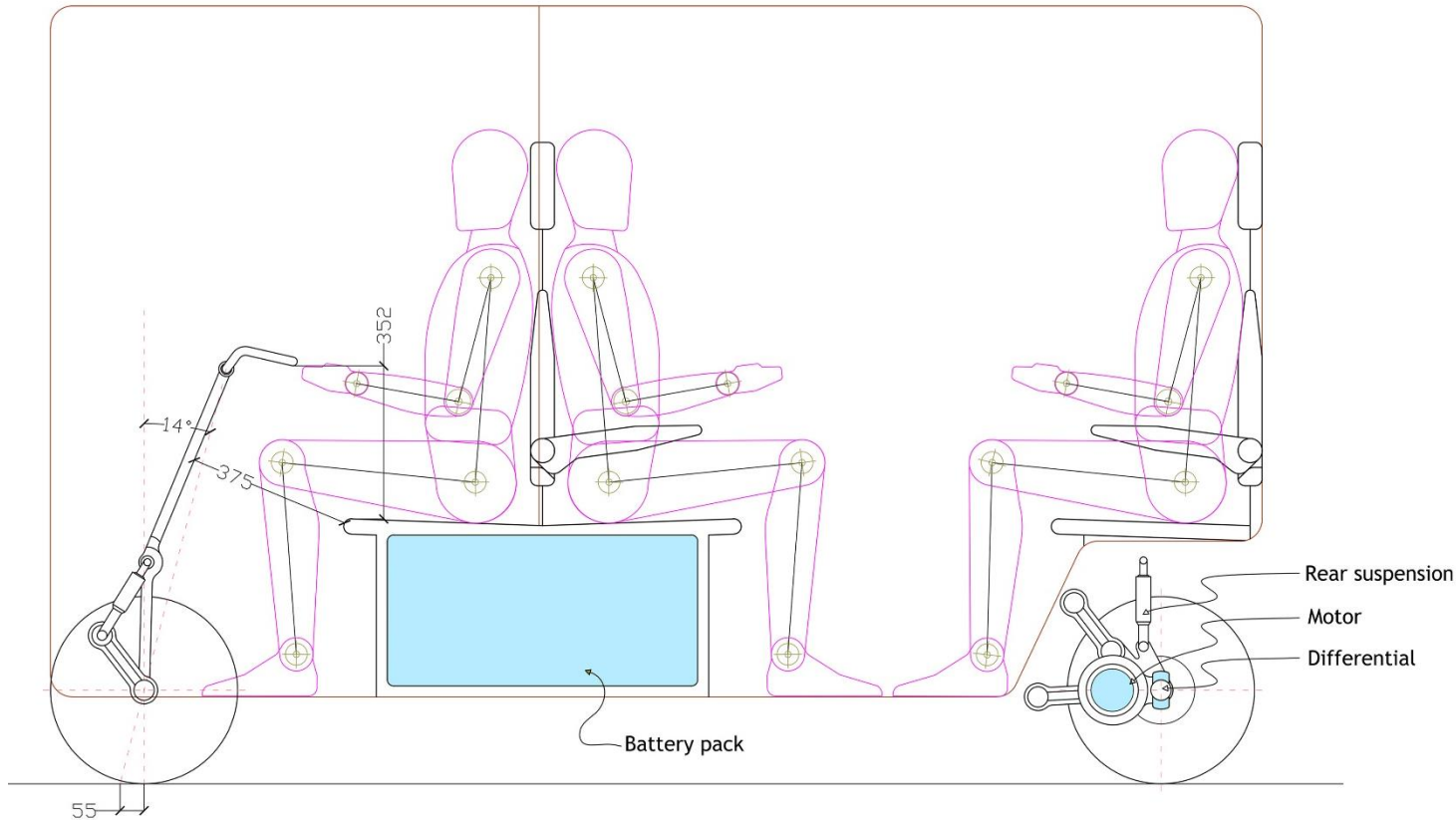
## 7. SEAT DESIGN

Figure – 9: The final seat dimensions



## 8. TECHNICAL PACKAGING

Figure – 9: The technical packaging of the vehicle



The vehicle does not have any complicated technical components.

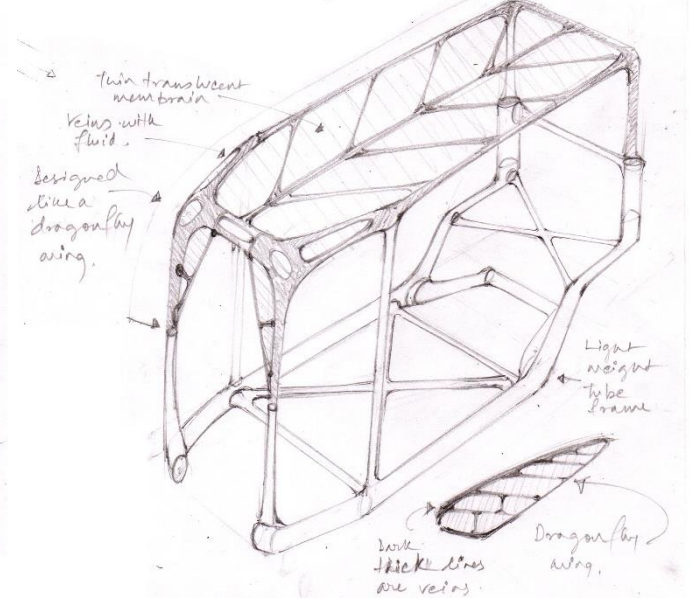
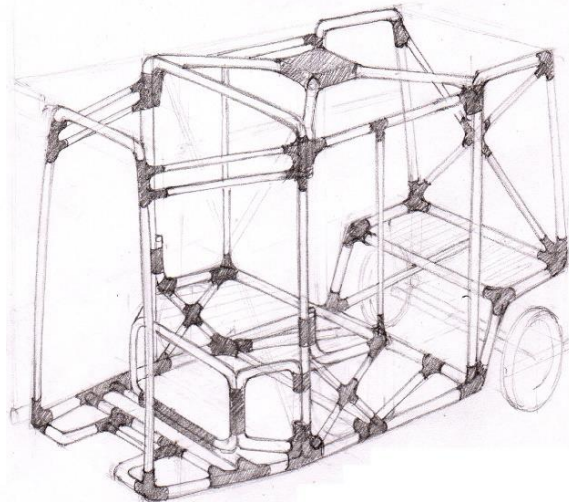
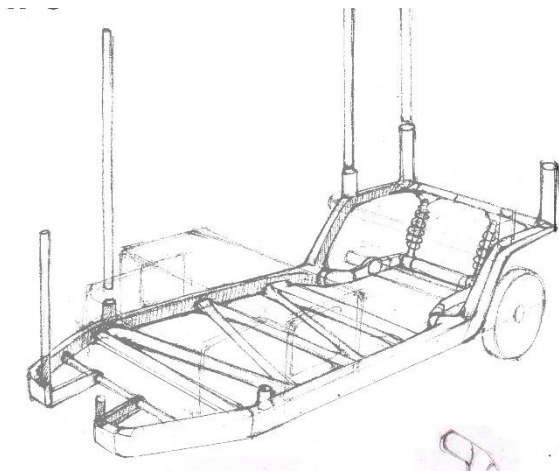
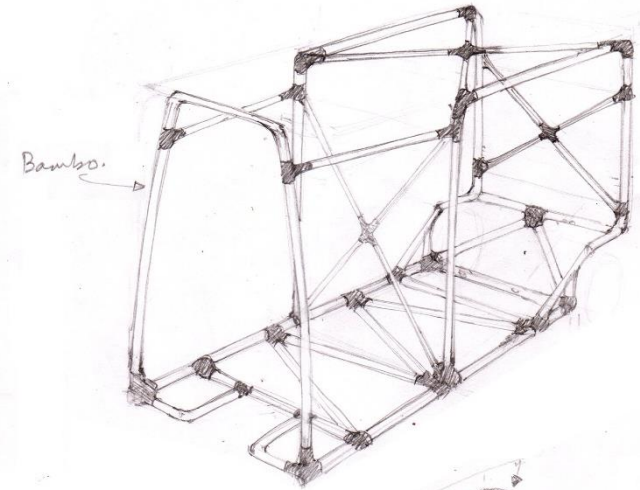
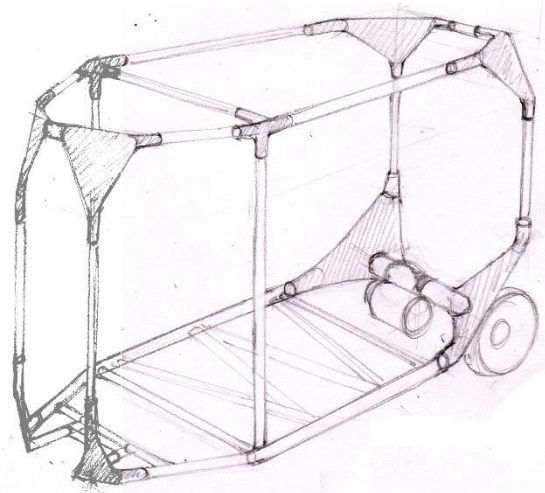
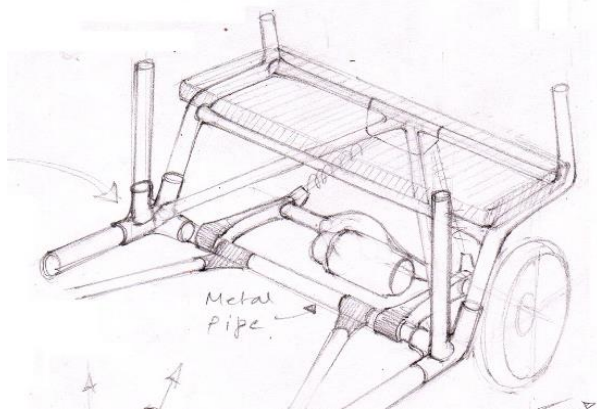
The major components are,

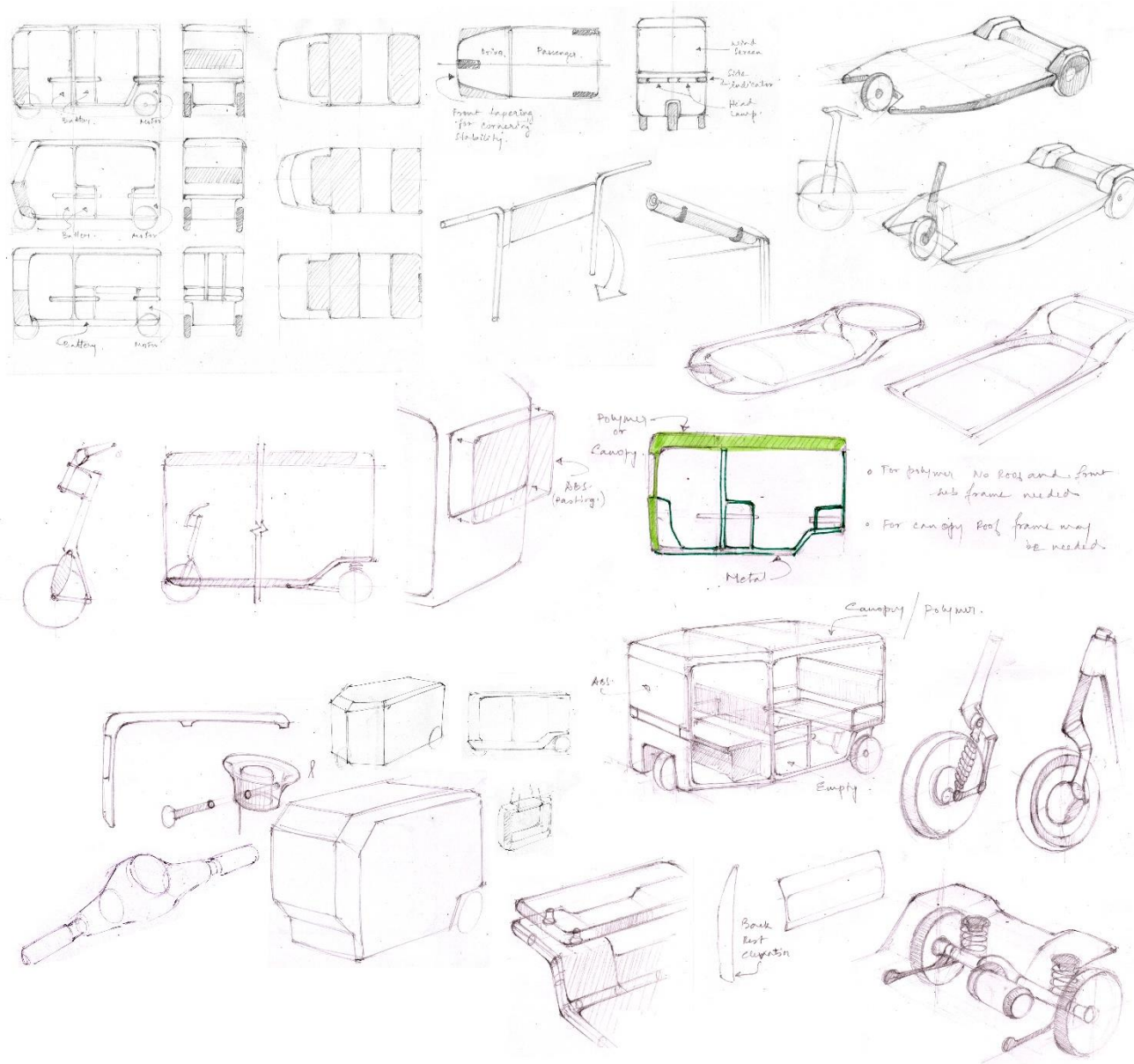
1. **The battery** – is stored under the driver and passenger seat
2. **The electric motor** - mounted on the rear axil
3. **The differential** - is in the rear axil
4. **Controller** - in the front dashboard
5. **Brake system** - as the speed of the vehicle is limited to a maximum of 25 kmph so heavy-duty braking is not needed. A set of hydraulic brake lines can be easily installed.

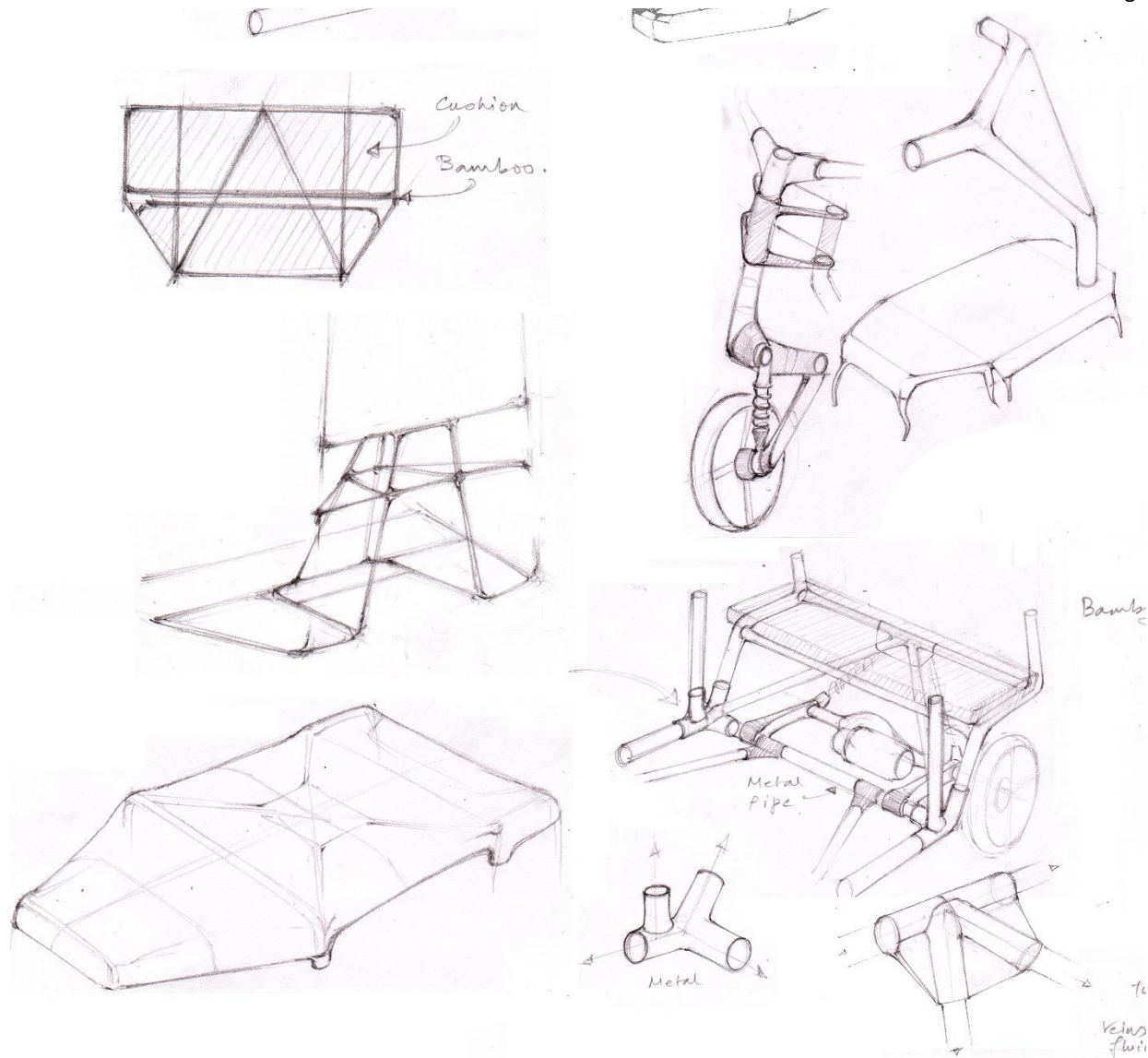
## **V. CONCEPT DEVELOPMENT**

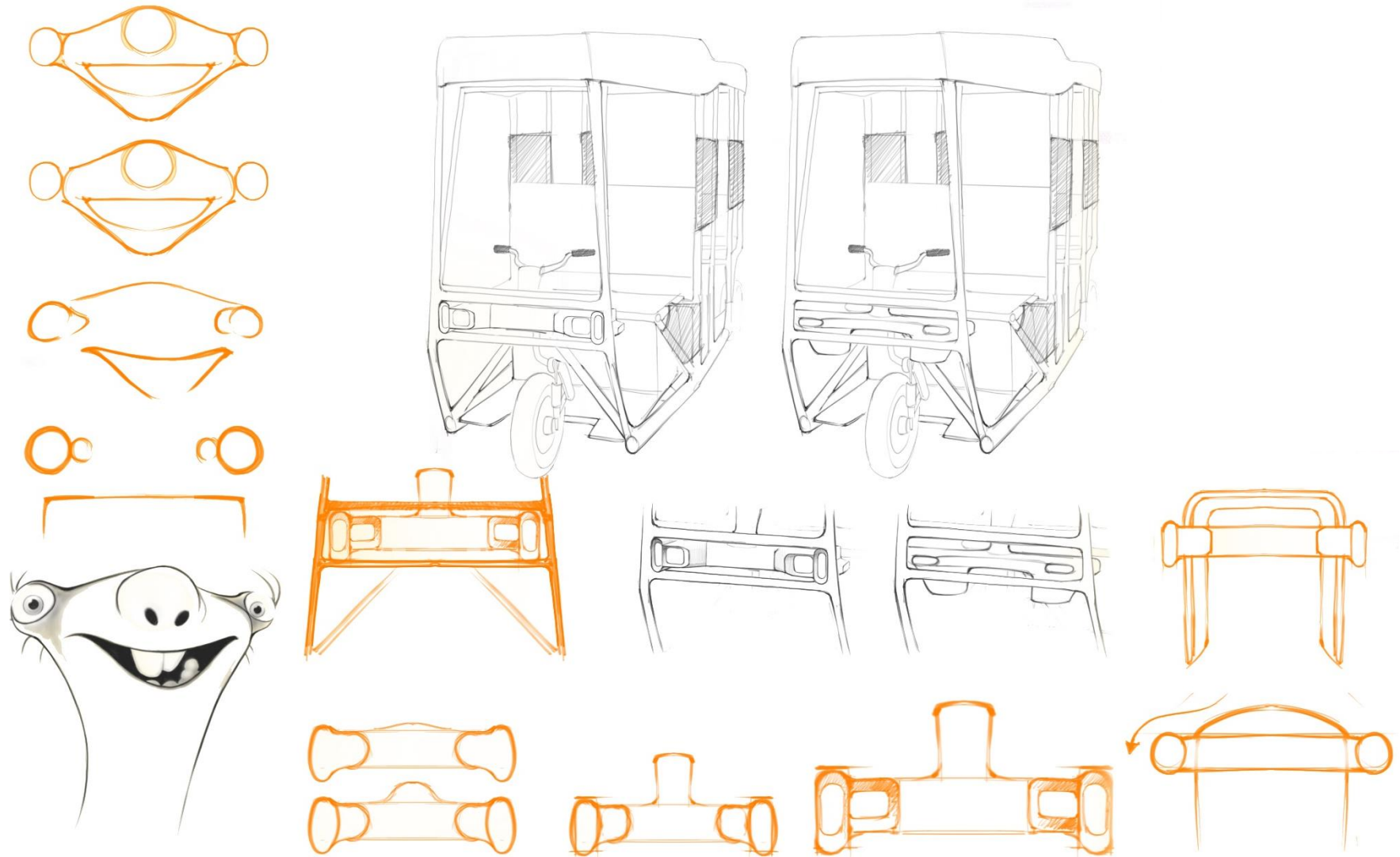


## 2. IDEATION



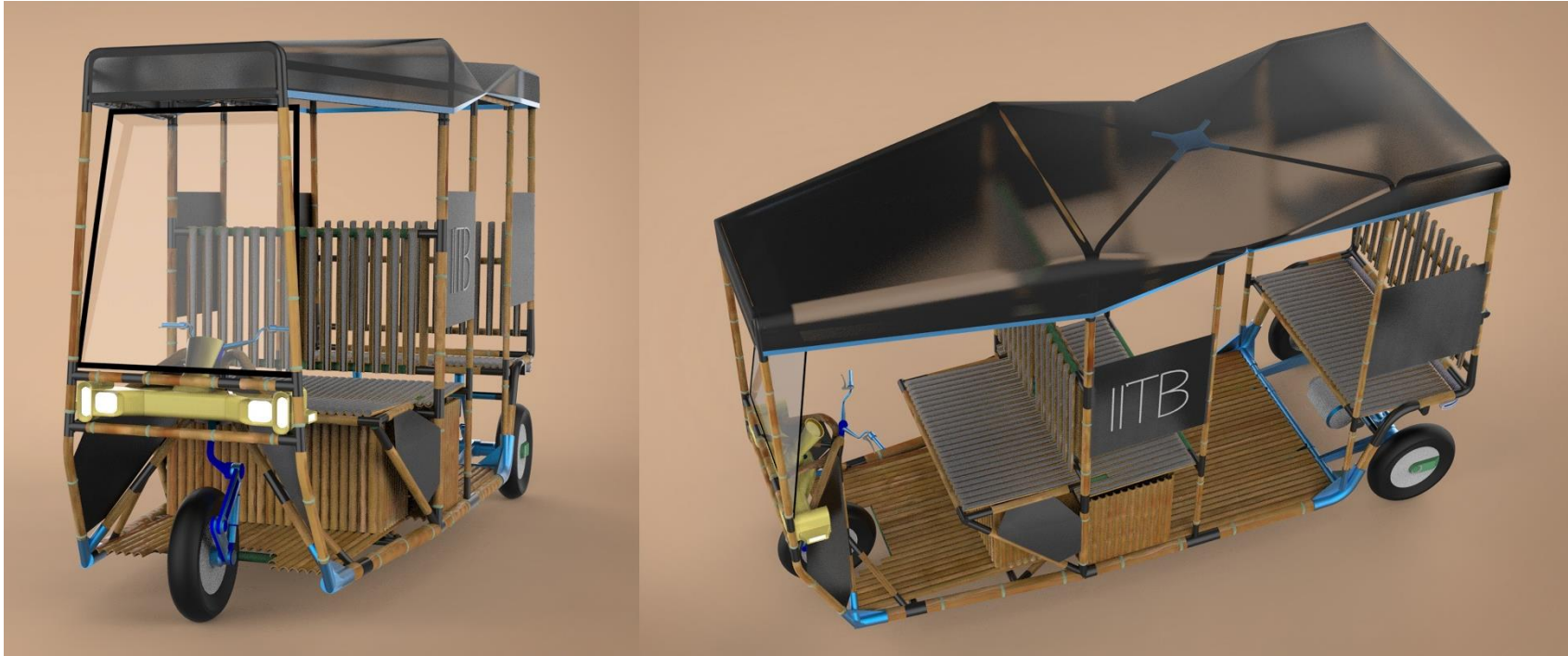




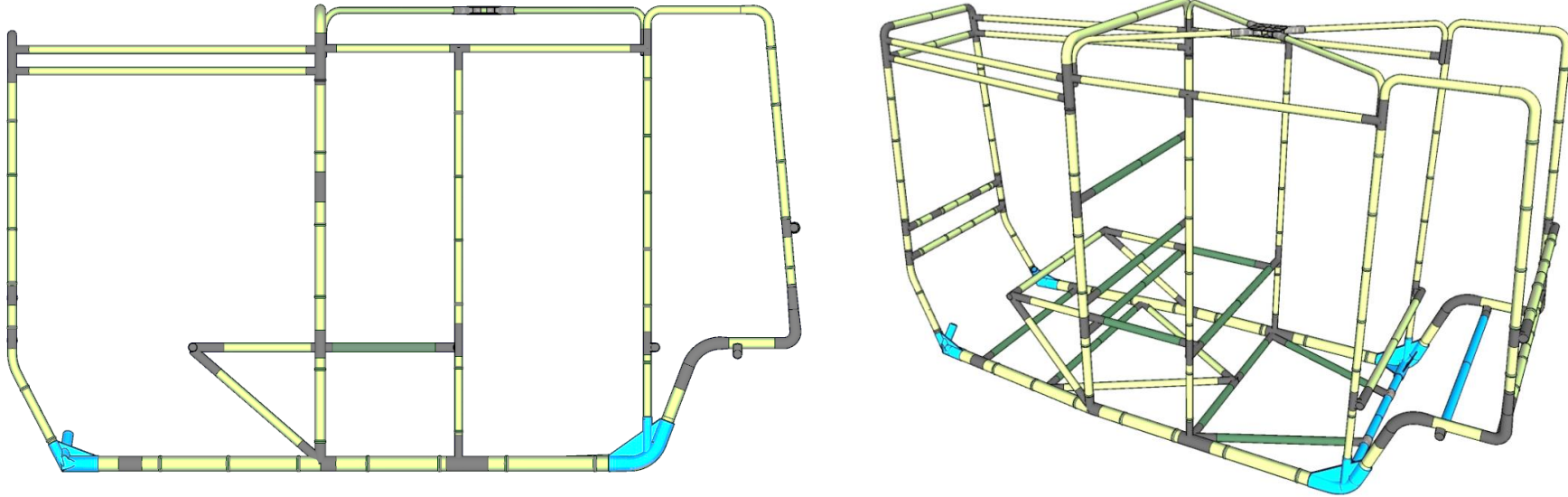


INITIAL CONCEPT:



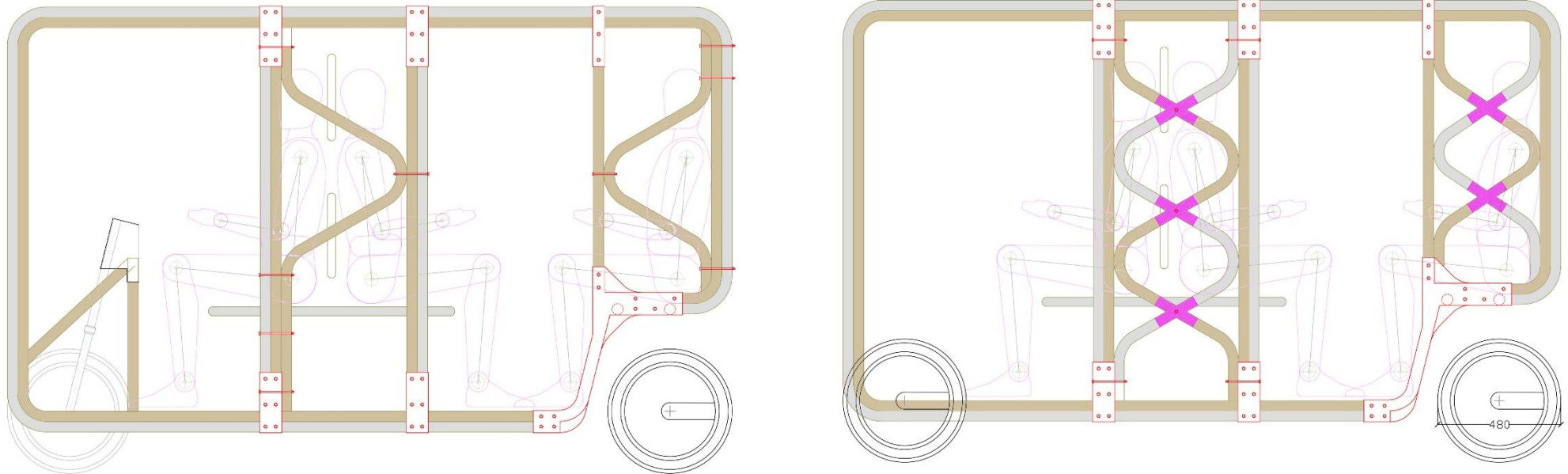


## **VI. CONCEPT MODIFICATION**

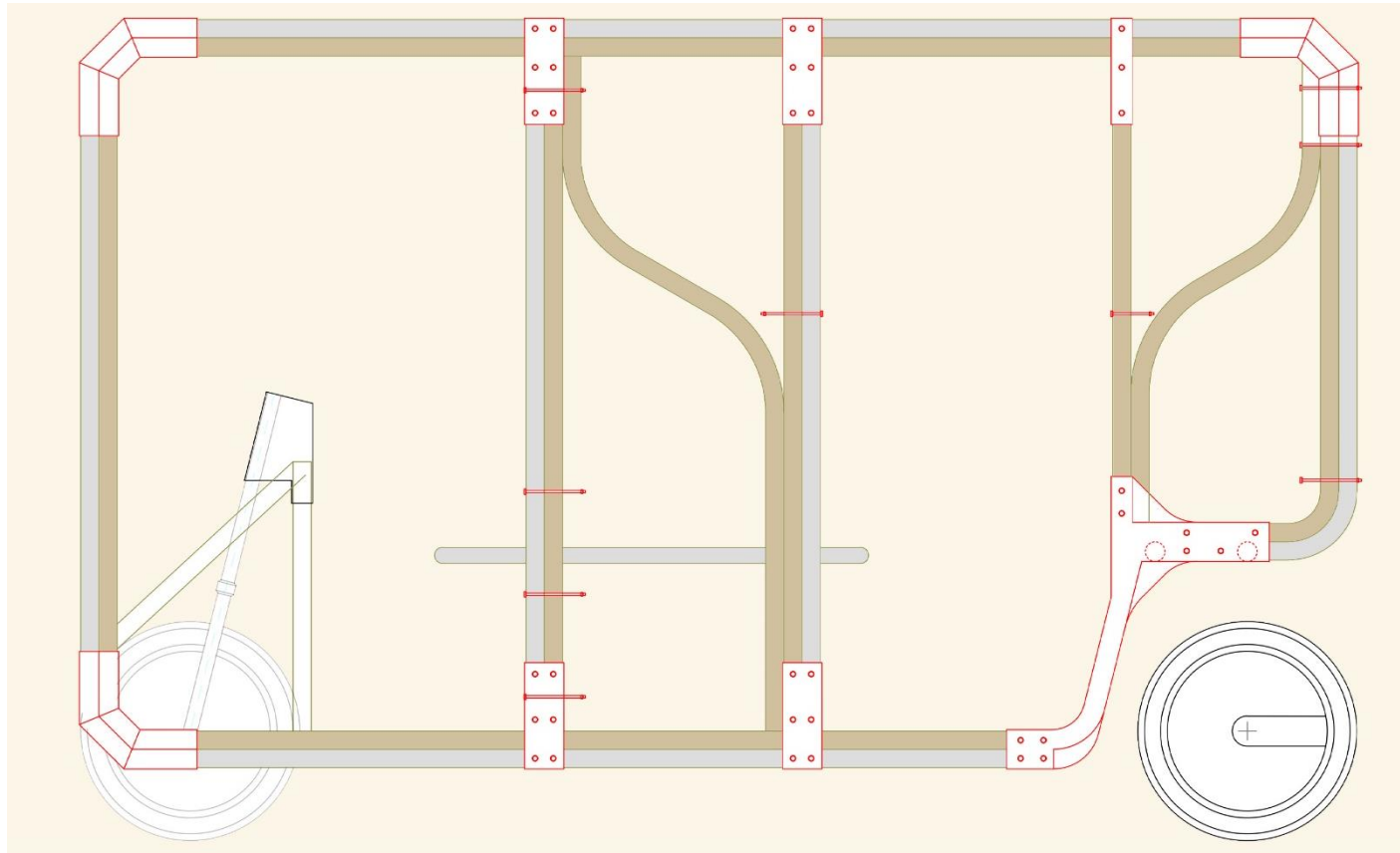


In this concept, the structure is made of single-layer bamboo which might result in an overall weak structure. Also, multiple cut sections increase the number of joined components increasing the chances of the overall weight of the vehicle. The components marked in blue colour will be made of metal which adds to the structural rigidity of the vehicle. This concept has a converging sort of design language towards the front.

The number of metal parts might be less as the vehicle will be subjected to forces from multiple axes/directions.



In these concepts, the idea was to use an adequate number of bamboo so that the structure is stiff and strong. The tapering form of the vehicle towards the front has been lost on purpose to reduce the complexity of the building. The bends have been further reduced for ease of manufacturing.

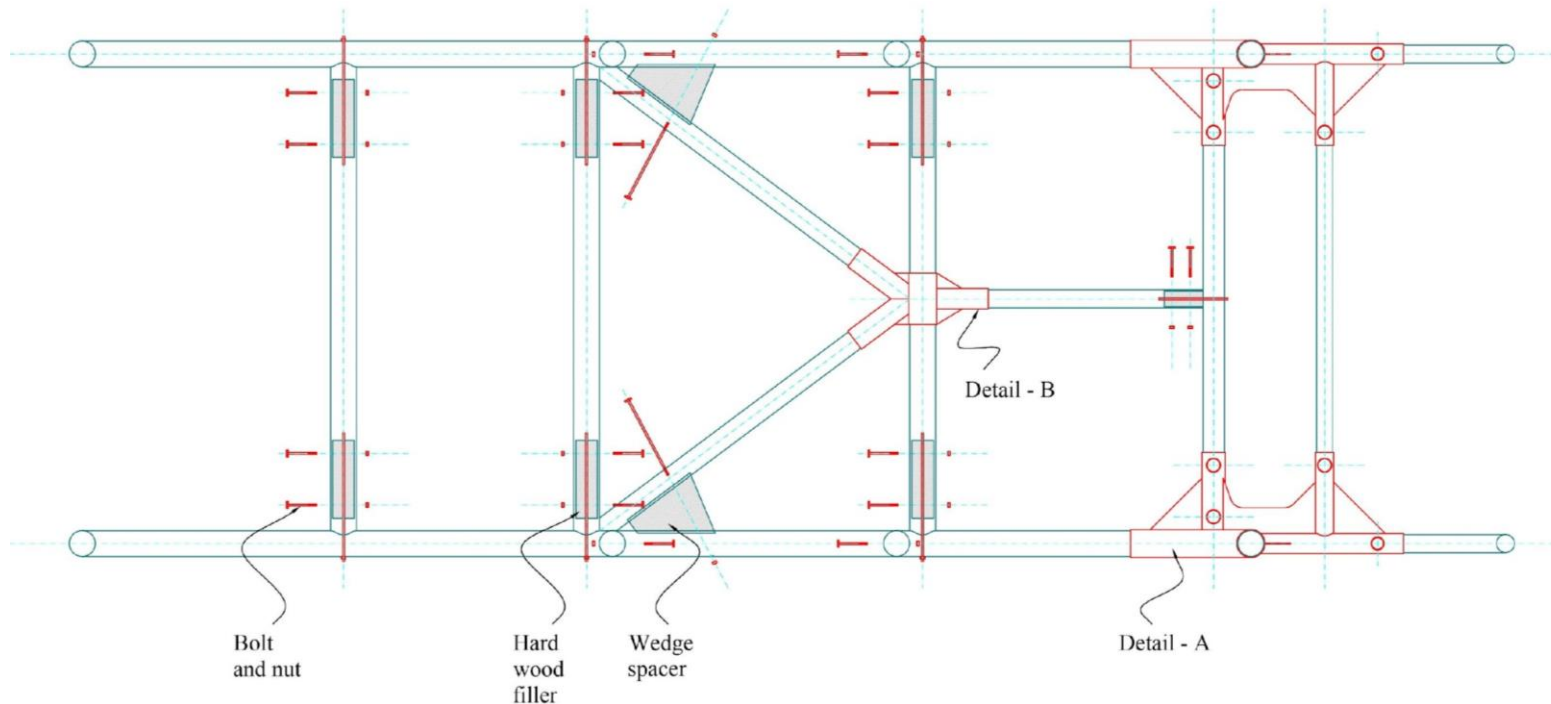


This is the final layout that has been taken forward, as it has the minimum number of curves and the corners have been joined Using metal joinery to make them sound and strong.

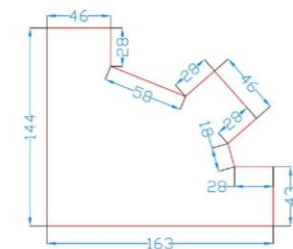
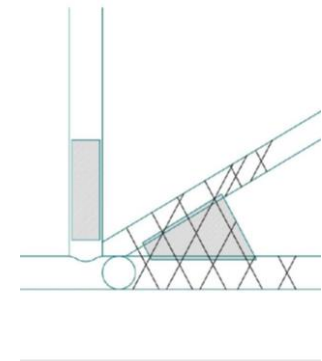
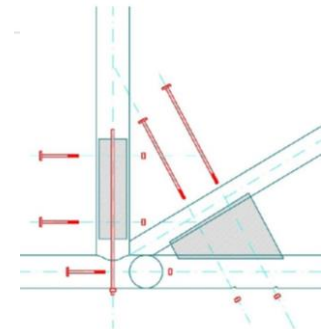
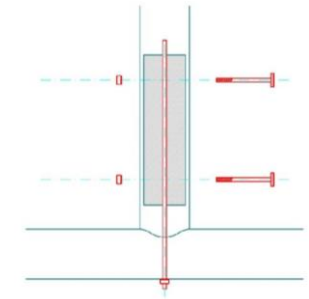
- This concept has single bamboo support in the structure which connects the

side frames at the lower section of the vehicle.

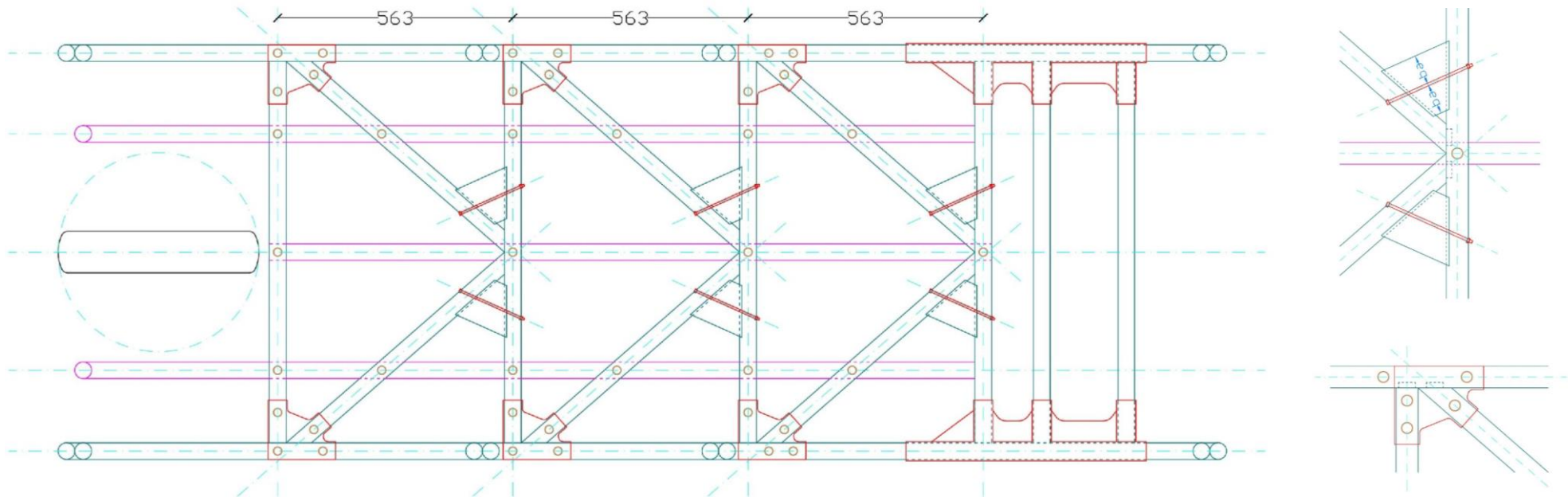
- The Y-shaped support structure is there to stiffen the build of the chassis.
- There is a triangular wedge provided in the angled corner to prevent flexing and slipping.
- Hardwood is filled inside the hollow bamboo where the joineries are made.
- The joineries are then secured by drilling bolts and nut

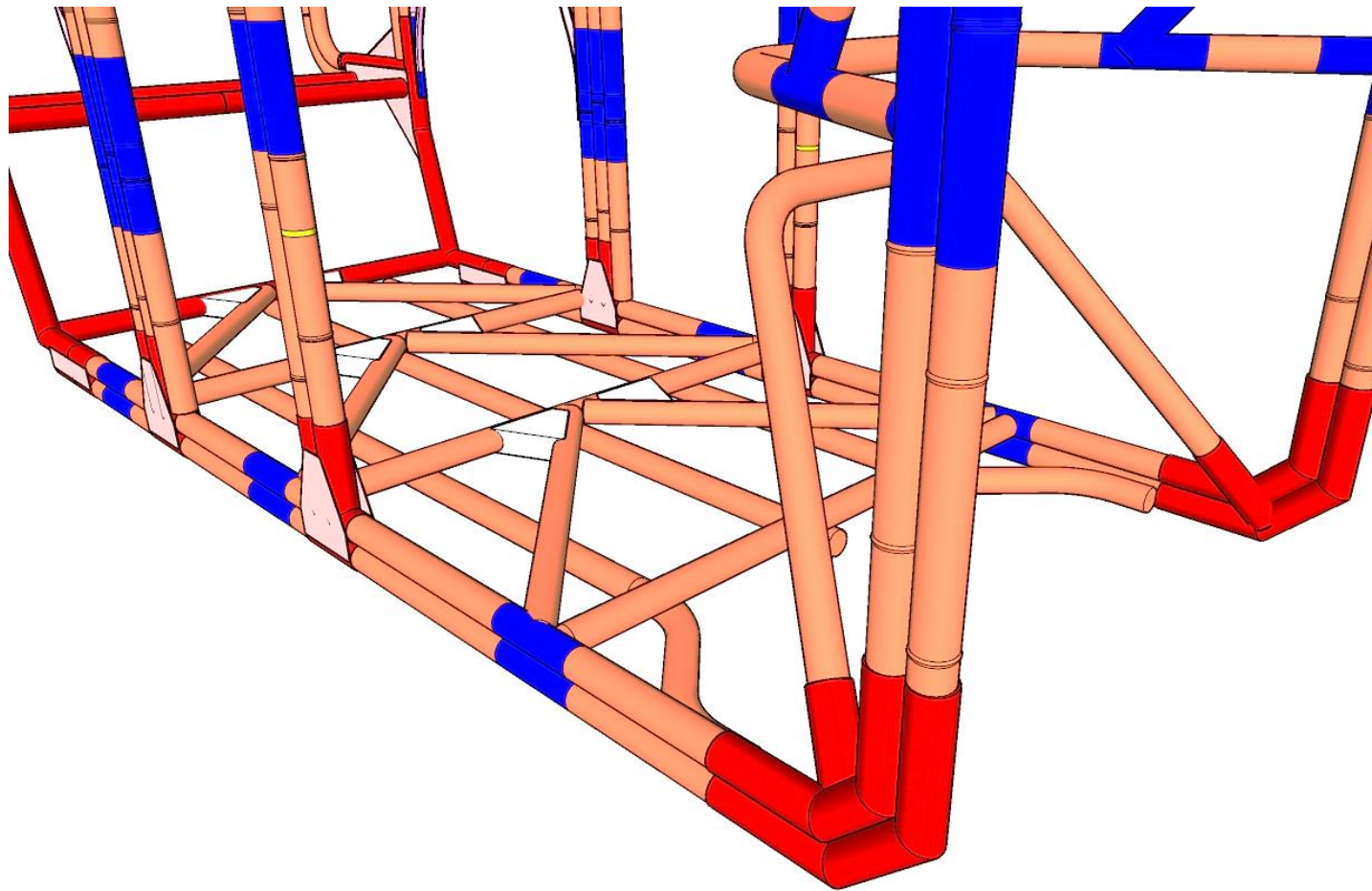


- This concept has double-layer bamboo support in the structure which connects the side frames at the lower section of the vehicle.

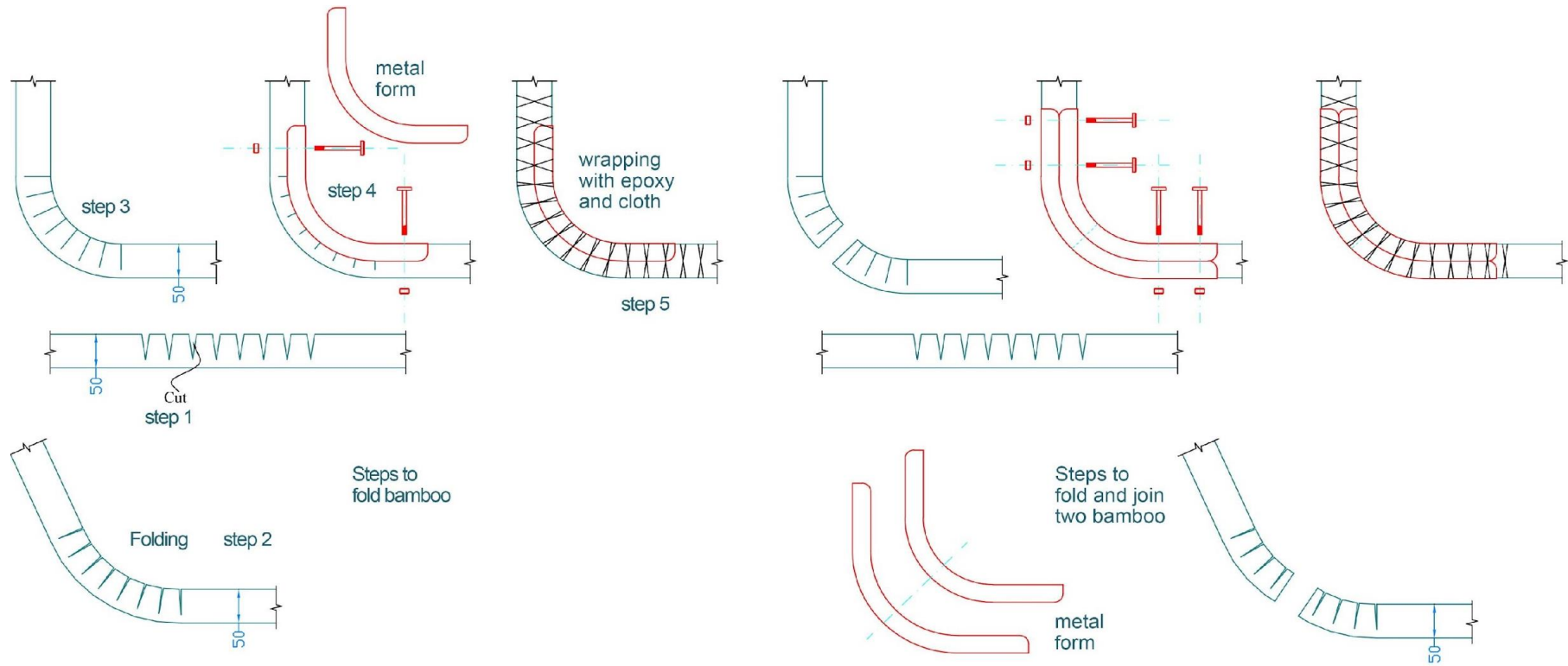


- Triangulation of the support structure makes the build of the chassis stiffer.
- The wedges are replaced by metal plates that prevent flexing and slipping.
- The joineries are then secured by drilling bolts and nut



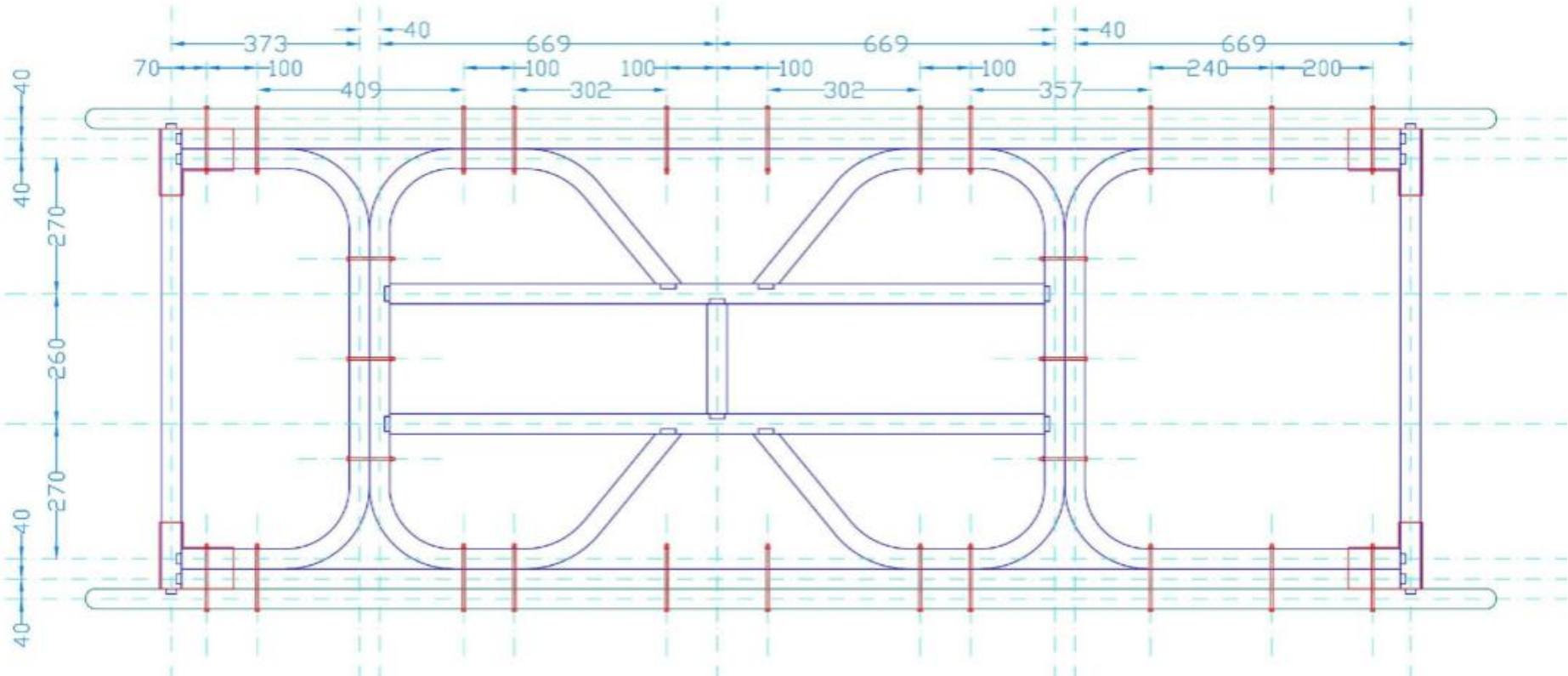


This is the final layout of the base that has been taken forward, as double-layer chassis provide more rigid support and a sound base to build on.

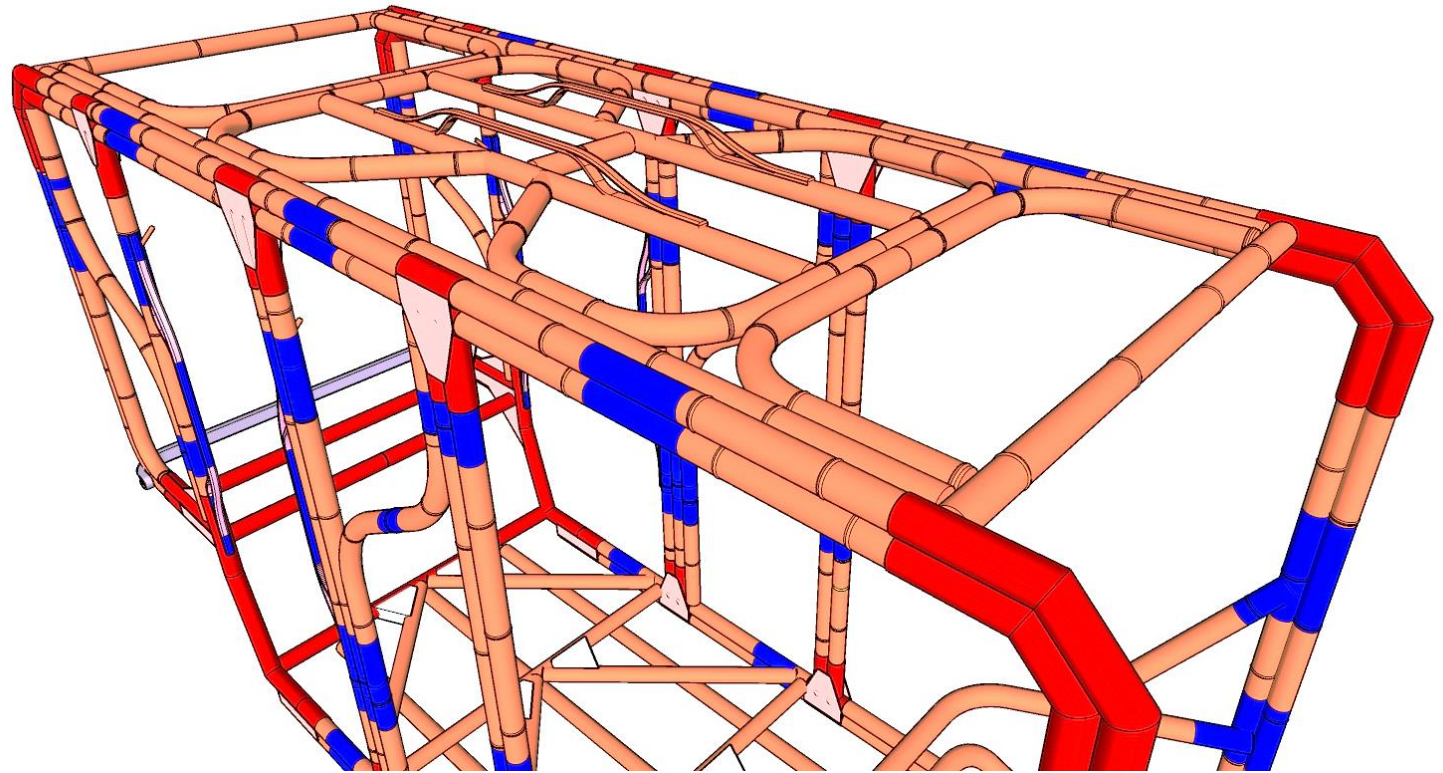


These are some of the corner joineries that I have explored which when implemented might need changes based on the load-bearing capacity and the flexibility of installation.

- This is the roof structure of the vehicle
- The primary aim was to create a sound structure that is aesthetically appealing



This is the final layout of the roof that has been taken forward because a single layer of the members is lightweight. Also, it is aesthetically pleasing.



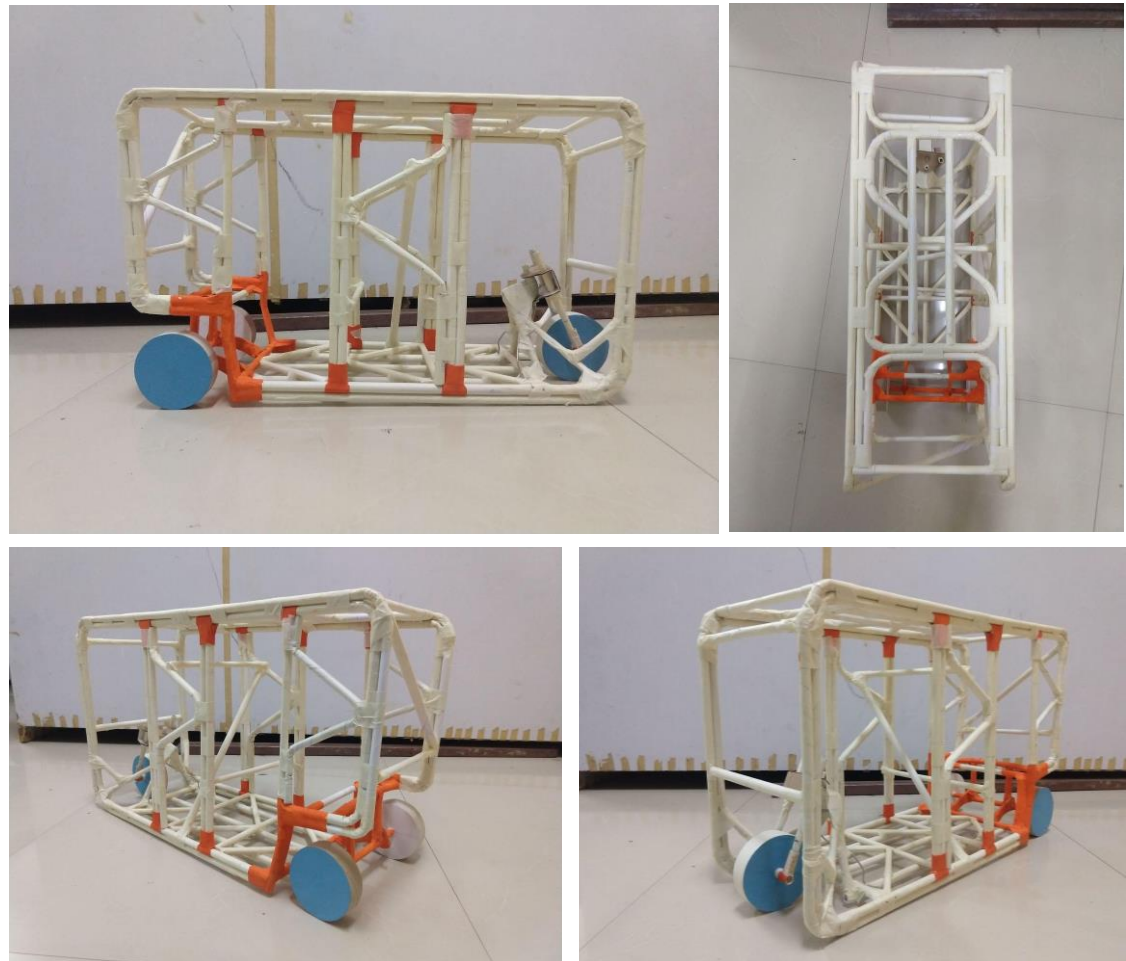
## Concept Development

This is a scale model of the e-Rickshaw that was built to understand the construction of the unit.

The model is built using paper rolls and the joineries are also made of the same material.

The orange portions depict the parts which will be made of metal in the actual prototype.

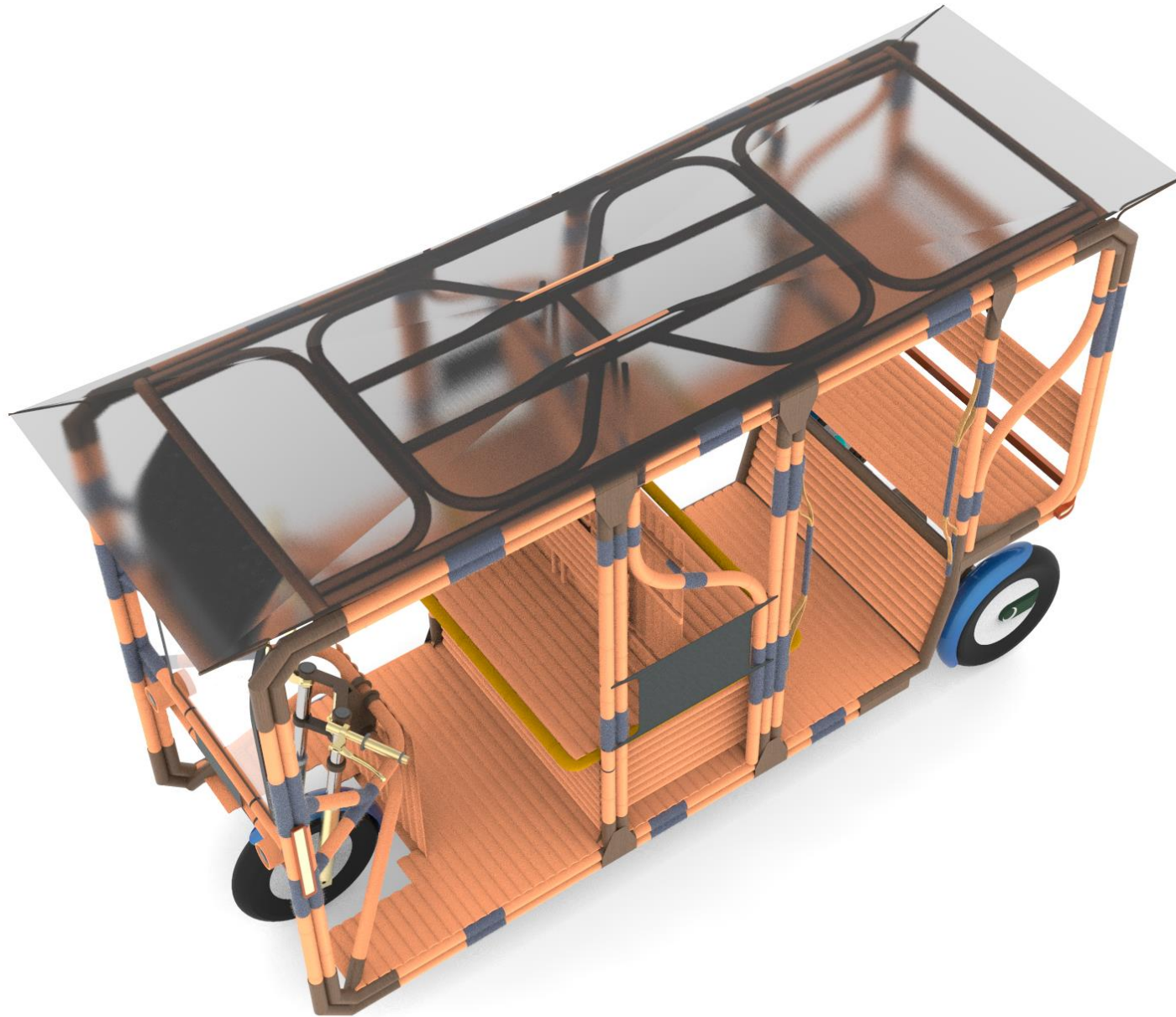
This scale model of the e-rickshaw helped us understand how the joineries can be achieved and how the bends on bamboo should be contoured.



## **VII. RENDERS**

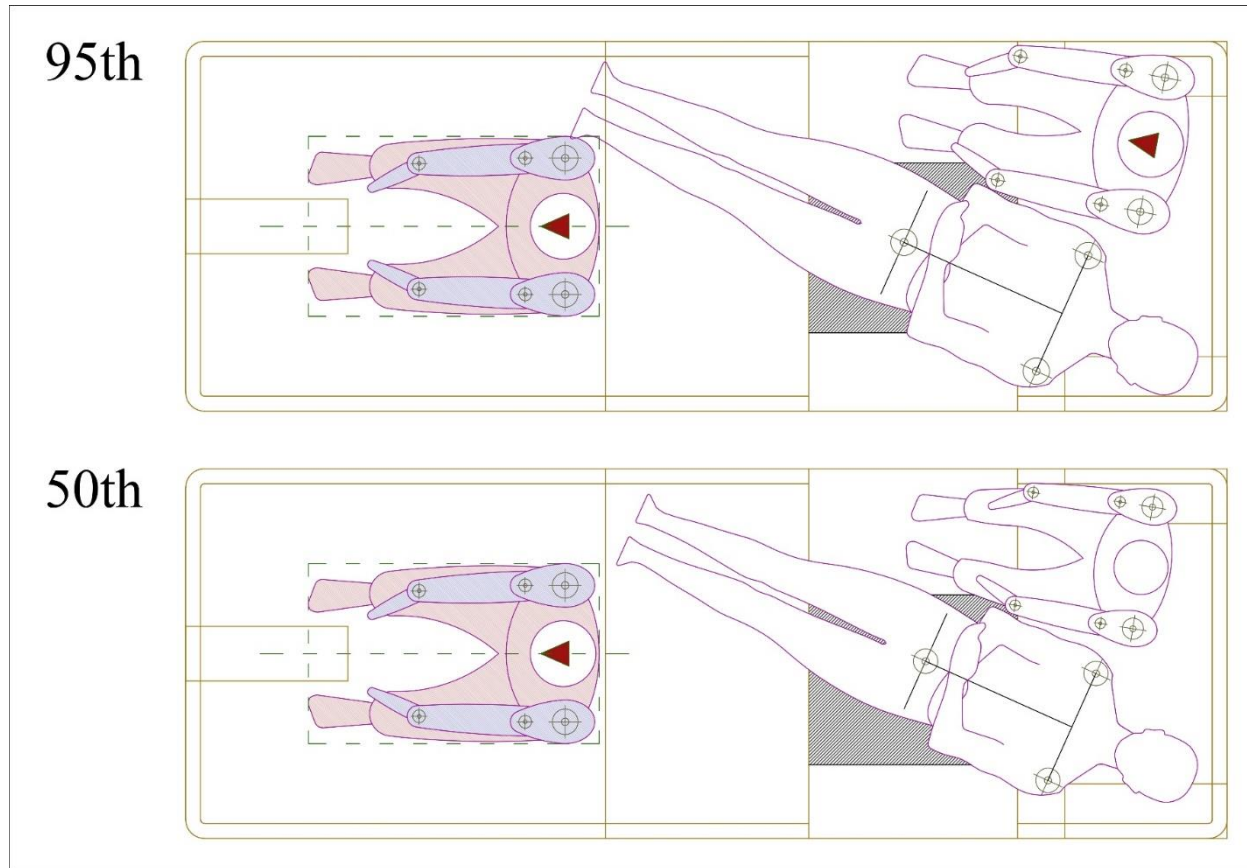








## **VIII. CONVERSION OF PASSENGER VEHICLE TO AMBULANCE**



The conversion of a passenger vehicle to an ambulance is a very simple step. Before the patient lay down on the e-rickshaw the driver will pull out one of the backrests from the passenger seat and bridge the gap between the two passenger seats. Then the patient may lie down.

**Figure – 10:** Packaging of the ambulance

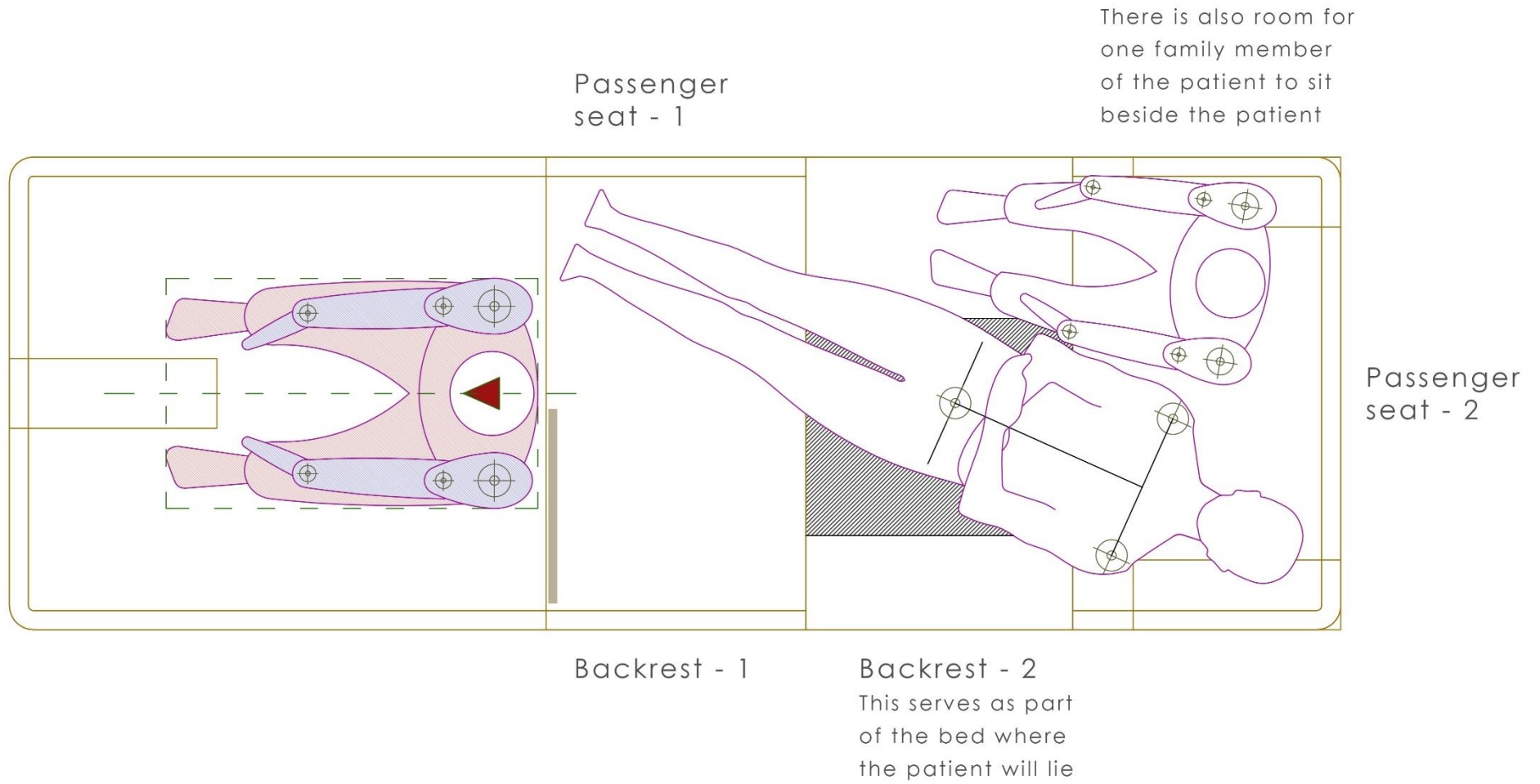
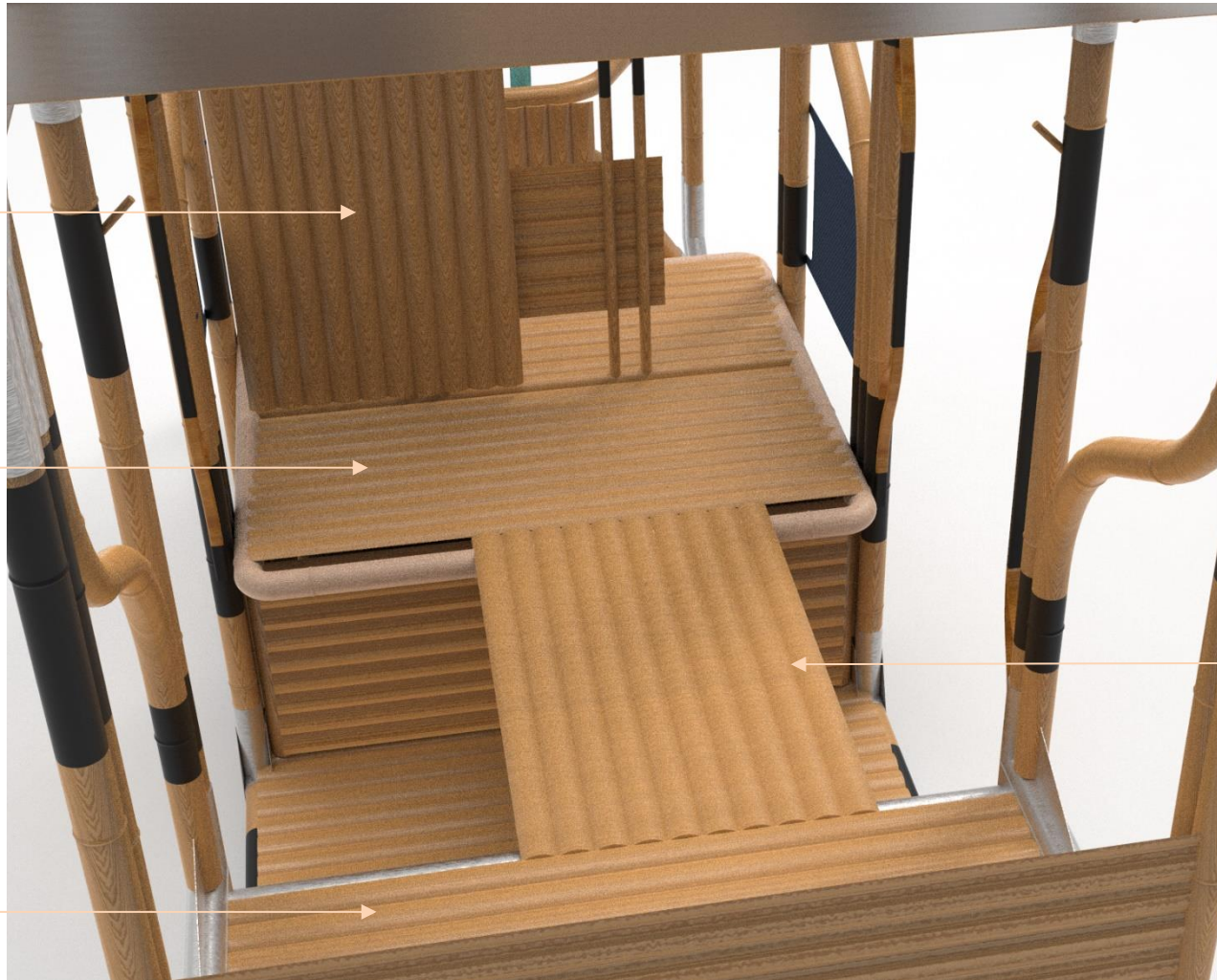


Figure – 11: Final Packaging of the ambulance

Backrest -1

Passenger  
Seat - 1

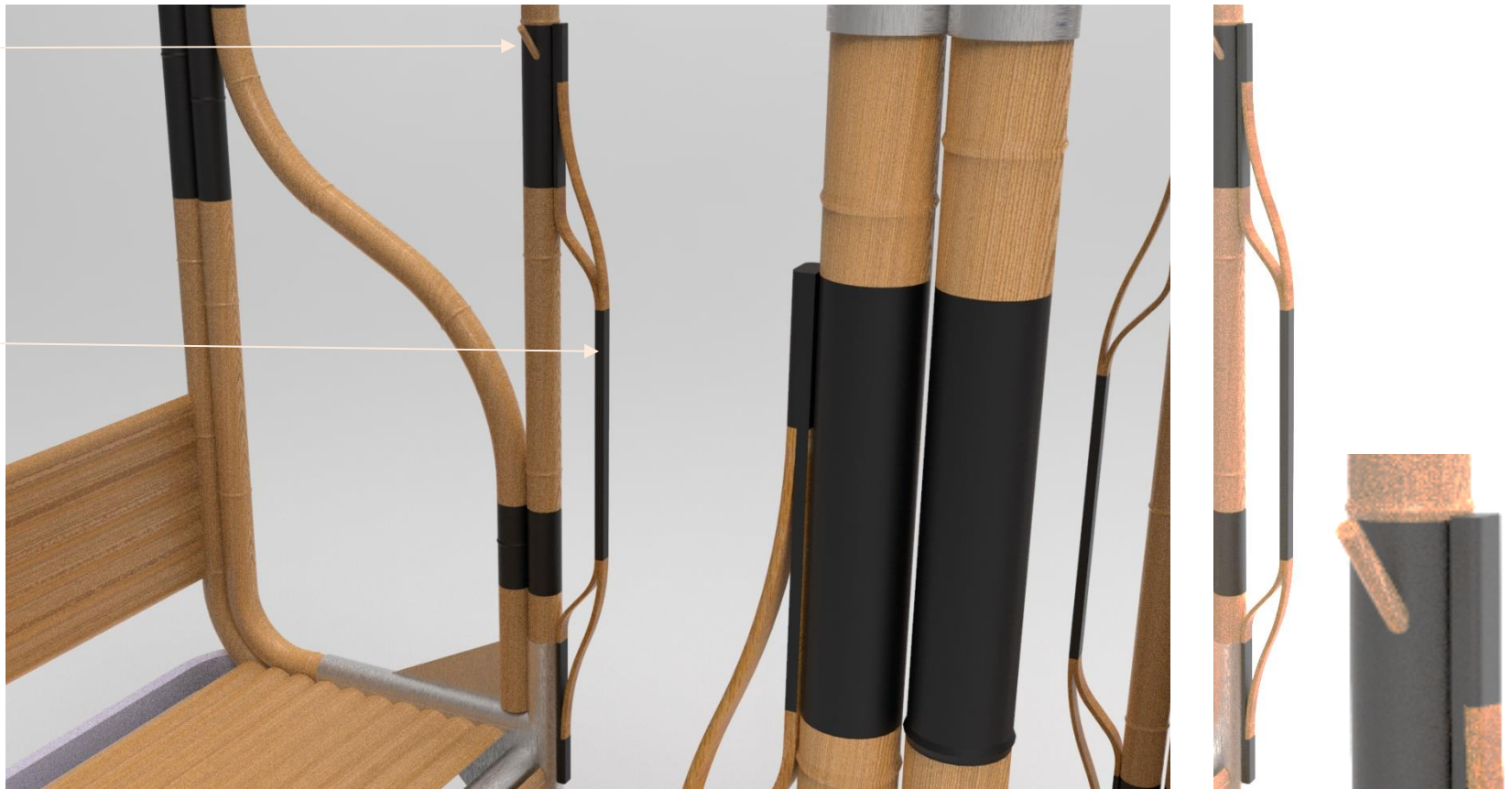
Passenger  
Seat - 2



Backrest -2

Peg hanger  
for hanging  
saline bottle

Comfortable  
Handel bar



# **IX. CONVERSION OF PASSENGER VEHICLE TO CARGO VEHICLE**



BACK REST  
AS DOOR



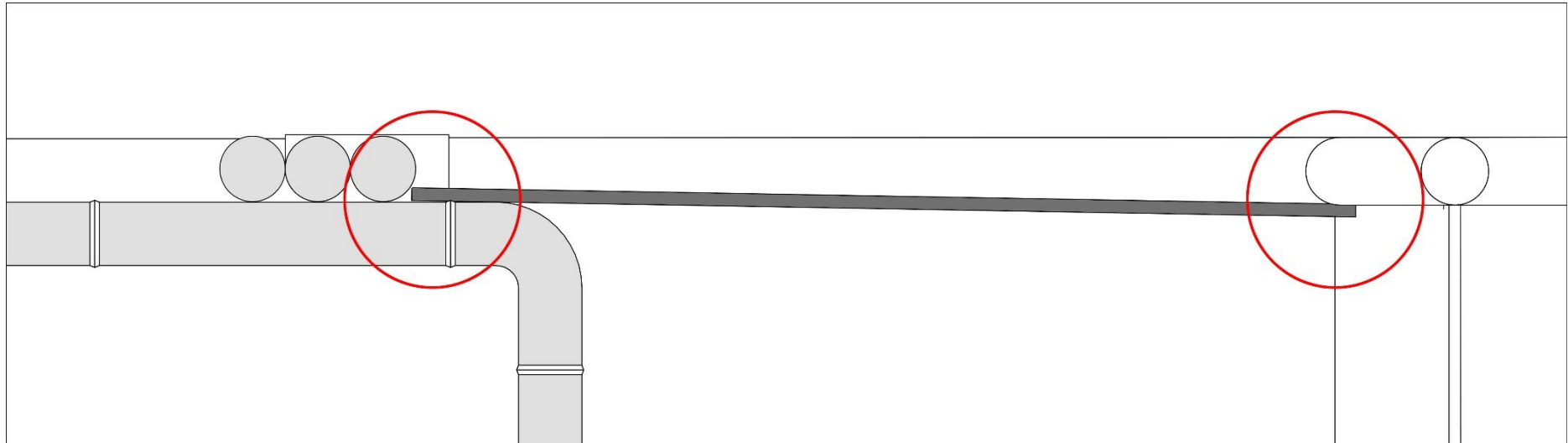
SLOT TO INSERT  
THE PANEL



SLOT 1

BACK REST

SLOT 2

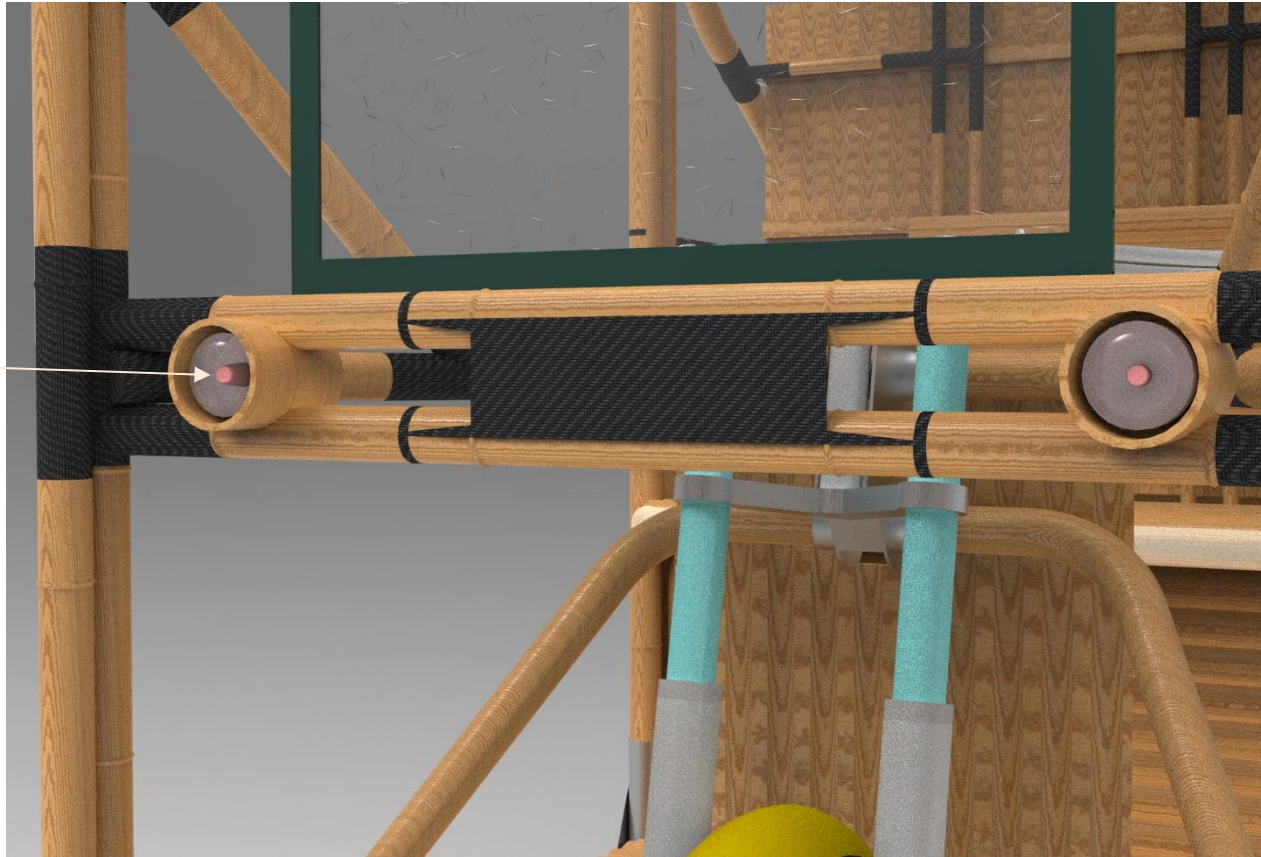


## **X. FEATURE DETAILS**

The battery compartment has a hatch type door



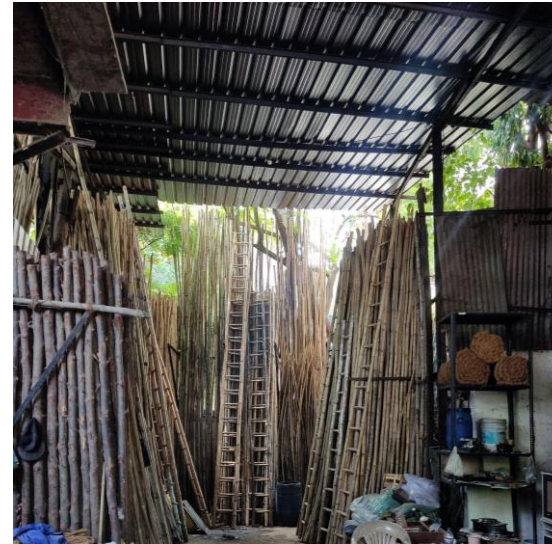
The headlamp  
Is integrated  
Within the  
hollow bamboo  
section to make  
it look  
coherent



# **XI. SCALE MODEL AND FULL-SCALE WORKING PROTOTYPE (work in progress)**

### Procurement of Bamboo

SIDE					
Length	Qty.	Total Qty.	No. of poles		
One side		Both side		Total length of members	
2200	2	4	3		8800
1400	2	4	2		5600
1500	4	8	4		12000
1100	1	2	1		2200
2800	2	4	4		11200
1600	2	4	3		6400
2100	2	4	3		8400
1600	2	4	3		6400
BOTTOM					
Length	Qty.	Total Qty.			
2200	2	2	2		4400
1800	1	1	1		1800
950	4	4	2		3800
700	6	6	2		4200
ROOF					
Length	Qty.	Total Qty.			
2500	2	2	2		5000
950	2	2	1		1900
1350	2	2	1		2700
250	1	1	1		250
1450	1	1	1		1450
2050	1	1	1		2050
2100	2	2	2		4200
TOTAL NO OF PIECE			39		
BUFFER			11		
TOTAL NO OF PIECE WITH BUFFER			50		



## Materials Used

- Solid Bamboo
- Assam Bamboo
- Jute thread
- Araldite (Epoxy Adhesive)



## Tools used

- Vice
- Hacksaw
- Blow torch
- Heat gun
- Hammer
- Screwdriver
- Measuring tape
- Cutter



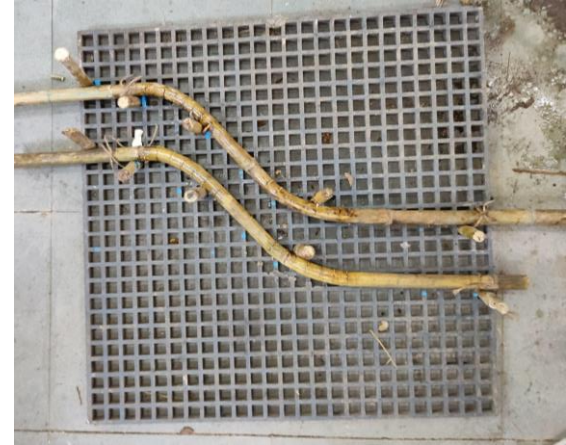
## Cutting Bamboo

The bamboo was measured and cut according to the design

For the bend, slits were made in V shape, where 60% -70 % from the bamboo's diameter had to be cut, for a 90° bend 8 - 10 Slits had to be cut while 6-8 slits for a 45° bend.



## Bending and heating



### Learnings

It was found that the bamboo had



To be heated to an optimum temperature because beyond that it had the tendency to become brittle. The nodes were the densest area, therefore, required closer slits to bend. Moreover, the slits that were cut had to be 60%-70% of the bamboo diameter, because lesser than that they had the tendency to crack from the rear and the sides, while if the slits were over-cut the bamboo would snap. We had to therefore bend using moisture, which was the most suitable way to bend in our case.



### Dry fitting

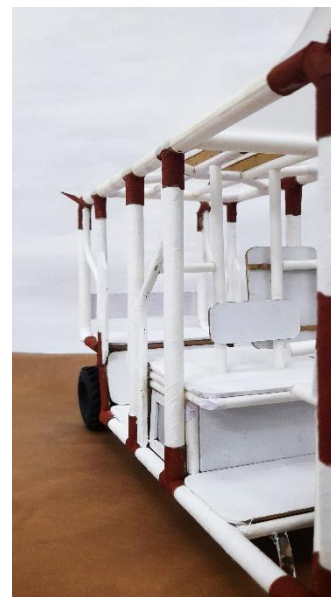
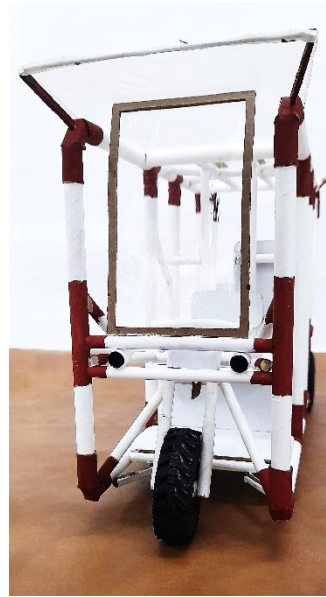
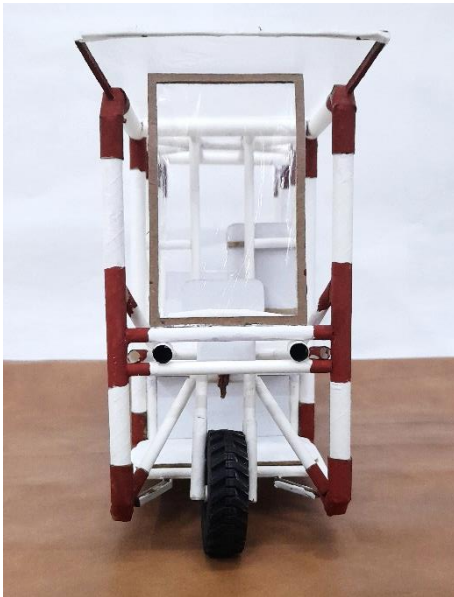
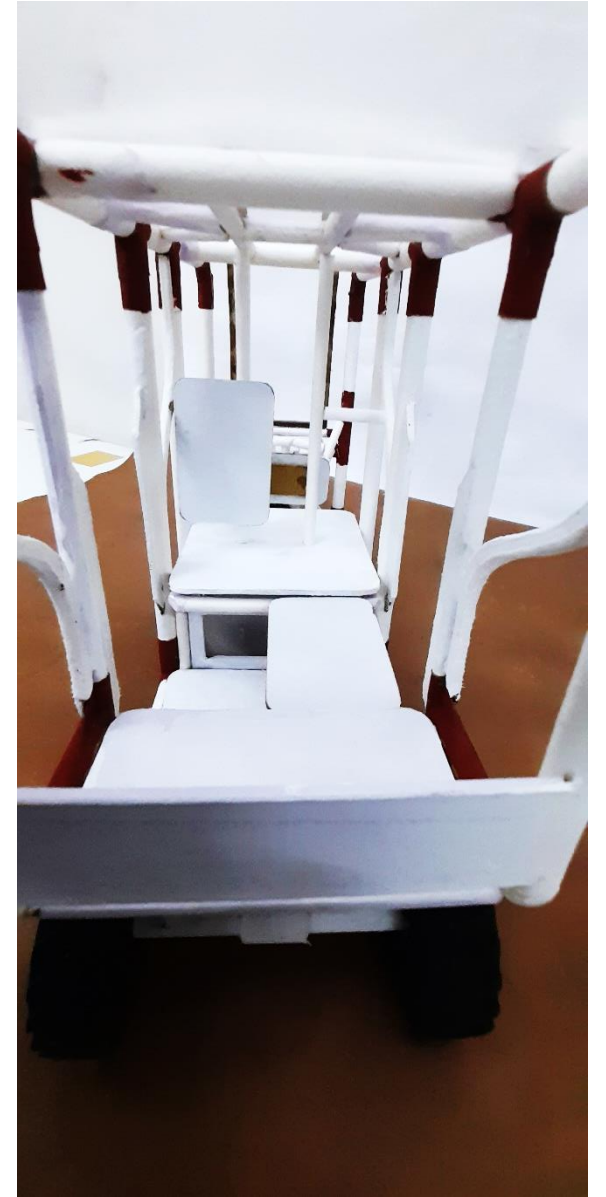
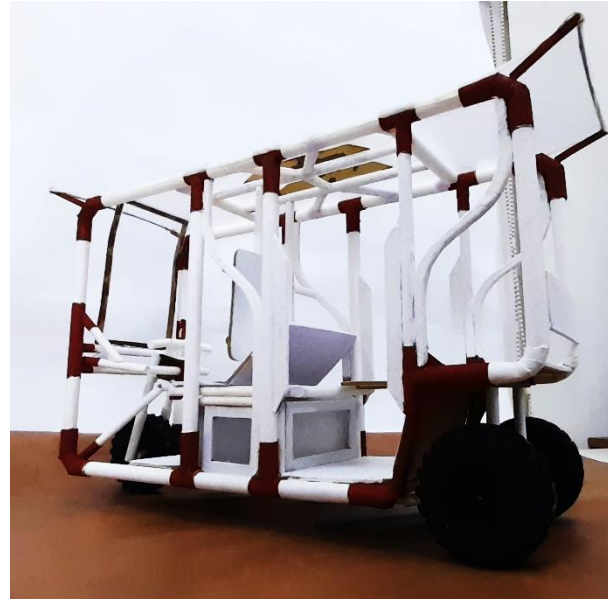




**Metal fabrication and bamboo preparation**



Scale model



## Bibliography

1. **Context:** <https://theprint.in/opinion/dashboard/deathtrap-or-economic-miracle-rise-of-e-rickshaws-show-safety-should-go-beyond-cars/1091223/>
2. **Average speed of vehicles:** <https://economictimes.indiatimes.com/news/politics-and-nation/bengaluru-has-second-slowest-commute-speed-study/articleshow/70912200.cms>