

Design Project- 2



Design of an E- shuttle for IIT Bombay

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Submitted by,
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Mobility & Vehicle Design

Declaration

I declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated any idea/data in my submission.

I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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Roll No: 176390001

Date: 19/12/2018

Approval sheet

The Mobility and Vehicle design project report entitled 'Design of an E- Shuttle for IIT Bombay' by Onkar Khot is approved in partial fulfilment of the requirement for Master of Design degree in Mobility and Vehicle Design.

Guide: Prof. Sugandh Malhotra



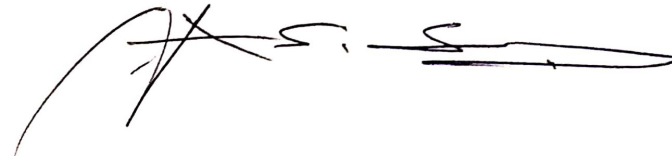
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External Examiner:



Chairman:



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I also thank to security people at main gate of IIT Bombay, manager of Tum-tum and fellow classmates and friends who supported and helped me with the creative inputs during the project.

Abstract

IIT Bombay, a top ranked educational institute in India is facing the problem with first mile and last mile connectivity. Residents, students and visitors can reach to the main gate by public transport, but after entering the campus they don't have any vehicle to reach to the home, college or hostel. Also, staff and students who don't have cycles or personal vehicles face inconvenience because there is no any transport solution to reach to the work or college. They have to wait for an auto rickshaw. Also, in the night, it is very difficult to get an auto rickshaw, so they have to walk 2 to 3 kilometres to reach to their home or hostel. In rainy season, the situation is even worse. Due to high demand, chances of getting an auto rickshaw are less.

So, the last mile and first mile connectivity problem leads to increase in number of 'personal vehicles' on roads of the campus and this has become major issue for road congestion and parking space. Rapid growth in the personal vehicles has become the prime reason for air and noise pollution in the campus of IIT Bombay.

After initial user study, it was found that an internal transportation system run by IIT Bombay administration can be proposed. This system can facilitate transportation and provide connectivity between the various important landmarks within the campus such as gates, hostel complexes and market. After collection of all user data, Frequency and routes are designed. Based on all data, an electric shuttle is designed. Both interior and exterior form of the vehicle is designed with advanced technology and material for the best experience.

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1 Introduction

India, one of the fastest growing economies in the world, is achieving growth rate of 7.3% per annum. And urban areas play major role in the economic growth of the country. With growing population, the country is working hard to transform itself over the next few decades. To improve public transport has always been an agenda of the country. Government is investing huge amount of money to improve public transport by developing modes like metro railway, mono rail etc, but there is still rise in number of private vehicles registered per year. The study says that, unavailability of first mile and last mile connectivity, is one of the reasons for people not to use public transport and use personal vehicles.

IIT Bombay, a top ranked educational institute in India is facing the problem with first mile and last mile connectivity. Residents, students and visitors can reach to the main gate by public transport, but after entering the campus they don't have any vehicle to reach to the home, college or hostel. Also, staff and students who don't have cycles or personal vehicles face inconvenience because there is no any transport solution to reach to the work or college. They have to wait for an auto rickshaw. Also, in the night, it is very difficult to get an auto rickshaw, so they have to walk 2 to 3 kilometres to reach to their home or hostel. In rainy season, the situation is even worse. Due to high demand, chances of getting an auto rickshaw are less.

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After initial user study, it was found that an internal transportation system run by IIT Bombay administration can be proposed. This system can facilitate transportation and provide connectivity between the various important landmarks within the campus such as gates, hostel complexes and market. After collection of all data, design brief is formulated.

2 Pre-research

2.1 Existing shuttle service study across the world

This study is done to understand the current scenario of electric shuttles across the world. Manufacturing technology, experimentation, technical problems etc. has been observed. The study helped to know the advanced technologies used in the vehicle, technical specifications, seating capacity, aesthetics etc. The information is used for benchmarking.

Navya Arma



EasyMile ez-10



CityMobil2



Agra Tourism



E-Rickshaw



E-Rickshaw

Image 2.1 Existing shuttle service study across the world

2.1.1 Navya Arma



Image 2.1.1.1 Navya Arma exterior



Image 2.1.1.2 Navya Arma interior

Navya, a French start-up automotive company has introduced an autonomous e shuttle in the University of Michigan's North Campus. The shuttle has a "safety conductor" rather than a driver on board.

The university deployed two fully-automated, 15-passenger, all-electric Arma shuttles, to service a two-mile route between the Lurie Engineering Centre and the North Campus Research Complex on Plymouth Road. The shuttle can carry a maximum of 15 passengers, and lacks a steering wheel or pedals. The vehicles are being deployed in partnership with Mcity, the university's 32-acre testing facility automakers and tech start-ups often test their self-driving cars.

Each vehicle is driven around the area by a human to map the route in 3D. The pod is then able to find its way round using built-in lasers, sensors and cameras that check where the car is against the 3D map, while detecting obstacles, hazards and pedestrians.

UM has become the first college campus to deploy driverless shuttles on public roads to transport students, faculty and staff, studying how passengers react to the vehicle as a way to gauge consumer acceptance of driverless technology, Mcity Deputy Director Carrie Morton said.

2.1.2 Specifications of Navya Arma

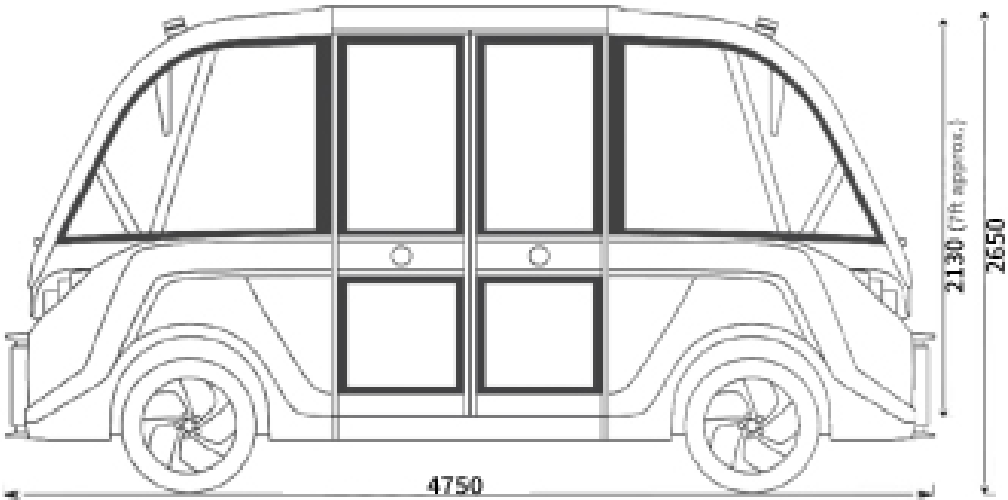


Image 2.1.2 Navya Arma specifications

Dimensions

Length m	4.75
Width m	2.11
Height m	2,65
Clearance m	0.20
Tyres	215/60 R17

Energy

Battery	Battery pack LiFe
Capacity kWh	33
Average autonomy hours	9
Charging technology	Induction / Plug

Drive

Drive wheels	2
Engine	Electric
Power kW	15 (25 peak)
Maximum speed km/h	45
Operating speed km/h	25

Capacity

Total passengers	15
Sitting	11
Standing	4

2.1.3 Local Motors Olli



Image 2.1.3.1 Local Motors Olli exterior



Image 2.1.3.2 Local Motors Olli interior

Car maker Local Motors has partnered with IBM to create “Olli”, the world’s first self-driving, electric minibus whose chassis is manufactured using 3D printing. The automated vehicle, which can carry up to 12 people, is moving passengers around Washington DC and Berlin. “Olli understands human language, so you can walk in and say, ‘I’d like to get to work’. That then lets you as a passenger relax and enjoy your journey” – Bret Greenstein, IBM.

It takes about 24 hours to print an Olli, after which it is fitted with its battery and an IT system that makes use of IBM’s “Watson” cognitive learning technology. Watson interact conversationally with them,

Watson also helps Olli to analyse and learn from “high volumes of transportation data, produced by more than 30 sensors embedded throughout the vehicle”. Olli’s activity is supervised by a human at all times.

The University at Buffalo will use Olli for autonomous vehicle education and mapping while also testing it for campus transportation. The project is being co-managed by the New York State Energy Research and Development Authority and the New York State Department of Transportation, to reduce greenhouse gas emissions by 40 percent by 2030.

2.1.4 3D printed Olli

Material Used: Carbon fibre reinforced ABS

Local Motors has made history by 3D printing its first Olli, self-driving shuttle in the company's Knoxville microfactory. Local Motors has long been innovating the future of vehicle 3D printing, and this Olli is believed to be the only 3D printed transit vehicle on Earth.

If the vehicle is changed, the Local Motors can simply change the file, and print a batch of Ollis that best fit the campus' needs. In fact Architects, Urban Designers, Transportation Planners, and other disciplines can be involved in the future with co-designing future Ollis with the Local Motors 3D printing team.

Now campuses and cities don't have to fit a generic shuttle to their city, rather a new shuttle can be designed and printed to fit to their city. This is completely revolutionary.

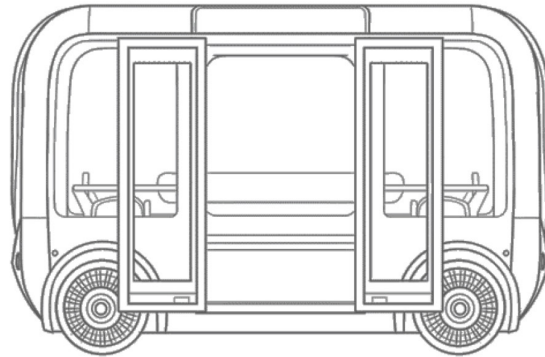
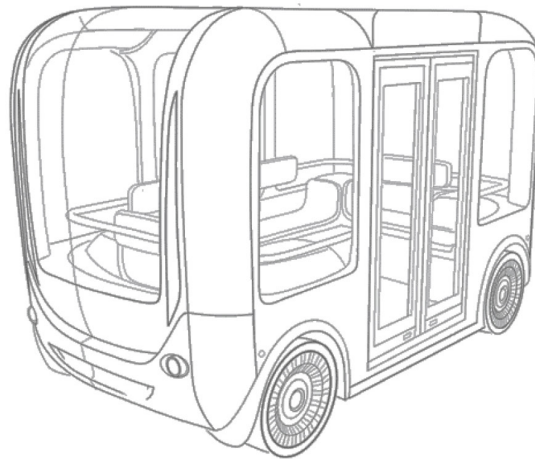


Image 2.1.4.1 Local Motors Olli chassis 3 D printed



Image 2.1.4.2 Local Motors Olli chassis 3 D printed

2.1.5 Specifications of Local Motors Olli



Length mm	3920
Width mm	2050
Height mm	2500
Wheelbase mm	2526
Weight	2654kg
Range	60km
Max. speed	40km/h
Max. torque	240Nm
Charge time (230V)	3 hours
Transmission	9.59.1 gear ratio
Seating capacity	12 (8 sitting, 4 standing)

Image 2.1.5 Local Motors Olli CAD sketch

2.1.6 EasyMile EZ10



Image 2.1.6.1 EasyMile ez10 exterior



Image 2.1.6.2 EasyMile ez10 interior

EasyMile EZ10 is an electric vehicle runs on the roads in Paris that can carry up to 10 people (6 seating positions and 4 standing positions or wheelchair), the EZ-10 moves autonomously by using GPS tracking system, a visual guidance, a collision detection system and the SLAM technology.

During the initial identification of the route that the EZ-10 automatically take the two on-board cameras and the LIDAR to register a mapping of references. The on-board computer analyses and then marks all the significant points and environment statistics (control points and in 3D vision.

The potential applications are numerous: pedestrian city centers, gentle mobility areas, pedestrian tunnels and shared with cycling lane, intermodal area for linking between self-service bike rental and car-sharing stations, airports, amusement parks, parking spaces, health centers, ports, or even industrial sites.

With a maximum and redundant security both for pedestrians and its passengers, EZ-10 adapts its behaviour and determines its speed, or even its total stop, depending on its surrounding environment.

3 Research

3.1 User Research

To understand the sensitivity of the problem and current connectivity issues in the campus, user research is done by asking people questions related to the transportation in the campus and through the Google forms. The result of the feedback is noted and inferences are drawn.

Questionnaire:

1a. Name

1b. E-mail Id

1c. Age

1d. Gender

1e. Association with IIT Bombay?

1f. How many people are in your household?

1g. How many private vehicles are used by your household?

1h. Are you an IIT Bombay campus resident?

2. Which vehicle do you prefer to drive in IITB campus?

3. How do you go to work in campus?

4. If you hire an auto-rickshaw, how much do you need to walk and wait?

5. What things do you usually carry in your bag while traveling in campus? (Multiple clickable options)

6. Campus residents use a bag to carry laptop, groceries, water bottle, umbrella, books, etc. What would be the approx. weight of the bag that you normally carry around in the campus?

7. For what purpose, have you used your vehicle more frequently in past one month? (Please choose only one option in every row)

8. Typically, you need transportation from/ to: (multiple clickable options)

9. What is your approx. weekly expenditure on travel within campus?

10. What mode of payment do you prefer to use for any purchases within campus? (Multiple clickable options)

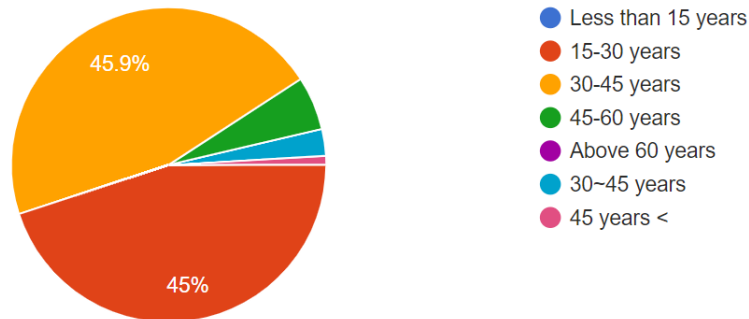
11. Was your decision to buy a vehicle (two-wheeler or four-wheeler) based on lack of convenient public transport on campus?

12. What mode of transport would work best for you to move around IIT Bombay campus? (Multiple clickable options)

13. Rank the following priorities for campus transport in descending order.

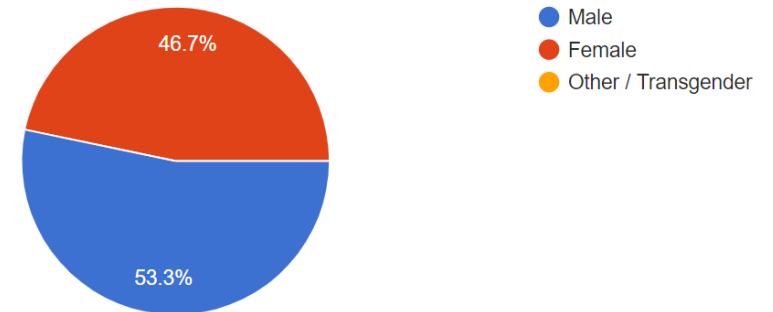
Results and Inferences

Age



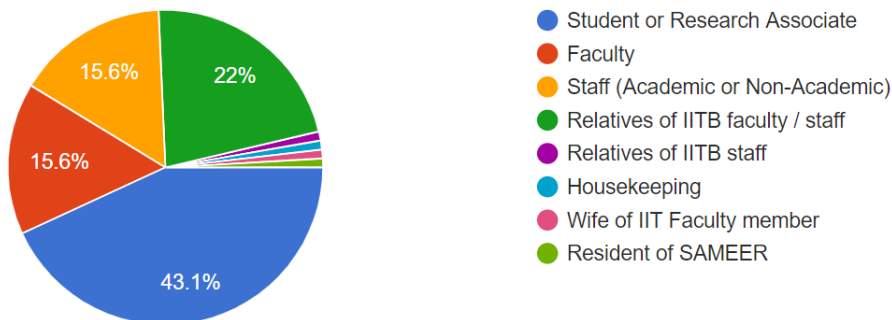
- 15- 30 year old- 45% - Most of them are students
- Above 30 year old- 55% - Most of them are households
- Also there are elderly people who needs accessories to hold in the vehicle

Gender



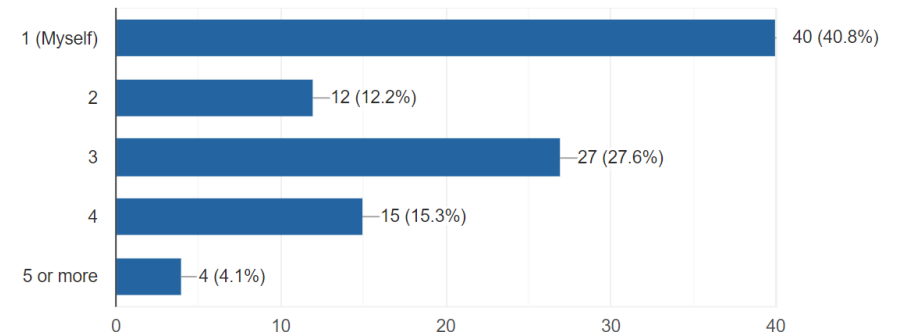
- The numbers show almost equal ratio, but students sex ratio in IIT Bombay is about 10:2
So, there are large number of female residents in the campus
- Needs seat reservation for female user

Association with IIT Bombay



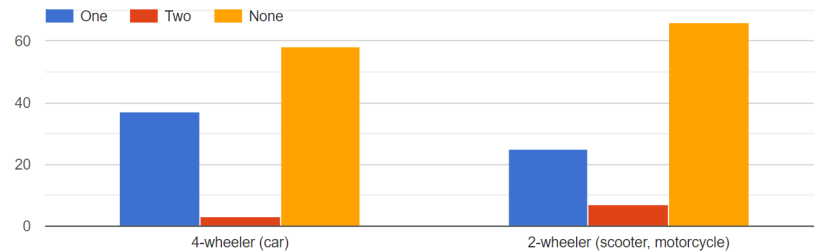
- All faculty have there own vehicles.
- Mostly students are going to use the shuttle so more standing space can be provided.

How many people in the house



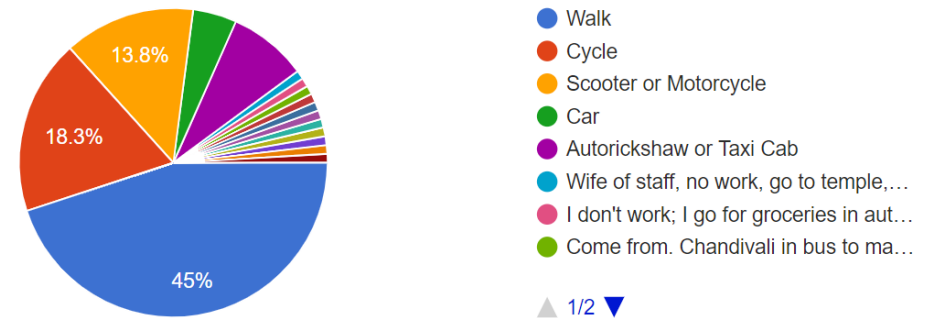
- There are many families with total 3 and 4 members.
So, there are large number of families with children.
Need to provide special safety features for school going children.

How many private vehicle you own?



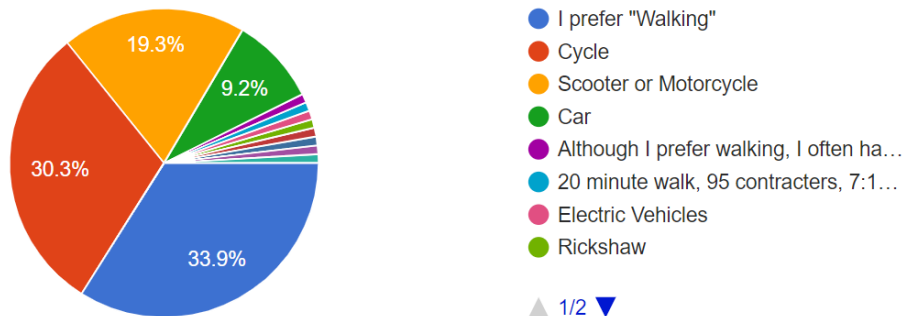
- There are 37 people with atleast one vehicle.
I.e. 60% families have atleast 1 vehicle.

How do you go to work?



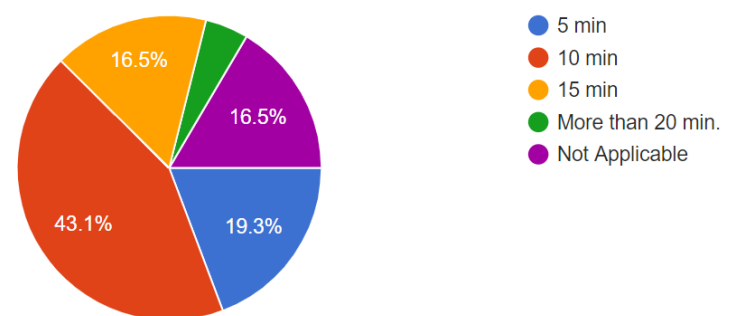
- Number of students with cycle- 18.3% i.e. 42% of total students.
Considering 10,000 students in the campus, 5800 students don't have cycle.
I.e. 60% non student prefer going to work by vehicle.

Which vehicle do you prefer to drive in campus?



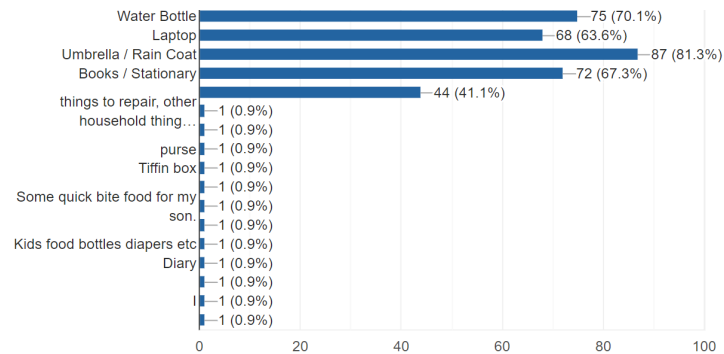
- 36% non students prefer vehicle

How much do you need to walk / wait for auto?



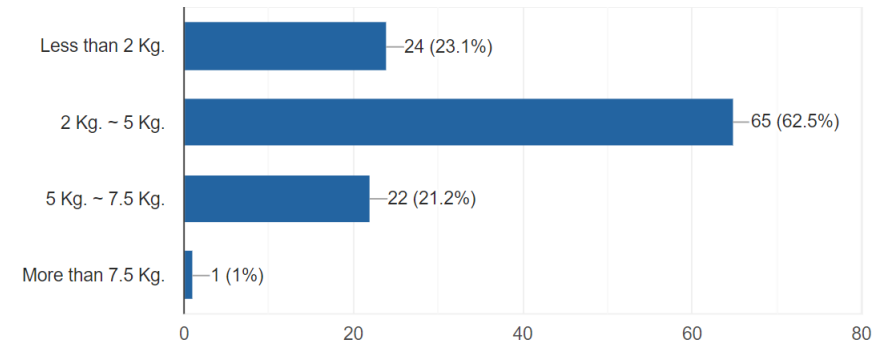
- 43% have to wait for minimum 10 minutes.
So, high frequency is required to save their time.
I.e. 60% non student prefer going to work by vehicle.

What things do you carry?



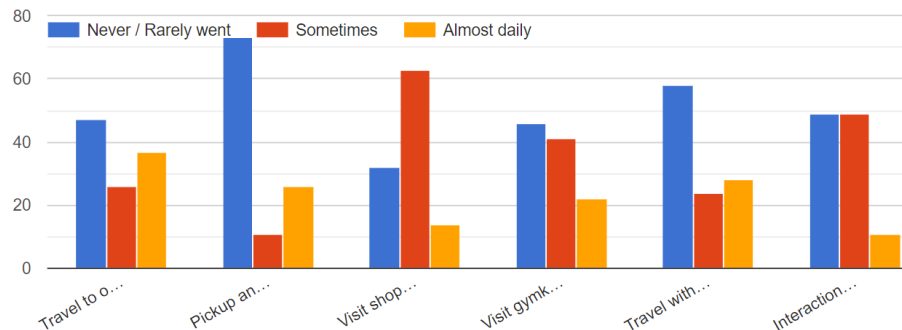
- In the rainy season most of the people carry umbrella or raincoat.
- Water bottle, books and laptops are mostly carried by people for which they use backpacks. Which means that backpacks are used by most people.

How much your luggage weighs?



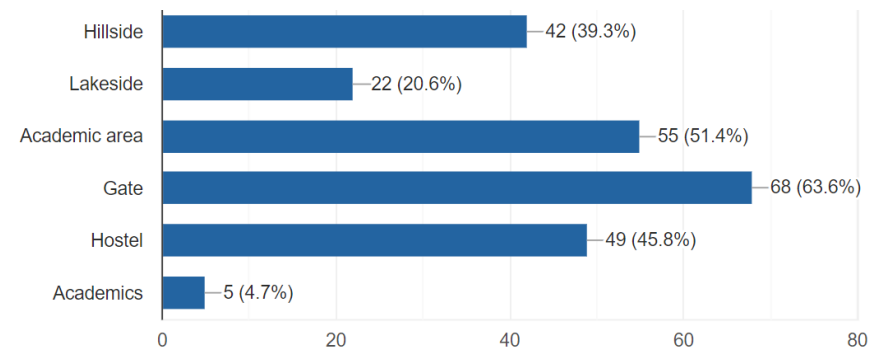
- 50% of luggage weighs between 3.5kg and 7.5 kg
So, Luggage space should be designed for minimum human efforts.

Where do you go more often using personal vehicle?



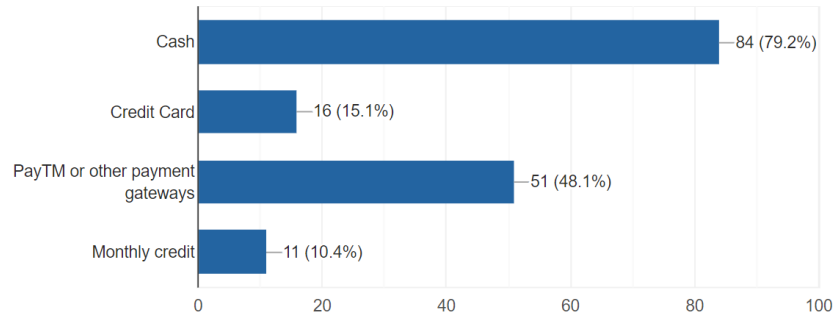
- Academic area and Market gate connectivity is equally important as main gate connectivity.

You need transportation from?



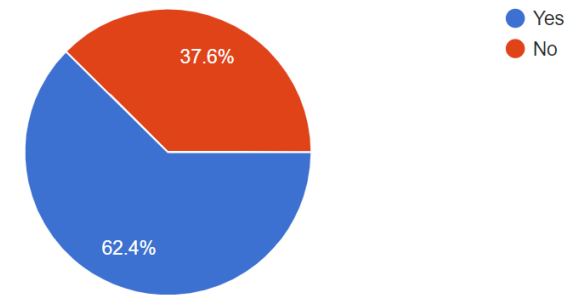
- The data is used to order the frequency of shuttle according to the locations.

Preferred mode of payment



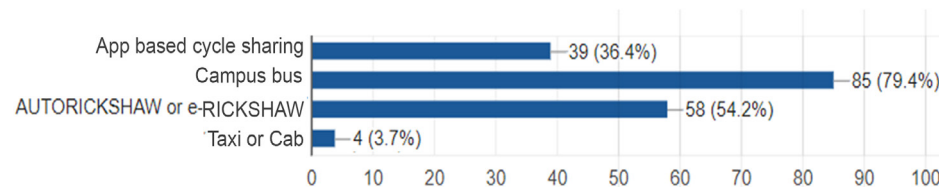
- After cash mode, e- wallets are preferred by the users.

Lack of public transport in campus made you to buy a vehicle?



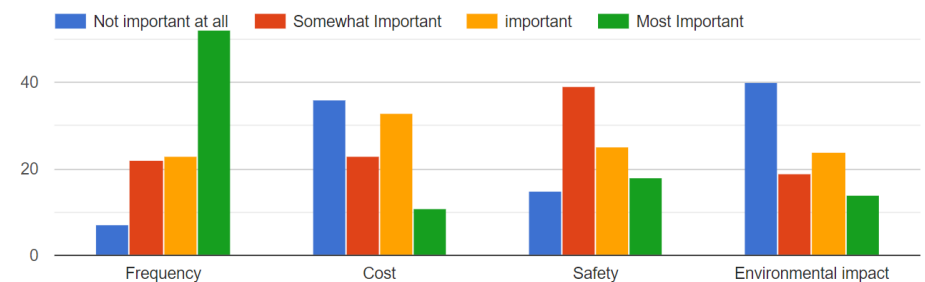
- Good public transport service is highly required in the campus to improve connectivity, convenience and air quality.

What mode of transport would work best?



- Campus bus is most preferred mode of transport over auto rickshaw and cycle sharing.

What is your priority?



- Frequency is the top priority for the residents.

3.2 Scenario at Main Gate



Image 3.2 IIT Bombay main gate

The objective of the study was to analyse the influx of the auto rickshaws and cabs to calculate the average incoming number of people per hour in a day from the main gate and what people carry with them.

This study helped to calculate frequency of the shuttle at main gate and design the luggage space.

Number of Auto rickshaws and cabs enter in the campus per hour

Time	Autos	Cabs
10AM to 11AM	125	25
11AM to 12PM	86	17
12PM to 1PM	75	22
3PM to 4PM	83	24
4PM to 5PM	71	25
5PM to 6PM	72	16
Total	512	129

So, average **85 autos and 21 cabs per hour** enter into the campus. Each auto and cab contains 1 or 2 passengers. Therefore around **155 people** come into the campus per hour.

What things people carry while entering into the campus



90% people carry backpacks. some women carry handbags, purses and messenger bag.

3.3 Scenario at Hostel 12/ 13/ 14



Image 3.3.1 Scenario at hostel 12/13/14



Image 3.3.2 Scenario at hostel 12/13/14

The objective of the study was to analyse the influx and outflux of the students at the peak time which is 8:30AM to 9:30AM and use the information to calculate the frequency.

Total number of students going out in the time period are calculated. Also, how many auto rickshaws arrive within the time period are calculated, which proved the high desirability of the transport solution within the campus.

Number of students go out between 8:45AM and 9:45AM - **340**

Number of auto rickshaws come to H14 between 8:45AM and 9:45AM - **82**

The values are used to calculate frequency of the shuttle at peak time.

3.4 Study of existing solution in IIT Bombay



Image 3.4.1 Tum-tums



Image 3.4.2 Tum-tums

The study was conducted to understand the details about the previously existing transportation system called Tum-tum. The detailed information is collected from the manager of Tum-tum.

Number of buses - 15 (11- 24seater, 2- 34seater, 2- 50seater)

Routes-

- 4 buses- Start from 7AM for school kids. After school time gets over, runs from H15 to SOM.
If not full enough, runs via H1 - H5 - H8.

- 2 buses- H1 - H5 - SOM at 8:15AM .

- 2 buses- H12 - SOM - Main Gate at 8:15AM .

- 7 buses- H12 - SOM at 8:15AM .

Frequency-

5-6 buses per hour in class timings from H12
2-3 buses after class time gets over

Night time-

11 PM to 7 PM from SOM- Main Gate and cover whole campus in half an hour. In medical emergency- Driver had all rights to turn the bus towards hospital.

By observing the user research and the data above, it is found that frequency of the buses was less and people had to wait for the buses for long time.

The routes data is used to map the new routes.

3.5 The need



Image 3.5.1 Shut down service of Tum-tum



Image 3.5.2 Auto rickshaws as a mode of transport

Based on the user research and scenarios at hostels and main gate, it is found that, campus residents are facing inconvenience because there is no vehicle to commute to work, school, college, the gates, temple etc. So, people are using their personal vehicle or auto rickshaw or go by walk. Students who don't have cycle are facing inconvenience. If they are late then they have to catch auto rickshaw. If auto rickshaw is not available, then they have only one option of walking. So, frequency is a big problem to be solved.

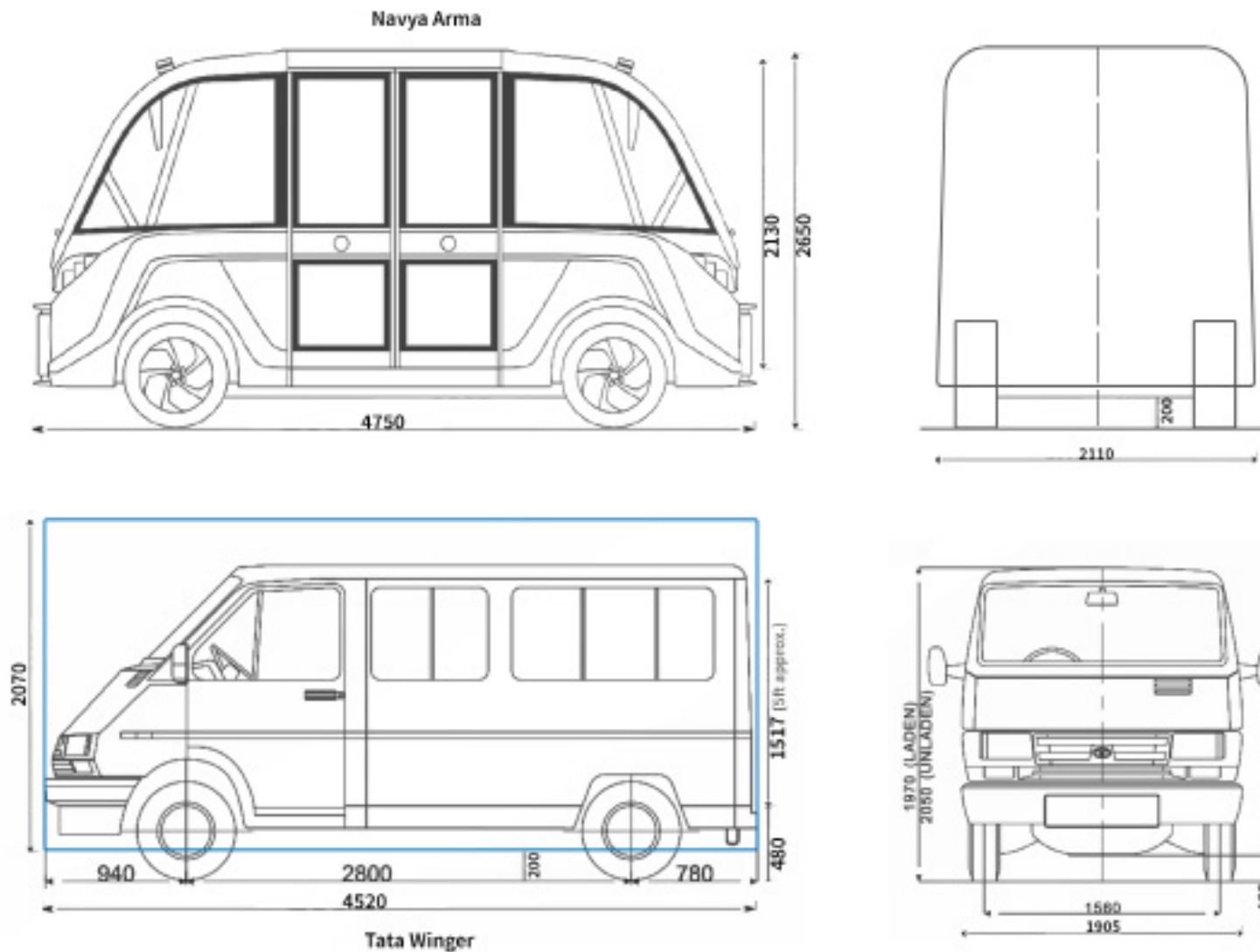
Auto rickshaws are again an issue. Auto drivers drive the auto rickshaw very fast which results in risk of accident. Even security at main gate and market gate are facing problems and health issue due to continuous flow of auto rickshaws. Because they are creating air and noise pollution.

Also, in rainy season, the probability of getting auto rickshaw is very less due to high demand. So, people go to work or college by walk with umbrella or raincoats. In the night time, residents face inconvenience due to no transport solution within the campus.

Hence, there is a need of electric shuttle service for better connectivity in the campus.

4 Capacity, Specifications, Frequency and Routes

4.1 Comparison between Arma and Tata Winger



Tata Winger chassis is selected to save the cost and time required for manufacturing. Comparison of the dimensions and packaging between Navya Arma and Tata Winger is done to find the seating capacity and changes required in dimensions for standing passengers.

The blue rectangle is volume of the new shuttle.

All dimensions are in mm

Image 4.1 Comparison between Arma and Winger

4.2 Specifications of the shuttle

Rules and regulations of ARAI and Ministry of Transport, GOI are studied for the dimensional requirements. Navya Arma is benchmarked for energy, drive and capacity.

Technical specifications are derived as follows,

Length mm	4520
Width mm	1905
Height mm	2070
Wheelbase mm	2800
Door width mm	1200 (Double door)

Energy

Battery	Battery pack LiFePO4
Capacity kWh	33
Charging technology	Induction / Plug

Drive

Drive wheels	2
Engine	Electric
Power kW	15 (25 peak)
Maximum speed km/h	45
Operating speed km/h	25

Capacity	15+1
Total passengers	15
Sitting	11
Standing	4

4.3 Frequency Calculation at Hostel 15/ 16



Image 4.3 Hostel 15

The study was conducted to analyse the influx and outflux of the students at the peak time which is 8:30AM to 9:30AM.

Total number of students going out in the time period are calculated. Also, how many auto rickshaws arrive within the time period are calculated, which proved the high desirability of the transport solution within the campus.

Number of students go out between 8:30AM and 9:30AM - **610**

Consider,

Total outflux = 600

According to user research,

42% students have cycles

So, approximately 250 students walk or take auto

Considering 15 seater e shuttle,

15-16 rounds are necessary

Therefore, **Frequency = 1 shuttle/ 4min...** for peak hours

4.4 Routes



Image 4.4 IIT Bombay map

H- Hostel
 SOM- School of Management
 RM Lab- Rapid Manufacturing Lab
 IDC- Industrial Design Center
 CSRE- Center of Studies in Resources Engineering
 - Peak time period routes

Routes are mapped by studying results of user research. The previous bus services routes are also taken into consideration. At peak time period frequency of some of the routes can be increased.

From 7AM for school kids from residential area to school
 After school time gets over, runs from H15 to SOM. If not full enough, runs via H1 - H5 - H8.

H12 - H9 - H8- SOM- Main Gate

H15- Central library- Cummins Lab- RM Lab- IDC

H15 - H1- H5 -H8 - SOM- Main Gate

H12 - H9 - H8- Central library- Cummins Lab- RM Lab- IDC

H12 - H9 - H4- H1- Central library- Cummins Lab- RM Lab- IDC

Main Gate - Gulmohar- Chemical Dept. - Market Gate - CSRE - Power House - Ananta - H15 - SOM

Market Gate - Chemical Dept. - SOM- H1 - H5 - H9 - H12

Market Gate - H10- Main gate- White House- Temple

5 Design Brief

Design an e-shuttle for IIT Bombay and give the students, residents, faculty, staff, relatives of the staff access to entire new mode of transportation and solve the problem of connectivity within the campus by considering following factors :

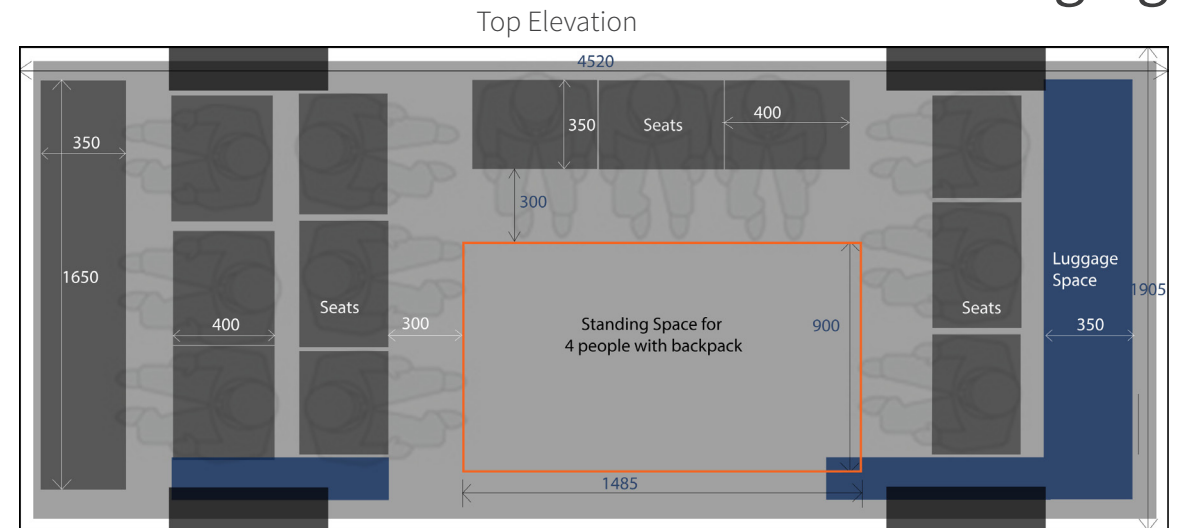
1. The shuttle should have big day-light opening to experience the environment of IIT Bombay.
2. It should have big door to handle crowd at peak time- width: 1200mm
3. The ground clearance should be less for ease of ingress and egress- 200mm
4. It should express IIT Bombay character
5. Effective package design for ease of passenger movement- C-type seat arrangement for 9 people and standing space for 4 people with backpack. 2 people can sit on co driver seat.
6. Space to keep backpack for different types of luggage like umbrellas, milk, grocery etc

6 Packaging

The results of user research and design brief leads to the package design which fulfil all the requirements.

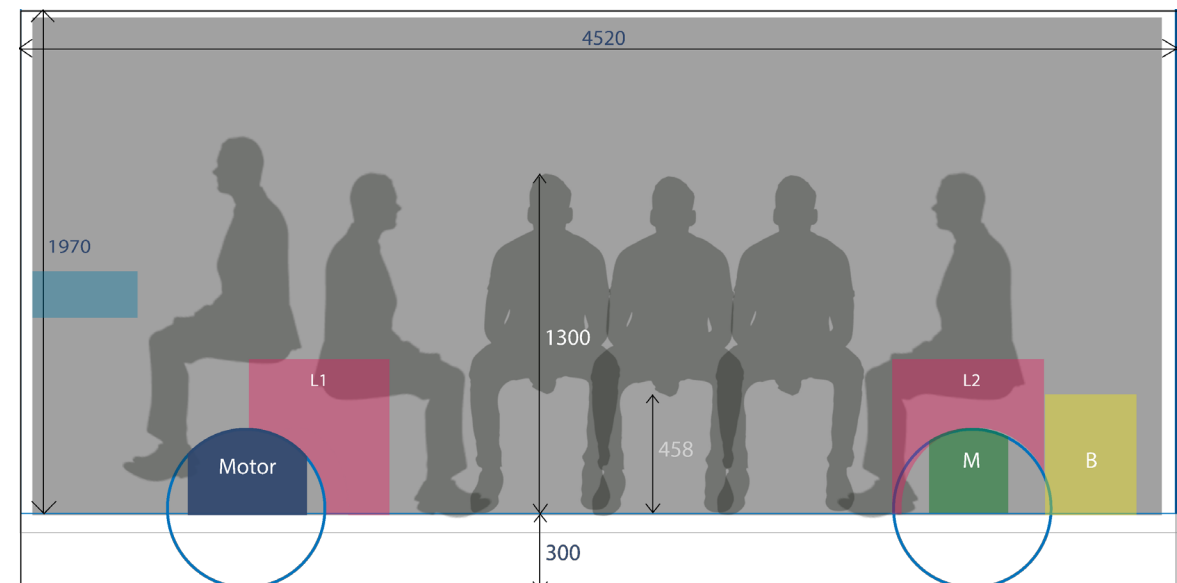
Chassis:

TATA Winger



Wheelbase = 2800

Side Elevation



L = Luggage space

D = Dashboard

B = Battery compartment

M = Maintenance kit

Image 6 Packaging

All dimensions are in mm

7 Design

7.1 Understanding IIT Bombay

Vision 2020

To be a leading global technology university that provides a transformative education to create leaders and innovators, and generates new knowledge for society and industry.

Mission

- To create an ambience in which new ideas, research and scholarship flourish, and from which the leaders and innovators of tomorrow emerge.
- To address problems faced by the nation and the world through the talent we nurture and the research we do.
- To provide an education that transforms students through rigorous coursework and by providing an understanding of the needs of society and industry.
- To collaborate with other academic and research institutes around the world to strengthen the education and research ecosystem.

Core Values

The core values adopted by the Institute as enduring principles are Integrity, Excellence, Accountability, Transparency, and Empathy.

- Integrity: Research and teaching shall be carried out in an environment of academic freedom and honesty. The Institute will adhere to the highest standards of ethics in all its activities.
- Excellence: The Institute is committed to excellence in all spheres of its activities, and through reviews, will work towards continuous improvement.

- Accountability: IIT Bombay, an Institute of National Importance established by an Act of Parliament, has been a recipient of public funds and recognizes that it is accountable to the people of India (through the IIT Council and Board of Governors of IIT Bombay) and to all its immediate stakeholders including students, staff, faculty, alumni and industry.
- Transparency: The Institute will function according to defined procedures and rules, which will be informed to all stakeholders. The Institute will make public all important information related to its functioning.
- Empathy: An awareness of the conditions of the weaker sections of our society and contributions towards solution of their problems will form an integral part of the research and education programmes of the Institute.

Goals

- Enhance engagement with society and industry
- Broaden educational areas
- Improve internal support systems
- Enhance student experience
- Broaden funding base
- Attract international students and faculty
- Advance frontiers of knowledge
- Enhance diversity
- Enhance alumni engagement
- Develop a cleaner and greener campus

7.2 What is IIT Bombay

Vision and Mission of IIT Bombay is depicted in the pictorial form to understand it clearly. This image board is used for ideation. The words which interpret IIT Bombay are Natural, Transparent, Technical, Visionary, Diverse and Energetic.

IIT Bombay

NATURAL

TRANSPARENT

TECHNICAL

VISIONARY

DIVERSE

ENERGETIC



Image 7.2 What is IIT Bombay

7.3 Exterior Image Board

The another approach is designing the shuttle by putting architectural elements in it.

The campus architecture is observed and some common design elements are captured.

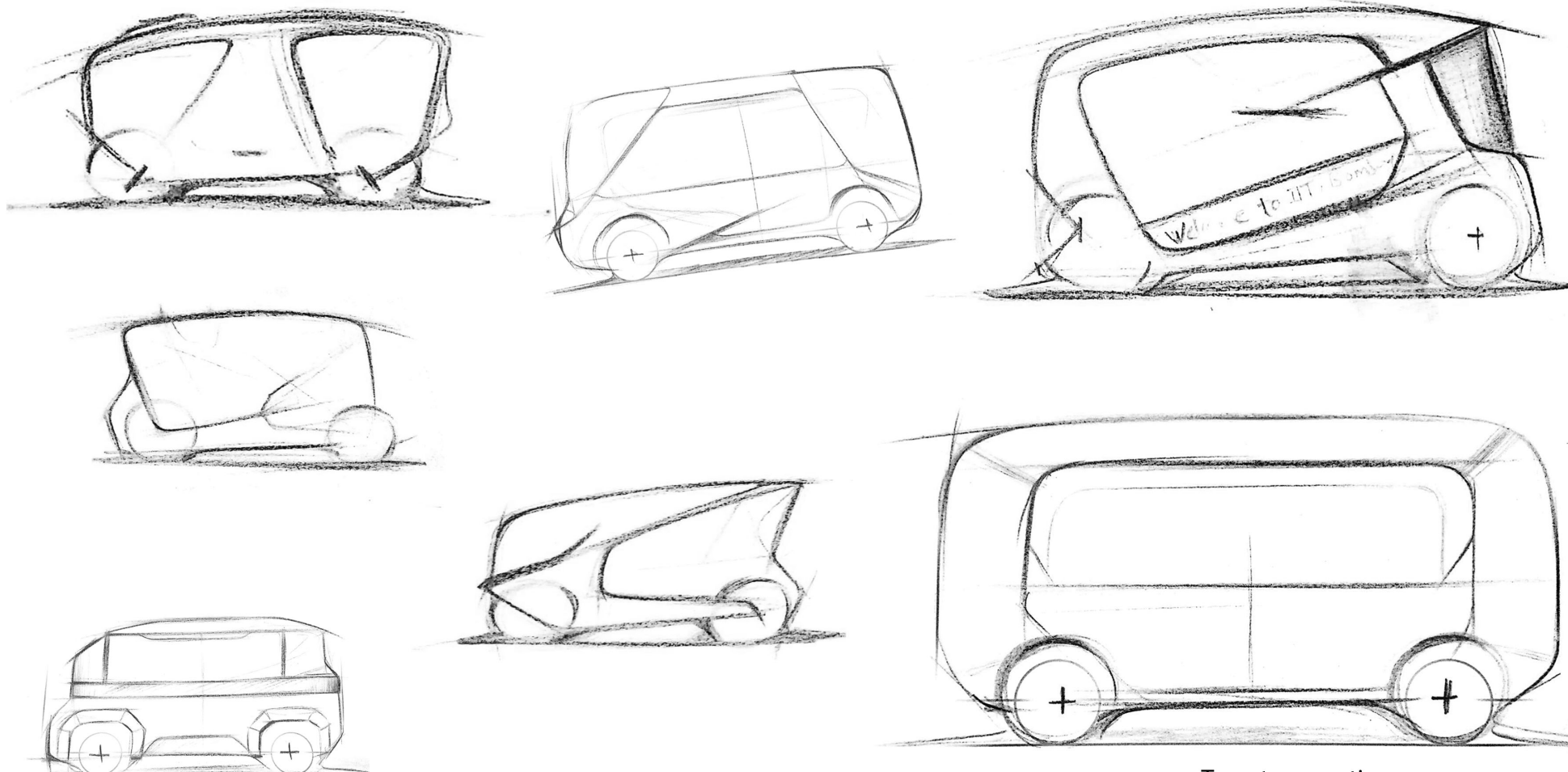
The square windows, triangular fleet of roof, circular arch are the mostly used design elements in the IIT Bombay architecture.



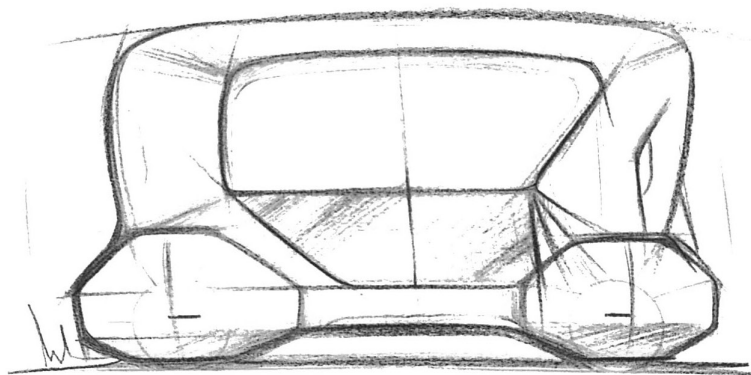
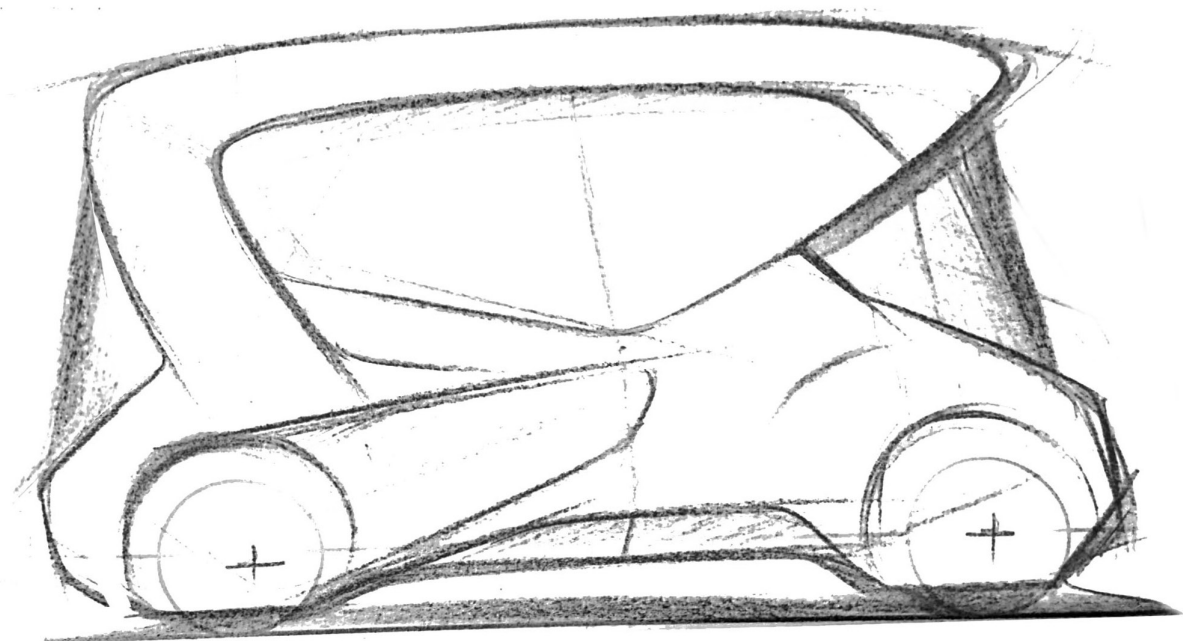
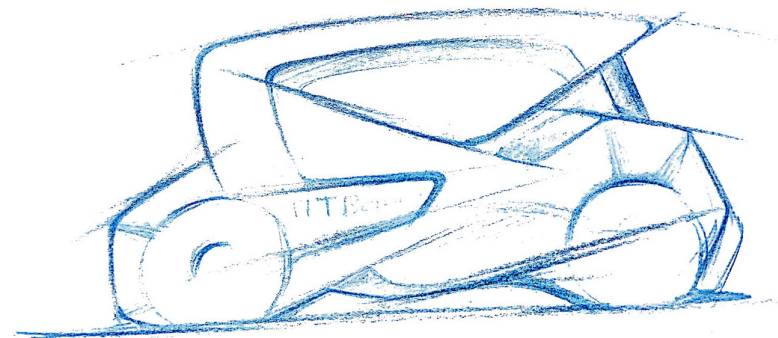
Image 7.3 Exterior image board

7.4 Ideation

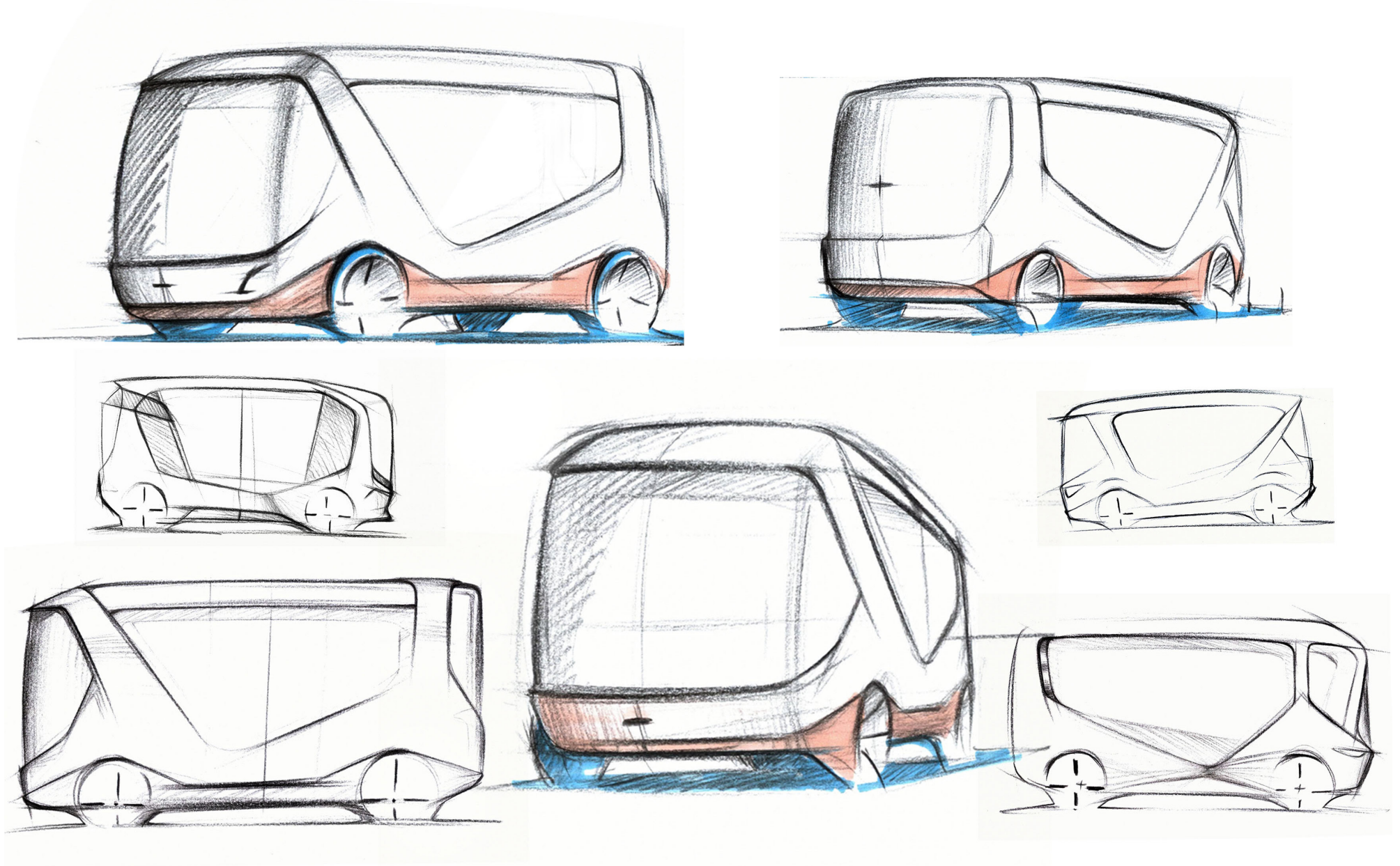
Approach 1: Technologically advanced i.e. complex and mechanical aspect of IIT Bombay is taken into consideration. The surfaces are more complex in nature.



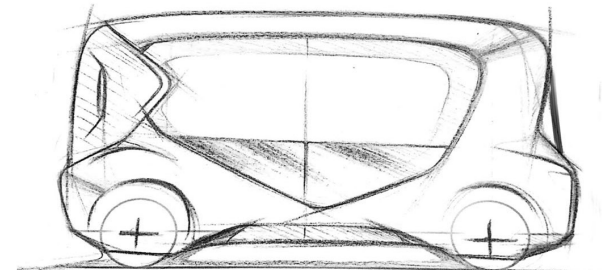
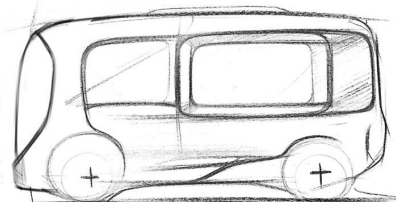
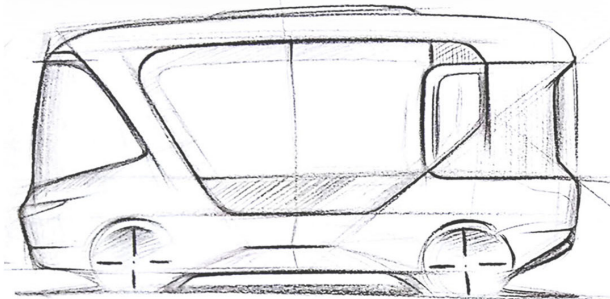
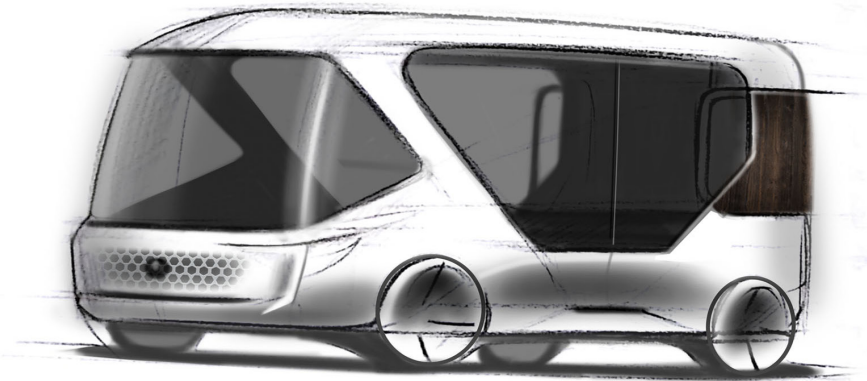
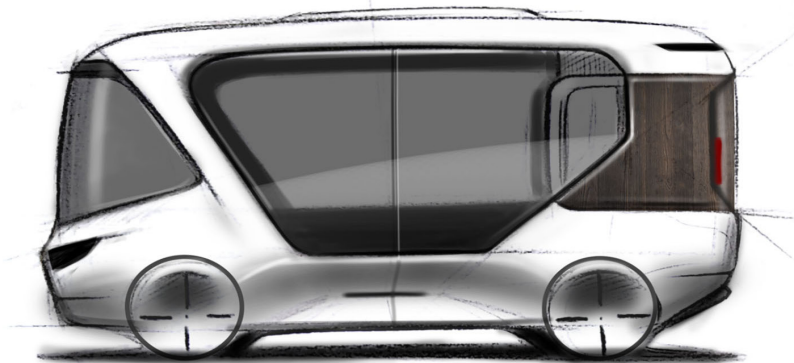
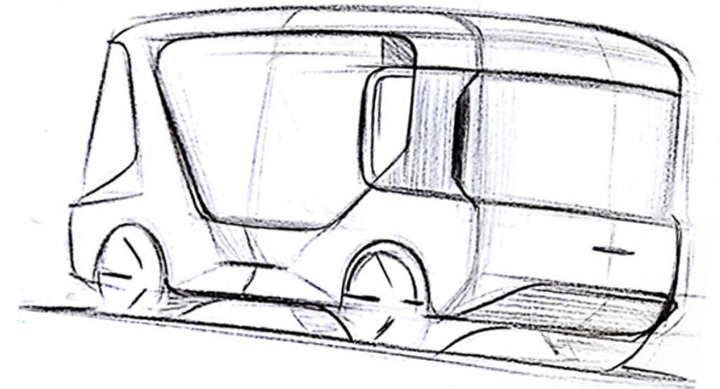
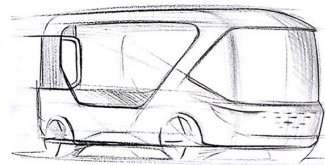
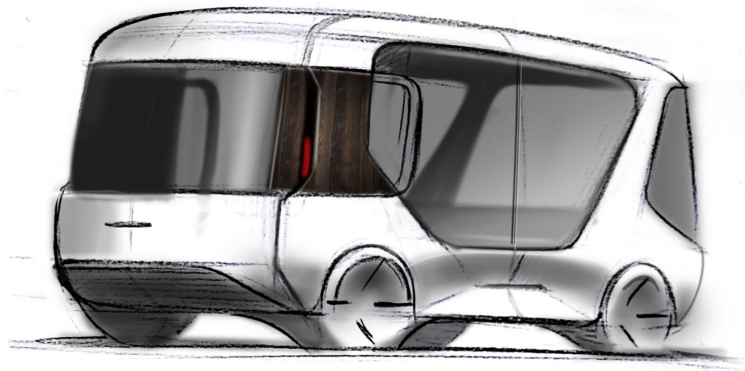
Target proportion



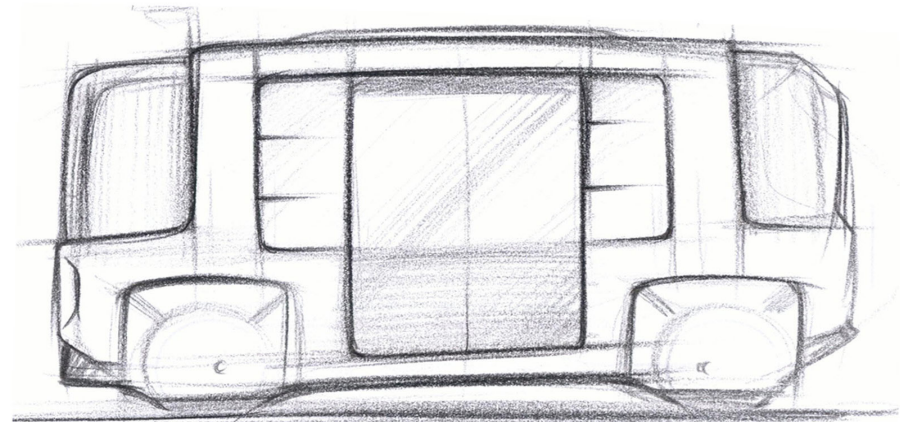
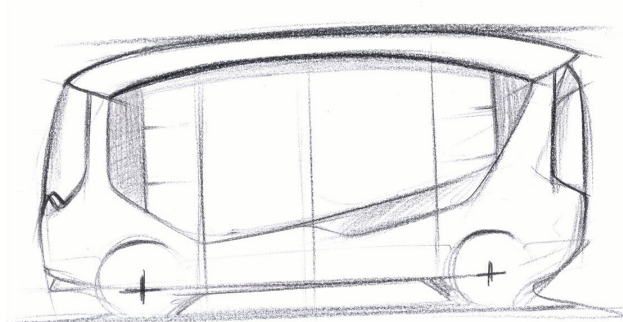
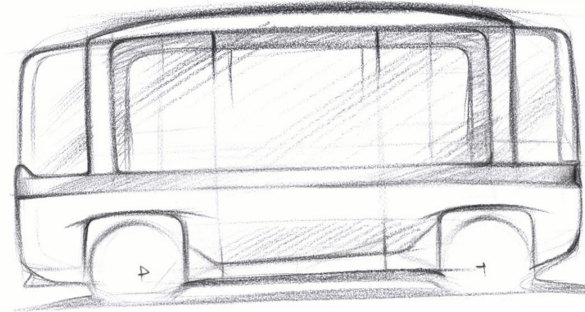
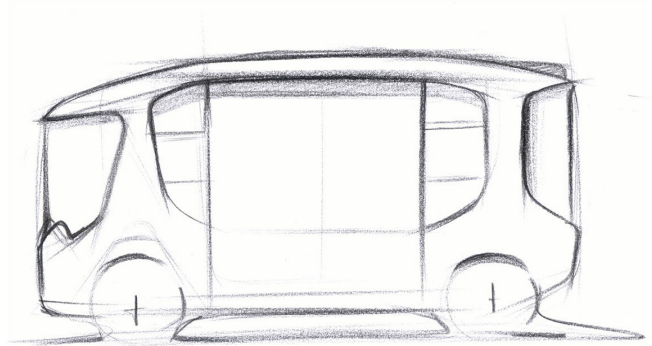
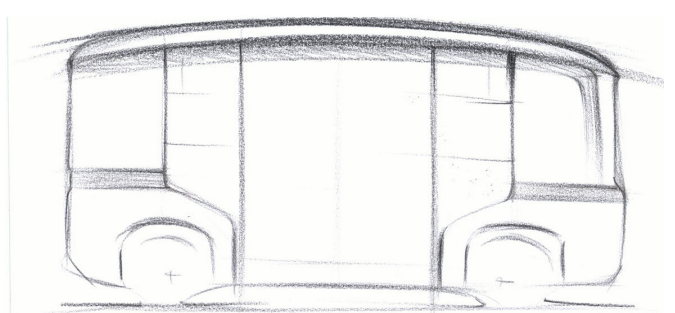
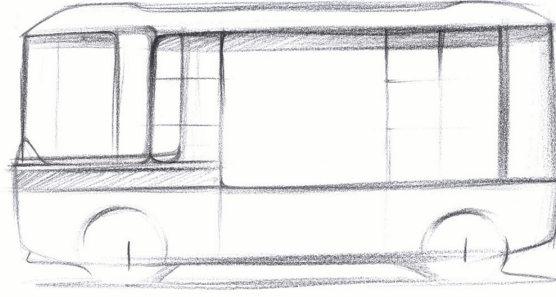
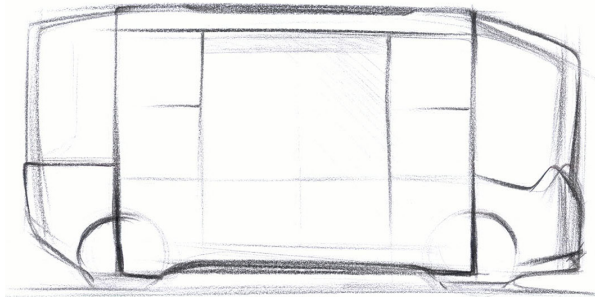
Approach 2: Open and natural character of IIT Bombay is depicted in this approach. The beautiful environment in the campus can be explored while travelling.

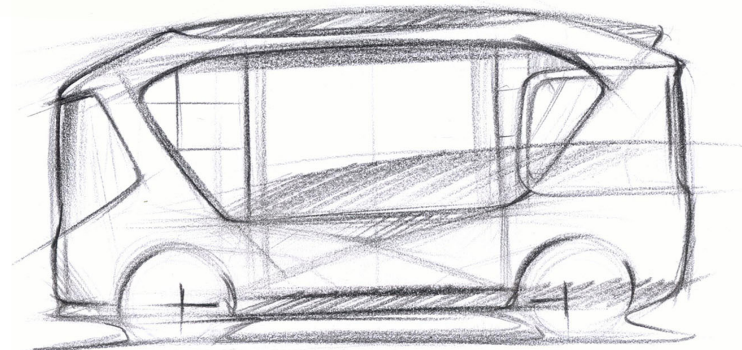
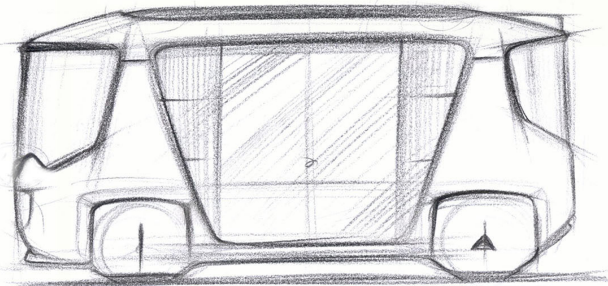
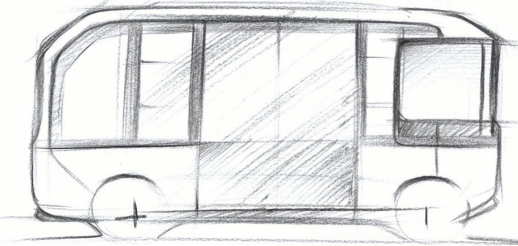
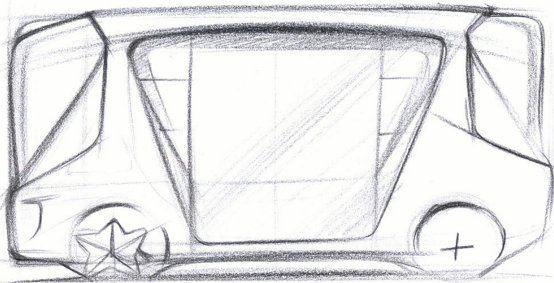
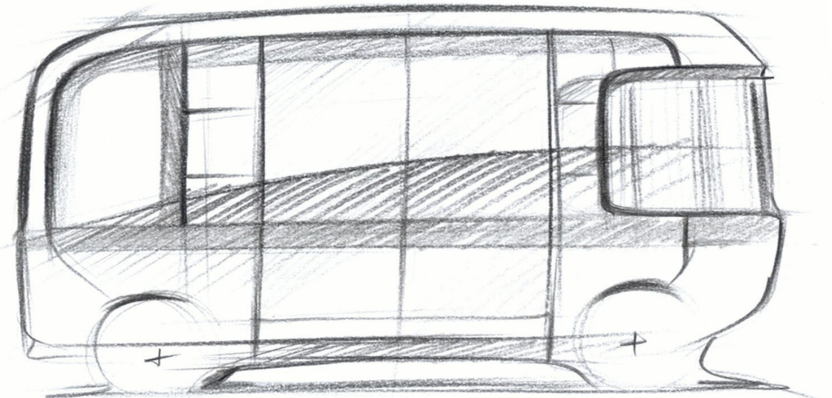
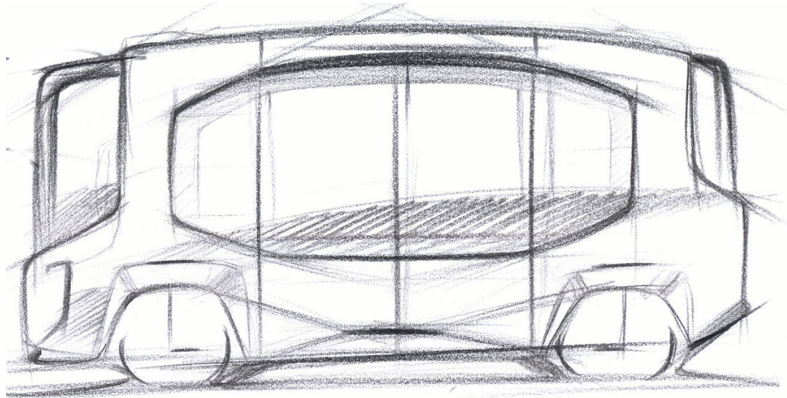


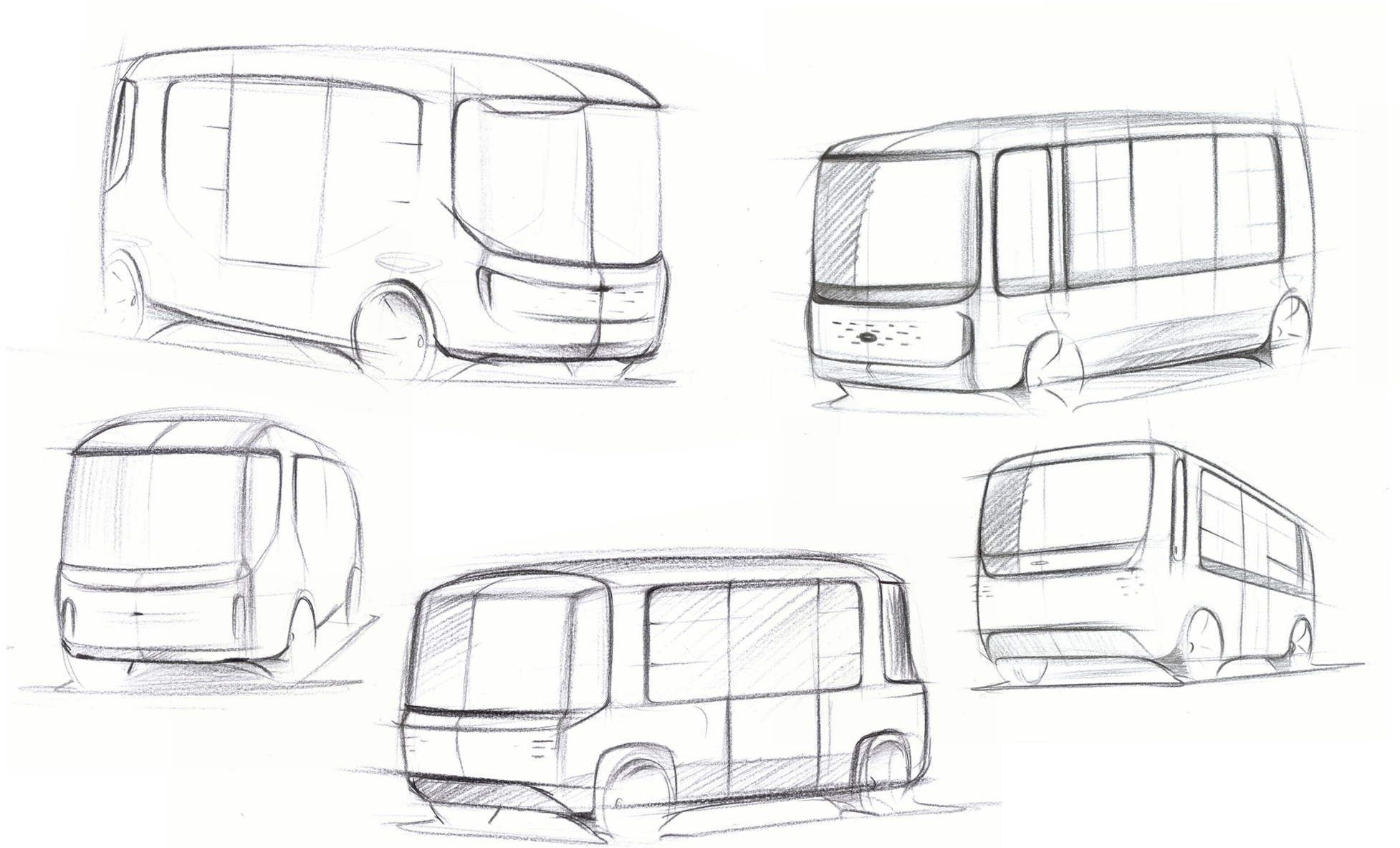
Ideation



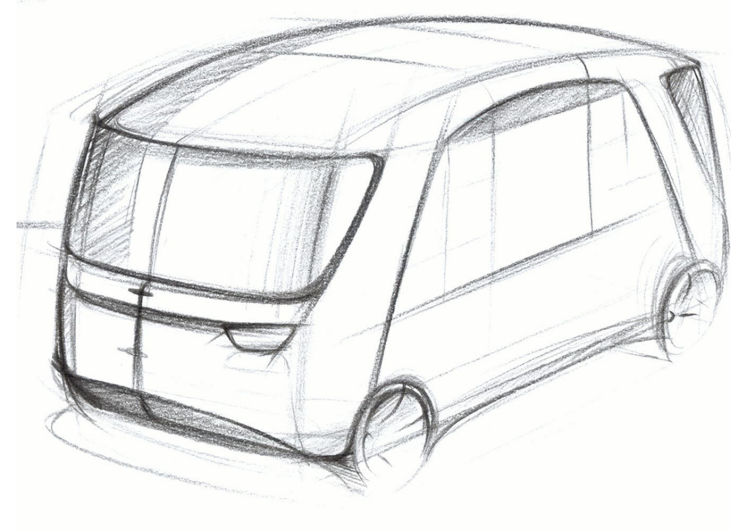
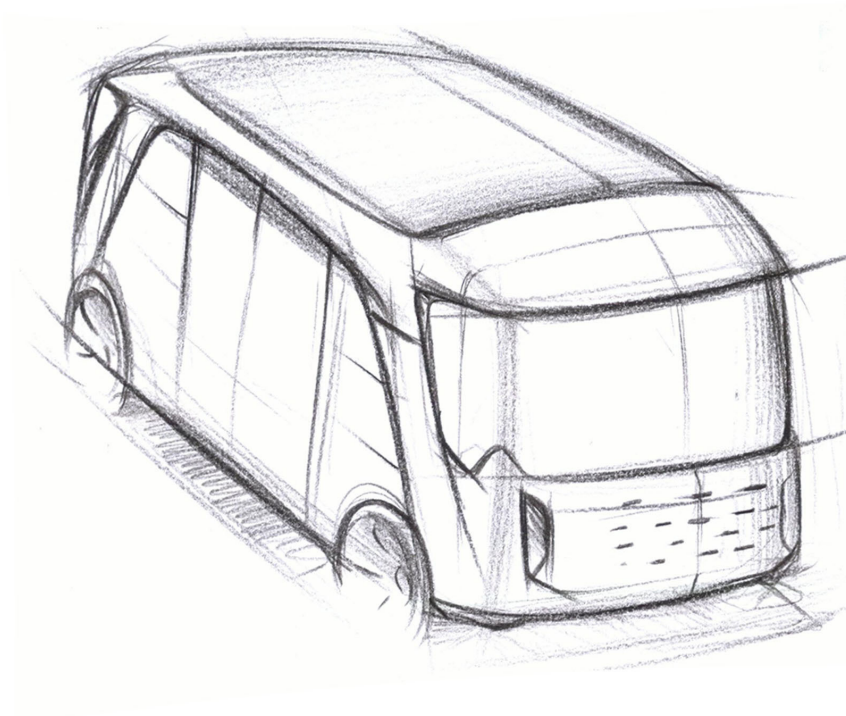
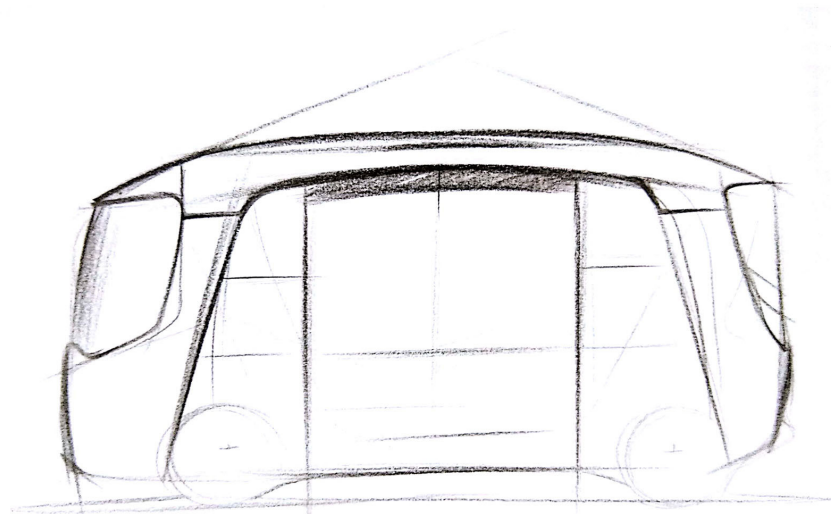
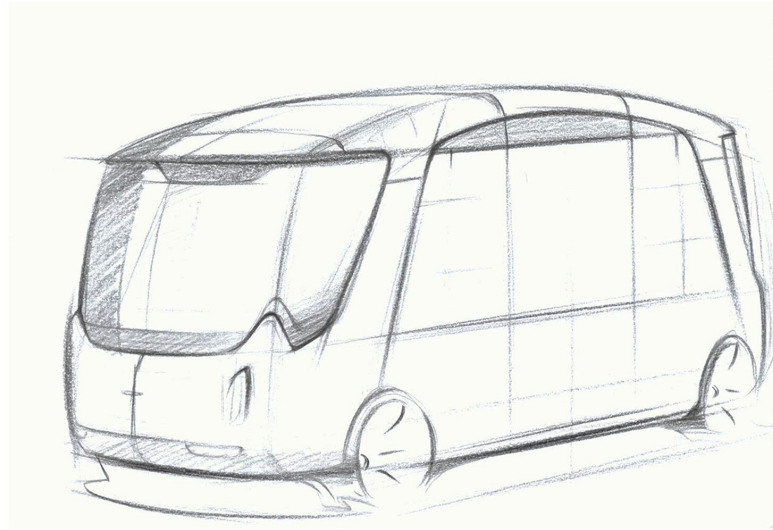
Approach 3: Architectural elements are put in this approach. Image board of some of the most commonly found elements is used.







Sketch Development

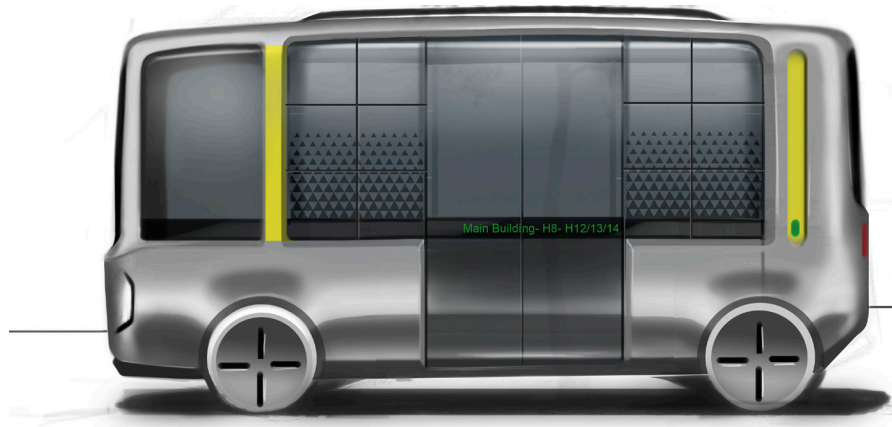


7.5 Sketch Development

Approach 3 is selected as a final approach because approach 1 is less cost effective and difficult to manufacture because of complex surfaces.

Approach 2 seems unidirectional. It is expressing only open and natural character of IIT Bombay.

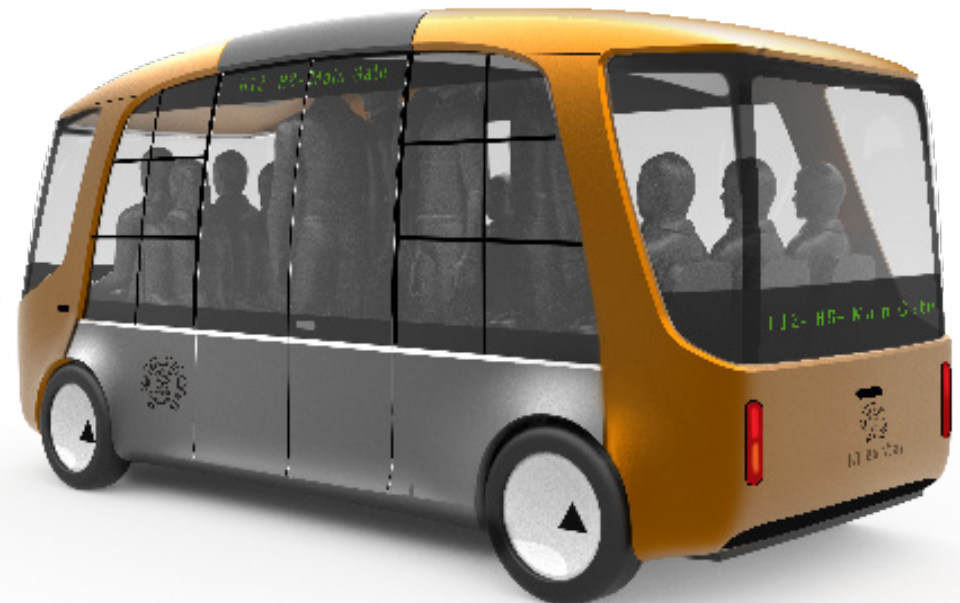
Approach 3 is perfect combination of Open, natural, transparent and the architectural elements which depicts IIT Bombay character.



Final Concept



7.6 Final Concept

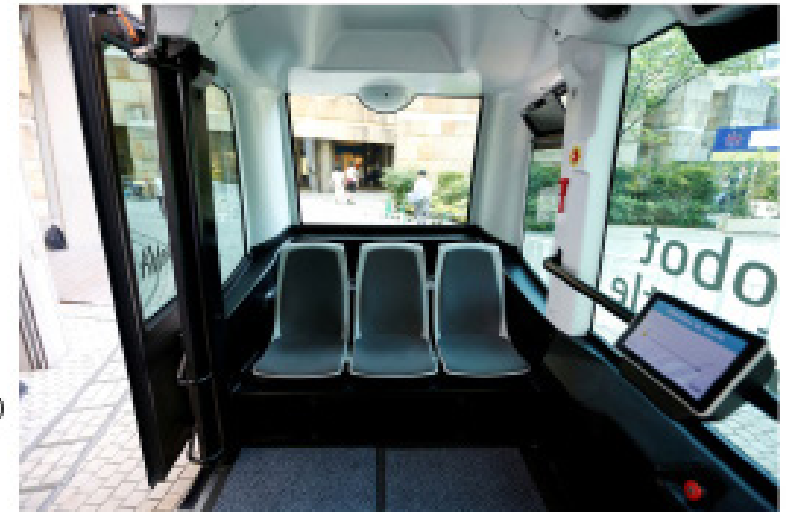


7.7 Interior

7.6 Existing Interior Designs of E- Shuttles



Navya Arma



EasyMile EZ10

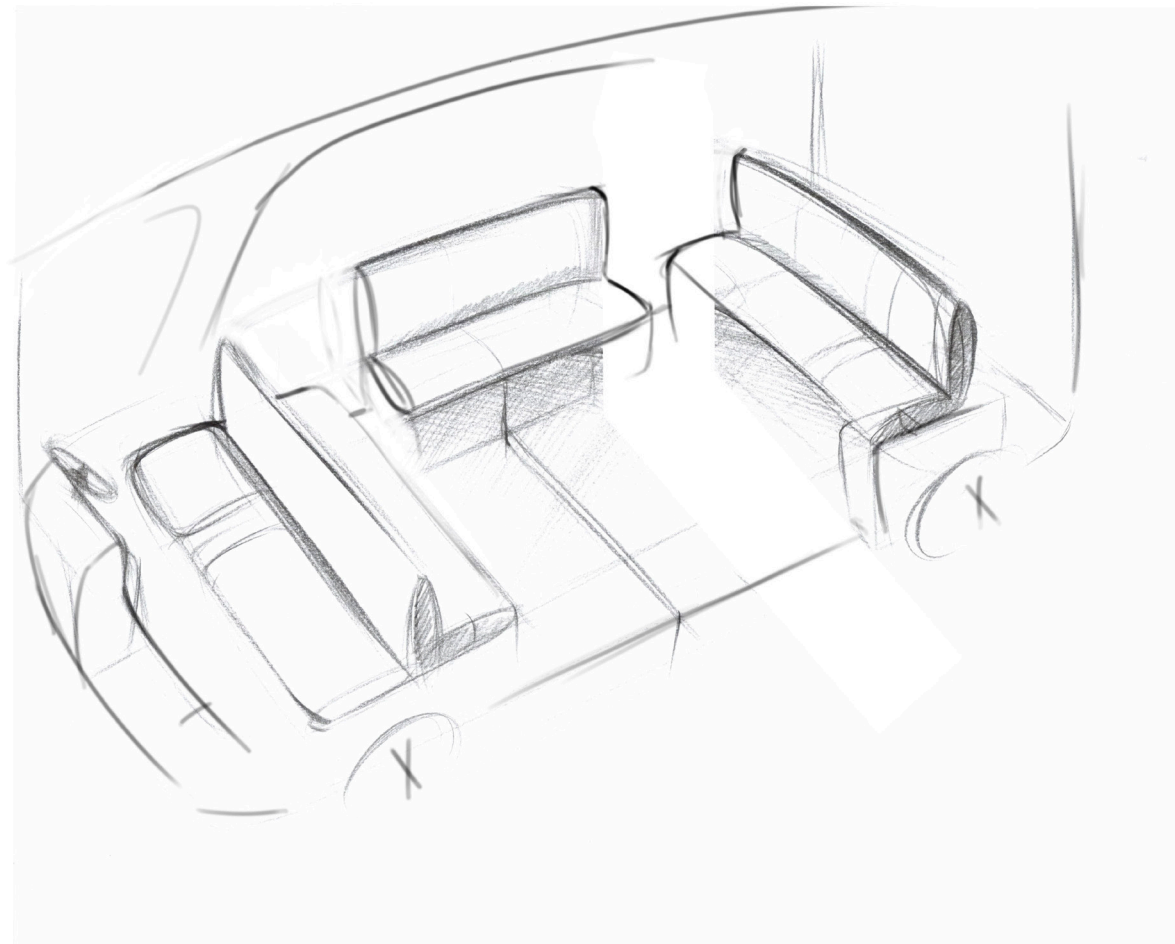
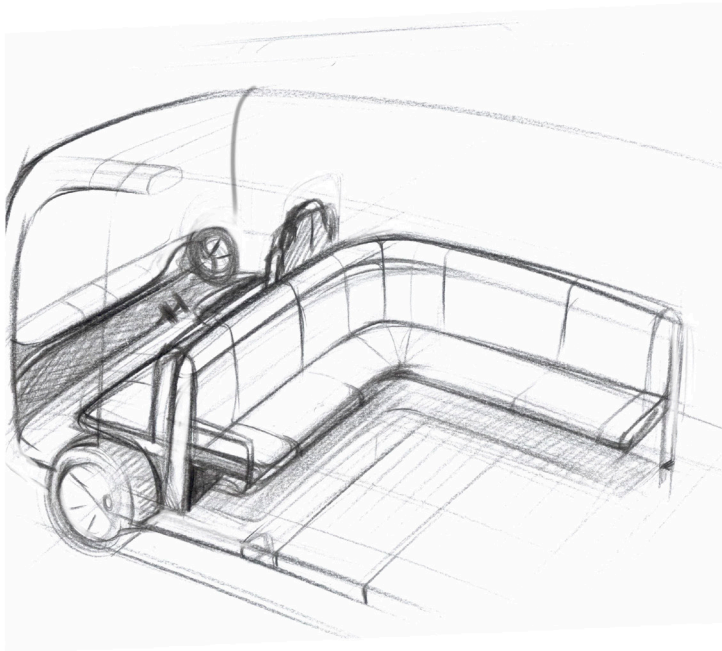


Renault EZ-G0

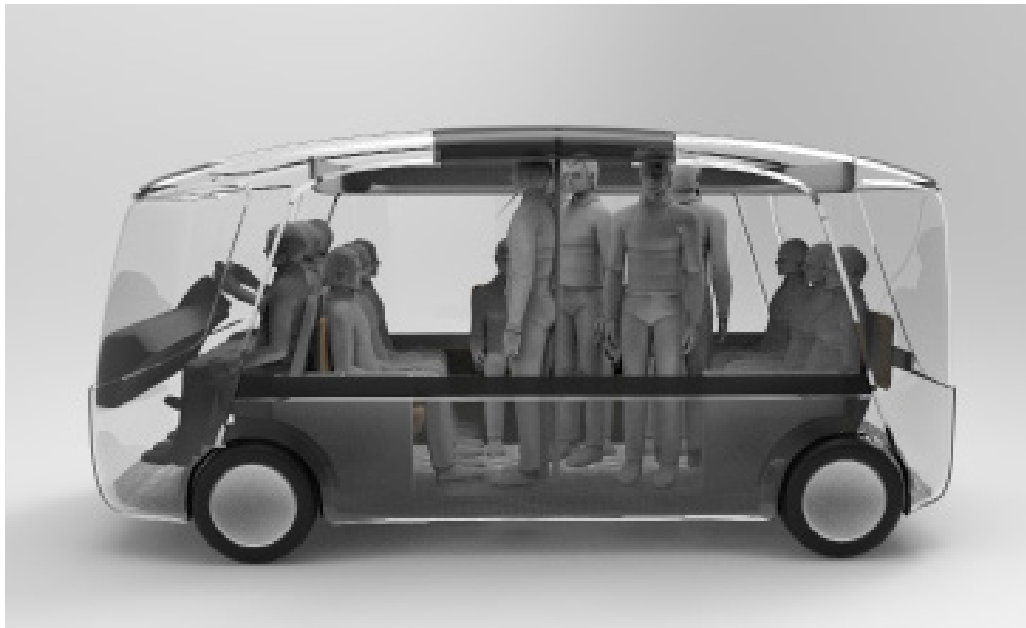
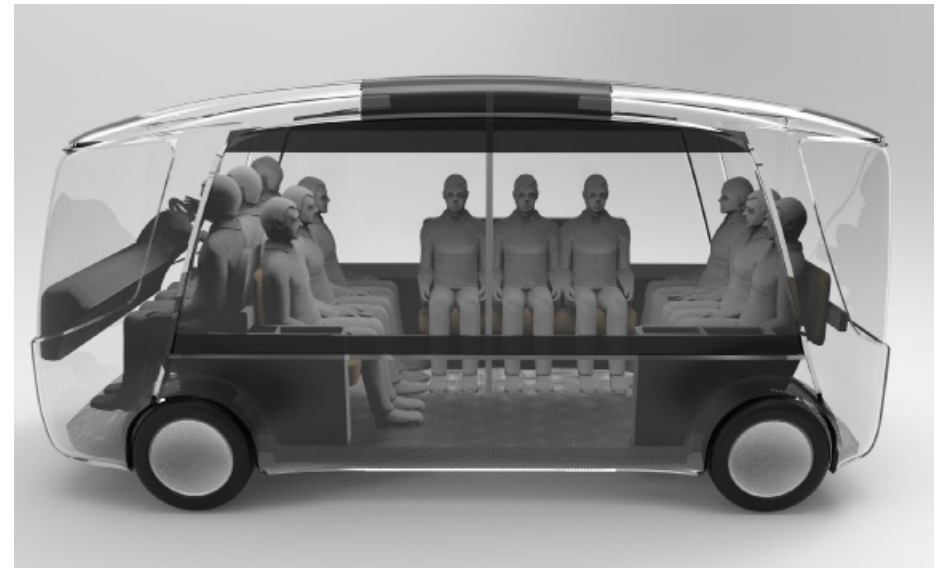
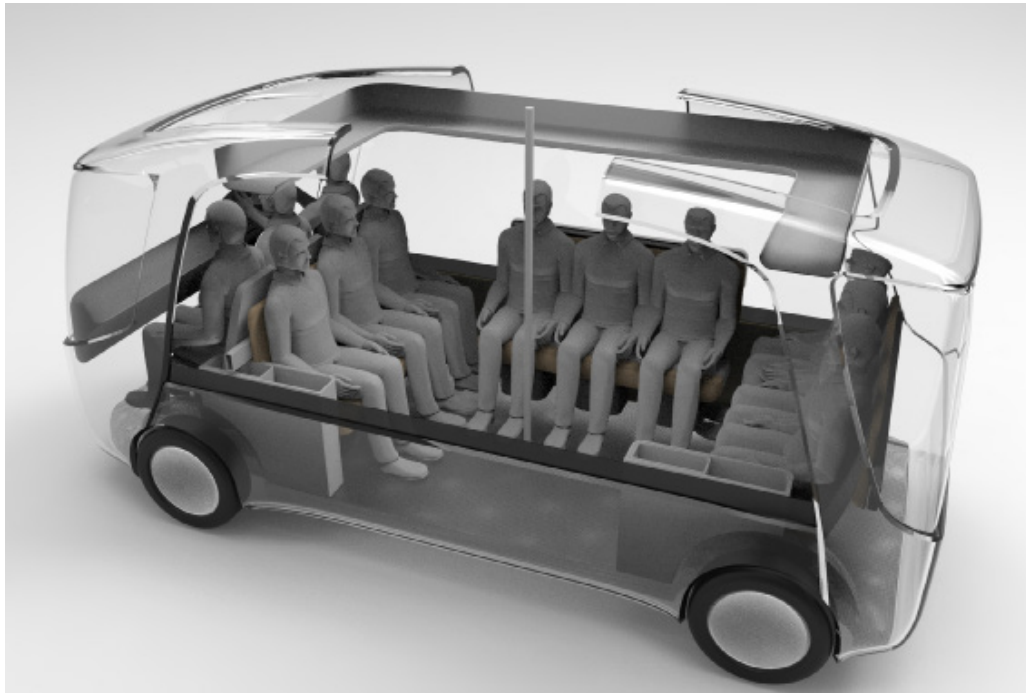


Local Motors
Olli

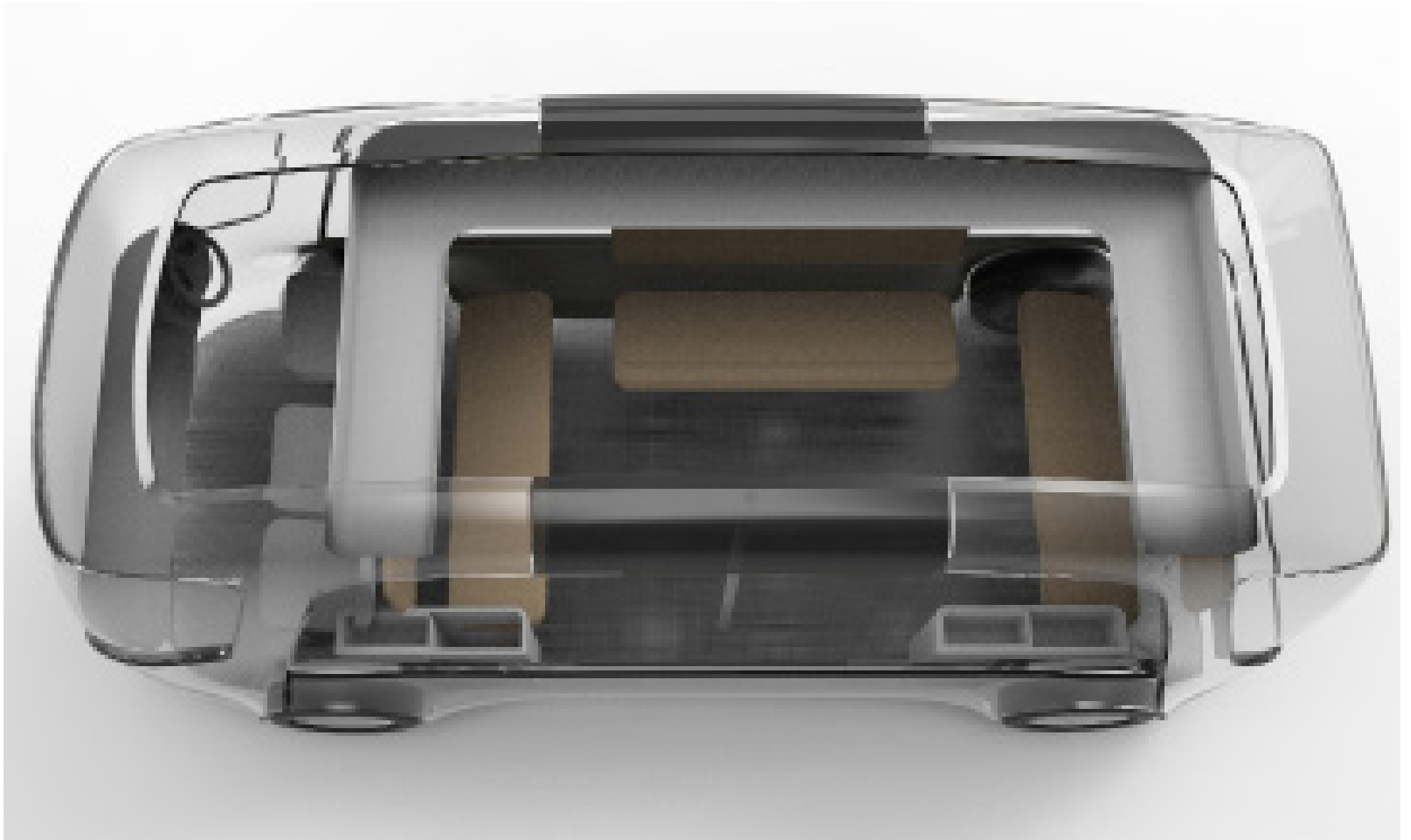
7.7 Ideation



7.8 Render

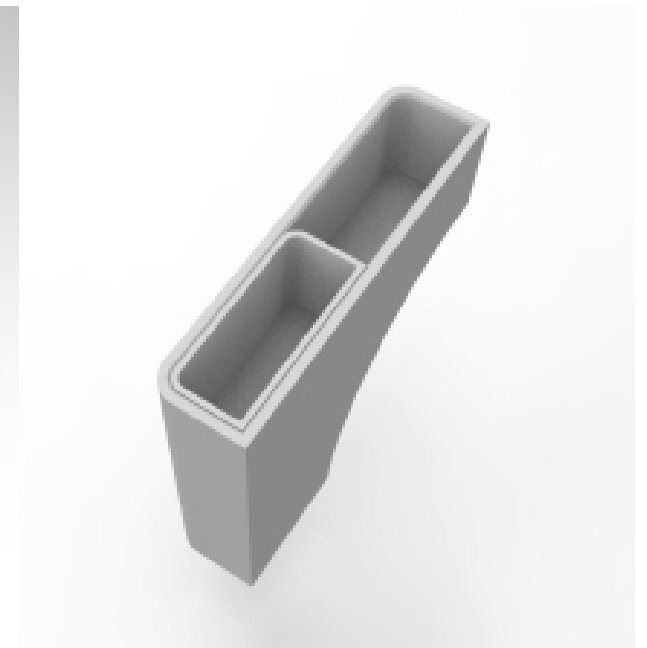
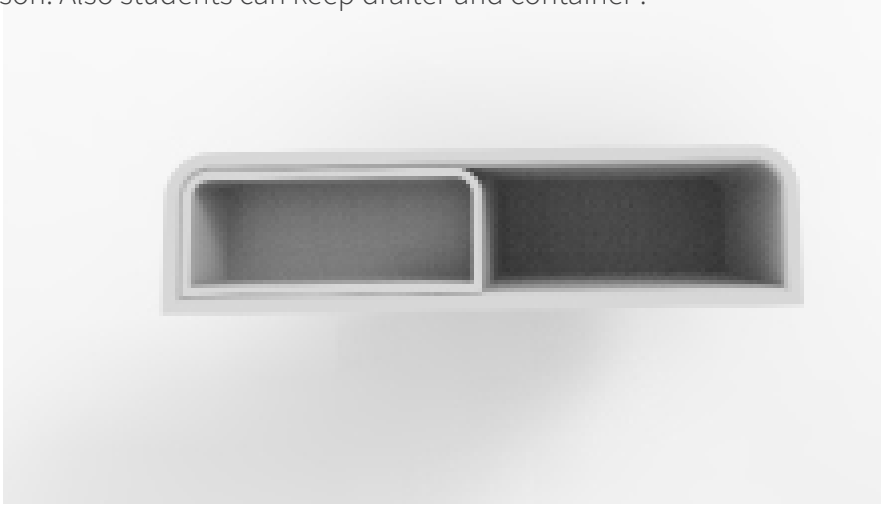


7.8 Render



The Storage box is designed in such a way that residents can keep small amount of grocery product like milk, biscuits, 1-2 kg of cereals, grains , pulses, sugar, salt etc. The sliding drawer enables access to the long compartment which can be used to keep umbrellas in rainy season. Also students can keep drafter and container .

7.8 Render





7.9 Physical Model



8 References

1. <https://mcity.umich.edu/shuttle/>
2. <https://www.theverge.com/2017/6/21/15848098/michigan-driverless-shuttle-navya-mcity>
3. Olli the printed self-driving minibus hits the road in America
<http://www.globalconstructionreview.com/news/olli-printed-self-driving-mini7bus-hi7ts-roa7d/>
4. <https://localmotors.com/2017/05/15/worlds-first-3d-printed-shuttle-olli/>
5. <https://3dprint.com/222340/olli-university-at-buffalo/>
6. <http://www.ligiergroup.com/ligier-group/meet-the-ez10-the-driverless-shuttle.html>
7. <http://www.easymile.com/>
8. <http://www.iitb.ac.in/en/about-iit-bombay/institute-vision-mission>
9. <https://www.jayeshpillai.com/>
10. <http://www.iitb.ac.in/en/about-iit-bombay/campus-map>
11. Urban Bus Specification, Ministry of Urban Development, Urban Transport Division