

Design Project-2 : Electric 'Drive from wheelchair' micro cab for differently abled people



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Acknowledgment

I sincerely would like to thank my guide Prof. Nishant Sharma for guiding me in completing the project. I would also like to thank Prof. Sugandh Malhotra for his inputs and critique on the project.

I also extend my thanks to Mr. Prabhakar Sir from Fellowship for physically handicap for his suggestions and inputs during my project

I also thank all my batch mates, for keeping me motivated and all those people who have influenced me in the making of this Project 2, to the best of my ability.

Finally and most importantly, I express my deep and sincere gratitude to my parents, who have been my pillars of strength throughout. Nothing can be compared to the love and care that they have conferred upon me in every step of my life. Truly, I would have been nothing without them.

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1. Introduction

Nowadays transportation is a part of human life, abled person can travel easily by different means of transport, but for disable, travelling is not easy. There are over 2.7 Crore people with disabilities out of which 54 lakhs have a disability in movement in India. In our society, the number of disabled persons is also considerable; some of them born with a disability. Some get disabled due to accidents (road, workplace, natural calamities). There are some utilities like wheelchairs, tricycles which are used by the disabled persons.[1] Depending upon the disability, different products are available like a wheelchair, crutches, tricycles, customized vehicles. People majorly use a wheelchair for mobility and for long-distance they prefer trike and public transport.

In India, most of the handicap people are unemployed and suffering from poverty. However, there are different NGOs who are supporting the handicap people and developing some employment for them with art and craft, fabrication workshops, tailoring, etc. Now differently able people are equally treated as normal people. They as equal rights as an average person have.

2. Pre-Research

2.1. Current Cab service situation in India [2]

Cab Services in India has grown significantly in India. Call Taxi app (CTA) increased the perceived usefulness, ease of use, playfulness and subjective norms. Self-service mobile technologies give control to commuters to access much information with the help of technology.

- Ola and Uber are two significant players in the organized cab service sector in India. Both Uber and OLA entered the taxi services market in India having many similarities, such as the concept of taxi aggregators, air-conditioned taxi services, low price and app-based taxi services, luring passengers of major metropolitan cities.
- Its advantage of door to door service and now because of technological advancement, customers were able to book cabs at a competitive price in just one click using their smartphones.
- Consumer not only use cab service for commutation but also for visiting a shopping mall, attending a late-night party or going out on a special occasion.



Fig 1: Traffic with many ola uber cabs

HOW THEY COMPARE		
	Ola	Uber
Launch	2011	2013
Valuation	\$5 billion	\$60 billion
Funds raised	\$1.16 billion	\$1 billion
Key Investors	SoftBank, Tiger Global, DST	Google Ventures, Baidu
Tech platform	App	App
No. of cities covered	102	26
No. of vehicles on platform	450,000	250,000
Market share	70%	50%
No. of employees	8,000	300

PS: Data for Uber is India specific Source: Industry; companies

Table 1: Comparison of Ola and Uber [2]



Fig 2: Ola Electric cabs

2.2. Electric Cabs [3]

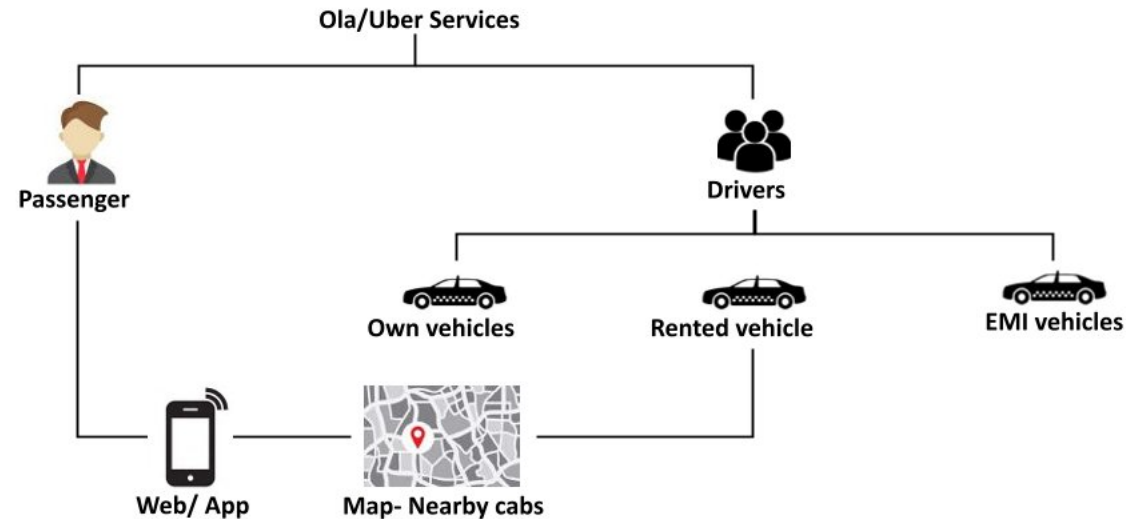
The government plans to order cab aggregators like Uber and Ola to convert 40 percent of their fleet into electrifying by April 2026, according to a report by Reuters. With this, the government is hoping to boost the adoption of electric vehicles (EVs) as part of its commitment to the 2015 Paris Climate Change Treaty.

- Ola Electric Mobility (OEM) was initially established to enable Ola's electric mobility pilot programme in Nagpur. Ola announced 'Mission: Electric' to bring 1 million electric vehicles on Indian roads by 2021.
- Lithium has made a fantastic start with its all-electric cab fleet in Bangalore. Lithium has over 200 vehicles that criss-cross the city of Bangalore. Each of these 200 vehicles is traversing 200 to 300 kilometres every day.

2.3. System of Cab Services in a city



Fig 3: Lithium Technologies



Cars Used as Cabs	Maruti Suzuki Wagon R	Maruti Suzuki Swift	Maruti Suzuki Swift Dzire	Maruti Suzuki Ciaz	Honda Amaze	Alto 800	Hyundai Xcent	Hyundai i20	Hyundai Eon	Toyota Innova	Toyota Etios Diesel	Nissan Micra Diesel
Price	₹4.19 Lakh - ₹5.69 Lakh	₹5.14 Lakh onward	₹5.83 lakhs - ₹9.11 lakhs	₹8.20 lakh - ₹11.38 lakh	Rs. 5.93 - 9.79 lakh	Rs. 3.04 - 4.24 lakh	Rs. 5.79 - 8.82 lakh	Rs. 5.50 - 9.32 lakh	Rs. 3.33 lakh (Discontinued)	Rs. 14.93 - 23.47 lakh	Rs. 6.93 - 9.16 lakh	Rs. 6.63 - 8.13 lakh
Mileage	21.5 kmpl	28.4 kmpl	21-28 kmpl	26.82 kmpl	23.8 kmpl	24.7 kmpl	25.4 kmpl	22.54 kmpl	22.0 kmpl.	11.36 kmpl	23.59 kmpl	23.19 kmpl
Dimensions	3655 x 1620 x 2435 mm.	3655 x 1620 x 2435 mm.	3995 x 1735 x 1515mm.	4490 x 1730 x 1485mm.	3995 x 1695 x 1501mm.	3395 x 1515 x 1475mm.	3995 x 1666 x 1520mm.	3995 x 1760 x 1555mm.	3495 x 1550 x 1500mm.	4735 x 1830 x 1795mm.	4265 x 1695 x 1510mm.	3825 x 1665 x 1530 mm.
Boot Space	341 Litres	341 Litres	378 Litres	510 Litres	420 Liters	177 Litres	407 Litres	285 Litres	215 Litres	300 Litres	592-Litres	251-Litres

Table 2: Existing cars use for Cab Services

2.4. Physically Disabled People

A physical disability is a physical condition that affects a person's mobility, physical capacity, stamina, or dexterity. It can include brain or spinal cord injuries, multiple sclerosis, cerebral palsy, respiratory disorders, epilepsy, hearing and visual impairments and more. According to the 2011 census, 20.3% of people with disabilities in India have movement disabilities, 18.9% have hearing impairments, and 18.8% have visual impairments [4]. There are over 2.7 Crore people with disabilities out of which 54 lakhs have a disability in movement in India.

2.4.1. Type of Physical Disability

Disability is part of the human condition. Almost everyone will be temporarily or permanently impaired at some point in life, and those who survive to old age will experience increasing difficulties in functioning[4]. There are some type of Physical Disability which is common to find out.

- 1. Non-Ambulatory** : means a person who is unable to leave a building unassisted under emergency conditions.
- 2. Semi-Ambulatory** : Impairments that cause individuals to walk with difficulty or insecurity. Individual using braces or crutches, amputees, arthritics, spastics & those with pulmonary & cardiac ill's may be semi-ambulatory.
- 3. Sight** : Total blindness or impairments affecting sight to the extent that the individual functioning in public areas is insecure or exposed to danger.
- 4. Hearing** : Deafness or hearing handicaps that might make an individual insecure in public areas because he is unable to communicate or hear warning signals.

2.4.2. Current Mobility for handicap

The current mobility solutions for handicap are very limited and they are not designed according to the users comfort. Depending upon the disabled part of body, people use different products like crutches, wheelchairs, tricycles, customized vehicles, etc. Crutches are commonly used for walking for shorter distances, then manual wheelchairs and hand-cranked tricycles are useful for the persons with leg disability. This is also use for short distance traveling, to make it affordable and convenient many different designs are available and for high end mobility and for the people who can afford expensive wheelchair, automatic wheelchairs are designed such that persons with hands & legs disability can be

For Short distance mobility



Fig 4: Crutcher Support



Fig 5: Wheelchair



Fig 6: Underarm Crutcher



Fig 7: Electric Wheelchair



Fig 8: Prosthetic Legs

For Long distance mobility

Most of the Handicap people don't travel long distance because of the unavailability of the vehicle. The public transports like buses, trains, taxis are not comfortable for the handicap people. They are not designed according to the users. People also use some personal vehicle like tricycle and customized vehicle (scooter, cars, etc.) for long distance traveling.



Fig 9: Local Trains



Fig 10: Buses



Fig 11: Taxi/Cabs



Fig 12: Tricycle



Fig 13: Customized Scooter

3. Research

3.1. Cabs/Taxi for Differently abled people

Long distance traveling for a handicap person is very difficult. The number of wheelchair-friendly traveling options is ridiculously low. Buses, trains are not wheelchair user friendly and they are not designed for the last mile connectivity. Government provided free services for Handicap people but Taking bus from a bus stop is really difficult option for a handicap person and they have to travel in taxi or auto to reach at the bus stop. They always need some assistant to guide them inside the bus. It is very challenging for them to travel long distance.

There are different startups and companies are working on the long distance traveling problems. KickStart Cabs, Ezymov, Mobicab, Mobility India and Meru with Meru Enable are some of the Indian initiatives that have aimed to make ridesharing for the disabled mainstream.

3.1.1. KickStart Cabs

Kickstart cab is a Bangalore based company. The kickstart Vehicles are equipped to accommodate wheelchair users and help people, especially those with disabilities and senior citizens, to commute from one corner to another with least restrictions, maximum safety and comfort. The drivers are trained to assist users who have difficulties getting in and out of vehicles and buildings.

The Kickstart Cabs currently charges Rs 800 for a single two-hour trip or a distance of 20 km for the Wheel Chair Ramp Model. A similar trip on the turn-out wheelchair model costs Rs 700. It is an online service which can be availed by making a booking through Kickstart's website or over the telephone.



Fig 14: Kickstart cab with rear door entry



Fig 15: Kickstart cab with assistant helping the handicap user

3.1.2. EzyMove Mobility Simplified

Ezy Mov is a new age company with traditional values which was started by professionals from varied business fields. Started in 2015 with India’s first wheelchair taxi, today boasts of a technically advanced fleet of cabs fitted with world class equipment like hydraulic lifts and wheelchair restraint systems and are driven by a team of professional and courteous drivers. Now the EzyMove are serving in Mumbai, Goa and Jamshedpur.[6]

They provide services like-

Standby Wheelchair : In case of emergency

Equipped with Wheelchair Lift : For a safe and efficient boarding

Specially Trained Drivers : Sensitized and Courteous

Extra Room for Co-Passengers : To cherish the feeling of togetherness

Wheelchair Locking System : For Safety



Fig 15: EzyMove cab with rear door entry

Revised fares in INR w.e.f. 1st April, 2019. Rates applicable within Mumbai limits				
Tata Winger - 3 Seater		Point to Point One way charges	Maruti Eeco - 2 Seater	
Day (8AM to 9PM)	Night (9PM to 8 AM)		Day (8AM to 9PM)	Night (9PM to 8 AM)
400	500	Base Fare	300	400
5	5	Inclusive of Kms	5	5
30	40	Additional Km charge	25	35
Tata Winger - 3 Seater		Rental Packages	Maruti Eeco - 2 Seater	
1,000		2 Hours/20 Kms	750	
1,750		4 Hours/40 Kms	1,500	
2,600		6 Hours/60 Kms	2,250	
3,400		8 Hours/80 Kms	3,000	
35		Additional Km charge	25	
180		Additional Hour charge	120	

* Waiting charges for Tata Winger @ Rs.3 per minute & Maruti Eeco @ Rs.2 per minute
 * All prices are inclusive of applicable GST
 * Toll & Parking charges to be paid as per actuals

Table 3 : Fare of EzyMove cab service

3.1.3. Mobicab [7]

Mobicab is also a mumbai based company. The vehicles are modified to suit the needs of wheelchair users. The aim of Mobicab is to make commuting within Mumbai, and traveling outside the city accessible for wheelchair users. The vehicles are modified according to the handicap users needs.



Fig 16: Mobicab use Maruti Ecco



Fig 17: Hydraulic lifting



Fig 18: Ramp provision from the rear door



Fig 19: Mobicab for wheelchair users

3.1.4. Mobility India

Mobility India is a Bangalore based company. Their service was launched in association with the Jaipur Limb Campaign and Andersen Consulting, UK way back in November, 2000. The service is a boon to wheelchair users who otherwise find it difficult to commute to different parts of the city. This service enables residents of Bengaluru city, including people with disability and senior citizens to commute with maximum safety and comfort to their desired destination without any worries. The Taxi Fare for 20km is Rs 400/- and waiting charges are Rs 100/- per hour.[8]

The service is beneficial to:

- People with disabilities who need to regularly commute from their homes.
- Ones attending rehabilitation services of hospitals for physiotherapy and other treatment.
- People with disabilities traveling on personal, social, and leisure activities.
- Senior citizens requiring transportation that takes care of their special needs.



Fig 20: Side Entry for wheelchair users

3.1.5. London Black Cab/taxi

London Black Cab/taxi is a British-based firm London Electric Vehicle Company (LEVC) and its battery-powered TX taxi, the iconic taxi is a zero emissions way to hitch a ride. Black cabs spend most of their time in cities where air pollution is at its worst and an electric vehicle is at its best. Cab drivers are also keen to invest in a vehicle for their work that is future-proofed against potential costs such as Low Emissions Zone charges and rising diesel costs.[9]

The London Black Cab is designed to accommodate 6 passengers, They have provision for wheelchair accessibility without extra fare but the black cab is a premium class cab which is expensive compare to other cabs or taxis.



Fig 21: Space for wheelchair inside the cab

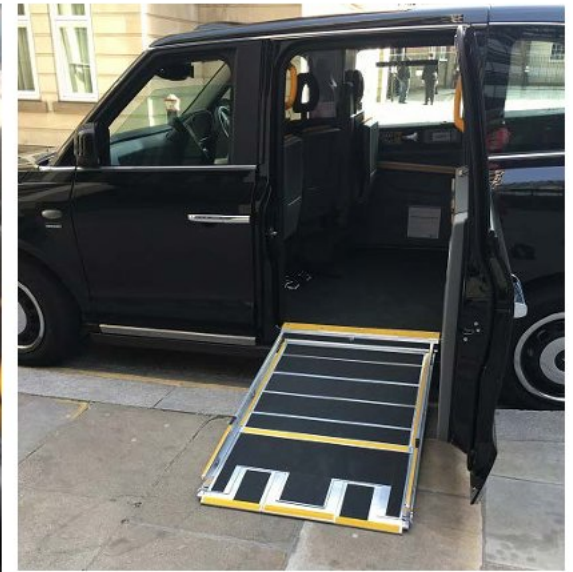


Fig 22: Side Entry for wheelchair

3.2. Micro Cars drive by differently abled people

People with disabilities are faced with many challenges throughout life, but driving is not one of them. Transportation is possible for people in wheelchairs, but it is certainly not easy. The process of climbing out of a manual wheelchair and into a modified vehicle (and then collapsing the chair) takes considerable time and puts substantial strain on a person's shoulders. With just a few special modifications and some training, many disabled adults can safely and easily get behind the wheel and drive cars on roads and highways. As normal people, physically disabled people also want to drive by their own without any assistant. Handicap people simply look for ways to be independent with whatever means they could.

Tricycle are the most common vehicle for handicap people for mobility but it also required lots of strength to move as it is human powered. Now motorized cycles are also available in the markets but they are not weather resistant and comfortable. People want their personal car which has roof properly designed for their comfort. The aspiration of handicap users are also same as normal users but their are very less provision provided to them for transportation. There are some examples where designers developed some great products for transportation for the wheelchair users.

3.2.1. Harold Downey's wheelchair micro-car

Wheelchair micro-car was invented back in the 1950s. Back in October of 1956, Harold Young of Downey California designed a three wheel car for himself, with 10HP wheelchair accessible micro-car that he drove on city streets for many years. The hand controls he installed were a push-stop, pull-to-go lever design, similar to the mechanical driving aids being used today. The micro car was first self assisted vehicle, where the wheelchair user can get inside the car without any help. Hooks attached the dashboard were used to secure the wheelchair in place. [10]

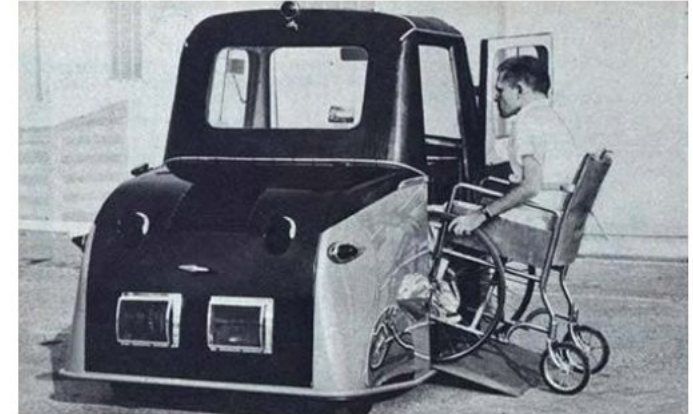


Fig 23: Wheelchair micro-car

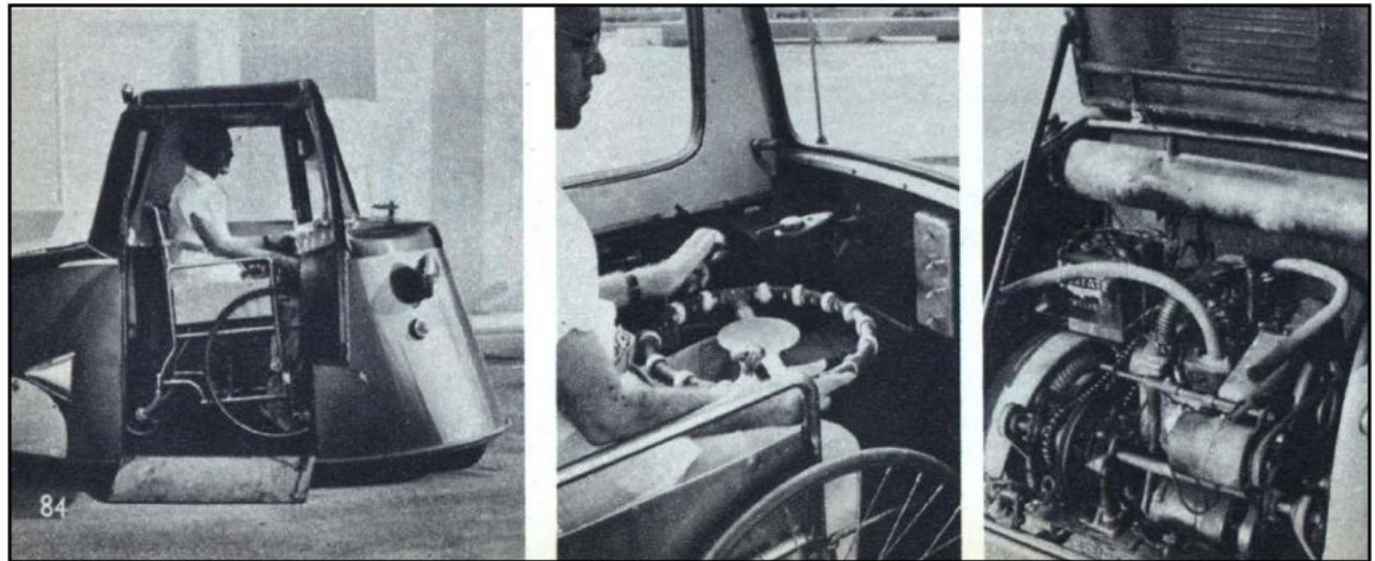


Fig 24: Harold Downey's wheelchair micro-car could reach top speeds of 45 mph.

3.2.2. Kenguru (Micro Car)

Kenguru has been built from the ground up for people in wheelchairs. It is a small nimble electric vehicle one designed specifically for quick, easy access by, and driving from, a wheelchair. The Kenguru, is an electric powered micro-vehicle with a top speed of 25 mph. It can travel around 60 miles per day. It has a motorcycle-like handlebar steering design with a throttle for acceleration. The entire rear of the vehicle is a hatch that can be raised, allowing a wheelchair passenger to roll in using a built-in ramp. The Kenguru has only a single door to the rear of the vehicle for direct wheelchair access. It's opened by remote control. Inside the driver is nestled in a 350-kg (772-lb) fiberglass cocoon 2125 mm (83.6 in) long, 1620 mm (63.8 in) wide and 1525 mm (60 in) tall. That's extremely compact. Empty weight with the batteries increases to 550 kg (1200 lb). the Kenguru price-tagged at about \$25,000 and can be reduce to \$20000. [11]



Fig 25: Kenguru is an electric vehicle made specifically for wheelchair users.



Fig 26: Kenguru has an automatically lowering ramp, which comes down as the back door opens, using remote control



Fig 27: Kenguru on roads



Fig 28: Kenguru features motorcycle type handlebar controls

3.2.3. Canta (vehicle)

The Canta is a two-seat micro-car from the Netherlands specifically created for disabled drivers. It was developed in 1995 by Waaijenberg together with the Delft University of Technology. It is classified as a mobility aid because the width of the vehicle is only 1.10 meters and it can be used on cycle paths as well as sidewalks and footpaths. No driving license required for the vehicle. The Canta microcar is equipped with a rear-entry ramp, the Canta pneumatically raises up off the ground when the engine is started and the driver is ready to move. It comes with a Honda 5-stroke, 160cc engine (200cc optional) and has a top speed of 28 mph. The hand controls of Canta can be placed on the left or right side, depending on the need. The Canta is legal in the Netherlands and used by users on cycle paths and sidewalks as a mobility aid. [12]



Fig 29: Canta used by elderly person



Fig 30: Canta used by a wheelchair user

3.2.4. Elbee

Elbee is a vehicle designed for people who use wheelchairs. The Smart car look-alike was designed by Pavel Hušek. It is a special two-seat vehicle for wheelchair users, enables them to drive at 80km/h on highways directly from the wheelchair – whether electrical or manual. It is constructed with a remote control front door and access ramp allowing you to roll into car. Elbee is made from aluminum and composite materials. It weighs 882 lbs. The two-seater has two engine types electric and combustion. Elbee cost around at \$25,000. [13]



Fig 31: Elbee front door opening



Fig 32: Elbee with wheelchair

4. User Research

User Research is important to understand their perspective and the problem which they are facing. The best way to understand physically disabled problems is by talking with them. They know much better than their problems than others. The User research helps to understand the aspiration, need and problems of the users. The research was qualitative for the better understanding of the problems related to handicap while using public transport and personal vehicle.

The user study was carried out on two different NGOs, Nasheo (National society for equal opportunity for the Handicapped, India) and Fellowship for physically handicapped.

Nasheo (National society for equal opportunity for the Handicapped, India) Established in 1968, National Society For Equal Opportunities For the Handicapped, India (NASEOH, INDIA) has been steadily working towards developing comprehensive rehabilitation opportunities for the persons with disabilities so as to facilitate integration into the mainstream of the society.

Fellowship for physically handicapped. FPH has been working towards helping differently abled individuals live with dignity and self respect in an economically self-sufficient and productive manner. Vocational training is imparted to the beneficiaries FREE OF COST, including facilities like hostel, lunch, pick up and drop, medical and educational support.

The following page shows the questions asked and the results obtained in this stage.

4.1. Questionnaires

The questionnaires are arranged in a way to understand the users daily life scenarios and to gather quantitative data.

Project 2 : Micro Cab Services for differently Abled

SURVEY QUESTIONNAIRES

NAME

AGE

OCCUPATION

DISABILITY

1. WHAT ARE THE MODES OF TRANSPORTATION DO YOU USE FOR LONG DISTANCE TRAVEL ?
 BUSES LOCAL TRAIN CABS/TAXI OTHERS

2. HOW FREQUENTLY DO YOU USE PUBLIC TRANSPORT ?
 DAILY WEEKLY MONTHLY

3. DO YOU TRAVEL WITH YOUR WHEELCHAIR WHILE TRAVELING ?
 YES NO

4. DO YOU FACE ANY PROBLEM WHILE TRAVELING IN PUBLIC TRANSPORT ?
 YES NO

5. WHAT ARE THE MAJOR PROBLEM YOU FACE WHILE TRAVEL ?

6. DO YOU NEED ANY ASSISTANT WHILE TRAVELING?
 YES NO

7. DO YOU THINK THE TAXI & CABS SHOULD PROVIDE SERVICES FOR DIFFERENTLY ABLED PEOPLE ALSO ?
 YES NO

8. DO YOU WANT A SEPARATE VEHICLE FOR LONG DISTANCE TRAVEL OR IS IT FINE TO TRAVEL WITH OTHER PASSENGERS ?
 YES NO

9. HOW MUCH CAN YOU SPEND FOR A LONG TRIP (10 km-20km) IN A CAB OR TAXI ?

10. HOW EFFECTIVE IT IS IF WE PROVIDE INTERVENTIONS FOR DIFFERENTLY ABLED PEOPLE IN CAB SERVICES eg. OLA / UBER ?

11. DO YOU HAVE ANY EXPERIENCE WHICH YOU WANT TO SHARE ?

Project 2 : Micro Cab Services for differently Abled

SURVEY QUESTIONNAIRES

1. What is your Daily scenario?
2. What are the places you visit regularly?
3. How many members are their in your family?
4. Which type of transport you daily use?
5. What are the daily travel roots?
6. Which mobile phone do you use?
7. Do you know about Ola or Uber services?
8. What type of work you do regularly?
9. What is your interest and hobbies?
10. How much do you earn in monthly basis?
11. What are your aspirations for traveling?
12. Do you travel long distance trips ?
13. What problems do you face while traveling in a public transport?
14. Do people around you help while traveling
15. Which type of transport you use while traveling ?
16. Who help you while traveling long distance?
17. Do you need a vehicle to commute daily for traveling?
18. How much can you spend on daily travel?
19. Which type of vehicle will be good for your traveling?

20. What are you aspiration related to a taxi/cab for Handicapped people?
21. What type of services/Intervention can we provide for Handicapped people?
22. Do you mind if it is a sharing taxi?
23. If we provide you a taxi how much can you pay for daily use?

4.2. User Analysis



Name : T. Ganesan
Age : 54
Occupation : Welding & Fabrication
Disability : Accidental Paraplegic
Place : Ghatkopar

- Mr. T. Ganesh is an employee in **welding and Fabrication** department in Naseoh (National Society for equal opportunity for Handicapped, India). He is working their from 15 years.
- He lost his legs in an **Accident**.
- He use to daily commute in his **tri-cycle** for short distance and sometime use **taxi** services for long distance commute.



Name : Jagjit Singh
Age : 35
Occupation : Welding & Fabrication
Disability : Polio Paraplegic
Place : Vadala

- Mr. Jagjit singh is an employee in **welding and Fabrication** department in Naseoh (National Society for equal opportunity for Handicapped, India). He is working their from 8 years.
- He is Polio Paraplegic from childhood
- He use to daily commute in his **tri-cycle** for short distance but he don't use taxi services. He rarely prefer taxi for long distance.



Name : Mangal
Age : 40
Occupation : Art & Craft
Disability : Paraplegic
Place : Vadala

- Ms. Mangal work in Art & Craft department in Naseoh. Where they do different types of work like jewelery, painting and different craft work..
- She is also Polio Paraplegic and use **tri-Cycle** for Short distance commute and she don't like to go long distance travel because she always need his brothers help to Assist her in Taxi. She feel like she is depended on him.



Name : Vijay Kumar
Age : 38
Occupation : Tricycle Workshop
Disability : Accidental Paraplegic
Place : Byculla

- Mr. Vijay Work in **Tricycle workshop** in FPH. He use tricycle for daily commute. Not able to use normal taxi and cabs because of high rates.
- He usually don't prefer any public transport for long distance travel.
- He want that the fare of taxi and cabs should be half for the Handicap users.He is comfortable to spend 40 Rs in a day for both trip.

User Analysis



Name : Shushal Gyakwad
Age : 35
Occupation : Prosthetic Leg Workshop
Disability : Polio Paraplegic
Place : Vikhroli

- Mr. Shushal Gyakwad work in Prosthetic leg Department in FPH.
- He use **BEST Bus** for daily commute. He also use prosthetic legs which make it easier to travel in Buses.
- For end mile connectivity he use **Auto and Taxi**. which is little expensive for the handicap user.
- For small distance - going to market and nearby places he use tricycle.
- He don't need any **assistant** while traveling.
- For daily traveling he can spend not more than 50 Rs for both side.
- Using Wheelchair while traveling is much difficult as compare to prosthetic legs, but it is not available for all type of users.



Name : Pascal Fernandis
Age : 36
Occupation : Tricycle workshop
Disability : Polio Paraplegic
Place : Bandra

- Mr. Pascal work in Vocational training center in Fellowship of physically disabled. He work on the fabrication of tricycle and wheelchair.
- He use **Artificial legs** for small commute and travel in train for long distance. He is comfortable with all type of public transport.
- He traveled **US, UK** for company related work when he was in Oasis.
- He daily travel 3hr from Bandra to mahalakshmi (**11 km**) by using riksha, train, bus.
- Aspiring Vehicle : **London Blackcab**
- **Omni and WagonR** can be use as micro cabs. Sliding door are easy to use by Handicap people. He can spend 50 rs a day for traveling.



Name : Prabhakar
Age : 40
Occupation : Prosthetic Leg dept Supervisor
Disability : Paraplegic
Place : Ghatkopar

- Prabhakar works as a Supervisor of Artificial Leg Dept. in FPH.
- He Daily travel **10 km** from Sion to Mahalakshmi in his customized scooter. He like traveling in his scooter daily.
- The scooters are **customized** according to the user.
- Before coming to FPH he work as a taxi driver with his prosthetic legs.
- The taxi services are good option for handicap user if it is designed **according to the handicap user**.
- He always prefer to help handicap users when he was a taxi driver.
- Aspiration : he want to buy a Handicap accessible driving vehicle for himself.
- He want to earn money by **driving taxi**.



Name : Swarna Khopar
Age : 37
Occupation : Accountant
Disability : Polio Paraplegic
Place : Dali Road, Parel

- Swarna Khopar work as accountant in FPH.
- She live in Dalia road, Parel and daily commute in customized scooter.
- Sometime for traveling long distance she use taxi and private cab and use crusher for indoor movement.
- For Daily travel she can pay not more than **50 Rs in a day**.
- Taxi/Cabs are more comfortable than buses and train and they have last mile connectivity.
- She daily travel in her scooter and sometime she also **give lift to the people**. She prefer that she can use her scooter as **Sharing taxi** also.
- Using scooter in **monsoon time** is more difficult.

4.3. Current Scenario

People use wheelchair for short distance travel and use tricycle or modified scooters for daily long distance travel. Handicap people are working in different NGOs workshop like Prosthetic Leg Workshop, Tricycle workshop, Art & Craft etc. Most of the people use foldable wheelchair.

- Users rarely go for traveling because of unconvinent public transports.
- Some users also wanted to drive their own car as they like driving but their are no provision for that.
- The users want to develop job opportunities for the handicap people.



Fig 32: Physically disable people (Nasheo (National society for equal opportunity for the Handicapped, India)

Differently abled people use for long distance traveling

Local Trains



Pros

- Cheap fare
- Covers long distance
- Special coach for Handicap

Cons

- Stations are not designed according to handicap people
- Difficult to reach the station

Buses



Pros

- Special seat for Handicap
- Long Distance travel
- Free Pass for Handicaps

Cons

- No last mile connectivity.
- No wheelchair accessibility
- Assistant required

Cabs/Taxis



Pros

- Last mile connectivity
- Long distance travel.
- Easily Available in town

Cons

- Expensive for long distance travel.
- No provision for wheelchair.
- Assistant Required

Tricycle



Pros

- Affordable vehicle.
- Good for short travel
- No need of any Assistant

Cons

- Human powered make it difficult for long distance.
- Difficult to ride in uphill.

Scooter



Pros

- Comfortable for short and long distance travel.
- No assistant required.

Cons

- Expensive for a handicap user.
- Difficult to use in monsoon.

4.4. Users Insights

- People use **TriCycle, modified scooters, Taxi and buses** for long-distance.
- Users **Do not prefer buses and local trains** because they are not easy to access.
- People face **problem in Public transports** as they always need some **assistant to help** them throughout their travel.
- Handicap people majorly use a **folding wheelchair** for commute, which is easy to carry while travelling.
- The **wheelchair** is the most **comfortable space** for them.
- Some Paraplegic people are **not able to feel their legs** which make them uncomfortable while travelling in a Taxi/Cab.
- Handicap people feel **good** when they **travel with other passengers**.
- Handicap people are aware of online cab services like **Ola/ Uber**, but they are expensive.
- People do not want to invest more than **50 Rs in a day for travelling**.
- They want to do some jobs in which they can also **earn through it**.
- Handicap People want to **drive a vehicle on their own and want to earn from it**.
- While using Taxi or Cab, some driver does not help them for sitting.

5. Post Research

After getting information from the users and observation, we found the handicap people want a new type of vehicle which is design for them. The design of the vehicle should be barrier-free with wheelchair accessibility. They do not want any assistant to judge them. It is essential to understand the needs and problems of handicap users.

To understand the interior of the vehicle, first, we have the understand the ergonomics of the wheelchair. There are different problems we will face while designing related to the dashboard, entry/exit, ramps, seating. It is crucial to identify that problem prior so that the packaging of the vehicle will get easy to design.

5.1. Ergonomics of wheelchair

Length of wheelchair : 42" (1067 mm)
Width of wheelchair : 25" (635 mm)
Height of wheelchair : 36" (914 mm)
Height if wheelchair : 53" (1350 mm)
with user sitting on it
Seat width : 20" (508 mm)
Seat height : 18" (475 mm)
Hip to knee legroom : 27" (685 mm)
Folded Width : 11" (280 mm)

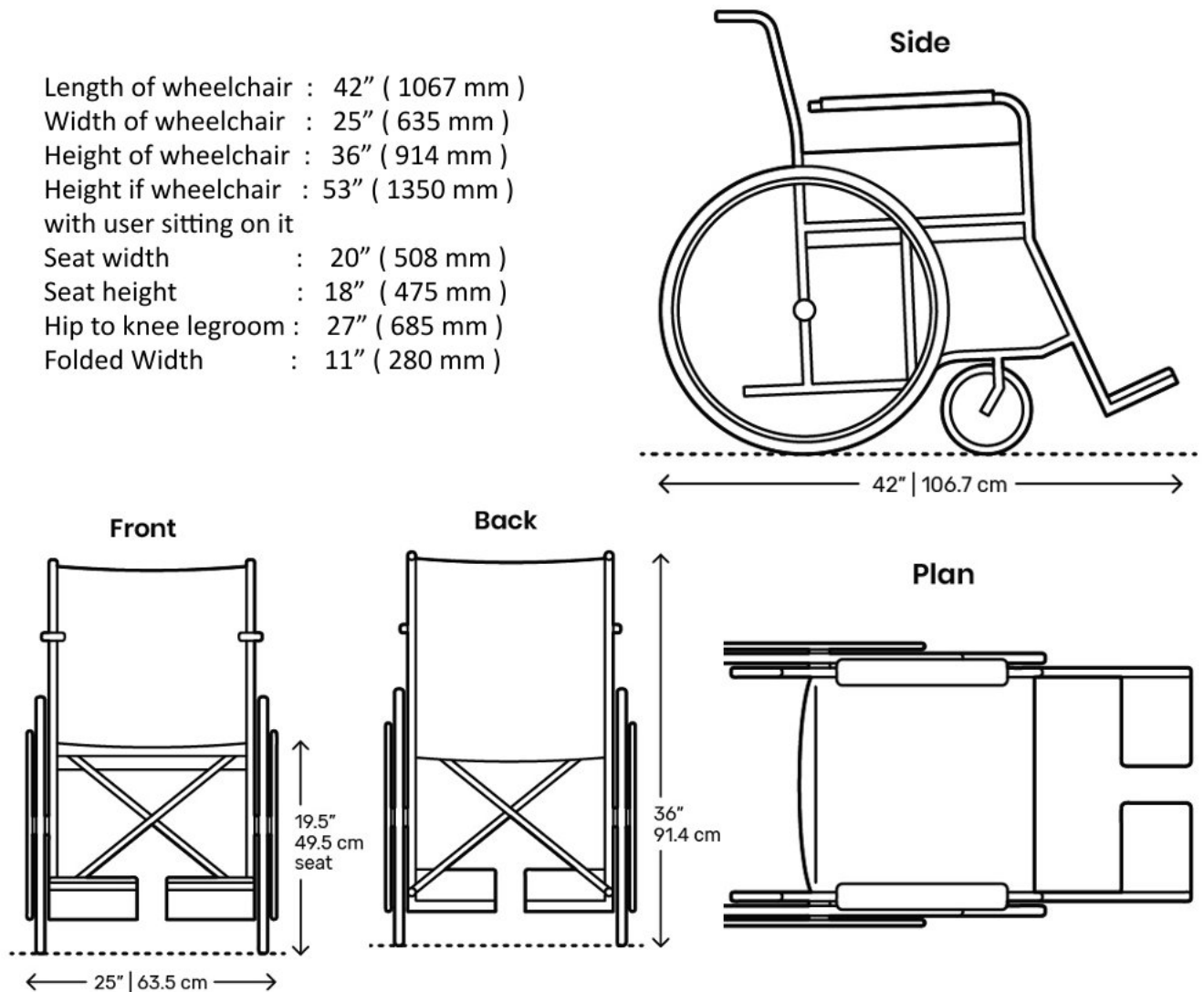


Fig 33: Wheelchair Dimensions [14]

Ergonomics of wheelchair

It is essential to understand the dimension and ergonomics of the wheelchair for designing a vehicle for handicap user. [14]

- Manually operated equipment must be designed to be easily accessible from a wheelchair.
- Allow space at least 350 mm deep and 700 mm high under the Dashboard.
- Width of entry and exit for a wheelchair should be min. 900 mm.
- The Slope of the ramp should be min. 1:12.
- A wheelchair user's movement pivots around his or her shoulders. Therefore, the range of reach is limited, approximately 630 mm for an adult male.
- While sitting in a wheelchair, the height of the eyes from the floor should be 1190 mm for an adult male.

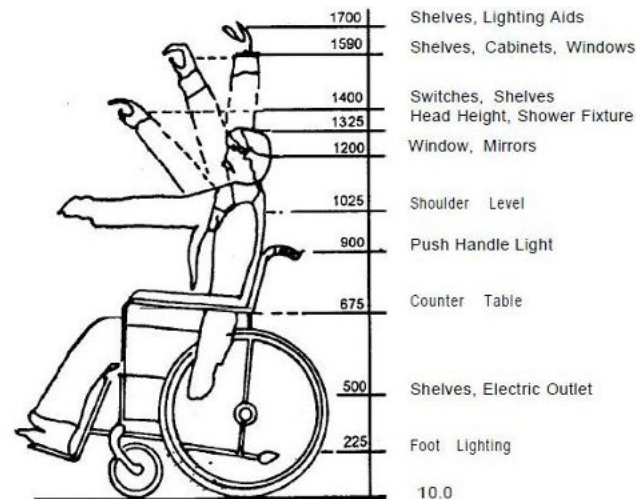


Fig 34: Typical Dimensions for Essential uses with in easy reach

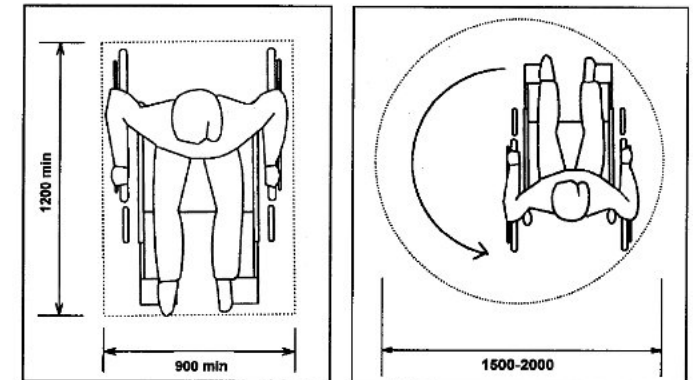


Fig 35: Space Allowance for turning

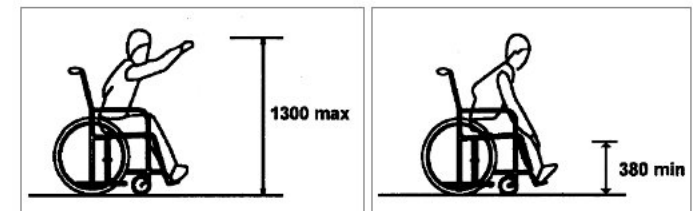


Fig 36: Forward reach without obstruction

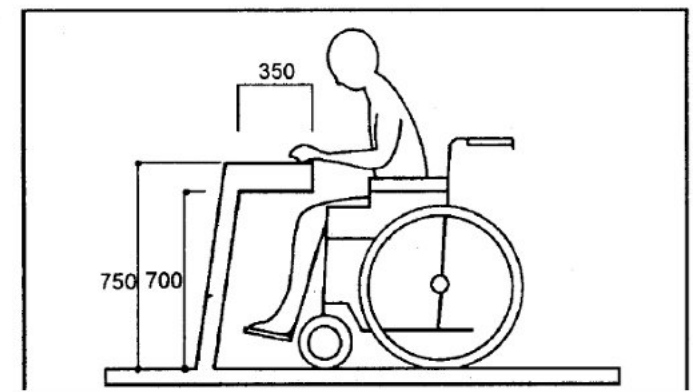


Fig 37: Space required for wheelchair footplate

Force and stress on wheelchair user in slope

A wheelchair user faces many difficulties in their everyday attempts to use ramps, especially those of some length. There are several types of manual wheelchairs, among which there stands out the basic manual push rim propelled models (Vanlandewijck et al., 2001; van der Woude et al., 2001).

The forces user applies to each wheel are symmetrical (Arnet et al., 2013). Then:

$$F_t(\alpha > 0) = F_p + F_{\text{drag}}$$

F_{drag} = the rolling resistance force, α is the slope of the ramp.

$F_t(\alpha > 0)$ being responsible for the forward movement of the wheelchair

F_p is the force applied by human

Given $F_t(\alpha > 0)$ one can determine the torque $M_{\alpha c}$ needed to move the chair up a ramp

Ramps are a major problem for users' everyday lives. It requires changes of inertia need more upper limb strength than those needed to maintain speed on the flat. It is important to design a braking system for the wheelchair.

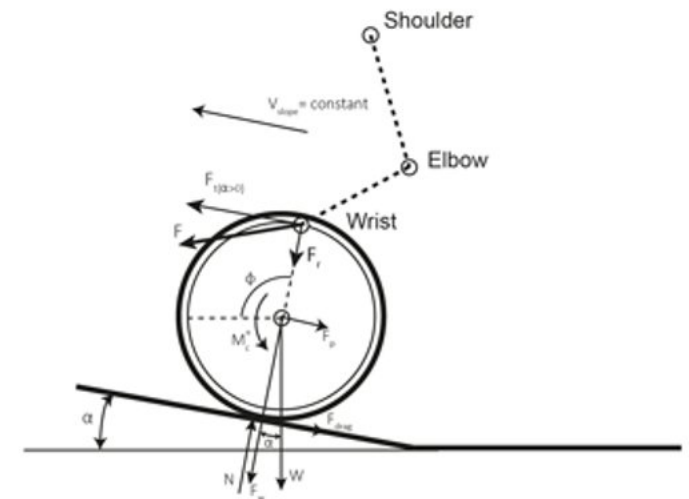


Fig 36: The forces and torques on the push rim of the wheelchair when climbing a slope at constant speed.

5.2. Quadricycle Vehicle

A new category of small vehicles - Quadricycles, has been approved by the Indian government and in particular the Ministry Of Road Transport and Highways. This new category, which will mainly be used to classify small four-wheeled personal vehicles (or commercial vehicles). In order to meet the criteria of a 'Quadricycle', a vehicle will give to weight less than 475 kg (kerb weight). It will have to pass a list of emissions, crash and other norms which will be laid down by the government and the Automotive Research Association Of India - ARAI. [15]

The quadricycle vehicle will be compatible with the new design of a vehicle for wheelchair users. It is lightweight with a speed of maximum of 70 Km/h.

Quadricycles norms

Weight \leq 475 Kg

Power \leq 20 Ps

Speed \leq 70 Km/h



Fig 38: Renault Qute



Fig 40: Renault Twizy



Fig 39: Mahindra Atom



Fig 41: Eicher Polaris

5.3. Understanding the Problems of wheelchair cars

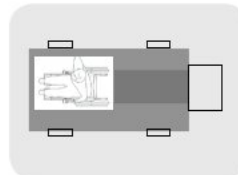


How will the wheelchair user get inside the vehicle ?

Using Ramp- understanding the angle of ramp
Ground Clearance - the minimum ground clearance of a vehicle.
Assistant or non assistant vehicle
Hydraulic Lifting.



Fig 42: Hydraulic lift for wheelchair, Ramp



How will the wheelchair user go to the driving position?

Space distribution for the wheelchair accessibility and enough breathing space for the wheelchair to move around.



Fig 43: Rear view of a car



How to convert the wheelchair into comfortable seat?

Using Ramp- understanding the angle of ramp
Ground Clearance - the minimum ground clearance of a vehicle.
Assistant or non assistant vehicle



Fig 44: Comfortable Wheelchair types

To make wheelchair comfortable people uses modified wheelchair which are highly adjustable and expensive too. Cost around 40,000 Rs.



Locking system for the wheelchair

The locking mechanism of wheelchair with the vehicle is important for the safety reasons.

The wheelchair should be stable while driving the vehicle.



Fig 45: wheelchair locking system, EZ locks

EZ locks are used for locking wheelchair inside the vehicle and sometime wheelchair restraints are also used for same. 4 point securement system.



What will be the driving system for wheelchair user?

Modified steering design with gear shifting

Joystick - automatic control

Handle Bar - throttle drive



Fig 46: Steering, Joystics, handle bar



Dashboard Design

The dashboard of vehicle should be designed according to the handicap users with minimal interface.

The controllers on dashboard should be interactive.



Fig 47: Dashboard for Handicap

Most of the vehicles are customized for handicapped users and for some the whole control system given on the handle bar only to give better reach.



Placement of passenger seats

As the vehicle use for taxi services the placement of the passenger seat is important. It should be comfortable for both passengers and for the driver.



Fig 48: Foldable seats are used for passenger area.



Safety and Security

The wheelchair user should be able to escape from the vehicle in emergency situation.

The passage of exit should be easily accessible.
Seat belt Weather protection safety.



Fig 49: Safety and security for Handicap people

Emergency doors are next to the wheelchair position.
Weather protection

5.4. Vehicle Dimension study

The dimension study helped to understand the scale of the vehicle and how much space will require for usability. The dimensions vary in different segments of the vehicle, but for the wheelchair accessible car, the passenger vehicle segment will be useful to study.

Auto Rickshaw

Space for 3 Passenger

Length : 2625 mm

Width : 1300 mm

Height : 1710 mm



Kenguru

Remote control Rear opening

Length : 2125 mm

Width : 1620 mm

Height : 1520 mm



Bajaj Qute

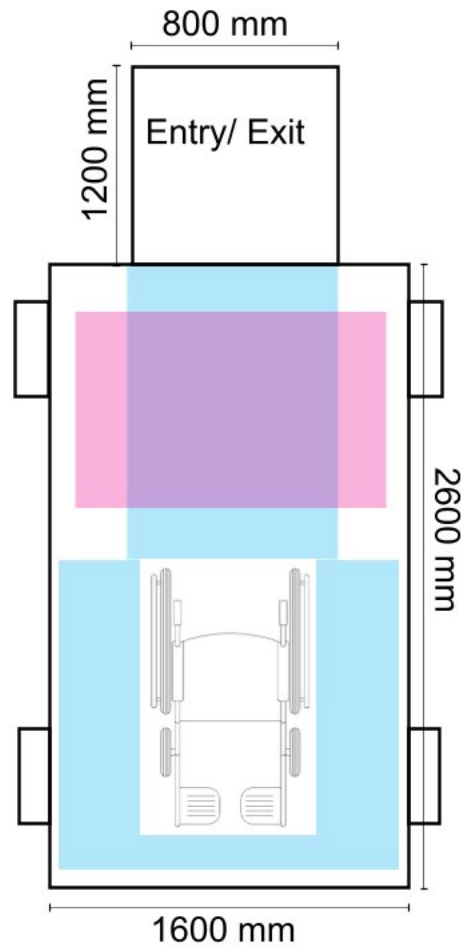
Space for 4 Passenger

Length : 2750 mm

Width : 1312 mm

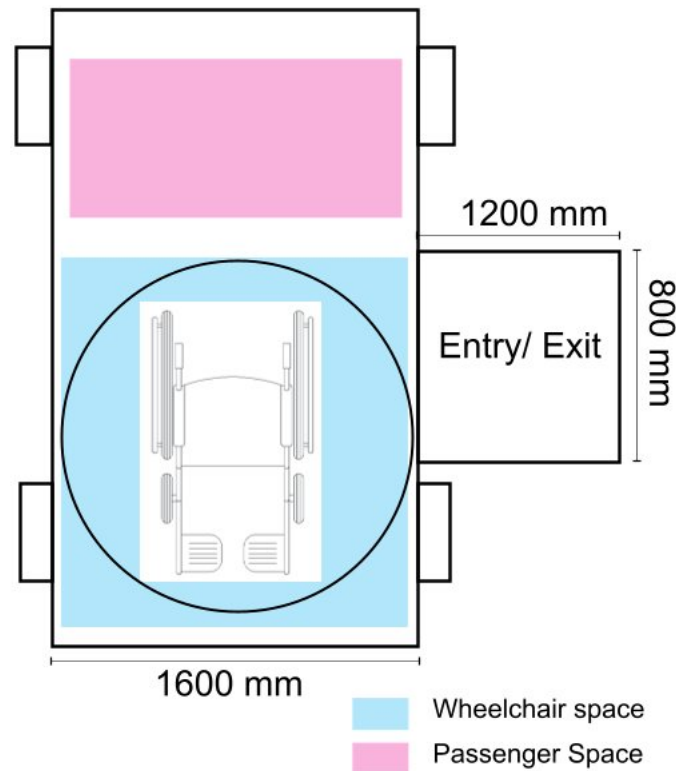
Height : 1652 mm

5.5. Dimensioning and Entry/Exit of the vehicle



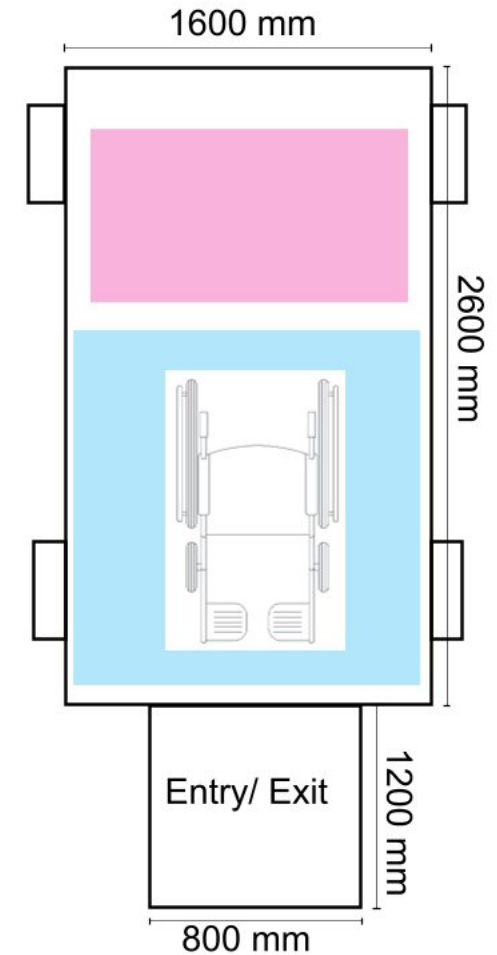
Rear Entry and Exit

- Required much space for wheelchair
- Less space for passenger seat.
- Foldable seats can be adjusted.



Sideways Entry Exit

- Turning will be difficult from the side entry.
- Space for passenger seats.
- Complete seat can be provided at the back.
- Required much side space for entry exit



Front Entry Exit

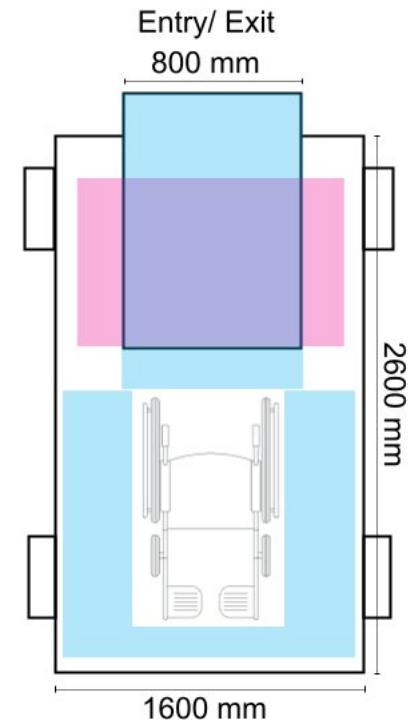
- Easy to access from front.
- The dashboard position will be attached to the opening door.
- Space for Passenger seat.
- Not Safe in emergency situation

5.6. Study Insights

From the study, the sideway and front entry/exit are not feasible as it required much outside entry/exit space with is very difficult in parking areas and dangerous in emergencies. The front door entry is dangerous if they have to evacuate vehicle in an emergency. The positioning of the dashboard to the door is also an expensive task.

- The rear door entry is a good option as it does not affect the dashboard space and require less space compare to side entry. Still, the ramp will increase the length of the vehicle.
- The Ramp space should be included in the structure of the vehicle. It can be a part of the vehicle itself.
- The passenger seats should be foldable so that it does not affect the wheelchair entry/exit.
- The railing should be provided at the entry/exit point for handicap user.
- The total length and width of the vehicle are 2600 mm and 1600 mm.
- The wheelchair locking system should be provided in the driving position.
- The handlebar and dashboard should be designed according to the user's comfort.

- The space distribution for both passenger and wheelchair user should be provided.



Rear Door entry/exit with inserted ramp

- Required space for wheelchair
- Less space for passenger seat.
- Foldable seats can be adjusted.
- The structure of vehicle can be resigned.
- Ramp inserted inside the structure.

6. Design Brief

Design a vehicle for physically handicap people (Paraplegic) who uses a wheelchair for a regular commute. The purpose of the vehicle is to provide job opportunity for the paraplegic people. The Design of the vehicle is a four-wheeled electric driven taxi/cab which will accommodate one wheelchair driver + 2 passengers. The entry and exit of the wheelchair will be from the rear door of the vehicle. The driving system will be handlebar throttle control which is easy to control by the wheelchair users.

Accessories designed for the wheelchair.

- Can provide comfort to the driver
- Can be attached with the standard wheelchairs
- It Should be a shock absorber
- Locking system provision

Specification:

- It should not have larger foot print as it designed for city.
- Rear Door entry and exit for the wheelchair driver and side entry/exit for passengers.
- It should have wheelchair locking system for the driver.
- The passenger seats should be foldable for wheelchair entry/exit.
- The design of handle bar and dashboard should be according to the user usability.

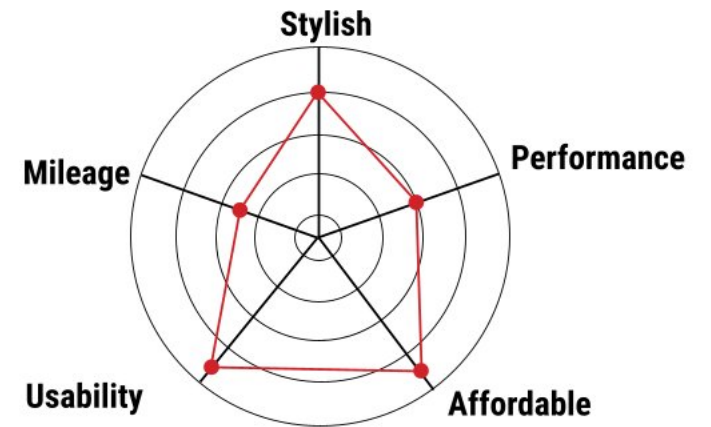
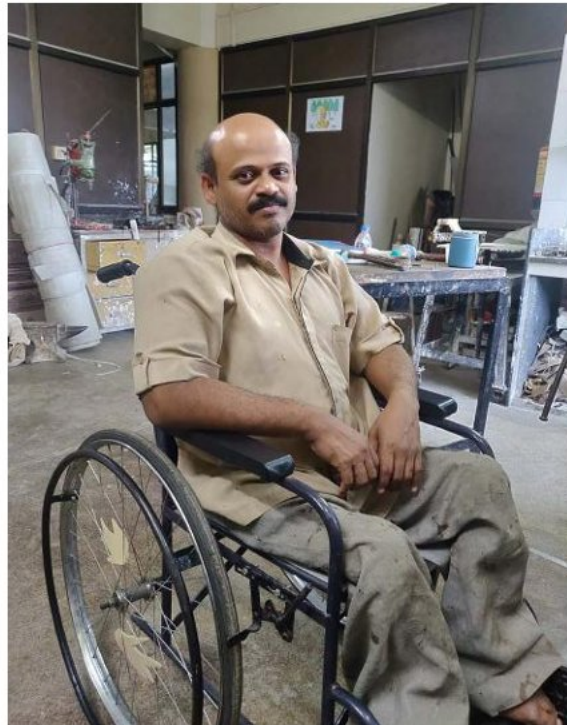
Aesthetics:

- It should be welcoming for the passengers to look at.
- It should reflect as a passenger vehicle only.
- It should look secured.

Consideration for Vehicle -

- Tentative Dimension for the exterior (LxWxH)
2600 x 1600 x 1700
- Approximate wheelbase: 1865mm
- Approximate ground clearance: 160mm
- Approximate wheel dimension: 155/ 65 R 14

7. User Persona



Name : Shushal Gyakwad
Age : 18-35
Occupation : Workshop incharge, worker
Disability : Paraplegic
Place : Vikhroli to Mahalakshmi



8. Interior Concept

8.1. Layout 1

The concept presents the interior of the vehicle with foldable seats and sideways sitting for the passengers .

- The Ramp is placed at the rear door which is a structure part of the vehicle.
- The handle bar is straight like handle bars of scooter.
- The wheelchair lock is at the center of the driver position.
- The seat are foldable and the passengers will sit sideways.

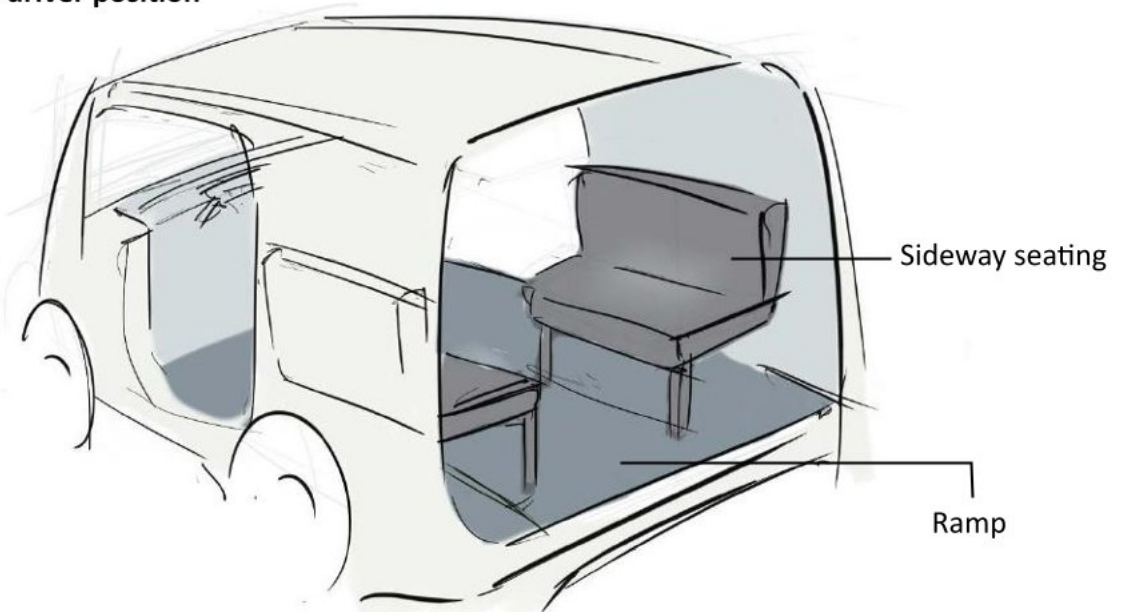
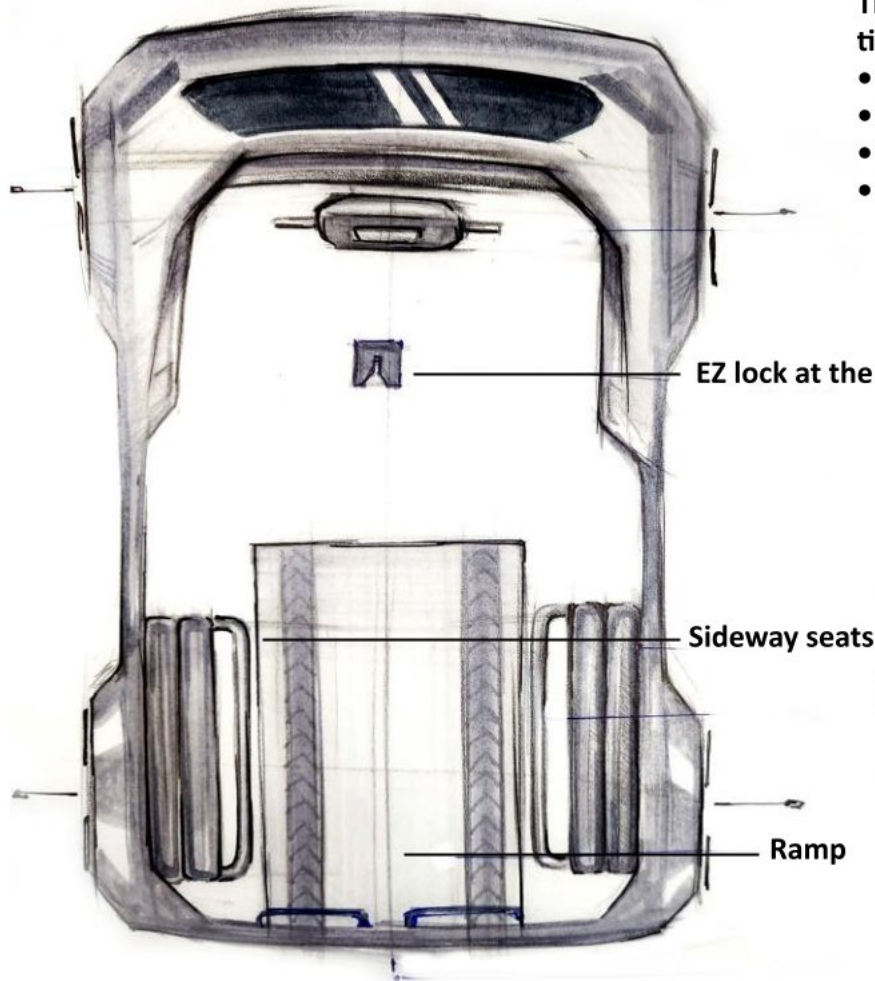


Fig 50 :Interior Layout Design 1

8.2. Layout 2

The concept presents the interior of the vehicle with foldable seats attached to the rear door.

- The Ramp is placed at the rear door which is a structure part of the vehicle.
- The steering is provided as at the center of the vehicle.
- The wheelchair lock is at the center of the driver position.
- The seat are attached to the rear door of the vehicle.

Seats are attached to the rear door of the vehicle.

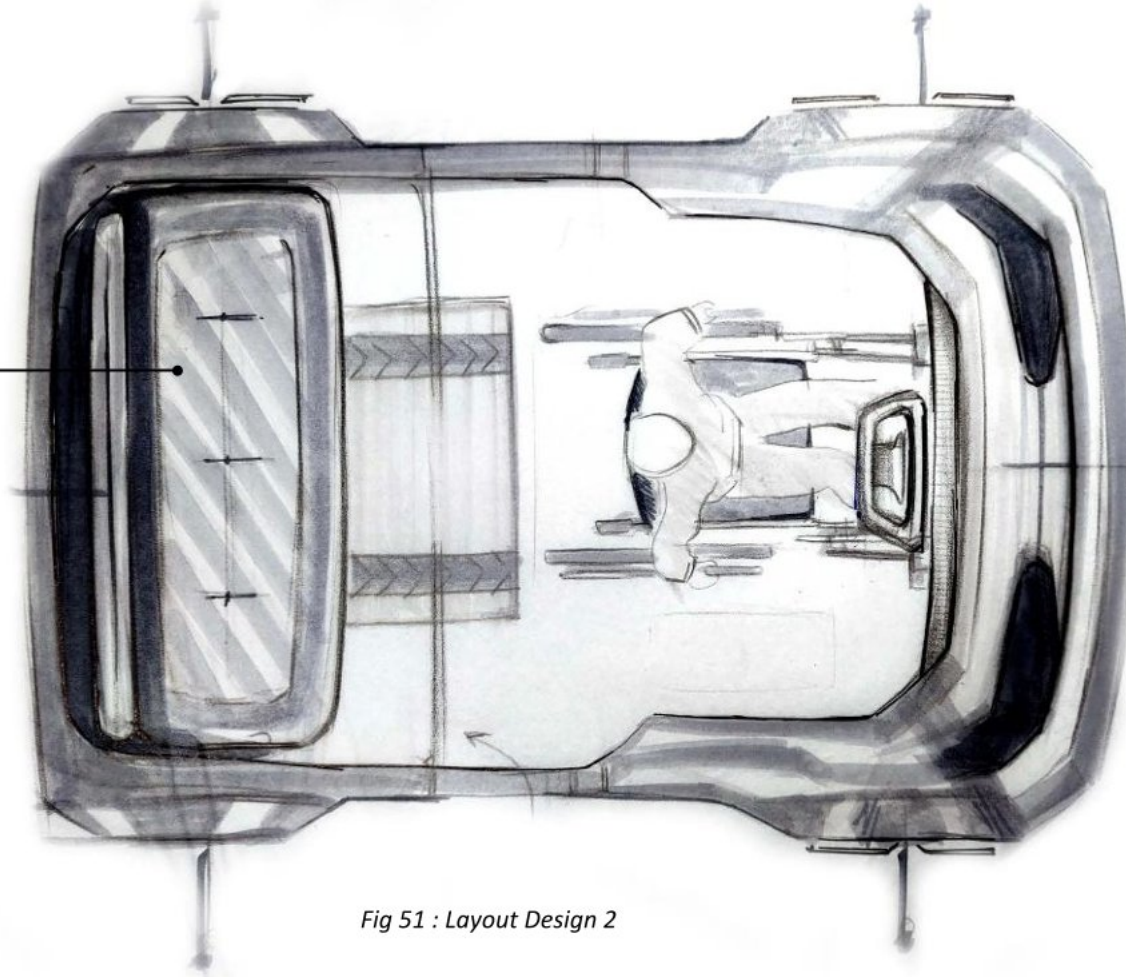


Fig 51 : Layout Design 2

8.3. Layout 3 and final Layout

The concept presents the interior of the vehicle with Double foldable seats with front facing

- The Ramp is placed at the rear door which is a structure part of the vehicle.
- The steering is provided as at the center of the vehicle.
- The wheelchair lock is at the center of the driver position.
- The seat are attached to the sides with double folding seating.
- Emergency exits are provided as side door 900mm opening.

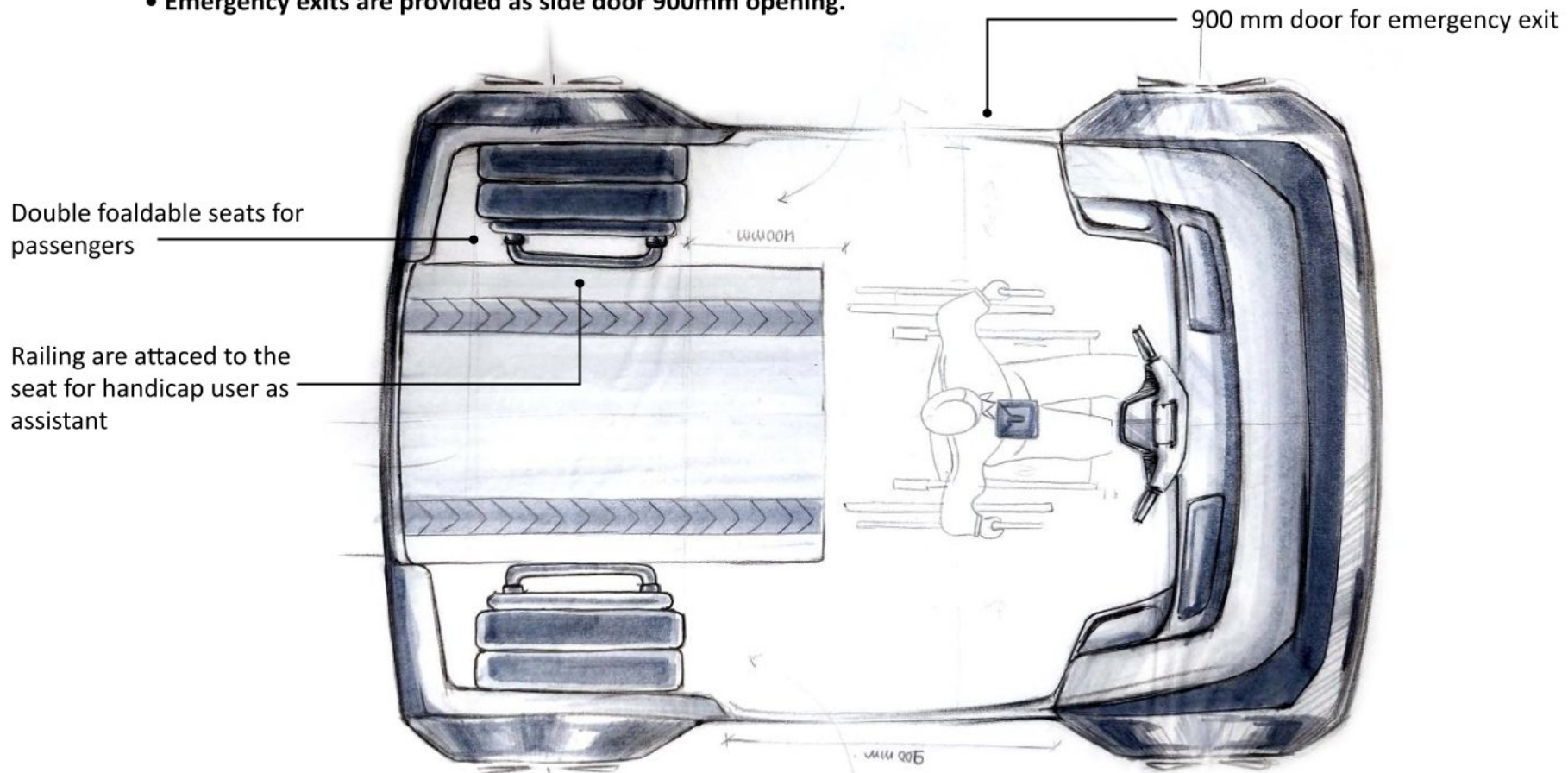


Fig 52 : Layout Design 3

9. Packaging

The packaging of the vehicle is done according to the ergonomics and the research data.

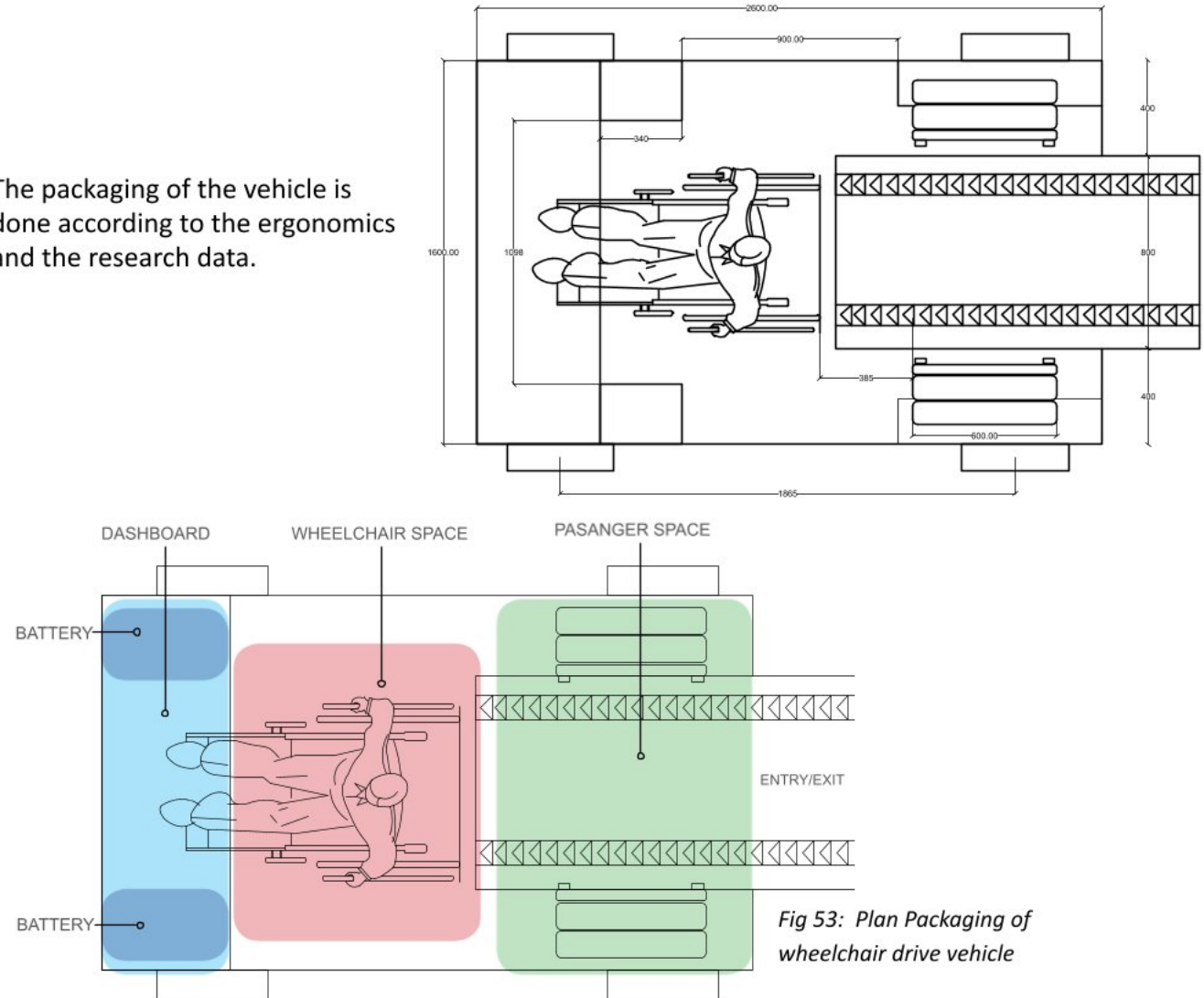


Fig 53: Plan Packaging of wheelchair drive vehicle

The packaging of the vehicle is done according to the ergonomics and the research data.

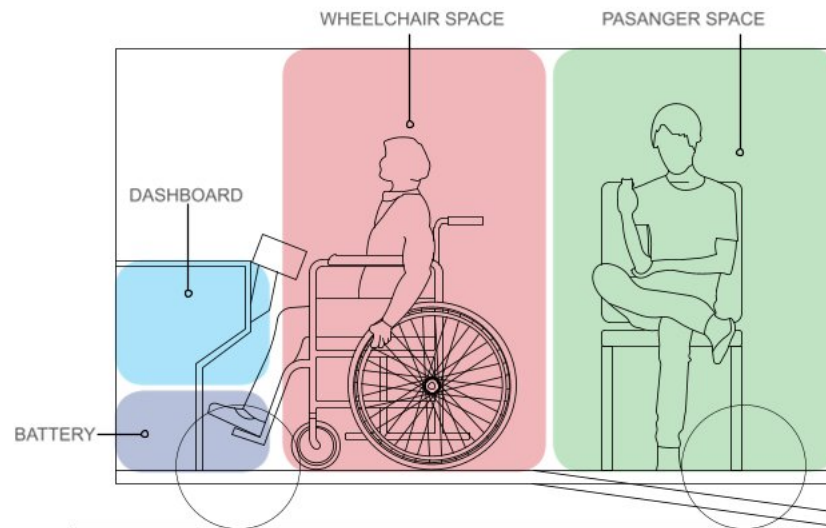
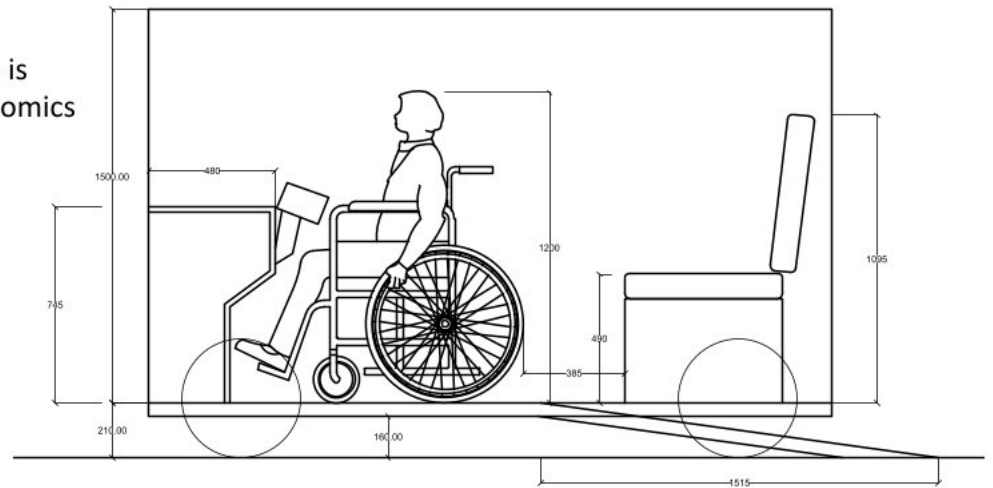


Fig 54: side view Packaging of wheelchair drive vehicle

10. Component Design

10.1. Chassis Design

The Electric car chassis is smooth, power, wide torque range, cheap running costs and minimal maintenance. The Design has the advantage of the simplicity and flexible packaging offered by electric technology. The basic layout for an EV suits a wide range of applications and can be easily tuned with different size motors, batteries, gearing and size. It demonstrates a simple and compact system with a low centre of gravity that is strong, stiff and straightforward to build.[16]

Drive - The front-wheel drive, one electric motor powers each rear wheel. It Eliminates the need for a differential and CV joints.

Motors - AC Induction. Have excellent torque over the full speed range.

Batteries - Batteries can be stored in the front of the vehicle. It needs to be matched to the motors and controllers.

Chassis - Aluminum chassis with a battery attached to it provides a high level of strength and stiffness from a straightforward and light structure.

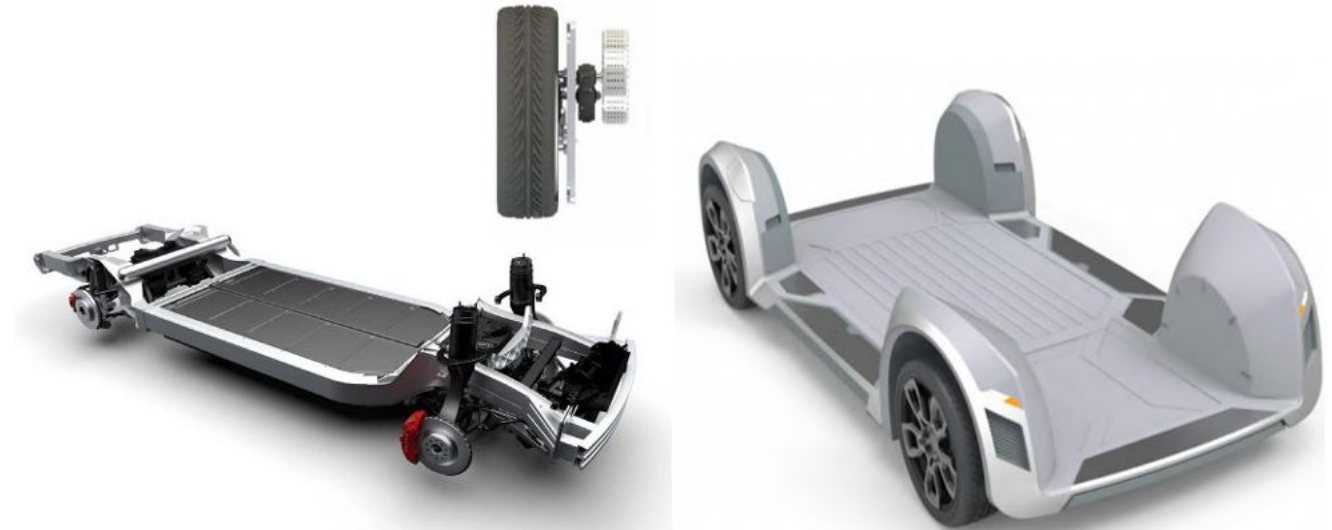
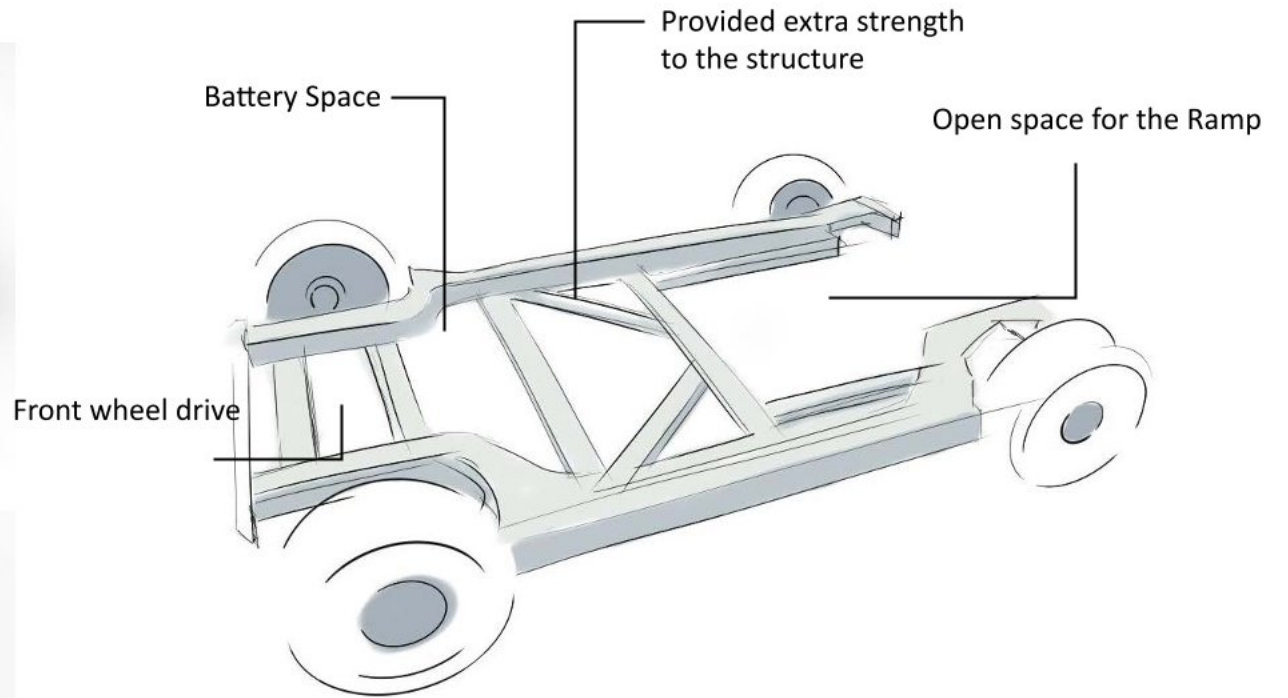
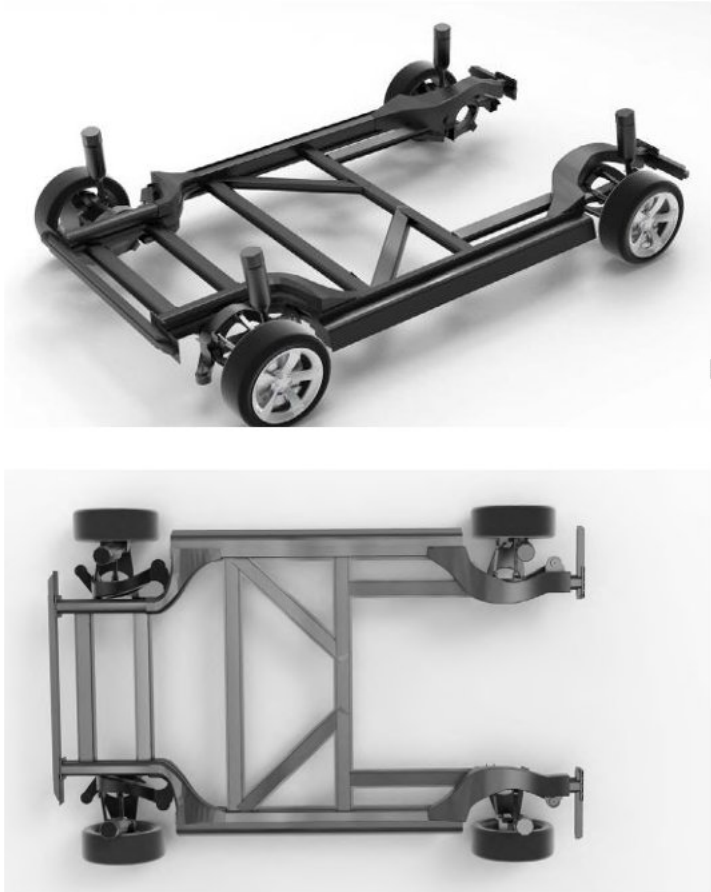


Fig 55: Electric Chassis design

Chassis Design



The Structure of chassis is designed according to the users usability. The rear part of the chassis is open for the ramp. It required C-type of structure because of the opening. The front part of the chassis is heavy compare to the rear part.

Fig 56: 3D Chassis design in Blender

10.2. Wheelchair Design

The wheelchair need to be redesigned for the handicap drive to provide comfort and balance in drivers position.

- The wheelchair should be shock absorber and seats should be comfortable as the handicap drive will drive the vehicle for long period.
- It should be economical for the user.
- Locking system should be their in the wheelchair.



Fig 56: Comfortable wheelchairs

- Most of the comfortable wheelchair are expensive which are not affordable by most of the wheelchair users.
- The design of the wheelchair should be modular. Which can be use in foldable wheelchairs.

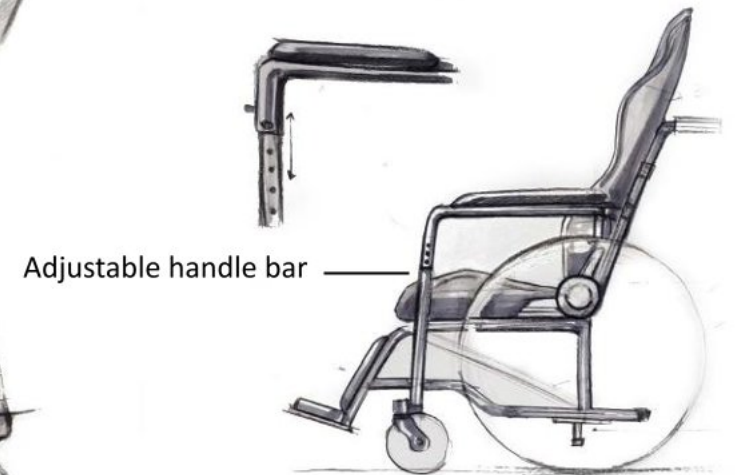
Ideation



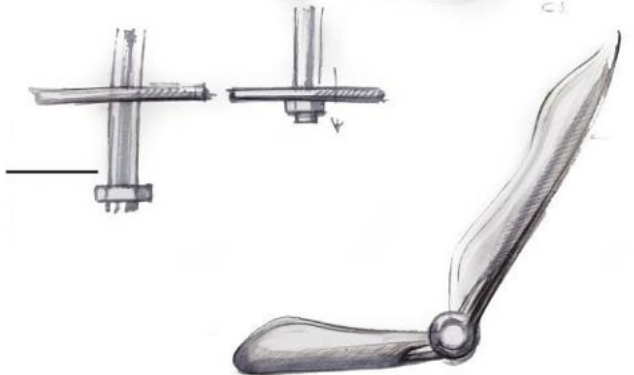
Wheelchair Design



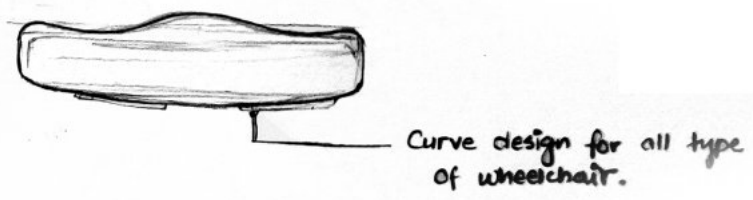
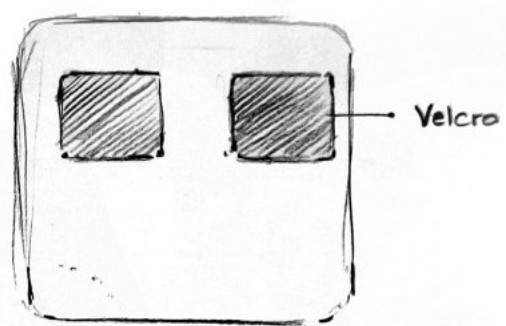
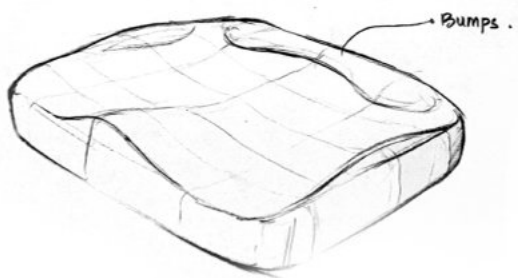
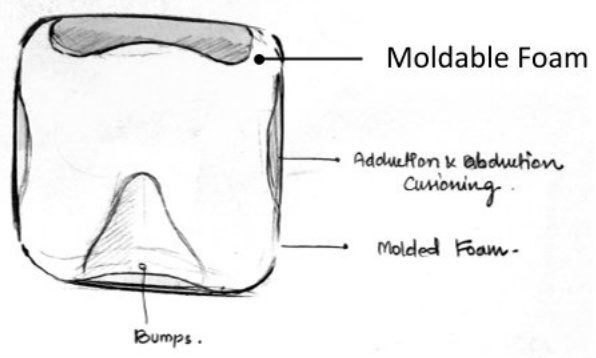
- Detachable seats for foaldable wheelchair which can be use while driving.
- The bottom of the seat is little curve so that is can fit into the foldable wheelchair.



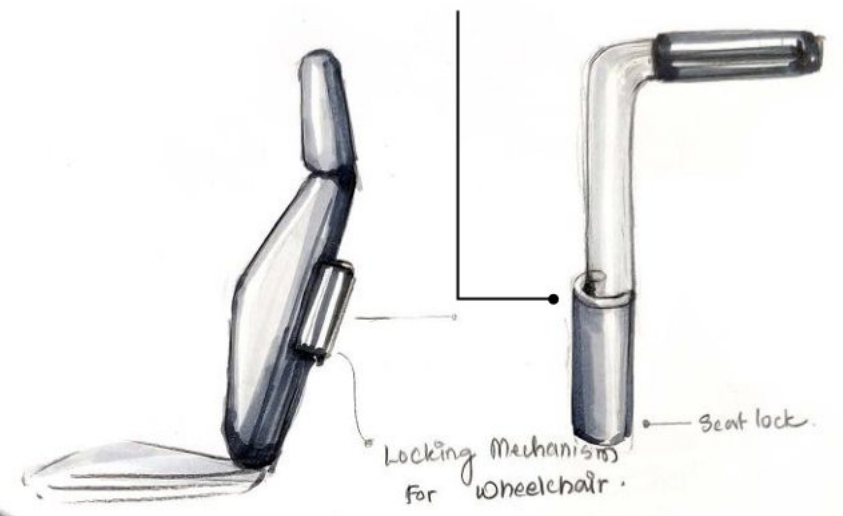
Locking hook at the bottom of the wheelchair which will directly connect to the EZ lock.



Detachable seats



Locking Mechanism for wheelchair



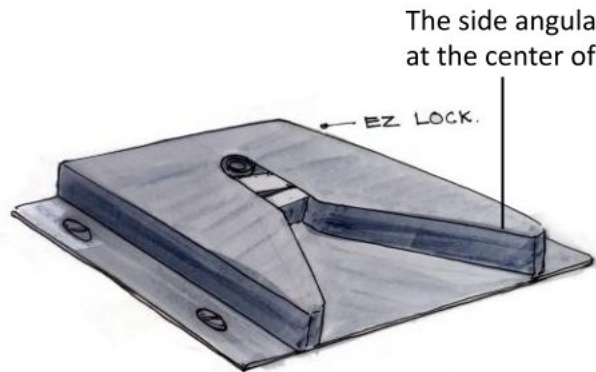
Final Wheelchair Design

The final concept of the wheelchair is modular. The seats are designed in such a way that it can be attach with the existing foldable wheelchair. The design of the seats are according to the drives seat comfort. The hand rests are also adjustable which will be helpful while using the vehicle handle bar. The wheelchair is also modified with locking bolts which will lock the wheelchair with the vehicle.

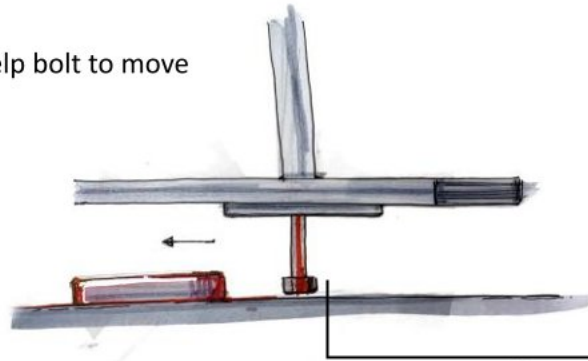


10.3. Locking System

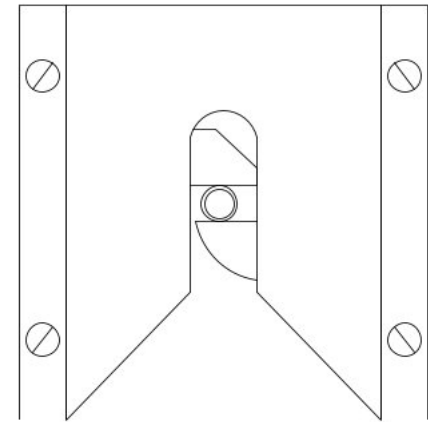
The locking mechanism of wheelchair with the vehicle is important for the safety reasons. The wheelchair should be stable while driving the vehicle. The EZ lock is available in the market. It is widely used by handicap users.



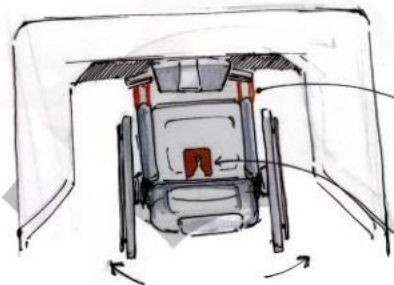
The side angular edges help bolt to move at the center of the lock



The bolt directly attached with the EZ lock.



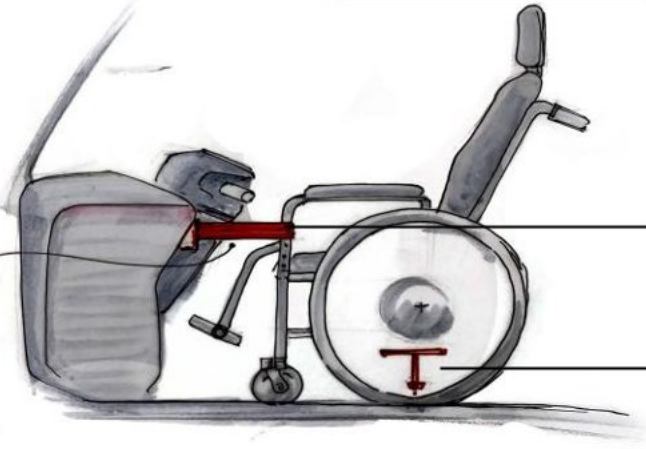
EZ Lock System



BELT LOCK.

AXIAL ROTATION.

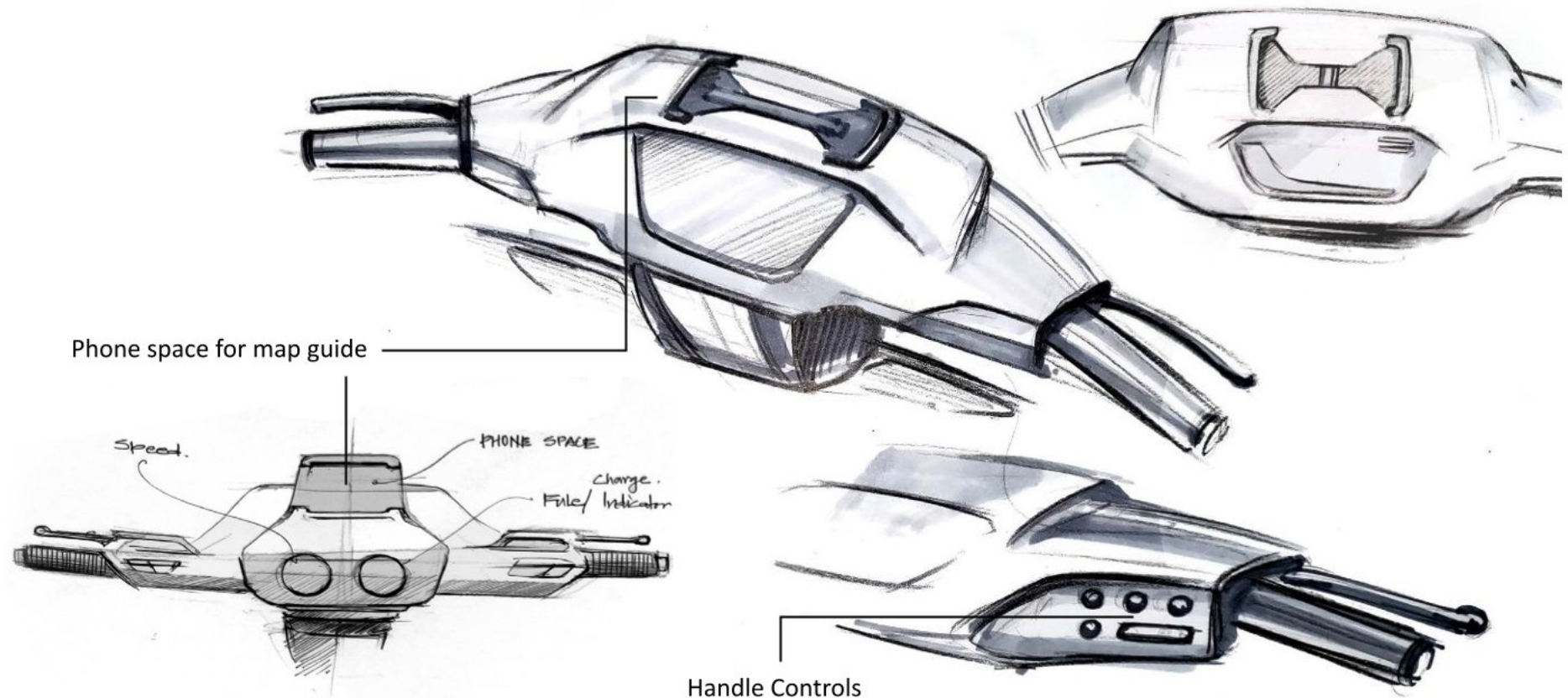
Belt lock is also provided to protect from axial rotation while driving.



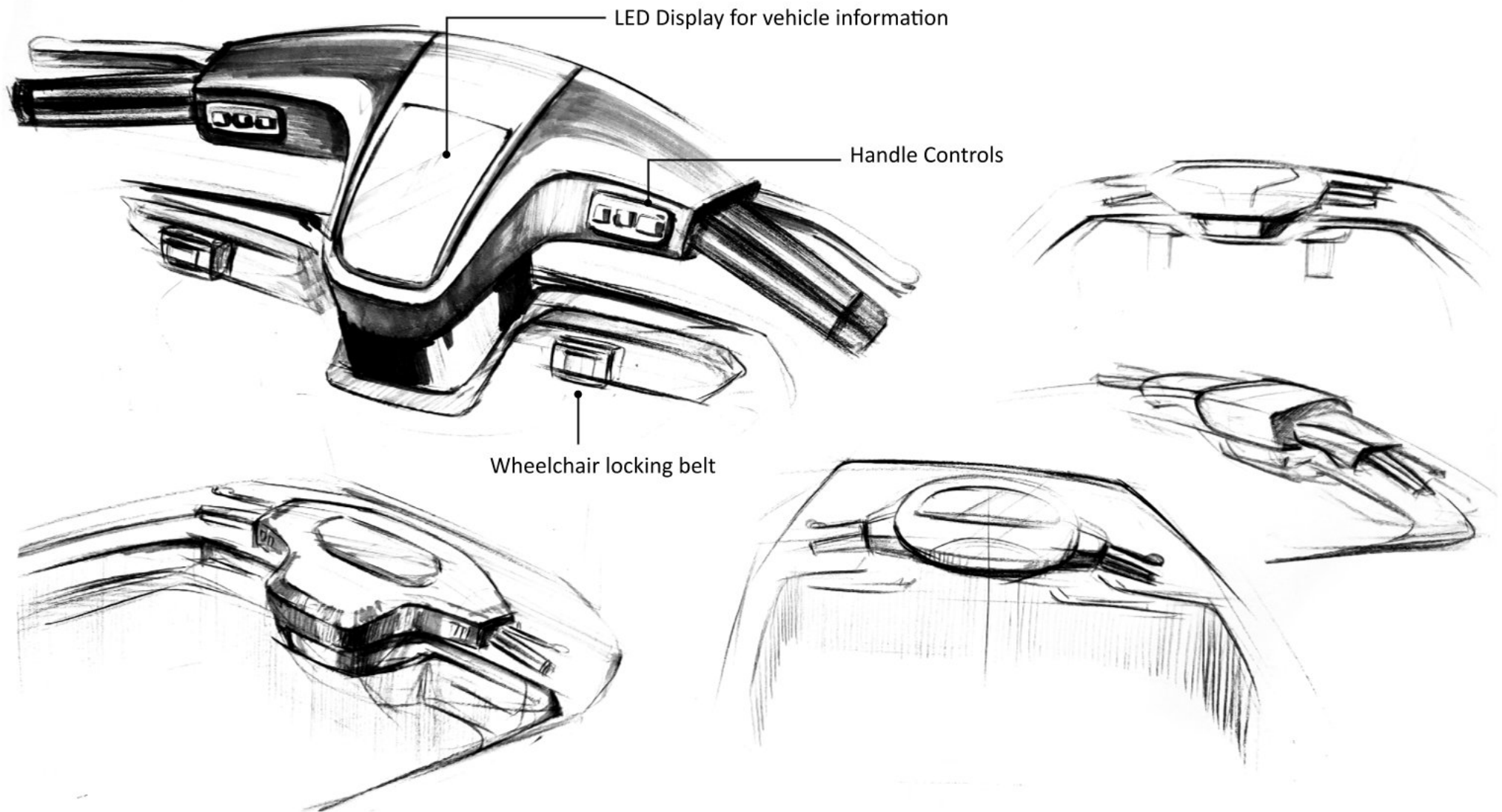
The EZ lock placed at the center of the driving position to lock the wheelchair from the center.

10.4. Handle Bar

There are different types of drive system like steering wheel, joystick control, handle bar. Which are easy to use by an abled person, but for a disabled person, it is difficult to use a steering wheel with other controls, and joystick control is expensive for a passenger vehicle. The handlebars are a good option for handicap users, with less control complexity and good user interaction. The Drive system will be completely electrical, which does not require gear shifting.

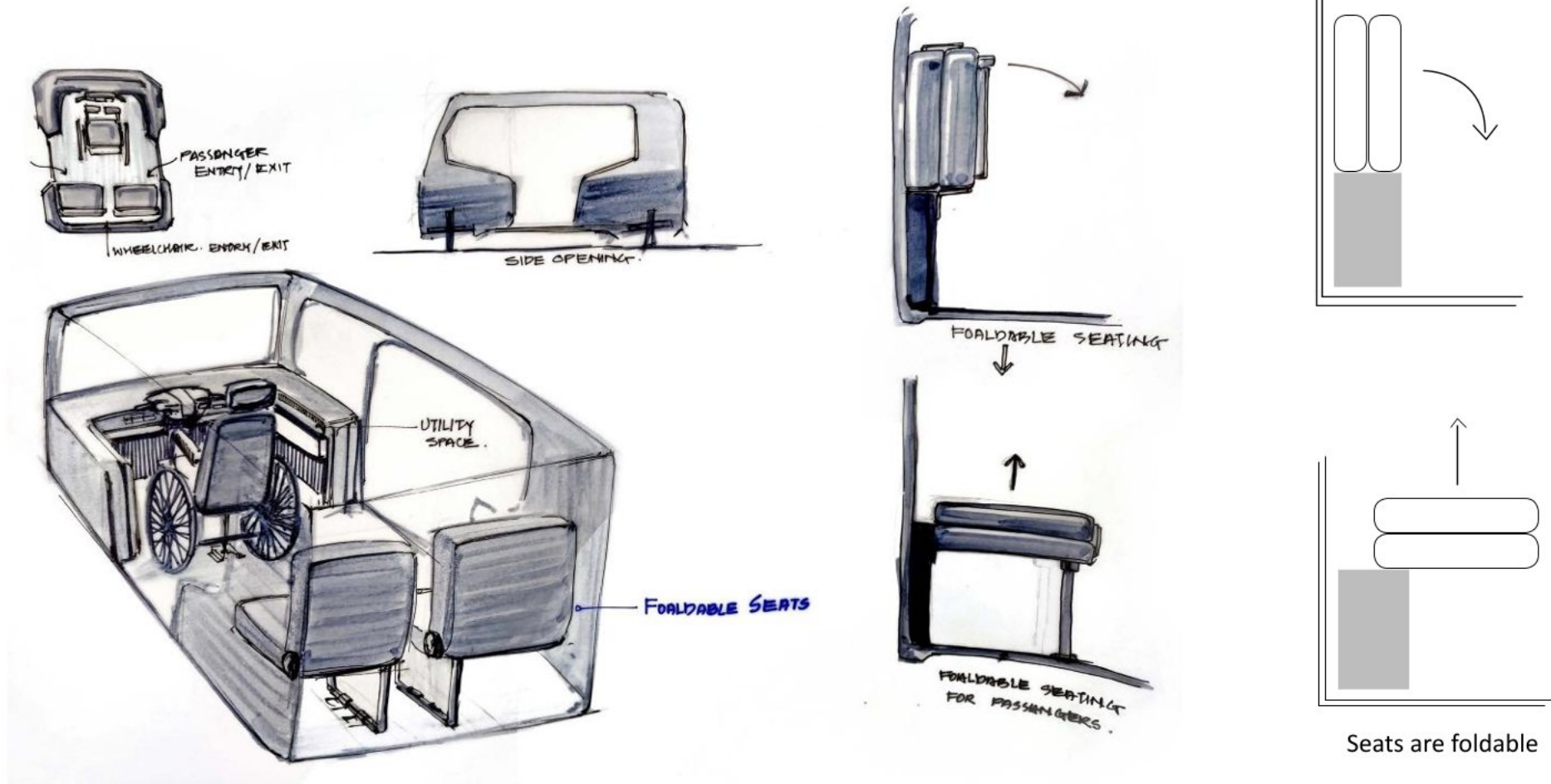


Final Concepts

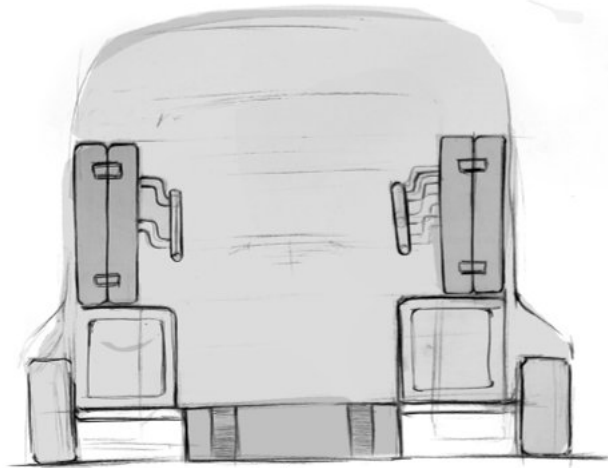


10.5. Passenger Seat

The passenger seat should be foldable to give proper space to the wheelchair driver to get inside from the rear door of the vehicle.

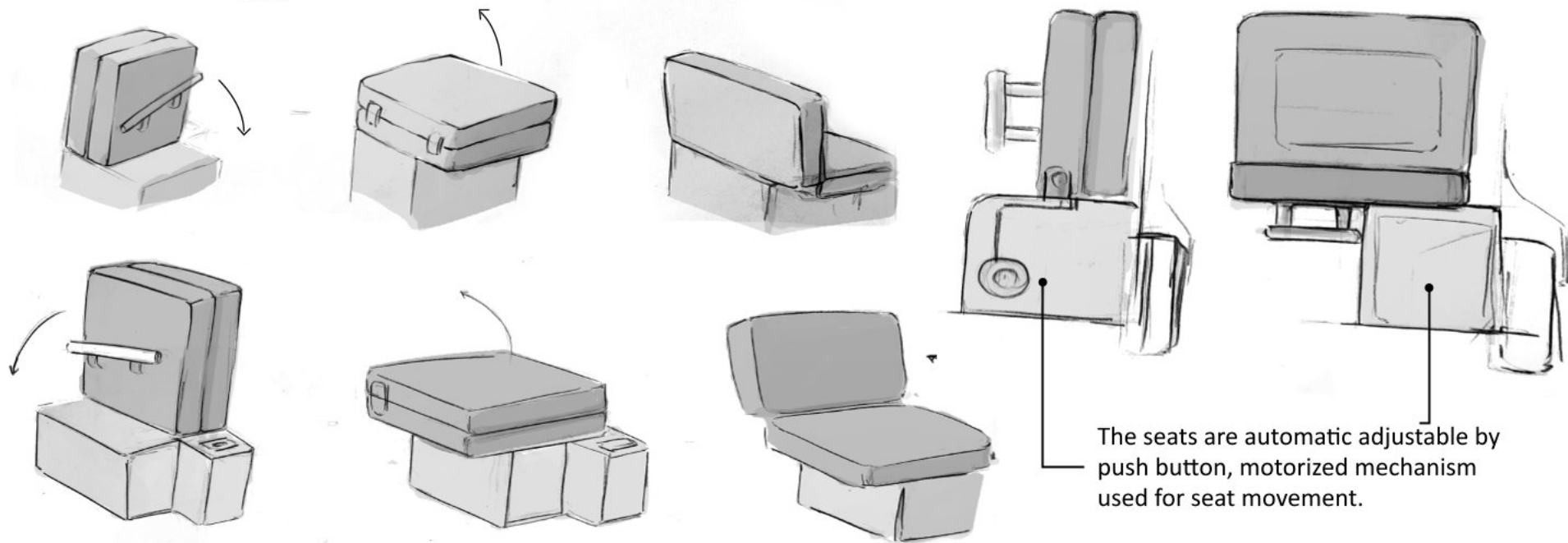
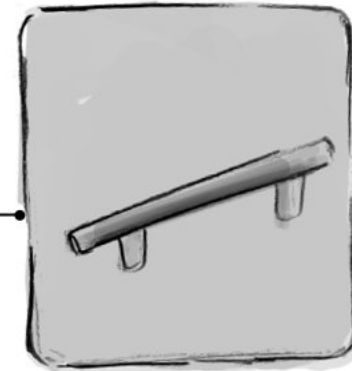
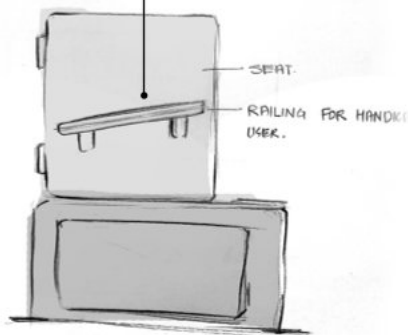


Concept 1

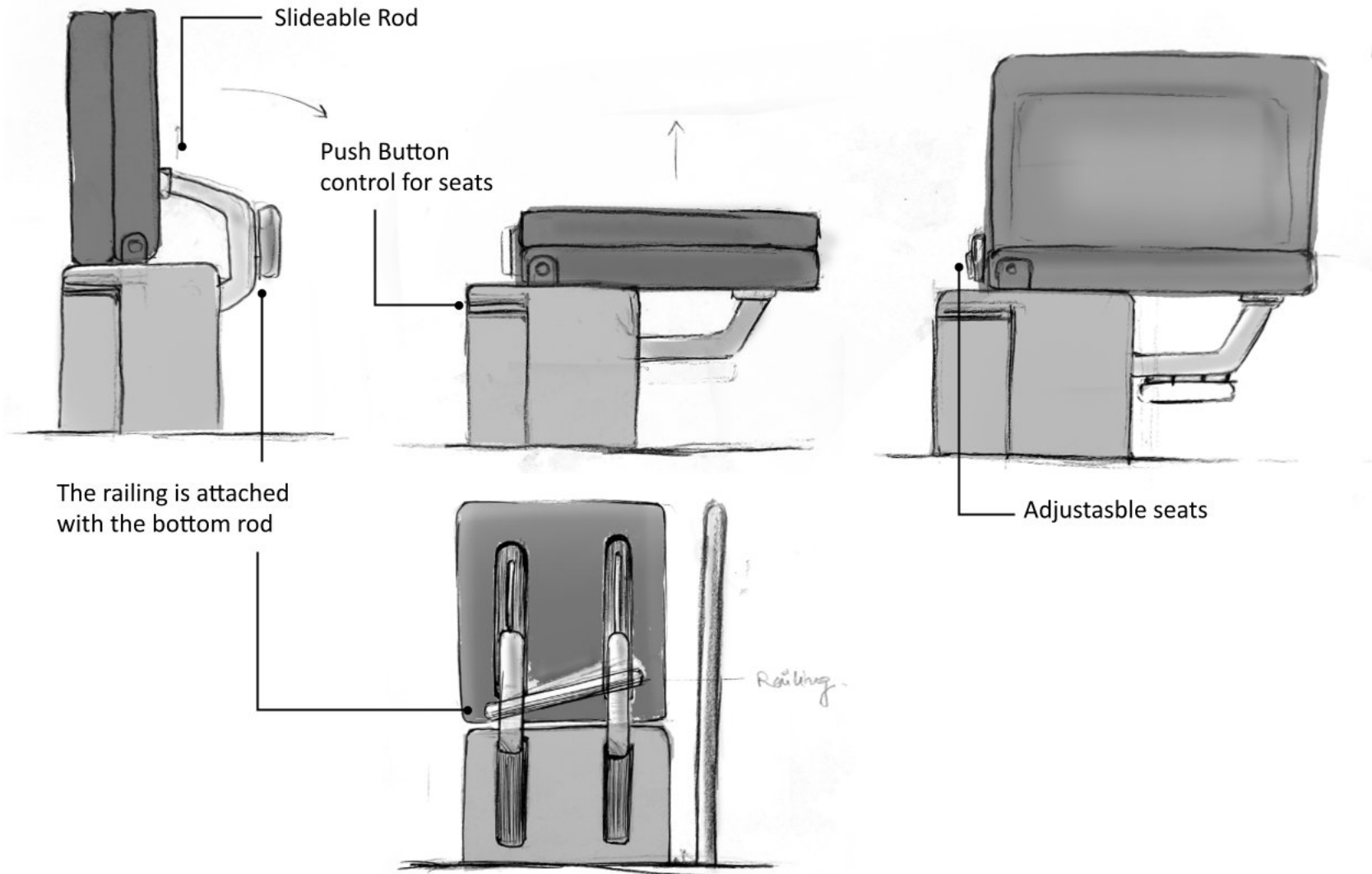


Section

Railing attached to the seat rear for Handica users to get inside the vehicle



Concept 2 and final concept



10.6. Dashboard Design

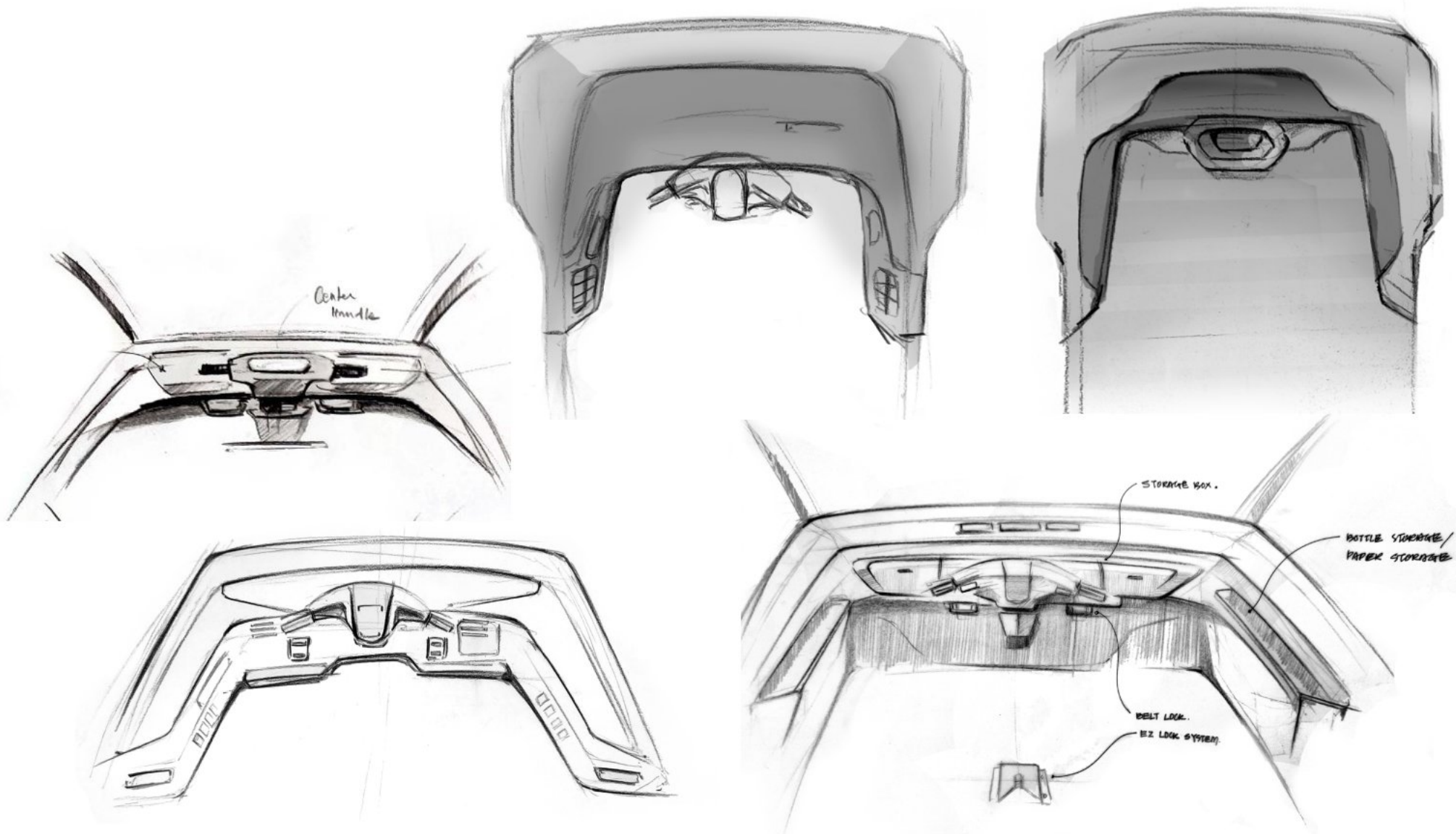
The dashboard of the vehicle should be designed according to the handicap users with a minimal interface.

- The controllers on the dashboard should be interactive.
- Most of the vehicles are customized for disabled users and for some the whole control system given on the handlebar only to give better reach.

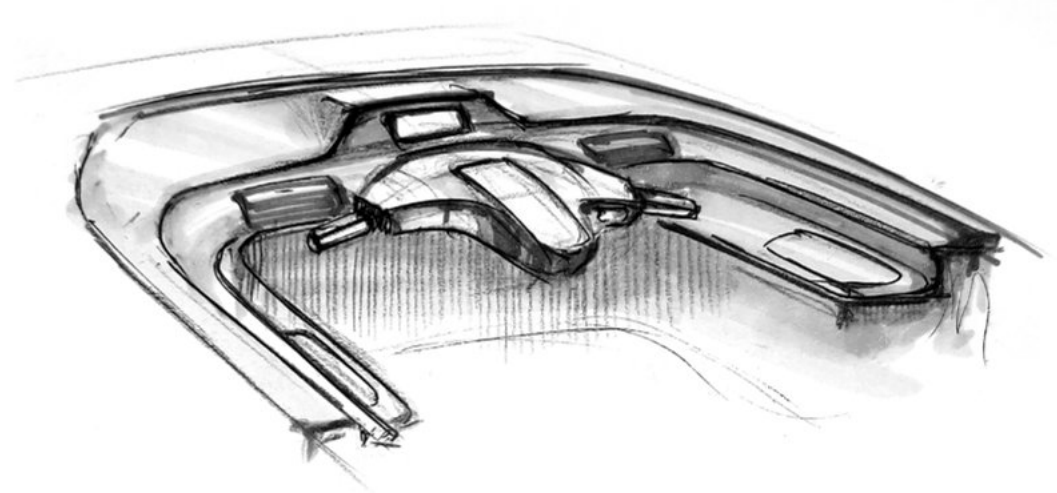
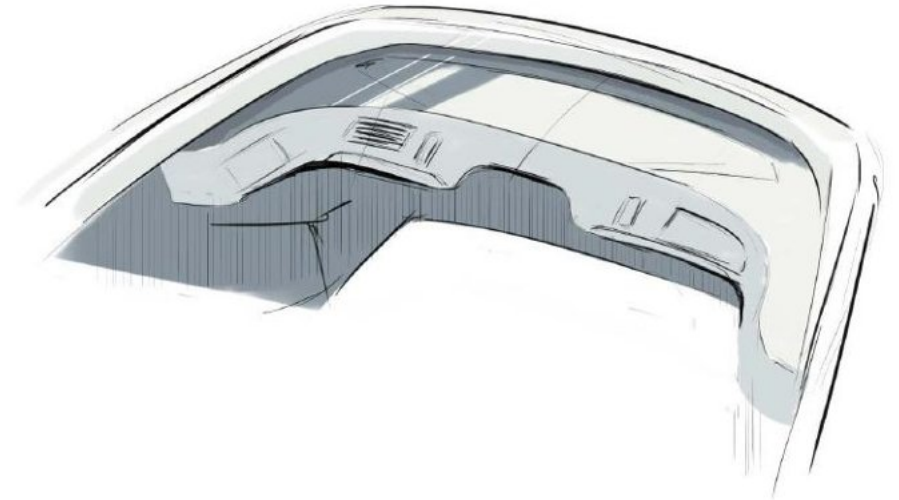
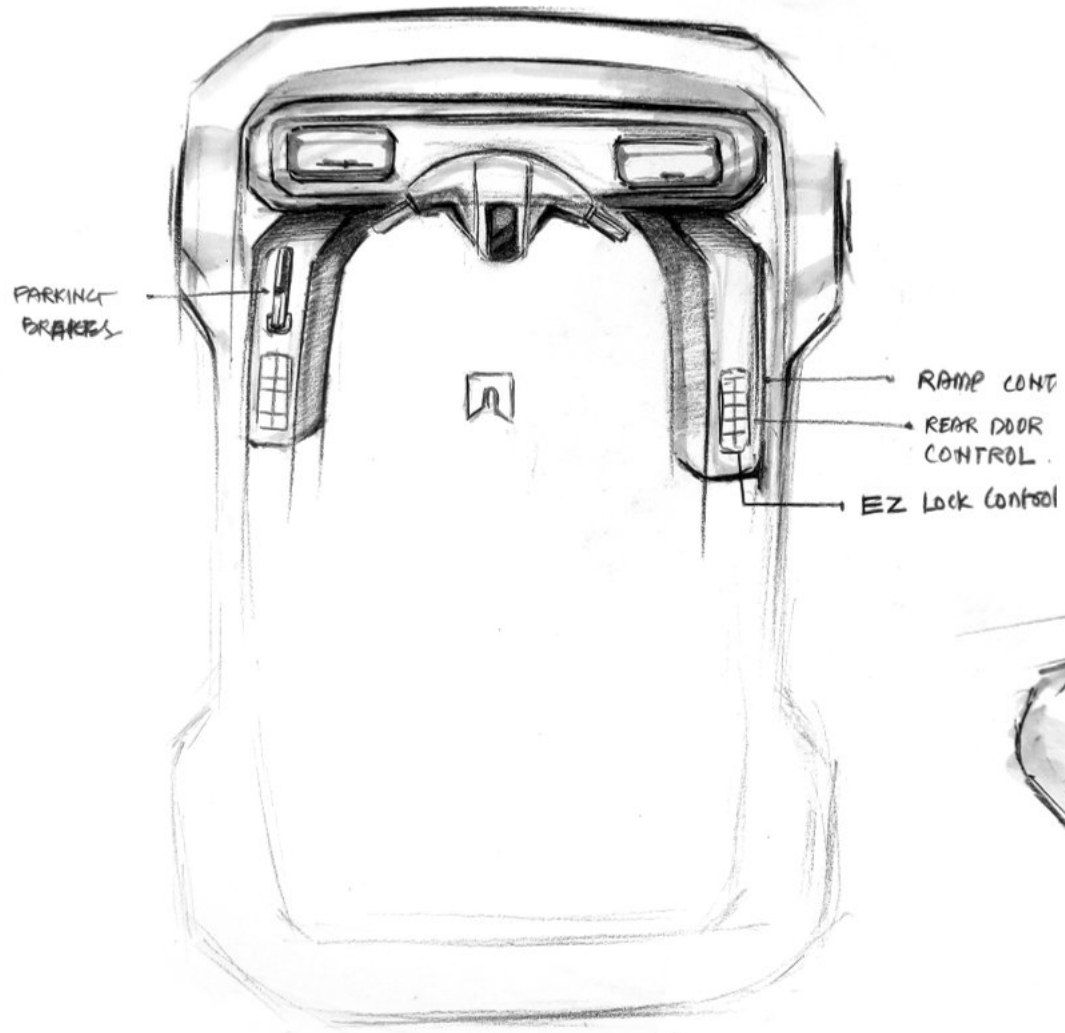


Fig 57: Dashboard for Handicap

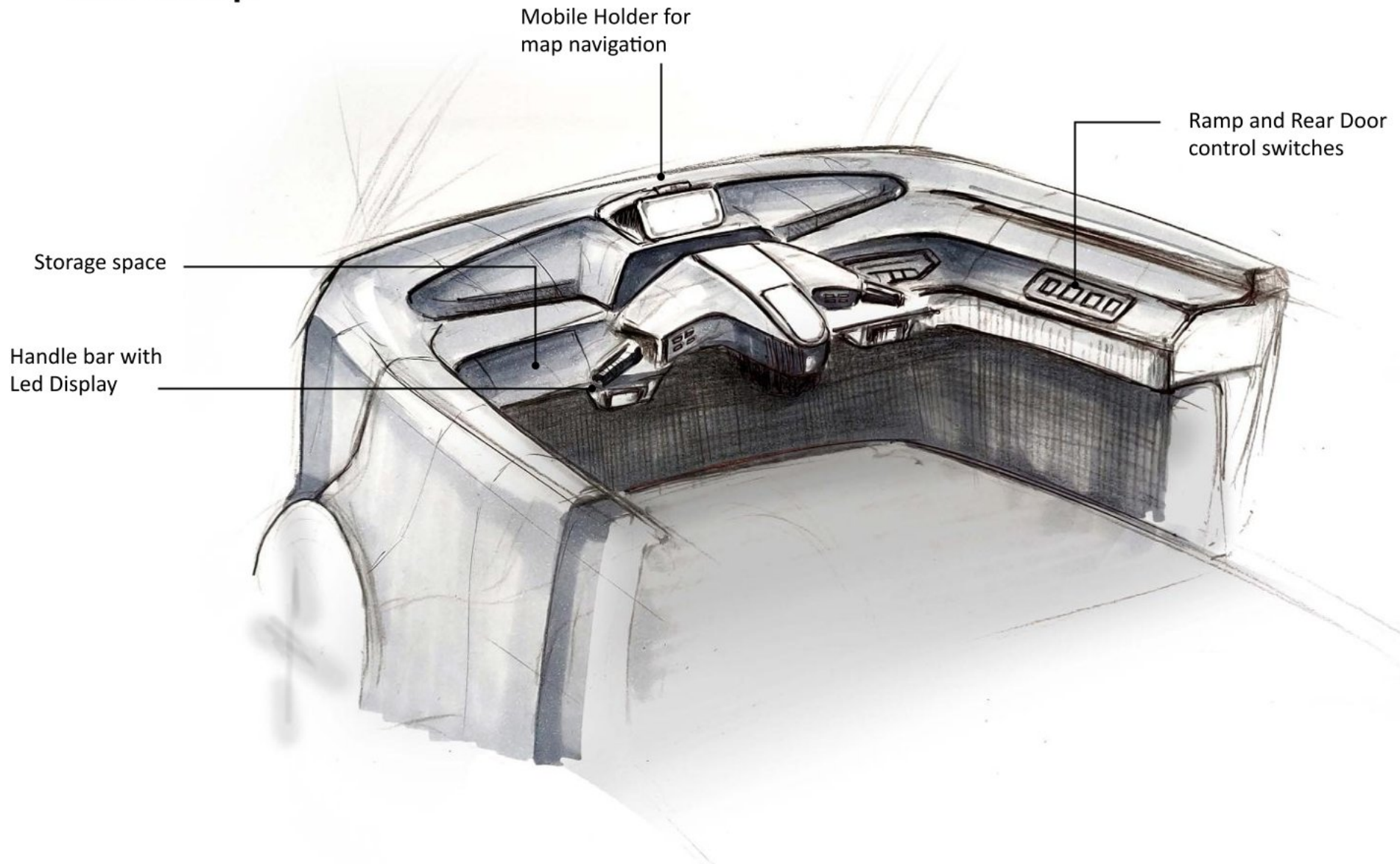
Design Ideation

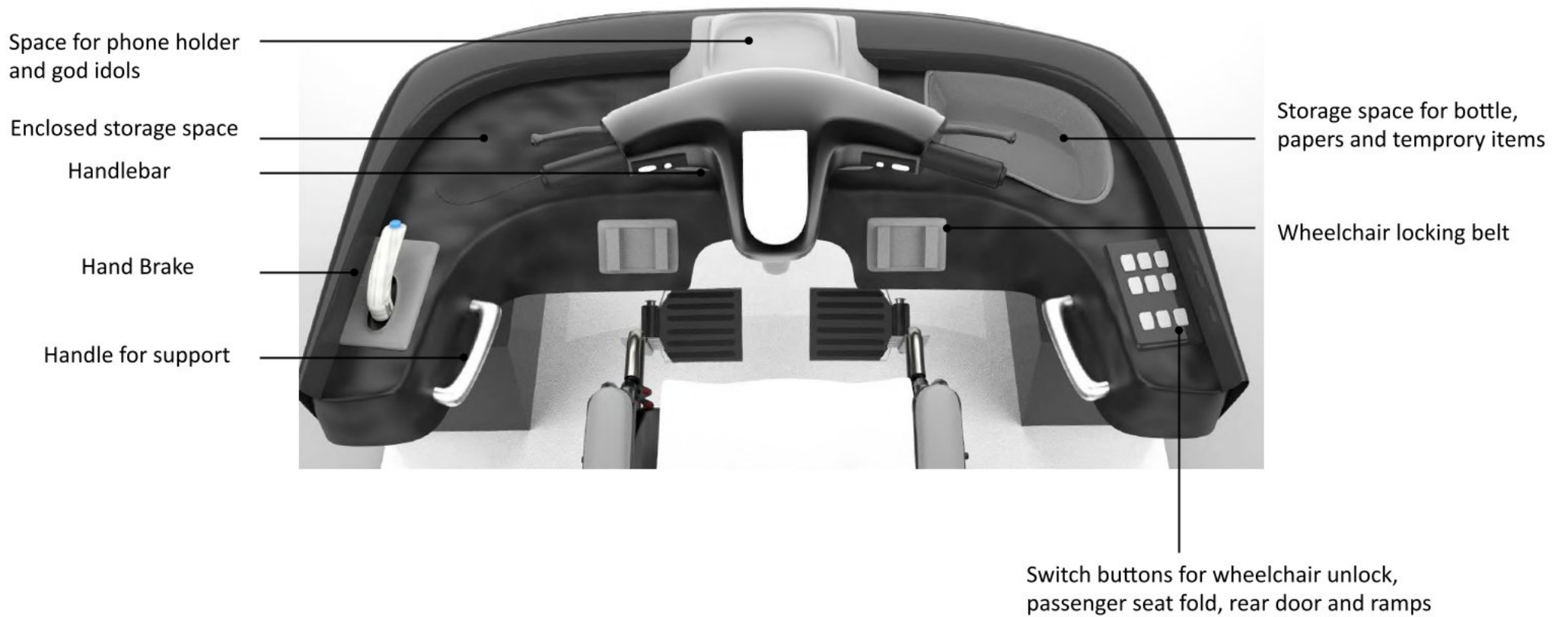


Concept



Final Concept





11. Exterior Design

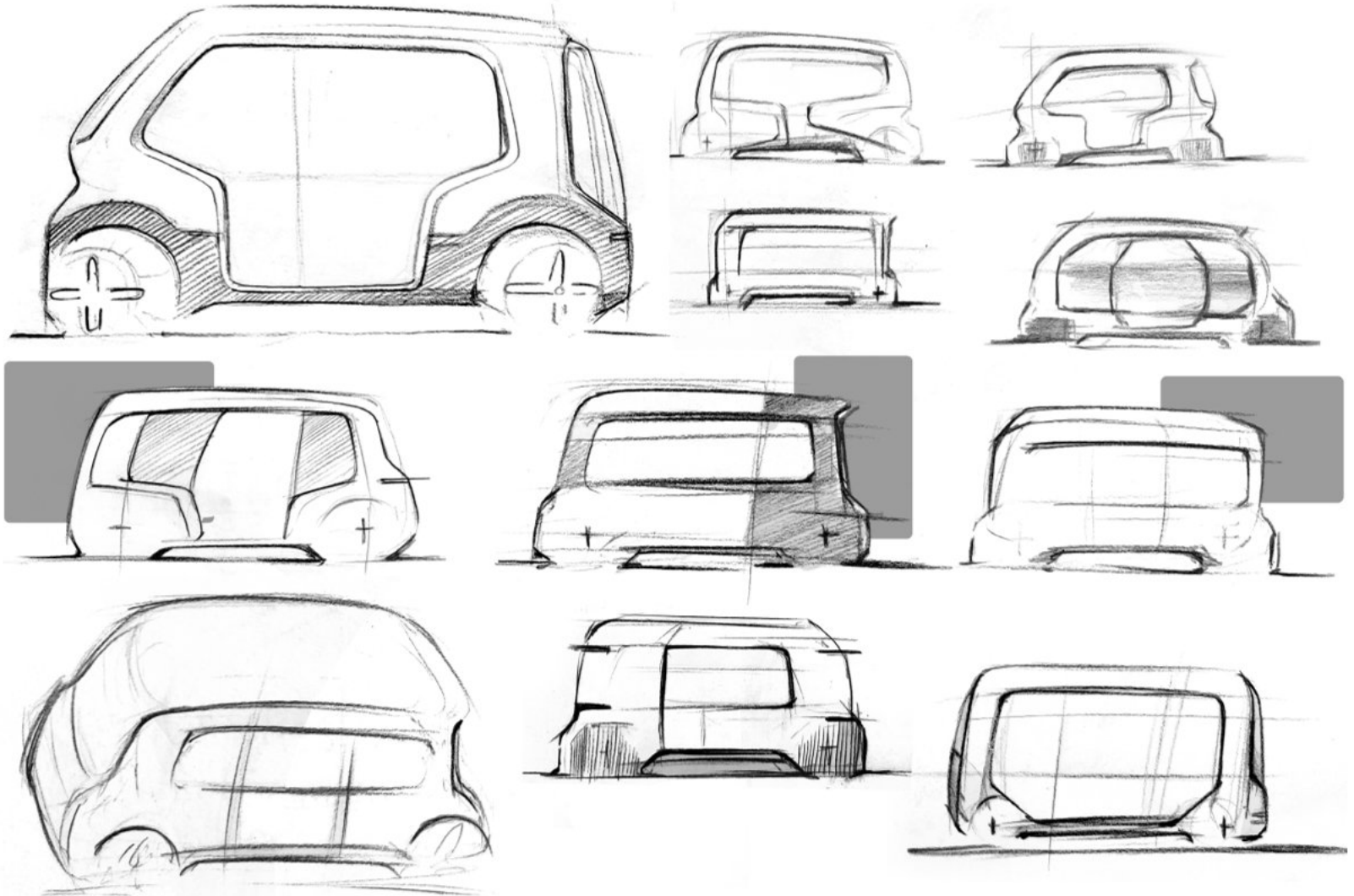
11.1. Moodboard

The moodboard is according to the passengers as they mainly focus on the aesthetics of the cab. The exterior should look like electric car and it should be more **Comfortable and Confident**.

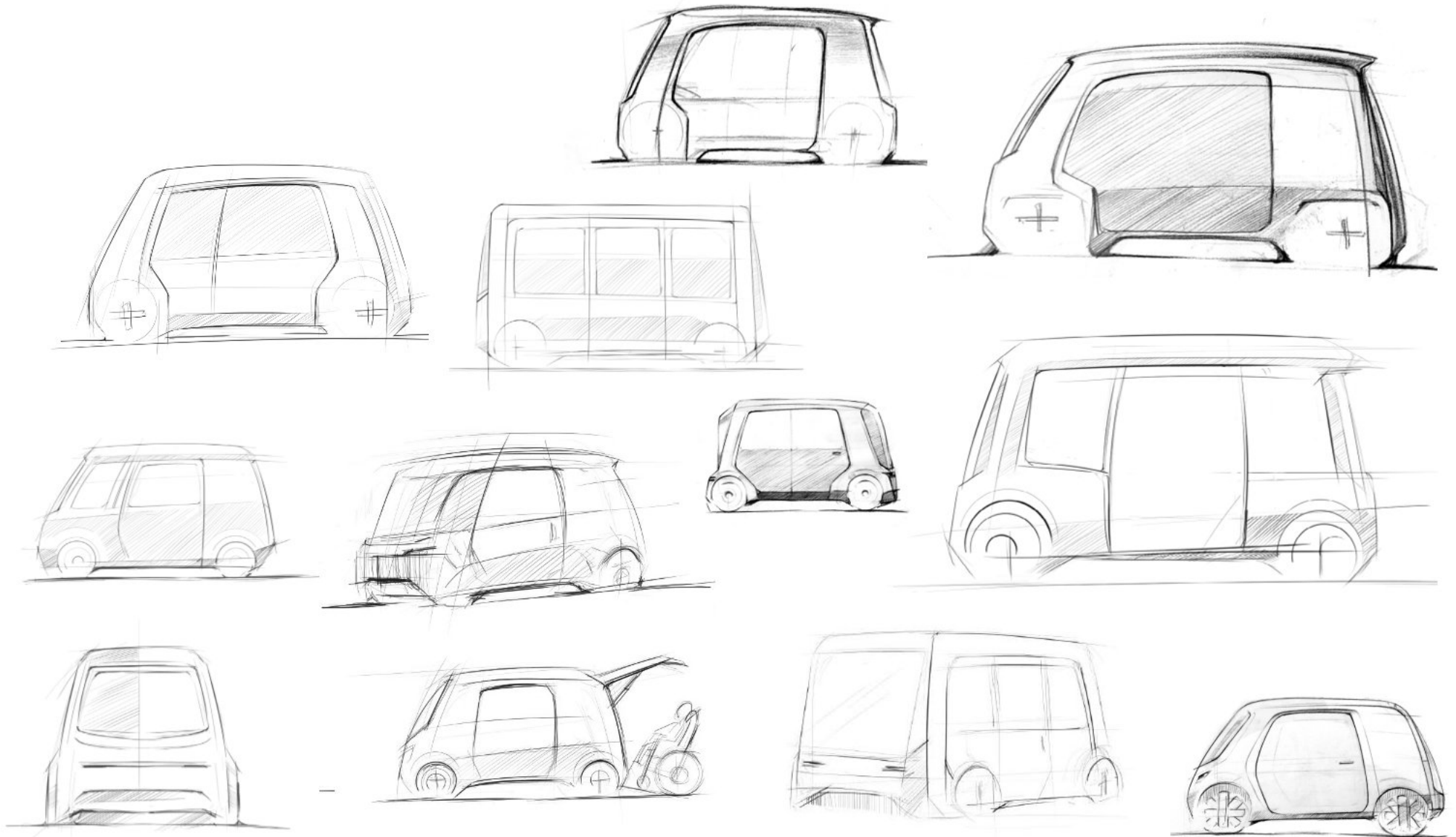


11.2. Exterior Ideation

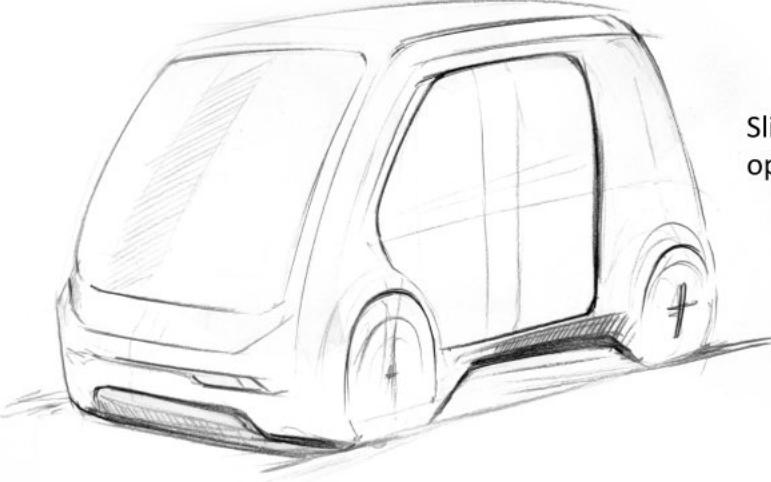
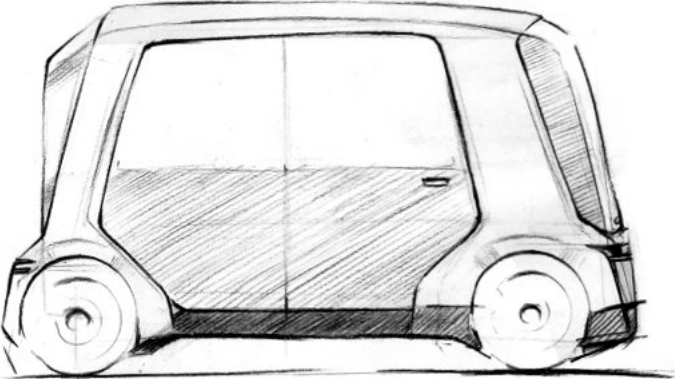
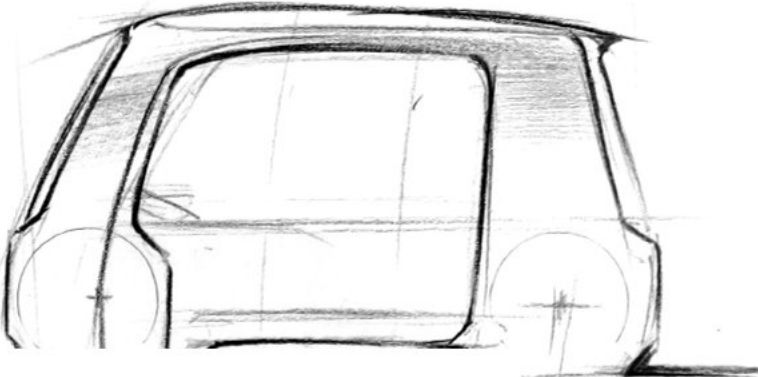
The next stage is the ideation exploration. The exterior design of the vehicle should be attractive, modern and pleasing for the passengers. It should be designed according to the passengers perspective.



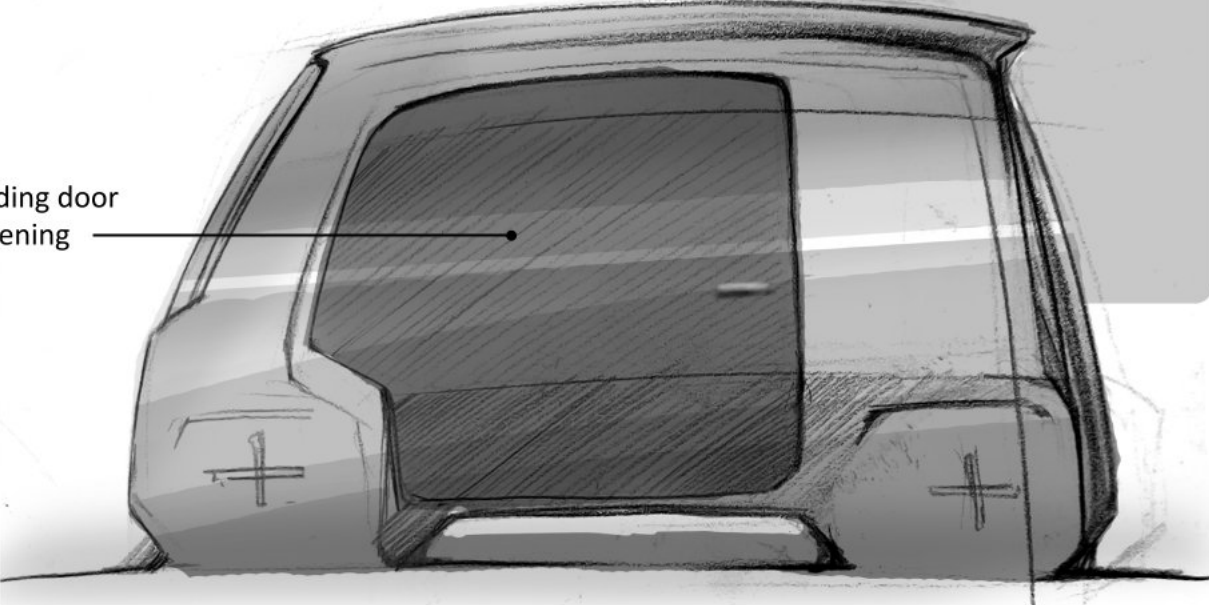
Ideation sketches



11.3. Concept 1

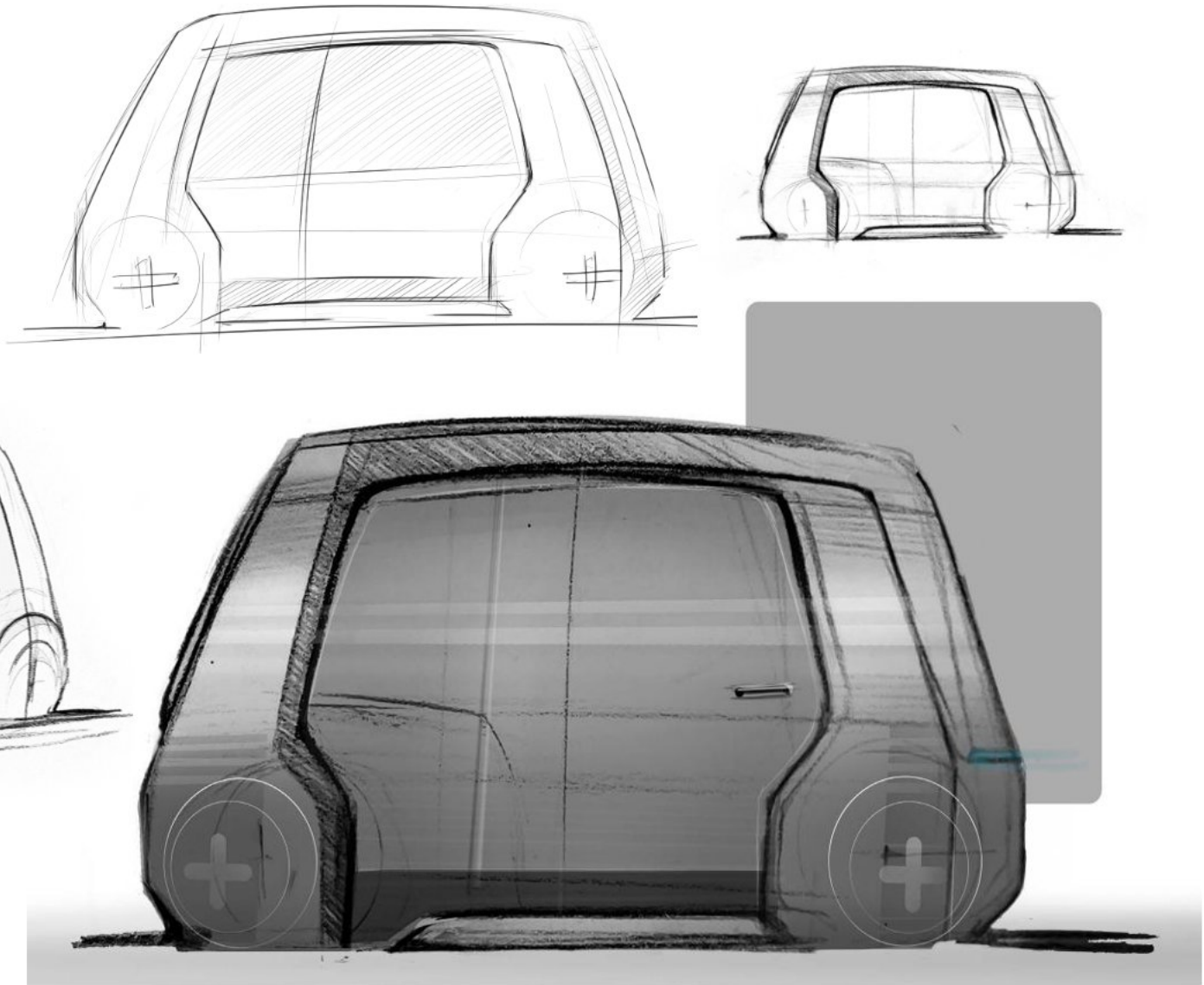


Sliding door opening



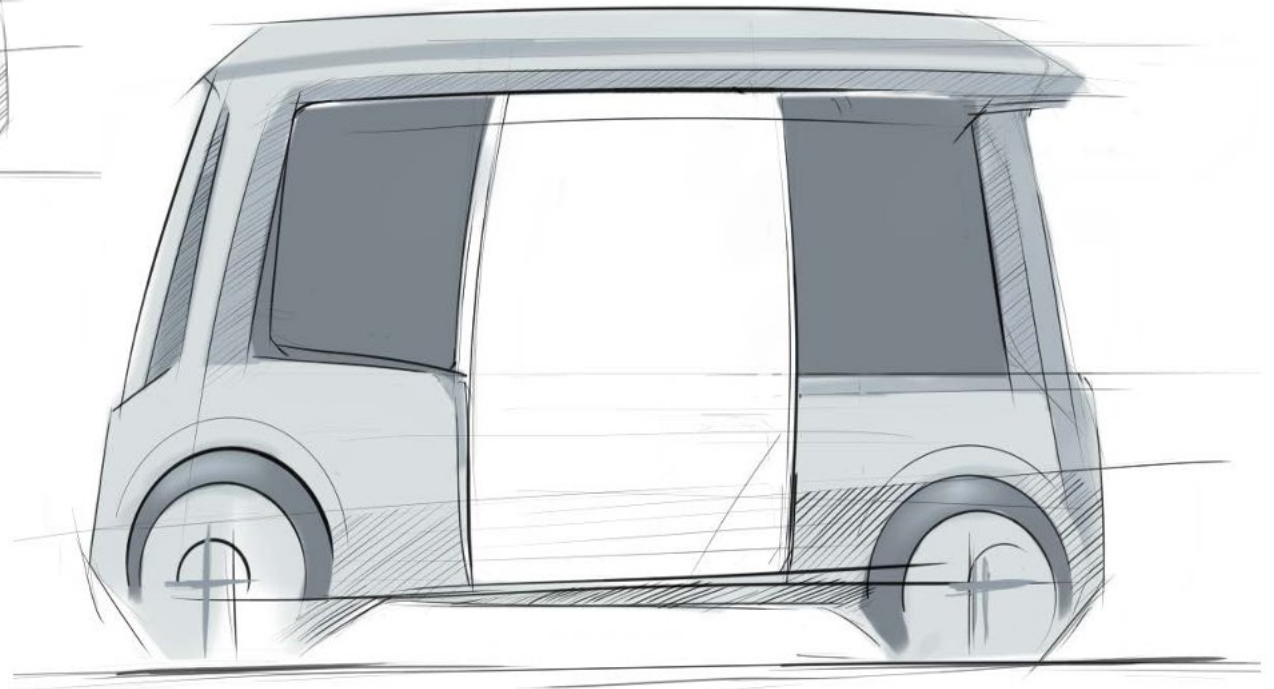
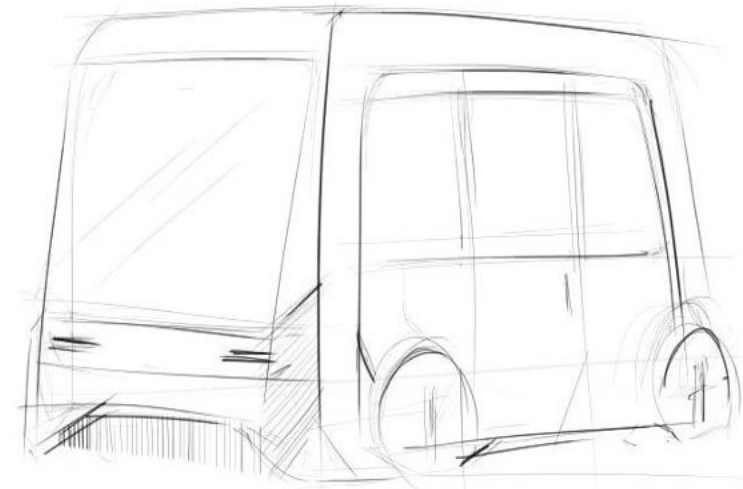
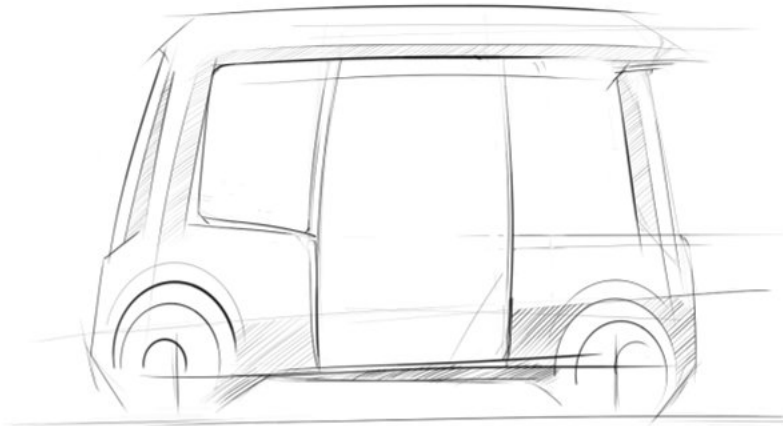
11.4. Concept 2

The design language is minimalistic and Sophisticated.



11.5. Concept 3

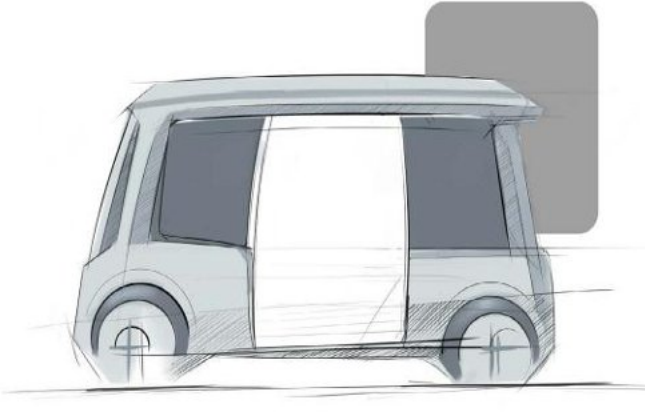
The concept design is more toward the usability of the vehicle. It is more functional rather than looking attractive. Hop-in Hop-off Passenger seats.



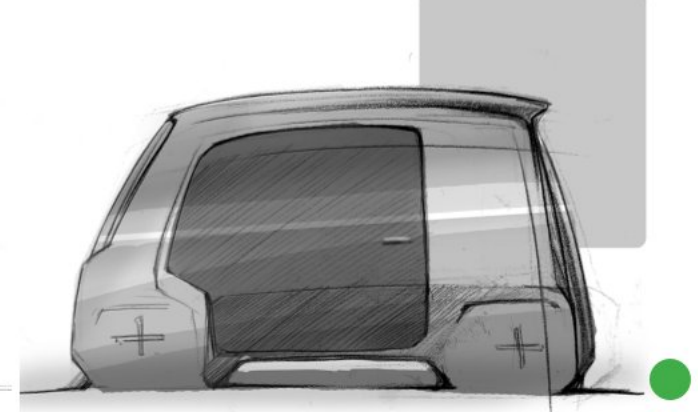
12. Concept Evaluation



- The design is more futuristic and sophisticated.
- It looks like an autonomous car doesn't look like a drive from wheelchair vehicle.



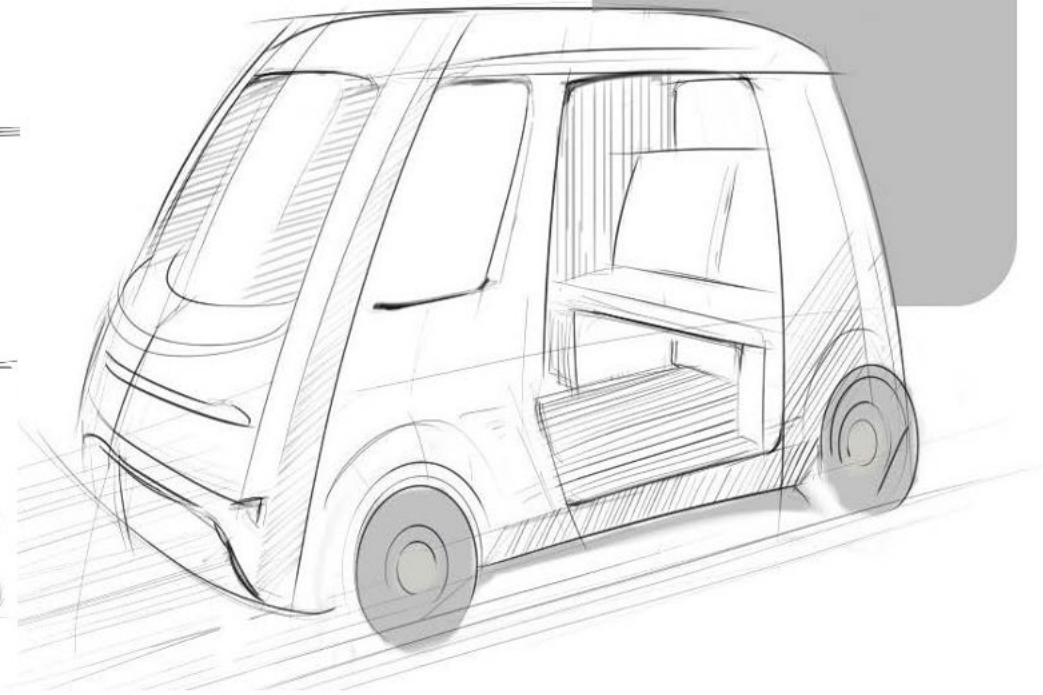
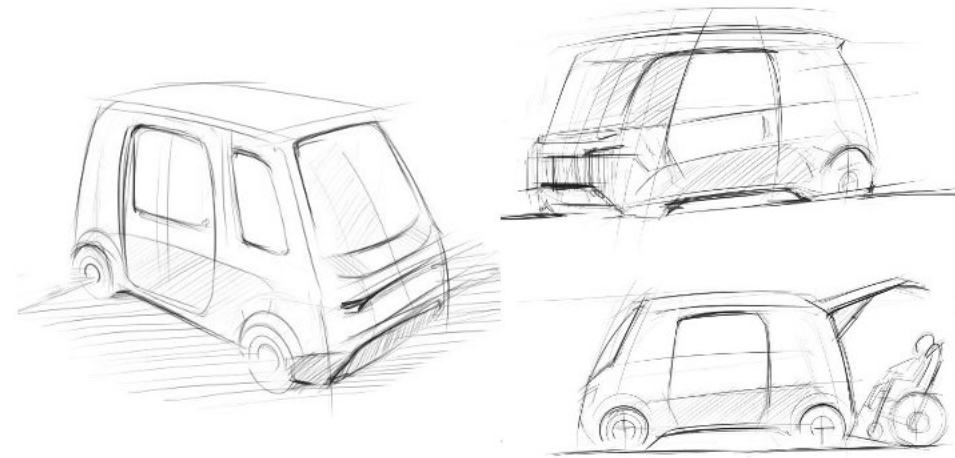
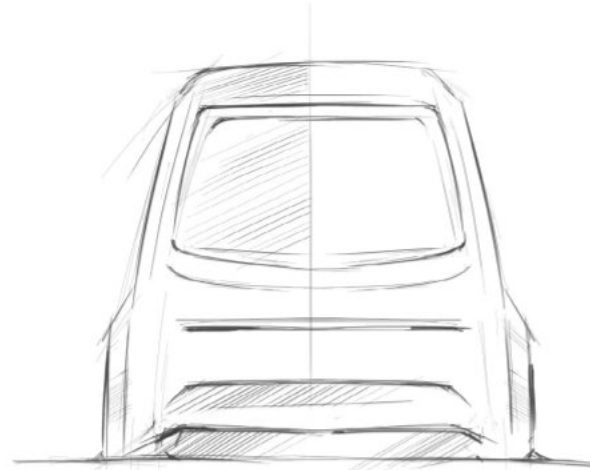
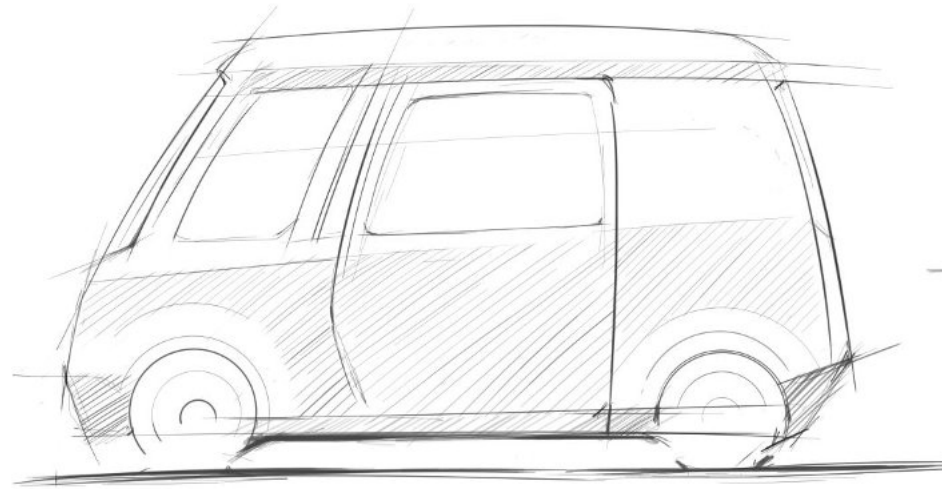
- The concept design is more toward the usability of the vehicle. It is more functional rather than looking attractive. Hop-in Hop-off Passenger seats.
- Look like a Golf cart.
- Functional design.



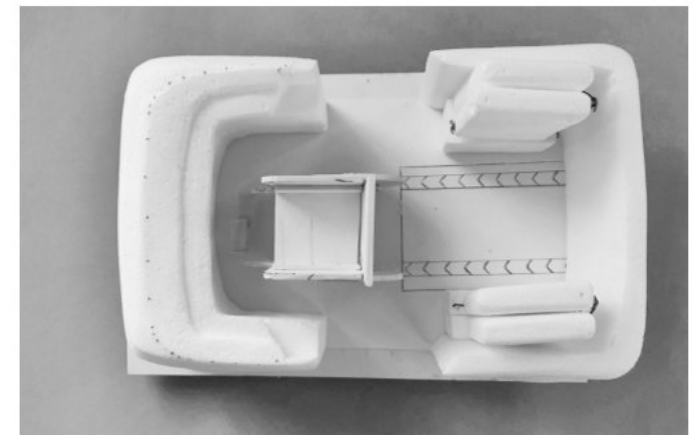
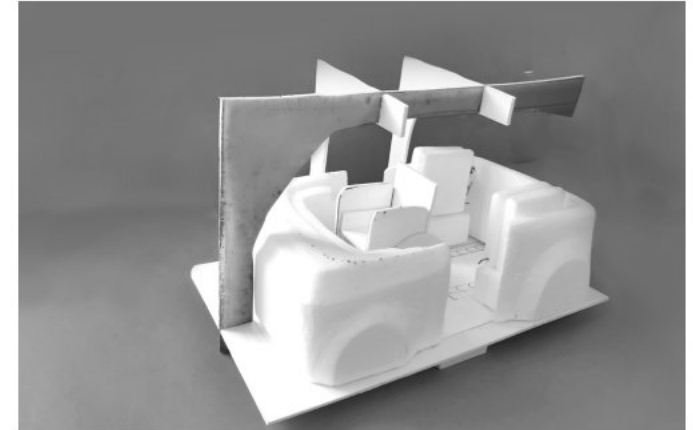
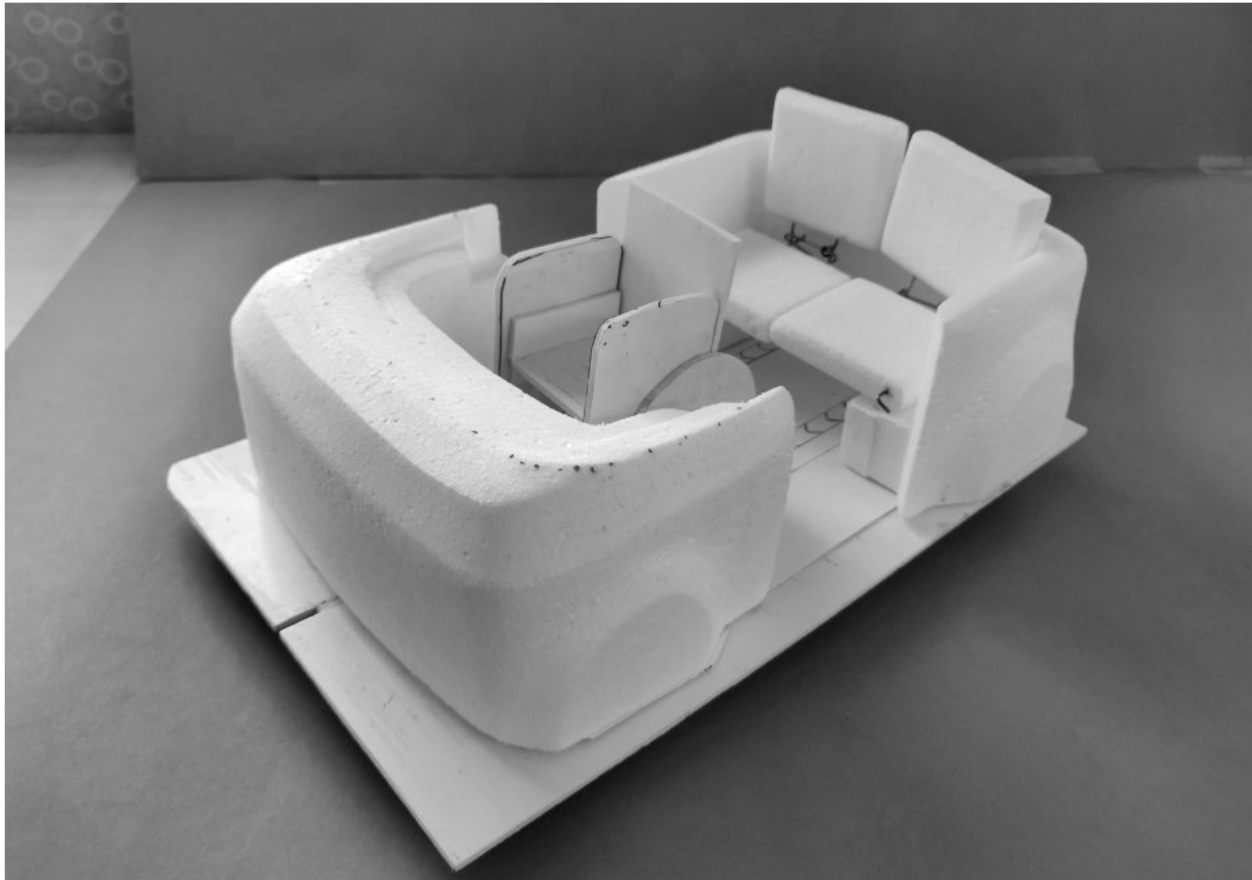
- Simple and attractive design language.
- It doesn't look like a drive from wheelchair vehicle.
- The identity of the user should reflect on the vehicle.

13. Final concept

The design language of a car which is driven by wheelchair users should reflect the identity of the users. The design should be minimalistic and expressive.

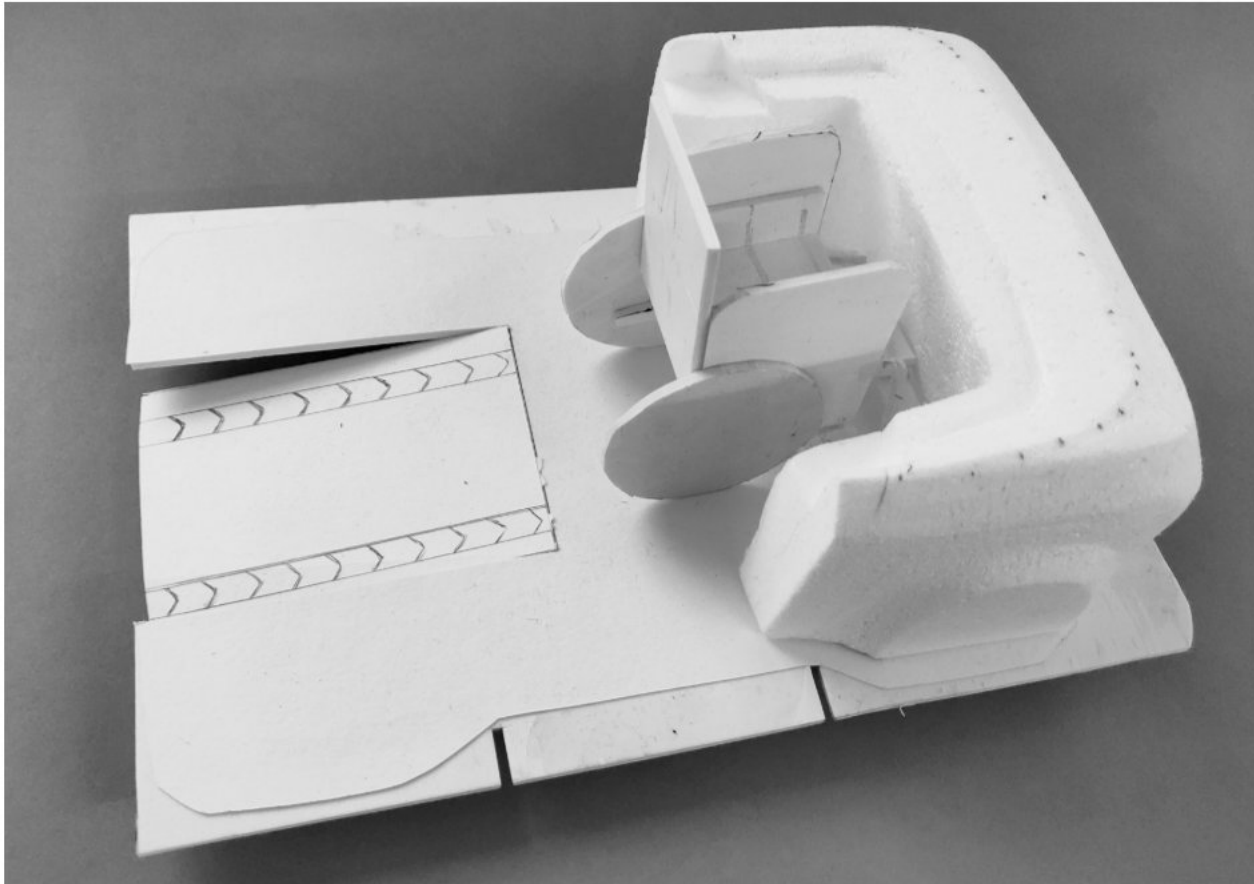


14. Mockup Model



To understand the proportion and scale of the vehicle mockup model are made.
Understanding of the volume and spaces inside the vehicle.

Mockup Model



Ramp Space included in the structure of the vehicle

15. Renders



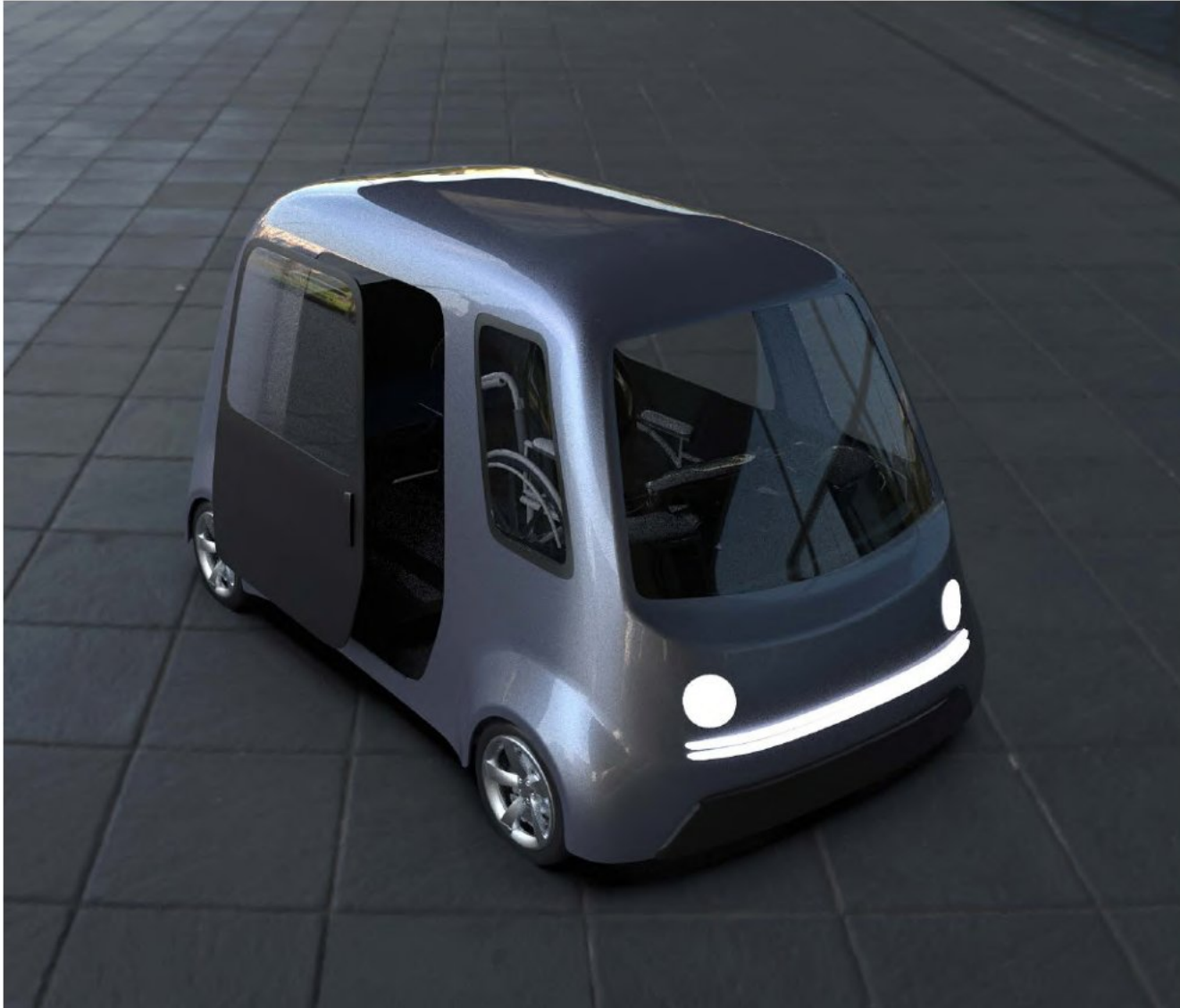
Renders



Final Renders



Final Renders



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