

Design project-2

Motorised Vehicle for Paraplegic

Submitted by:

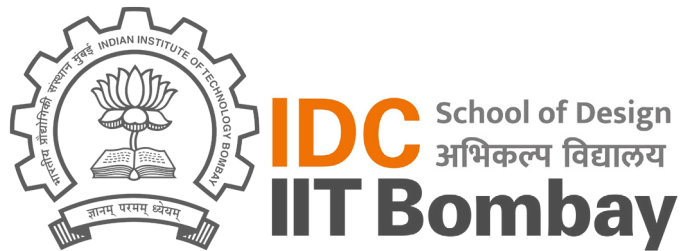
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DECLARATION

I declare that this written report represents my own idea in my own words, and where others, ideas or words have been included, I have mentioned the original source. I also declare that I have adhered to all principles of academic honesty and integrity and have not falsified, misinterpreted or fabricated any idea, data, facts or source in my submission. I understood that any violation of the above will be cause for disciplinary action by the institute and can also penal action from the source from which proper permission has not been taken, or Improperly cited.



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Master of Design

Mobility and Vehicle Design

IDC School of Design

Indian Institute of Technology, Bombay

Date: 20/12/2018

APPROVAL SHEET

This Mobility and Vehicle Design project titled 'Motorised Vehicle for Paraplegic, by Roshan Kumar Sahu is approved in partial fulfilment of the requirements for Master of Design degree in Mobility and Vehicle Design at IDC, IIT Bombay.

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Date: 20/12/2018

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I thank my family and friends for their support and guidance.

A handwritten signature in black ink, appearing to read 'Roshan', with a long horizontal stroke extending to the right.

Roshan Kumar Sahu

Date: 20/12/2018

ABSTRACT

The abrupt onset of spinal cord injury (SCI) is tragic and has a profound impact on the individuals and their families. In the Indian setup, as in most developing countries, very little is known about the exact incidence of SCI as there is no national database. In India, approximately 1.5 million people live with SCI ^[1]. Approximate 20,000 new cases of SCI are added every year and 60-70% of them are illiterate ^[8], poor villagers. Majority of them are males in the age group of 16-30 years ^[8], signifying higher incidence in young, active and productive population of the society. People suffering from SCI manages to do everyday work without fail. But unfortunately they face lots of problem and one of them is daily commute to their work place. Motorized vehicle is life line, it not only saves time but also provides convenience and freedom to move anywhere. In current scenario of India paraplegic person drives vehicles which are not designed specifically for them. Current design does not fulfill all their needs and sometimes it creates problems. But with the design enhancement their problem can be solved. The project would require a case study into the present vehicles for paraplegic person. Find out all the short-comes of available design and re-think a complete new design. The new design will allow the driver a confidence and hassle free ride. Also it will fulfil all basic requirements like carrying crutches, wheel chair, luggages, etc can be covered in the device. All this can complied to the final product which would be the design of motorized vehicle for Paraplegic, along with a scale model.

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01 INTRODUCTION

The abrupt onset of spinal cord injury (SCI) is tragic and has a profound impact on individuals and their families. In India, approximately 1.5 million people live with SCI. Approximately 20,000 new cases of SCI are added every year and 60-70% of them are working professional. Those working professional manages to do everyday work without fail, but unfortunately they face lots of problems and one of them is reliable mode of commute to their workplace. In Indian context available options for them to commute to the workplace are less, one of them which is widely used is motorized vehicle with side wheels. Motorized vehicle has become a lifeline for them which saves time and provide freedom to commute anywhere, but it comes with drawbacks like difficult ingress and egress, stability, weather protection and many more. The project prime focus was to identify crucial problems faced with current vehicle and explore ideas to solve them and incorporate as a personal mode of transport.

Research phase began with a systematic study of their daily routine from home to workplace and vice versa. Systematic study included videography of ingress and egress along with personal interview, motivation of the exercise was to identify problems and need that will be solved and incorporated in the new design. Based on the valuable insights gathered from user study the brief was constructed along with technical details and package.

01 INTRODUCTION

1.1 Scope of project

As movement disabled population whose only mode of transport is motor vehicle with side wheels and motorised vehicle has become life line for them to support their movement on road movement need. The scope of the project is design of Motorised Vehicle for Paraplegic which will be Reliable and more Practical than existing one. Ingress and egress as well as reverse mode are few major issues in available mode of transport will be solved effectively. Seat must be designed ergonomically and safeguard such that it provides them safe and comfortable ride. The new design will impart a new mode to the user by solving all the current problems.

1.2 Defining indian context

India is one of the most diverse country in the world. Before buying any product people usually think of purchasing cost and also think parallel of maintenance cost of product. Even the become ready to compromise with comfort and many other issues related to ergonomics. So the product should be designed in very ready to compromise with-cost with all the ergonomic consideration.

Affordability: We must think of correlation between disability and poverty.

Usability: We must think of the usability aspect where design is for paraplegic population.

01

1.3 Current scenario

**Disabled Population by Sex and Residence
India, 2011**

Residence	Persons	Males	Females
Total	26,810,557	14,986,202	11,824,355
Rural	18,631,921	10,408,168	8,223,753
Urban	8,178,636	4,578,034	3,600,602

Figure 1 Disabled population by Sex and residence India, 2011
<http://enabled.in/wp/disabled-population-in-india-as-per-census-2011-2016-updated/>

**Disabled Population by Type of Disability
India : 2011**

Type of Disability	Persons	Males	Females
Total	26,810,557	14,986,202	11,824,35
In Seeing	5,032,463	2,638,516	2,393,94
In Hearing	5,071,007	2,677,544	2,393,46
In Speech	1,998,535	1,122,896	875,63
In Movement	5,436,604	3,370,374	2,066,23
Mental Retardation	1,505,624	870,708	634,91
Mental Illness	722,826	415,732	307,09
Any Other	4,927,011	2,727,828	2,199,18
Multiple Disability	2,116,487	1,162,604	953,88

Figure 1 Disabled population by Type of Disability India, 2011

In the Indian setup, as in most developing countries, very little is known about the exact incidence of SCI as there is no national database. In India, approximately 1.5 million people live with SCI. Approximate 20,000 new cases^[9] of SCI are added very year and 60-70%^[8] of them are illiterate, poor villagers. Majority of them are males in the age group of 16-30 years, signifying higher incidence in young, active and productive population of the society. There has been substantial decrease in male female.

01

1.3 Current scenario

Over all disabled population is 2.1% of Total population ^[8] of India out of which 49% are literate ^[8] and only 34% are employed ^[8]. Research shows that lack of mode of transportation and infrastructure are two major cause of this scenario where only 34% are employed ^[8]. The population who are employed are those population who can afford personal mode of transportation.

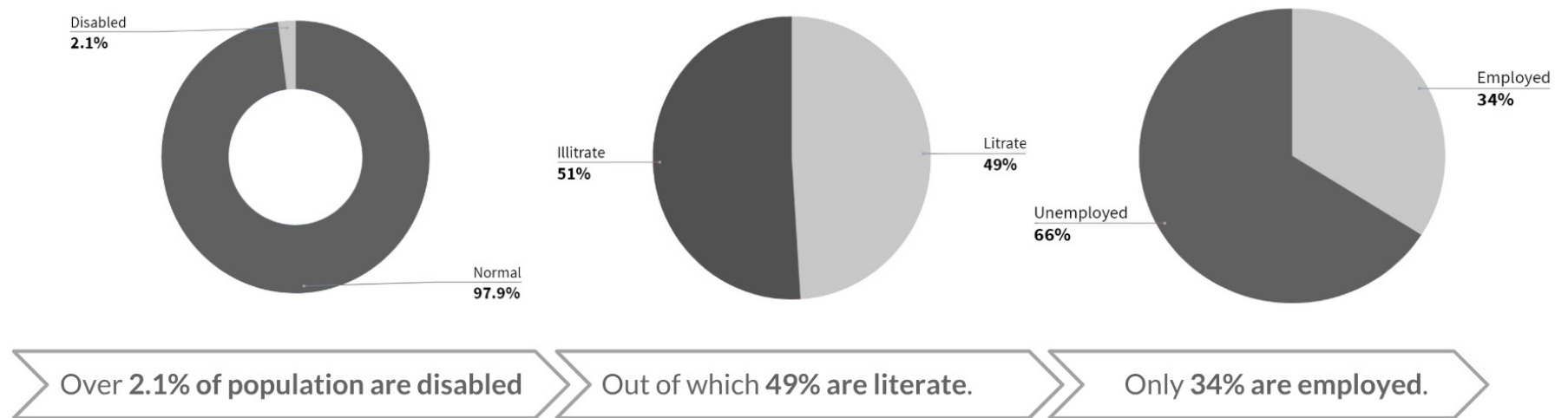


Figure 2 Pie chart for population ratio, illiteracy ratio and employment ratio

*According to census of india

01

1.4 GOVERNMENT INITIATIVES

After Digital India, Clean India, and Skill India, the government is all set to launch the Accessible India Campaign which will focus on making India a disabled-friendly country.

A joint venture by the Department of Empowerment of Persons with Disabilities and Ministry of Social Justice and Empowerment, Accessible India Campaign will be first launched in seven cities including Delhi, Tamil Nadu, Gujarat, Assam, Rajasthan, Maharashtra and Haryana. The programme will focus on grievances of people with disabilities and the problems they face in mobility.

Part A: Built Environment Accessibility

Objective 1 :Enhancing the proportion of accessible government building. Conducting accessibility audit of at least 50 most important government buildings and converting them into fully accessible buildings by July 2016 in the following cities. Converting 50% of all the government buildings of National Capital and all the State capitals into fully accessible buildings (July 2018). Conducting audit of 50% of government buildings and converting them into fully accessible buildings in 10 most important cities / towns of all the States (other than those, which are already covered in Target 1.1 and 1.2 above) (July 2019).



Figure 3 Built Environment Accessibility

01

1.4 GOVERNMENT INITIATIVES

Part B : Transportation System Accessibility

Objective 2 : Enhancing proportion of accessible airports
Conducting accessibility audit of all the international airports and converting them into fully accessible international airports (July 2016). Conducting accessibility audit of all the domestic airports and converting them into fully accessible airports(March 2018) .Enhancing the proportion of accessible railway stations. Ensuring that A1,A & B categories of railway stations in the country are converted into fully accessible railway stations (July 2016). Ensuring that 50% of railway stations in the country are converted into fully accessible railway stations (March 2018). Enhancing the proportion of accessible Public Transport. Ensuring that 25% of Government owned public transport carriers in the country are converted into fully accessible carriers (March 2018).



Figure 4 Transportation System Accessibility

01

1.4 GOVERNMENT INITIATIVES

Part C: Information and Communication Eco-System Accessibility

Objective 5: Enhancing proportion of accessible and usable public documents and websites that meet internationally recognized accessibility standards. Conducting accessibility audit of 50% of all government (both Central and State Governments) websites and converting them into fully accessible websites (March 2017). Ensuring that at least 50% of all public documents issued by the Central Government and the State Governments meet accessibility standards (March 2018). Enhancing the pool of sign language interpreters. Training and developing 200 additional sign language interpreters (March 2018).



Figure 5 Information and communication ecosystem accessibility

Objective 7: Enhancing the proportion of daily captioning and sign-language interpretation of public television news programmes. Developing and adoption of national standards on captioning and signlanguage interpretation in consultation with National media authorities. (July 2016). Ensuring that 25% of all public television programmes aired by government channels meet these standards. (March 2018).

End result of all these initiative is very poor, the infrastructure promised was not delivered and hence forcing the disabled population to be self reliable for there mobility related issues. Available infrastructure doesn't allow them to use public transport, the only option left is to own a personal vehicle.

02 PRELIMINARY RESEARCH

2.1 TYPES OF VEHICLE

Primary survey was conducted with the users and over internet, to find out the vehicle options available for disabled population, how much it costs and most common. As a summary, it was found that side wheels and side cars are preferred options by the major population because it is economic, self balancing and only options available within reach.

The available types of Mobility in Indian context are:

1. Automatic scooter with side-wheels
2. Automatic scooter with side-car
3. Car modified with all hand controls



Figure 6 Scooty with side wheels



Figure 7 Scooty with sidecar



Figure 8 Car modified with all handle control

02

2.1 PRIMARY SURVEY



Figure 9 Scooty with side wheels

1. Automatic scooter with side-wheels

It costs around 40,000 INR additional to vehicle cost. It can be attached to any two wheelers but mostly installed in automatic scooter. It most preferred modifications because no good options available at reach. There is no reverse mode available as non geared vehicles are not designed for reverse mode operation. This modification is approved by RTO, it is legal to drive wheels with such modification.



Figure 10 Scooty with side cars

2. Automatic scooter with side-car

A sidecar is a one-wheeled device attached to the side of a motorcycle, scooter, or bicycle, producing a three-wheeled vehicle. It costs around 45,000 INR additional to vehicle cost. It is preferred in second place after Side wheels. In this modification no reverse mode available as non geared vehicles are not designed for reverse mode. Usage of two wheeler with side car is banned in India and RTO does give permission to ride such vehicle on Indian road. Users like to ride side car attached vehicle as wider distance between two wheels makes it more stable.

02

2.1 PRIMARY SURVEY



Figure 11 Car modified with all handle control

3. Car modified with all hand controls

An automobile adapted for ease of use by people with disabilities. Today automobiles, whether a car, truck, or a van, can be adapted for a range of physical disabilities. For example: Foot pedals can be raised, or replaced with hand-controlled devices. Automotive adaptive hand controls also make it possible to adjust acceleration as well braking.

There are two main types of automotive adaptive controls, those that provide an external source of power to actuate existing vehicle controls and those that modify OEM components to alter the operation of vehicle control systems. Generally, these are referred to as servo-type motion control systems and reduced effort or zero effort control systems, respectively.

Adaptive vehicle control products are commonly prescribed by rehabilitation centers and installed by mobility equipment dealers and installers who specialize in vehicle modifications for persons with disabilities, seniors, and persons who have a need for greater mobility. It cost around 1,00,000 INR for such modification on any car. Such modification is approved by RTO, they give authorisation to ride it on roads.

Additional expensive modification available:

- Ramp for friendly access.
- Hydraulic access unit.

02

2.2.1 CEREBRAL PALSY:

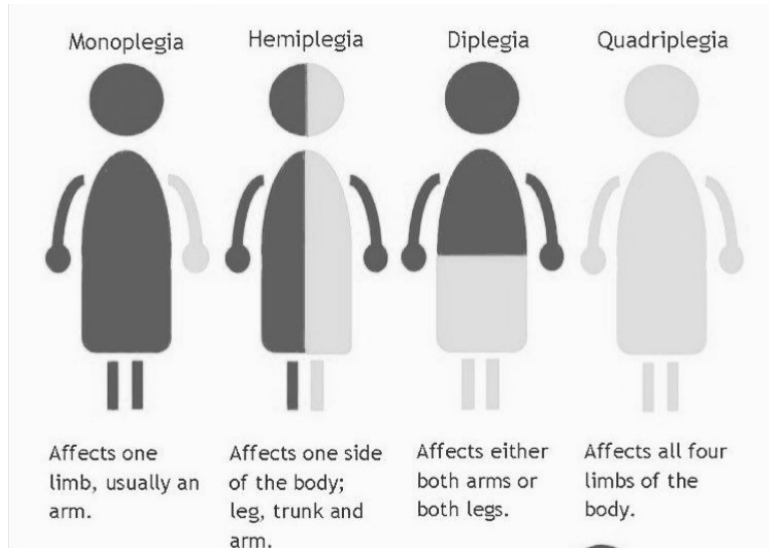


Figure 12 Cerebral palsy

Cerebral palsy (CP) is a group of permanent movement disorders that appear in early childhood. Signs and symptoms vary among people. Often, symptoms include poor coordination, stiff muscles, weak muscle, and tremors. There may be problems with sensation, vision, hearing, swallowing other muscles, and tremors. There may be problems with sensation, vision, hearing, swallowing and speaking. Often babies with cerebral palsy do not roll over, sit, crawl, or walk as early as other and speaking, Often babies with cerebral palsy do not roll over, sit, crawl or walk as early as other children of their ages. Difficulty with ability to think or reason and seizures each in about one third of people with CP. While the symptoms may get more noticeable over thermal development the underlying prob of the brain that control movement, balance, and posture. the underlying problems do not worsen over time. Cerebral palsy is caused by abnormal development problems occur during pregnancy; however, they may also occur during childbirth, or shortly after birth. Often the cause is unknown.

02

2.2.2 MUSCULAR DYSTROPHY :

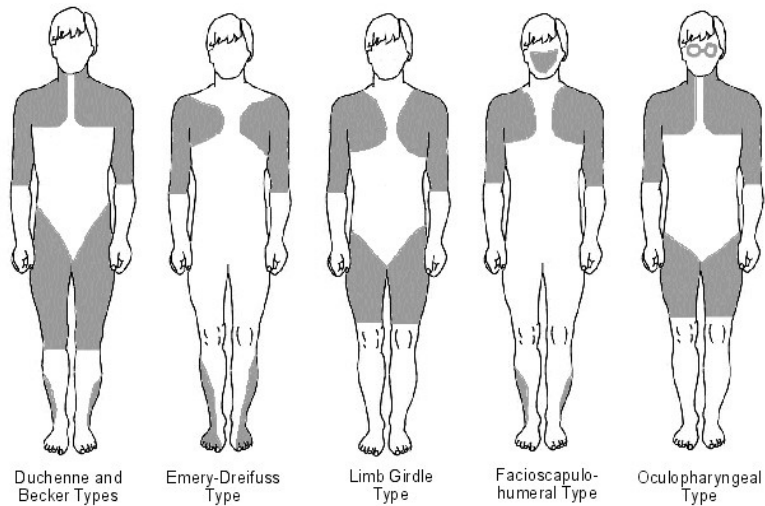


Figure 13 Main areas of muscular weakness in different types of dystrophy

Muscular dystrophy (MD) is a group of muscle diseases that results in increasing weakening and breakdown of skeletal muscles over time. The disorders differ in which muscles are primarily affected, the degree of weakness, how fast they worsen, and when symptoms begin. Many people eventually the degree of weakness, how fast they associated with problems in other organs. There are nine main categories of muscular dystrophy that contain more than thirty specific types. The most common main categories of muscular dystrophy (DMD) which typically affects males beginning around the age of and myotonic dystrophy. They are due to mutations in genes that are involved the mutation patterns This can occur due to either inheriting the defect from one's parent, or autosomal dominant. Diagnosis often involves blood tests and genetic testing occurring during early development. Disorders may be X-linked recessive, autosomal recessive, muscular dystrophy, Physical therapy, braces, and corrective surgery may help with some symptoms. Assisted ventilation may be required in those with weakness of breathing muscles. Medications used include steroids to slow muscle degeneration, anti-epileptic drugs to control seizures and some muscle activity, and immunosuppressants to delay damage to dying muscle cells. Outcomes depend on the specific type of disorder.

02

2.2.3 PARAPLEGIA:

Paraplegia is an impairment in motor or sensory function of the lower Extremities. The word comes from iconic Greek: “half-striking”. It is usually caused by spinal cord injury or a congenital condition such as spinal bifida that affects the neural elements of the spinal canal of the spinal canal that is affected in paraplegia is either the thoracic, lumbar, or sacral regions. Common victims of this impairment are veterans or members of the armed forces. If four limbs are affected by paralysis, tetraplegia or quadriplegia is the correct term. If only one limb is affected, the correct term is monoplegia. Spastic paraplegia is a form of paraplegia defined by spasticity of the affected muscles, rather than flaccid paralysis.

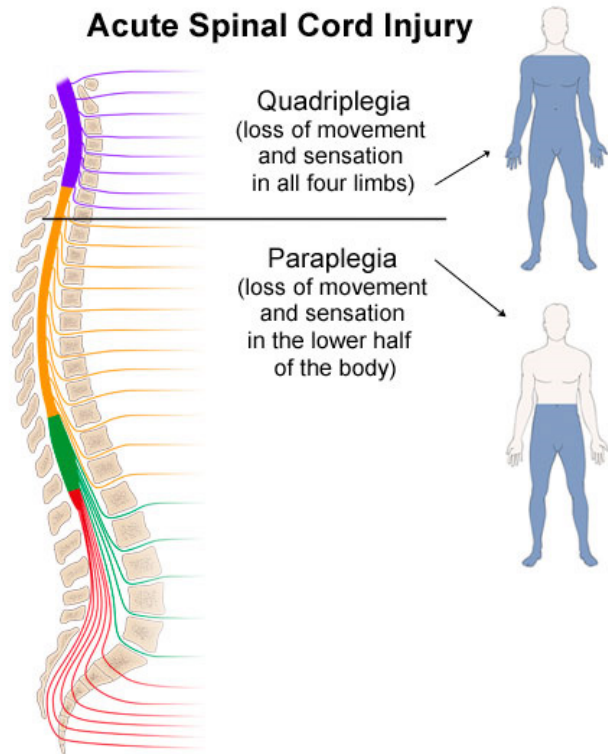


Figure 14 Spinal cord Injury

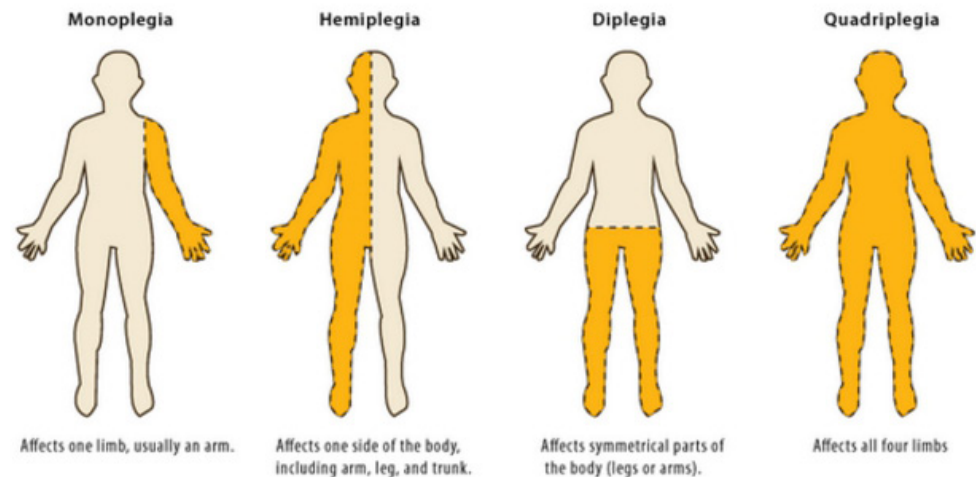


Figure 15 Impairment due to Spinal cord Injury

02

2.2.4 POLIOMYELITIS:

Poliomyelitis, often called polio or infantile paralysis, is an infectious disease caused by the poliovirus. In about 0.5% of cases there is muscle weakness resulting in an inability to move. This can occur over a few hours to few days. The weakness most often involves the legs but may less commonly involve the muscles of the head, neck and diaphragm. Many but not all people fully recover in those with muscle weakness about 2% to 5% of children and 15% to 5% have headache, neck stiffness and pains. Minor symptoms such as fever and a sore throat and up to 5% have headache, neck stiffness and pains in the arms and legs. These people are usually back to normal within one or two weeks. In up to 70% of infection there are no symptoms. Years after recovery post-polio syndrome may occur, with a slow in the arms and legs. These people are usually back to normal within one or two weeks. In up to 70% of infections there are no symptoms similar to that which the person had during the initial infection. Infections there are no symptoms. Years after recovery post-polio syndrome may occur, with a slow development of muscle weakness similar to that which the person had during the initial infection. Poliovirus is usually spread from person to person through infected fecal matter entering the mouth. It containing human feces and less commonly from infected saliva. Those who are infected may spread the disease for up to six weeks even if no symptoms are present. The disease may be diagnosed by finding the virus in the feces or detecting antibodies against it in the blood. The disease only occurs naturally in humans.

02

2.2.5 AMPUTATION:

Amputation is the removal of a limb by trauma, medical illness, or surgery. As a surgical measure, it is used to control pain on individuals as a preventative surgery for such problems. A special case is that of congenital antries, amputation of the hands, feet or other body parts is or was used as a form of punishment for people who committed crimes. Amputation has also been used as a tactic in war of congenital amputation, a congenital disorder, where fetal limbs have been cut off by constructive and acts of terrorism; it may also occur as a war injury. In some cultures and religions, minor amputation or mutilations are considered a ritual de animals (such as lizards that shed their tails, salamanders that can regrow many missing body parts, and hydras, flatworms, and starfish that can regrow entire bodies from small fragments), once removed, human extremities do not grow back, unlike portions of some organs, such as the liver. A transplant or a prosthesis are the only options for recovering the loss.

02

2.3 VISIT TO A MANUFACTURER

Factory visit to agency who manufacture side wheel manufacturer was conducted to get brief idea on sales figure and scope of developing new product. A manufacturer was chosen: Kozi wheels is Indian manufacturer of Side wheels, Sidecars, all Handicapped Accessories for vehicle. Plant is located in Industrial zone of MIDC at Rabale, Navi Mumbai. Company is pioneer in sidecars and imports to USA, Canada, Australia, Brazil and Korea. They started there business with sidecars and noe they have entered the buisness of vehicles for disabled. They manufacture 10-15 vehicles per month comes for modification. They fabricate most parts, install it on vehicles and also provide service to them. They sell Side Wheels at 30,000 INR and sidecar at 40,000 INR.



Figure 16 Side wheel developed by Kozy wheels



Figure 17 Indication bulb on side wheels



Figure 18 Wheel cover is painted same colour of body

03 USER RESEARCH



A qualitative user study was done with the paraplegic people living in the urban areas of Mumbai to understand their daily routine. It was an attempt to know and understand how paraplegic person manage their daily activity and find out how they complete daily commute to their work place and what type of mobility device they use. They were interviewed to find about the type of mobile device they use and what led them to make that a choice. Observational study was apart of user study where videos were taken to identify the areas where the user face difficulty and critically examine how they use it.

03 USER RESEARCH

3.1 USER STUDY



| User 1:

Mr. Prashant, PHD scholar at IIT Bombay doing his research on climate control. He is from Jodhpur, Rajasthan. He walks using crutches. He has Activa with side wheels. He is driving for past 6 years. He is paraplegic where his lower part is less effective and he uses crutches to walk. He lives alone in IIT Bombay hostel and manages his travel using Honda Activa with Side wheels. He uses the vehicle within the campus area going to cafeteria, lab, etc. He has also used it to go out in the city where he had travelled 40kms in one trip. Long distance travel is a hectic part in such vehicle.



About vehicle:



Daily average distance travelled: 8kms.



Maximum speed: 45kmph



Vehicle cost (with attachment): 70,000 INR

03

3.1 USER STUDY

| User 1:

History of vehicle:

Using vehicle for past 6 years and current vehicle is his second vehicle. Sold the first vehicle because it was old. Bought it without any loan and it was the only choice available in market. No chance of bargain the cost of attaching side wheels was fixed.

Problems with current vehicle:

- No reverse mode in vehicle he has to push the vehicle every time when vehicle is parked.
- He faced problems in ongested space as it was difficult to manoeuvre the vehicle.
- He also mentioned about big stone on road creates problem, he has to be carefull and avoid such big stuff in road..
- During raining he has to either wait or get wet in rain as there is no weather protection on the vehicle.

03

3.1 USER STUDY

| User 2:

Mr. Mendes is from Goa. He lives in Mumbai and works at Maritime training institute, Powai as Account manager. He has a family with two children. Uses Activa with side car as he daily commute vehicle to his office. He mostly had a person to accompany him when goes office, mostly he find people who works with him. He place his wheelchair in side car when needed like he is going out where no wheelchair is available. Driving the same vehicle for past 10 years. He takes cab for long distance travel while if he has to go alone he manages move within city in his vehicle.



About vehicle:



Daily average distance travelled: 2kms.



Maximum speed: 40kmph



Vehicle cost (with attachment): 80,000 INR

03

3.1 USER STUDY

| User 2:

History of vehicle:

Using current vehicle for past 10 years and current is the second vehicle. His first vehicle was Honda activa with side wheels, but he sold that because it toppled once. His financial situation is good enough but there is unavailability of such vehicle. He bought this current vehicle without any loan and it was the only choice available in market. Had to fight for Sidecar to get approval from RTO still dint get.

Problems with current vehicle:

- No reverse mode available he has to rely on other person to get vehicle out of parking space.
- He has to face rain and sun as there is no weather protection available in his current vehicle.
- RTO of India doesn't give approval for side-car even on the basis of disability. .
- Ingress and egress extremely difficult in current vehicle.
- The previous vehicle toppled on uneven surface..

03

3.1 USER STUDY

| User 3:

Mr. Ubed khan, 28 years old. Works in Paraplegic foundation, Sion, Mumbai. He drives Honda Activa with side wheels daily from home to work. He lives in Palwadi, Mumbai which is 4 kms from his office. He is riding current vehicle for 4 years. He takes long trip in the current vehicle where he has travelled 40kms in on way. He is bought the vehicle from a garage, the original owner wanted to sell the vehicle. He was more concerned about service and maintenance cost of vehicle.



About vehicle:



Daily average distance travelled: 15kms.



Maximum speed: 70kmph



Vehicle cost (with attachment): 95,000 INR

03

3.1 USER STUDY

| User 3:

History of vehicle:

He is using Honda activa with side wheels for past 3 years and current one is his first vehicle. He saw the vehicle in garage and it was on sale, so he bought it. Bought it without any loan and it was the only choice available in market.

Problems with current vehicle:

- Reverse mode is not available, hence he has to find people to pull vehicle out of parking place.
- His vehicle slips in raining days, which is quite risky.
- There is no weather protection available in current vehicle.
- Vehicle service and maintenance charges are high.
- Vehicle break down like punctured tyre, engine not igniting on road has created problems in past.

03

3.1 USER STUDY




| User 4:

Mr Rajendra is 54 years old. He works at Paraplegic foundation, Sion Mumbai. He lives in Sion and drives tricycle to his office. He had once Honda activa with side wheels but he sold that vehicle because his one hand became more weak. Since scooty has all the controls on hand he was unable to control vehicle. Now he drives tricycle because his one hand is weak and it is the only available once he has.

Problems with current vehicle:

- Weather protection is unavailable, he has to face rain and sun.
- Ingress and egress is extremely difficult as only one side is available to get in and out of tricycle.

About vehicle:

-  Daily average distance travelled: 2kms.
-  Maximum speed: 10kmph
-  Vehicle cost: 7000 INR



03

3.2 VOICE OF USER



Prashant (27), Activa with side wheels
No reverse mode, Big stone creates problem.



Mendes (40), Activa with side car
No reverse mode, No weather protection.



Ubed (28), Activa with side wheels
Vehicle maintenance charges are high.



Rajendra (54), Activa with side wheels
Ingress and egress is difficult.

03

3.3 PROBLEM IDENTIFICATION



Figure 20 Observational study



Figure 21 Observational study

- No reverse mode in current available vehicle makes it difficult to get out of parking space leading it to liability.



Figure 22 Observational study

- Because of no weather protection available in current vehicle user has to suffer from rain and sun.

03

3.3 PROBLEM IDENTIFICATION



Figure 23 Observational study



Figure 24 Observational study

- Ingress and egress is extremely difficult due to disproportionate height difference between vehicle and wheelchair.



Figure 25 Observational study

- Two wheeler seats are not designed ergonomically, user has to adjusted to have comfortable ride.

03

3.3 PROBLEM IDENTIFICATION



Figure 28 Observational study



Figure 29 Observational study

- Vehicle has no grab bar to hold and support movement of user because they rely mainly hand support.



Figure 30 Observational study

- There are no practical place to hold crutches in vehicle, makes it difficult to hold crutches efficiently.

04

ERGONOMIC CONSIDERATION

4.1 BODY DIMENSION

To design motorised vehicle for paraplegic, the study of basic Indian anthropometric data was carried out which helped to set the basic parameters for the design. Measurements of popliteal height from ground, buttock-popliteal length were taken from 5th percentile female and rest of the measurements were taken from the 95th percentile male. Taking knee height and buttock-knee length from 95th percentile male ensures that the handle position will be such that it won't obstruct when used by any tall person. Using popliteal height and buttock-popliteal length of a 5th percentile female insured that it won't be uncomfortable for any short person to use the device. The most comfortable way to sit while riding is the upright position where backbone is close to perpendicular to the seat.

SELECTED STRUCTURAL BODY DIMENSION (MM)		
BODY FEATURES	95TH PERCENTILE MALE	5TH PERCENTILE FEMALE
HEIGHT	1865	1515
SITTING HEIGHT,ERECT	901	738
CERVICAL TRUNK	667	531
MID SHOULDER	630	499
SHOULDER BREADTH	479	349
HIPBREADTH	406	269
POPLITEAL	466	374
BUTTOCK-POPLITEAL	509	394
ELBOW HEIGHT	268	150

[Reference: Indian Anthropometric Dimensions(For Ergonomic Design practice) by Debkumar Chakrabarti]

04

4.2 SEAT DIMENSION AND HEIGHT

Seat dimension is decided by Indian anthropometric data for design and sitting posture should be relax having alert position. Seat height is chosen as the height of wheelchair around 550mm, so there should not be significant height difference between vehicle seat and wheelchair. Pillion seat is at same height level as drivers and it is normal seat with no back rest.

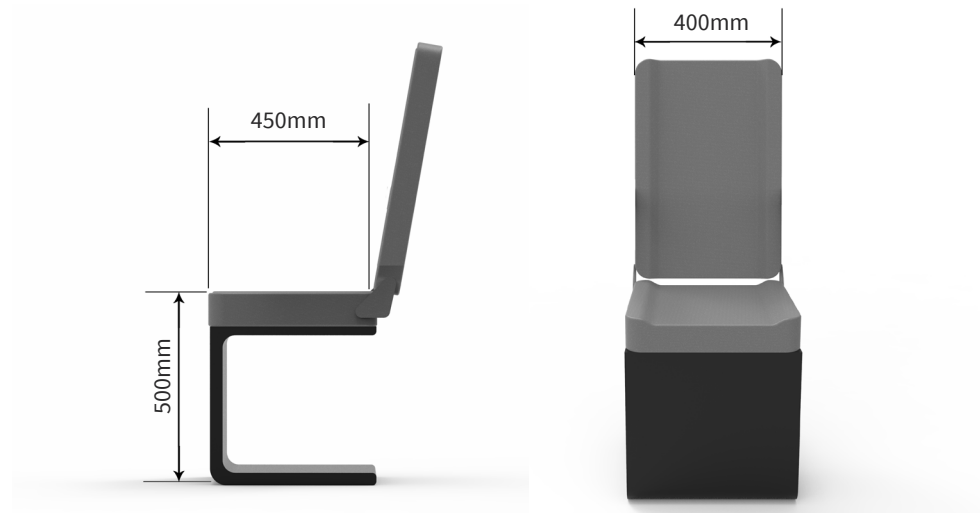


Figure 30 Ergonomically designed seat

04

4.3 VEHICLE DIMENSION STUDY

Desired vehicle length is decided so as to maintain the foot print of vehicle which is currently available. Width is decided such that the vehicle is dynamically stable by maintaining center of gravity inside vehicle. Height is decided by taking height of 95th percentile male as reference and giving significant headroom. Ground clearance is kept same, which is 150mm but floor height is reduced to 190mm. Wheel base is kept 1400mm

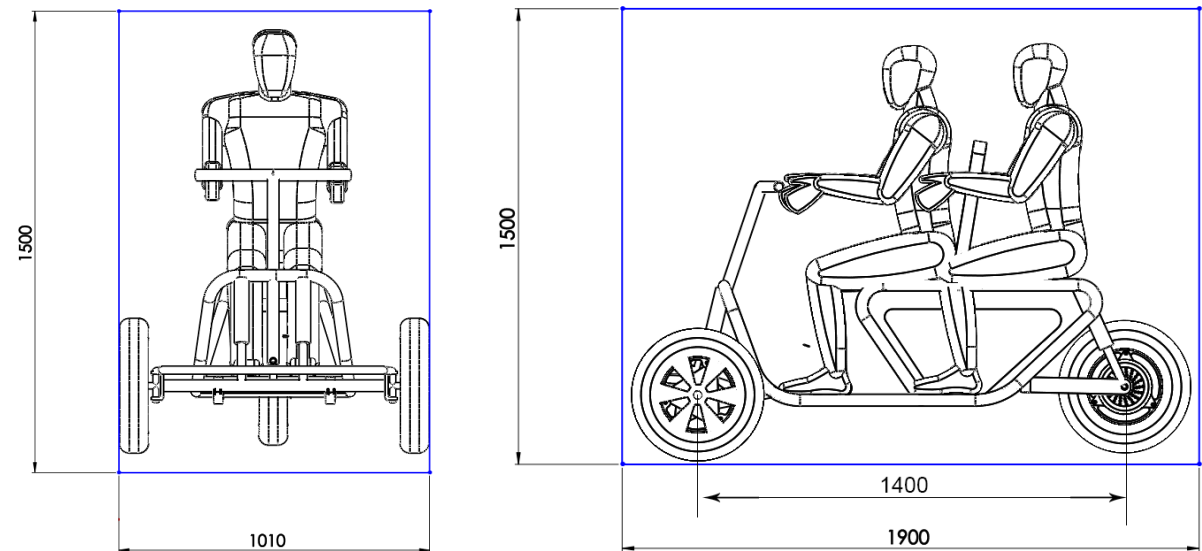


Figure 32 Vehicle package by considering Indian anthropometric data.

All dimensions in mm

04

4.4 FRAME SELECTION

Many different frames were considered and compared to select the most suitable frame for the vehicle. Frames like Underbone frame, Trellis frame, Monocoque, Cradle frame, Perimeter frame etc were compared. Out of all these frames Underbone frame being a step-through frame came up as the most suitable one for the required application, using underbone application has benefits like easy to manufacture, cheap, good rigidity and flexibility to achieve complex architecture.

To select the material for the frame two types of alloy steel were considered viz. Plain carbon steel and Chromiummolybdenum steel. These two types of alloy steel are the most commonly used and offer the most suitable properties for building a frame. Chromium-molybdenum steel is better in terms of weldability, formability, strength, ductility, and toughness. Hence, Chromium-molybdenum steel is chosen as a proposed material to be used for the frame. AISI 4130 Alloy Steel is the proposed grade of alloy steel which can be used for building the frame.



Figure 33 Underbone frame of motor bike



Figure 34 Chromium-molybdenum steel tube

04

4.5 MOTOR SELECTION

Selecting the motor for the drive is one of the most crucial parts of the architecture as it will define the speed, load carrying capacity and duration for which vehicle can work on every charge.

The two basic type of motors i.e. AC motors and DC motors were compared first. Both have their benefits and limitations and are suitable for different kind of applications here, where we need to maintain low speed and higher efficiency with enough power to easily manoeuvre over high grades and rough terrains DC motor seemed to be the suitable one. DC motor has different benefits over AC motor like better low-end torque and higher peak efficiency. There are different kind of DC motor available like hub Brush less DC motor (BLDC), Brushed DC motors etc. Hub mounted Brushless DC motor is advantageous as it eliminates transmission, service cost and weight. Motor is directly mounted on hub along with braking system.



Figure 35 1000Watt DC motor with throttle and controller



Figure 36 1000 watt Hub BLDC motor

Considering the weight of vehicle and pulling capacity, following specifications of motor is selected:

Power rating: 1500 Watt DC motor

04

4.6 BATTERY SELECTION

To find the suitable type of battery for the required purpose, four most commonly used batteries for the automotive field were compared viz. Molten-salt (Na-NiCl_2), Nickel Metal Hydride (Ni-MH), Lithium Sulphur (Li-S) and Lithium Ion (Liion).

Molten salt batteries offer the lowest energy consumption and also has a low price but they have the drawback of having a very narrow band of working temperature where they perform well. Hence, it's an extra work to maintain the right working temperature for the batteries. Whereas, Nickel metal hydride does not have any such conditions but have the lowest energy density, power and are heavy too making them unsuitable for the use in automotive applications. On the other hand, Lithium-sulfur offers many good properties like low weight and good energy storage capacity but has the drawback of being the highest energy consumption making them not suitable for the automotive field as sometimes vehicles tend to stand still for days before they are used again. Lithium-Ion whereas offers moderate energy consumption but has many other beneficial properties like increased life cycle, high energy storage capacity, low weight and continuously decreasing price. All these properties make it the suitable one to be used for the vehicle.



Figure 37 Lipo battery pack construction



Figure 38 Lipo Battery



Figure 39 Lipo Cell

Battery dimension: 265mm x 175mm x 68mm

Battery capacity: 48Volts 20.8Ah

Weight: 12 kgs

No. of cells: 200

05 DESIGN BRIEF

Design Motorised Vehicle for Paraplegic satisfying the following requirements:

Target user:

- Paraplegic person uses crutches or wheelchair.
- Working professional who commute daily.

Technical consideration:

- Approximate dimension: 1900*1500*1010mm
- Approximate ground clearance: 150mm
- Floor height: 170mm
- Seat height: 550 mm
- Wheelbase: 1400mm
- Wheel size: 90/100-10(Tubeless)
- Pillion seat.

Features:

- It should have Improved Ingress and Egress.
- It should have Weather protection.
- It should impart experience of Self-sufficient and Confidence while manoeuvring and parking.
- It should impart Easy and Safe ride.

06 IDEATION

The ideation phase began with identifying the components to built a vehicle and solving the identified problems. The main purpose of ideation is to explore the possibilities for different aspects of motorised vehicle such as ingress egress of user, frame type, powertrain, control systems,etc. The direction thought for the motorised vehicle is ease of use, reverse mode, weather protection, pillion seat, manoeuvrable, safe and storage.

Understanding the scenario of the user who is a disabled person in India where majority of its physically disabled users are in poor financial situations. Hence the product should offer a cost effective solution. Basic considerations towards ergonomics and ingress-egress were fixed throughout the ideation to ensure comfortable experience during extended duration of use.

Quick mock-ups were explored with GI wire to replicate basic structure of vehicle and how the problems were solved. Basic purpose of this study was to understand how available solutions can be executed.

06

6.1 WIREFRAME

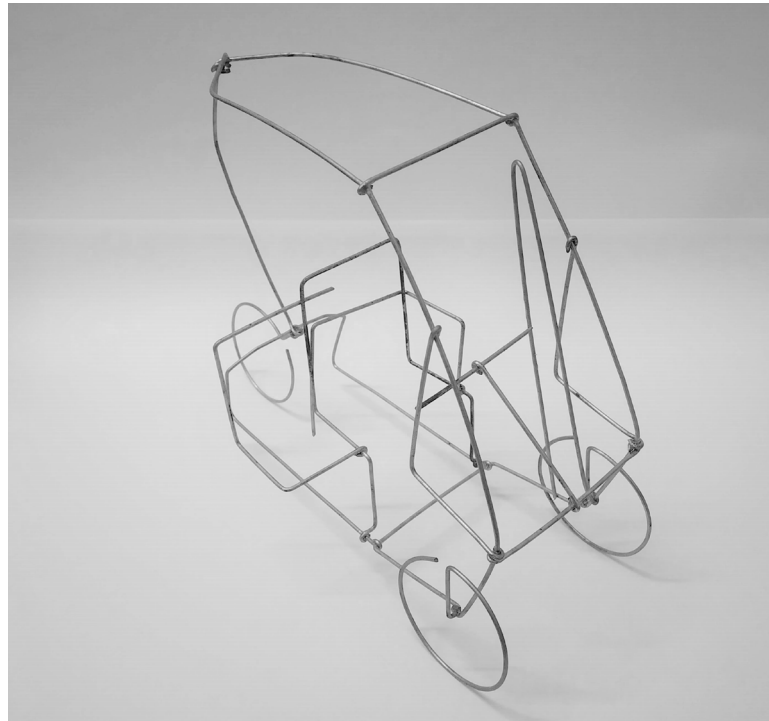
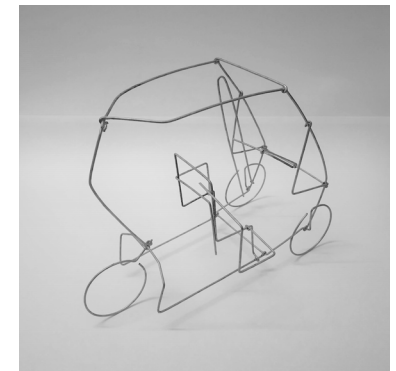


Figure 41 Wireframe ideation

This model has tadpole frame with handle bar type steering system having electric hub motor propulsion powered by lithium ion batteries. Seats are designed with mechanism for easy ingress and egress along with pillion seat and weather protection roof top. Grab handles are present in roll bar to assist the ingress and egress. For users who uses crutches, they can place crutches in front near handle bar for easy access. It has bucket type seat and side support for extra safety. Laminated glass windshield is provided and utility box is placed in front.



06

6.1 WIREFRAME

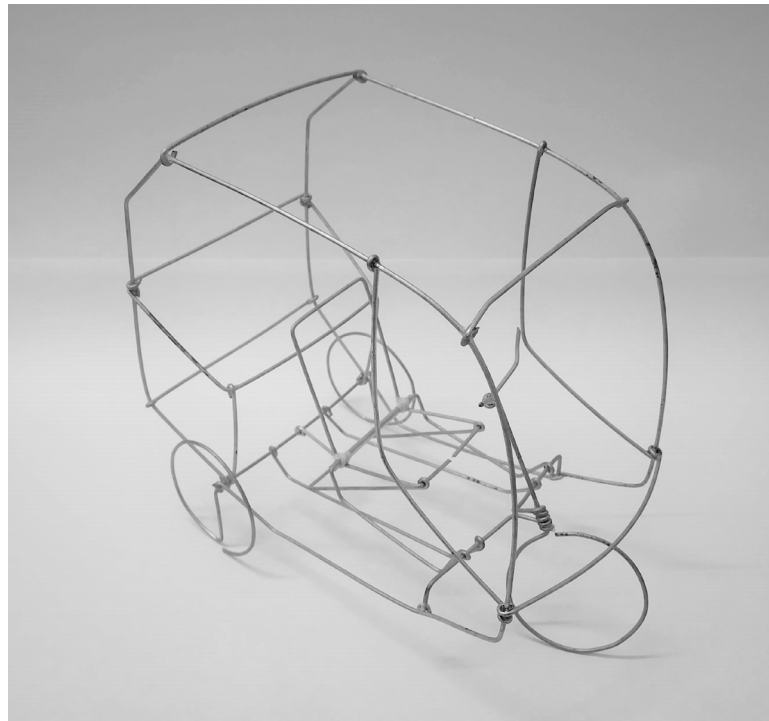
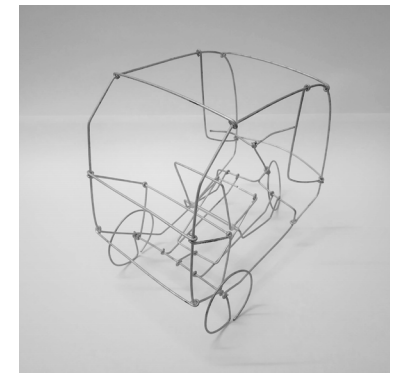


Figure 42 Wireframe ideation

This model has delta frame with handle bar steering system having rear wheel electric motor propulsion with lithium ion batteries. Here seats are designed for easy ingress and egress with no pillion seat and weather protection roof top. Grab handles are present in roll bar to assist the ingress and egress. For users who uses crutches, they can place crutches along the side. It has bucket type seat and side support for safety. Laminated glass windshield s provided and utility box in front and rear.



06

3.1 WIREFRAME

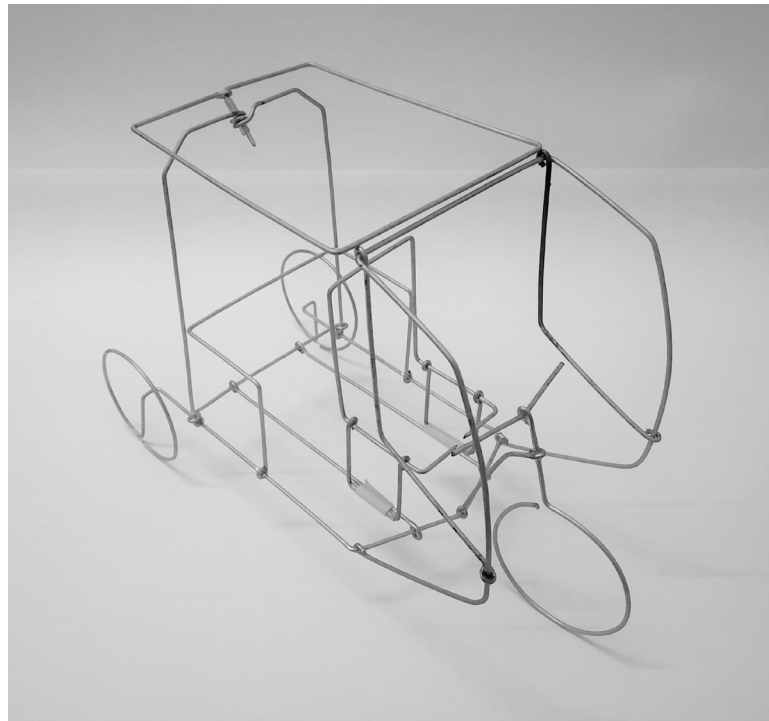
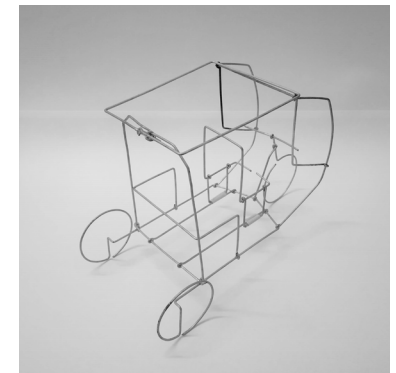
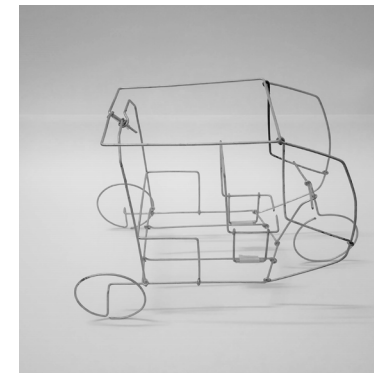


Figure 43 Wireframe ideation

This model has delta frame with handle bar steering system having rear wheel electric motor propulsion with lithium ion batteries. Here seats are designed for easy ingress and egress with pillion seats and open-able weather protection roof top. Grab handles are present in roll bar to assist the ingress and egress. For users who uses crutches, they can place crutches in front near handle bar for easy access. It has bucket type seat and side support for safety. Laminated glass windshield is provided and utility box is placed in front.



06

6.1 WIREFRAME

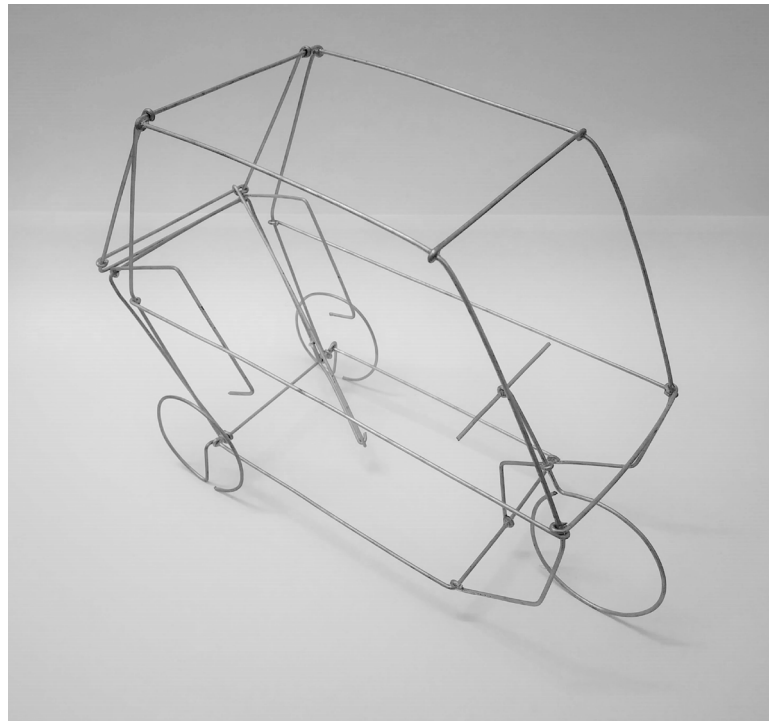
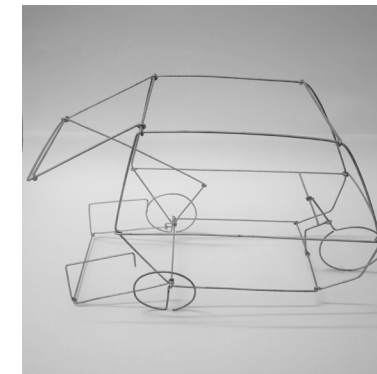


Figure 44 Wireframe ideation

This model has delta frame with handle bar steering system having front wheel electric hub motor propulsion with lithium ion batteries. For easy ingress and egress, rear door with ramp is provided and weather protection roof top. Grab handles are present in roll bar to assist the ingress and egress. It has lock mechanisms to lock wheel chair safety. Laminated glass windshield s provided and utility box is place in front.



06

6.1 WIREFRAME

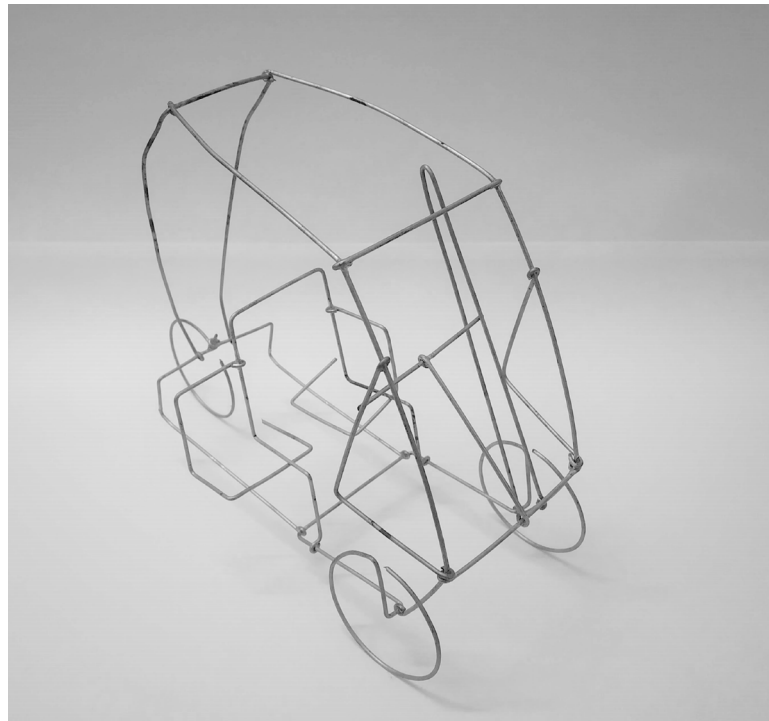
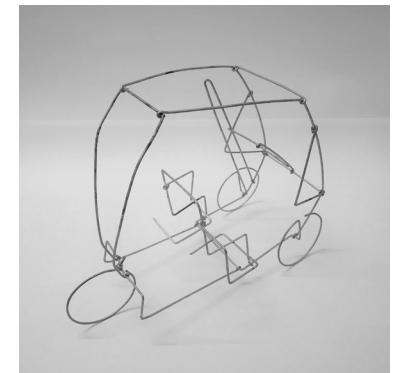
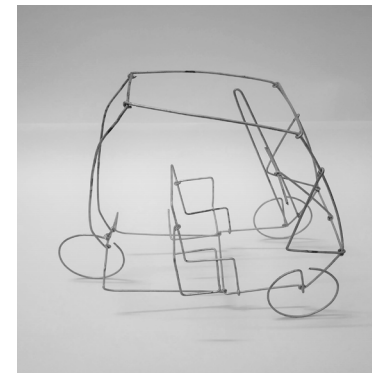


Figure 45 Wireframe ideation

This model has tadpole frame with handle bar type steering system having electric hub motor propulsion powered by lithium ion batteries. Seats are designed with mechanism for easy ingress and egress along with pillion seat and weather protection roof top. Grab handles are present in roll bar to assist the ingress and egress. For users who uses crutches, they can place crutches in front near handle bar for easy access. It has bucket type seat and side support for extra safety. Laminated glass windshield is provided and utility box is placed in front.



06

6.1 WIREFRAME

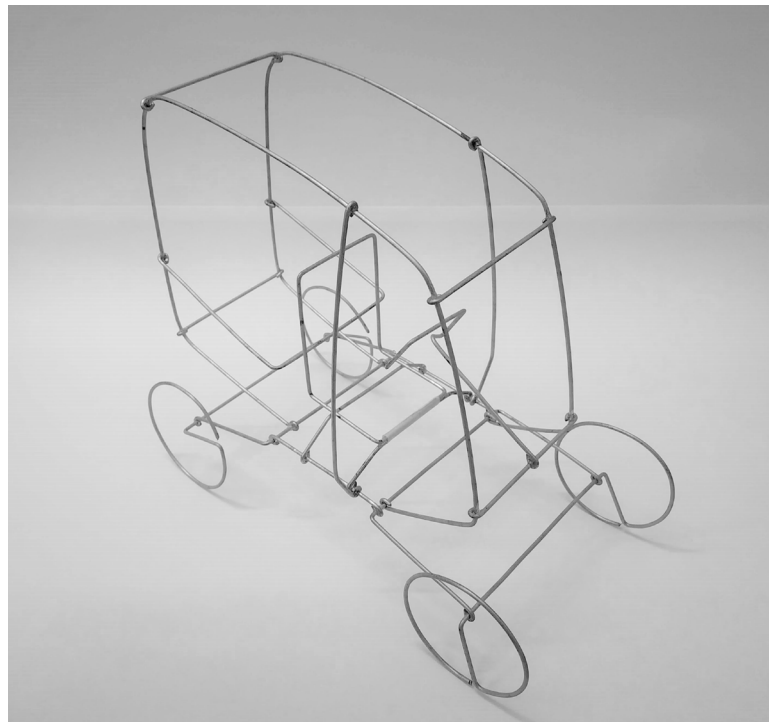
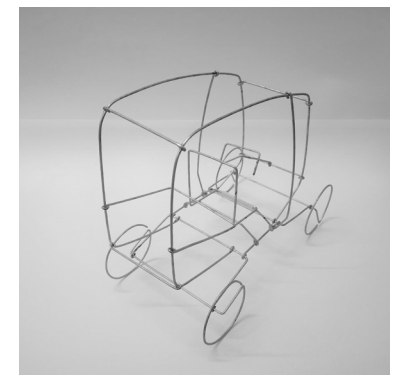
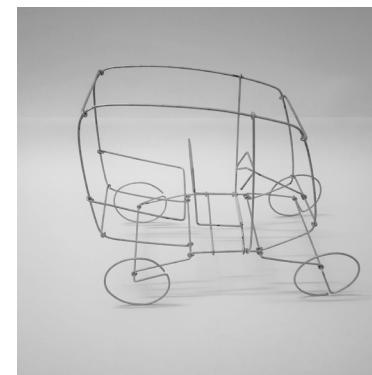


Figure 46 Wireframe ideation

This model has four wheels with front wheel steering system having rear wheel electric motor propulsion with lithium ion batteries. Here seats are designed for easy ingress and egress with no pillion seat and weather protection roof top. Grab handles are present in roll bar to assist the ingress and egress. For users who uses crutches, they can place crutches along side for easy access. It has bucket type seat and side support for safety. Laminated glass windshield s provided and utility box placed at front.



06

6.1 WIREFRAME

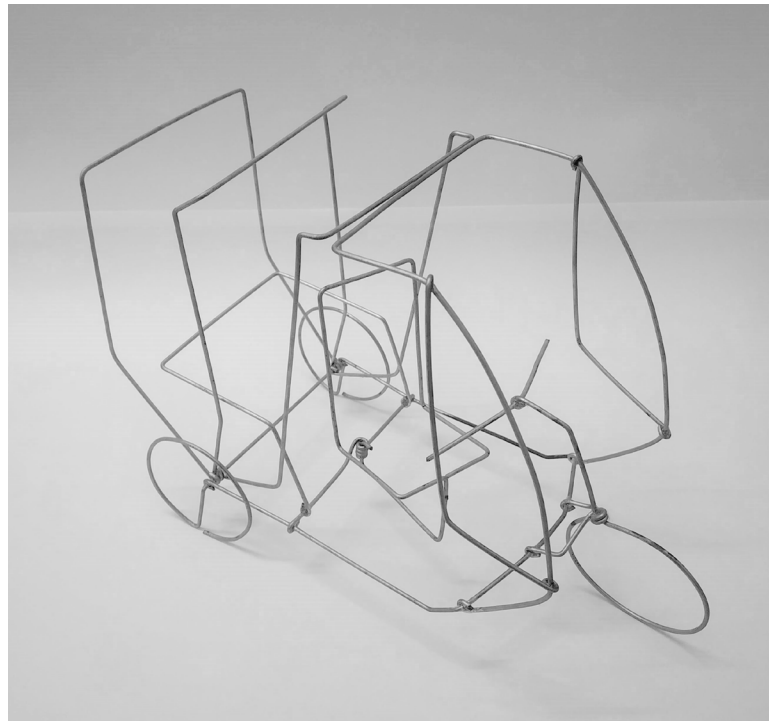
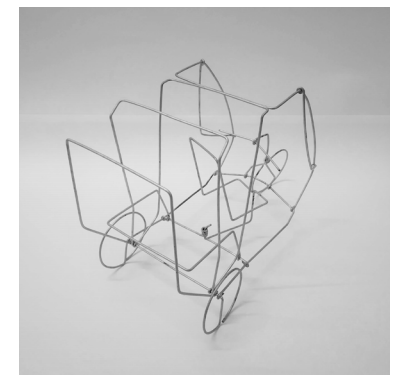
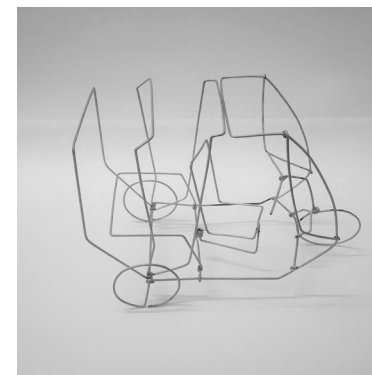


Figure 47 Wireframe ideation

This model has delta frame with handle bar steering system having front wheel electric hub motor propulsion with lithium ion batteries. Here seats are designed for easy ingress and egress with pillion seat and open-able weather protection roof top. Grab handles are present in roll bar to assist the ingress and egress. For users who uses crutches, they can place crutches in front near handle bar for easy access. It has bucket type seat and side support for safety. Laminated glass windshield is provided and utility box is placed in front.



07 CONCEPT

7.1 CONCEPT DEVELOPMENT

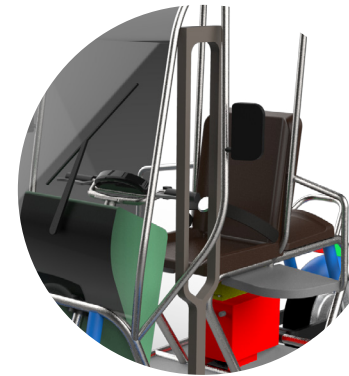
Concept development started after doing wire-frame mock-ups. These concepts are based on wire-frame models without outer body panel which will be added on the final concept. Each concept is a mixture of solutions listed for identified problems in morphological chart. Final concept will change after evaluating the best solution for all the identified problems. All the concept are based on the same vehicle architecture which is proposed earlier. Concepts are made by keeping few things on mind like the new vehicle should solve all the problems and should not compromise all existing features available in currently used vehicle like utility box, pillion rider seat,etc

07 CONCEPT

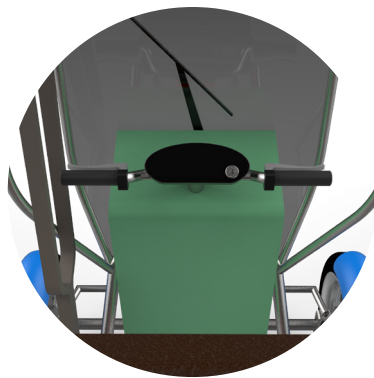
Concept-1



Seat equipped with extension which rotates and goes inside. Seat extension is provided for easy ingress and egress from wheel chair to vehicle seat.



Crutches can be held on either sides. Grab handle is provided to assist movement.



Handle bar has all the control for brake and reverse mode button. Front section has utility box which is accessible.



Front seat is bucket type seat with seat belt on it for extra safety. Vehicle has pillion rider seat also.

07 CONCEPT

Concept-1



Figure 50 Concept-1 render



07 CONCEPT

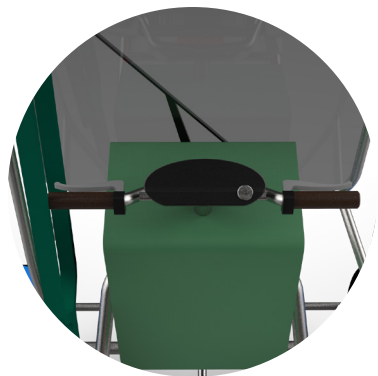
Concept-2



Seat equipped with hand operated openable extension seat which flips out from side. Seat extension is provided for easy ingress and egress from wheel chair to vehicle seat.



Crutches can be held on either sides. Grab handle is provided to assist movement.



Handle bar has all the control for brake and reverse mode button. Front section has utility box which is accessible.



Front seat is bucket type seat with seat belt on it for extra safety. Vehicle has pillion rider seat also.

07 CONCEPT

Concept-2



Figure 52 Concept-2 render



07 CONCEPT

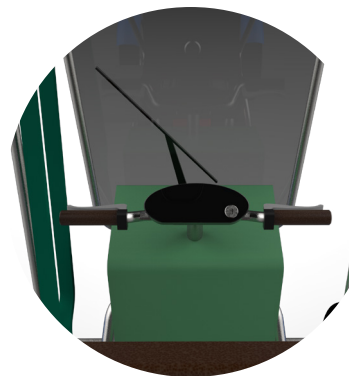
Concept-3



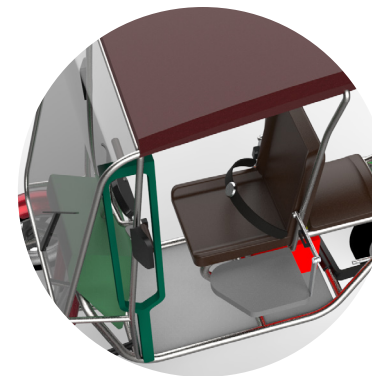
Seat equipped with extension which slides of either side. Seat extension is provided for easy ingress and egress from wheel chair to vehicle seat.



Crutches can be held on either sides. Grab handle is provided to assist movement.



Handle bar has all the control for brake and reverse mode button. Front section has utility box which is accessible.



Front seat is bucket type seat with seat belt on it for extra safety. Vehicle has pillion rider seat also.

07 CONCEPT

Concept-3



Figure 54 Concept-3 render



07 CONCEPT

7.2 MORPHOLOGICAL CHART

Morphological was generated from different concepts and final direction was identified to make a final concept.

	Concept-1	Concept-2	Concept-3
Number of wheels	3	3	4
Steering	Front wheel	Rear wheel	Front wheel
Motor	Hub motor	Hub motor	DC motor
Weather protection	Hard top	Soft top(rexine)	Hard top

07 CONCEPT

7.3 FINAL CONCEPT



07 CONCEPT

7.3 FINAL CONCEPT



07 CONCEPT

7.3 FINAL CONCEPT



Features:

1. Four wheeled vehicle for better stability.
2. Ratchet mechanisms for set extension.
3. Seat belt for safety.
4. Pillion seat.
5. Bucket sea to provide extra body support.
6. Electric vehicle, easy reverse mode.
7. Storage compartment.

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(Figure 5) <http://accessibleindia.gov.in/content/>

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(Figure 11) <https://www.jayhatfieldmobility.com/uploads/mobility-logo-1460480207.jpg>

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