Eco-friendly Mobility Solution for Future

Project 3

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Industrial Design (2007-09)

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Approval Sheet

The Industrial Design Project 3 entitled
'Eco-friendly Mobility Solution for Future'
by Amey Dhuri, 07613007 is approved in
partial fulfillment of the requirement of the
Master of Design degree in Industrial Design.

Guide:

Chairperson:

Internal Examiner:

External Examiner:

Acknowledgement

I wish to thank to my guide Prof. Ramachandran for his valuable inputs, support and encouragement throughout the project.

I am grateful to Prof. B.K. Chakravarthy for his inputs and valuable feedback.

Thanks to my batchmates for their help.

Contents:

Abstract

Mobility is the state of being in motion. Environmentally friendly, eco-friendly or nature friendly are synonyms used to refer to goods and services considered to inflict minimal harm on the environment. Today traffic rate is increasing which has led to pollution, congested roads and parking problems. The Persons occupancy per car is also very less. My project aims at designing a mobility solution to carry a minimum of 2 adults. The targeted user group will be office going people who will use this car in city limits. The vehicle will run on a eco-friendly platform and will be easy to park and occupy minimum space. This Vehicle is for use in 10 years from now.

Eco friendly mobility

What is Mobility ?

Mobility is the state of being in motion.

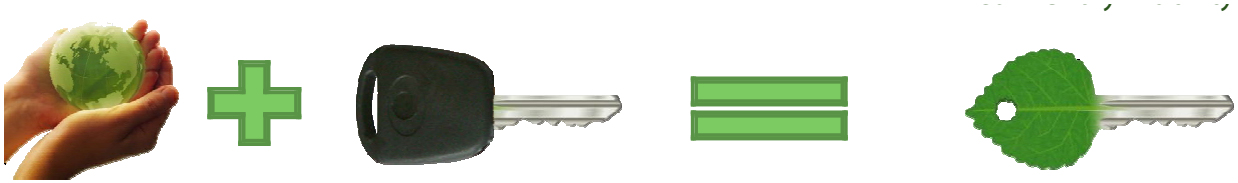
What is Eco friendly ?

Environmentally friendly, eco-friendly and nature friendly are synonyms used to refer to goods and services considered to inflict minimal or no harm on the environment.

Eco friendly mobility

Refers to mobility solutions which

- Produce no toxic emissions
- Run on renewable energy source



Transport scene in India

The picture of the transport scene in India is very vivid. We still use Bullock carts in some parts of our country. On the other hand we have the technology to create the Tata nano. In India we have all the forms of transport such as Family, personal, public and cargo in the form of cars, buses, trains, trucks etc.

Till today the energy requirements for these transports systems are met by fuels which are derived from non renewable energy sources. It is not India alone who is in this scenario but it is a world wide situation.

There has been a huge demand for these fossil fuels and the rate at which we are using them, it is predicted by researchers that the fuels will become exhausted soon by the year 2050.

In the process of burning fuels to do work we result in being the major contributors towards the carbon footprint.

Transport scene in India

The number of vehicles on the roads are rising. Rapid increase in motorized mobility during the last two decades or so is primarily due to increase in household income, increase in commercial and industrial activities, availability of motorized transport, and improvement in road transport infrastructure. Attractive finance schemes are also a major contributors towards this rapid growth.

This growth has led to adding lot of vehicular volumes on the roads. Most of the road width is used as parking space resulting in very less space for movement of traffic which ultimately leads to traffic congestion.

In India the traffic rate is increasing day by day. In metros like Mumbai, Delhi etc we have people commuting in vehicles round the clock. The traffic rate also has a varying vehicle density at different times of the day.

Mobility in India

Classification

The Indian mobility can be divided into 4 major categories Family, personal, public and goods transport.

Family and personal mobility are the two categories which account for the most of the mobility volumes and also have a high rate of increase as compared to public or goods transport.

Most of the mobility volumes are accounted by the working class people and significant number within this working class uses family and personal transport vehicles as daily means of mobility.

Considering these aspects family and personal transport category was selected as an area to develop a mobility solution for the future.

Family and personal transport vehicles

This category is further divided into two sub categories i.e two wheelers and four wheelers.

Two wheelers are classified into Mopeds, scooterets, Bikes.

In India we have cars in various shapes and sizes which are further classified into four segments. A segment, B segment, C segment, D segment.

Vehicle occupancy survey

The number of vehicles on road is incerasing day by day. The reasons for this rise in vehicular volumes are:

- Increase in household income
- Increase in commercial and industrial activities
- Availability of cheap motorized transport solutions
- Improvement in road transport infrastructure
- Attractive finance schemes

With the increase in number of vehicles, car occupancy has gone down. Most cars on the road have only one person in them.

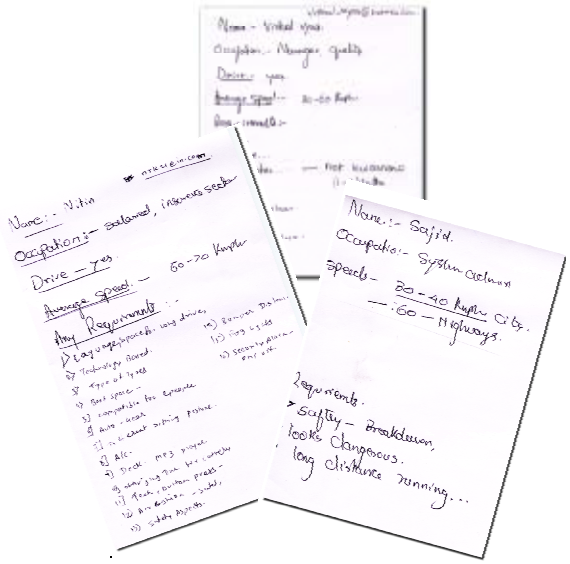
Car occupancy varies greatly with the purpose of the driver's journey. In the case of working class people the driver was unaccompanied most of the time in a day and most of the days a week. He would carry two or three people only on weekends or some special ocassions as a result of which the average number of people per car journey has become about 1.6.

User study

Working class people were interviewed, the users contained a significant number of 2/4 wheeler users.

Users were asked about common problems they face in their vehicles while driving in city. They were also asked to list down some features which they would like to have in a personal mobility vehicle.

This study helped to understand the mobility needs of people, and reasons why they prefer one vehicle over the other.



Comparison 2/4 wheelers

With the help of feedback given by the users a comparative study was done to understand the key features of the 2 categories and advantages of one over the other.

- A car can carry 4 people comfortably.
- It's a enclosed metal structure which provides better saftey.
- A car acts as a status symbol
- Comfort level is higher compared to 2 wheelers.
- Provides protection from heat, dust, rain
- Has more storage space.

- A bike can carry 2 people comfortably.
- Highly maneuverable
- It is highly manuverable in city traffic
- Parking is very easy in least possible time
- Has very less foot print
- Fuel economy is higher
- Purchase cost is lower
- Lower maintenance and operating costs

Inferences

From the user study and comparison of 2/4 wheelers some inferences were made:

- Small cars are preferred for city travel as they easy to park and provide better fuel economy.
- Bikes provide better manuverability with fuel economy and can be easily parked in minimum space.
- Some people use rickshaws for daily commuting as they are cheaper, easily available, faster through traffic, and you dont have to bother about parking.
- People plan their journey by thinking about the parking scenario they will be facing when they reach their destination. Hence parking ability of a vehicle is a key point in making the choice for a vehicle.
- Cars provide a enclosed structure which has lot of benifits like safety, protection against dust, heat, rain etc. It is the most important feature of a car which is lacking in case of two wheelers
- Car is considered as a status symbol, people are more proud of owning a car than a two wheeler.
- A car offers a higher level of comfort as compared to a 2 wheeler.

Requirements for the future

Most important requirement for the future are mobility solutions which

- Produce no toxic emissions
- Run on renewable energy sources

Based upon the comparison of 2/4 wheelers, the user feedback and requirements of a car for the future specific challenges for the project were decided.

Eco-friendly mobility solution
Challenges for the project

Go Green	A new vehicle platform	A new approach
Eco-friendly drivetrain	Easy to maneuver through cojested roads	Using appropriate technology
Affordable	Reduce parking space & time	To lower running costs
Low maintenance	Small and compact	Use of alternative materials
Reliable	Better driving interface	Design for mass production

Design Brief

To Design a mobility solution to carry maximum 2 adults. It must run on a eco friendly platform. The targeted users will be office going people who will use this car in city limits. The vehicle should be able to quickly maneuver the city traffic, it must be designed to park in least time, and occupy minimum possible foot print.

Toyota i real

Uno bike

Segway

World Scenario

A brief study was done to understand what development is happening outside India. In the International market most of the major companies like Nissan, Toyota, Suzuki have already started to develope small and compact mobility vehicles, which are built on completely new platform have unique design features and a strong appealing factor.

Suzuki pixy

Toyota swing

Nissan PIVO 2

City car

Peugot future car

Smart city car

Indian scenario

Our current Indian market has two vehicles which run on BEV platform. These are the REVA car and the Chinese electric two wheelers.

Electric bikes

Reva

Benchmarking

Nissan Pivo 2

Suzuki pixy

Smart city car

Peugot future car

Reva

Concepts like Nissan Pivo2, Suzuki pixy have set a strong benchmark for city mobility vehciles.

When Compared with the vehicles from the International market Reva car lacks in the features presented by the international vehicles. It also does not make a impressive style statement as it looks old styled and more towards a traditional car.

Important Requirements

Closed exteriors----protection from dust, rain, sunlight

Easy to park----as lot of time is wasted in parking a vehicle

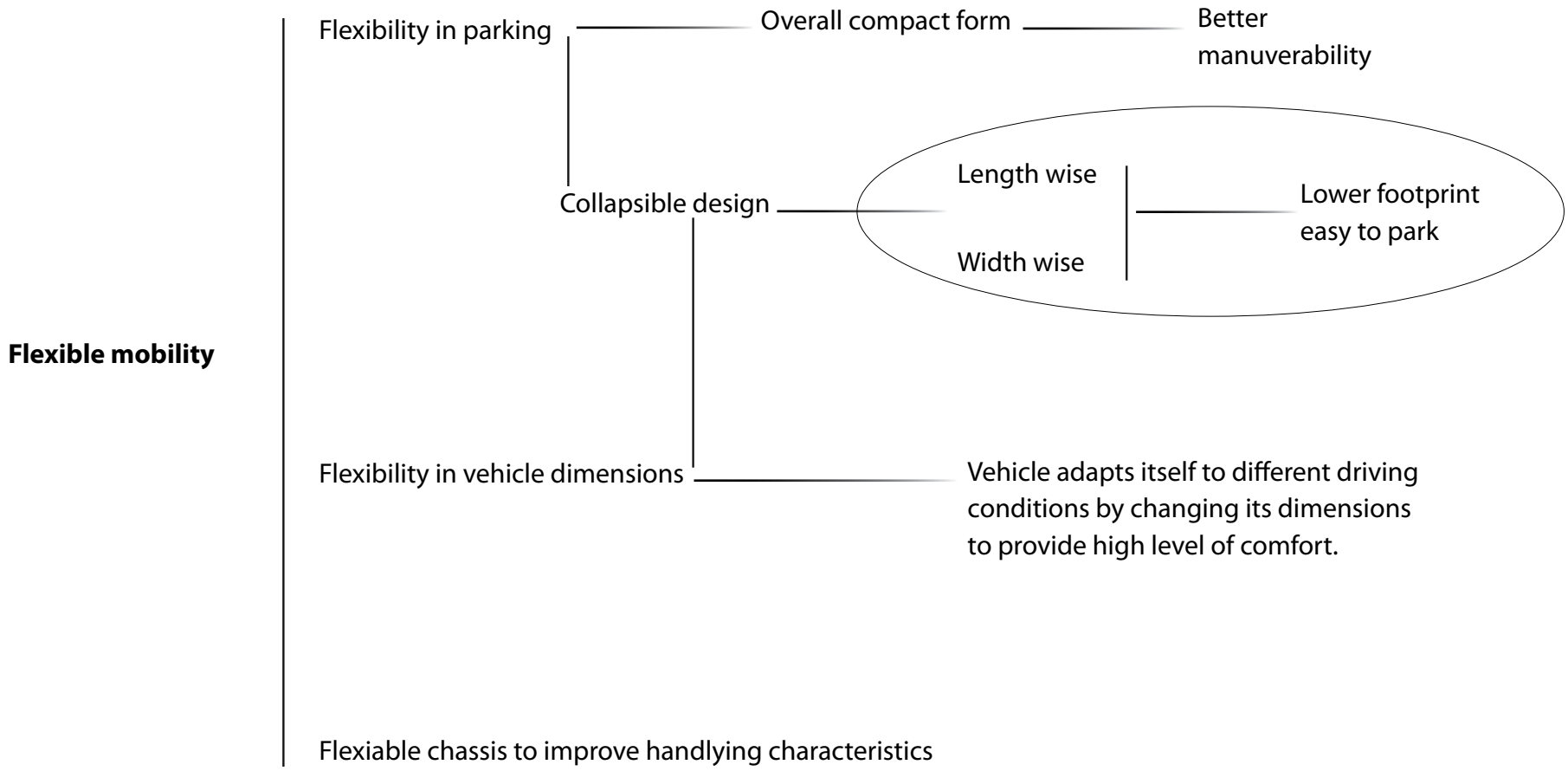
Maneuverability--- To negotiate traffic jams

A pivo2 vehicle parks it's self side ways by turning the wheels by 90 degrees. Such flexibility in parking reduces your parking time.

We require a compact design which can easily manuver through traffic and conjusted roads

Ideation

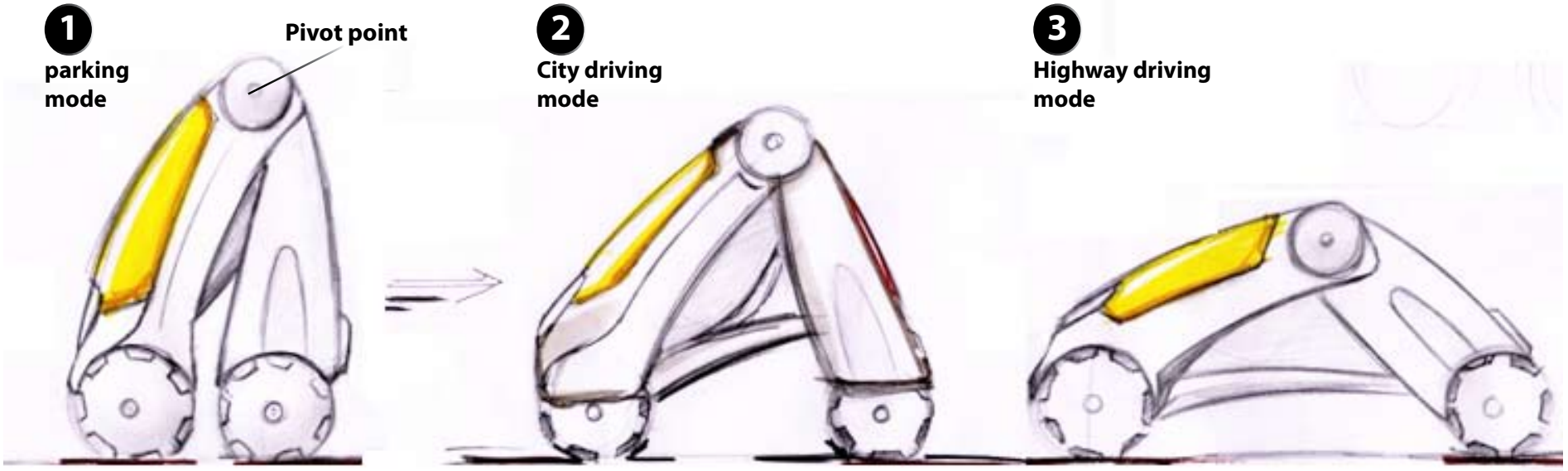
To start with the ideation process '**Flexiable mobility'** was chosen as a theme to develope the concepts.



Concept 1: Collapsible length wise

Inspirations - Inch worm, Flexible body mobile phone

In this concept the vehicle collapses lenght wise to take different forms in different riding modes providing a high level of comfort.

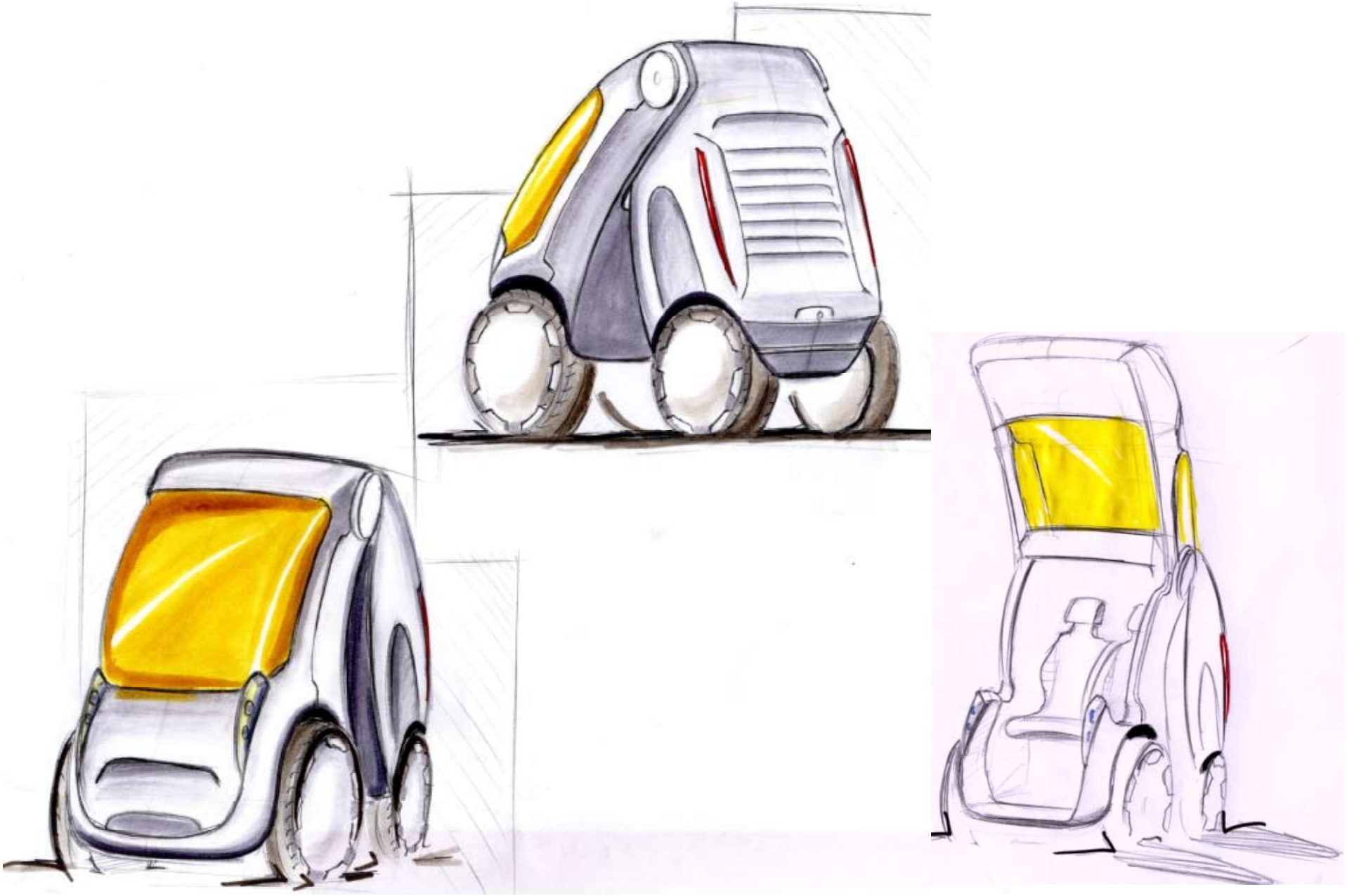


In parked condition the vehicle becomes compact to occoupy minimum footprint.

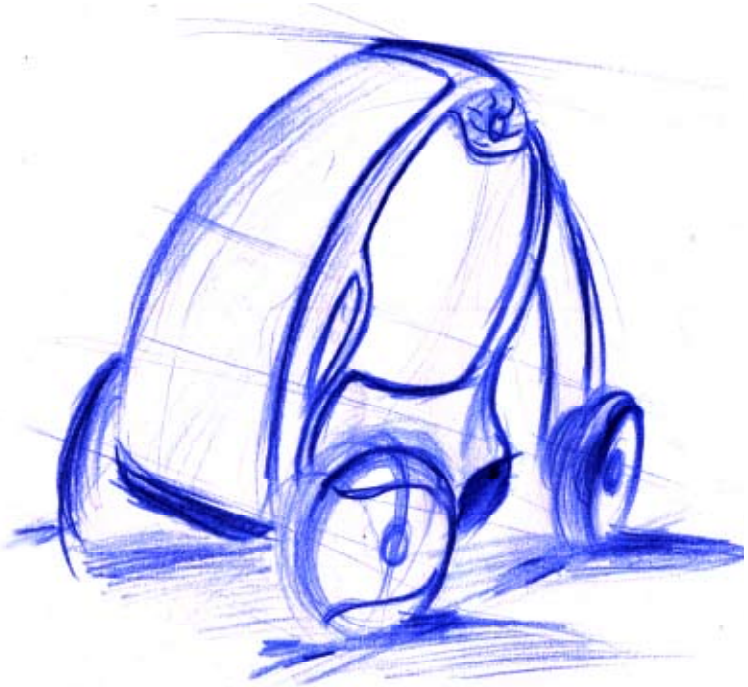
In city mode the vehicle streches so that the person sits in a more upright postre suited for everyday driving

In highway mode the vehicle lowers to provide a relaxed siting posture. with low centre of gravity.

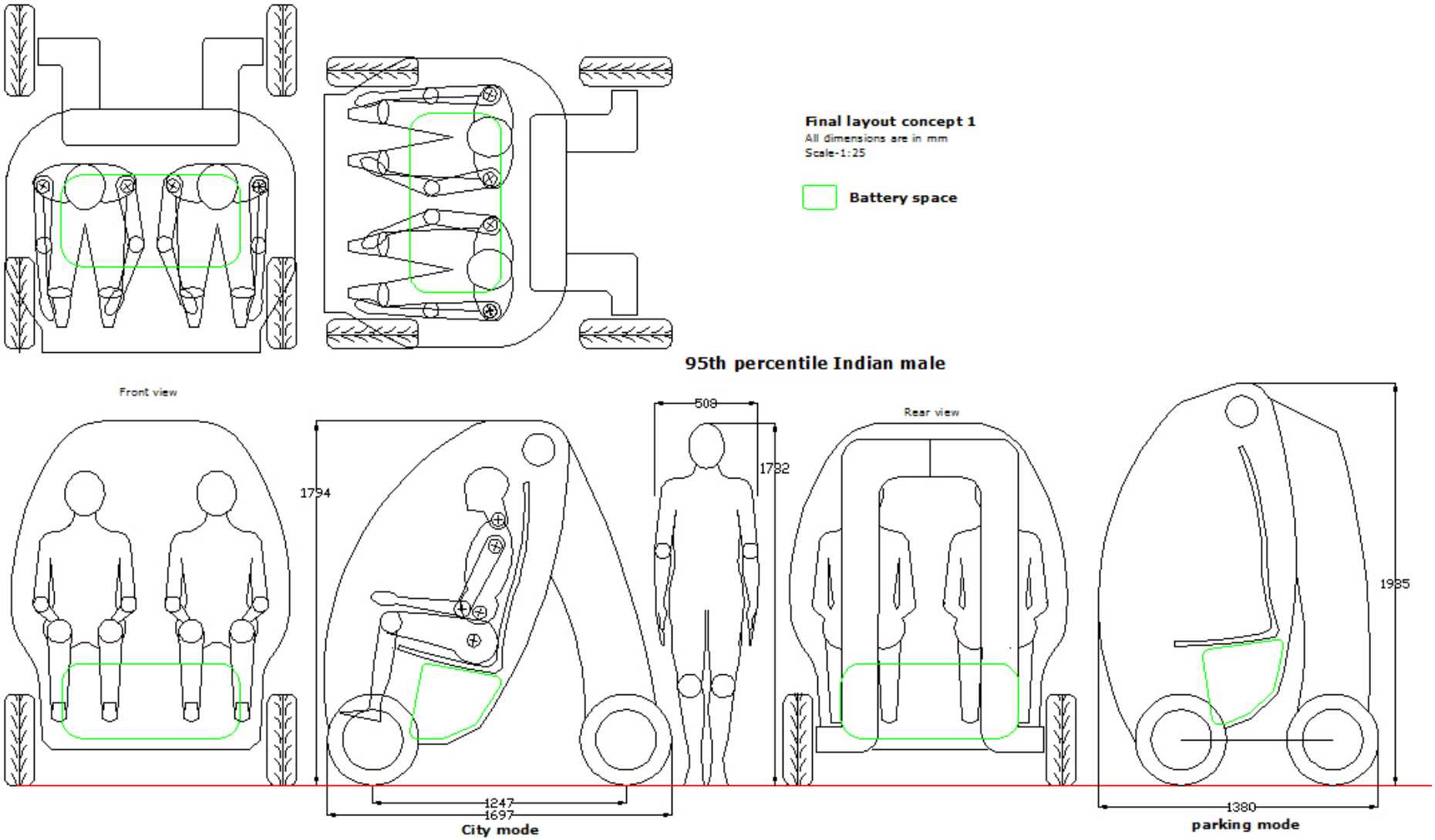
Concept 1: sketches



Further ideation styling options :



Layout and overall dimensions



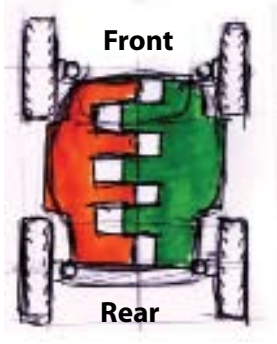
Concept 2 : Collapsible width wise

In this concept I explored the possibilities of a collapsible deisgn along the width of the car. It is easy to compress and expand a car along its length. During length wise compression the wheels are already aligned in the same direction and they rotate and turn in and out along the vehicles length to make it compact. While compressing a car along its width, the wheels conflict and create drag resistance as they have to move perpendicular to their direction of motion.

To effectively compress the car along its width its wheels can be rotated by 90 degrees inwards and then they can squeez the car along its width.

Top view

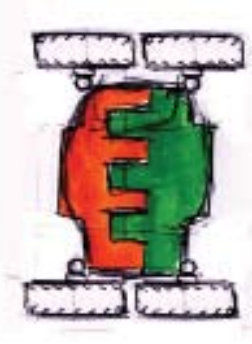
City mode
Expanded state



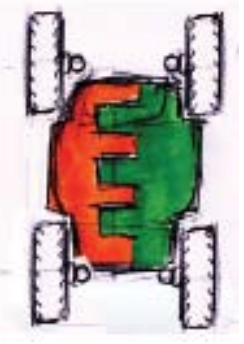
Wheels turn inwards-
Step 1

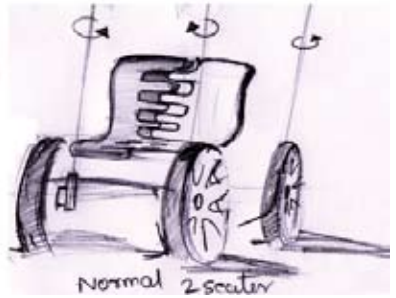
Wheels rotated by
90 degrees-Step 2

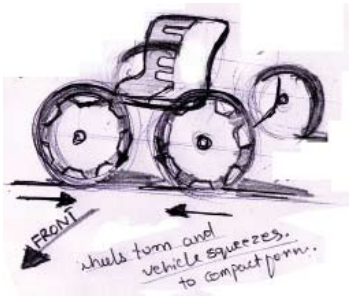
Vehicle squeezes
-Step 3



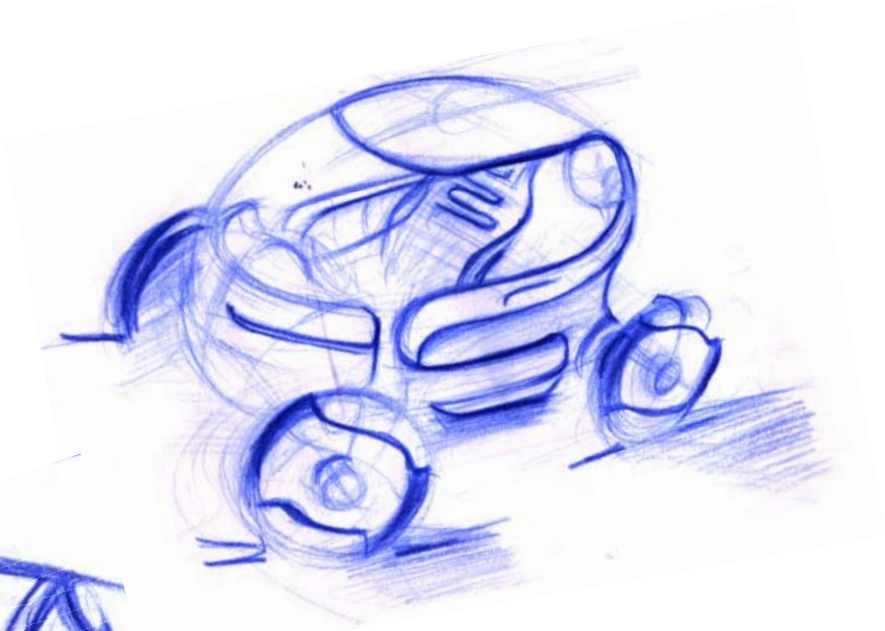
In Compressed mode it
turns into a single seater

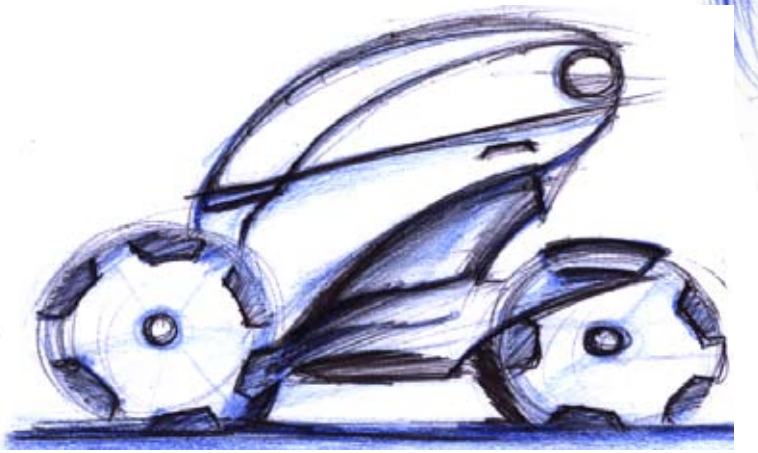






The seats also can be collapsable by having a ribbed design which meshes into each other to form a single seater from a double seater.



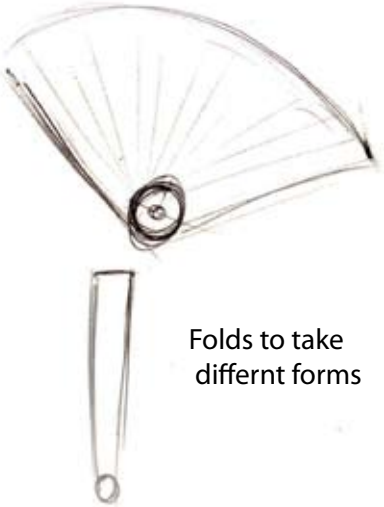


Layout and overall dimensions

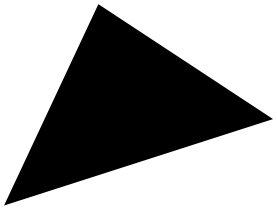
Concept 3 : Triangular platform

Ideation for collapsible designs was done looking at collapsible objects to get inspirations for my concepts.

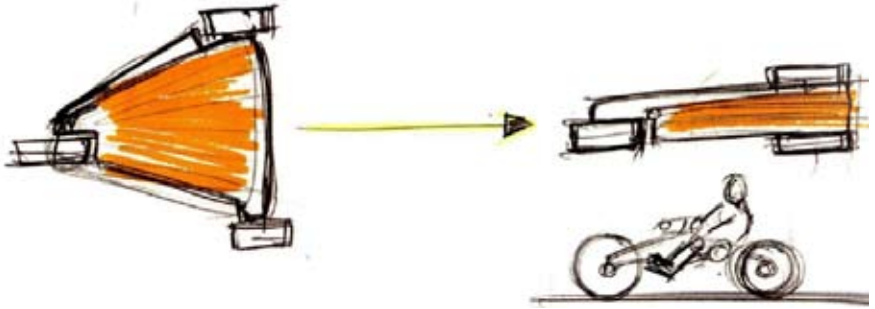
In this concept a japanese fan was used as an inspiration.



Folds to take differnt forms

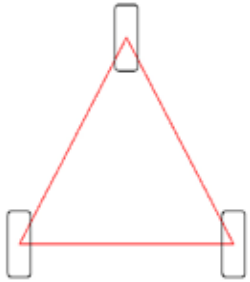


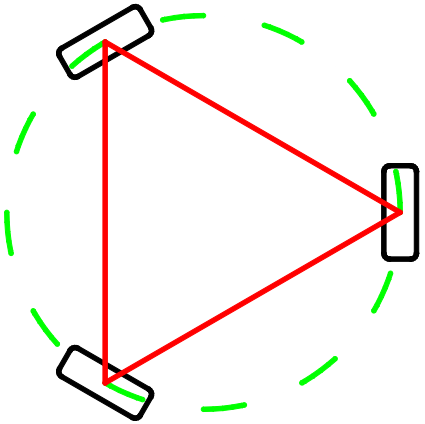
A triangular form



A triangular vehicle platform with three wheels at three corners which can fold to turn into a bike.

Another option was a triangular platform with three wheels at three corners.

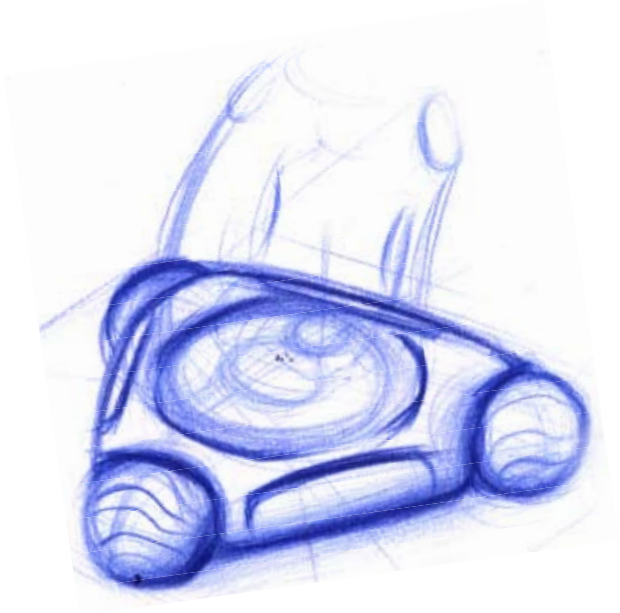


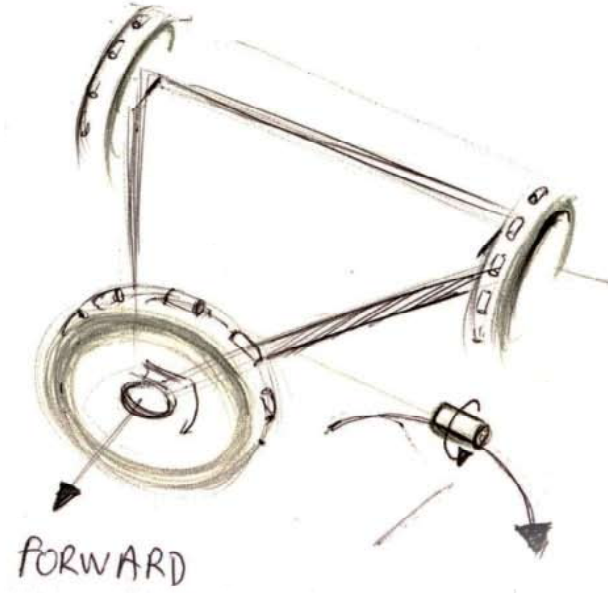


These three wheels can aligned in a circular orbit to provide 360 degrees of rotation for the vehicle at a stand still position.

Concept development

In this concept i tried to explore the possibilities of using this triangular platform to create a omni directional vehicle. Ideally rotaing sphere at the three corners could provide motion in all directions, but it is highly difficult to manufacture such a mechanism which houses a sphere and also provides a driving foce to it.





Another solution for a omni directional vehicle was to use a "Universal Wheel"

It is an assembly, which provides a combination of constrained and unconstrained motion when turning. When two or more of these wheels are mounted on a platform their constrained and unconstrained motions can be combined to provide omnidirectionality.

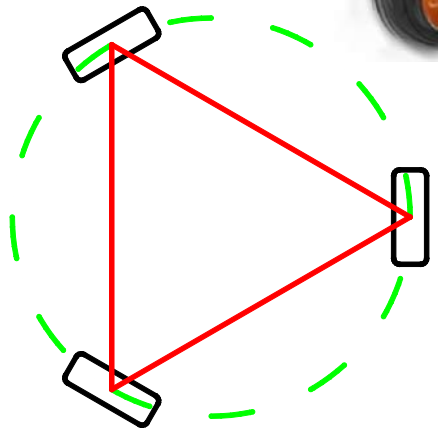
"Universal Wheel" involves a large wheel with many small rollers mounted on the periphery of the main wheel orientation. As the drive shaft turns, the wheel is driven in a normal fashion in a direction perpendicular to the axis of the drive shaft i.e., in the constrained direction of motion. At the same time, the small rollers allow the wheel to freely move parallel to the drive shaft, providing the unconstrained direction of motion.

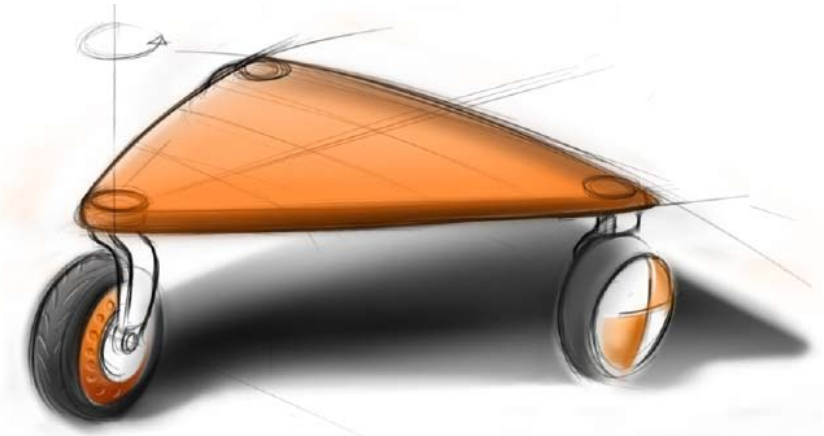
A simpler solution for omni directional movement could be achieved by looking at caster wheels.

A caster is defined as a wheel mounted to a fork, but has an additional offset steering joint. The steering joint allows the wheel to rotate freely in 360°. This allows for easy turning of objects without changing the direction of the chassis that the casters are mounted to.

The wheel is mounted on a specially designed arm which holds it from one side, the wheel could have a in wheel motor assembly to provide the driving force. The movement of the arm could be controlled by electo mechanical actuators.

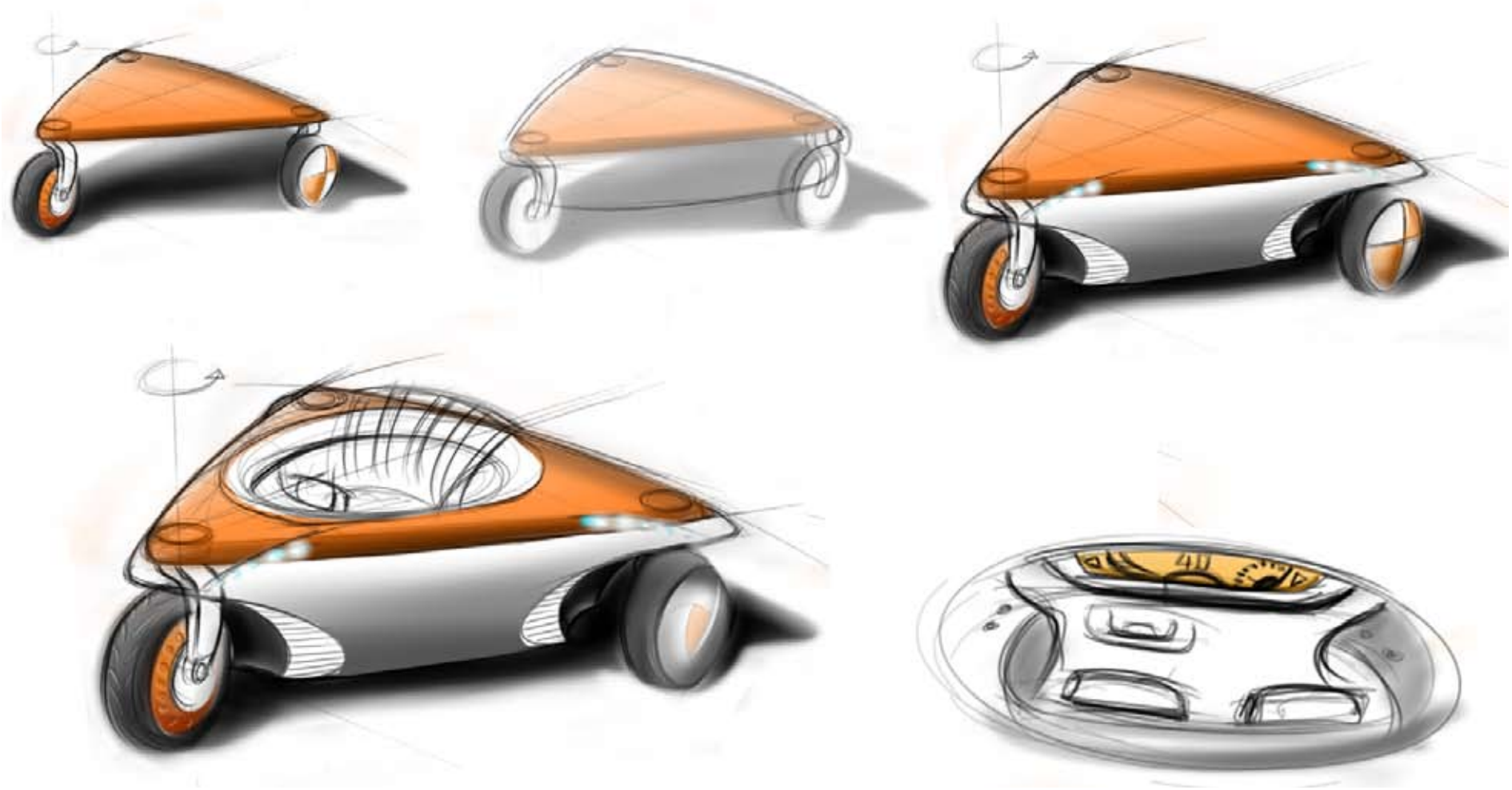
In this layout the arm could turn to align the wheels in a circular orbit to povide 360 degrees of rotation.





The above image shows a basic triangular platform which can be use to develope a omnidirectional vehicle.

Concept development

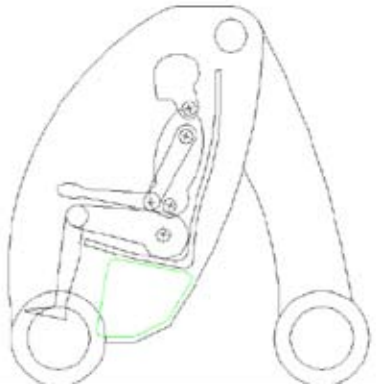


The images above show the basic concept development from a triangular platform to a vehicle with interior space to occoupy 2 persons.

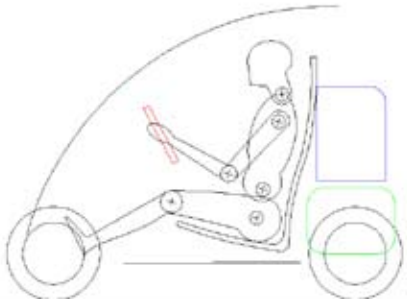
Concept evaluation criteria:

Three concpets were derived and evaluation was done to select the final concept which could be taken forward.

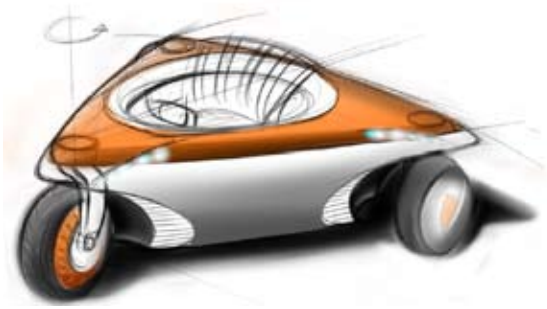
Concept 1

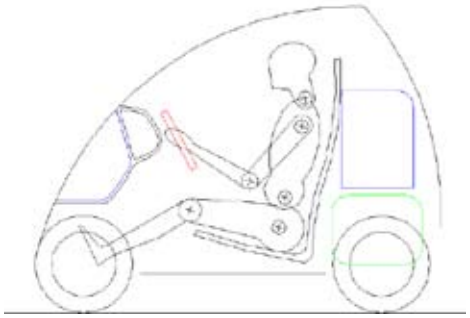


Concept 2



Concept 3





Evaluation Criteria:

Ease of parking

Minimum foot print

Concept Uniqueness

Maneuverability

Cost factor

'Car*ness*'

Evaluation chart:

The concepts were graded on a scale of 1-5

Evaluation Criteria	Credits	Concept 1	Concept 2	Concept 3
Ease of parking	9	3	4	5
Minimum foot print	8	4	2	4
Concept Uniqueness	7	4	3	4
Maneuverability	6	4	3	4
'Car*ness*'	5	3	4	2
Boot space	4	2	4	3
Total		134	127	151

Concept evaluation :

Three concpets which were derived were evaluated, based upon the evaluation done 'concept 3' got the maximum number of points followed by 'concept 1' and then 'concept2'.

Concept 2 was a vehicle which had a four wheel layout and could collapse along its width. In case of collapsible design it is a tedious process to compress a vehicle along its width and such a system would also have more complexity in its design which could increase the overall cost factor, hence concept 2 was not developed further and possibilities were to explored with concept 1 and concept 3.

It was seen that concept 3 occoupies a larger foot print compared to concept1 whereas concept 1 is a compact vehicle with unique features like tall boy design and varying wheelbase with length wise collapsibility. These features provided it a certain edge over other concepts and brought it closer to the design theme which is 'flexible mobility'.

So to improve the concept 3 concept amalgamation technique was followed where further ideation was done to implement the unique features of concept 1 into concept 3 so that concept 3 fits in better within the design theme of flexible mobility and stands out from the other 2 concepts.

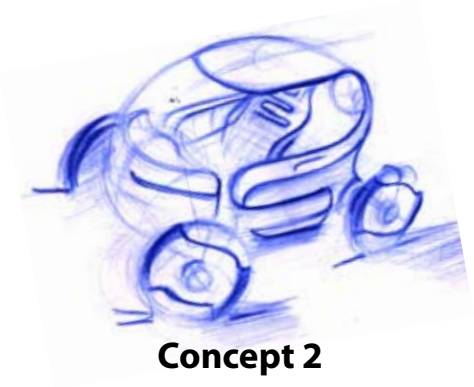
Key features of each concept and how they differ from one another.

Concept 1

Collapsible length wise

Tall boy design

Occoupies minimum foot print



Concept 2

Collapsible width wise

360 degrees self rotation

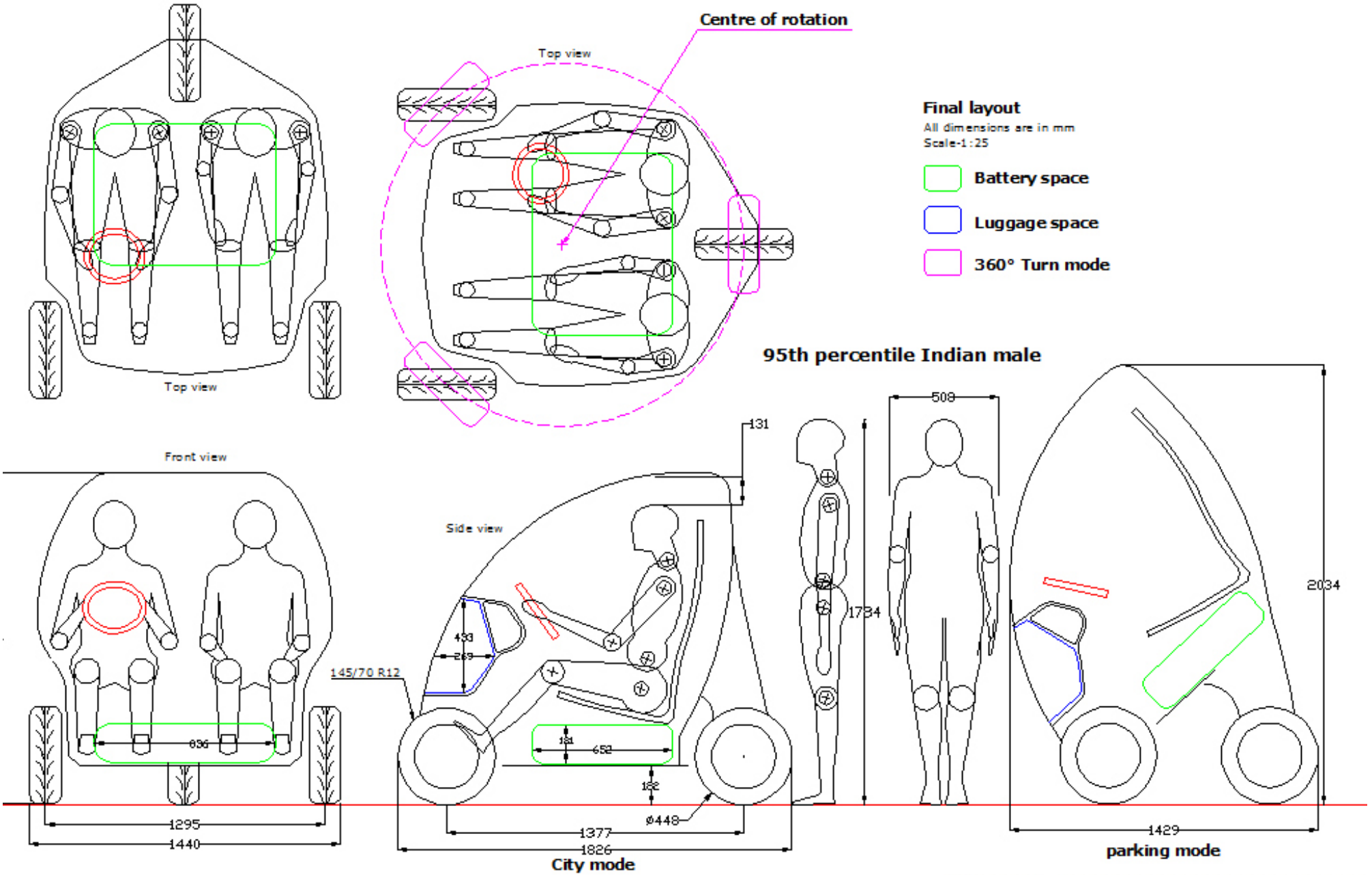
Higher boot space

Concept 3

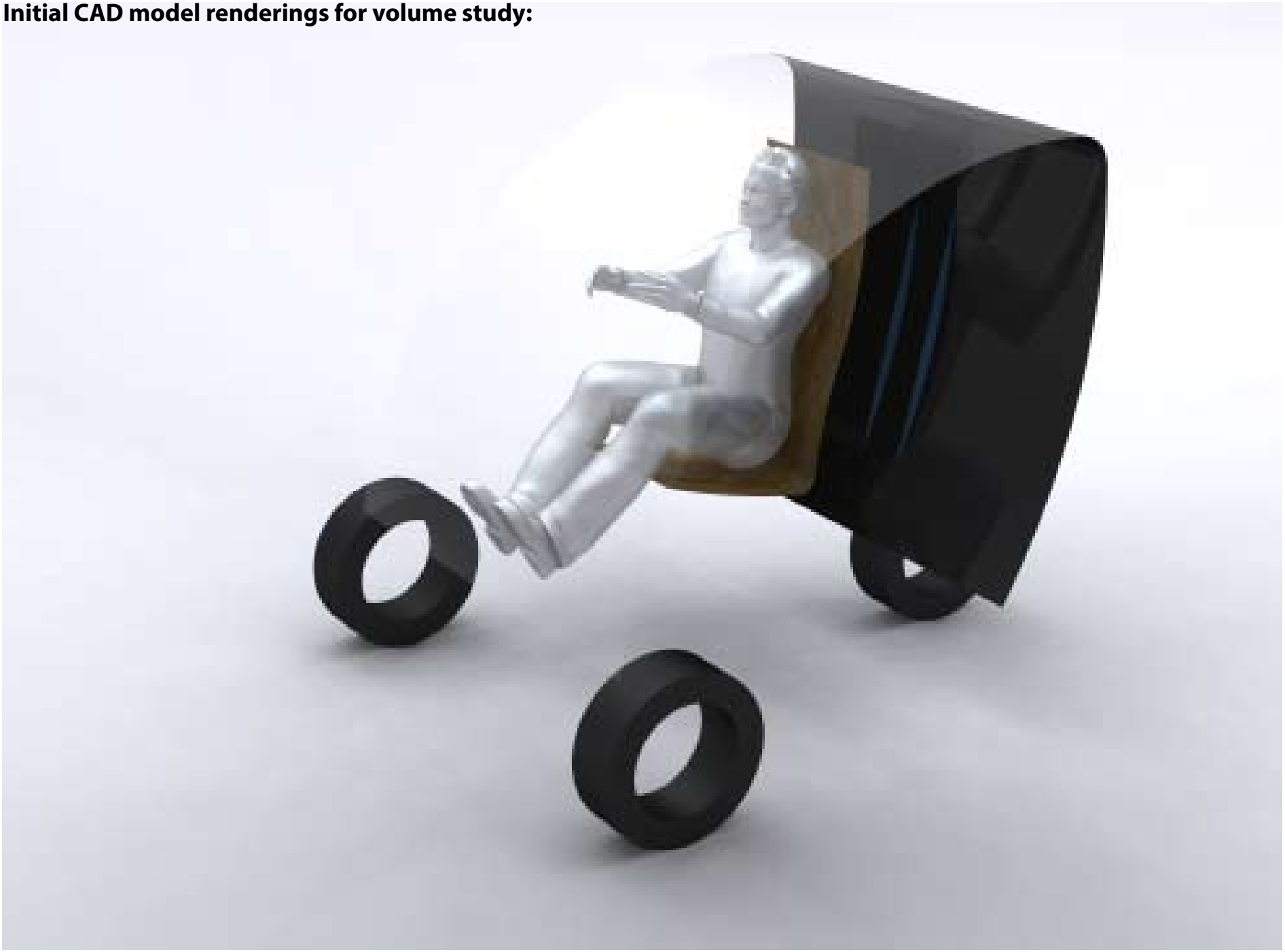
Triangular Platform, higher manuverability similar to a rickshaw

360 degrees self rotation.

Concept 1 + concept 3 - Final concept



Initial CAD model renderings for volume study:



Initial CAD model renderings for volume study:

Initial CAD model renderings for volume study:

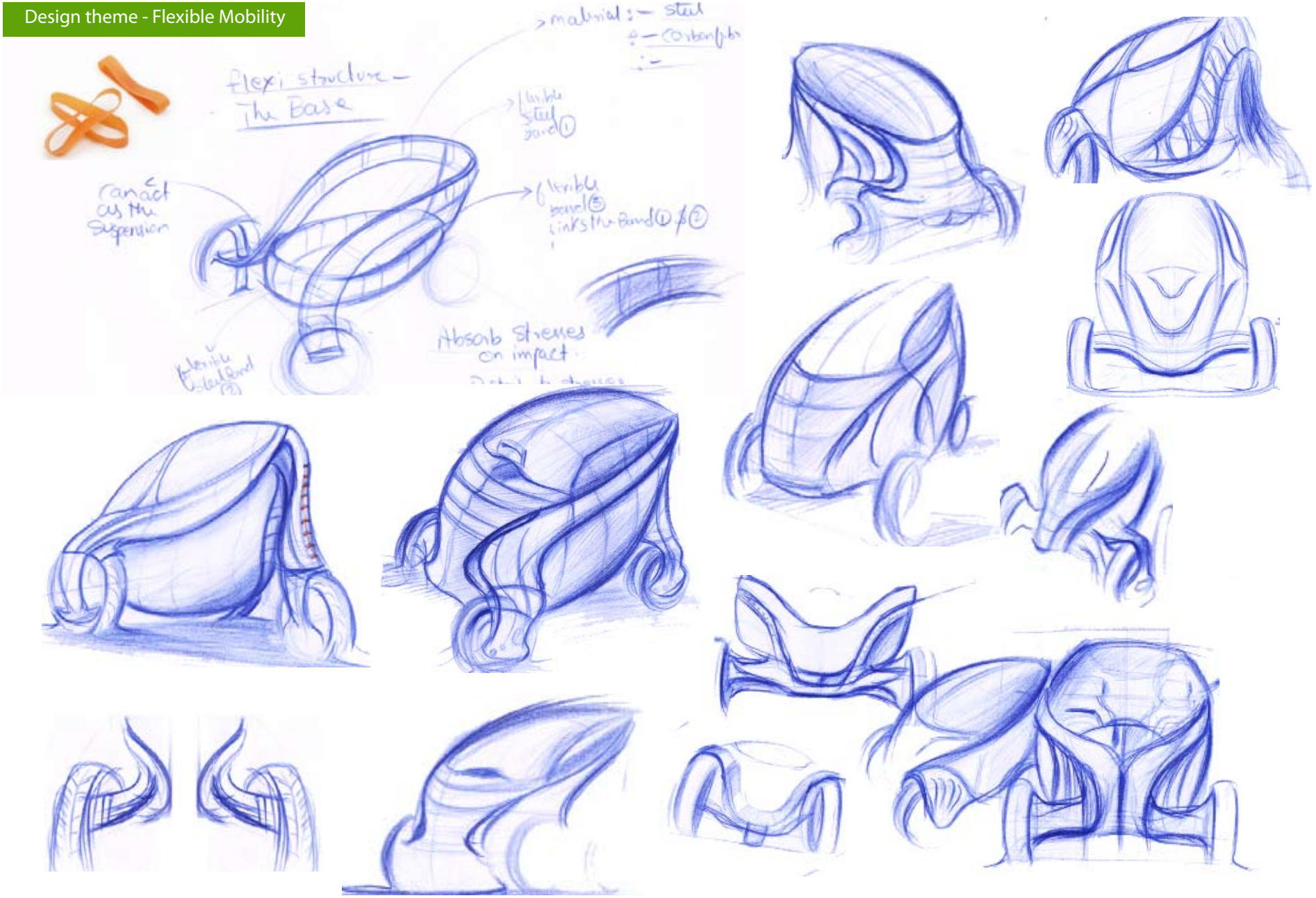
Initial CAD model renderings for volume study:

Initial CAD model renderings for volume study:

Initial CAD model renderings for volume study:

Mood board:


SPRINGY
AGILE
FLEXIBILITY
BANDS
FUNCTION FOLLOWS FORM
BIONIC
SMART MATERIALS
YOGA
ORGANIC
ARCHITECTURE


material :- steel
flexi structure -
The Base
flexible steel band
flexible band
can act as the suspension
Absorb Stresses on impact

Exterior

Interiors

clay modelling process

1:5 scale model

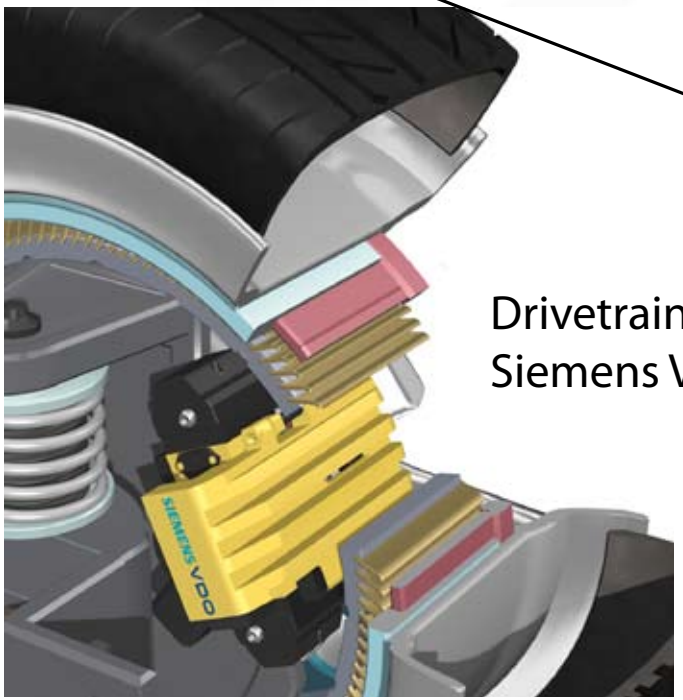
Collapsible Design

Driving mode

Parking mode

Zero turning radius

1:5 scale model



Drivetrain
Siemens VDO ecorner

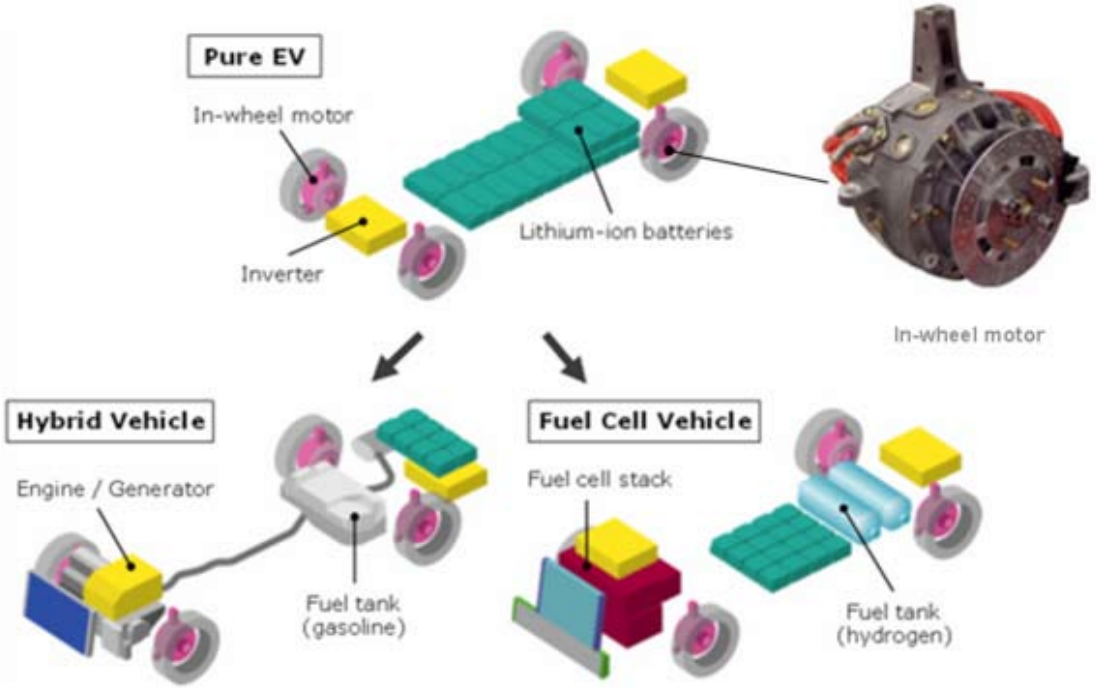
Eco friendly technologies:

To have a car which is non polluting it should run on a eco-friendly source of energy, some of the eco friendly technology platforms which are currently used in production cars are :

Battery electric vehicles--BEV

Hybrid electric vehicles--HEV

Fuel cell vehicles---FCV



Eco friendly technologies:

Battery electric vehicles - BEV
The battery electric vehicle, or BEV, is a type of electric vehicle (EV) that uses chemical energy stored in rechargeable battery packs. As with other electric vehicles, BEVs use electric motors and motor controllers instead of internal combustion engines for propulsion.

This technology is very reliable and cost effective. It is a zero emission platform.

Hybrid electric vehicles - HEV
A hybrid electric vehicle (HEV) is a hybrid vehicle that combines a conventional propulsion system with a rechargeable energy storage system (RESS) to achieve better fuel economy than a conventional vehicle. Its secondary propulsion system, additional to the electric motors, means that it does not require regular visits to a charging unit as a battery electric vehicle (BEV) does.

The primary purpose of a hybrid vehicle is to achieve better fuel economy compared to conventional IC engines. At the same time, hybrid engines cut down gases emitted and are generally considered a 'cleaner' alternative to combustion engines.

Fuel cell vehicles - FCV
A Fuel cell vehicle or FC vehicle (FCV) is any vehicle that uses a fuel cell to produce its on-board motive power. Fuel cells onboard the FCVs create electricity using hydrogen fuel and oxygen from the air.

Fuel cells are in their early developnment phases. The problems concerning the storage of hydrogen onboard the vehicle and necessity for having hydrogen refueling stations make this idea difficult to implement in the current Indian scenario.

A Hybrid platform increases the effiency and reduces emissions rather than eliminating it. HEV is better than a conventional IC engine car, but BEV is a better option compared to a HEV as it is a zero emission platform.

Fuel cell technology is still far away from being implemented for mass production cars, as it is still in development phase and implementing costs are higher.

A BEV platform is the most economical and cost effective option.

Comparing all the three eco-friendly platforms BEV was chosen as the ideal platform for development of a future mobility solution.

BEV-Battery electric vehicle:

The concept of battery electric vehicle is to charge batteries on board vehicle for propulsion using the electric grid.

The main advantages of battery electric vehicles are:

- No pollutants are emitted directly by the vehicle potentially reducing urban pollution.
- Gasoline is indirectly replaced by whatever is being used to generate domestic electricity, reducing dependence on foreign commodities.
- The electrical energy stored within the battery can be generated by any source, including renewable, nuclear, natural gas, coal and petroleum.
- It is also possible to implement regenerative bracking to increase the vehicle efficiency.
- Battery electric cars are becoming more and more attractive with the advancement of new battery technology (Lithium Ion) that have higher power and energy density (i.e. greater possible acceleration and more range with less batteries).

Drive train

In wheel motors

The concept will be using wheel motors.
The wheel motor also called wheel hub motor, (wheel hub drive, hub motor or in-wheel motor) is an electric motor that is incorporated into a wheel and drives it directly.
The advantages of In wheel motors are:

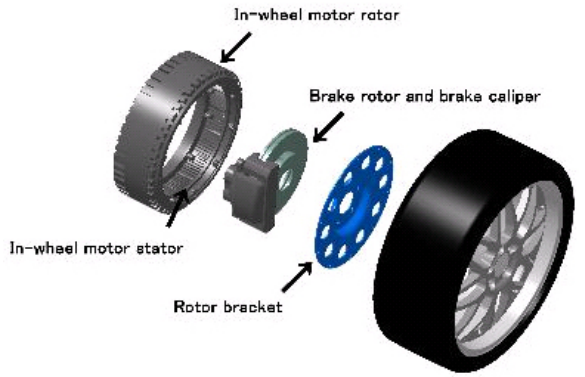
- **Energy efficiency is one of the biggest advantages of direct drive in-wheel motors.** A conventional vehicle uses mechanical means to transmit power from a centrally mounted engine/motor to the the wheels. The mechanical transmission must have multiple gear ratios to compensate for an IC engine having no usable power at engine speeds lower than 1000 rpm.

- **An electric motor has maximum torque from zero rpm** so it does not need as many gears as an ICE, but with a single electric motor in a vehicle it still needs mechanical transmission. A fundamental fact about gear power transmission is that each gear in a mechanical transmission introduces power loss. With several gears between an engine and wheel the losses add up to approx 30% in a two wheel drive vehicle and 40% in a four wheel drive vehicle. By mounting an electric motor directly inside a wheel and deleting the mechanical transmission then there are exactly zero transmission losses between motor and wheel.

- **Regenerative braking is another advantage of wheel motors.** A motor will easily turn into a generator any time the rotor is traveling faster than the applied drive frequency. In practice this means any time a vehicle is not accelerating, it will naturally regenerate.

- **Drive by wire.** Each wheel motor can be precisely electronically controlled and therefore, modern control systems such as ABS, traction control and stability control can become software functions and can be included in any wheel motor equipped vehicle at very little extra cost. In fact with electronic control of brakes (and acceleration) opens a whole world of new automated vehicle dynamics options including.

- **Weight savings.** Eliminating mechanical transmission inc. gearboxes, differentials, drive shafts and axles provides a significant weight and manufacturing cost saving.



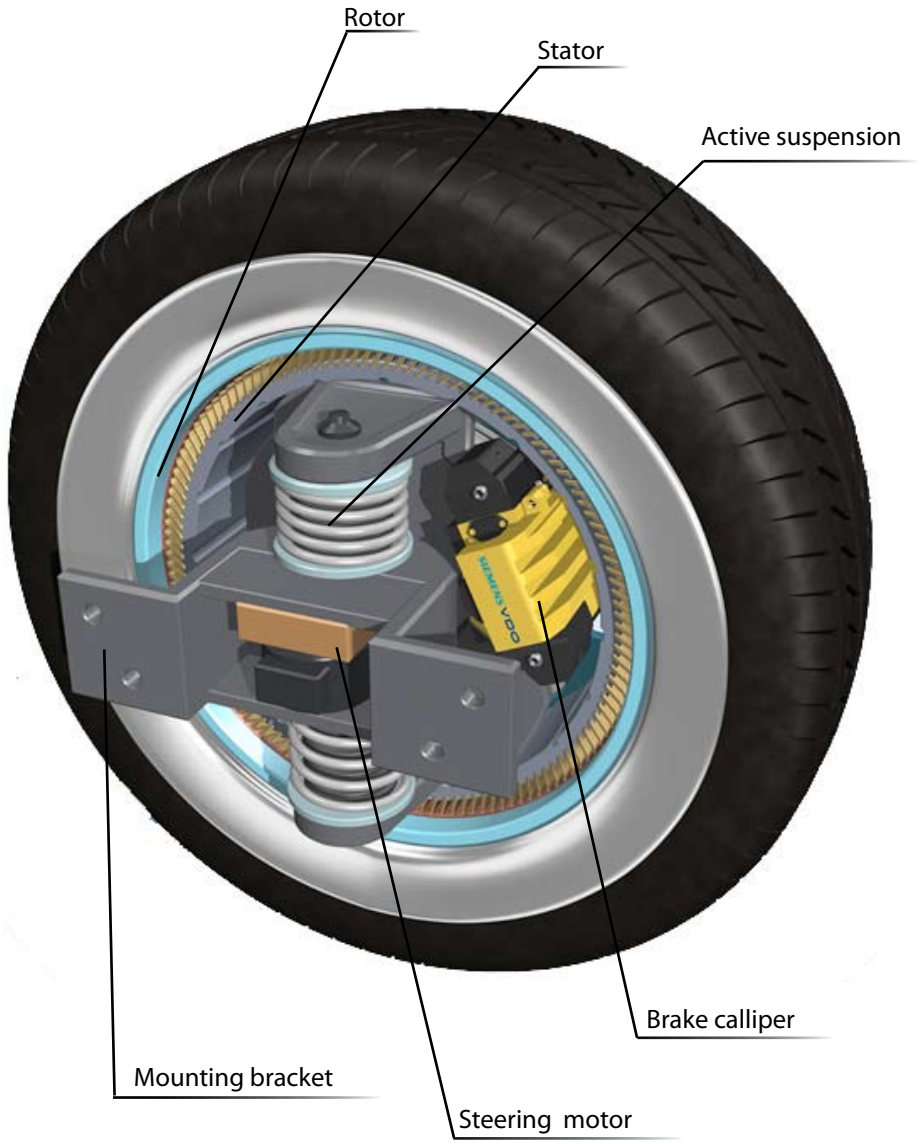
Siemens VDO-eCorner

motor-in-hub concept
The final concept will be driven on this platform

Siemens VDO's eCorner concept integrates an automobile's drivetrain, steering, shock absorbers and brakes into a single wheels, completely removing the need for the traditional engine architecture. The transition from an internal combustion engine to an eCorner wheel hub motor will result in decreased emissions, increased energy efficiency and lower costs for consumers due to the elimination of hydraulic and mechanical systems to maintain and service.

The eCorner concept has a electronic motor integrated into the wheel hub, allowing for more efficient power use and independent rotation from the rest of the car. Next up is an active suspension system and Siemens' very own electronic wedge brake (EWB). Finally, the independent steer-by-wire function built into the wheel allows for some very interesting maneuverability. Siemens expect cars that would use such functionality to be common in 5 years or so.

The drive-by-wire technology is projected to use up to 96 percent of the available energy needed for vehicle propulsion, where as current gasoline and diesel engines use less than 50 percent of the energy and future full hybrids systems are expected to use approximately 85 percent. eCorner saves and stores useful energy when the vehicle reduces speed, because the wheel hub motors act as auxiliary brakes using a generator effect, which helps to charge the battery.



Technical specifications:

Type	: Hatchback
Doors	: 2
Pay load	: Maximum 2 adults
Top speed	: 60 km/hr

Dimensions: (City/Parking) mode

length	: 1826/1249 mm
width	: 1440 mm
height	: 1534/2034 mm
wheel base	: 1377/748 mm
ground clearance	: 180 mm
Tyres	: 165/70 R13

Integrated power system

Technology	: Siemens VDO-eCorner
Motor	: Brushless electric in wheel motors with permanent magnets
Battery weight	: ~80/100 kgs
Battery technology	: Lithium-ion

All dimensions are in mm-millimetres

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Thank you

Concept 1 concept2 concept 3 evaluation chart

The Omnidirectional Vehicle – The concept of having a mobile platform which was capable of movement in any direction without actually turning at any stage was appealing at the very first instance. Not only because it did not employ the redundant turning motion at any stage but also because it made use of the vector addition concept which said that by adjusting the three vectors (each inclined to the other at 120°) we could actually get the required direction vector.

The reduction of the redundant turning motion also helped us to get rid off the space, which any vehicle would take while turning. It could very well be imagined that the platform was capable of sharp corner turns. Thus it could easily be employed for parking purposes. Apart from this the platform could be taught to follow a path and then it could very well be used a spy platform in the enemy camp.

Thus began the journey of taking the project up as the degree project. We have tried our level best to make the model as close to the specifications we proposed when we started the campaign.

A "Universal Wheel" is an assembly, which provides a combination of constrained and unconstrained motion when turning. When two or more of these wheels are mounted on a platform their constrained and unconstrained motions can be combined to provide omnidirectionality.

Universal Wheel involves a large wheel with many small rollers mounted on the periphery of the main wheel orientation. As the drive shaft turns, the wheel is driven in a normal fashion in a direction perpendicular to the axis of the drive shaft i.e., in the constrained direction of motion. At the same time, the small rollers allow the wheel to freely move parallel to the drive shaft, providing the unconstrained direction of motion.

In principle the roller axis can be mounted at any non-zero angle with respect to the wheel orientation. One degree of freedom is in the direction of wheel orientation. The motion of rollers provides the second DOF. The third DOF is rotational slip about the point of contact.

Two wheelers are the most widely used means of transport in India. But for many riders they are lot more than just a vehicle. It's a product which they use to reflect their identity. My project aims at designing a bike which is targeted at Indian youth.

Data collection was done to understand the history of two wheelers in India. Different segments and sub segments in the Indian bike industry were studied for their distinguishing character and design values. With user study and bench marking various aspects of bikes like styling, performance and usability were compared. A design brief was prepared after analyzing the data. Creative modes of explorations like metaphors based styling was done based on the themes which reflected Indian youth. Ideation was done to generate concepts. These concepts were then refined and based upon user feedback one was chosen and was developed further as the final concept.