Bionics in Mobility Design

Smart Transportation for Smart Cities

MOBILITY & VEHICLE DESIGN PROJECT II

MVD II-31

PANKAJ KULI

146390008

GUIDE : PROF. NISHANT SHARMA

INDUSTRIAL DESIGN CENTRE

INDIAN INSTITUTE OF TECHNOLOGY, BOMBAY

2016

DECLARATION

I declare that this written submission represents my idea in my own words, and where others' ideas or words have been included, I have adequately cited and referenced 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/sources in my submission. I understand that any violation of the above will be cause for disciplinary action by the institute and can also invoke penal action from the sources from which proper permission has not been taken, or improperly cited.

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APPROVAL SHEET

This Mobility & Vehicle Design project report entitled “Bionics in Mobility Design”, by Pankaj Kuli is approved in partial fulfilment of the requirement for Master of Design degree
In Mobility and Vehicle Design.

Project Guide :

Chair Person:

Internal Examiner.:

External examiner:

Acknowledgment

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Pankaj Kuli

Date:.

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0. Abstract

Design inspired by nature, bionic design, biomimetic, biomimicry, or biologically inspired design have been a source of inspiration for design activities for a long time. Design endeavors in several technical disciplines may lead to ground-breaking new concepts when natural systems are considered as a source of inspiration. Despite the success attained in several cases from the use of this approach in design, the bio-inspired design approach may still have room for improvement, in order to become more systematic.

1. Introduction

The concept of bionics, with a history of human survival and development from ancient to modem, has been keeping pace with the times. Since the ancient times, the nature has been the source of human invention and discovery of important principle of science and technology. For example, Ban LU lived during the Spring and Autumn Period invented saws by biomimetic design, which rely on the morphological characteristics of the toothed grass, and became one of the earliest bionic designers in China. Before three thousand years BC, our ancestors imitated bird nest in the tree to defense beast. The imitations of the entrance hall in front of some ancient temples are the elephant legs. Leonardo Da Vinci lived in A.D. 1,500 years emulated bird's wing for bionic flying, and a series of equipment drafts and models are made. They became the prototype of the modem helicopters. Based on the imitation of fishes, ancients logged for making ship. The pectoral fins and tail fin of the fishes was be imitated as twin screw and rudder, so freedom of water transportation is obtained.

Through a detailed study and imitation of the flying organs of birds, and according to the principle of bird's flying structure, then the manned flight glider can be made. In modem times, some disciplines such as biology, electronics and dynamics promote the rapid development of bionic design, especially in the areas of industrial design. Using bionic designs for the variety of biological simulation and re-creating bring many excellent products.

2. Pre-research

IR 1

Before arriving at an inspiration, a pre-research was done which includes study of Bionics and various example of bionics in the field Mobility Design.

2.1. Bionics

What is Bionics?

Bionics is the application of biological methods and systems found in nature to the study and design of engineering systems and modern technology

The word **bionic** was coined by **Jack E. Steele** in 1958, possibly originating from the technical term bion (pronounced *BEE-on*; from Ancient Greek: βίος), meaning 'unit of life' and the suffix -ic, meaning 'like' or 'in the manner of', hence 'like life'.

Bionics ≠ Biomimetic ≠ Biomimicry ?

Bionics

IR 2

Coined by an engineer and psychiatrist of the Air Force's Aerospace Medical Division, **Jack E. Steele** in 1958 with emphasis on neuroanatomy.

Biomimetics

IR 3

Coined by a biomedical engineer **Otta H. Schmitt** - Concentrated on producing a device that explicitly mimicked the electrical action of a nerve.

Biomimicry

IR 4

Coined by **Janine Benyus,** a natural sciences writer with a degree in natural resource management and English literature/writing from Rutgers University.

Coined by different people at different point of time for different initial purposes.

The exact difference between these words is still a debate.

However, terms like biomimicry or biomimetics are more preferred in the technology world in efforts to avoid confusion between the medical term bionics.

All of them have different intention but same goal – To derive inspiration from nature for the purpose of better design.

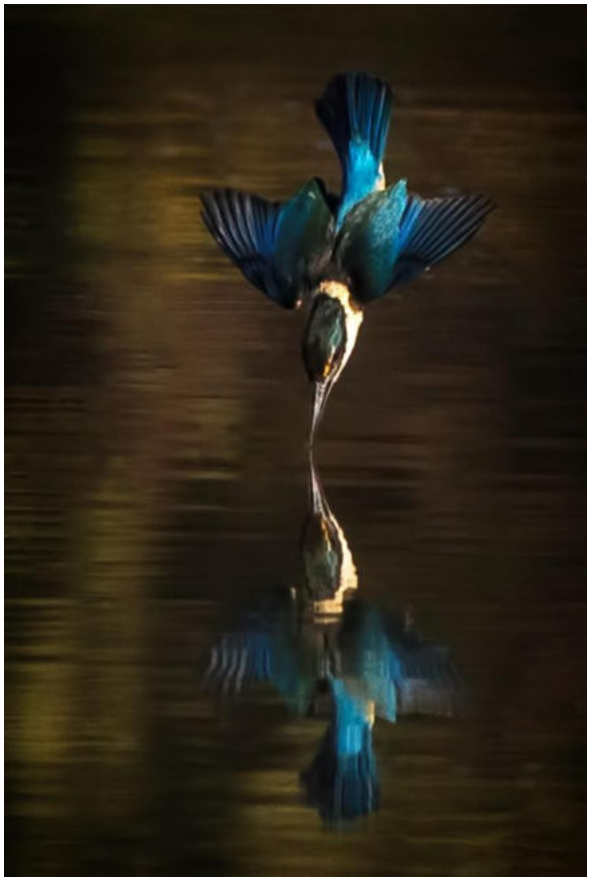
IR 5

Why bionics ?

IR 6

Nature has 3.8 billion years of design experience. learning from these deep design lessons, we can model innovative strategies, measure our designs against these sustainable benchmarks, and allow ourselves to be mentored by nature's genius using Life's Principles as our aspirational ideals.

IR 7



IR 8

2.1. Examples

2.1.1. SHINKANSEN BULLET TRAIN

Inspiration

kingfisher, a fish-eating fowl that creates barely a ripple
when it darts into water in search of a meal.

Innovation

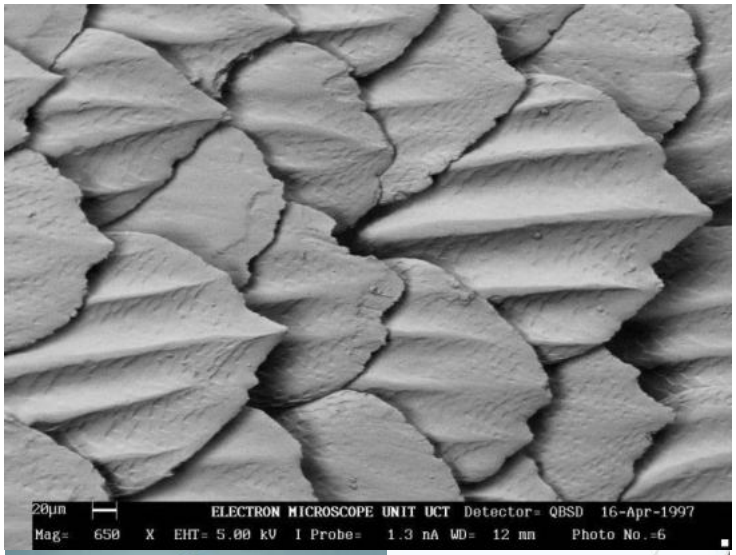
High speed train silently slices through air

The Shinkansen Bullet Train has a streamlined forefront and structural adaptations to significantly reduce noise resulting from aerodynamics in high-speed trains.

The more streamlined Shinkansen train not only travels more quietly, it now travels 10% faster and uses 15% less electricity

.

IR 9



IR 10

IR 11

2.1.2. DENTICLES

Inspiration

The skin of sharks reduces drag by having a scales with longitudinal grooves.

Innovation

Decrease fuel consumption in water craft, increase performance in swimsuits, reduce friction inside pipes.

Industrial Sector(s) interested in this strategy

Transportation, manufacturing

IR 12

2.1.3. FEET ADHESIVE

Inspiration

Geckos have no difficulty mastering vertical walls and are apparently capable of adhering themselves to just about any surface. However gecko toes are not sticky in the usual way like chemical adhesives. Instead, they can detach from the surface quickly and remain quite clean around everyday contaminants even without grooming.

Innovation

Synthetic setae emulate the setae found on the toes of a gecko and scientific research in this area is driven towards the development of dry adhesives.

Industrial Sector(s) interested in this strategy

There has been a wide range of application of synthetic setae, also known as "gecko tape", ranging from nanotechnology and military uses to health care and sport

IR 13

IR 14

2.1.4. Honeycomb Tires

The tire of the future doesn't need air, therefore it can't go flat – which could be a real lifesaver for members of the military. Responding to the government's need for tires that can support lots of weight, survive an IED attack and still speed away at up to 50mph, developers Resilient Technologies and Wisconsin-Madison's Polymer Engineering Center realized that nothing was more perfect than Mother Nature's design of the honeycomb. The series of hexagon shapes is extremely strong, and distributes weight evenly for a smooth ride

2.1.5. FISH CAR

IR 15

Inspiration
Shape of boxfish provides stability in turbulent water by creating self-stabilizing vortices from the water itself.

Innovation
Creating aerodynamic transportation.

Industrial Sector(s) interested in this strategy
Transportation, Energy

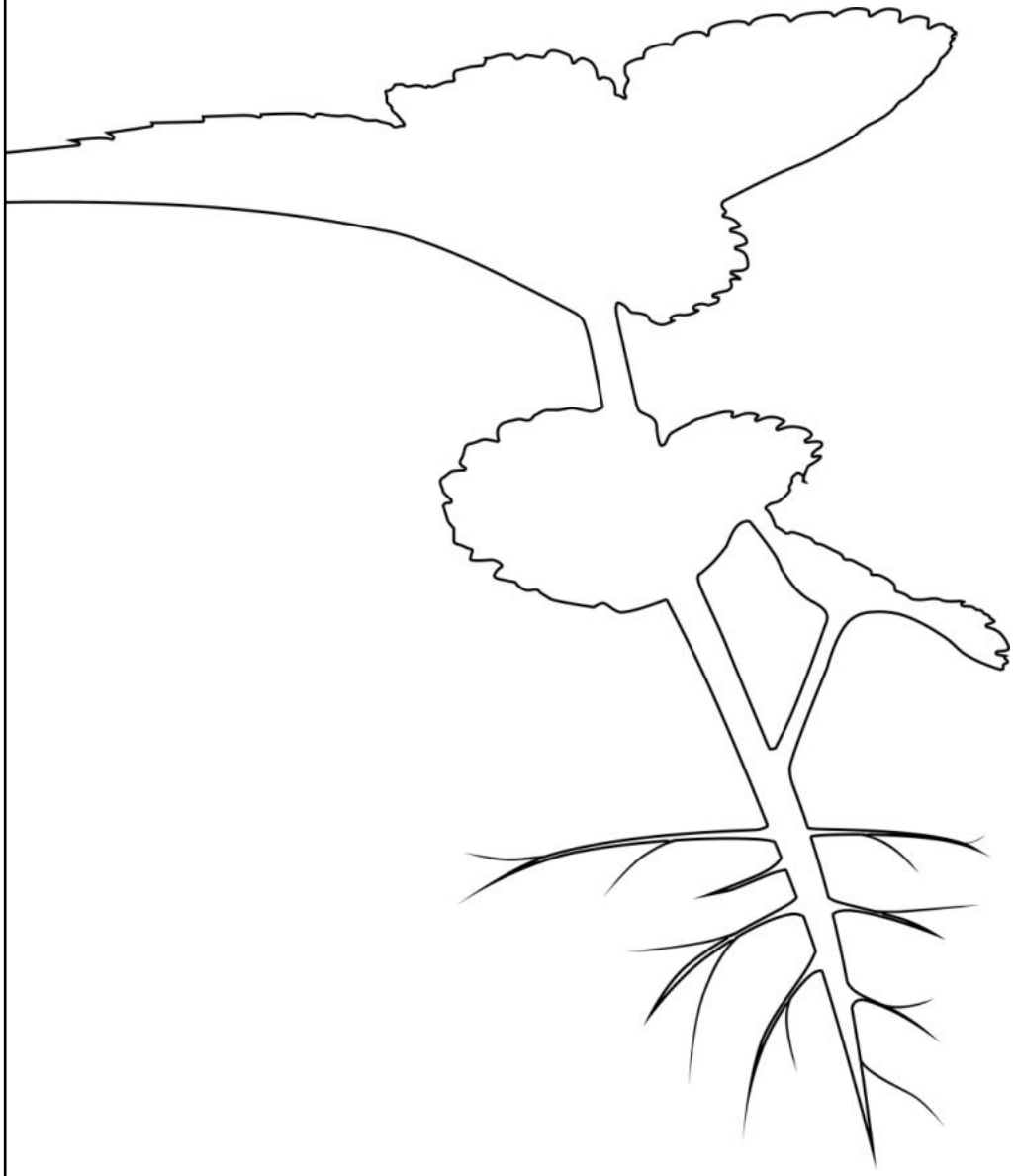
IR 16

3. Inspiration

Plant

According to those who believe that all living things are a result of evolution, life evolved from simple to complex. Plants, which are simpler than animals, are believed to have evolved before animals. Plants have various structures that enable them to survive, transport structures in plants by which water and trace elements move

For over three billion years, plants have been using sunlight as its primary energy source in photosynthesis. In the course of this process plants use sunlight to split water and produce energy-rich chemical compounds from carbon dioxide.

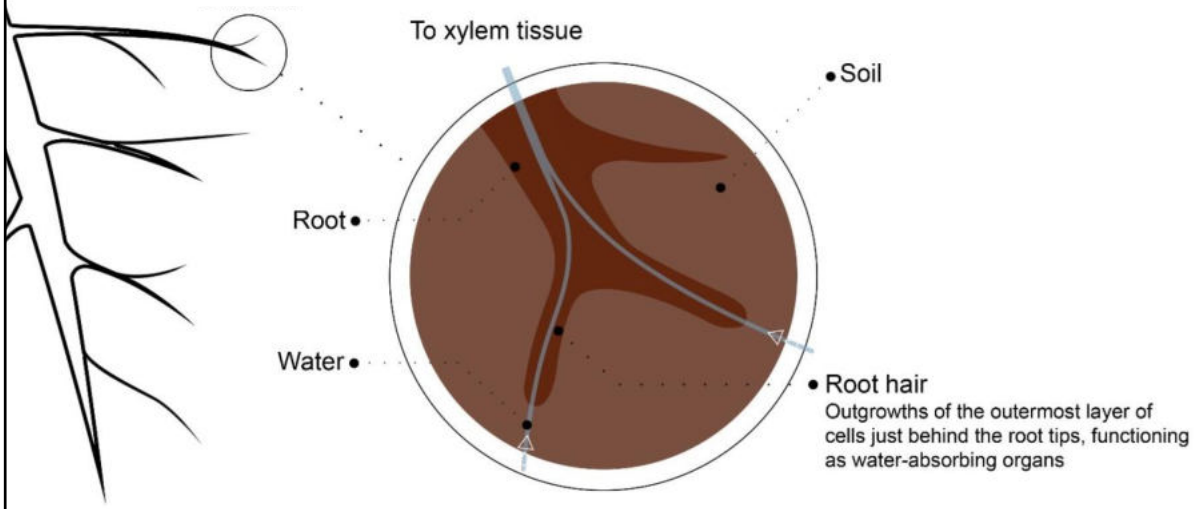


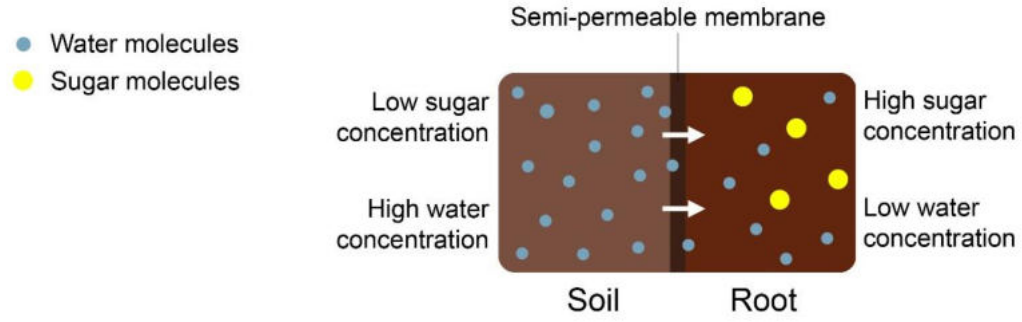
4. Research

4.1. Plant

The research include the study of various parts of a plant in detail, including transportation of nutrients and water, and photosynthesis.

4.1.1. Root





Mechanism of water absorption

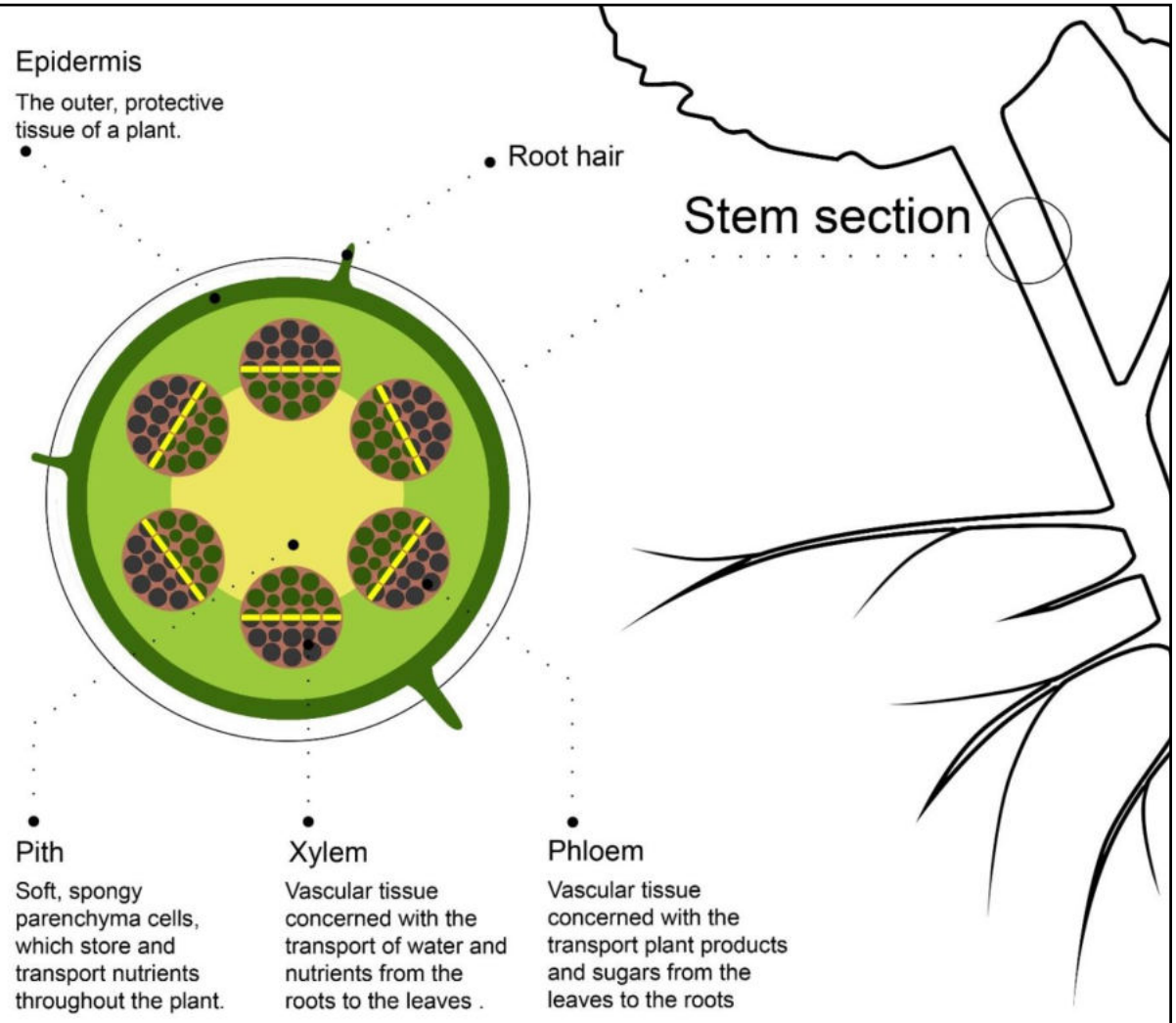
Water is highly essential for plants for various metabolic activities. Land plants get their water supply from soil which serves as the source of water and minerals to them. The way in which water from soil enters roots, particularly to the root xylem, is called "mechanism of water absorption".

Plants absorb water from the soil by osmosis. Root hair cells are adapted for this by having a large surface area to speed up osmosis. The absorbed water is transported through the roots to the rest of the plant where it is used for different purposes: It is a reactant used in photosynthesis

Osmosis is the spontaneous net movement of solvent molecules through a semi-permeable membrane into a region of higher solute concentration, in the direction that tends to equalize the solute concentrations on the two sides. It may also be used to describe a physical process in which any solvent moves across a semipermeable membrane separating two solutions of different concentrations.

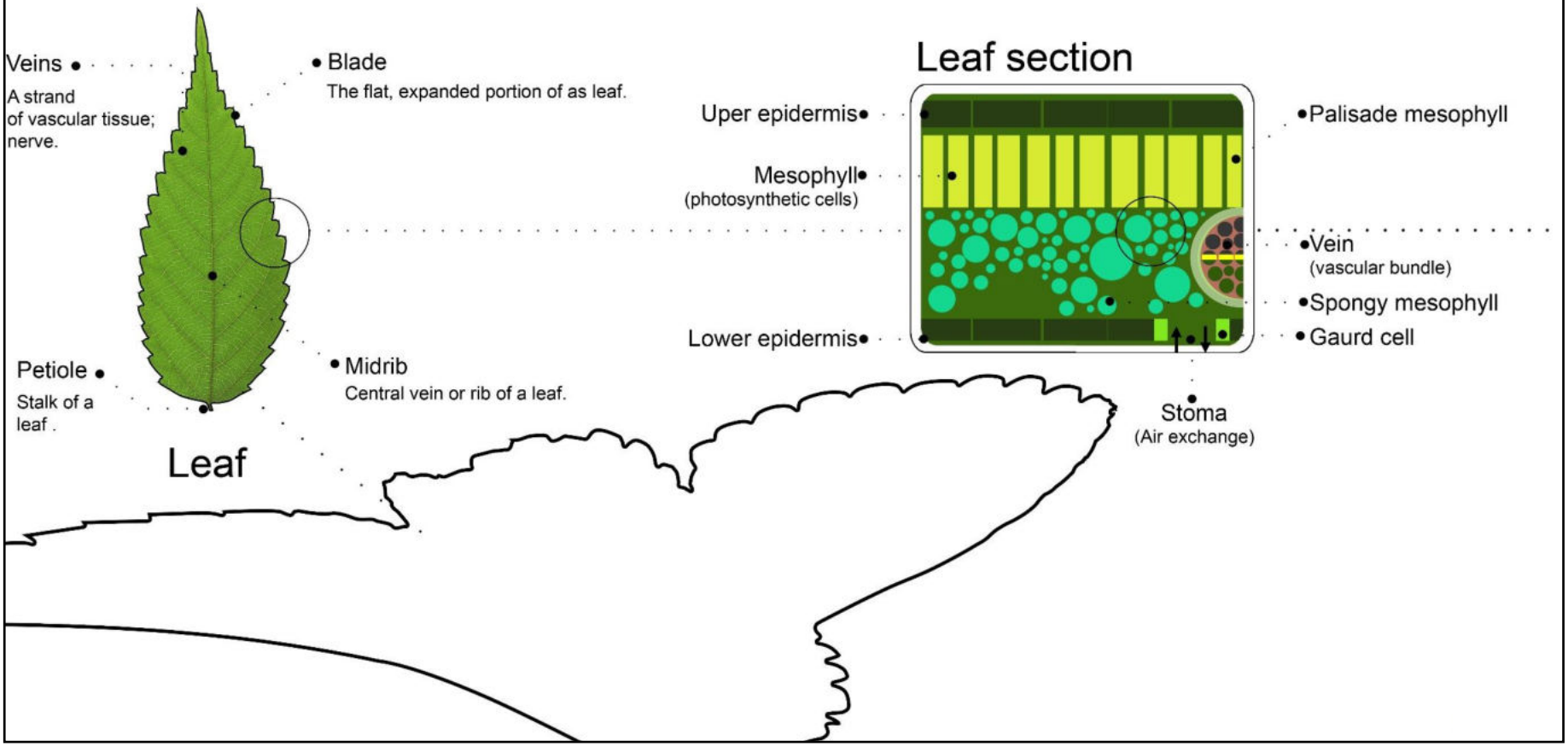
4.1.2. Stem

Stems have four main functions which are: Support for and the elevation of leaves, flowers and fruits. The stems keep the leaves in the light and provide a place for the plant to keep its flowers and fruits. Transport of fluids between the roots and the shoots in the xylem and phloem. Storage of nutrients.



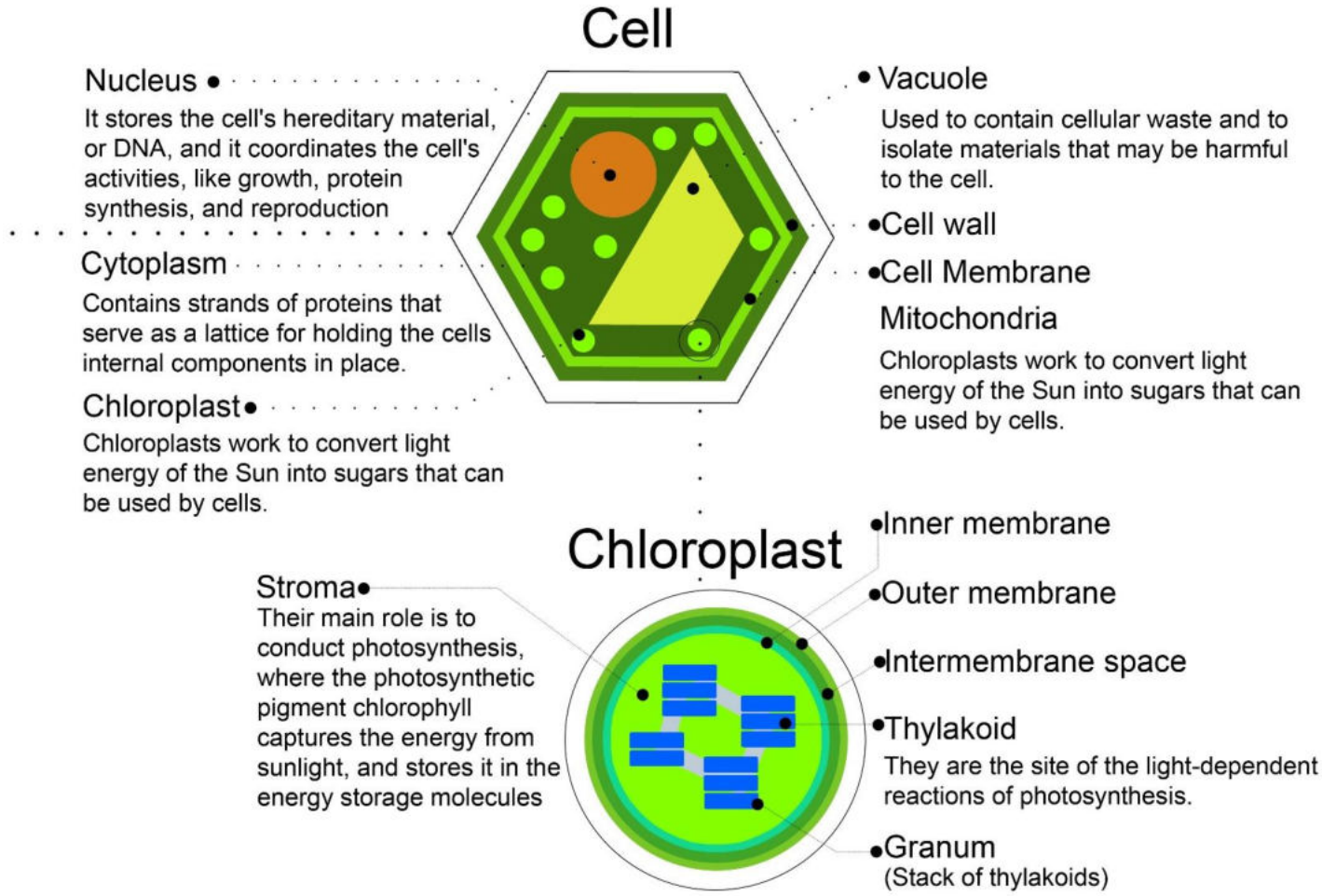
4.1.3. Leaf

Typically leaves are broad, flat and thin, thereby maximizing the surface area directly exposed to light and promoting photosynthetic function. They are arranged on the plant so as to expose their surfaces to light as efficiently as possible without shading each other.

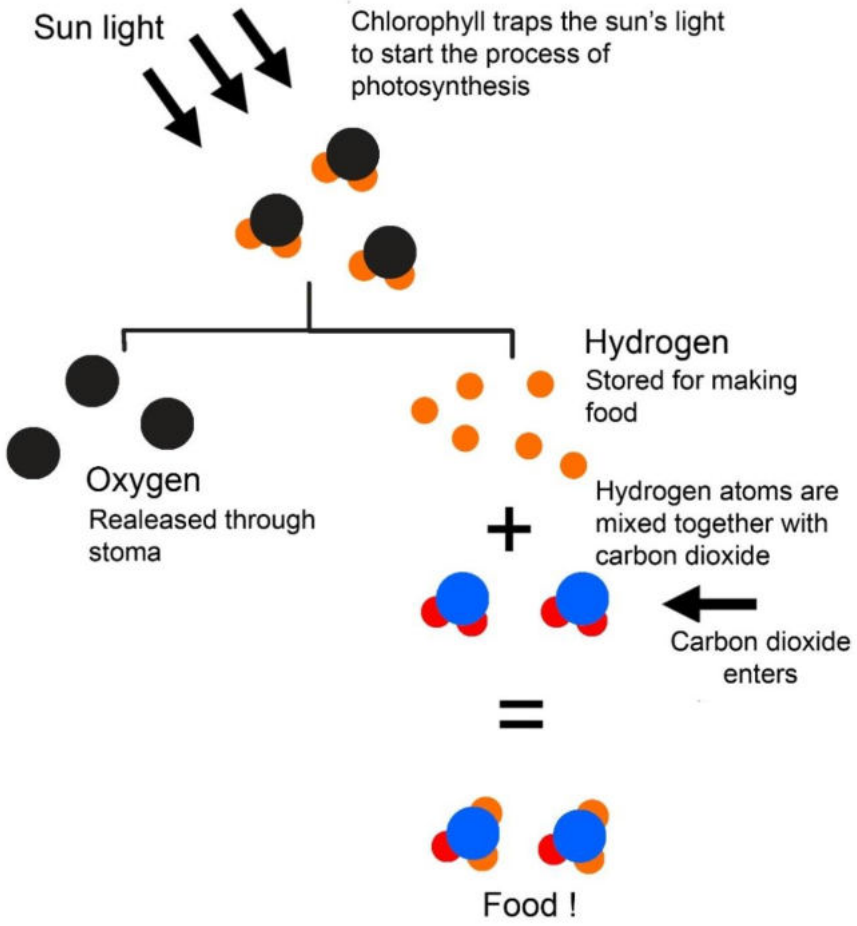


4.1.4. Cell

Mesophyll cells are specialized for photosynthesis. These cells in the middle of the leaf contain many chloroplasts, the organelles that perform photosynthesis



4.2 Photosynthesis



Photosynthesis is a process used by plants and other organisms to convert light energy, normally from the Sun, into chemical energy that can be later released to fuel the organisms' activities.

In all green plants, this process occurs in the leaves.

Carbon dioxide and oxygen enter and exit the leaves through pores called stomata.

Water gets delivered to the leaves from the roots through a vascular system.

The chlorophyll, present in the chloroplasts of the leaf cells helps in absorbing sunlight.

Chlorophyll and other carotenoids help in transferring light energy.

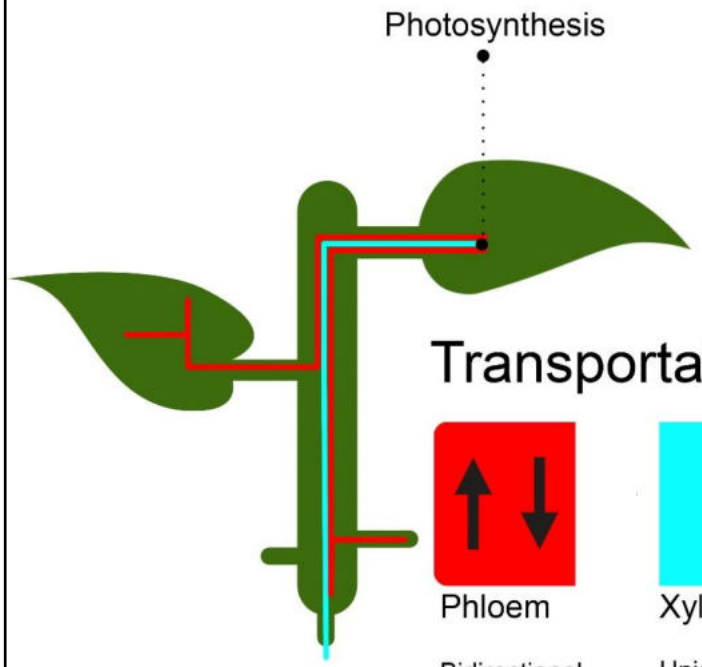
Photosynthesis is carried out in two phases.

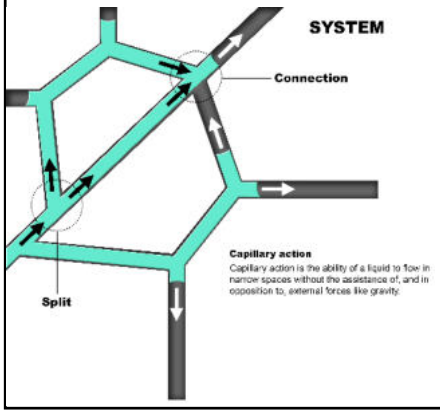
The light reactions produce carbohydrates by using ATP and NADPH

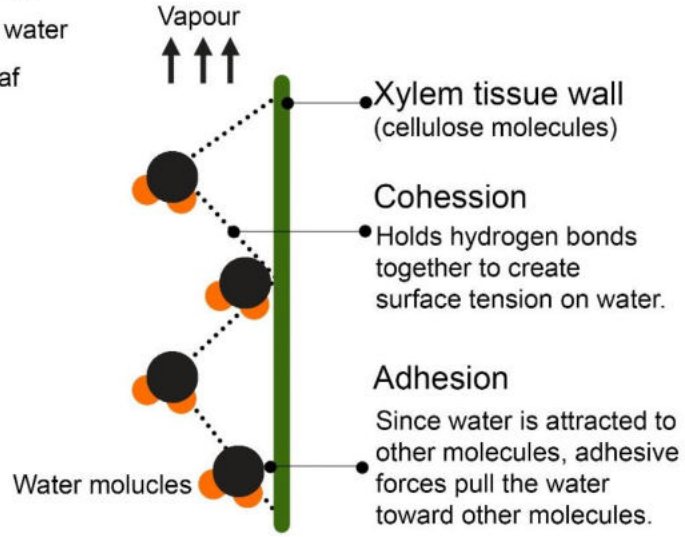
The dark reaction synthesizes sugar from carbon dioxide with the help of ATP and NADPH.

4.3 Transpiration

Transpiration is the process by which moisture is carried through plants from roots to small pores on the underside of leaves, where it changes to vapor and is released to the atmosphere. is essentially evaporation of water from plant leaves.



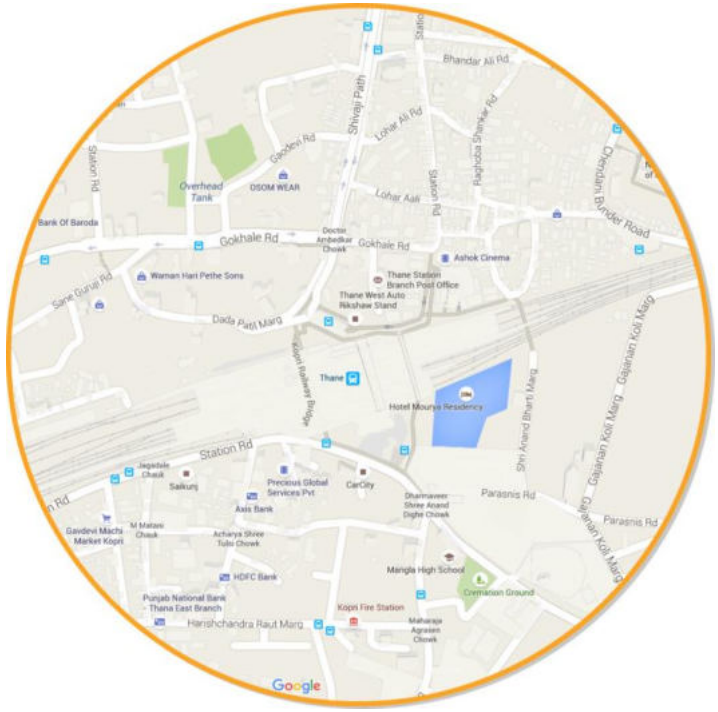




5. Case studies

The study includes the understanding of various feeder transportation Services which supplement the main mode of transportation in various Suburbs of Mumbai and other metropolitans around the globe.

5.1. Mumbai



5.1.1. Thane station

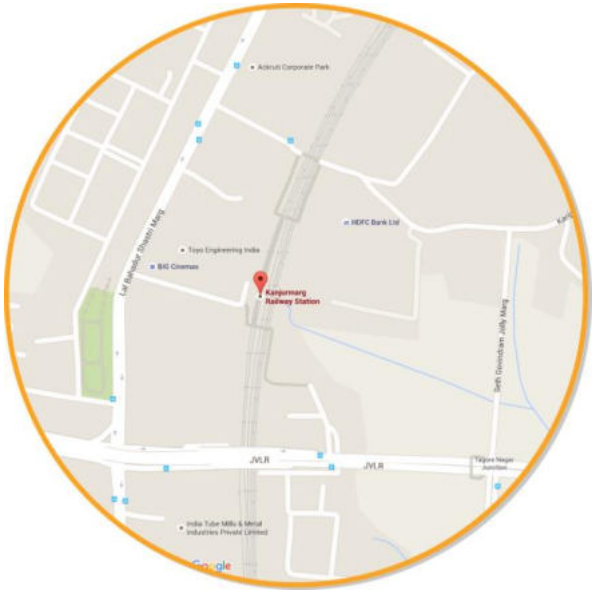
650,000 people daily

Parking for two-wheelers

Bus stand on the flyover connected to the station.

Thane is a railway station on the Central line of the Mumbai Suburban Railway network. It is one of the busiest railway station in India. Thane has been ranked as the busiest railway stations on the Mumbai

People use buses, autos and personal two wheelers to reach and move out of the station



5.1.2. Kanjurmarg station

Less crowded

No dedicated auto stand, autos are parked the crowded in the narrow and crowded lane

Bus stands are walking distance away.

Connected by a narrow lane on one side and a skywalk on the other side.

People use buses and autos to reach and move out of station

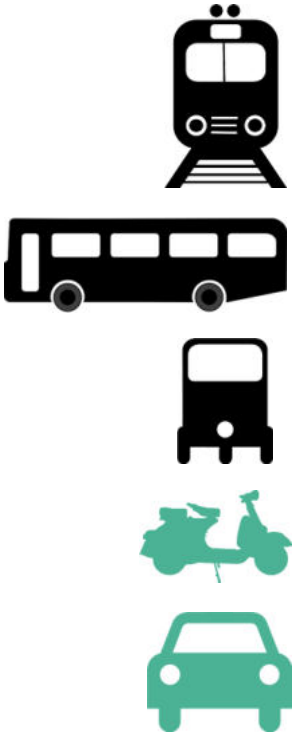
5.1.3. Andheri station

600,000 people daily

Private parking service around the vicinity of the station.

Connected with the Andheri metro station via a skywalk

People use buses, autos, personal two wheelers and merto to reach and move out of the station



5.2. International cities
5.2.1 New York

The transportation system of New York City is a cooperation of complex systems of infrastructure. New York City, being the most populous city in the United States, has a transportation system which includes one of the largest subway systems in the world; the world's first mechanically ventilated vehicular tunnel; and an aerial tramway

IR 20

Rail is by far the dominant mode of transportation in New York City.

IR 21

56% of the population of New York doesn't own car

Buses owned by MTA account for 80% of the city's surface mass transit.

IR 22

5,710 buses

IR 23

13,237 taxis

40,000 other for-hire vehicles

IR 24

In 2009, an estimated 200,000 city residents bicycle on a typical day,[61] and make 655,000 trips each day, greater than the number of the ten most popular bus routes in the city.

5.2.2. TOKYO

The **transport network in Greater Tokyo** includes public and private rail and highway networks; buses; motorcycle delivery services, walking, bicycling, and commercial shipping.

IR 25

Public transport in Tokyo is dominated by urban rail network

IR 26

44.4% **Train**
16.8% **Car**
13.4% **Bicycle**
9.4% **Bus**
6.8% **Walk**
2.5% **Motorbike**

IR 27

Public buses in Greater Tokyo usually serve a secondary role, feeding bus passengers to and from train stations.

IR 28

IR 29

Taxis also serve a similar role to buses, supplementing the rail system, especially after midnight when most rail lines cease to operate.

Walking and cycling are much more common than in many cities around the globe.

5.2.3. LONDON

London has an extensive and developed transport network which includes both private and public services. Journeys made by public transport systems account for 25% of London's journeys while private services accounted for 41% of journeys

IR 30

Tram

Journeys made by public transport systems account for **25%** of London's journeys while private services accounted for 41% of journeys.

2% of all journeys in London are made by bike

IR 31

Underground

IR 32

24-hour
bus service.

IR 33

IR 34

Water transportation through river Thames

IR 35

The iconic black cab remains a common sight. They are driven by the only taxicab drivers in the world who have spent at least three years learning the city's road network to gain 'The Knowledge'.

5.1.4. Inferences

MUMBAI

1 - 3 km

People prefer walking if their desitination is in short distance.

3 - 10* km

People take Bus or Auto if they have to travel long distance.

Personal

Some people park their personal vehicle in the station or nearby parking plaza.

5.1.4. Inferences

MUMBAI

88%

Commuters in Mumbai use public transport.

There are 246,458 black and yellow metered auto rickshaws, often simply called autos, in the Mumbai MMR as of 2008. Auto rickshaws are not permitted to enter Old Bombay

98,566 in Mumbai MMR. Beyond Sion and Bandra auto rickshaws are not allowed and one has to hire a taxi.

As of January 2015, the BEST has a fleet 3600 buses.

Traffic Jam

IR 17

As far as the private taxis and auto rickshaws, lesser said the better. They are the major cause of jams as they stop anywhere looking for a customer, suddenly turn as if they are the only ones on road.

Auto rickshaws have a top-speed of around 50kms / hr and a cruising speed of around 35kms / hr , much slower than the automobiles they share the road with. Traffic authorities in big cities try to implement mechanisms to reduce the resulting traffic slowing, but none have proven effective.

Sub standard and unsafe IR 18

Commuters have no choice but to take risks and avail cheapest, sub standard and highly unsafe mode of transport every day.

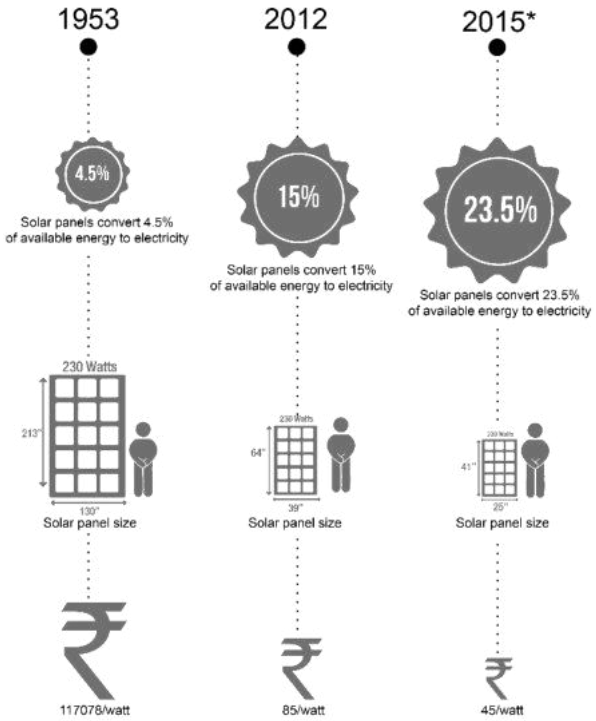
Time IR 19

A person spend 3-4 hrs on average in travelling every day. People spend their time by playing mobile games, chatting, making presentation on their phone , sending emails and some women even cut vegetables on the train itself.

6. Technology
6.1. Solar cells

Solar energy is radiant light and heat from the Sun harnessed using a range of ever-evolving technologies such as solar heating, photovoltaics, solar thermal energy, solar architecture and artificial photosynthesis.

Solar panels have come a long way since their inception in the 20th century. Efficiency, size and cost have improved dramatically, and the technology will keep improving as research and development move forward.



Weight : 390 kg
Capacity : 4 seater
Top speed : 130 km/hr
Distance covered on full charging : 1000kms

Tokai Challenger

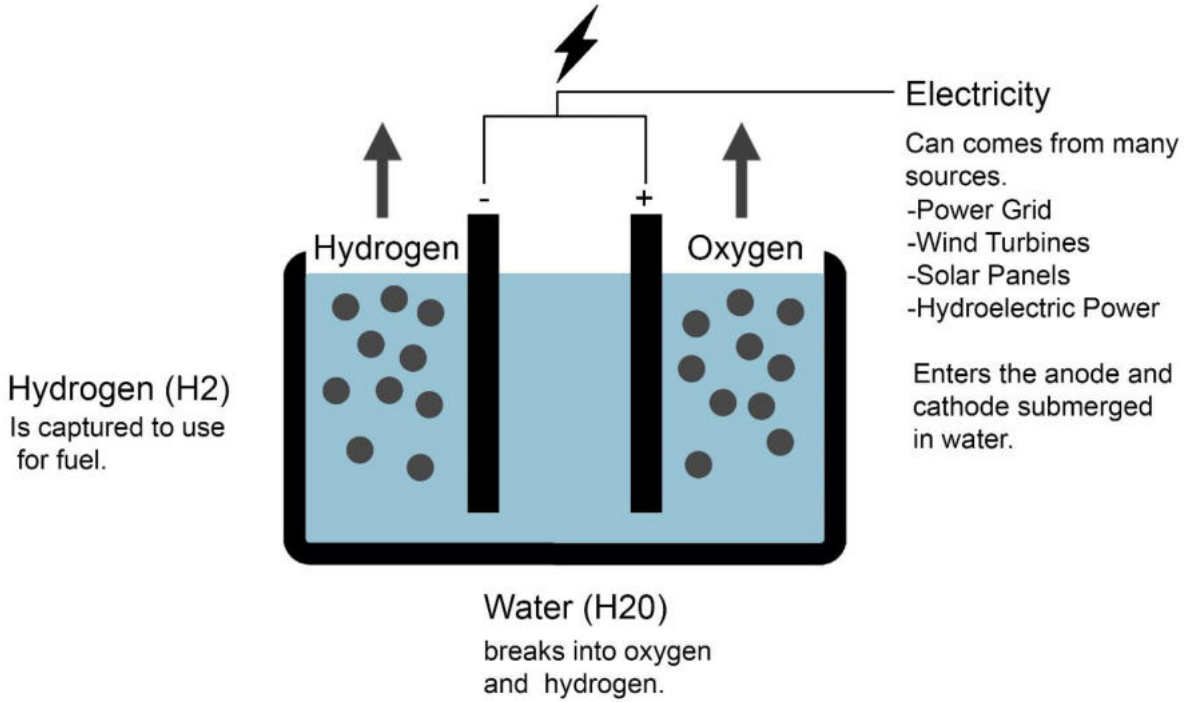
Weight : 160kg
Capacity : 1 seater
Top speed : 100.54 km/hr
Distance covered on full charging : 2998kms

Sunswift (eVe)

Weight : 299.4kg
Capacity : 2 seater
Top speed : 128 km/hr
Distance covered on full charging : 800kms

6.2. Electrolysis

Electrolysis of water is the decomposition of water (H_2O) into oxygen (O_2) and hydrogen gas (H_2) due to an electric current being passed through the water.

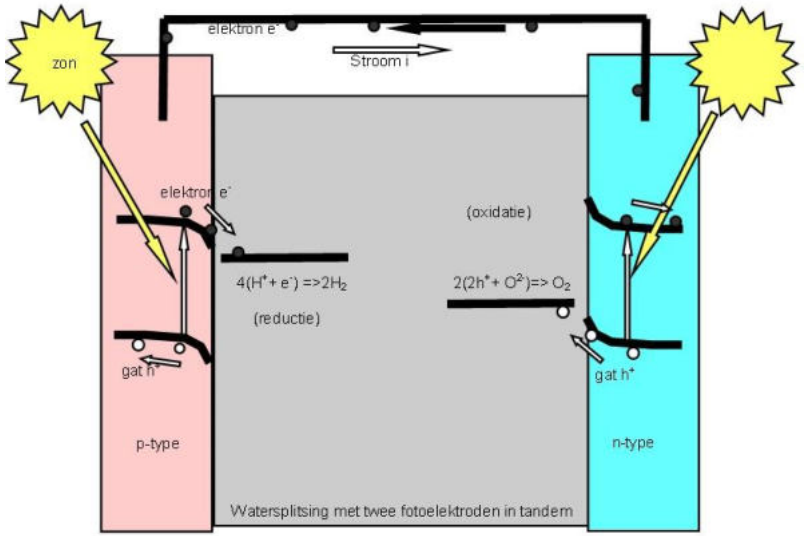


Power required to break 1 mole of water = 237.13 kJ
1 mole of water = 2g of H2 and 16g of O2 = 0.018 L H2O

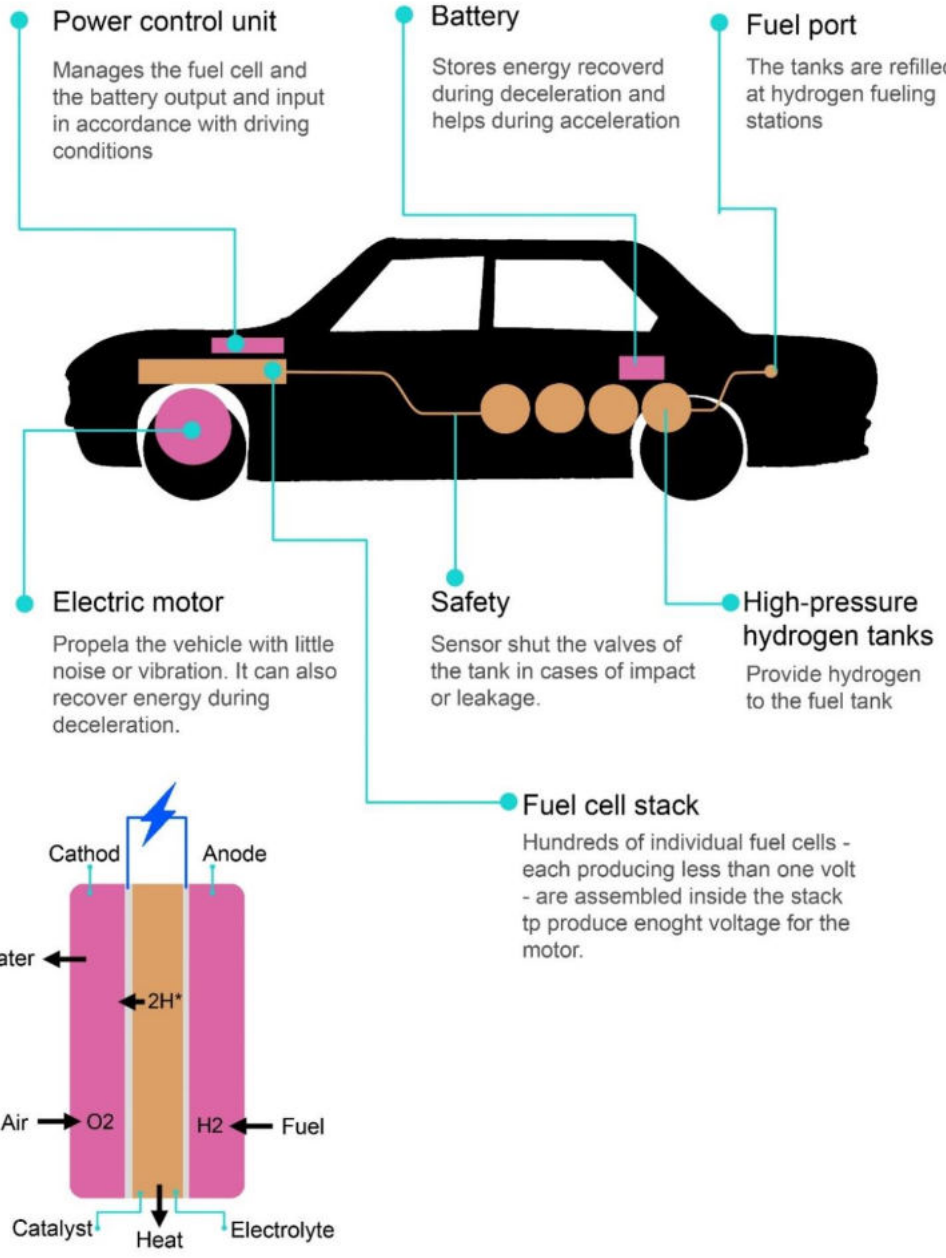
3.7L of Water can produce 6L (690 atm) of compressed Hydrogen

6.3. Photoelectrochemical cell

Photoelectrochemical cells or PECs are solar cells that produce electrical energy or hydrogen in a process similar to the electrolysis of water.

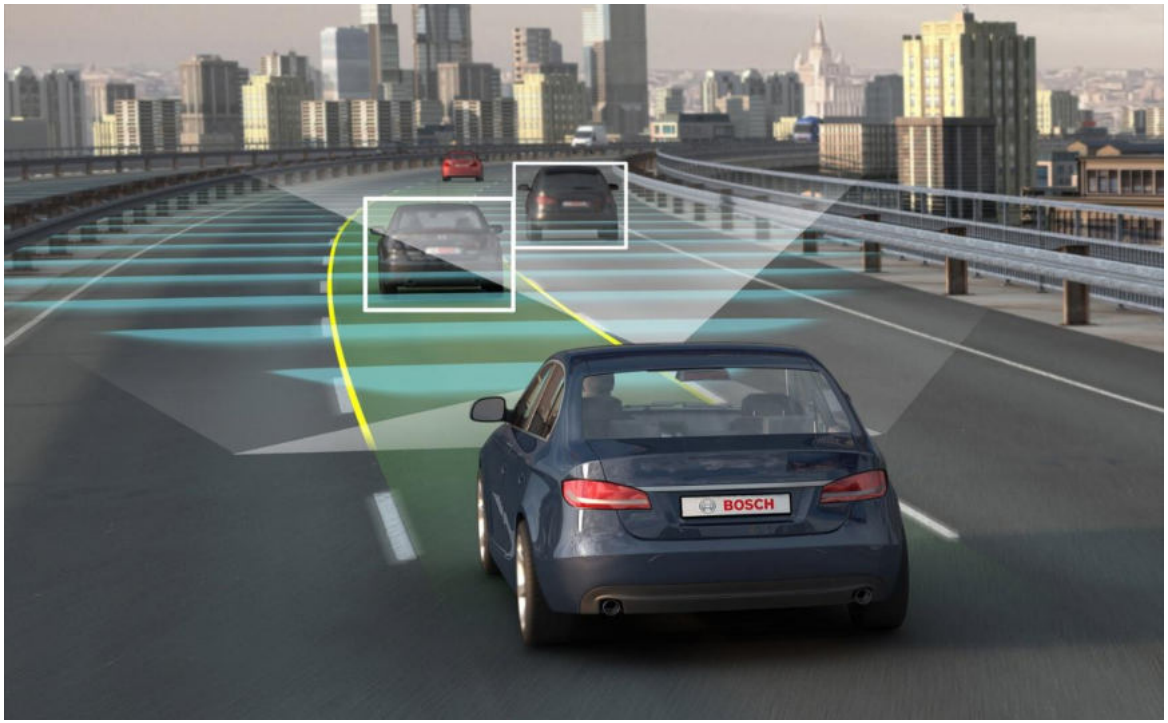


This type of cell electrolyzes water to hydrogen and oxygen gas by irradiating the anode with electromagnetic radiation. This has been referred to as artificial photosynthesis and has been suggested as a way of storing solar energy in hydrogen for use as fuel.



6.4. Fuel cell

A **fuel cell vehicle** (FCV) or **fuel cell** electric **vehicle** (FCEV) is a type of **vehicle** which uses a **fuel cell** to power its on-board electric motor. **Fuel cells** in **vehicles** create electricity to power an electric motor, generally using oxygen from the air and compressed hydrogen.

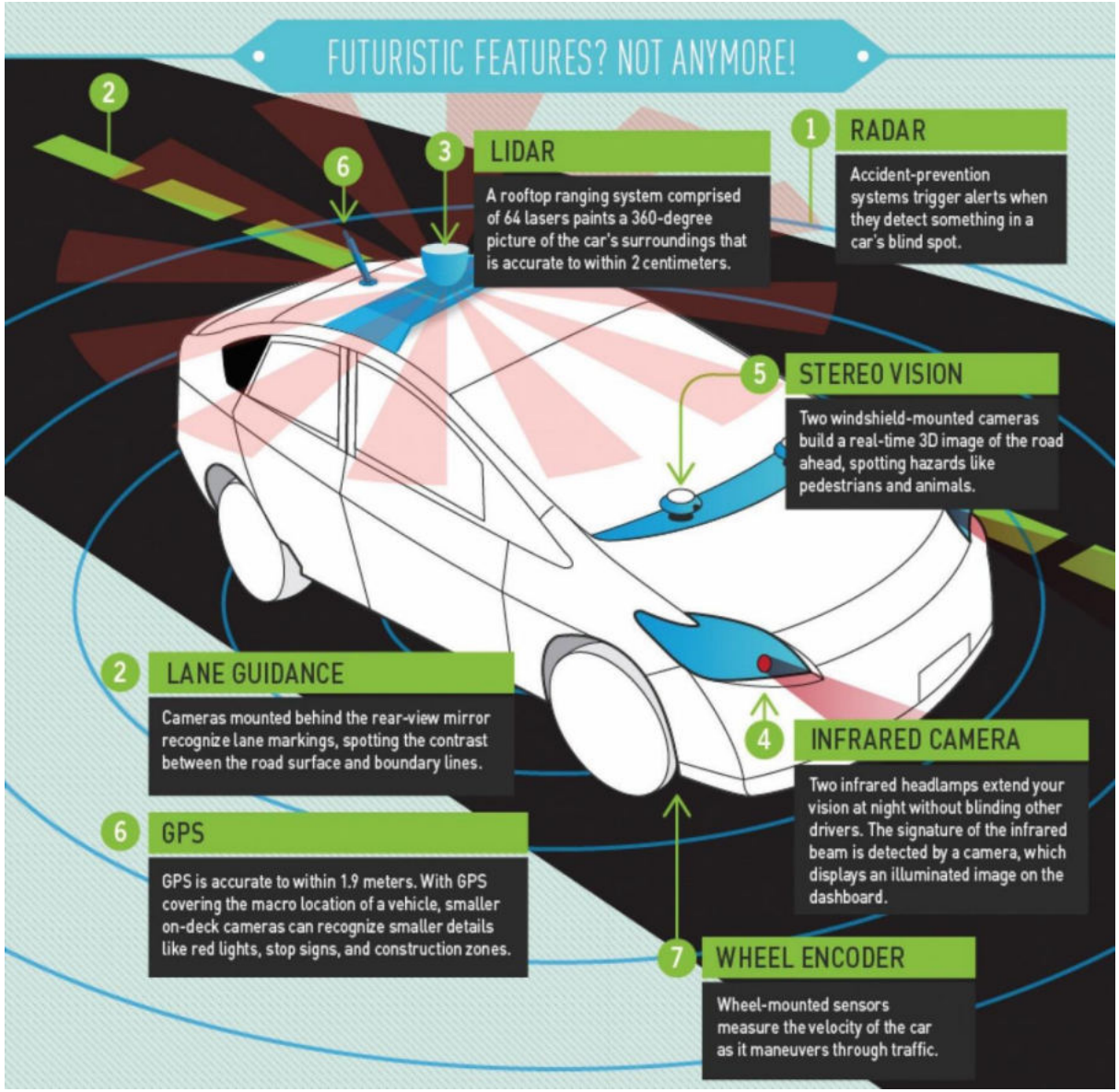


IR 36

6.5 Autonomous vehicle

In the United States, the **National Highway Traffic Safety Administration (NHTSA)** has proposed a formal classification system:

- **Level 0**: The driver completely controls the vehicle at all times.
- **Level 1**: Individual vehicle controls are automated, such as electronic stability control or automatic braking.
- **Level 2**: At least two controls can be automated in unison, such as adaptive cruise control in combination with lane keeping.
- **Level 3**: The driver can fully cede control of all safety-critical functions in certain conditions. The car senses when conditions require the driver to retake control and provides a "sufficiently comfortable transition time" for the driver to do so.
- **Level 4**: The vehicle performs all safety-critical functions for the entire trip, with the driver not expected to control the vehicle at any time. As this vehicle would control all functions from start to stop, including all parking functions, it could include unoccupied cars.



IR 37

6.5 Autonomous vehicle

Autonomous vehicles sense their surroundings with such techniques as radar, lidar, GPS, Odometry, and computer vision. Advanced control systems interpret sensory information to identify appropriate navigation paths, as well as obstacles and relevant signage.[By definition, autonomous vehicles are capable of updating their maps based on sensory input, allowing the vehicles to keep track of their position even when conditions change or when they enter uncharted environments. Autonomous cars have control systems that are capable of analyzing sensory data to distinguish between different objects on the road, which is very useful in planning a path to the desired destination.[

7. Design brief

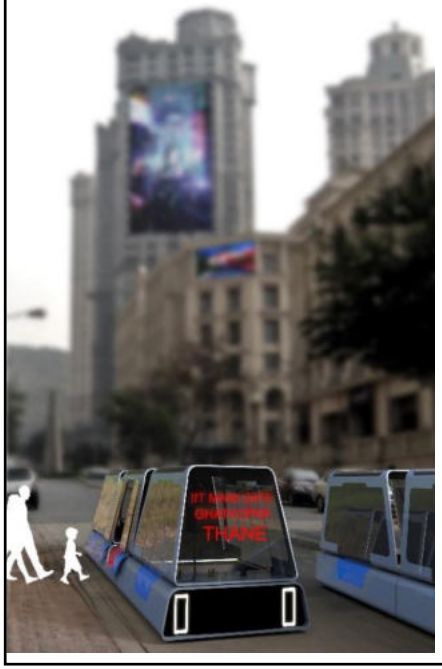
Design a transportation system for 15 years from now, which will run as a feeder service, drive autonomously by state of the art technology and communication system, taking inspiration from transportation of water and photosynthesis in a plant.

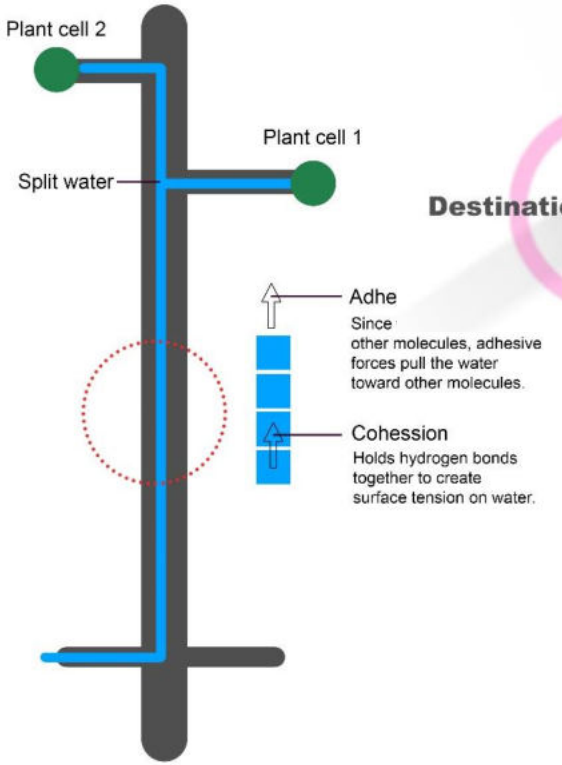
Objectives :

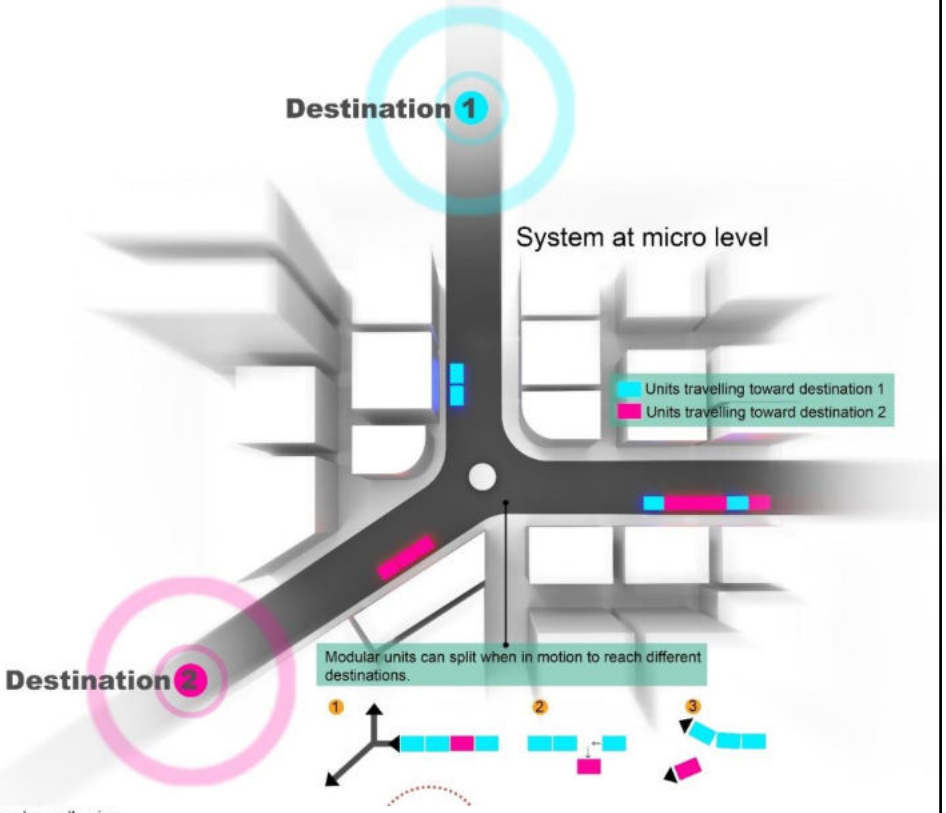
- The system will have modular vehicles of very small footprint which will carry 2-4 persons.
- The vehicle should be able to generate its own energy and sustain on the abundant resources of the nature.
- Solve traffic problems (Accidents, traffic congestion, noise).
- Power hubs (Fueling and depots) should be facilitated.
- Vehicle should have all the technology to run autonomously

8. Transportation system

Veins and tissues play a crucial role in the delivery of Water and food to the different part of the plant. Without veins, Plant would not be able to operate. Without veins, there would be no life. So does roads in a city. Without road a city would not sustain.



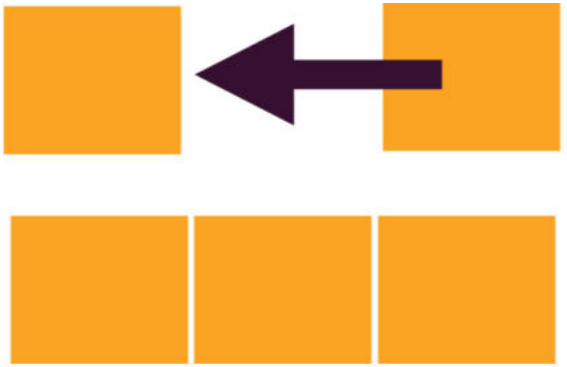




9.1. Scenario

Different modes of transport

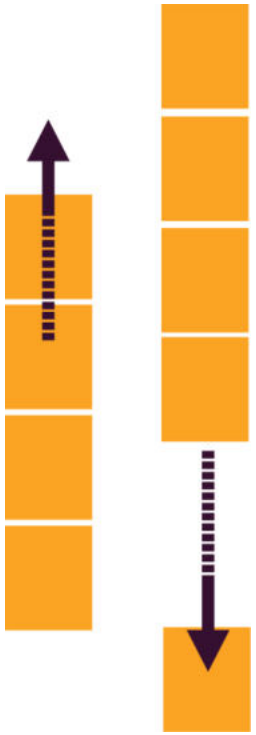
Modular transport



The smart routing system of Modular transit vehicle will autonomously drive the vehicles and join together modules, in order to redistribute passengers and optimize occupancy rate, cutting energy consumption and traffic footprint.

Chaos and disorder

Organized Traffic



Accidents

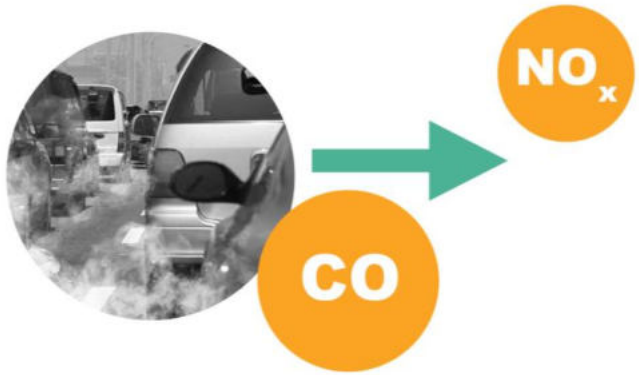
90%

of car accidents are caused by human errors: distraction., alcohol, tiredness etc

Reduce accidents

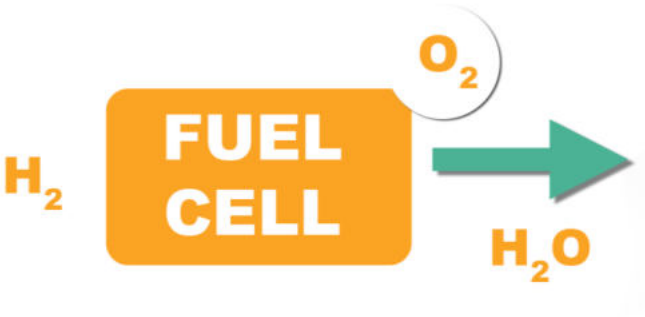
Autonomous vehicles will have 3600 vision and compute optimal driving adjustments thousand of times faster than human driver

Pollution

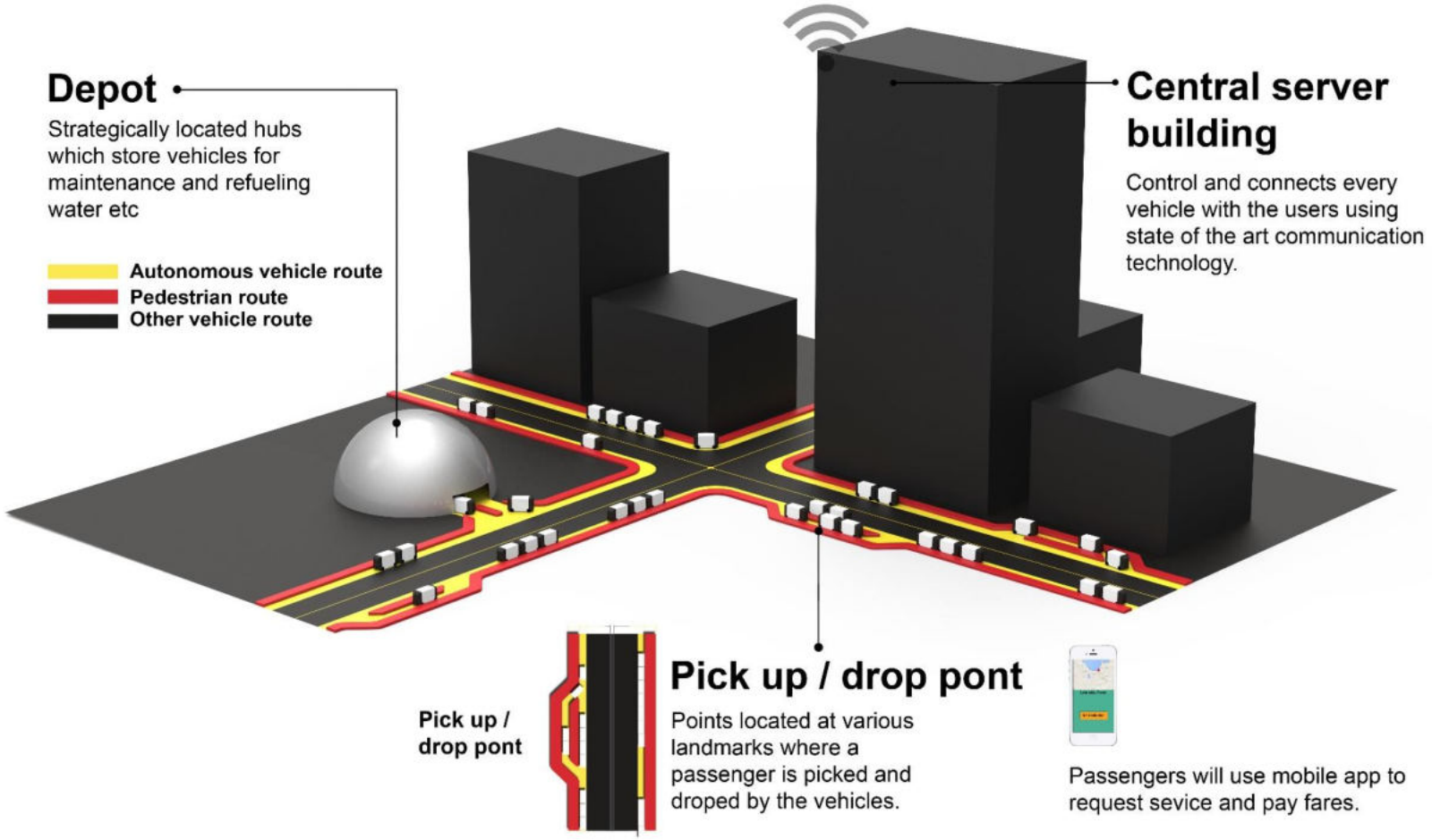


Nowadays, fossil fuel are the main cause of pollution and global warming.

Reduce Pollution



Through clean vehicle and fuel technologies, we can significantly reduce air pollution from our vehicles.


Depot
Strategically located hubs which store vehicles for maintenance and refueling water etc
Autonomous vehicle route
Pedestrian route
Other vehicle route
Central server building
Control and connects every vehicle with the users using state of the art communication technology.
Pick up / drop pont
Points located at various landmarks where a passenger is picked and droped by the vehicles.
Pick up / drop pont
Passengers will use mobile app to request sevice and pay fares.

9.2. Communication system

Confirmation
Vehicle no.
ID no.
Bill payment

Server/Service center
Generate a personal ID

Autonomous vehicle
Receive passenger pick up request

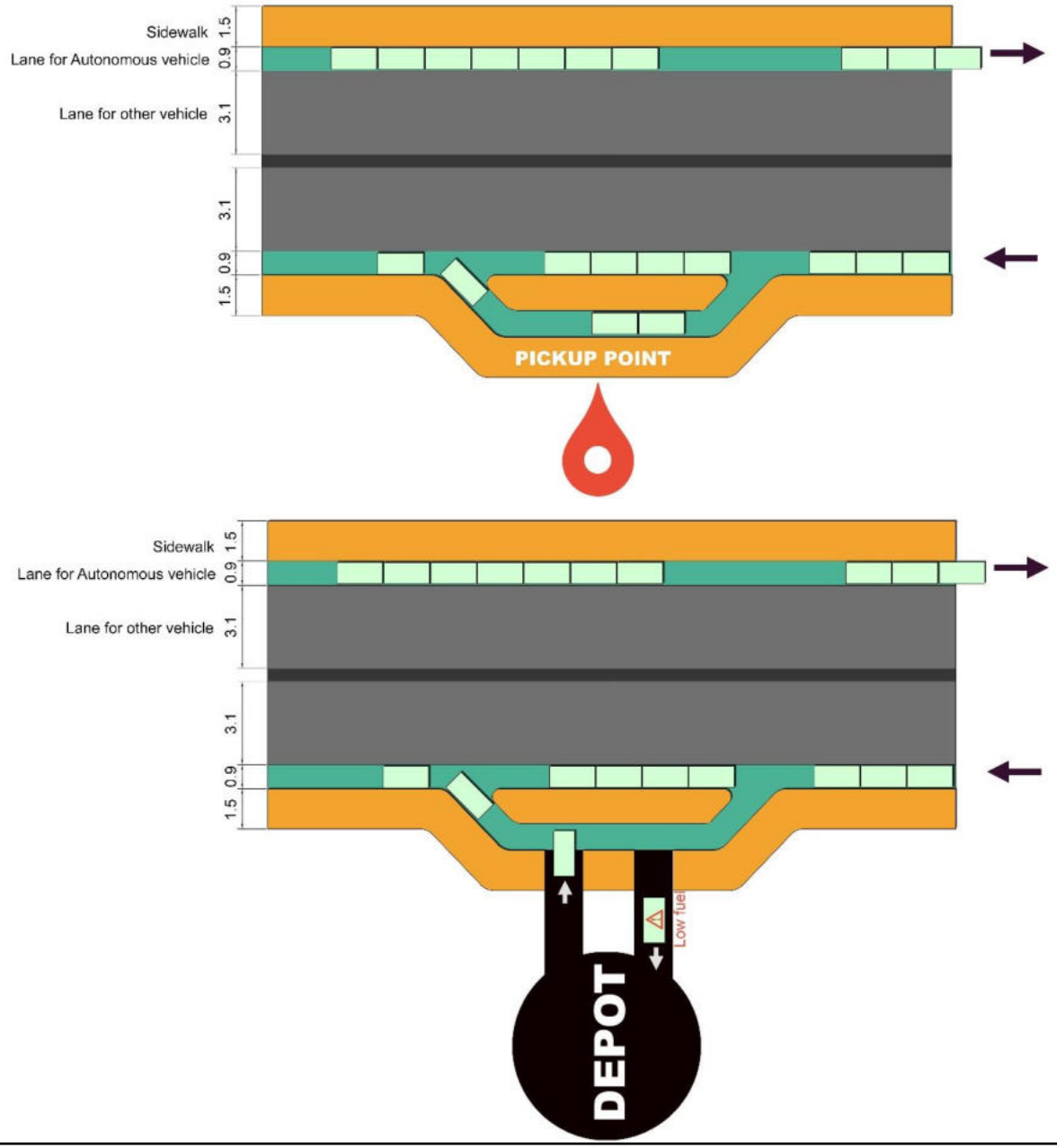
Pickup request
Passenger's current position
Pickup location.
Destination

Server/Service center
Efficiently allocate passenger pick up assignments
A comprehensive algorithm, that takes into account -

1. The traffic landscape of the city
2. Each of the autonomous taxi characteristics (i.e. location, fuel mileage, gas meter, etc.)
3. Each of the outstanding passenger pick up locations and respective destinations

Service somehow must decide what autonomous taxi should pick up the passenger.

9.3. Depots


Sidewalk
Lane for Autonomous vehicle
Lane for other vehicle
1.5
0.9
3.1
3.1
0.9
1.5
PICKUP POINT
Sidewalk
Lane for Autonomous vehicle
Lane for other vehicle
1.5
0.9
3.1
3.1
0.9
1.5
DEPOT

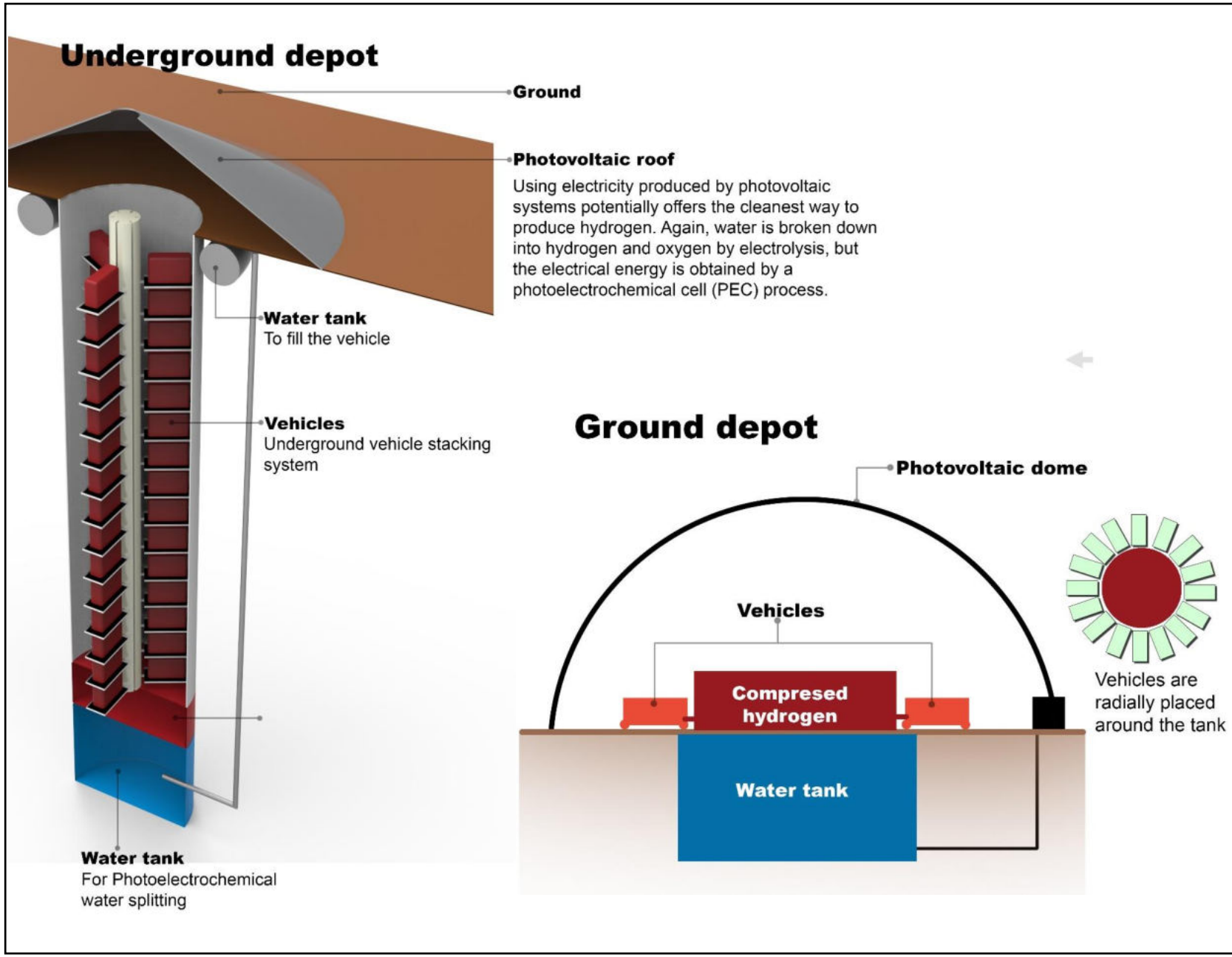

Underground depot
Ground
Photovoltaic roof
Using electricity produced by photovoltaic systems potentially offers the cleanest way to produce hydrogen. Again, water is broken down into hydrogen and oxygen by electrolysis, but the electrical energy is obtained by a photoelectrochemical cell (PEC) process.
Water tank
To fill the vehicle
Vehicles
Underground vehicle stacking system
Water tank
For Photoelectrochemical water splitting
Ground depot
Photovoltaic dome
Vehicles
Compresed hydrogen
Water tank
Vehicles are radially placed around the tank

Illustration 1

Depot

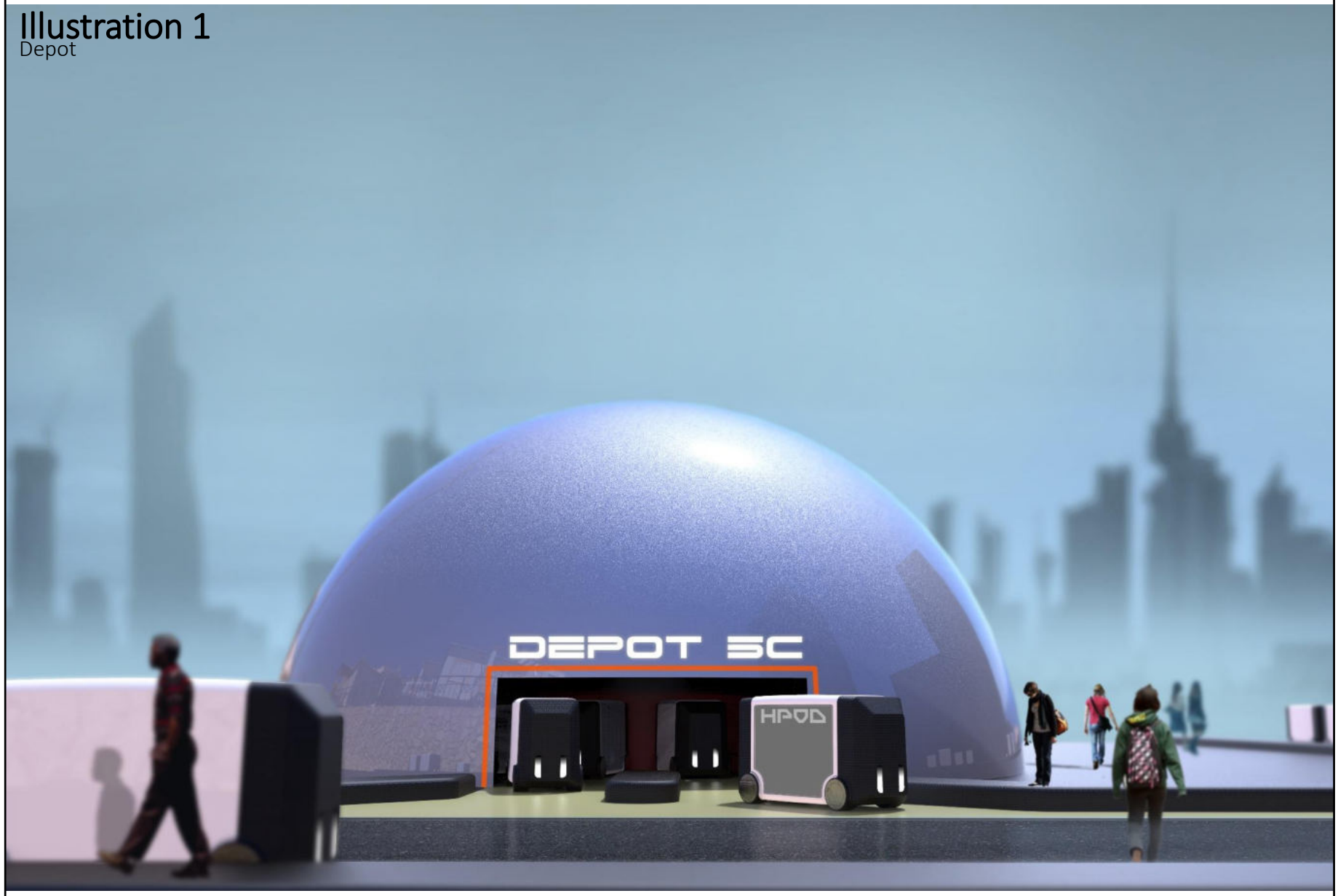
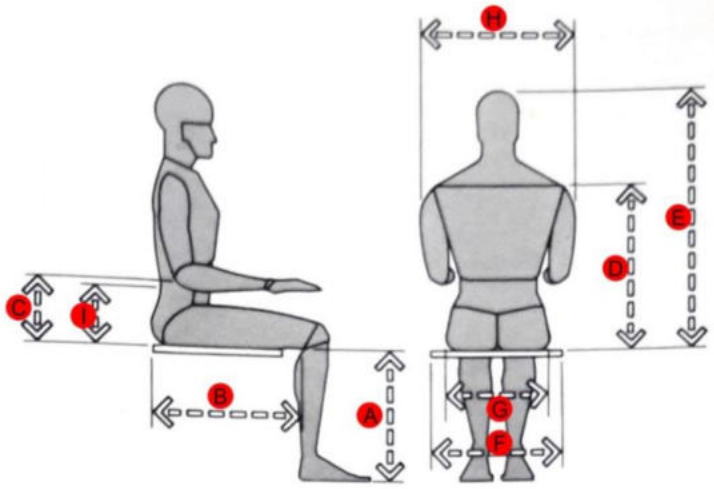


Illustration 2
Street

9. Vehicle

9.1. Packaging

The space is Designed considering 95th percentile Human factors.



	Percentile			
	5		95	
Measurement	in	cm	in	cm
A Popliteal height	15.5	39.4	19.3	49.0
B Buttock-Popliteal Length	17.3	43.9	21.6	54.9
C Elbow Rest Height	7.4	18.8	11.6	29.5
D Shoulder Height	21.0	53.3	29.5	63.5
E Sitting height normal	31.6	80.3	36.6	93.0
F Elbow to elbow breadth	13.7	34.8	19.9	50.5
G Hip Breadth	12.2	31.0	15.9	40.4
H Shoulder Breadth	17.0	43.2	19.0	48.3
I Lumber Height				

Pre packaging concept

Battery

Stores energy recoverd during deceleration and helps during acceleration

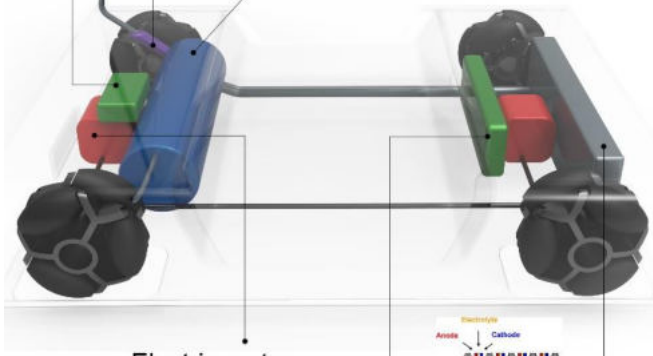
Water storage chamber

Stores water for electrolysis during artificial photosynthesis

Valve

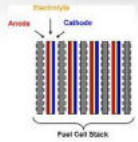
High-pressure hydrogen tank

Provide hydrogen to the fuel tank



Electric motor

Propel a the vehicle with little noise or vibration. It can also recover energy during deceleration.



Fuel cell stack

Hundreds of individual fuel cells - each producing less than one volt - are assembled inside the stack tp produce enoght voltage for the motor.

Power control unit

Manages the fuel cell and the battery output and input in accordance with driving conditions

Transparent roof

Transparent roof with small pores which collect water durind rain.

Silicon solar cell + Sun catalytix catalysts

Used for directly splitting water into hydrogen and oxygen

Water

Passenger compartment

See-through display glass

Display informations

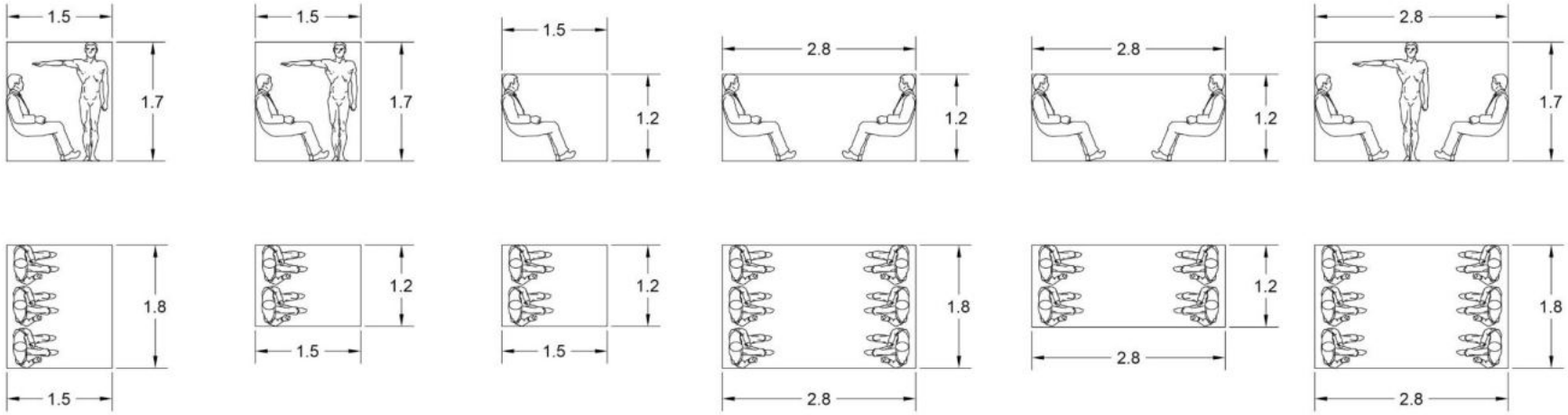
System compartment

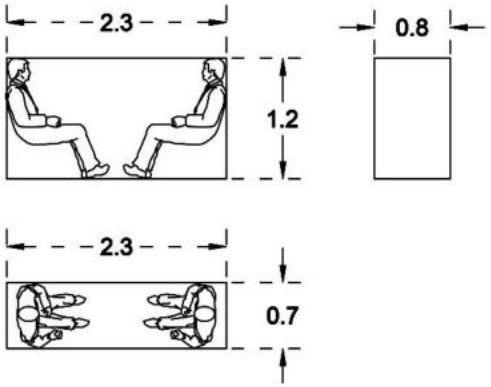
House all the major components which run the vehicle

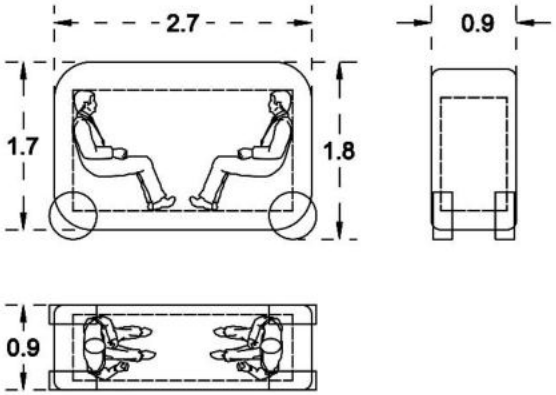
Omni wheel

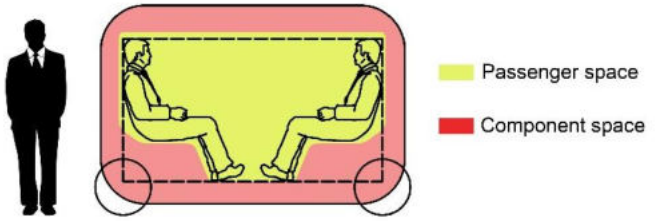
Omni-directional wheels are useful as they roll freely in two directions using the rollers mounted around its circumference. They can either roll like a normal wheel, or roll laterally using the rollers. Useful in confined spaces and allows forward/backwards and rotation without changing its orientation.

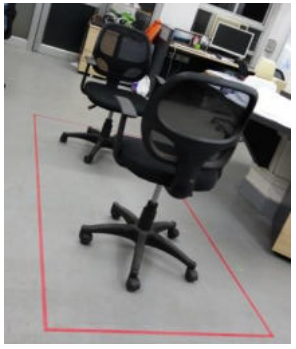
9.1.1. Explorations



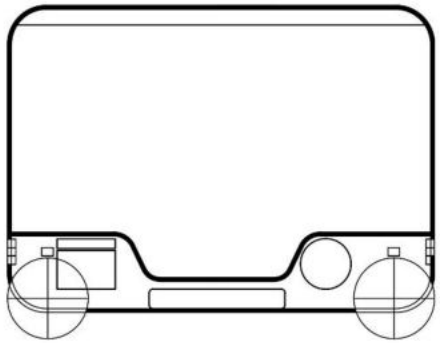






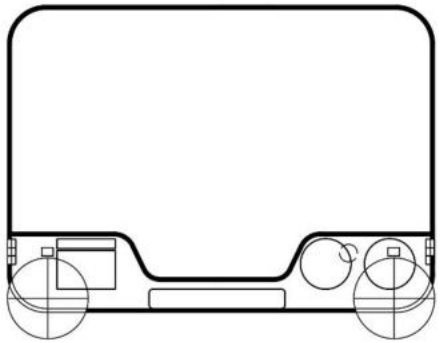


Set up made to simulate the space.



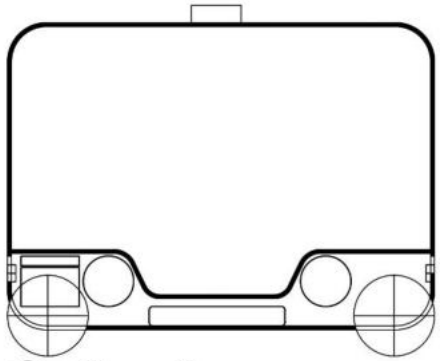
Option 1

Water reservoir on the top
6 LIDAR sensor on the sides of the vehicle



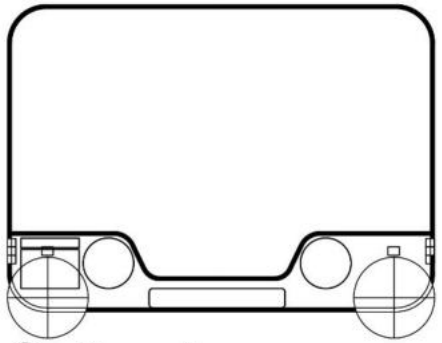
Option 2

Water reservoir behind the hydrogrn tank
6 LIDAR sensor on the sides of the vehicle



Option 3

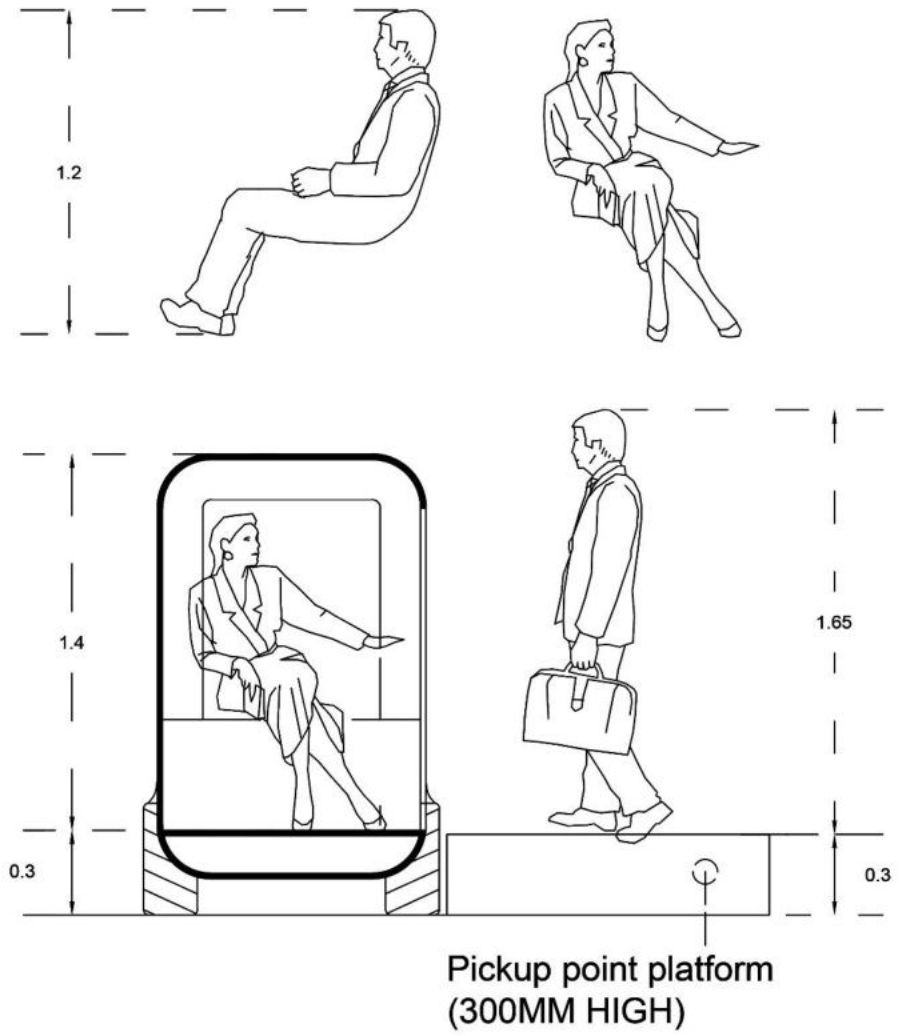
Water reservoir on the other side of the fuel tank
Single LIDAR sensor on top of the vehicle



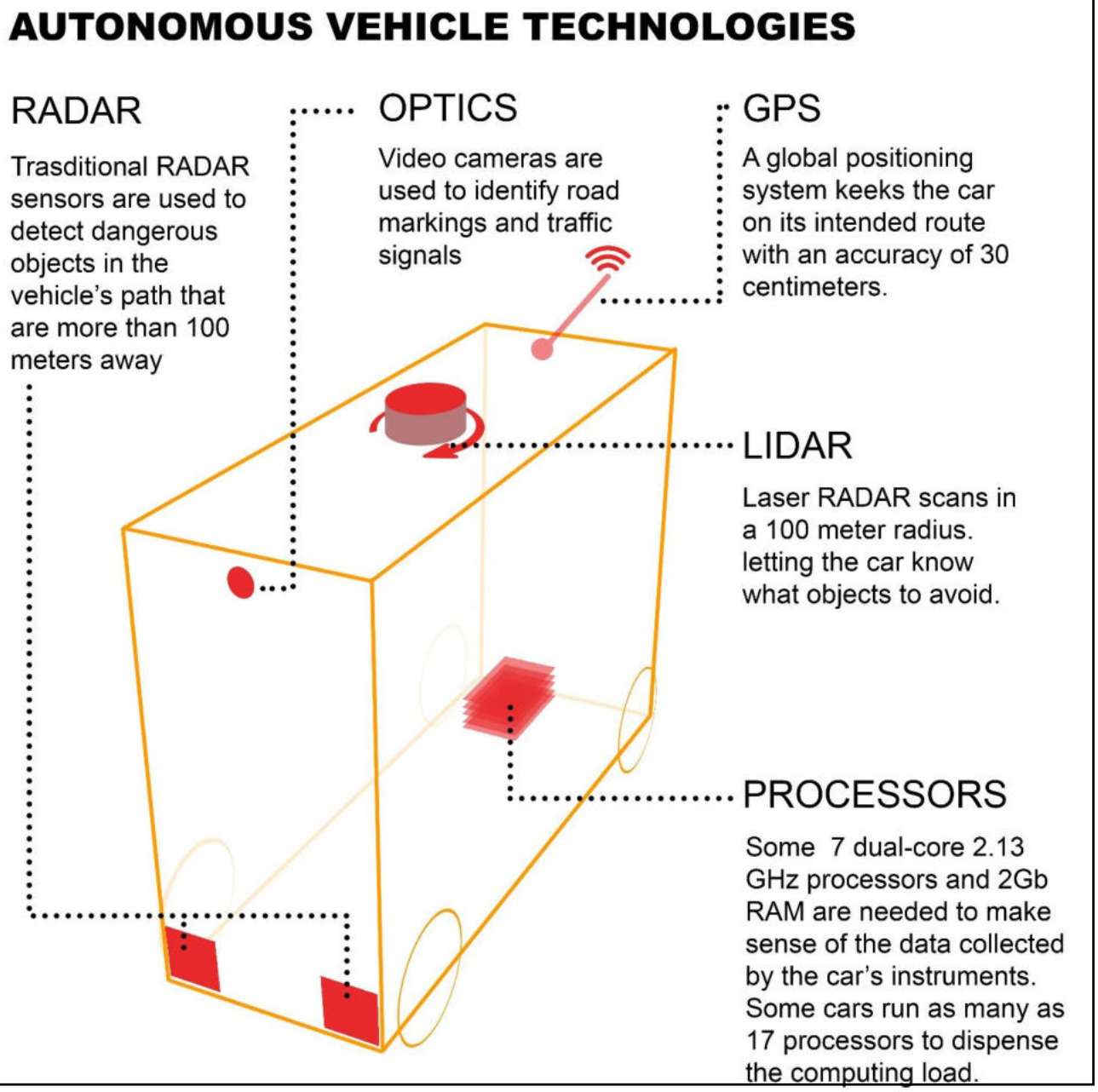
Option 4

Water reservoir on the other side of the fuel tank
6 LIDAR sensor on the sides of the vehicle

9.1.2. Occupant



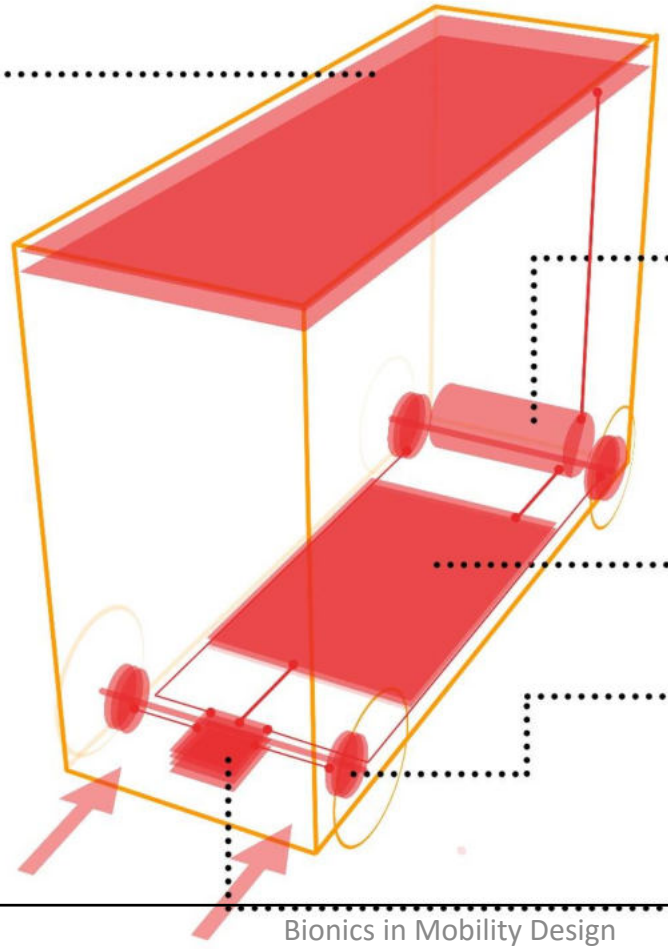
9.1.3. Component



HYDROCEN FUEL TECHNOLOGY & PEC

PHOTOELECTROCHEMICAL CELL

Photoelectrochemical cells or PECs are solar cells that produce electrical energy or hydrogen in a process similar to the electrolysis of water.



HYDROGEN TANK

High pressure hydrogen tank
Provide hydrogen to the fuel tank.

FUEL CELL STACK

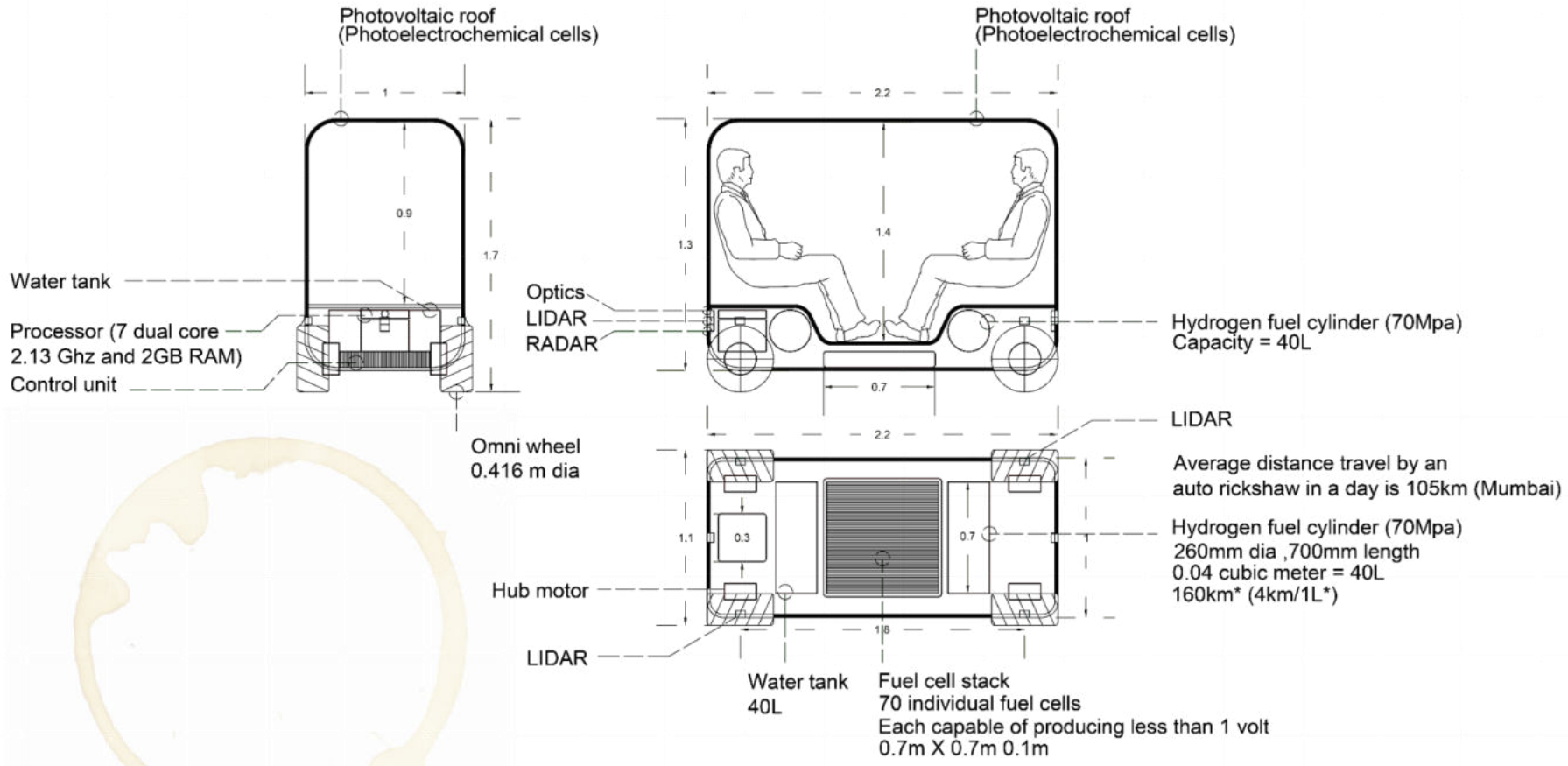
Hundreds of individual fuel cells - each producing less than one volt - are assembled inside the stack tp produce enoght voltage for the motor.

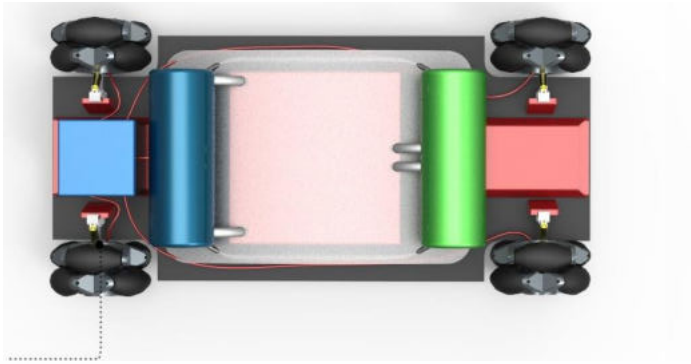
MOTORS

Propela the vehicle with little noise or vibration. It can also recover energy during deceleration.

CONTROL UNIT

Manages the fuel cell and the battery output and input in accordance with driving conditions


All dimensions are in meters
1Unit = 500mm
Photovoltaic roof
(Photoelectrochemical cells)
Photovoltaic roof
(Photoelectrochemical cells)
1
0.9
1.7
2.2
1.3
1.4
0.7
Water tank
Processor (7 dual core
2.13 Ghz and 2GB RAM)
Control unit
Optics
LIDAR
RADAR
Hydrogen fuel cylinder (70Mpa)
Capacity = 40L
Omni wheel
0.416 m dia
LIDAR
Average distance travel by an
auto rickshaw in a day is 105km (Mumbai)
1.1
0.3
0.7
Hydrogen fuel cylinder (70Mpa)
260mm dia ,700mm length
0.04 cubic meter = 40L
160km* (4km/1L*)
Hub motor
LIDAR
Water tank
40L
Fuel cell stack
70 individual fuel cells
Each capable of producing less than 1 volt
0.7m X 0.7m 0.1m
Not to scale



HUB MOTORS
Electric motor incorporated into the hub of a wheel and drives it directly

SOLAR CELLS
Harvest solar energy for photoelectrochemical reaction

HYDROGEN TANK
High pressure hydrogen tank
Provide hydrogen to the fuel tank.

PROCESSORS
Some 7 dual-core 2.13 GHz processors and 2Gb RAM are needed to make sense of the data collected by the car's instruments. Some cars run as many as 17 processors to dispense the computing load.

WATER TANK
Recycle water from the fuel cell or simply store water for photoelectrochemical reaction

OMNI WHEEL
Useful in confined spaces and allows forward/backwards and rotation without changing its orientation.

CONTROL UNIT
Manages the fuel cell and the battery output and input in accordance with driving conditions

HEAT INSULATION
Fiber glass

FUEL CELL STACK
Hundreds of individual fuel cells - each producing less than one volt - are assembled inside the stack tp produce enoght voltage for the motor.

9.2.1. Keywords for exterior

Following are the 3 different type of keywords for aesthetic explorations

EMPATHY

FRIENDLY

SOFT

DURABLE

ROBUST

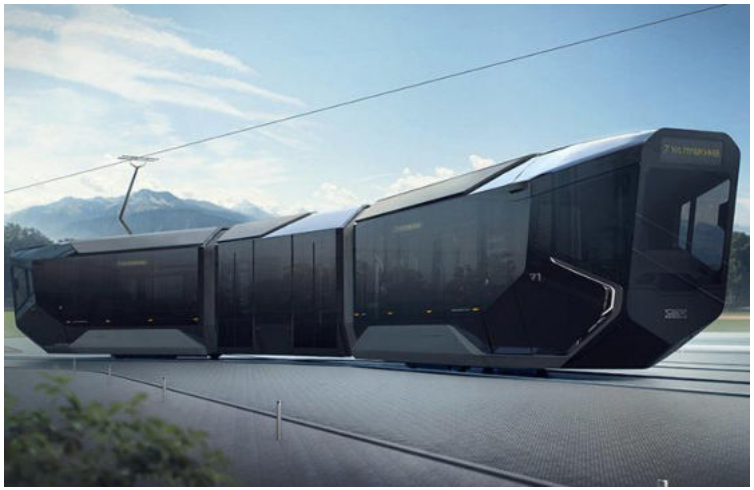
STURDY

CLEAN

SIMPLICITY

PURE

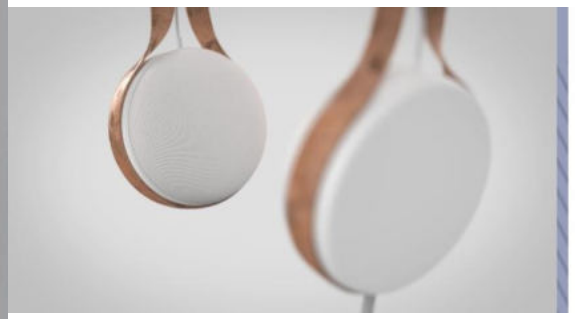
9.2.1. Image boards

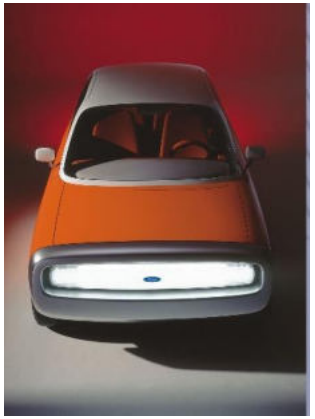


DURABLE

ROBUST

STURDY



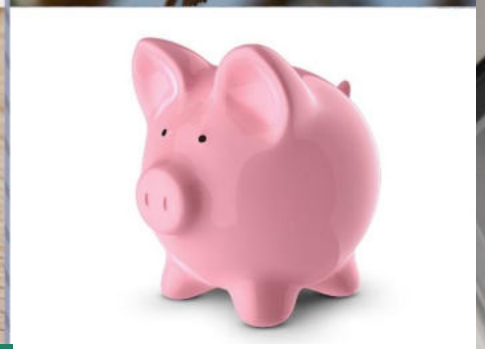


CLEAN

SIMPLICITY

PURE



EMPATHY

FRIENDLY

SOFT

DURABLE

ROBUST

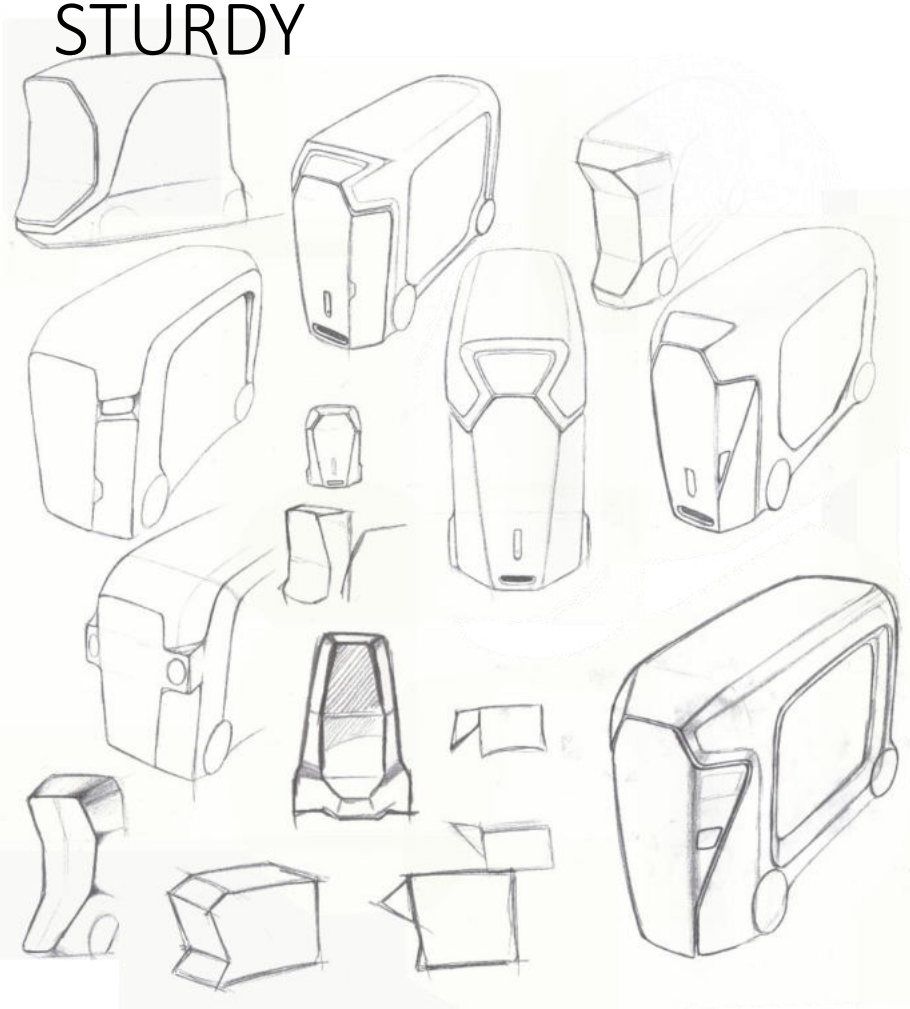
STURDY

Concept 1

DURABLE

ROBUST

STURDY



Concept 2

CLEAN

SIMPLICITY

PURE

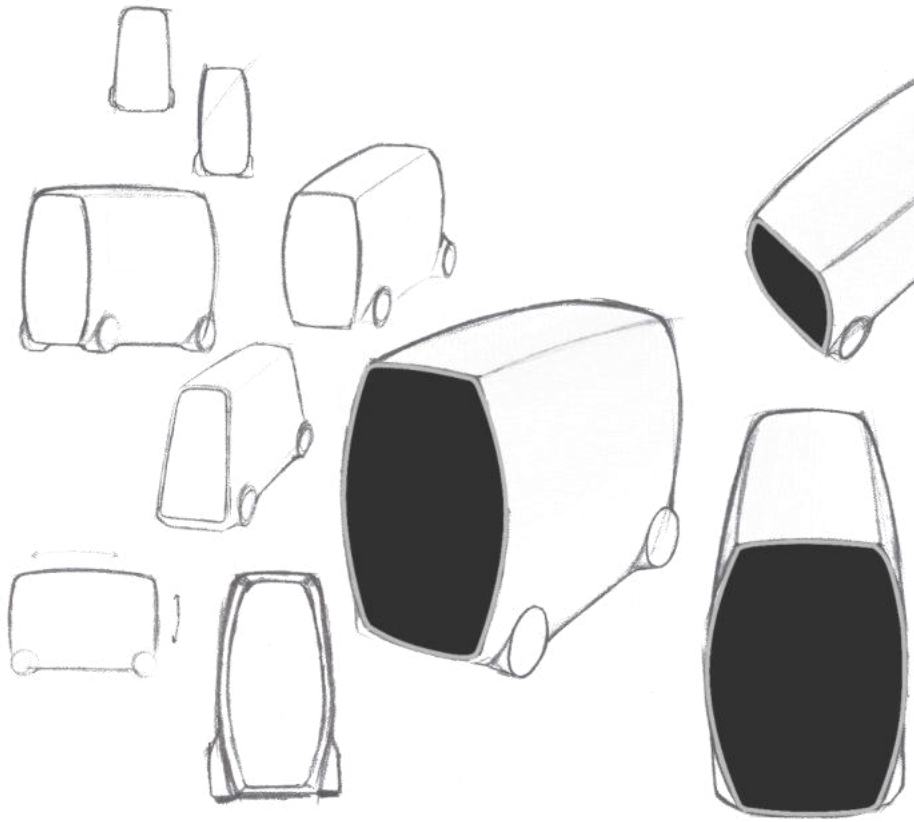
Concept 3

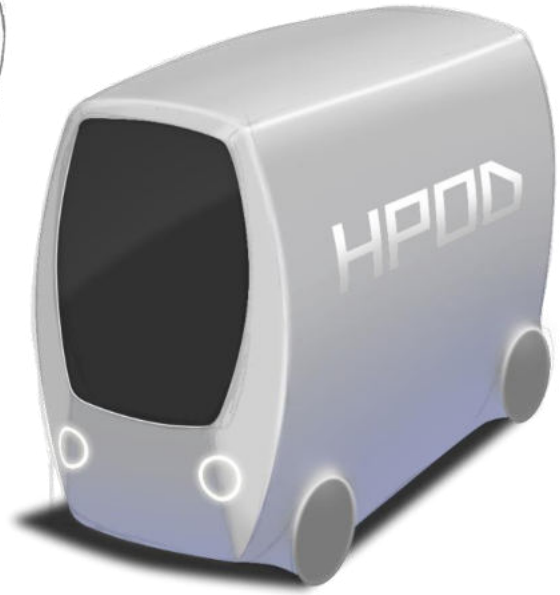
CLEAN

SIMPLICITY

PURE

Concept 4



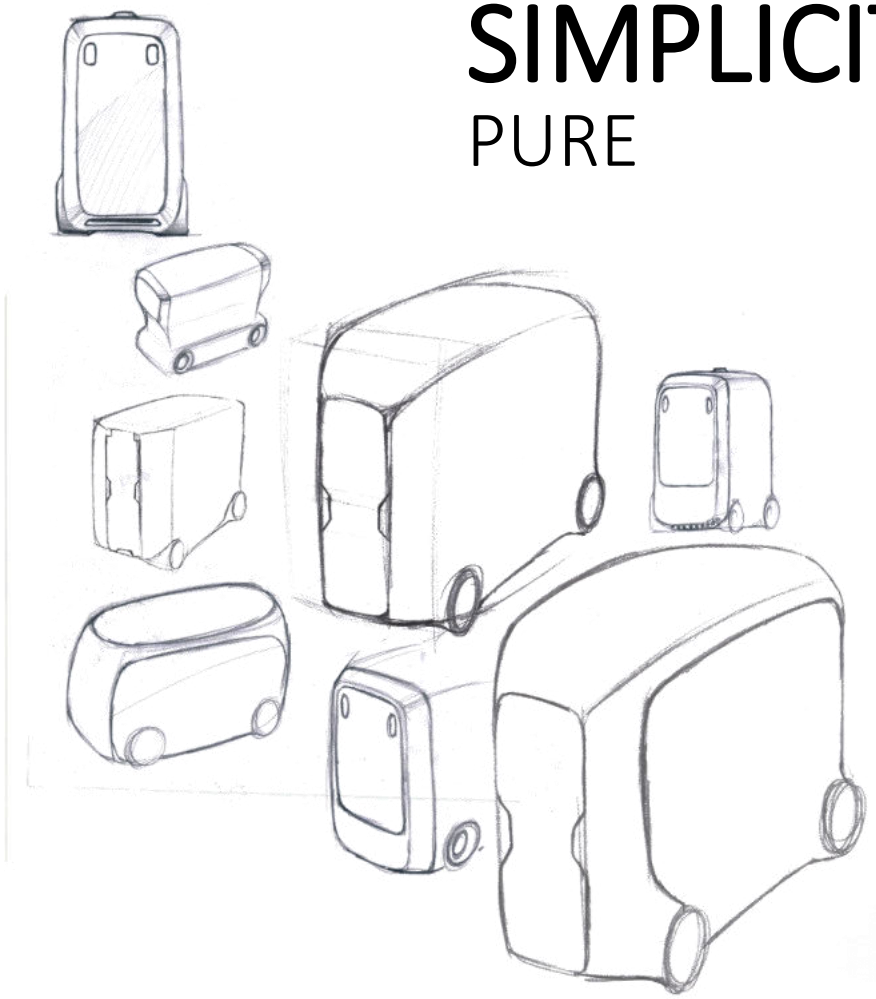


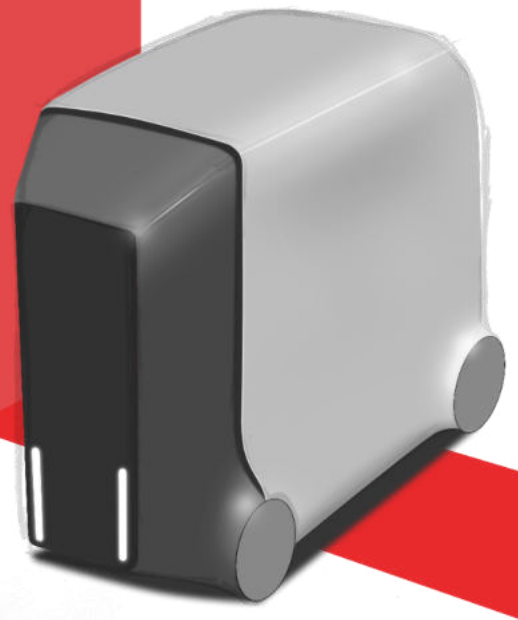
CLEAN

SIMPLICITY

PURE

Concept 5



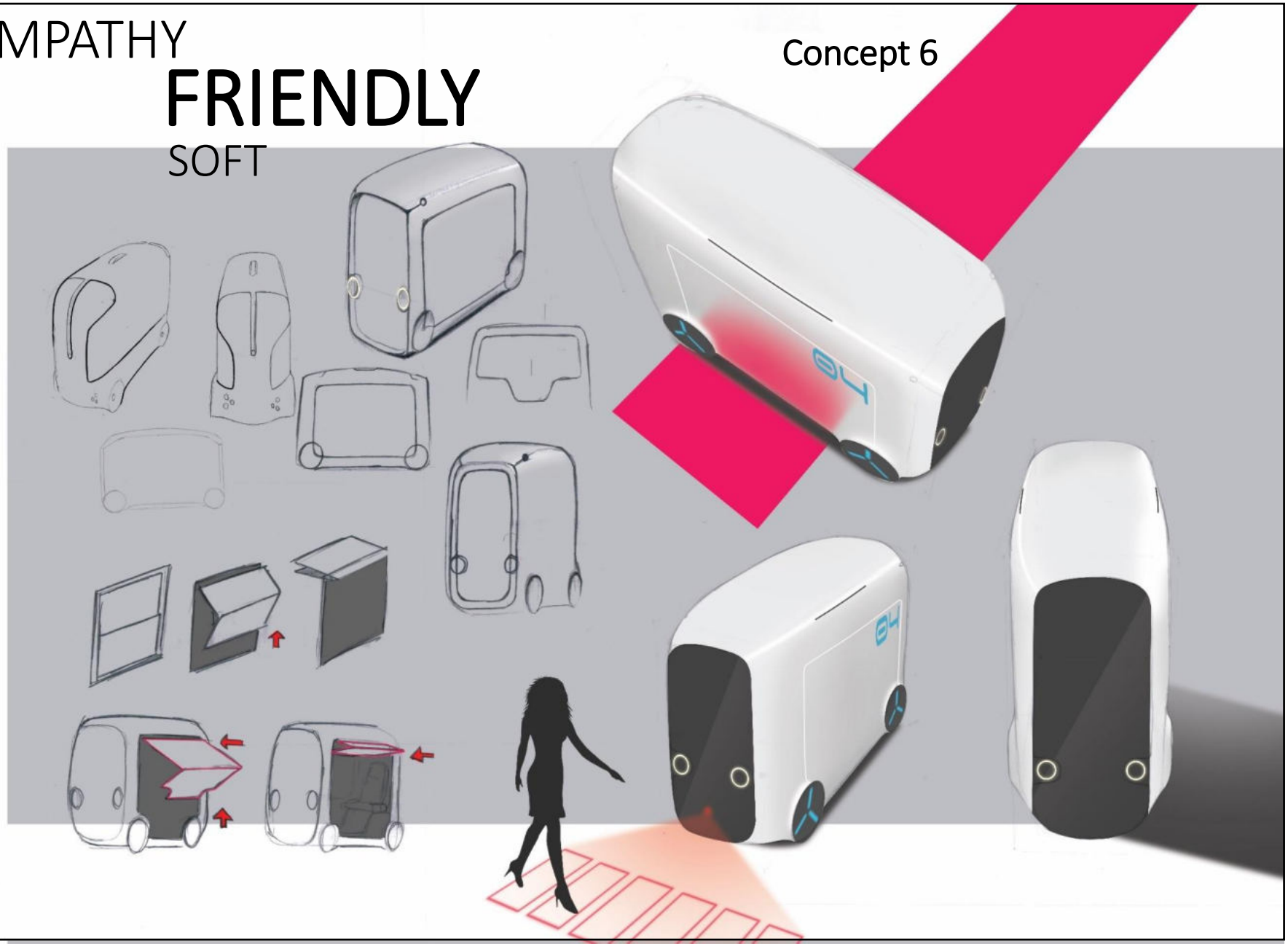


EMPATHY

FRIENDLY

SOFT

Concept 6

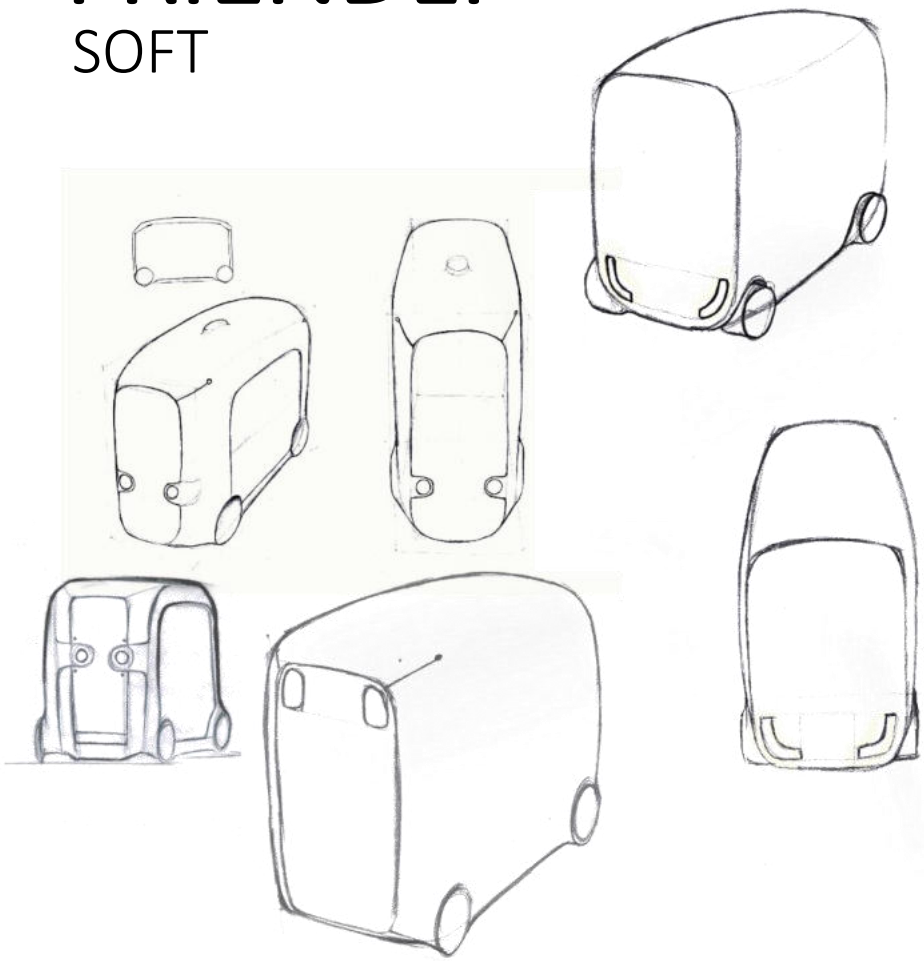


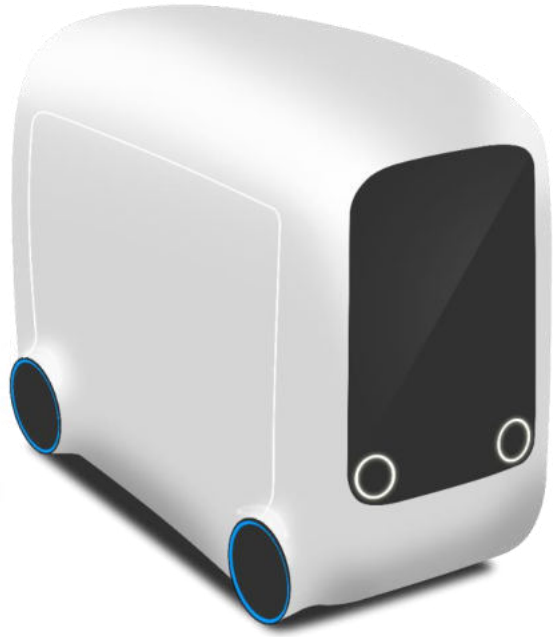
EMPATHY

FRIENDLY

SOFT

Concept 7





In progress

9.3. User evaluation

A brief and straight forward user evaluation was done to understand users' reaction to the form and aesthetics of the vehicle. The evaluation was done with different users from different places to get a broader perspective. The selected users use public transport in day-to-day life to commute from home to office and vise-versa. They were provided with a poster which explains everything about the scenario of the system and the 7 concepts. They were asked to select two or three concepts which they liked most and rank them accordingly.

1

Rohit
24
Architect
Mumbai

2

Abhishek
24
Architect
Delhi

3

Ramesh
25
Engineer
New York

4

Ankur
25
Engineer
Mumbai

5

Ajith
24
Student
Kochi

6

Sanjna
24
Engineer
Bengaluru

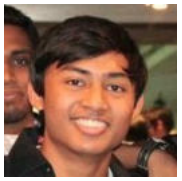
7

Hemachandiran
27
Designer
Ahmedabad

8

Shriya
24
Student
Atlanta

9



Jason
24
Architect
Muscat

10

Harsha
32
Engineer
Navi Mumbai

User 1

User 2

User 3

User 4

User 5

User 6

User 7

User 8

User 9

User 10

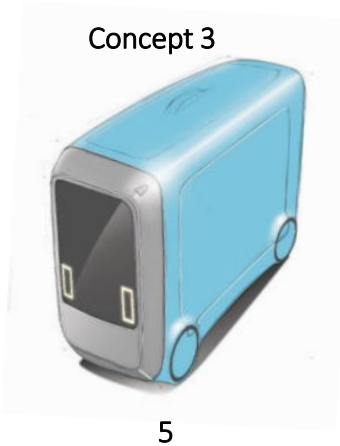
Concept 1

11

Concept 2

5

Concept 3



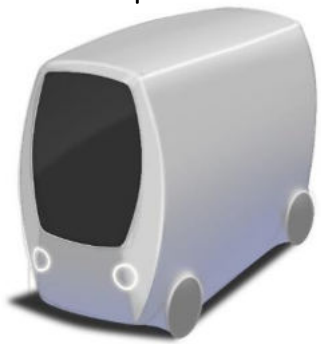
5

Scores

Concept 5 and concept 6 received the highest score.

Based on the evaluation concept 5 and concept 6 are taken forward and developed to a final concept .

Concept 4



2

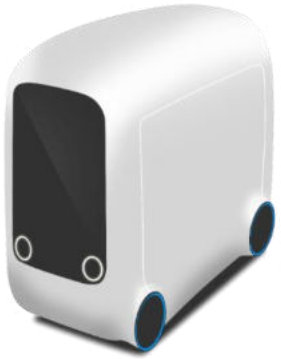
Concept 5

18

Concept 6

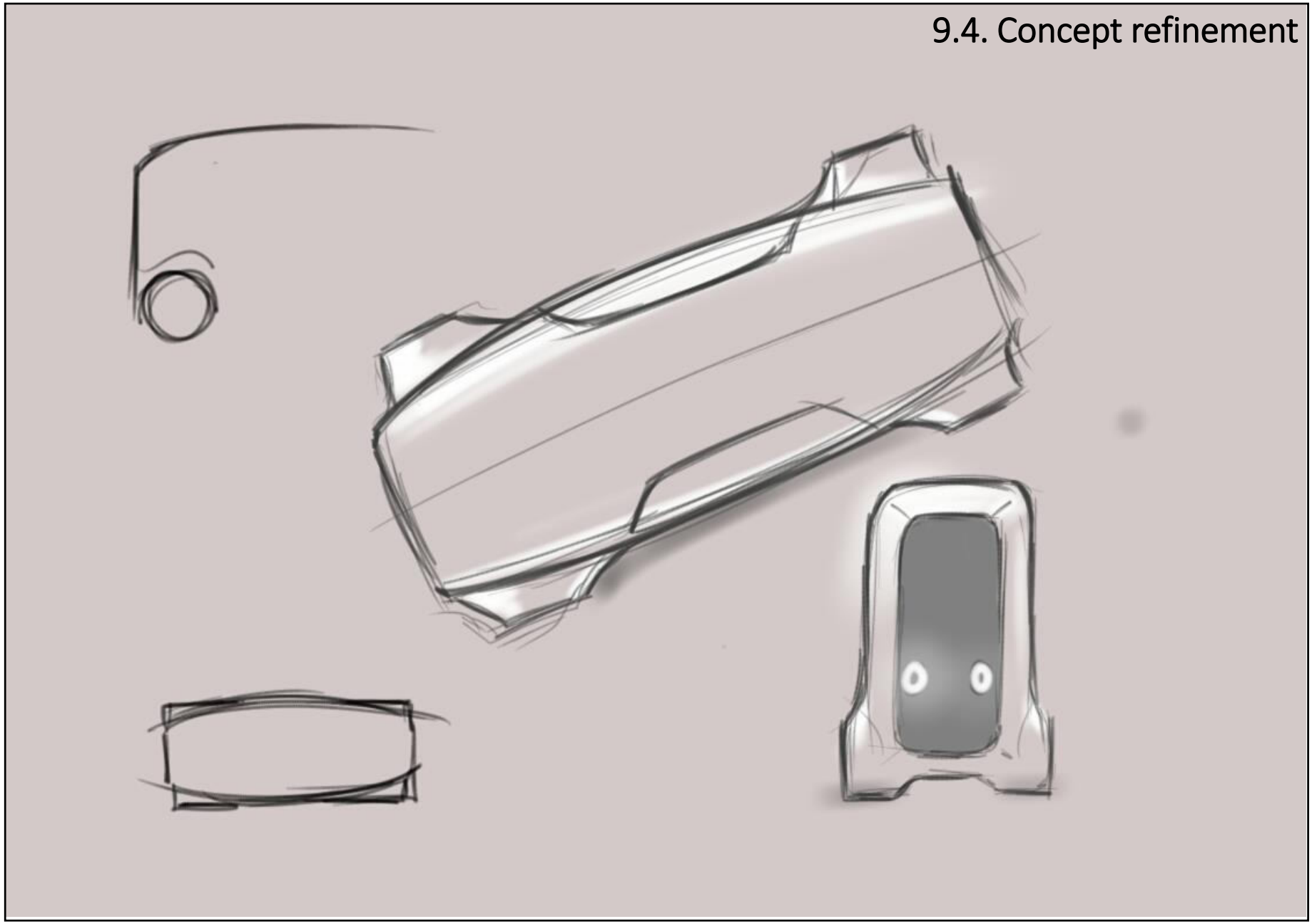
17

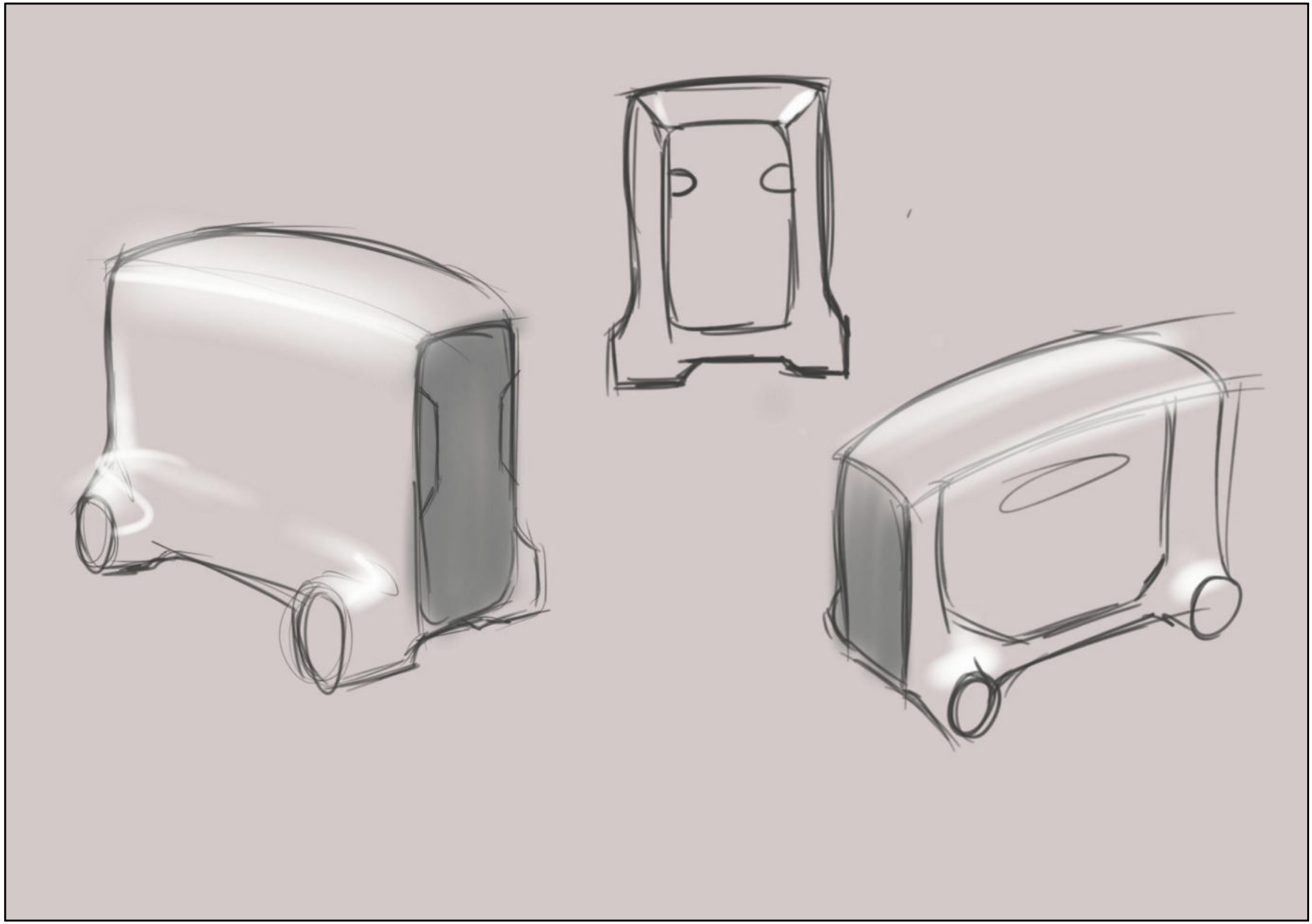
Concept 6



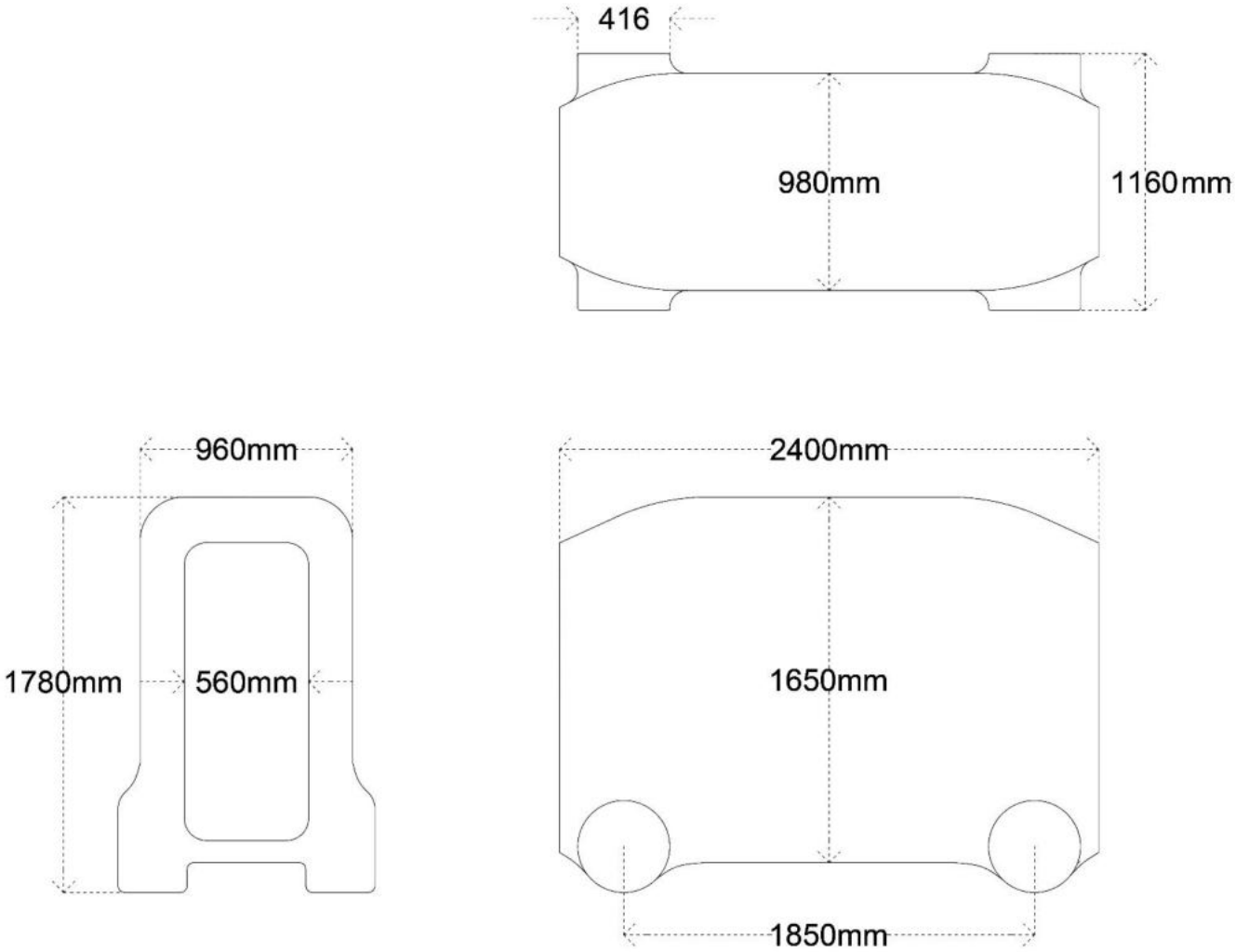
3

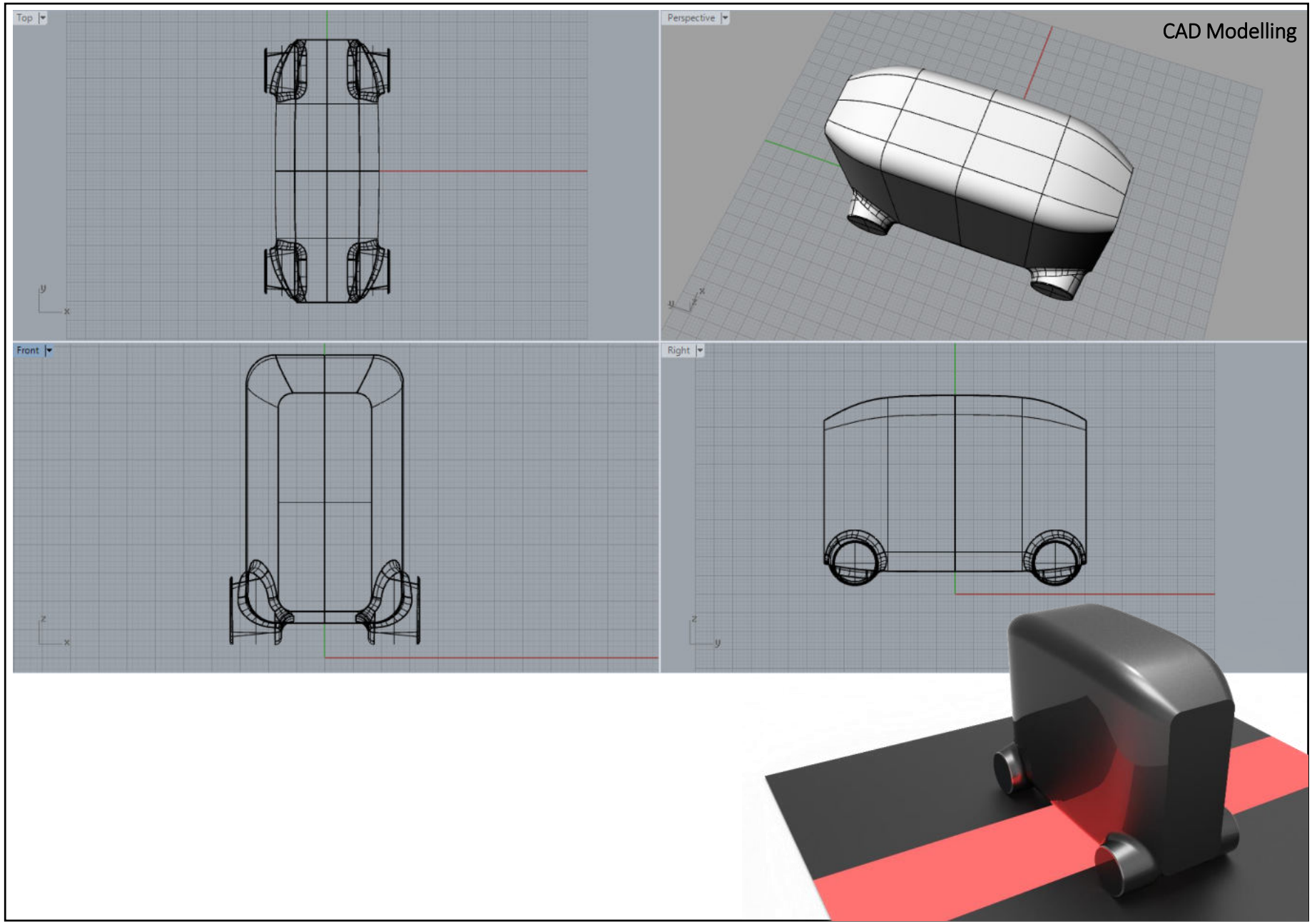
9.4. Concept refinement



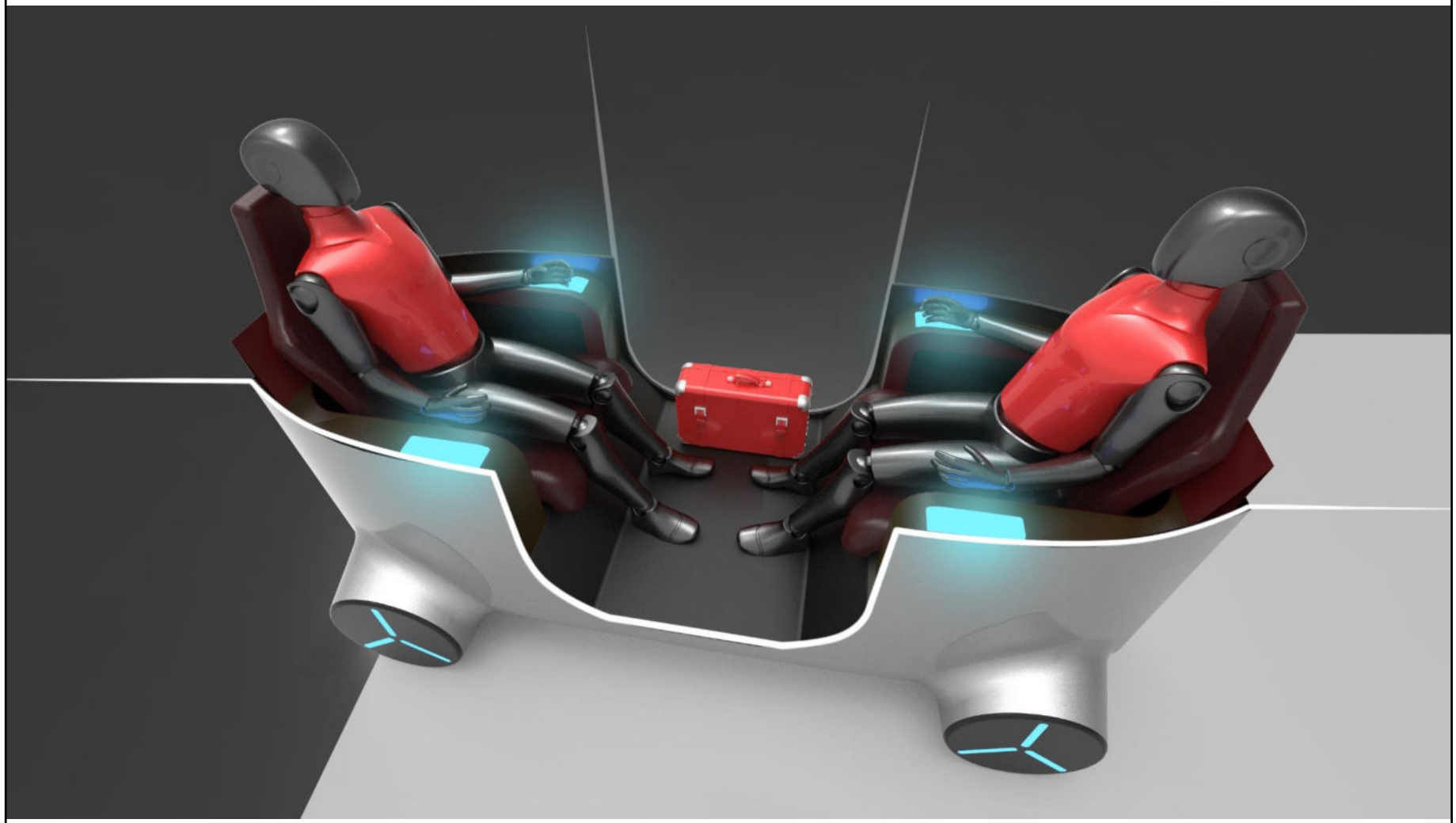


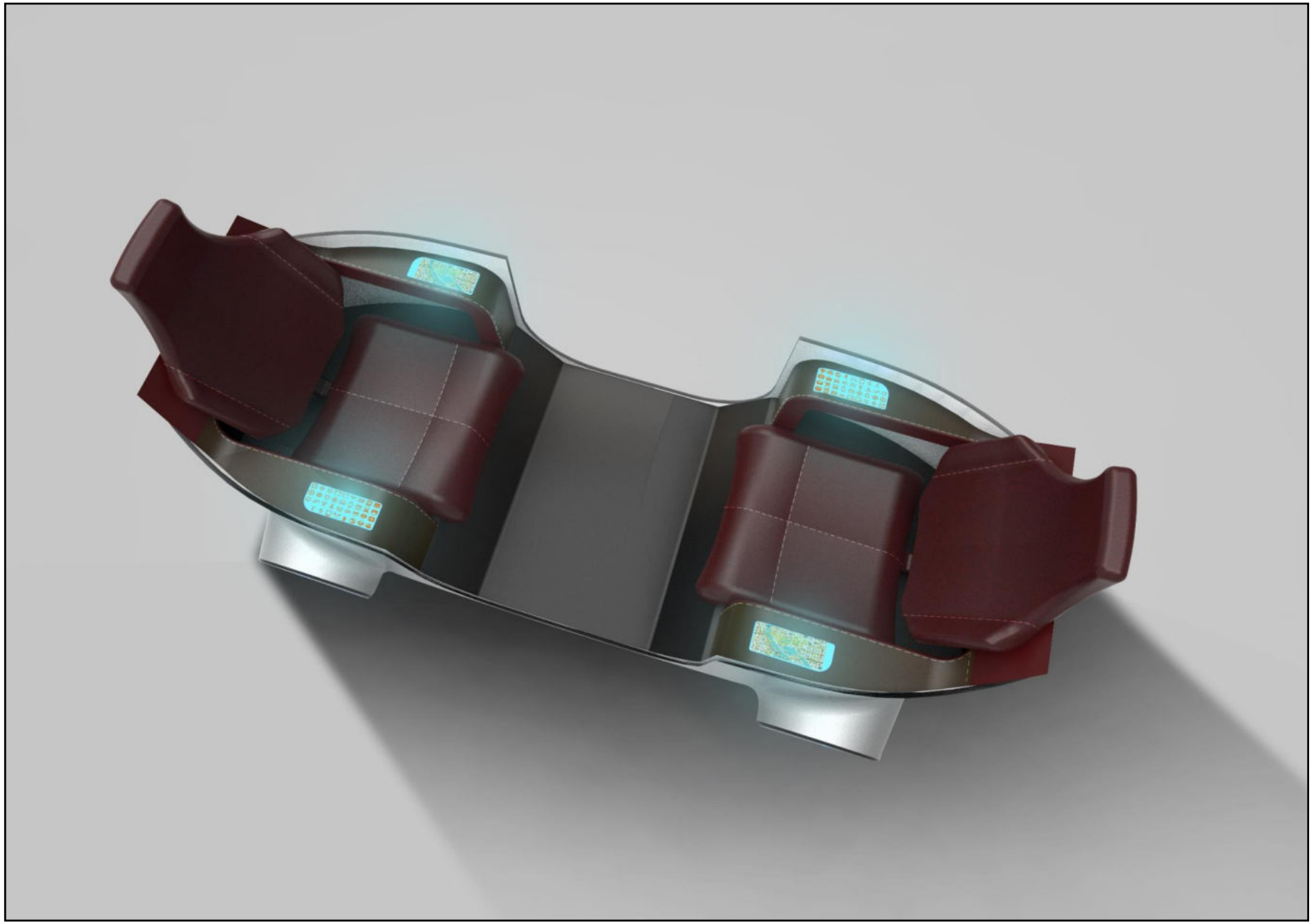
Working drawing



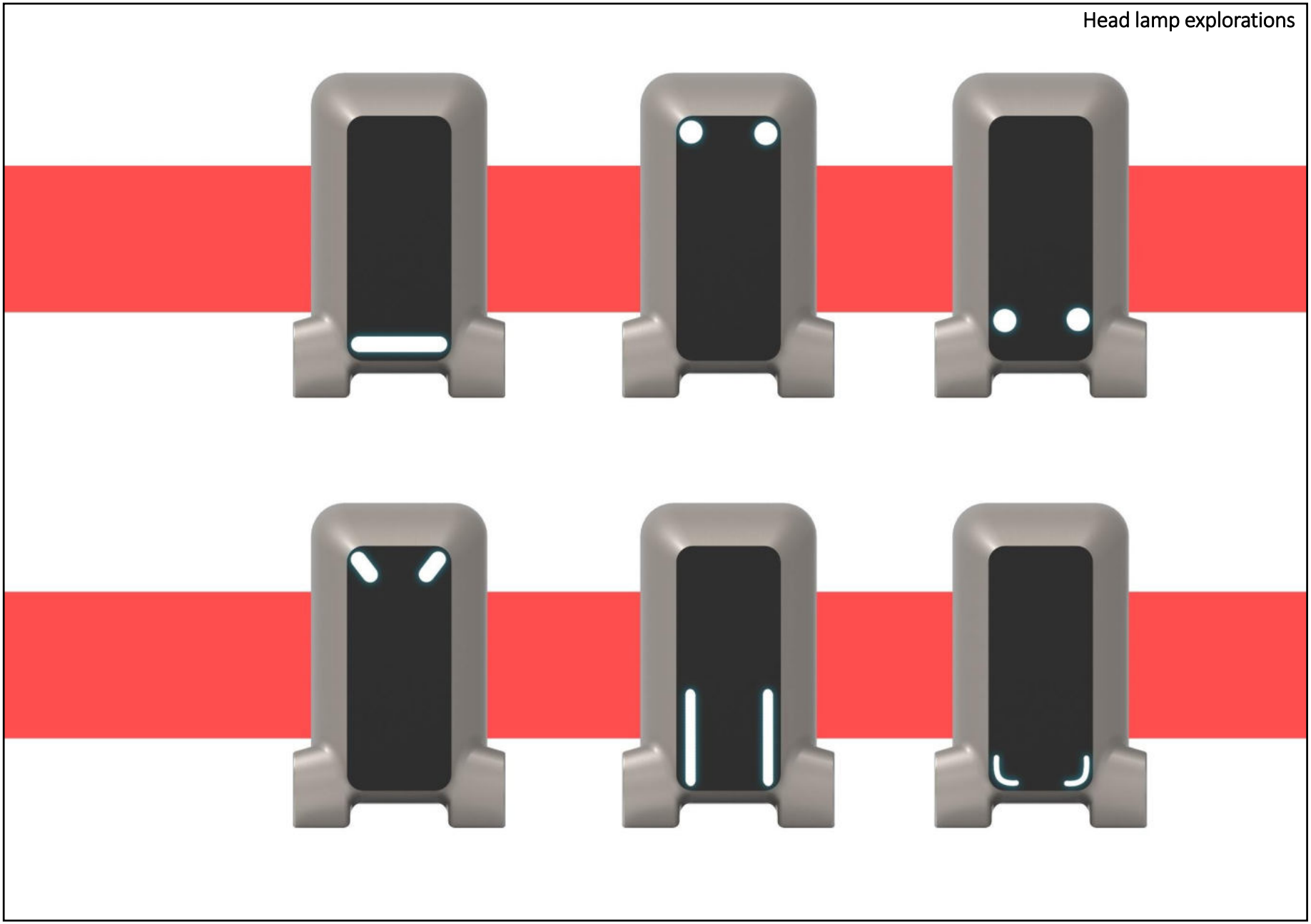

Top
Perspective
CAD Modelling
Front
Right

9.5. Interior



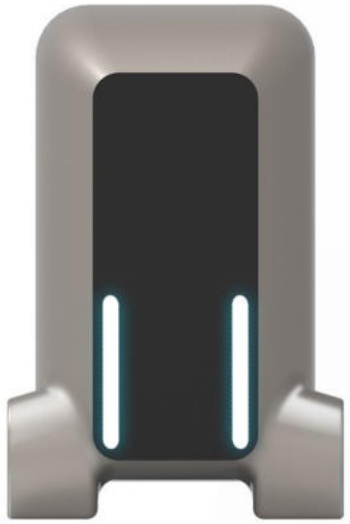


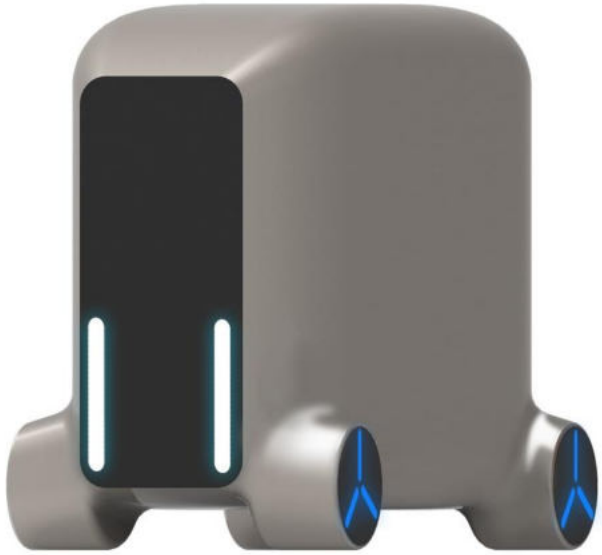
Head lamp explorations

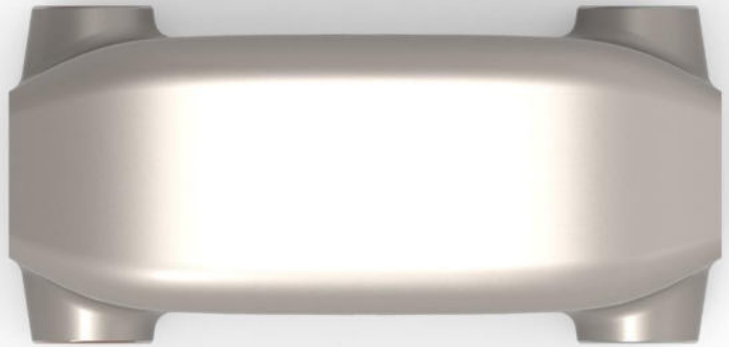


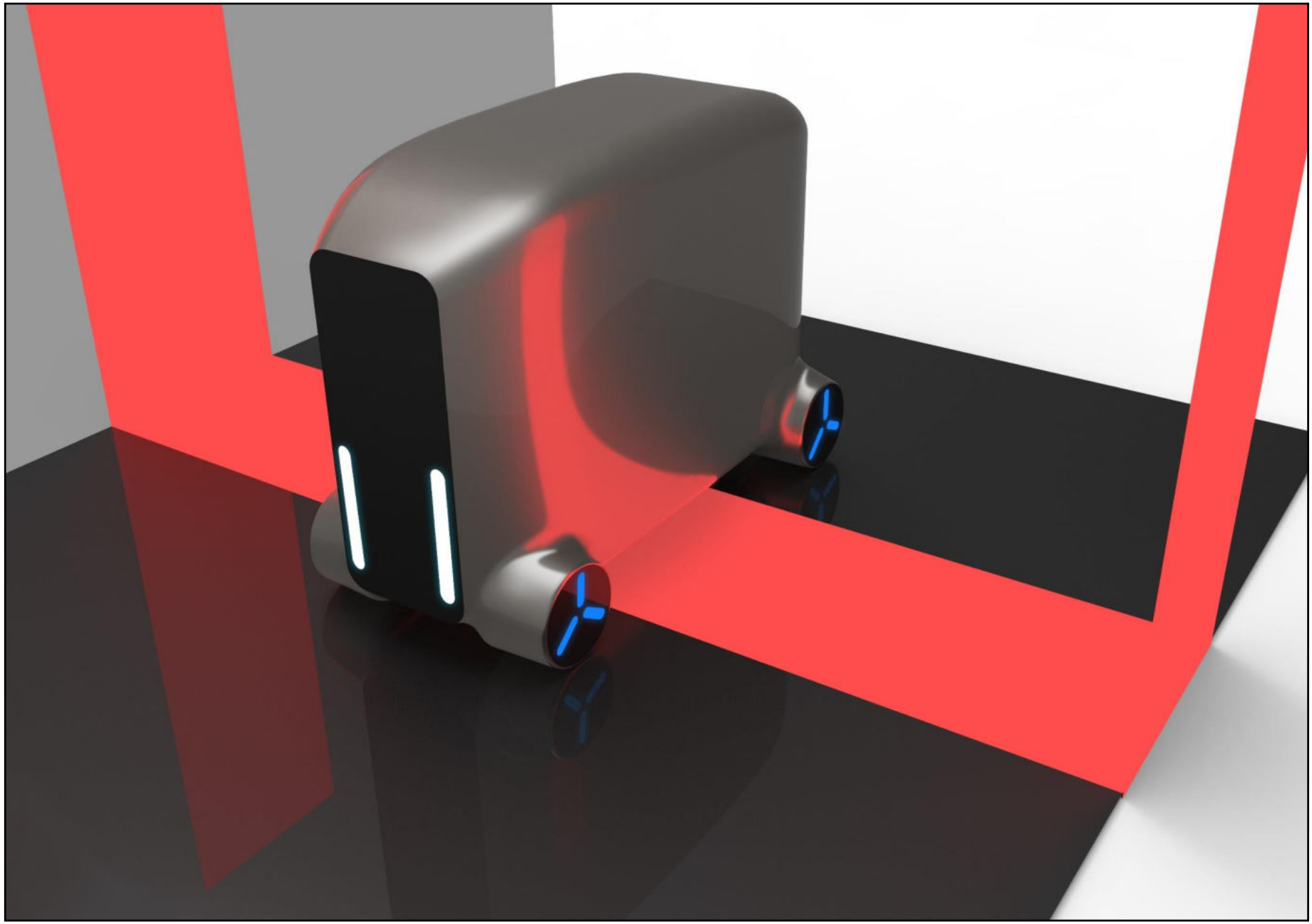
9.6. Final sketches and renders

Orthographic views

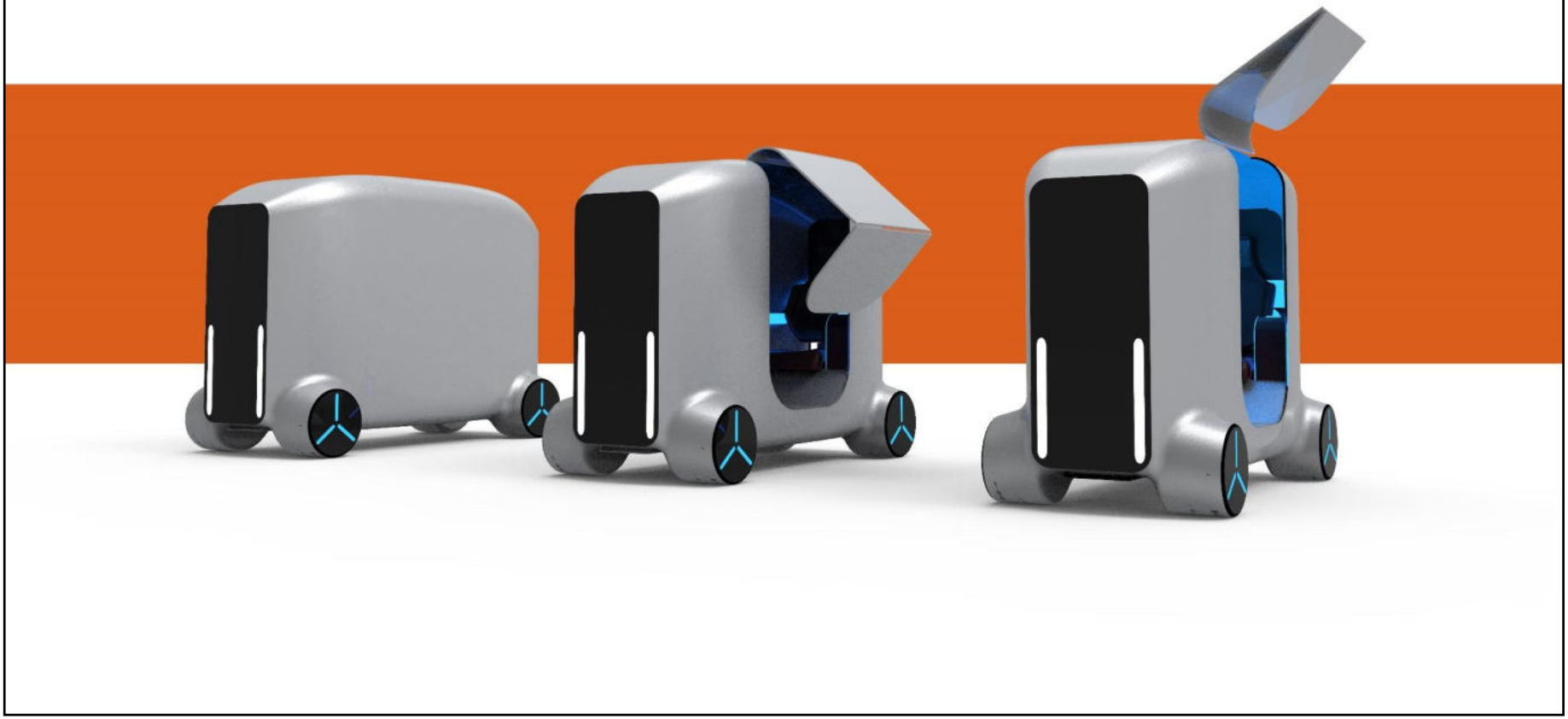








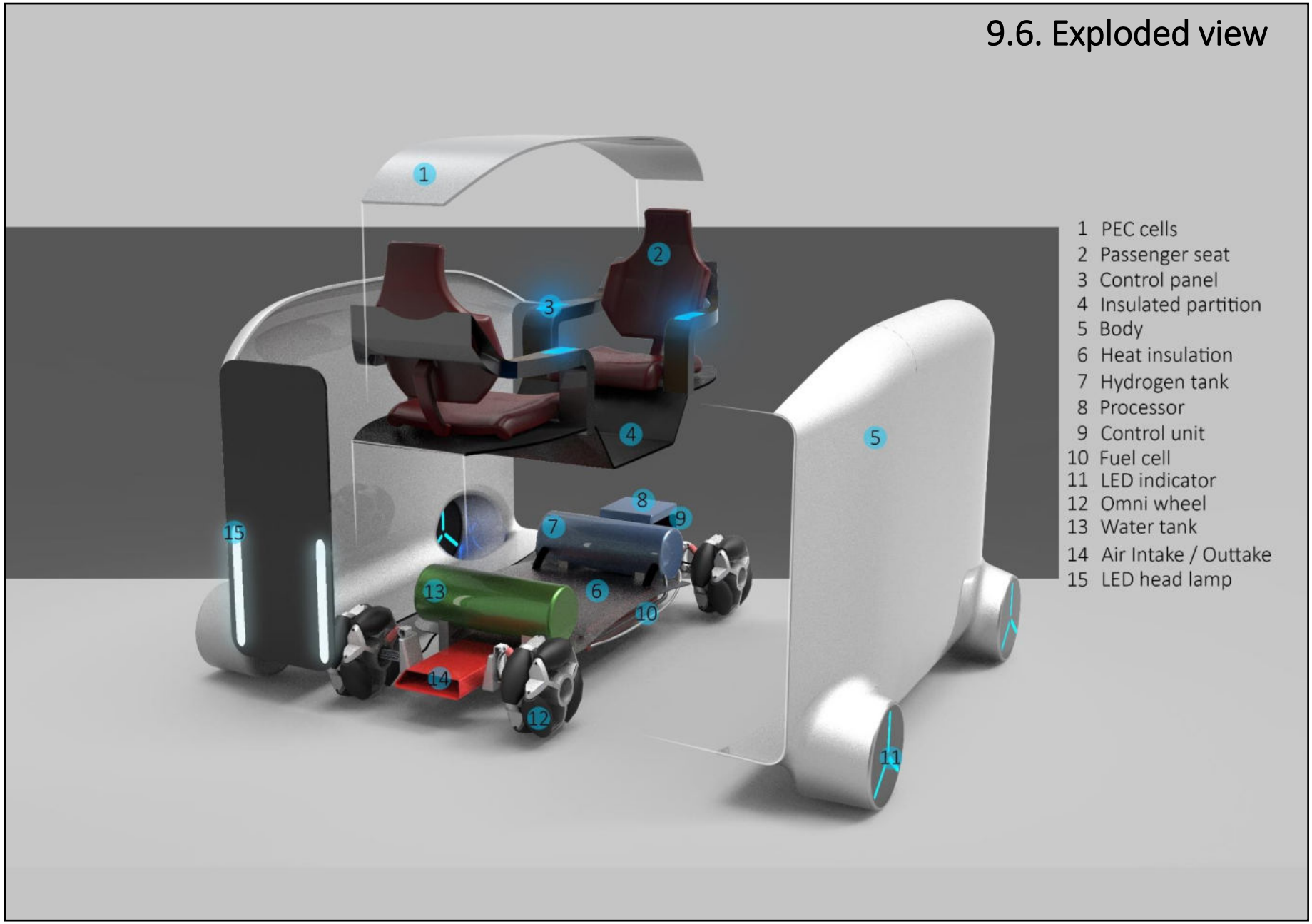
Door




SPOD
eat
drink
Dual carriageway ahead

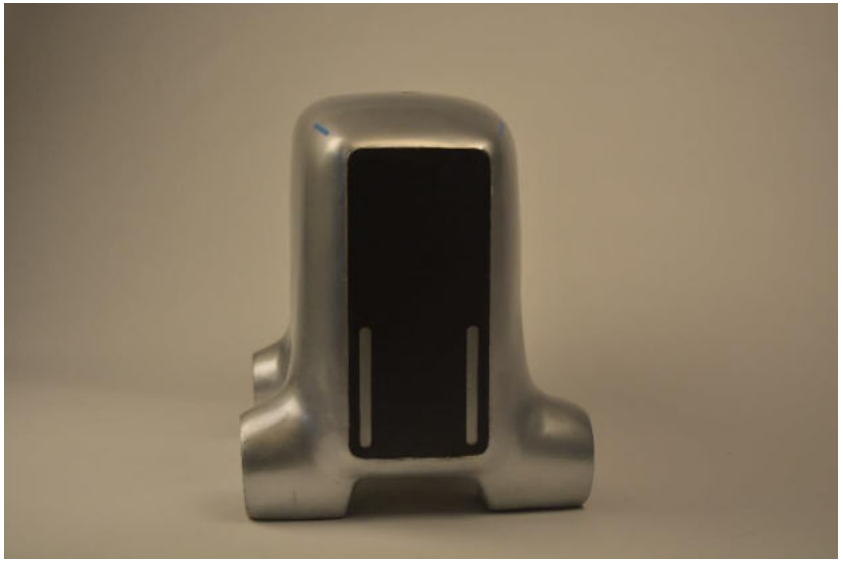

DEPOT 5C

9.6. Exploded view



10. Scaled Model

1:5



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In progress