Racecar Design for Le Mans

Design Project III
MVD III- 26

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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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APPROVAL SHEET

This Mobility and Vehicle Design project report entitled "Racecar Design for Le Mans", by Shreyas Ganesh Barve is approved in partial fulfilment of the requirements for Master of Design degree in Mobility and Vehicle Design.

Project Guide:-

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External Examiner:-

Date:-

Place:-

ACKNOWLEDGEMENT

I would firstly like to thank my guide, Prof. Nishant Sharma for the support and valuable inputs that he has provided during the course of project. I also thank Prof Lance for his inputs on the project.

Last but not the least, I would like to thank my family and all my dear friends at IDC and from other places for being a constant source of support and inspiration throughout the project.

Shreyas Ganesh Barve
Date:-

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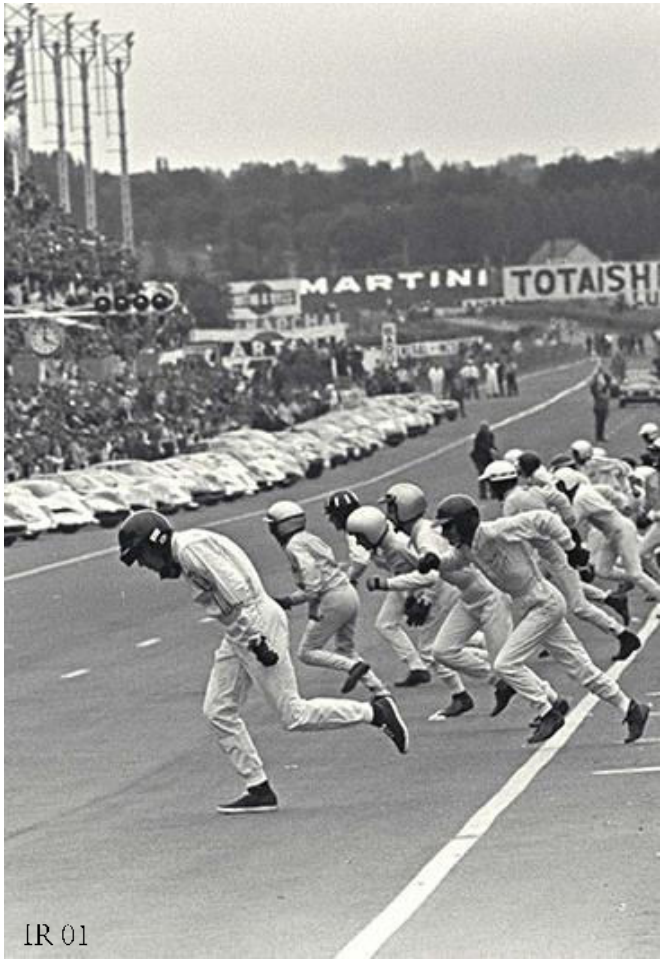
HISTORY



IR 01

The competition started in year 1923 at Le Mans Race circuit , France. The purpose of the event is been to provide a platform for the car manufacturers to test their innovations in actual conditions.

Le Mans first run was on 26 and 27th may 1923. It was originally planned to be a 3 year event , the winner will be the one who covers longest distance over the course of 3 events.

The event resumed in year 1949 after reconstruction of circuit facilities. During this period existing mainstream car manufacturers like Mercedes-Benz, Jaguar, Ferrari, Aston Martin started participating the event. In an unfortunate incidence during year 1955 ,80 spectators lost their lives, this incident led to introduction of safety measures for both drivers and spectators.

In later years vehicles of different classes were allowed to enter the event. It also gave the opportunity for the small scale car manufacturers to showcase their inventions and design.

THE CIRCUIT

Circuit de la Sarthe

IR 02

Circuit de la Sarthe also known as Circuit des 24 Heures. It is a semi-permanent race track it consists of local roads which remain open to the normal traffic during most of the year. Throughout the history the nature of circuit kept on changing due to newer regulations. In the current condition length of the circuit is 13.629 Km making it one of the longest circuit.

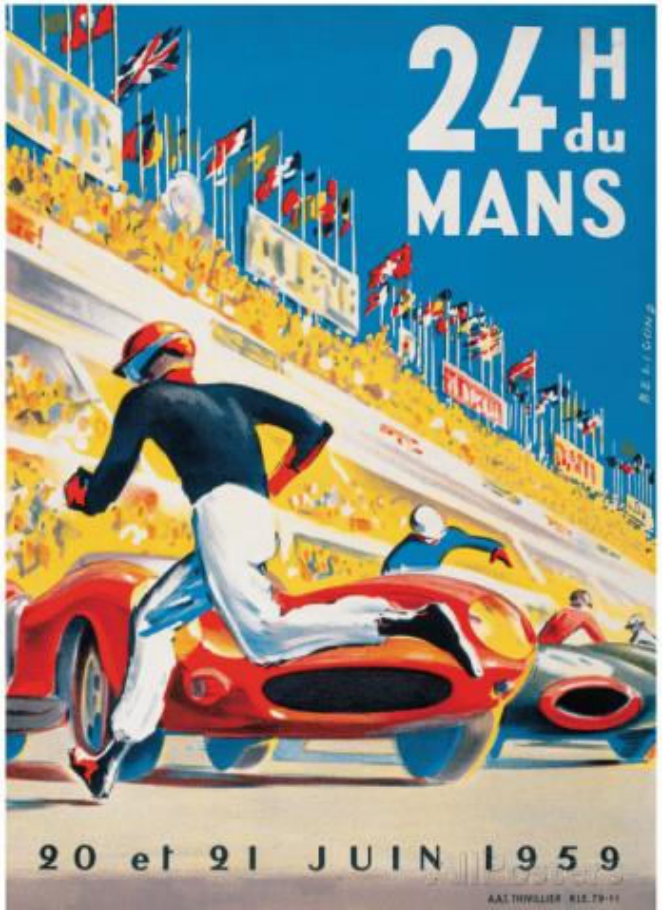
The pavilion can accommodate around 100,000 people.

Due to the current condition of the track the vehicles have to spent 85% time on full throttle. Overall it creates tremendous stress on almost all the components of the vehicle, especially engine, transmission etc.

At turns vehicles running with high speeds like 320km/hr have to slow down to lower speeds like 100km/hr creating stresses in suspension and braking systems.

KEY PLAYERS

WEC



IR 03

DRIVER SAFETY

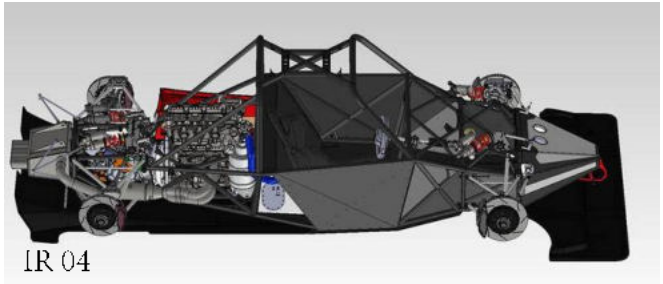
AERODYNAMICS

TYRES

PIT STOP DURATIONS

THE VEHICLE

Safety



IR 04

IR 05

IR 06

Active Safety

Vehicle Framework

In all vehicle drivers protection depends on he strength and energy absorption of structural components.

Entry and Exit

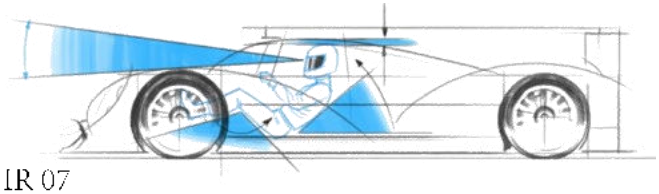
In case of any accidents it is vital to take the driver out and away from the vehicle because to provide medical services to the driver and after accident there is always a possibility of fire.

Fire

All the materials selected for vehicle should be tested for fire. In many cases due to high speed of impact the highly inflammable fuel catch fire. In case of fire driver and rescue crew should get enough time to get driver away form the car.

THE VEHICLE

Safety



IR 07

IR 08

Passive Safety

Visibility

Better visibility always allow the driver to have better idea about the surroundings. In crucial situations it provides more time to driver to react.

Vehicle Interior Comfort

Better comfort allows driver to concentrate on environment. Better MHI allows driver to gain important information at the right time.
Better comfort also reduces the stress levels in the drivers.

THE VEHICLE

Tires

Tires do play an important role at Le Mans race. As it' s a 24 hours race the track conditions do change throughout the race. At some times venue receives rain showers. Due to vast area covered by the circuit , it is possible that certain portion of the track is exposed to rain showers making it difficult to team to select the tires. Due to position of driver in the car it is difficult for driver to judge the road conditions , so in many cases Engineers take the call of tire change.

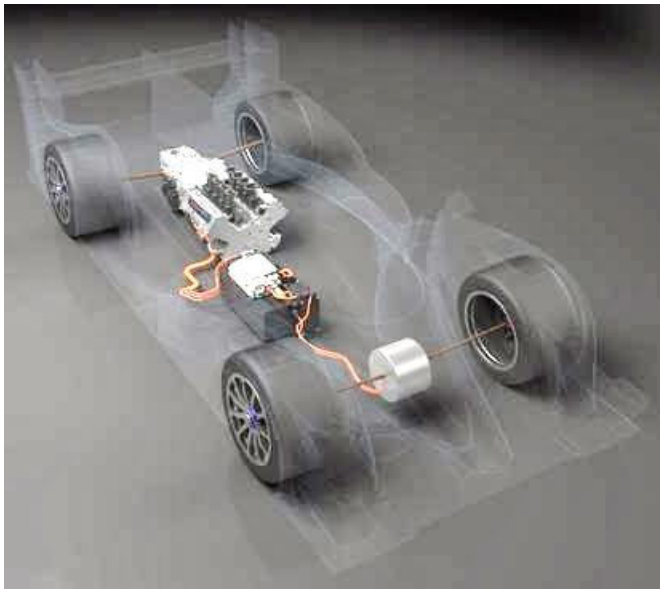
Track temperature also plays an important role in tire choice. Every LMP 1 vehicle does 3 to 4 stints on a set of tires

Normally following types of tires are provided to the teams.

- low temperature soft compound
- high temperature soft compound
- high temperature medium compound
- slick intermediate (no tread pattern)
- wet
- full wet

THE VEHICLE

Hybrid System



IR 10

From 2012 onwards Le Mans is a part of World Endurance Championship. Along with endurance efficiency also plays an important role. Due to tough regulations of WEC regarding the fuel consumption , fuel storage and engine capacity participants have to work hard on obtaining maximum efficiency in all sectors.

To achieve such high efficiency Hybrid Systems are introduced in almost vehicle along with Kinetic Energy Recovery system. At entry to corners while braking vehicles generate high amount of energy for reducing the momentum of the vehicle.

Kinetic Energy recovery system allow vehicle to store this high amount of energy and use it when required. There are 2 types of systems used in WEC vehicles.

Mechanical System stores the kinetic energy with the help of flywheel.

In Electrical System generators are coupled with wheel axles to store the energy in batteries or capacitors.

THE VEHICLE

Controls

IR 11

Controls to be provided in any race car is always very critical. Only required amount controls should be provided at right places. For WEC race car drivers are always linked to their engineers in garage. Many parameters are monitored by engineers at garage and only required information is provided to the driver reducing the flow of information towards the driver, it allows driver to concentrate more on driving.

Gear shifters are provided on the steering wheels, one for UP and other for Down. Clutch operation is automatic. With left and right foot driver takes care of throttle and brakes. On steering wheel it self an indicator is provided to prompt driver about changing gears.

On secondary control panel other less frequently used controls are provided such as wiper, heater, start etc.

THE DRIVER

Balaclava
The balaclava tucks under the fire-proof top. Drivers don't have issues with sweat as it gets soaked up by the nomex material and it is quite breathable.

Head and Neck Safety Device
HANS is mandatory for all race car drivers. Its made up of carbon compounds. It clips on to the side of the helmet with elastic straps and is designed to stop your back stretching and your head hitting the steering wheel.

Race Helmet
Helmets are fully made from carbon. Each helmet is designed for a specific driver considering drivers head size and comfort.

THE DRIVER

Visors
During endurance race ,intensity of light keep on changing that's why drivers carry visors of different shades.

Gloves
The gloves have got thinner and the nomex stitching has gone from the inside to the outside now which makes them feel very pliable.

Race Overalls
They are three or four layered nomex and they can withstand fire for at least 60-seconds.
The base design fits in with the team and then patches/names of personal sponsors and championship sponsors are applied.

Race Boots & Socks
The boots are cool and are completely fireproof, as are the socks of course.
They are very thin which is obviously critical for us to get a good feel for the pedals.

AUDI R18 E-TRON QUATTRO

Case Study

IR 14

AUDI R18 E-TRON QUATTRO

Specifications

Monocoque
Carbon fiber composite (CFC) with aluminum honeycomb and Zylon
side panels, tested according to the strict FIA crash and safety
standards, rear CFC crasher

Battery
Lithium ion battery

Engine
Audi TDI, turbocharged 120° V6, 4 valves per cylinder, 1 Garrett VTG
turbocharger, diesel direct injection TDI, fully stressed aluminum
crankcase ,Cubic capacity 4,000 cc, Power output Over 395 kW (537 PS)
Torque Over 800 Nm

Hybrid system
Type of accumulator Electric flywheel
accumulator, WHP, usable storage
capacity over 600 KJ

Motor Generator Unit (MGU)
One MGU on front axle, water cooled with integrated power electronics
, over 170 kW

Drivetrain / transmission
Drive system
Rear wheel drive, traction control (ASR), four-wheel drive e-tron quattro
in hybrid mode
Clutch:- Carbon clutch
Gearbox Sequential, electrically activated 7-speed racing gearbox
Differential Limited-slip rear differential
Gearbox housing CFC with titanium inserts
Driveshafts Constant velocity sliding tripod universal joints

Suspension / steering / brakes
Steering Electrically assisted rack and pinion steering

AUDI R18 E-TRON QUATTRO

IR 39

IR 40

Due to new regulations restricting the power limit for the vehicle, vehicles require lesser down force. Flow of air around the vehicle is used for following applications.

Combustion

For latest conventional engines large amount of air is required to obtain higher thermal efficiency.

Down force

At speeds over 300km/ hr it is vital that enough force is applied on the vehicle to keep the vehicle on ground and to provide grip at wheels.

Cooling

Many components generate high amount of heat when the vehicle is running. To achieve maximum efficiency of these components it is required to maintain its temperature.

NISSAN

IR 15

IR 16

Nissan GT-R LM Nismo

The vehicle got a layout in which the engine is positioned at the front and the drivers cabin is moved backward. The layout allows ample air supply to the engine. As engine and transmission is front vehicle gets better grip at the front making it easier to handle. It also counters the tendency of vehicle to spin off.

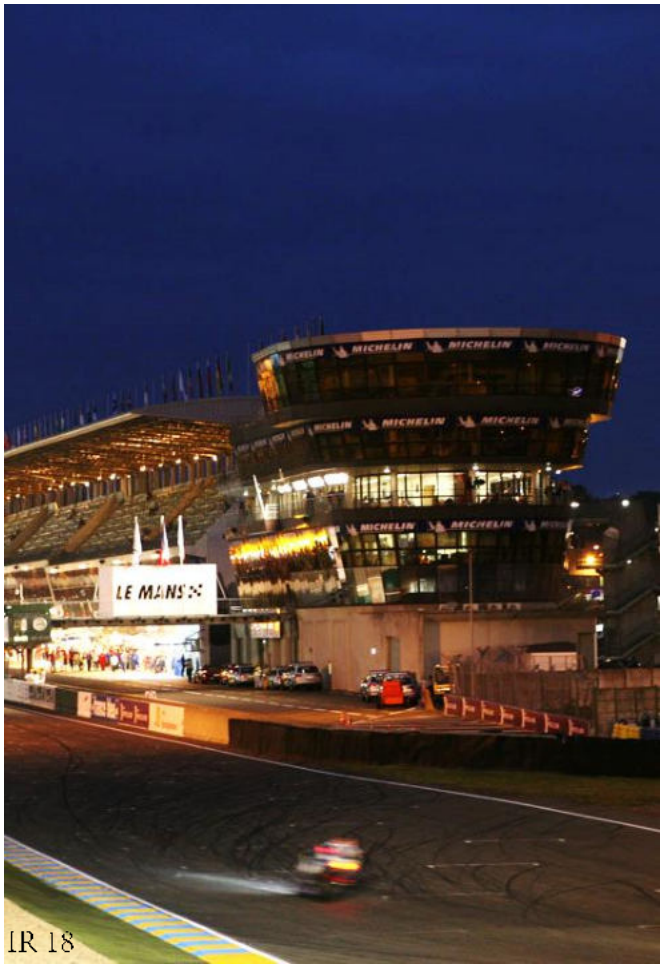
Deltawing

The DeltaWing was designed to reduce aerodynamic drag dramatically, to allow a marginally faster straight and corner speed than a 2009-2011 Dallara IndyCar on both ovals and road/street courses with half as much weight, engine power and fuel consumption. As the name suggests, it has a delta wing shape, with an unusually narrow 0.6 metres (2 ft 0 in) front track and a more traditional 1.7 metres (5 ft 7 in) rear track

WAY FORWARD

KEY PLAYERS

Future Le Mans



IR 18

Pits

Time spent in pits do play an important role in victory. Usually cars take 27 to 30 pit stops, Only 4 engineers are allowed around the vehicle. During pits teams usually do wheel change, refueling, vehicle maintenance and driver change.

Safety

Safety is given the top priority in all aspects of design, right from vehicle chassis to seam of drivers suit. WEC also defines regulations for driver safety. These are strictly maintained.

Corners

Time taken while taking the corners do matter. Vehicles have to reduce its speed drastically and quickly gain momentum at the exit of the corners. Nature of air flow around the vehicle also changes.

Wheels

Quality of tires define how vehicle can grip the surface and take corners at high speeds. In pit stops wheel change is the most commonly performed operation during the race.

KEY DRIVERS

For Future Mobility User POV

IR 19

IR 20

IR 21

Virtual Space

Lot of daily operations will be done is large cyber space available due to transparency, low cost and high data processing capacity.

Autonomous Transportation

Due to introduction of Autonomous vehicles the skill of driving among common people may get extinct by 2030.

Work From Home

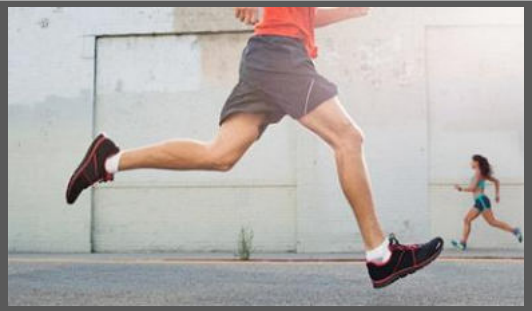
High speed internet connectivity will allow lot of human work force to do work from home which will reduce load on transportation system.

KEY DRIVERS

For Future Mobility User POV

IR 22

IR 23



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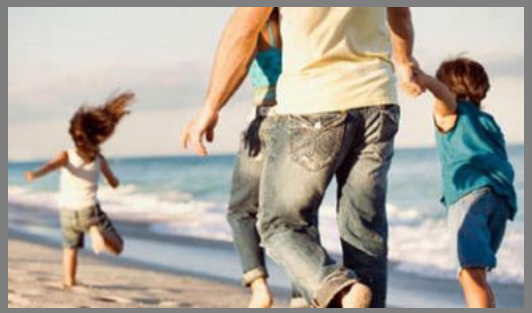


Respect to Nature

Awareness among people about global worming will make people more conscious about the nature and its state for human wellbeing.

Health Conscious

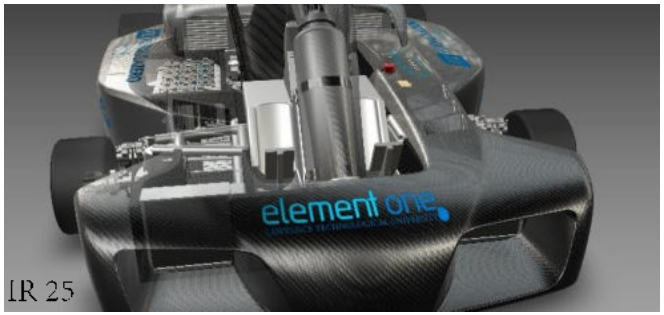
After rise in cancer and heart patient at the start of 21st century ,I believe population will be very much health conscious by year 2030.

Socially Active

Taking advantage of internet connectivity and time saved in traveling population will have more time to spend with family and relatives.

WHY AND WHAT IN 2030

Vehicle architecture



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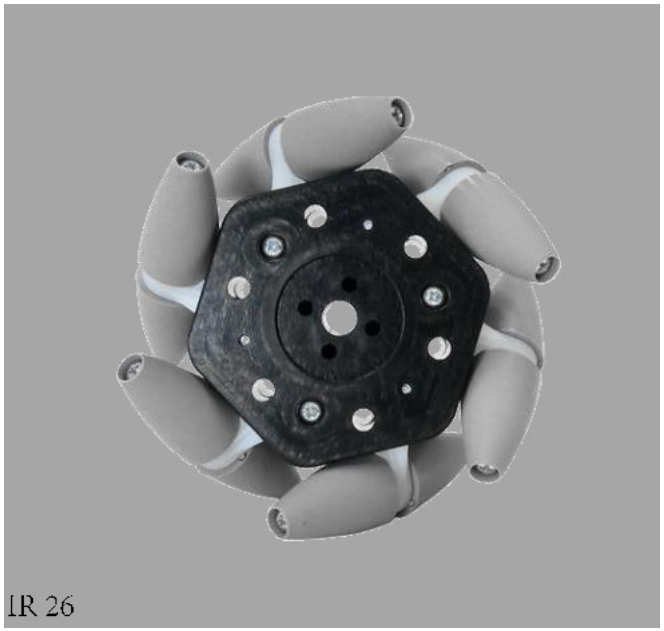

IR 26

Power Source

For overcoming the friction offered by air and land, power source in essential for any moving vehicle.

Till 2030 it is expected that vehicles will be powered mostly green power sources such as fuel cell, electric drives etc.

Wheels

Wheels are the components which allow vehicles to move on the surface with minimum friction along with providing comfort to the users.

The role of wheels will be enhanced in future. The technology is moving in a direction where we can have different functions integrated in the wheel itself.

Driver

In 2030 drivers car relay on computerized controls making vehicles autonomous.

DESIGN BRIEF

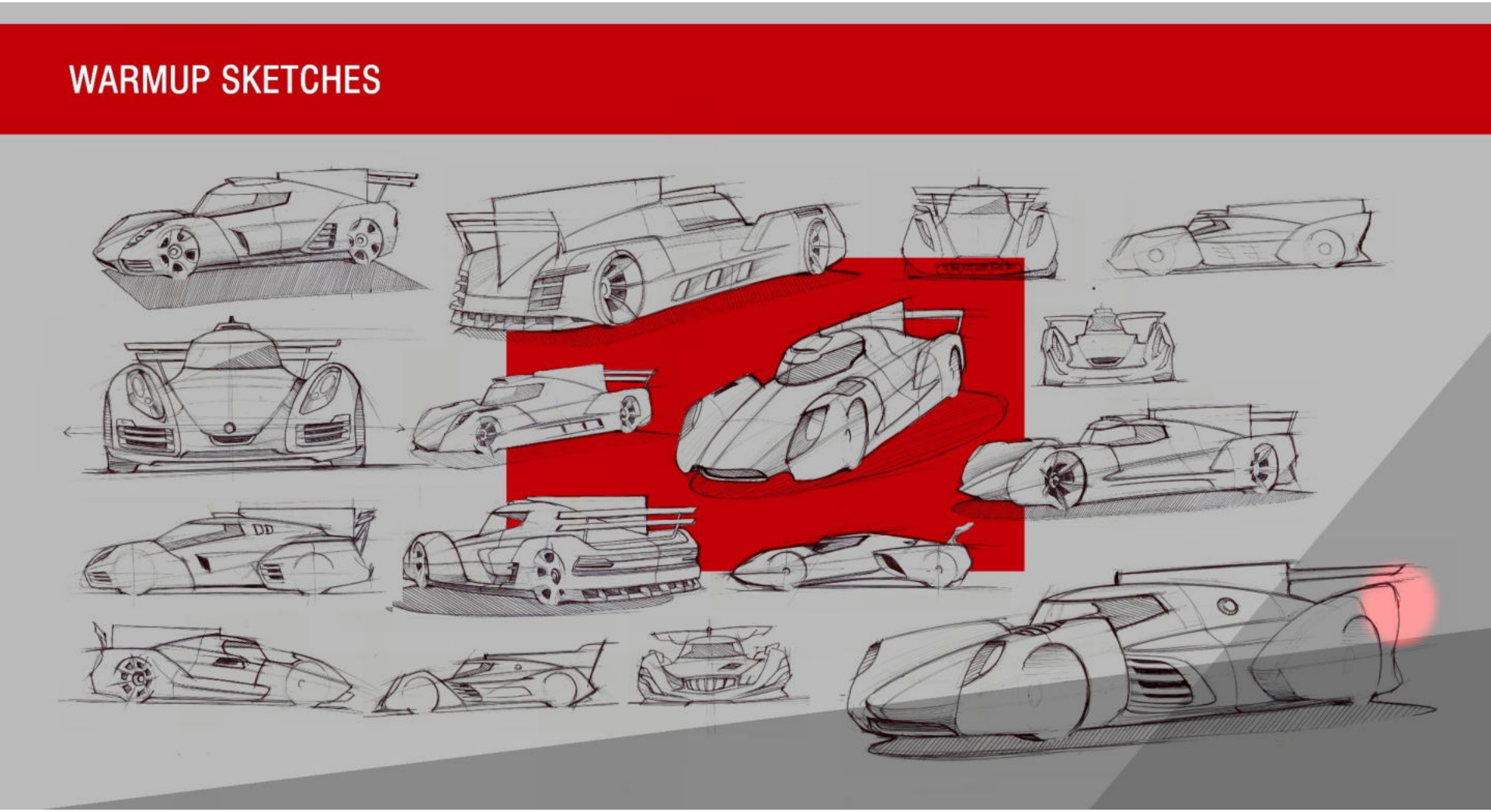
Designing the Vehicle Le Mans 2030 considering the possible developments in the field of tires, propulsion , structure etc.

Objective
Introduce a way to allow the vehicle to move in corners at higher speeds. Reducing the time taken.

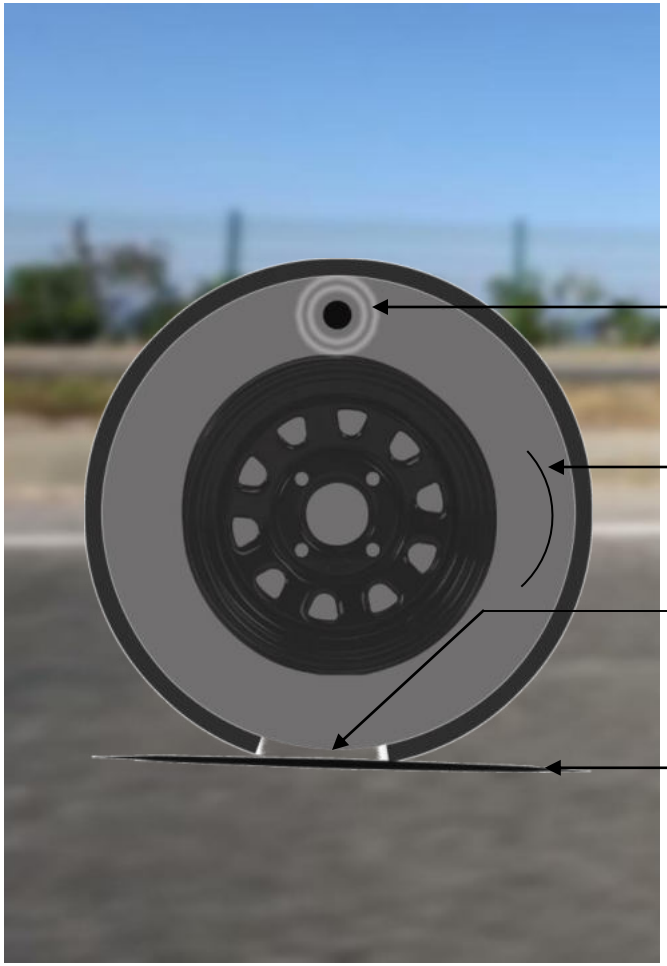
DESIGN

- Ideation
  - Wheel Ideation
  - Vehicle Dynamics
- Concept Generation
  - Concept 1
  - Concept 2
  - Concept 3
  - Concept 4
- Vehicle Architecture

IDEATION



WHEEL CONCEPT



The friction caused between tire and road leads to wearing of tires and eventually replacement of it. What if we can avoid this contact and establish contact between road and dynamic fluid.

Propeller
It will circulate the fluid in the closed volume provided instate of wheel.

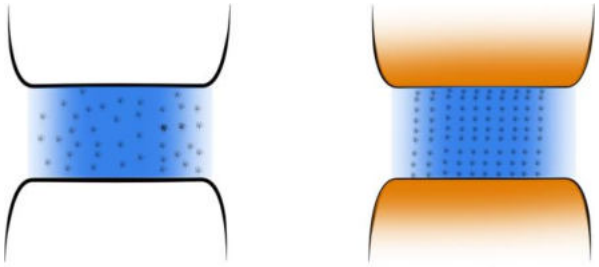
Dynamic Fluid
It will be a viscous fluid moving in the closed space.

Contact
The area where dynamic fluid comes in contact with the road surface.

Road Surface

FERROFLUID

Working Principle



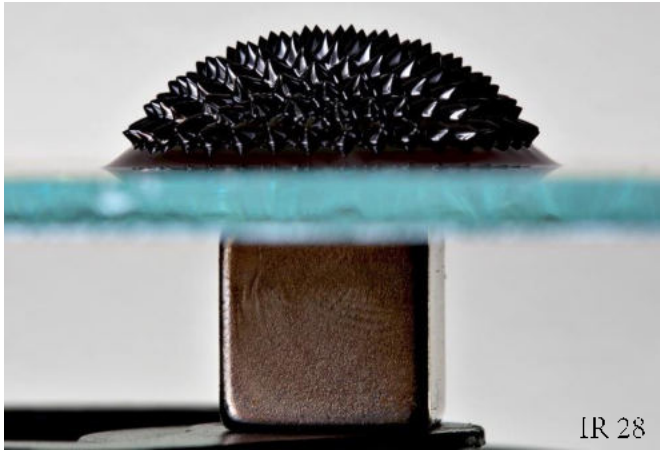
Magnetic Effect OFF Magnetic Effect ON

Circular magnet covered with FF

IR 27

The behavior of the Ferro fluid is as shown in the illustration. The fluid behaves as a normal fluid when there is no magnetic field. When magnetic field is generated in changes its behavior.

Ferrofluid (FF) is a colloidal dispersions of magnetic Nano-particles, which have a permanent magnetic moment. They have a diameter around 10 nm, showing behavior of single magnetic domains. Several types of particles can be dispersed, such as magnetite and cobalt ferrite and others.

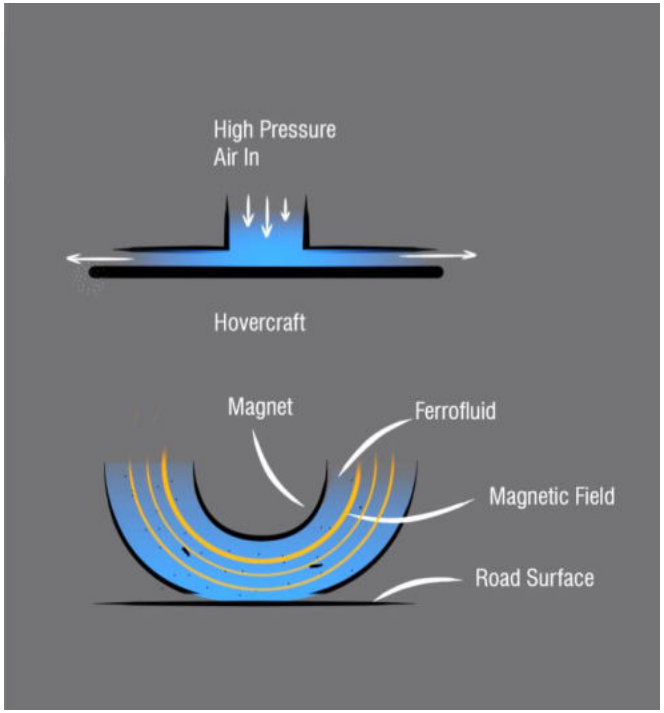


IR 28

FERROFLUID

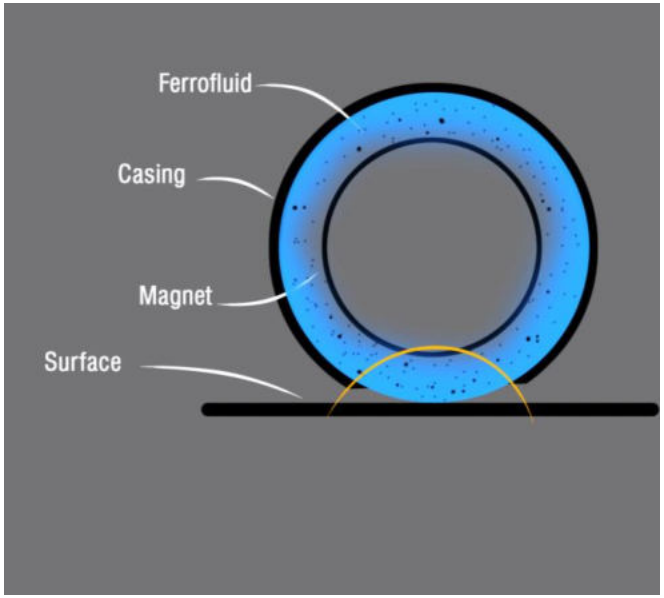
Working Principle

In case of hover craft high pressures allowed to escape through the gap-created between the 2 surfaces. It creates a cushion between the surfaces offering very low friction to the relative motion between the two surfaces.



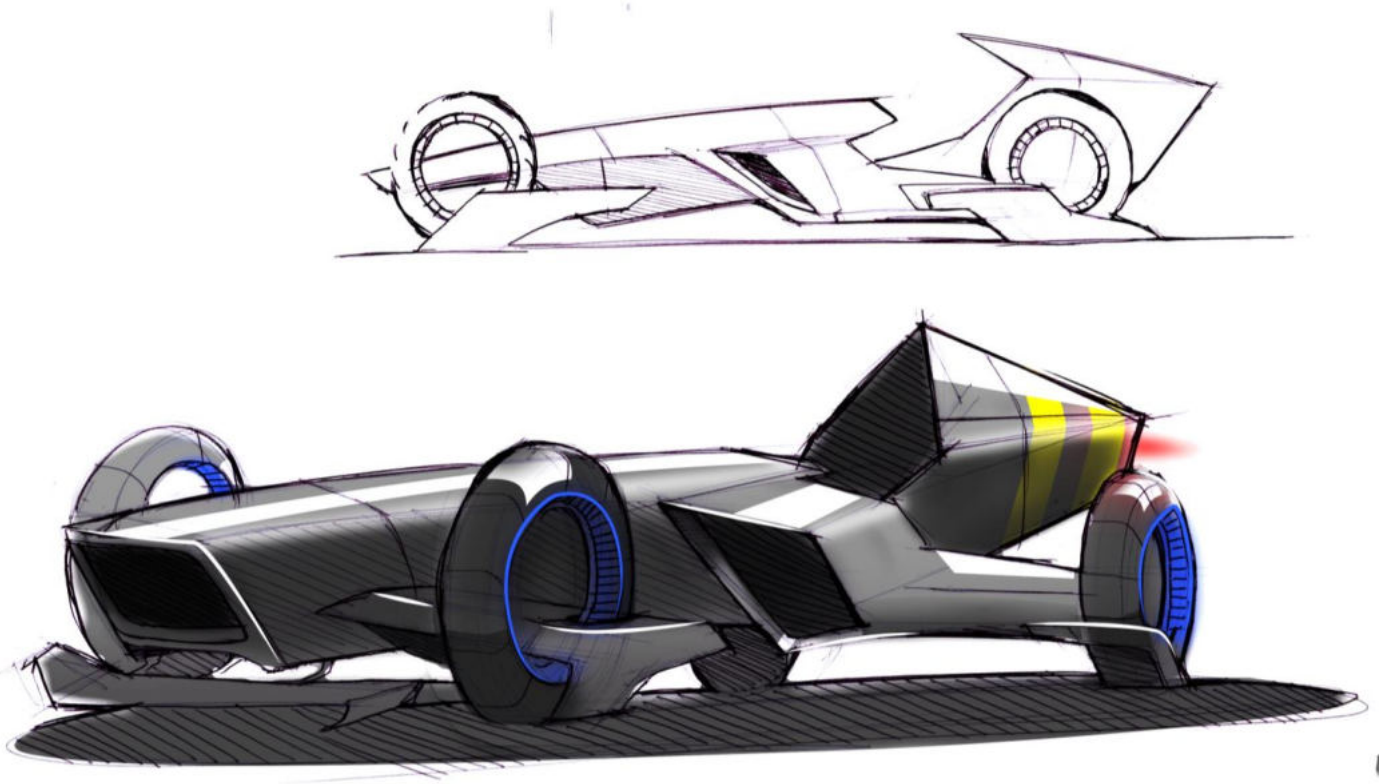
In case of Ferrofluid wheel the fluid will contain iron particles which will react to the magnetic field. The working principle is similar to the hover craft with further additions.

The magnetic field developed around the openings wont allow fluid to escape as it happens in case of hover craft. The cushioning fluid itself will be responsible for propulsion of the vehicle.



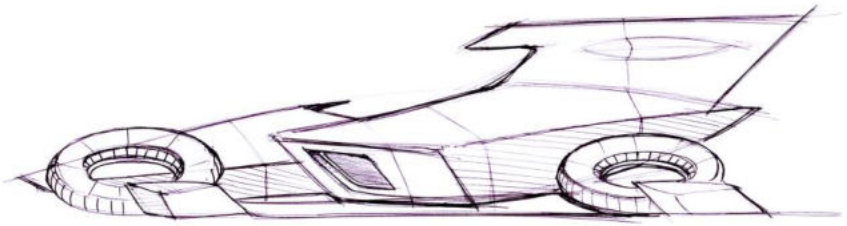
WHEEL CONCEPT

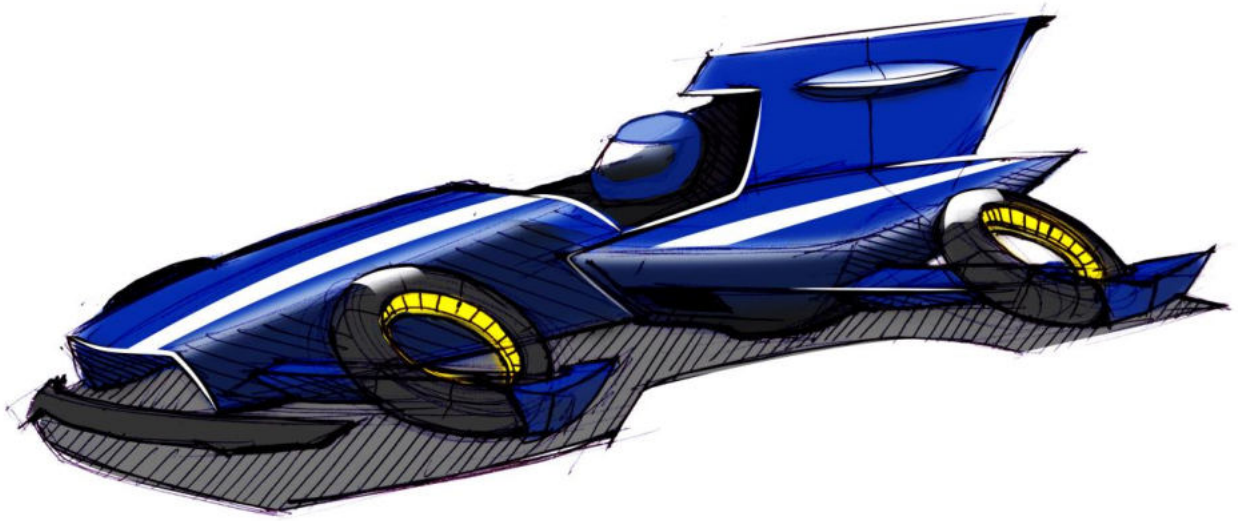
Following concept shows implementation of the idea explained in the previous page.



WHEEL CONCEPT

Taking the previous concept forward this concepts consists high pressure fluid inside the closed compartment inclined to the road.





MAGNETIC WHEEL

Working Principle

The wheel will consist roughly 4 major components. The wheel will be power by rotating magnetic field. There are no moving mechanical components in the system reducing frictional and transmission losses associated with any conventional vehicle. Controlling speed of the vehicle is also easier as it can be easily obtained by changing electrical parameters associated with the magnet.

FERROFLUID

Working Principle

Pads:- These will be made up of synthetic rubber. Inside volume will be nothing but Honeycomb structure made up of same material. This provision will avoid problems associated with punctures.

Rotor:- Rotor will hold the pads together and allow the flaps provided on the inside of pads to be in contact with dynamic Ferrofluid.

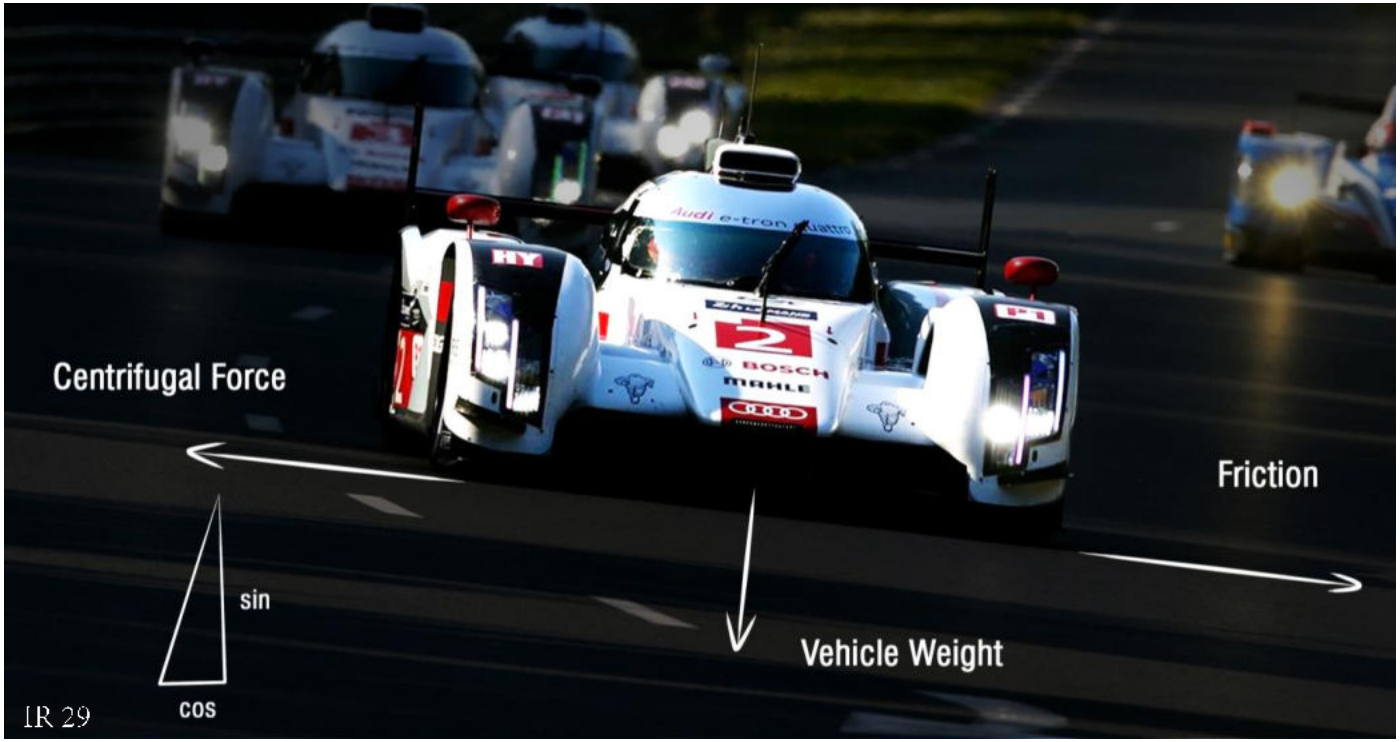
Casing:- Casing will harness the rotor no the outside and allow ferrofluid to rotate inside.

Magnets:- Magnet provided inside the casing will create the rotating magnetic field.

VEHICLE DYNAMICS

Centrifugal Force
Due to inertia generated in the vehicle, the vehicle will try not to change the direction creating radially outward force on the vehicle.

Friction
The friction caused between tire and road leads to wearing of tires and eventually replacement of it. What if we can avoid this contact and establish contact between road and dynamic fluid.



VEHICLE DYNAMICS

Current Technology


IR 30

Active Suspension

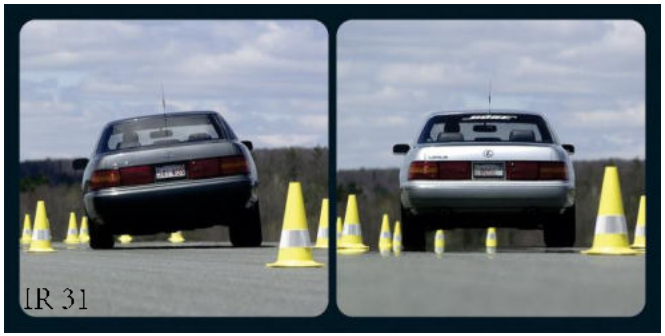
The system will react to the Terrain by changing the pressure in shock absorbers to maintain the vehicle stability by countering-the role experienced by the vehicle.

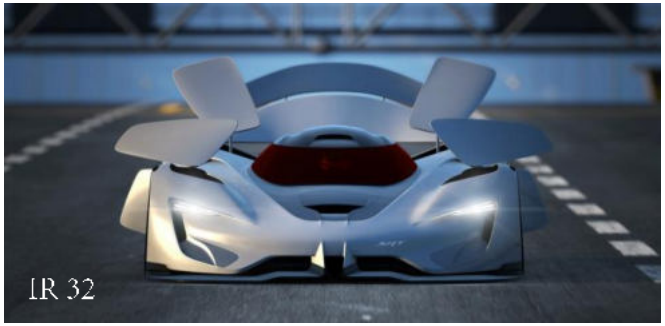
Active Aerodynamics

On board computer will adjust the spoilers provided on vehicle such a way that required pressure is applied on each wheels .

Traction Control

On board computer will provide required torque to balance the vehicle.


IR 31

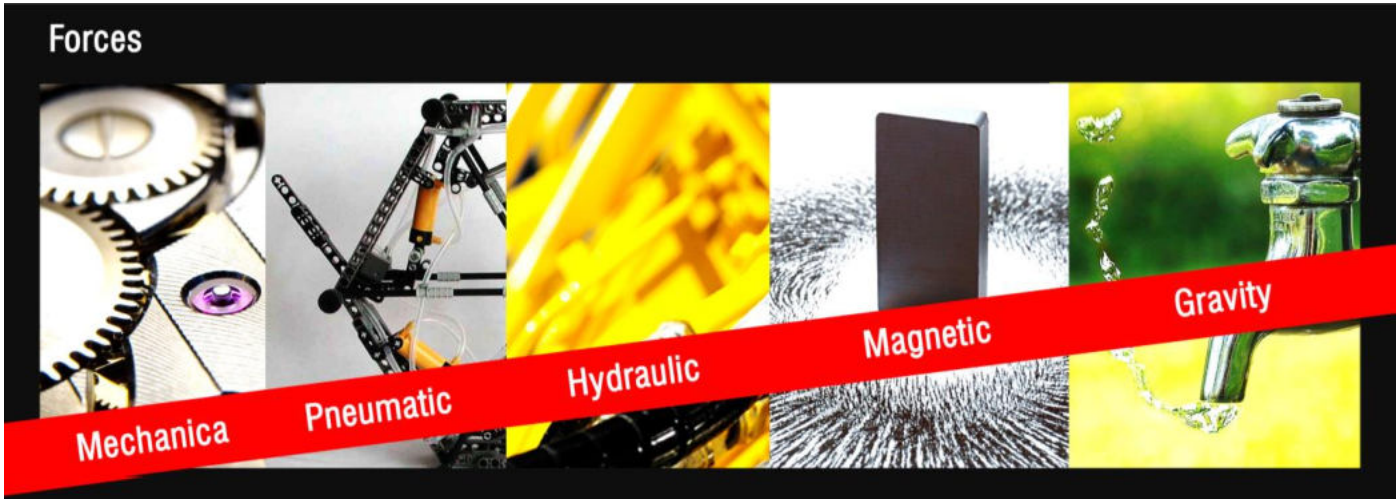

IR 32

VEHICLE DYNAMICS

Current Technology

To generate any kind of force in the system there are various options available. Following image shows different ways of generating force in the system.

The vehicle when turning encounters a couple of forces acting on it creating instability in the system , to counter these forces the vehicle need to generate counter couple to maintain control.



VIBRATING MECHANISM

Equipment

A vibration is a mechanism of any mechanical device which provide too & fro motion in any direction. A vibrator is a mechanical device to generate vibrations. The vibration is often generated by an electric motor with an unbalanced mass on its driveshaft.

The vibrating motor consists of a power source bearing and on the same shaft unbalanced weight is attached. When shaft rotates it creates unbalanced couple of forces on the shaft making it vibrate. This shaft is then rigidly attached to the system.

VIBRATING MECHANISM

Application

IR 34

Following images show application of vibrating motor in the industry.
A vibrating platform is used in laboratories for different applications.
In cell phones also to generate vibrations , small sized motors are used.
In industries vibrating conveyors are used to transfer material from one place to other.

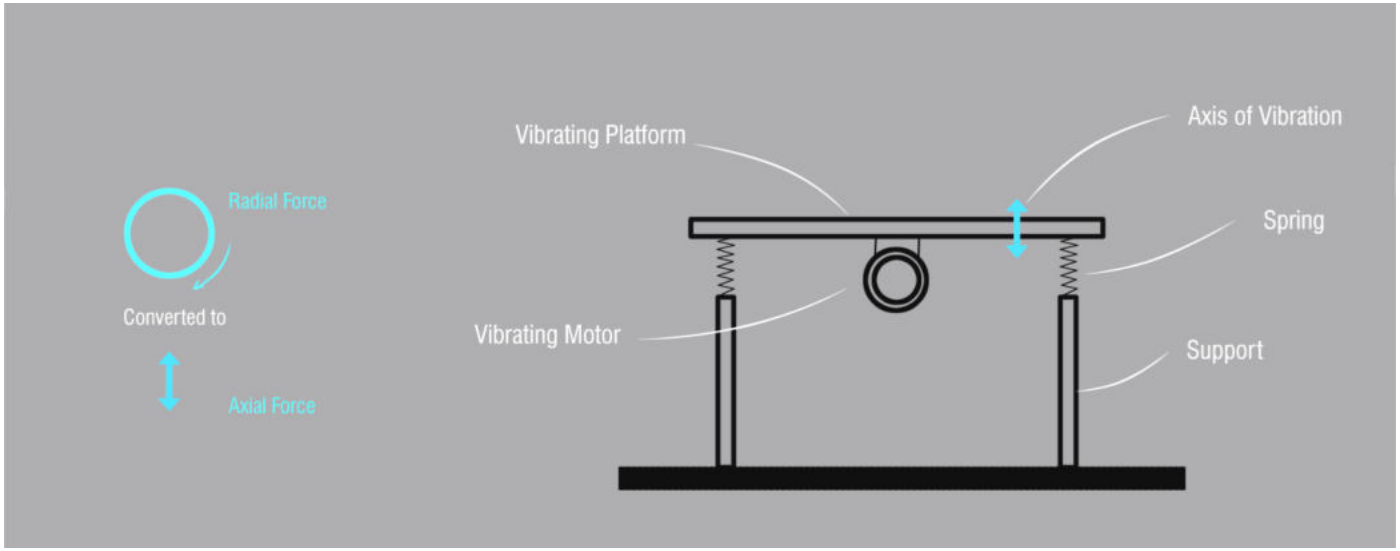
IR 35

IR 36

VIBRATING MECHANISM

Working Principle

The platform is provided with support , damper springs and a vibrating motor.
The structure allows the platform to vibrate in desired direction by construing other direction if vibrations.

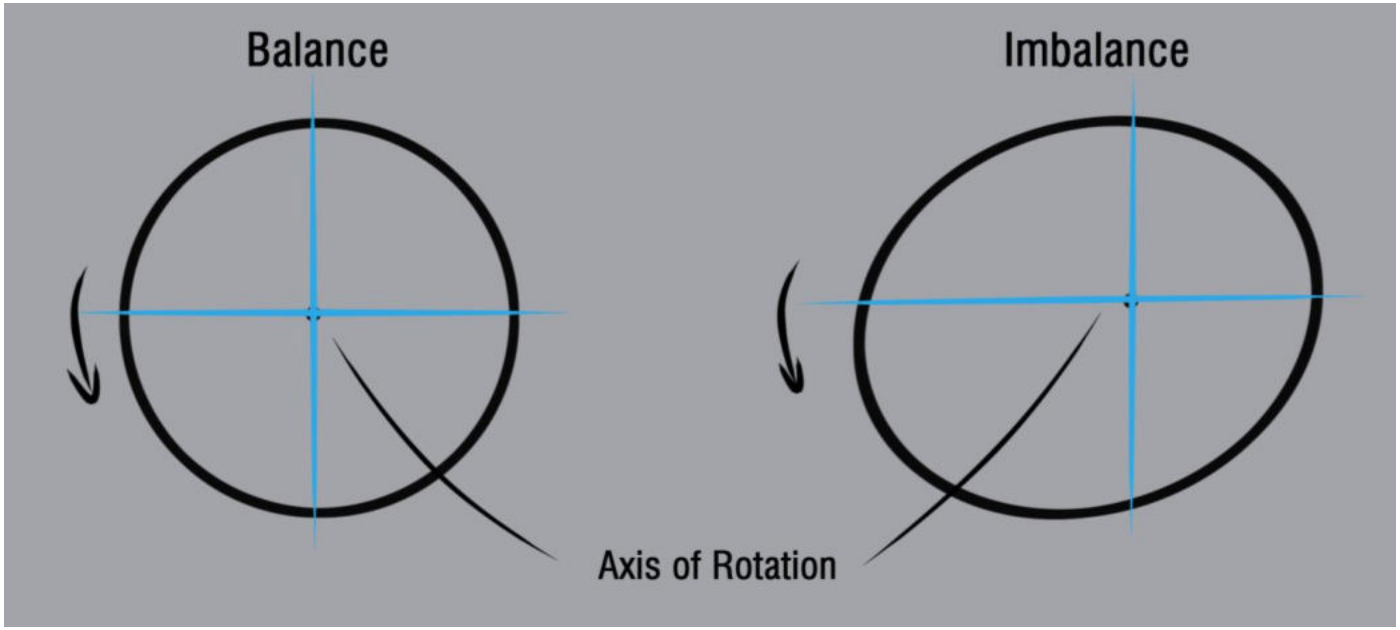


VEHICLE DYNAMICS

Working Principle

When body is rotating it stays in balance because force exerted at 2 extreme ends is same along with its distance from center.

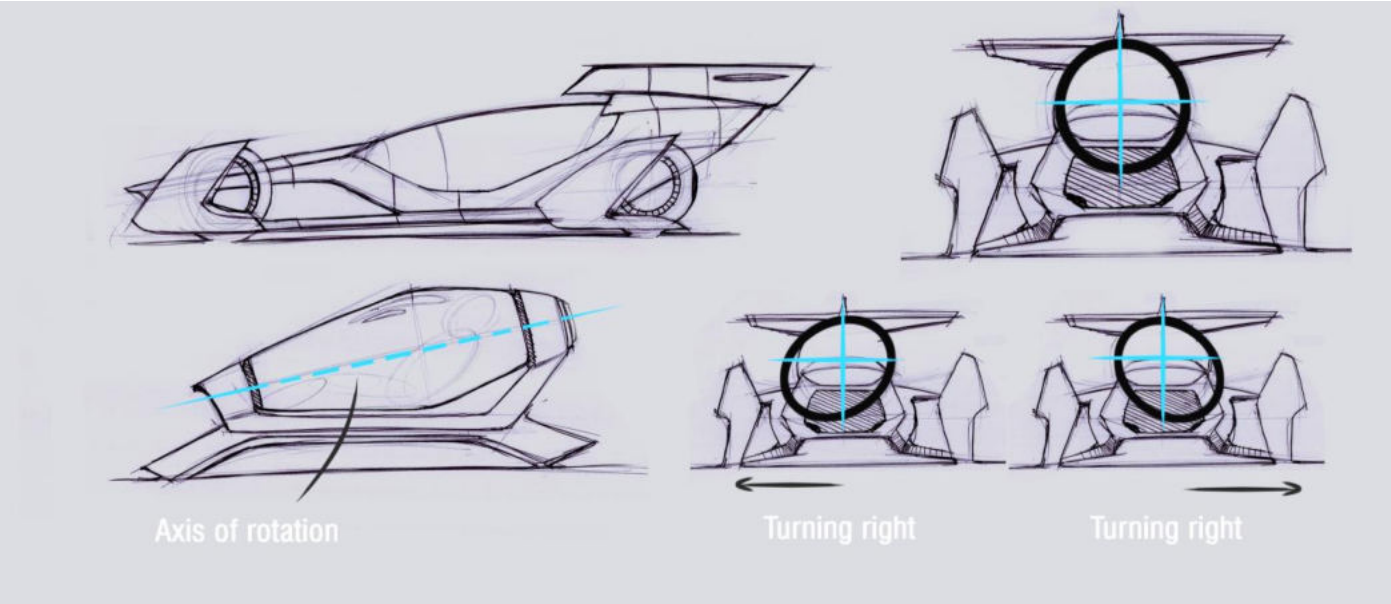
When cross section changes the distance between extreme end and the center changes. Which creates force of unbalance in nature.



VEHICLE DYNAMICS

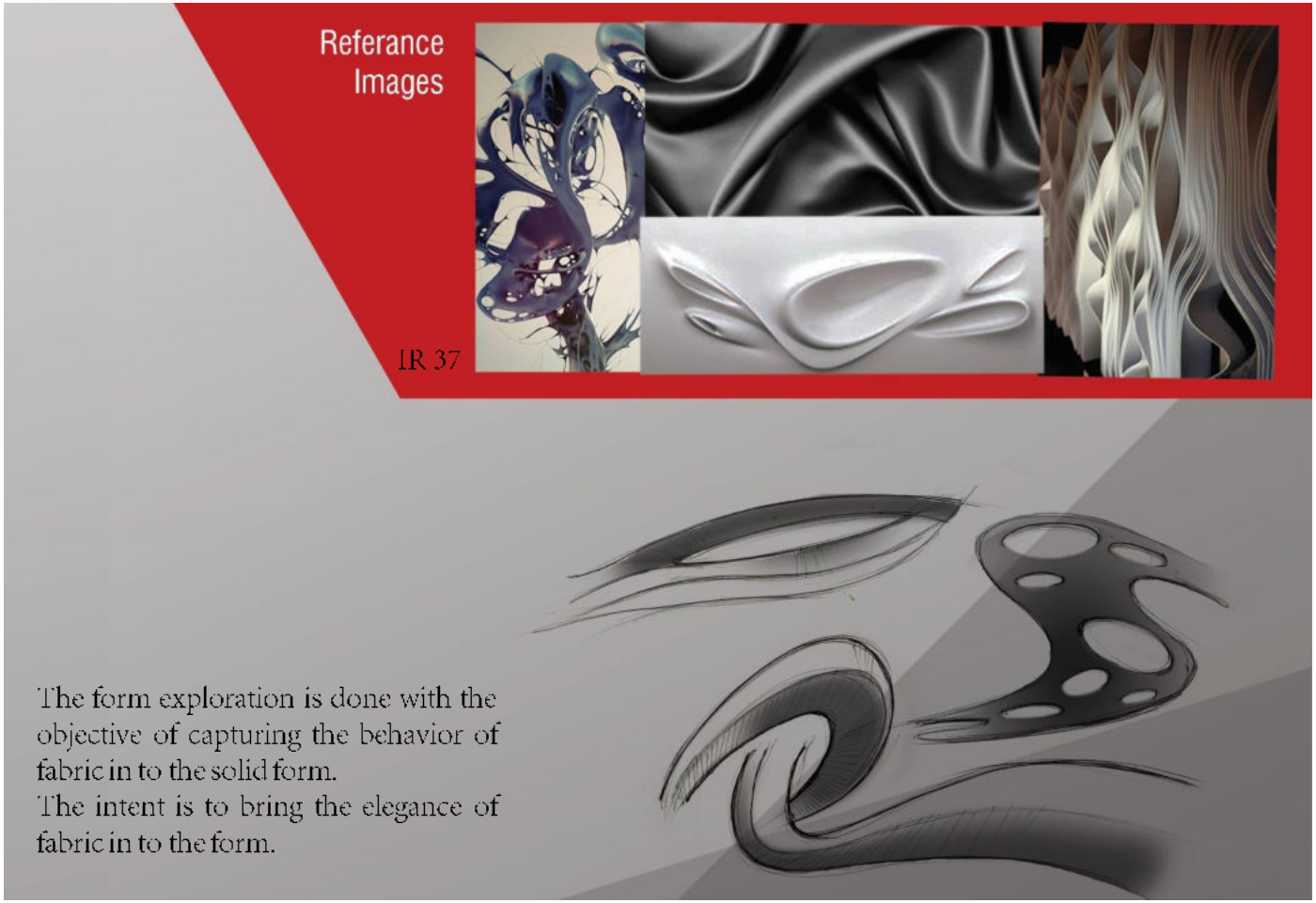
Application

Due to friction offered by tires on the outside of the vehicle the outward force acting on the vehicle is converted in to a force couple which tries to topple the vehicle. The shape changed by the rotating body will counter this force and all vehicle to complete corners with higher speeds.



CONCEPT 1

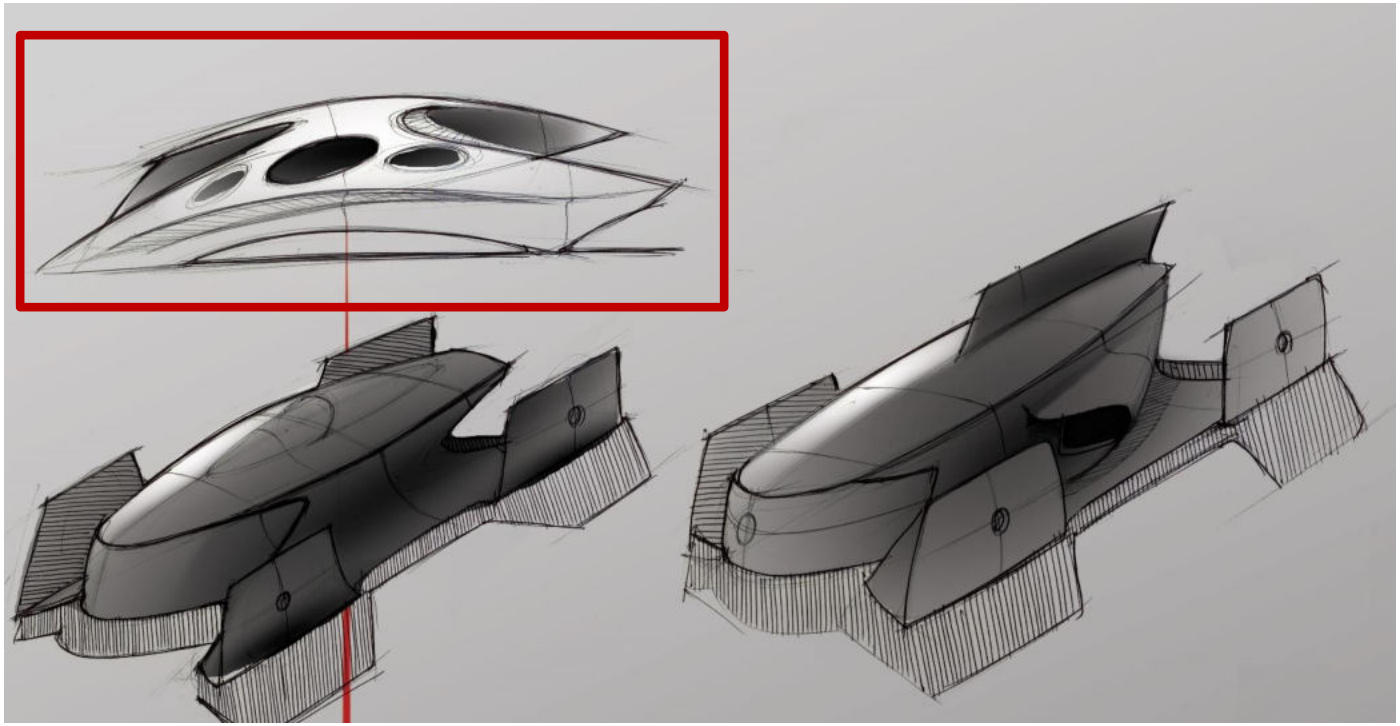
Inspiration



CONCEPT 1

Key Sketch

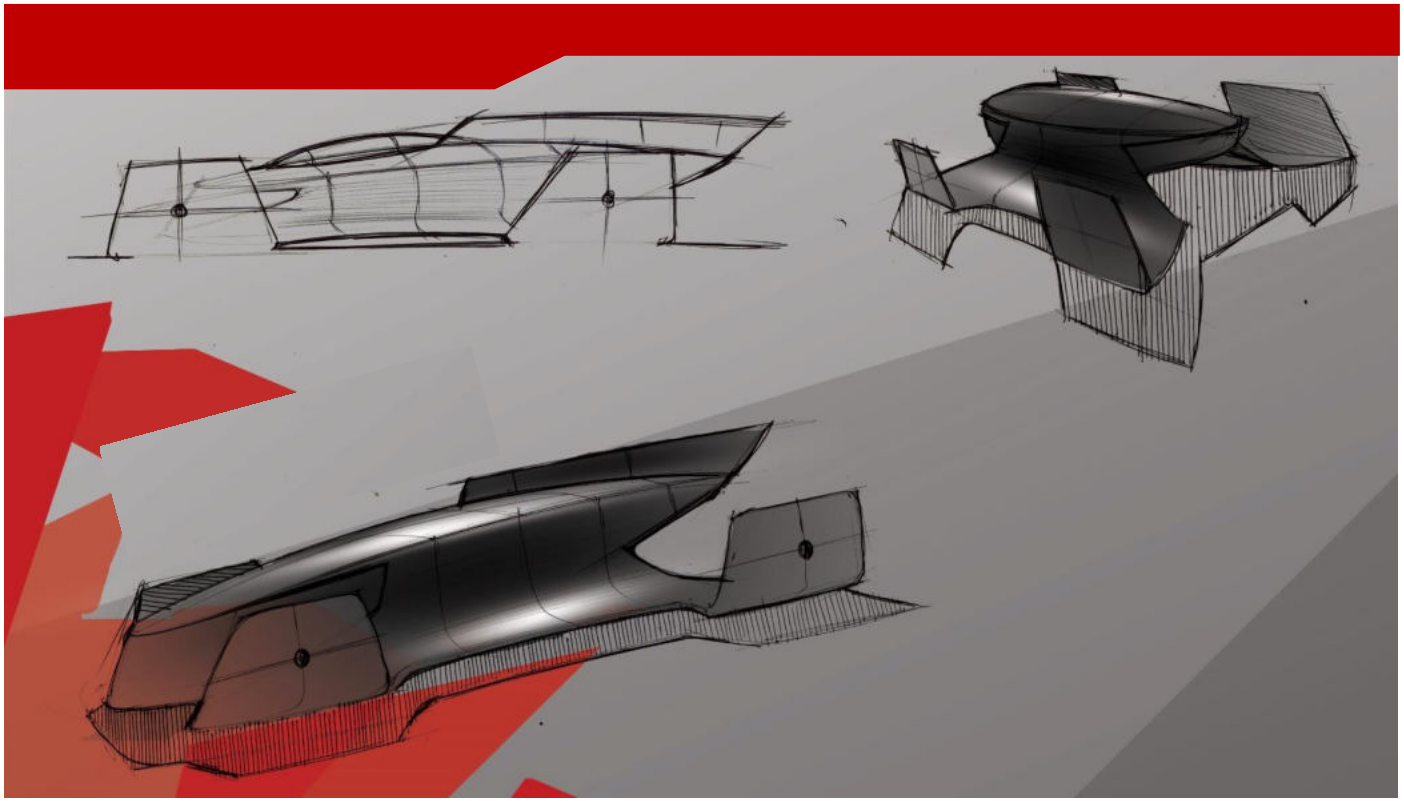
The ideation started with key sketch shown at the top. Remaining sketches show different automotive forms based on key sketch.



CONCEPT 1

Exploration

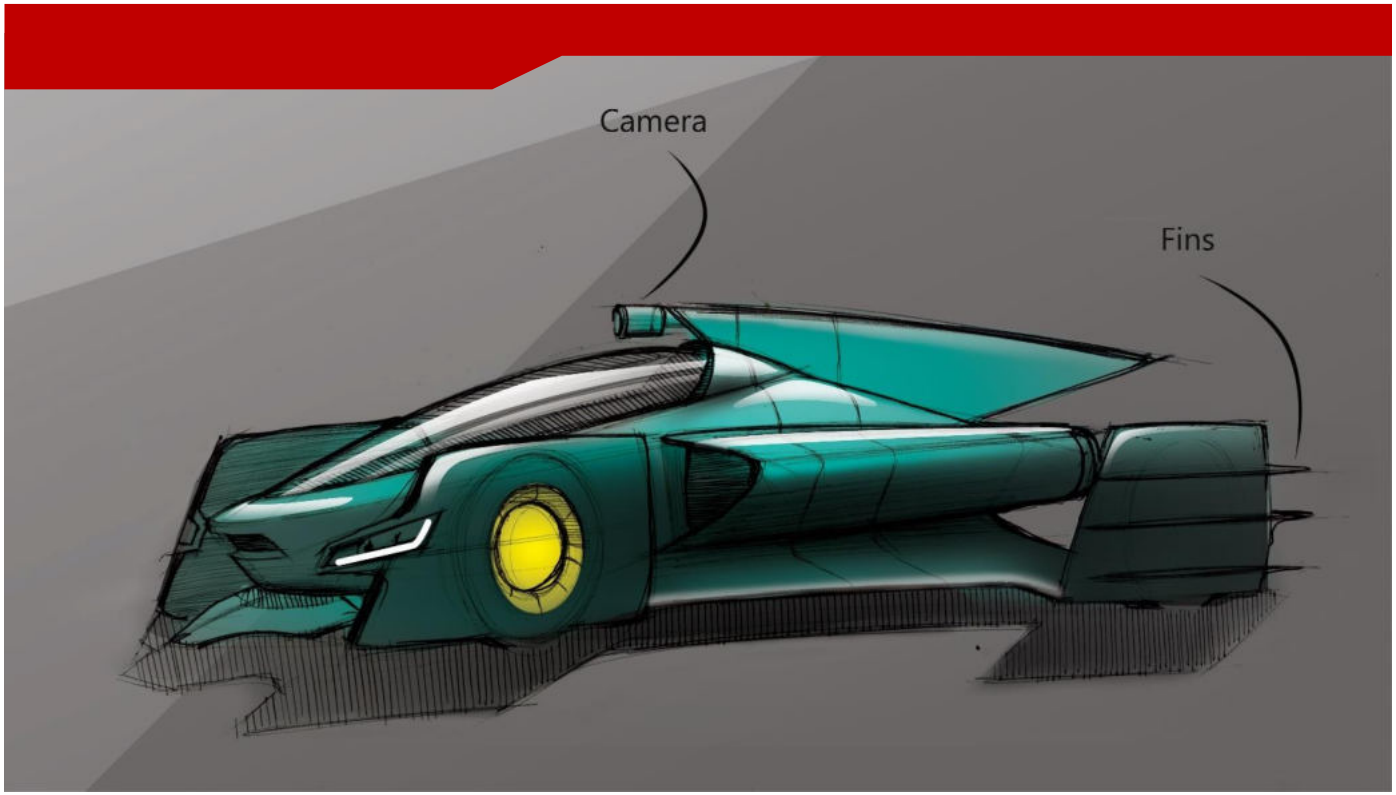
Following images show further development of original concept.



CONCEPT 1

Final

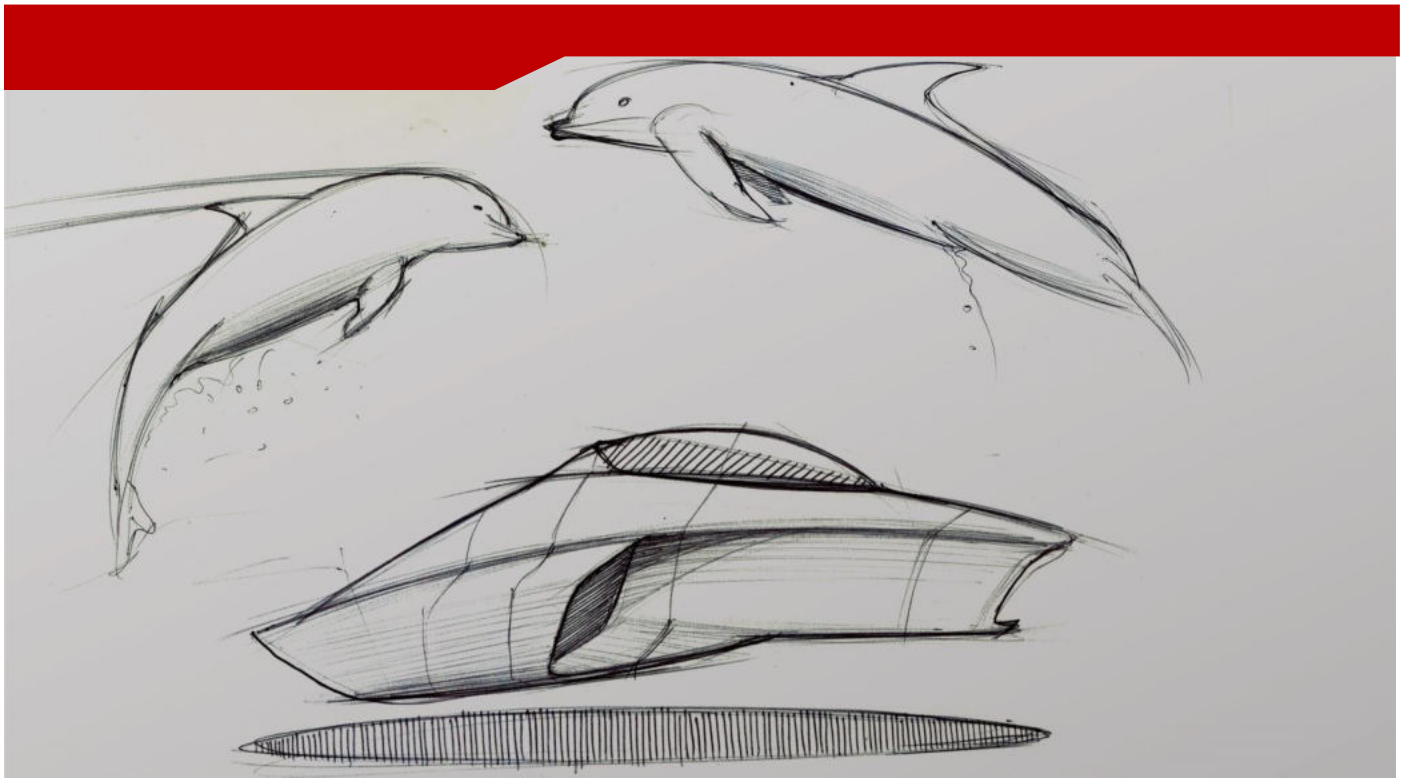
Below shown render shows the final form achieved through the explorations done.



CONCEPT 2

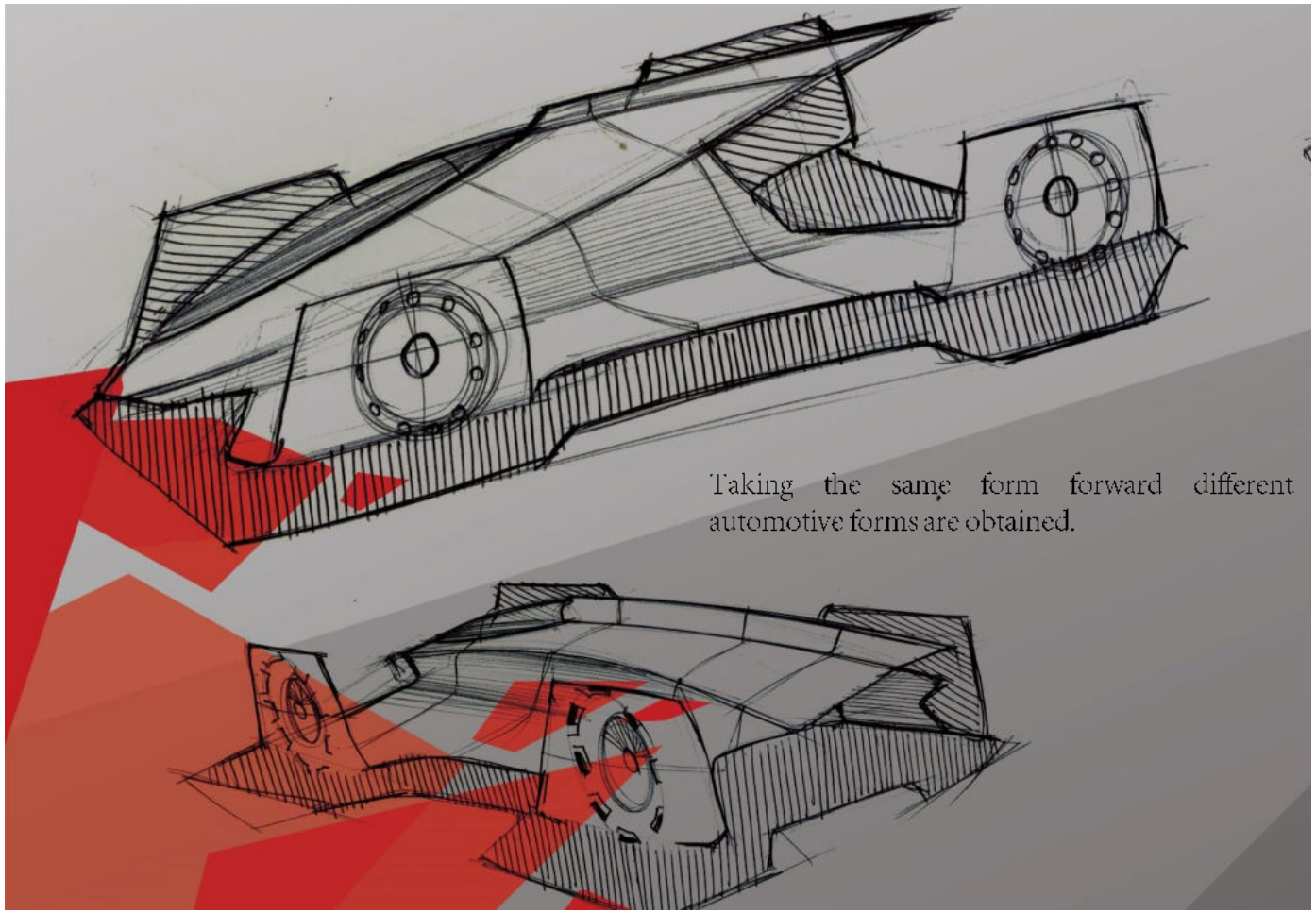
Inspiration

The objective is to replicate the elegant stance of a diving Dolphin.



CONCEPT 2

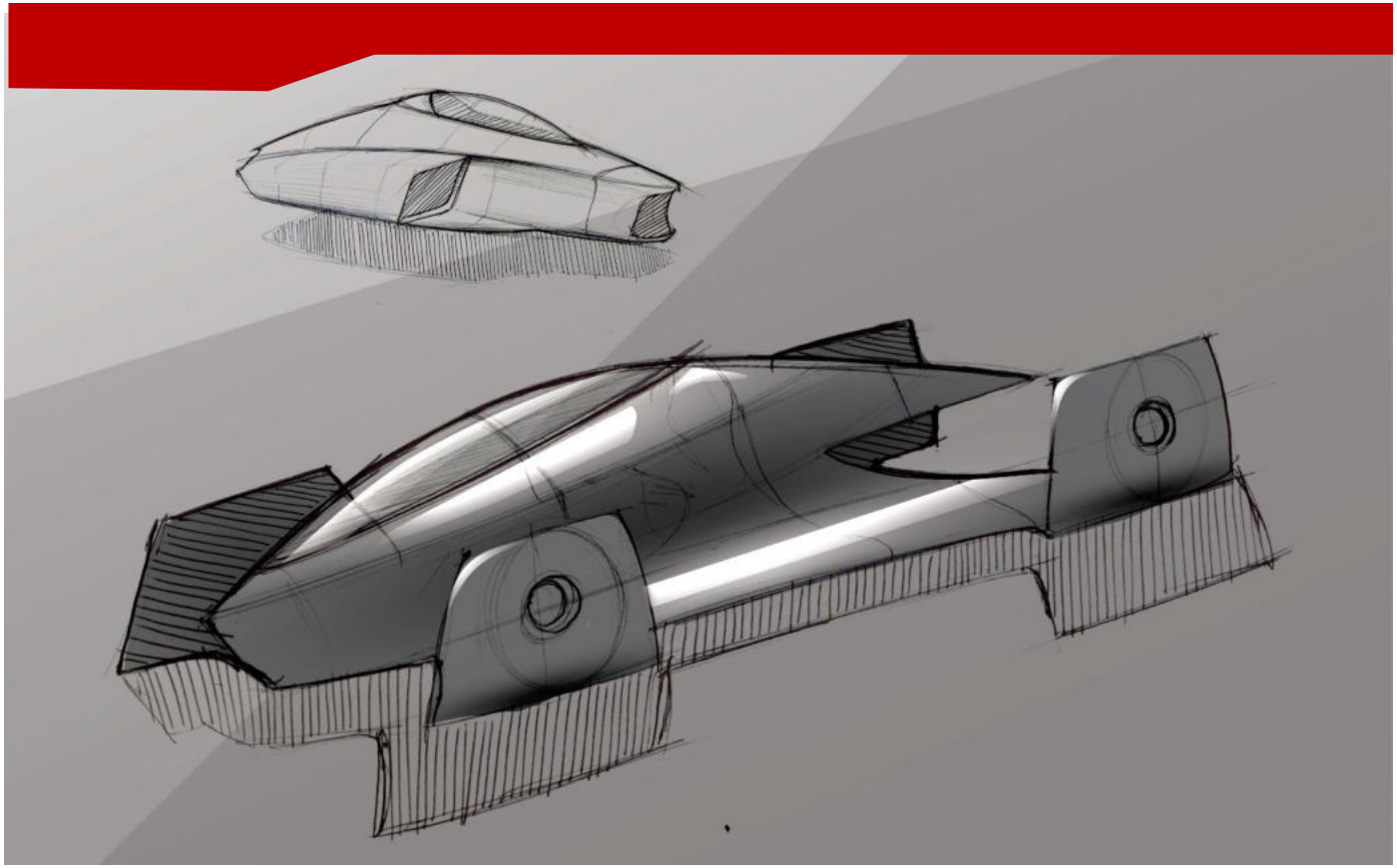
Exploration



CONCEPT 2

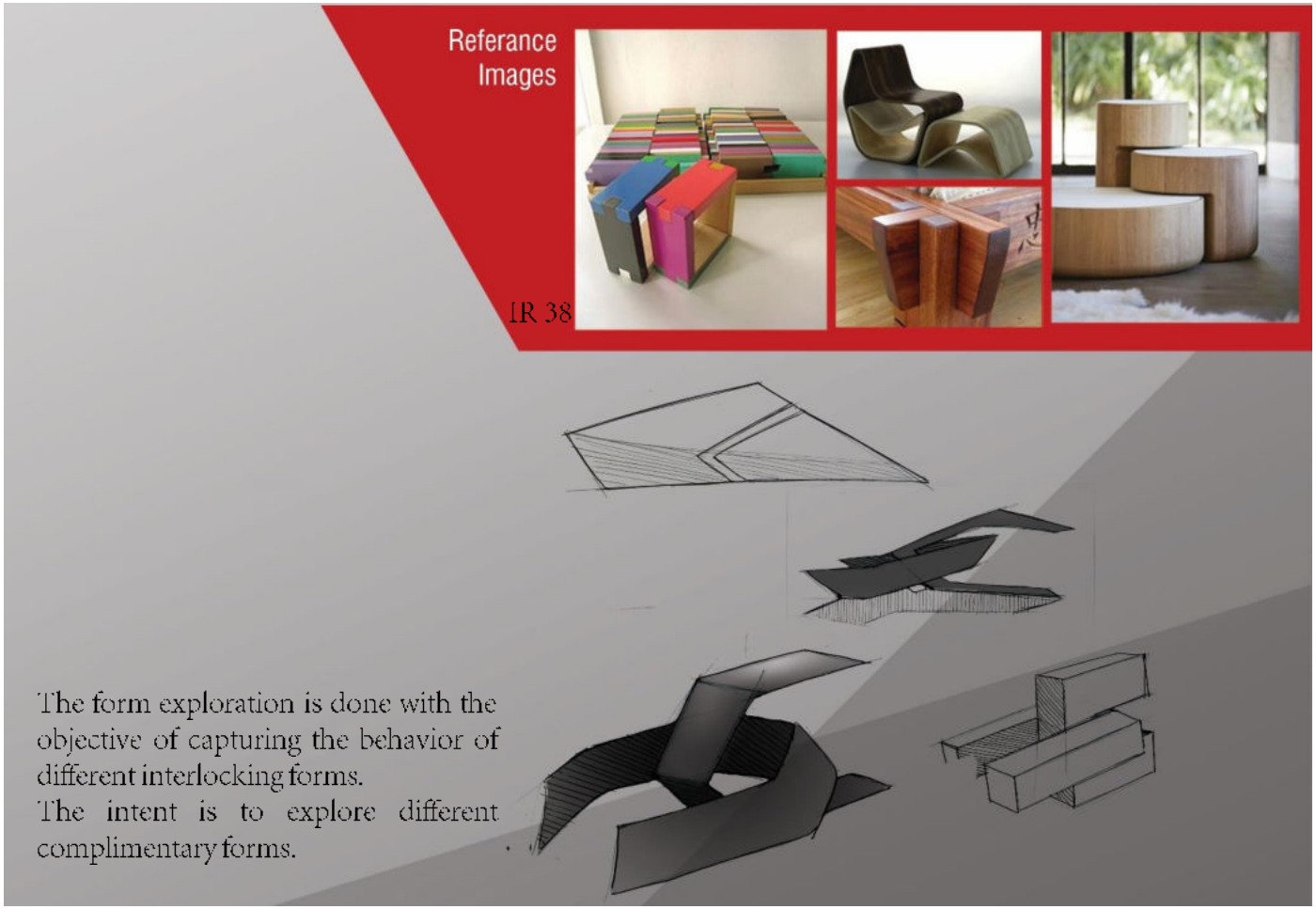
Final

Below shown render shows the final form achieved through the explorations done.



CONCEPT 3

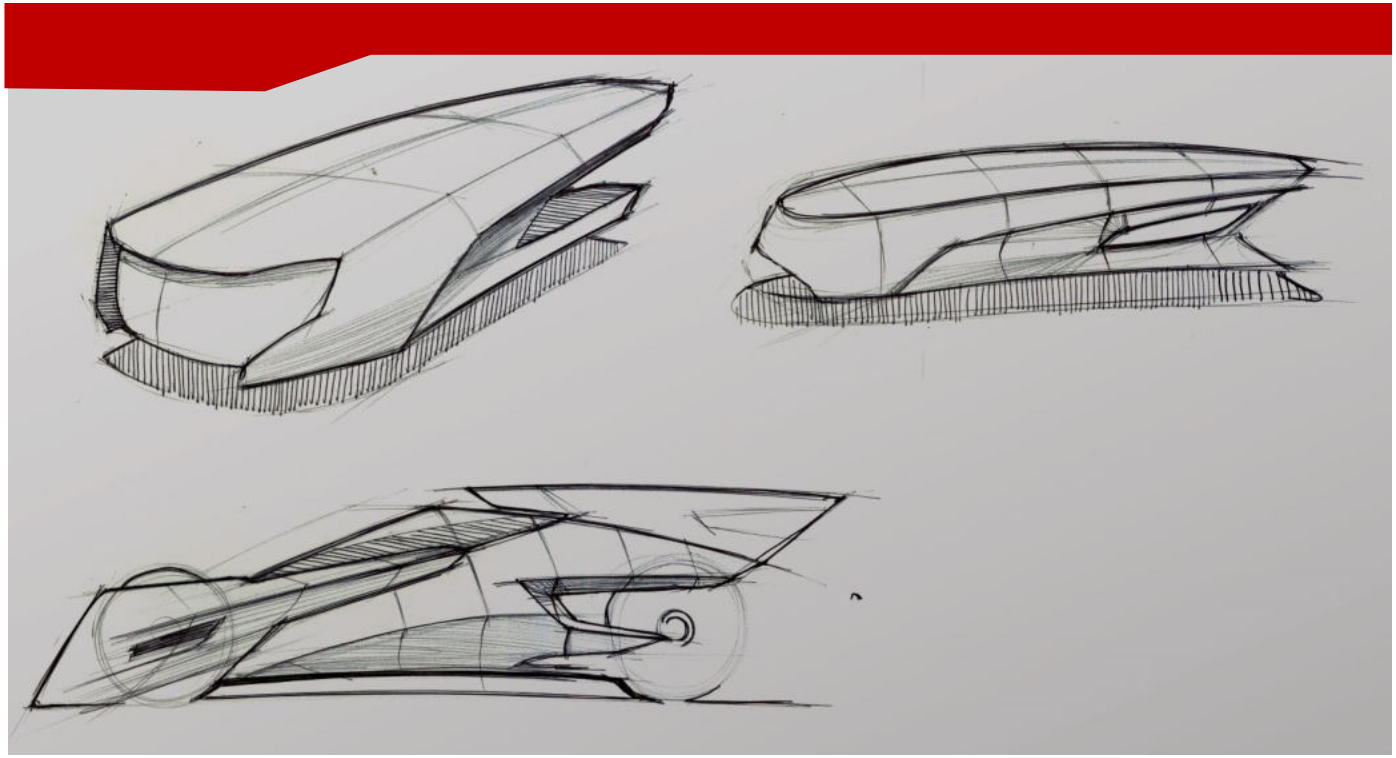
Inspiration



CONCEPT 3

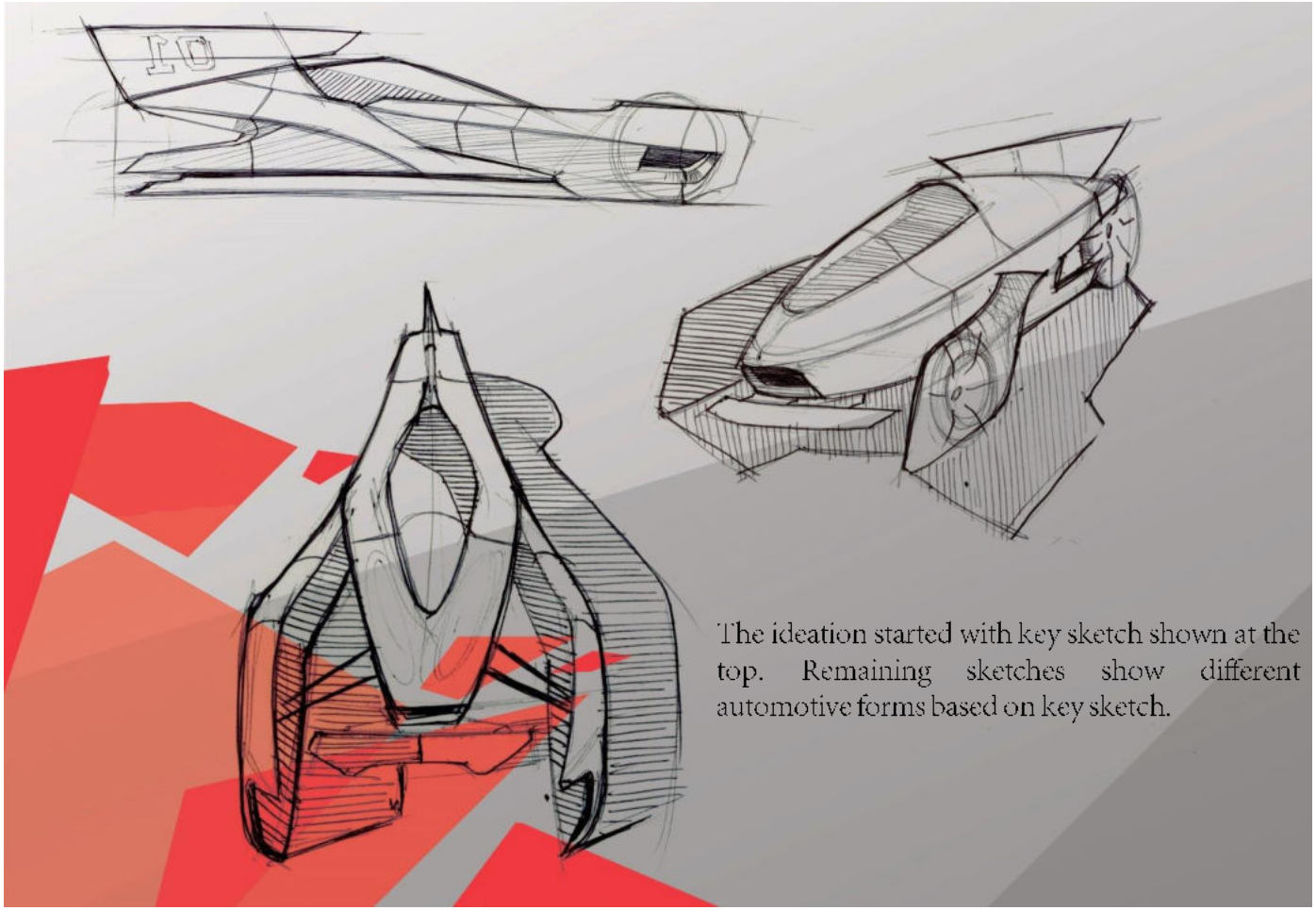
Explorations

Following sketches show different interpretation of basic form.



CONCEPT 3

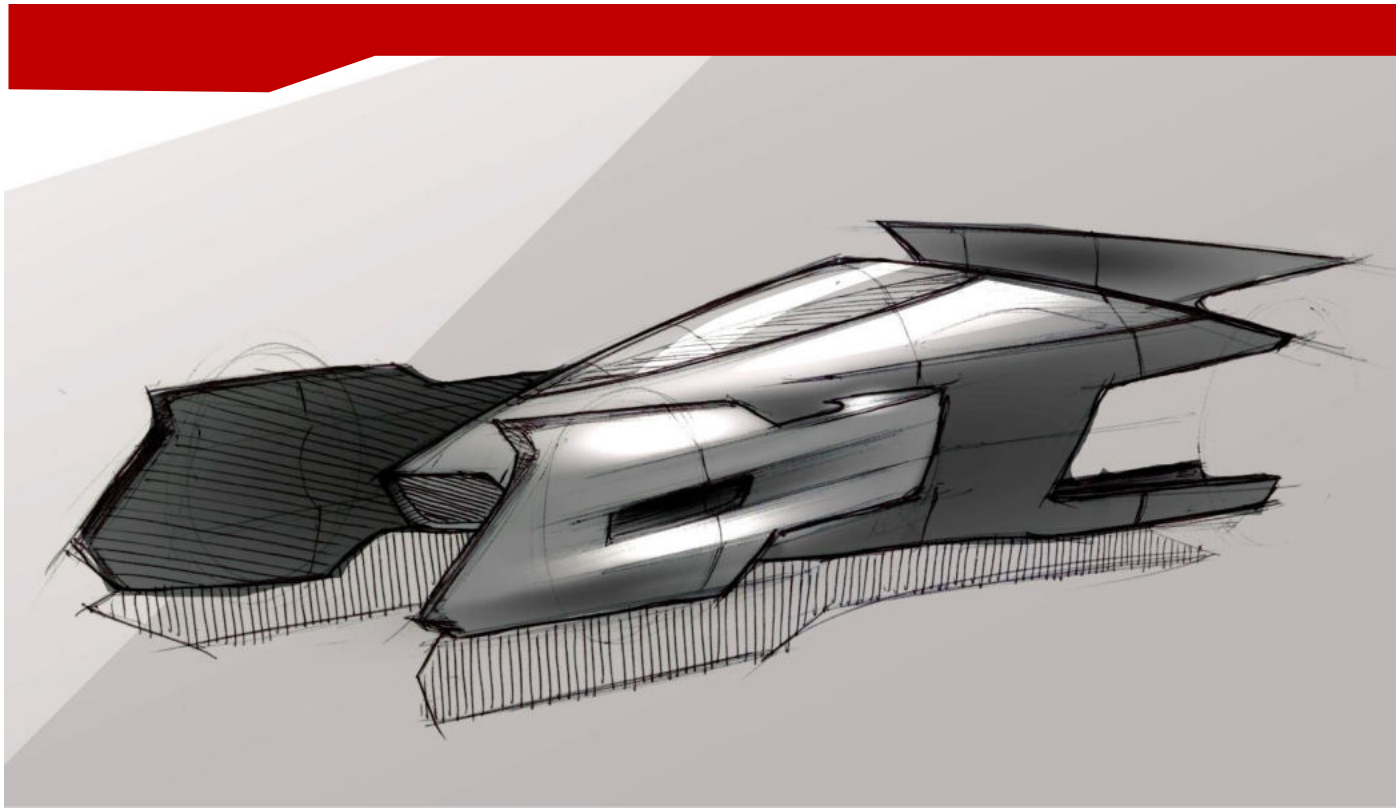
Explorations



CONCEPT 2

Final

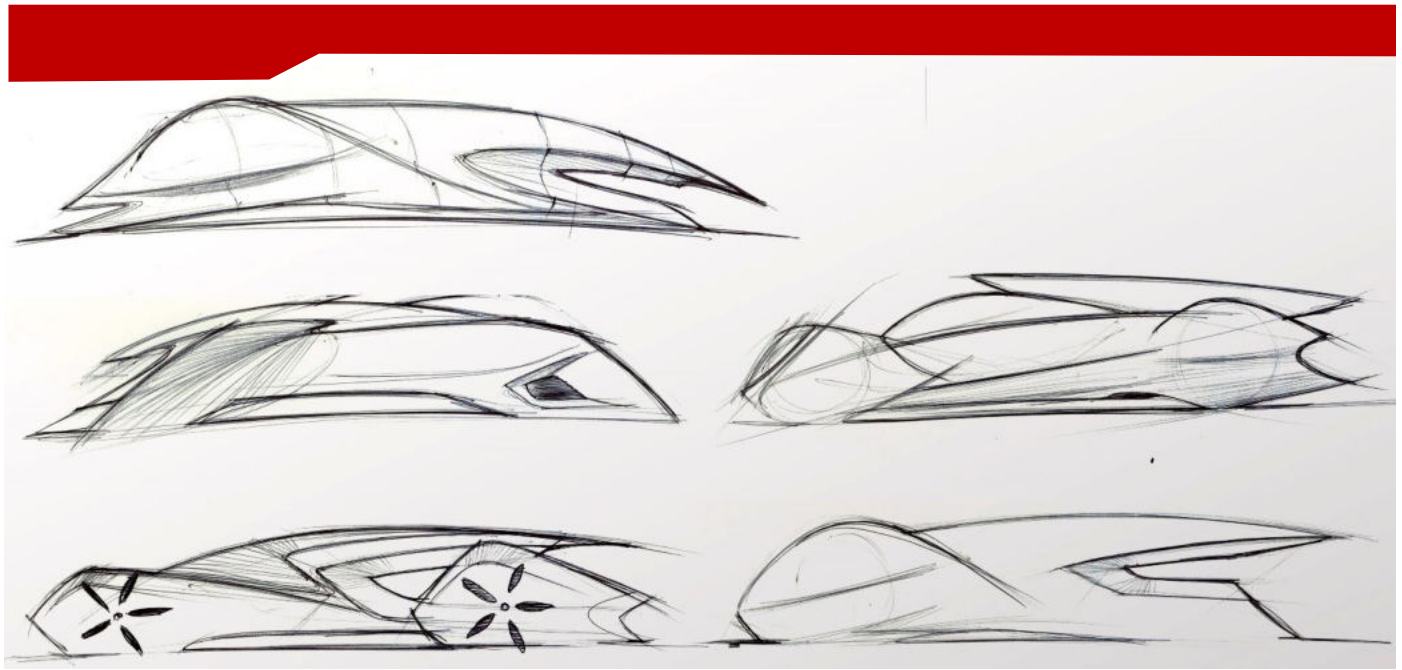
Below shown render shows the final form achieved through the explorations done.



CONCEPT 4

Exploration

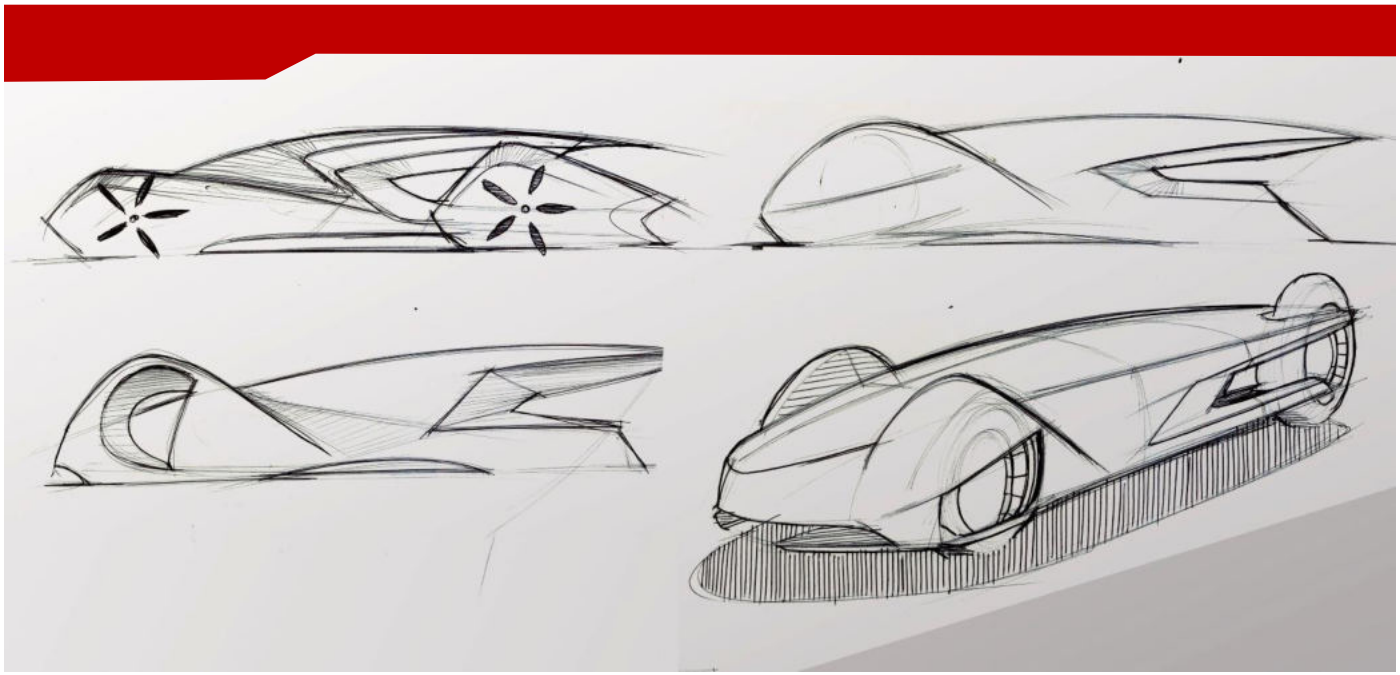
The ideation started with key sketch shown at the top. Remaining sketches show different automotive forms based on it.



CONCEPT 4

Exploration

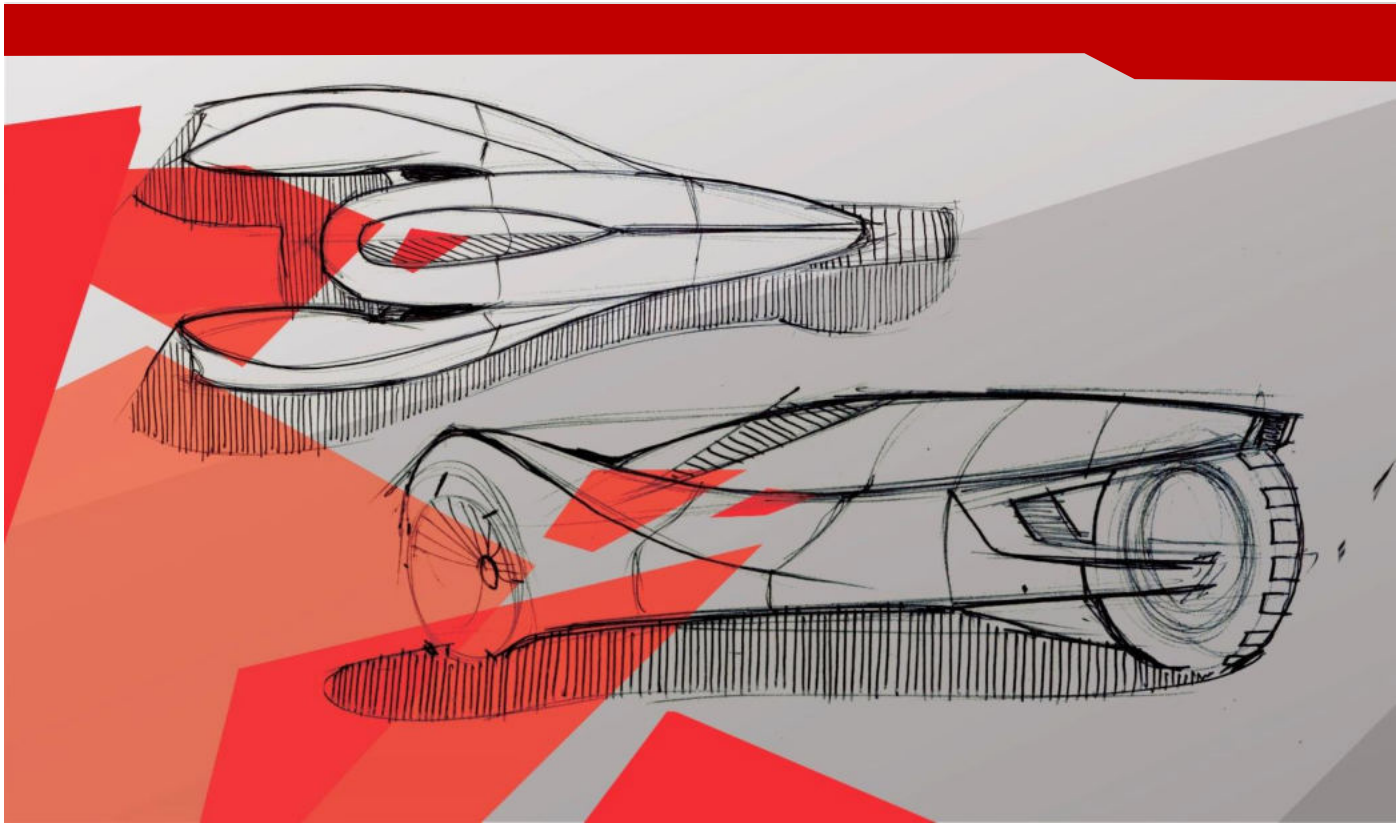
Following images show different side elevations derived from the exploration done before.



CONCEPT 4

Exploration

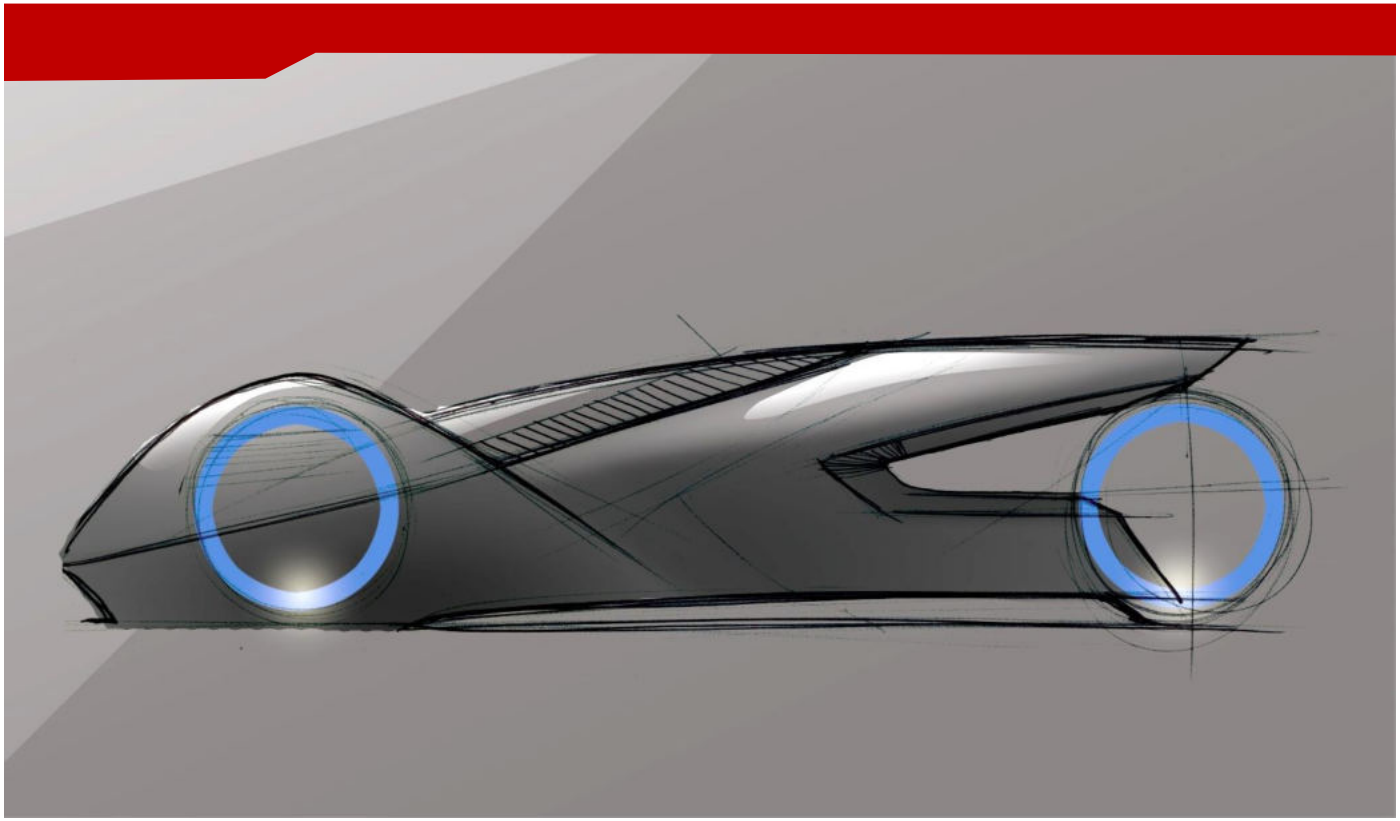
The ideation started with key sketch shown on previous page. These sketches show different automotive forms based on it.



CONCEPT 4

Final

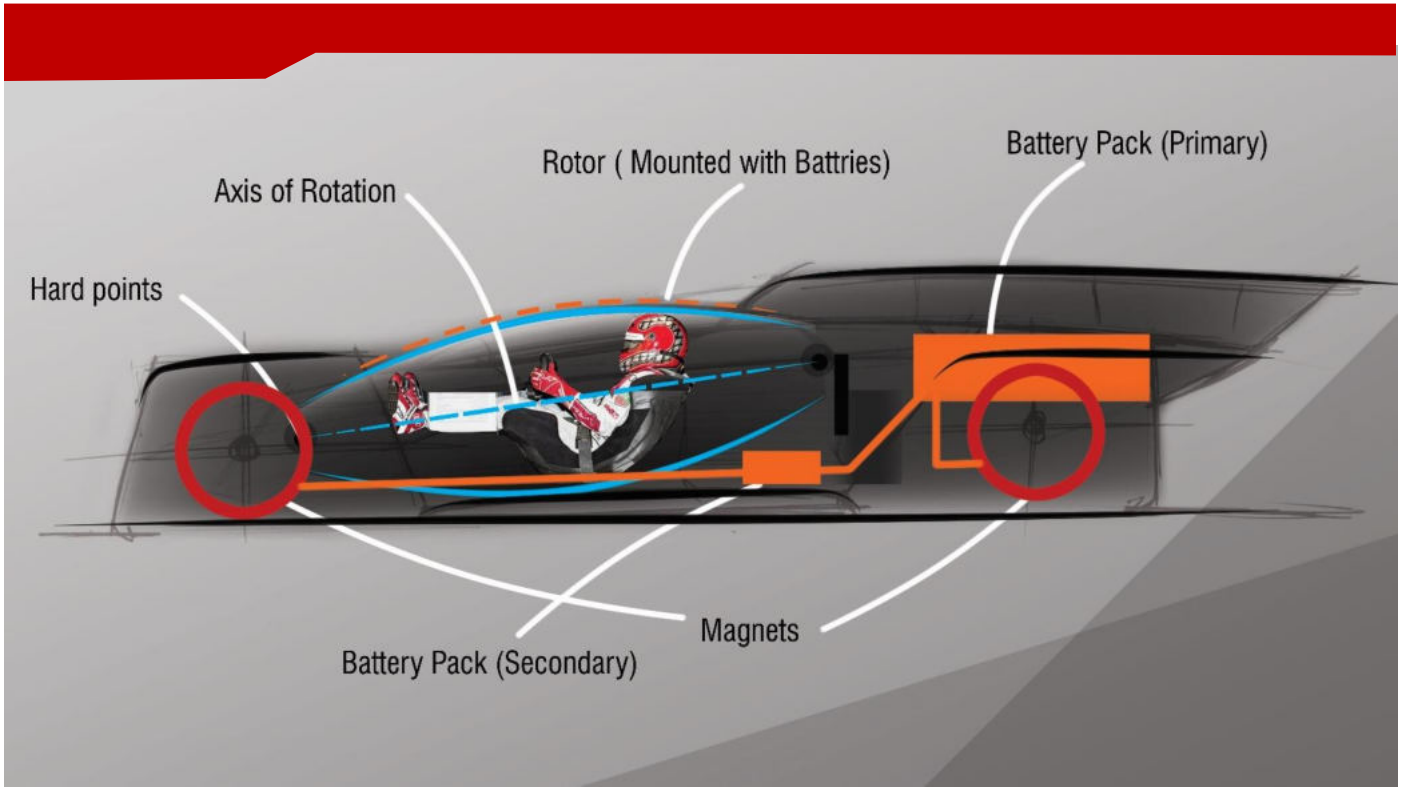
The following render shows final concept achieved through ideation done.



VEHICLE ARCHITECTURE

Proposed

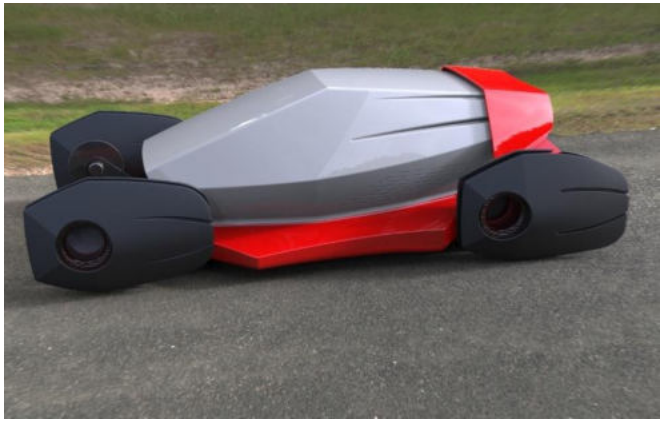
The vehicle will not have any moving components except the wheels. Power transmission will be mostly done electrically.



MODEL MAKING

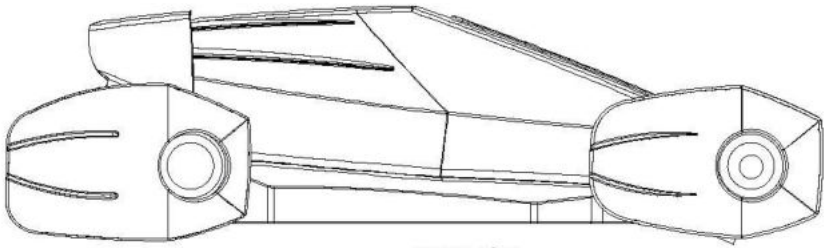
CAD data
Drawings
Physical Modelling (W.I.P)

Renders

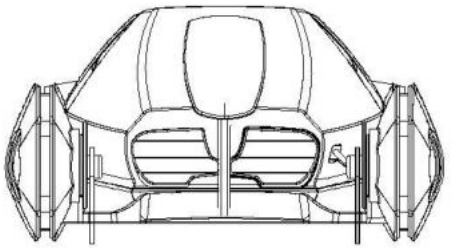


Renders

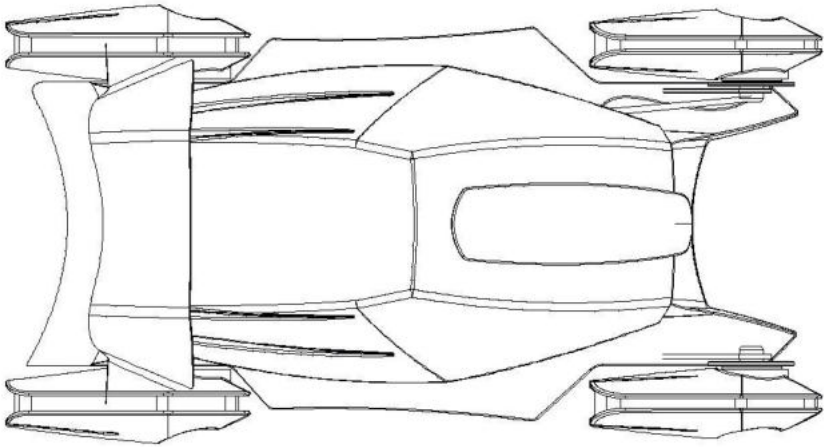
CAD Drawings



Front view
Scale: 1:20



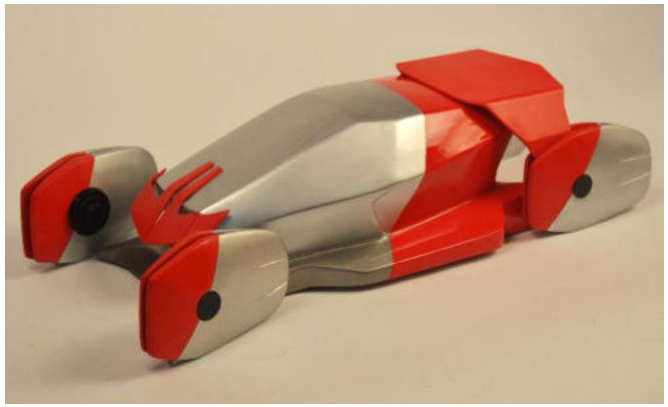
Right view
Scale: 1:20



Top view
Scale: 1:20

PHYSICAL MODEL

Work in Progress



Scale:- 1 to 8
Material :- MDF

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