

**ADVENTURE TOURING MOTORCYCLE
FOR INDIA**

MOBILITY AND VEHICLE DESIGN PROJECT II

MVD II-19

BY

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MOBILITY AND VEHICLE DESIGN PROJECT 2

ADVENTURE TOURING MOTORCYCLE FOR INDIA

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APPROVAL SHEET

This vehicle design project report entitled “ADVENTURE TOURING MOTORCYCLE FOR INDIA”, by Harish Kumar P is approved in partial fulfillment of the requirements for Master of Design degree in Mobility and Vehicle Design.

Project Guide:



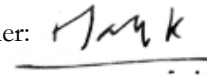
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Internal Examiner:



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Date: 19-11-13

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.

Signature: 

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Harish Kumar P

Date : 19-11-13

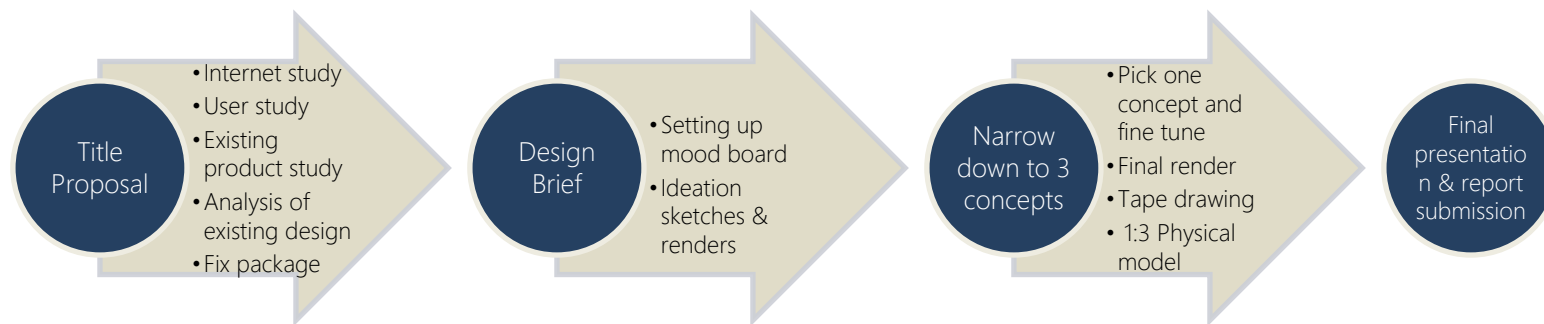
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1. ABSTRACT

Motorcycle tourism in India is growing in a rapid phase. Indians when wish to go for long rides especially to unexplored terrains, they usually take existing vehicles to those kind of tours. On the other hand there are motorcycles designed for the sole purpose of adventure touring. And those are very expensive for many Indians to afford. The project is about designing an affordable adventure tourer motorcycle to enable more Indian people to go for such touring. The idea is to take an existing commuter motorcycle from India, change its ergonomics for the purpose of on road and off road touring, consider the equipment Indians would like to carry and position them on the bike considering the usage pattern. Further the styling should also reflect the character of adventure touring.

The design process starts with internet study about the existing adventure tourers and the overall market of these kinds of motorcycles. Study on what Indians carry for touring and what is their view of an adventure touring motorcycle is done. Study of Indian two wheeler market and where does this segment fit in is analyzed. A design brief is made with all the insights derived during the research. In stage 2, Quick ideations and renders were made. A few interesting sketches were selected and developed to get some direction in the project. Ergonomics of the new vehicle is checked by building a rig. Different height users ranging from 5th to 95th percentile were selected and tested on the rig. The optimal positioning of the luggage was iterated using a 3D model. Using that as an underlay, more concepts were made and evaluated. In stage 3, the most promising concept is then taken for more detailing and detailed renderings were made. This was then taken to a tape drawing and 1:3 scale clay model was made.



STAGE 1

Types Of Motorcycles

Existing Adventure Touring Motorcycles

Product Study

The Need

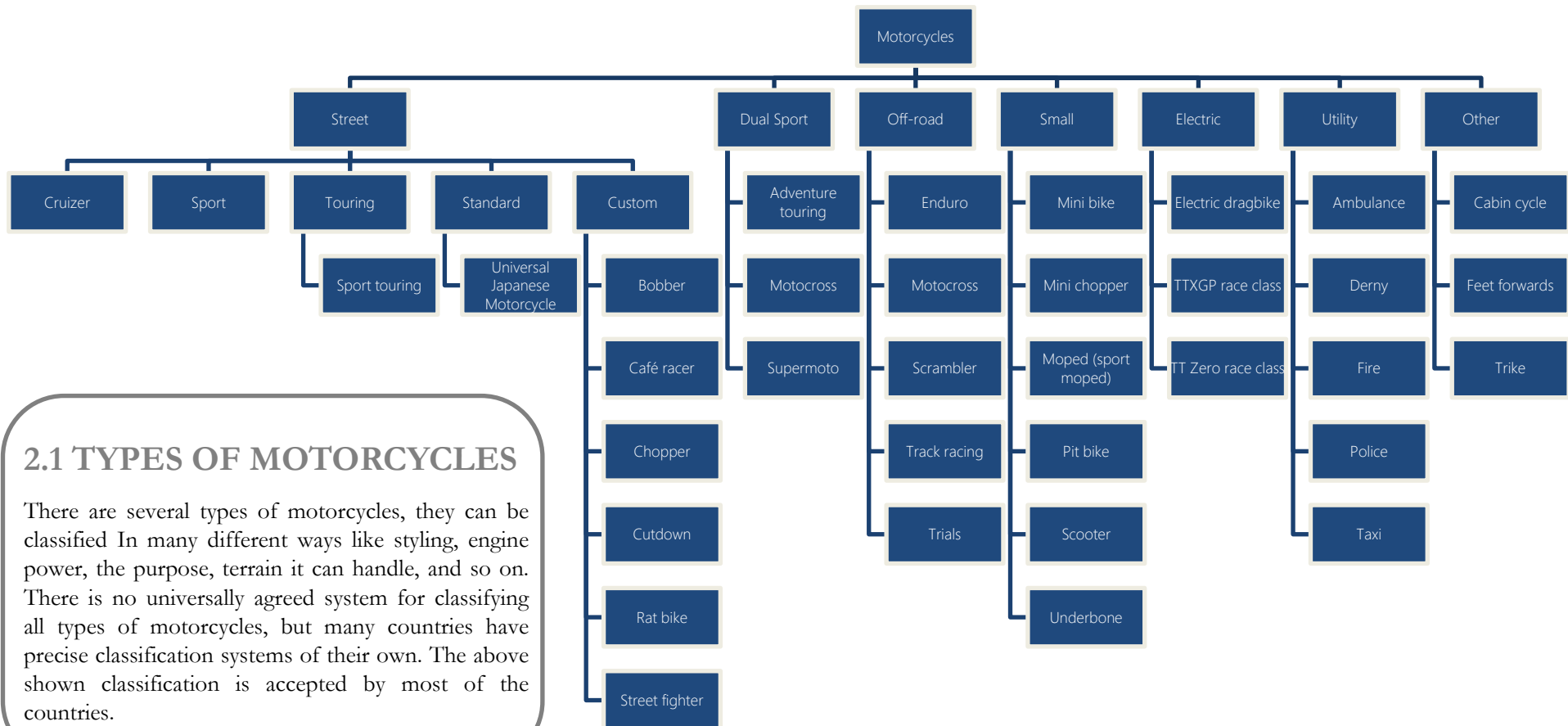
User Study

Inferences From User Study

Adventure Touring Motorcycle For Indian Market

Design Brief

2. RESEARCH



STREET

Street motorcycles are driven on flat roads. They can be driven at any high speeds.

Cruiser is a motorcycle which is used to ride on a long stretch, high speeds and high torque.

Sports, as the name suggests, they can be driven fast and it is maneuverable.

Sport tourer is a mixture of sports and touring motorcycle.

"**Universal Japanese Motorcycle**", are the motorcycles which are popularly seen in American magazine covers as Japanese motorcycles. They have the characteristic round headlamps and disconnected body.



IR 001

Cruiser



IR 002

Sports



IR 003

Sport tourer



IR 004

Universal Japanese
Motorcycle

STREET CUSTOM

These are special bikes which are used for specific purposes like racing and socializing. It has a strong community backup and followed for many decades.

A **bobber** is a motorcycle where the fenders (mud guards) are cut or bobbed to get that raw cruiser style.

The **café racer** is a light weight vehicle which is obtained by removing excess of weight from the existing street motorcycle.

A **chopper** is a motorcycle which is chopped from existing vehicles and joined to make a unique looking cruiser. They are famous in American countries. They are known for the large rear wheel, long wheelbase, pull back handlebars and forward set foot pegs.



IR 005

Bobber



IR 006

Café racer



IR 007

Chopper

SREET CUSTOM

A **Cutdown** is a scooter whose body parts are removed to make it more lighter. Usually Lambretta's cut down to bare frames. Vespa's are cut down by reducing the size of the body. They belong to a community called Scooter Boys and Mods. The Cutdowns are analogous to the Café Racers. The difference is they are done on motorcycles and these are done with scooters.

A **Streetfighter** is obtained by removing the body parts from the existing Sports bike to give that raw feeling. The characteristic attributes of these street fighters are low handlebars, large engine and tanks. They have naked chassis frame and engine parts to show the power.

Rat bikes are the motorbikes which have the characteristic old fallen apart looks. They are popular as they barely manage to run, it has become a community icon.



Cut down IR 008



Street Fighter IR 009



Rat bike IR 010

DUAL SPORT

Dual sport motorcycles are the ones which can be driven both on road and off road. They have the ability to handle any kind of terrain.

Adventure tourer motorcycles are used to cruise for long distances on flat roads and can handle off road terrains too. They are known for their power, agility and luggage carrying capability.

Supermoto is a combination of three motorcycles. They can be again driven onroad and off road, but only for racing purpose.

Motocross is driven on rugged terrains. They have the special long travel forks, low capacity two stroke engines and tires which can handle any rough terrain. They are also used for race and stunt purpose.



Adventure Tourer IR 011



Super moto IR 012



Motocross IR 013

OFF ROAD

Enduro bikes are made from motocross bikes, which are modified for longer distance travel, they have accessories like hand protectors, side mirrors.

Trials these are stunt bikes for balancing and testing the riders skills. It is not about riding it fast or racing. They are used only for show purpose.

Track racing are fast motorcycles which are driven on muddy grounds, they are fuelled by methanol and does not have any stopping mechanism.

A **scrambler** is a motorcycle used to drive on rough and muddy roads. They have high raised mufflers which protects the motorcycle from water getting inside the engine. They are usually retro styled and usually called as dirt bikes.



Motocross IR 014



Track racing IR 015



Scrambler IR 016



Trials IR 017



Enduro IR 018

SMALL

Scooter are two wheelers with a step thru foot board. These are unisex two wheelers as they can allow women wearing skirt also.

Underbones are motorcycles which has the pushed down head tube in the chassis frame which allows step through space. These are generally used for sports and commuting purpose. The fuel tank is kept beneath the seat as seen in scooters.

The moped is a mixture of a bicycle and a motorcycle. They have low capacity two stroke engines, usually 50 cc. The can also be pedaled as they are very light in weight.

A **pit bike** is a mini motorcycle to commute between the pit area and the podium area in the race track.

Mini choppers is scaled down form of a chopper motorcycle. They are made out of tubular frame chassis.



Sport moped IR 019



Mini Chopper IR 020



Pit bike IR 021



Underbone IR 022



Scooter IR 023

ELECTRIC

Electric Motorcycles are powered by electric motors instead of Petrol Engines. They usually are used in racing and niche market purpose.

TTXGP is the first motorcycle race which did not have any carbon emission or pollution. Azhar Hussain MBE found this race, it's the worlds premier electric motorsport race series.

TT Zero is an alternative for TTXGP even. Here Azhar Hussain was not involved. It happens at Isle of man, started on 2010.

Electric dragsters are the motorcycle which used high torque motor to deliver more power. The electric drag race is where all the electric motorcycles are put to real test, both in the technology and design.



IR 024
TTXGP race class



IR 025
Electric Drag bike



IR 026
TT Zero race class

UTILITY

Motorcycle ambulances are the vehicles which are used to give treatment to people who are in need for emergency medical attention. These have fully equipped first aid kits to act as a first responder.

A **Derny** is nothing but a bicycle which is motorized. These are usually used in Keirin racing and motor-paced road racing.

A **Fire Bike** is used as a fire engine in places where the traffic congestion is too high. They have limited water supply to put of fire, as a first responder and sustain till the fire engine arrives.

A **Police Motorcycle** is seen in many countries, used by the police department. The motorcycles are usually equipped with radios, additional lights and compartments for patrol related materials.

A **Motorcycle Taxi** is not a common sight in many countries. But they are available in few countries, where one pillion rider can be carried.



IR 027
Taxi



IR 028
Ambulance



IR 029
Derny



IR 030
Fire



IR 031
Police

OTHERS

A **cabin cycle** is a covered form of a bicycle or motorcycle. They are usually assisted by additional balancing wheels.

The **Feet Forward** motorcycle lets the rider to stretch out his feet. These are usually scooters with foot positions farther away from the seat to make the seat position as low as possible.

Trike is a motorcycle which has three wheels. These are usually customized from existing cruisers to give more control to the vehicle.



IR 032
Feet forwards



IR 033
Trike



IR 034
Cabin Cycle

Source: http://en.wikipedia.org/wiki/Types_of_motorcycles

2.2 Existing Adventure Touring Motorcycles

What is an Adventure tourer?

The Adventure Touring motorcycle are capable of going both on long paved roads and occasional off-roading. They usually have long suspension travel, high ground clearance, wind protection, powerful headlamps, hand protector, engine guards and many more protection features. They are not fully faired to avoid the body from getting damaged. They are known for the endurance and long travel range. Since people go for long rides in this, luggage becomes an integral part of the motorcycle. High tech luggage balancing mechanism and plenty of storage space is provided to make the rider feel secured and sound all the time.

2013 Ducati Multistrada 1200 S Touring



The Ducati Multistrada 1200s is known for its versatility. The sports bike makers have come with three configurations S Touring, S Pikes Peak and S Granturismo. This motorcycle offers four riding modes like none other motorcycle offers. It is very much evident that Ducati is trying to make it as versatile as possible.

The S Touring variant offers comfort even on a very long ride. Whereas the Pikes Peak gives a sporty flavor.

Engine : 1 twin cylinder, dual spark, liquid cooled

Displacement: 1198.4cc

Compression ratio: 11.5:1

Gearbox : 6 speed

Power : 150hp - 110.3kw @ 9250rpm

Torque : 91.82.lb-ft 124.5nm @7500rpm



2013 Triumph Tiger Explorer XC



IR 038



IR 039



IR 040

The Triumph tiger is arguably one of the most powerful Adventure Touring motorcycles out in the market. It produces 135 bhp, whereas the worlds best adventure tourer BMW GS 1200 produces only 110 bhp. The motorcycle competes with almost all the best Adventure Tourer out there in the market like KTM 990 Adventure, BMW 1200 GS, Ducati Multistrada.

Base Price: \$17,199

Displacement: 1,215cc

Engine Type: transverse in-line triple, 4 valves per cyl.

Transmission: 6-speed, hydraulically actuated wet clutch

Final Drive: Shaft

The very popular BMW R 1200 GS is acclaimed as the best Adventure Touring motorcycle. The striking features of this motorcycle like the asymmetric headlamps, high level mudguard protector and the boxer engine is carried on by many generations of this motorcycle.

Price: \$18,860

Displacement: 1,170cc

Engine longitudinal flat opposed twin

Transmission: 6-speed, hydraulically actuated wet slipper clutch

Final Drive: Shaft



IR 041



IR 042

2013 BMW R 1200 GS

Other Popular Adventure Touring Motorcycles



KTM 950 adventure

IR 043



KTM 990 adventure

IR 044



Suzuki V-Storm 650

IR 045



Suzuki V-Storm 1000

IR 046



Triumph Tiger 800

IR 047



Triumph Tiger 1050

IR 048



Kawasaki KLR650

IR 049



Husqvarna TR-650-Terra-01

IR 050



BMW F650 GS

IR 051



BMW F800 GS

IR 052

2.3 PRODUCT STUDY

The purpose of this product study is to look for possibilities for generating concepts. The exiting technology and their drawbacks can also be determined by this way.

The product semantics and the purpose of the components are also studied in this section. The unique attributes of the adventure tourer are studied in detail.

FUEL TANK



IR 053



IR 054

The BMW 1200 GS has a 20 Liter capacity and can go upto 33 Liter capacity with some after market modifications. The capacity is so high, so as to increase the distance covered. Additionally they have this fuel stage compartments to store emergency fuel.



IR 055



IR 056

The KTM adventure series has an interesting shape for its tank. The fuel is almost stored like a “sagging bag” tank so as to decrease the center of gravity and the visibility too. This also makes the riding more ergonomic.



IR 057



IR 058

The Ducati Multistrada has this aerodynamic profile tank which wraps around the fork to give more piercing the air effect. They also end up at the high level fork to give that characteristic Adventure tourer look.



IR 059



IR 060

The Triumph Tiger tank is similar to the Ducati's tank. This one also follows the aerodynamic profile and wraps around the forks.



IR 061



IR 062

Suzuki V-Storm has their tank ergonomically made to give rider comfort at the same time increase the fuel capacity. The tank is grown sideways rather than height wise to increase visibility.



IR 063



IR 064

Honda NC700 X has the fuel tank under the seat so as to increase the fuel capacity and make storage space under the front tank area.



IR 065



IR 066

STORAGE SPACE

The Adventure Tourers usually have provisions to carry huge luggage. The purpose of the vehicle will be lost if does not talk about the luggage carrying capacity.

The mostly used storage technique is the rear storage where many boxes and dry sacks can be tied down to racks. The dry sacks are bags which can handle any weather conditions.

The new advancements in these are the auto levelling mechanism which can keep the boxes in level even while taking a high speed turn. The boxes are also designed in a clever way to accommodate more luggage, or just collapse it to increase aerodynamics.



IR 067



IR 068

These are the different types of racks used in the current Adventure Tourers. They are made out of additional strength materials to handle any rugged terrain. They are also fitted with flat racks with holes to lock down the boxes or tie it down using straps.



IR 069



IR 070



IR 071

In addition to all the luggage support systems, there are more storage compartments like front helmet holder (usually found in rear tank vehicles). Under seat storage is popularly found in almost all motorcycles. Another compartment for storing the tools, that must have proper holders to prevent from making rattling noises while riding.

LUGGAGE THAT INDIAN MOTORCYCLE TOURING PEOPLE CARRY

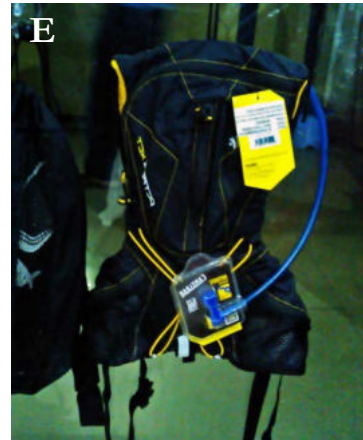


A2Z Motorcycle Superstore, based in Mumbai, India, is a shop for all the motorcycle accessories and camping equipment.

I would like to thank Mr. Rajiv for letting me do the following study about the luggage and accessories the riders carry with them.

Did a study about the existing luggage that an adventure touring people will carry with them.

The products are usually safety Products like helmets, riding jackets, riding gloves, riding pants, guards and armors and riding shoes. And also motorcycle accessories like, saddle bags, bungee nets, LED fog-lights, digital speedometers.



Rider Protection Gears

These are the popular rider protection gears. These are very essential for long touring. These also have some volume and consumes space when the rider is not riding. These are not suitable for summer conditions. Yet they cannot be discarded as they are the only safety gears available in the market.

A – Riding Boots

B – Riding Gloves

C – Knee Pad

D – Riding Helmet

E – Back Pack

F – Riding Jacket



Additional Equipment

The products shown on the left are the other equipment that the rider will carry all the time. These are usually additional lights for more illumination. Cleaning fluids, camping tent, pressure gauge for tires, Cranking charger for mobile and other similar equipment.

G – Additional LED Lights

H – Cleaning Fluids and Lubricants

I – Cranking Charger

J – Dry Sack

K – Tent Bag

L – Anti Theft System

M – Tire Pressure Gauge



IR 072



IR 073



IR 074



IR 075



IR 076



IR 077

MUFFLER

The muffler of these tourers are usually high raised ones so that water does not go inside. The muffler is placed such a way that it does not obstruct the side luggage too.

TIRES

Adventure touring tires are usually made of harder rubber for greater durability. They stay for a longer time than sports tires as they do not give the best grip like sports tires do. The tradeoff is that touring tires typically offer more grip at lower temperatures, meaning they can be more suitable for riding in cold or winter conditions whereas a sport tire may never reach the optimal operating temperature. These are also called as dual sport tires. Since the Dual sport has two characteristics, namely road and off road, they come in different variations.



IR 078

90% pavement
10% dirt.



IR 079

75% pavement
25% dirt.



IR 080

50% pavement
50% dirt.



IR 081

25% pavement
75% dirt.

Motorcycle Protection



Engine stone guard IR 082



Side Engine guard IR 083



High level Mudguard IR 084



Shock absorber mud protector IR 085



Headlamp Guard IR 086

PROTECTION

The protection can be in two ways, rider protection and motorcycle protection. Rider protection takes care of the person, both driver and the pillion. The motorcycle protection takes care of the essential motorcycle parts, usually tanks, engine, silencer and so on.

Rider Protection



Hand Guard

IR 087



Wind protector

IR 088



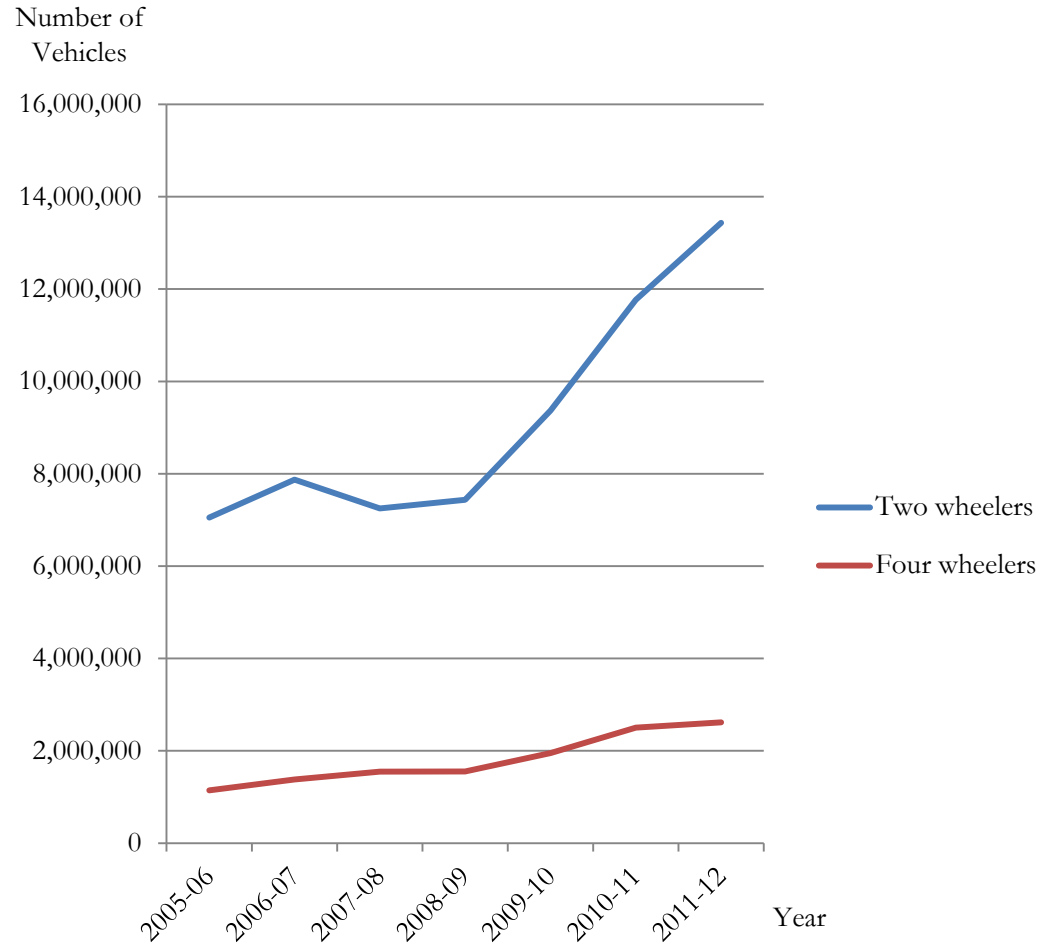
IR 089

Antilock Braking System,
Traction Control System



IR 090

Seat Heater



Source : <http://www.siamindia.com/scripts/domestic-sales-trend.aspx>

2.4 THE NEED

RECENT STATISTICS

According to Society of Indian Automobile Manufacturers (SIAM), the sales of two wheelers is increasing in a much faster pace than the sales of four wheelers. There was a sudden growth of 14.16 percent during the period of April – May 2012, whereas the Four wheeler market sales was only 4.66 percent. According to the data, the sales of two wheelers for the year 2012 -13 was 1,57,21,180. The number is mind boggling, the sales of two wheelers also shows the youth and the middle age population is increasing day by day. The figures clearly show the demand of two wheelers in India.

Goa with South India Motorcycle Tour

Golden Triangle Motorcycle Tour

Indian Coastal Motorcycle Tour

Himalayan Heights Motorcycle Tour

Motorcycle Tour in Himachal India

Indian & Nepal Motorcycle Tour

Nepal & Tibet Motorcycle Tour

Kerala Motorcycle Tour

Top of the World Motorcycle Tour

North East Motorcycle Tour

Rajasthan Classic Heritage Tour

North with south India Tour

South India Classic Motorcycle Tour

Rajasthan Desert Motorcycle Tour

MOTORCYCLE TOURING IN INDIA

The motorcycle touring industry is booming in India. Many motorcycle clubs and associations are offering package trips which provide accommodation, food and guidance for motorcycle enthusiasts. There are other section of clubs where they take it as a challenge to complete certain amount of distance and return back. They test the physical endurance and will power to reach unexplored places. Royal Enfield conducts Himalayan Odyssey which gathers Royal Enfield enthusiasts and make them ride from Delhi to Leh and back. This is a real test of stamina and determination. People are ready to spend dozens of thousands for participating in such events. XBhp magazine company conducts the Sunday breakfast ride which calls for motorcycle enthusiasts and ride to some scenic locations. There are motorcycling clubs which concentrate on women riders. Their main intention is to make them feel safe as they ride in groups and that will also make them feel equal in male dominant areas of the country.



2.5 USER STUDY

User 1 - Arunkumar Francis

- Age 28, Designer at TVS motorcycles.
- Owns a Honda CB400 super4.
- Longest trip : 900km - Pune to Bangalore.
- Does touring with his friends. Occasionally goes off-road.

According to him an Adventure Tourer must have these minimum characteristics

“

- able to maintain 120+kmph [25+bHp] on the highway.
- min, 13+lit tank [maybe a millage of 30+ is ok]
- good windshield & a detachable GPS/mapping device
- bright headlamps and a loud horn
- if possible a cattle catcher
- proper riding gear to go with..that's about it. ”



User 2 - Sudeep Babu

- Age 24, Software Engineer, Accenture
- Member of Royal Indians Enfield owners club and Xbhp
- 1700 kms round-trip Bangalore – Goa – Bangalore
- Owns Thunderbird, want to go to Himalayan Odyssey next year
- Have good knowledge about Adventure Tourers, planning to buy in the future
- Worried about the engine power and chassis strength

Expectations of an Adventure Tourer motorcycle

“ Apart from the comfortable Cruising speed of 110-120

- Long travel suspension for front and back.

- Wire spoke Rims (Preferably with tubeless tires)

- Dual purpose tires like Ceat Gripp or Pirelli Scorpion trails

- sufficiently large windscreen.

- sufficient luggage/ bungee chord mounting points

- ample lighting(headlamps)

oh yeah.. Engine Sump guard.. “



User 3 - Sachin

- Age 27, Designer, General Motors
- Owns a Yamaha R15 V2, Motorcycle enthusiast, Have been to many road trips, member of Yamaha motorcycling club and many more clubs in and around Bangalore.
- Has Decent knowledge about Adventure Tourers, have driven them also. Done a 700 Km stretch on his motorcycle.
- The long riding makes him tired at times on his R15, mainly because of posture.

He likes the concept of affordable Adventure Tourers as he couldn't afford a proper adventure tourer. He says that Adventure Tourers will be good for Indian roads as most of the roads in India are bad. He needs a motorcycle which has upright stance, long suspension travel, powerful engine but less displacement, added features that suit for camping and storage.



User 4 - Akshay Venganza Mudbidri

- Age 26, Travel Desk Advisor, Groupon India.
- Owns a pulsar 200 NS
- Rides with his friends usually, occasionally goes for planned tours.
- Concept of adventure tourer according to him is “they're comfortable, are designed to be able to be ridden on varied terrain (tarmac, dirt, off-road), usually have a decent tank range, are powerful enough to maintain high speeds all day long and are easy to maintain and service on the go. “

Would like to have the following in an Adventure Tourer

- comfortable and spacious seat
- decent wind protection,
- good tank range (atleast 400km per full tank)
- powerful headlights
- reliability of the bike as a whole.



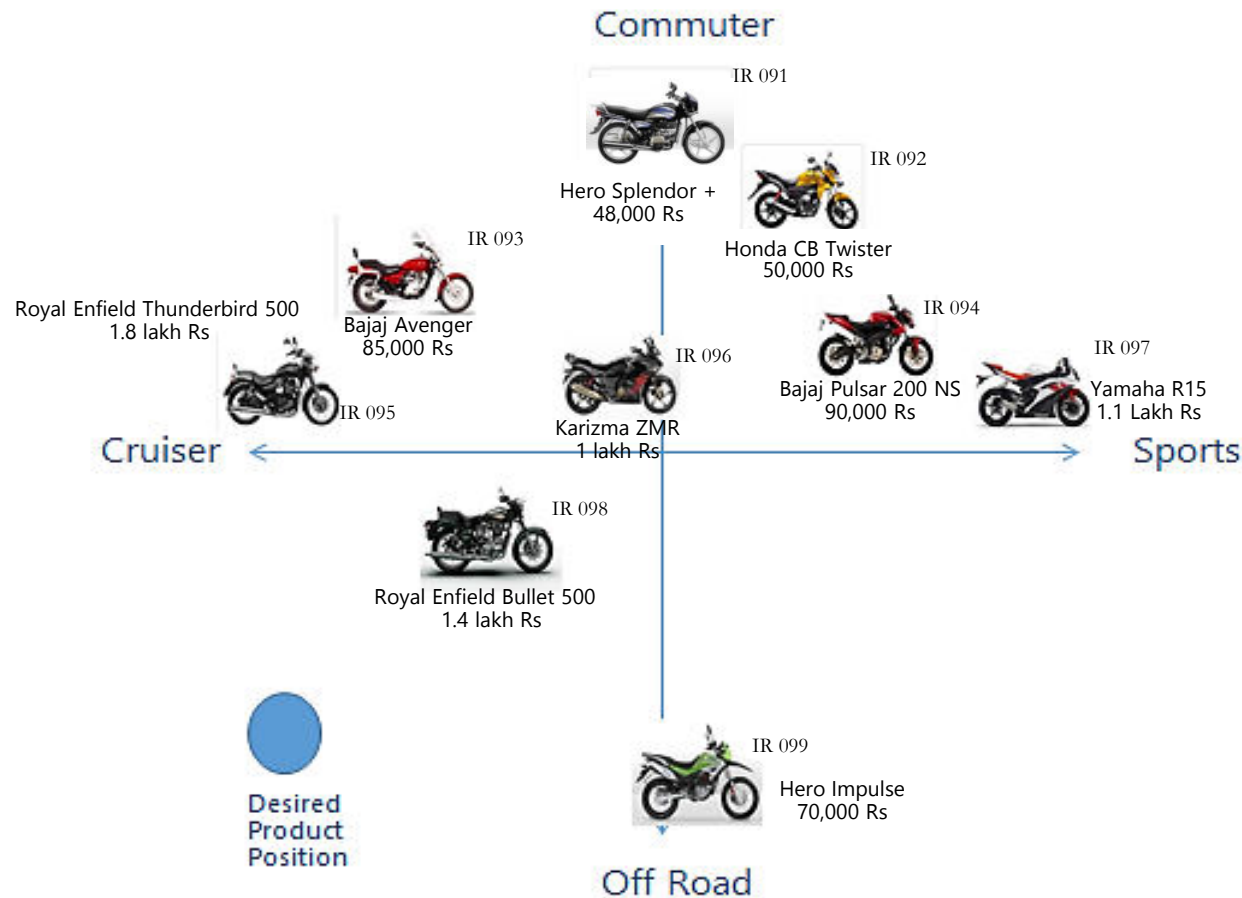
User 5- Deepak Mishra

- Age 30, Trainee AR, Omega Healthcare
- Owns a Pulsar 150 CC
- Have been to Bangalore – Kolkata –Bangalore
- Mostly rides alone, sometimes with his friends
- Does off-roading on the same bike.
- Not happy with its cruising capabilities .
- Doesn't want additional power, he thinks its waste of fuel and money.
- He hasn't driven any Adventure Tourer, more inclined to Sport Tourers like CBR 250. Likes the braking and car like feel of it.
- Fuel capacity is a big concern for him.
- Does not like Hero Impulse as it is not performing well, but likes its shock absorbers.

2.6 INFERENCES FROM USER STUDY

- Adventure tourer must have the following
 - Good fuel capacity
 - Wind protection
 - Good torque engine producing around 20 bHp power
 - Powerful headlamps
 - Relaxed seating posture
 - Ability to maneuver easily
 - Space for luggage and GPS controls
 - Dual purpose tires
- Displacement was never an USP of this product. Only torque matters, that too not on paper but based on experience. The torque provided by high end commuters will be more than enough for this application.
- People want to buy because of its versatility, but the cost is very high. They search for substitutes for those vehicles.

2.7 ADVENTURE TOURING MOTORCYCLE FOR INDIAN MARKET



PRODUCT POSITIONING GRAPH

The Product Positioning graph gives an idea of how the product is positioned with respect to the segment. If we see in the graph given, there are more sportier motorcycles are coming into Indian market. There are very less off-road vehicles. The closest Vehicle that meets the adventure touring capability is the Royal Enfield Bullet. That is mainly because peoples perception of that vehicle is being changed because of its marketing and history behind it. The desired product will be in between cruisers and Off-Road motorcycles.

EXISTING MOTORCYCLES IN INDIAN MARKET

The Existing motorcycles in the Indian market are mainly focused on the commuter segment. There are very few niche market segment bikes available. The special segment bikes like Hero Impulse and Bajaj Avenger are basically sharing common engine of commuter segment vehicle. Yet the perception of those vehicles are different because of the changes in ergonomics and styling.



IR 100

HERO IMPULSE

The only production Off-road two wheeler available in India.

“The Impulse's engine is substantially the same as the CBZ X-Treme but it wears a new cam, a new balancer shaft and a different carb spec which all make it very different from the Hunk/CBZX/Unicorn/Dazzler, the quartet sharing a much closer spec and a slightly more powerful state of tune than the Impulse”

source : http://ibnlive.in.com/news/hero-impulse-roadtest/209694-25-169.html?utm_source=ref_article



IR 101

BAJAJ AVENGER

A cruiser style motorcycle designed and manufactured by Bajaj Auto in India. Originally it was Bajaj Eliminator which had an air-cooled, single-cylinder Kawasaki engine. Available in 180, 200 and 220 cc variants. It Shares Bajaj Pulsars engine, Tuned for more torque.

150 CC MOTORCYCLE COMPARISON

Model features	Bajaj pulsar 150 cc Dtsi	Yamaha FZ S	Suzuki Gs150r	Honda Unicorn CB	Hero Xtreme
Type of engine	4-Stroke, DTS-i, Air Cooled, Single Cylinder	153cc, 4-stroke	Air-cooled, 4-Stroke, SOHC	149.1cc, 4-Stroke	149.2cc, ATFT
Engine displacement	149.01 cc	153 cc	149.5	149.1 cc	149.2cc
Mileage	62kmpl	47kmpl	55kmpl	60kmpl	60kmpl
Maximum power	14.85 bhp @ 9000 rpm	14 bhp/7500rpm	13.8bhp @ 8,500rpm	13.3 Bhp @ 8000 rpm	14.2 Bhp @ 8500 rpm
Maximum torque	12.5 Nm @ 6500 rpm	14 Nm/4500rpm	13.4Nm @ 6,000rpm	12.7 Nm @ 5500 rpm	12.8 Nm @ 6500 rpm
Starting	Self / Kick Start	self start	Electric & Kick	self start	self Start
wheel type	Alloy	Alloy	Alloy	Alloy	Alloy
Tire type	FrontTube-Type – 2.75 x 17", Rear: Tube-Type – 100 / 90 x 17"	100/60 – 140/60 mm	Front:2.75-18 42PRear: 100/90-18 M/C 56P	2.75 x 18", 3.00 X 18" mm	80/100 18 – 100/90 18 mm
Wheel base	1320 mm	1335 MM	1,335	1340 mm	1325.00 mm
Fuel Type	Petrol	Petrol	Petrol	Petrol	Petrol
Fuel Capacity	15 Ltrs	12 L	15.5 l	13 Ltrs	12.10Ltrs
Clutch	Wet Multiplate	Wet, Multiple	Wet Multi-Plate Type	Wet Multiple	Multiplate Wet
Gear Box	5 Speed	5 Speed	6-speed (1-Down, 5-Up)	5 Speed	5 Speed
Brakes	Front-240 mm Disc, Rear-130 mm Drum	disc front and drum at rear	Front: Hydraulic Single DiscRear: drum	Front Disc, Rear drum	disc in front and rear
Color	Plasma Blue, Cocktail Wine Red, Midnight Black	Red, Black, gold, blue	orange, greenish, blue, grey, black	Red, Black, silver	brown, orange, silver, red and black

Source : <http://www.era.la/top-5-best-150cc-bike-models-and-features-in-india.html>

Considering the price and the power factors, 150 CC commuter motorcycles are chosen. The bikes below 150 CC are underpowered according to the views from the users and testing it on hilly regions. On the other hand capacity more than 150 CC are on the expensive side and they do not give much difference in the power output. So all the 150 CC motorcycles are considered for comparison. In this segment the maximum power is produced by Bajaj Pulsar. Since that engine is already used for Bajaj Avenger, which is badged as a cruiser is a good option to go for. Moreover in the user research also similar comments were noticed.

2.8 DESIGN BRIEF

Aesthetic Intent

The Aesthetics of the adventure tourer should reflect its nature of ruggedness, capability of going on any terrain, safeness and one with nature.

The motorcycle should communicate with the rider that he is safe on the vehicle even while in riders point of view.

Technical Specifications

The technical Specifications are borrowed from Bajaj Pulsar as it got more power and most affordable in that segment. For an adventure tourer power is critical, at the same time this project is about affordability. So 150 CC is the best choice.

Engine : Engine Displacement (CC) - 149.1 CC

Engine Type DTS-I - Air Cooled

Power (PS@rpm) - 15.6 PS

Torque (Nm@rpm) - 12.5 Nm

Chassis Type : Double Cradle Frame

Length : 2055 mm

Wheel base : 1320 mm

Packaging

The riders pose should be upright with standard commuter vehicle foot pegs position. High visors for wind protection, high suspension travel and enough protection for rider and engine. The cost must be low as possible.

STAGE 2

Changes On The Commuter Vehicle

Mood Board

Exploratory Sketches

Directional Renders

Ergonomics

Luggage

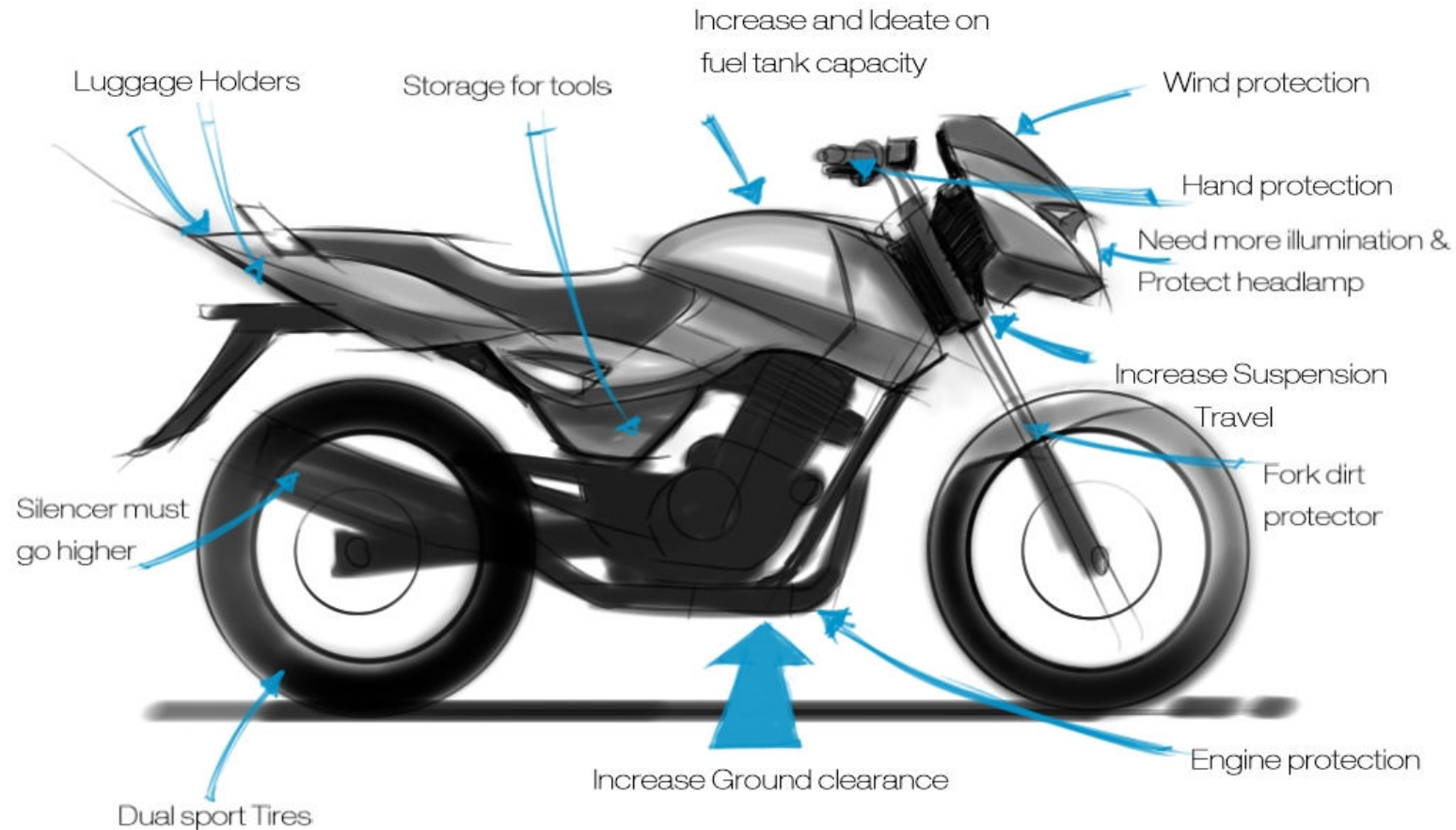
Concepts

Evaluation

3. Design

3.1 CHANGES ON THE COMMUTER VEHICLE

The following changes are need to be made in the existing vehicle to make it as an adventure touring motorcycle. These are the initial changes that was culminated from the user research and product study.



3.2 Mood Board Rugged

The Adventure Tourer must be rugged as it should be able to handle any kind of terrain. The ruggedness of the vehicle must be communicated through the bodyworks itself rather than relying on the additional fixtures. The additional fixtures like the engine protector, mud protectors should enhance it. The images selected here are based on how these products were marketed. Even if they are not really rugged, they give the feeling of the ruggedness.



IBR 01



IBR 02



IBR 03



IBR 05



IBR 04



IBR 06



IBR 08



IBR 07



IBR 09

Mood Board

Versatile

Versatility is the main expression that an Adventure touring motorcycle should portray. This motorcycle can be used for both long road cruising and off road purpose. Hence this must show the versatile nature of it. Showing versatile nature of a product can be done through exposing their multi functional capabilities. It can also be shown using colour as a communication medium. Every colour has a meaning. If properly chosen, the multi functional nature of the vehicle can be shown through colour itself.



IBR 10



IBR 11



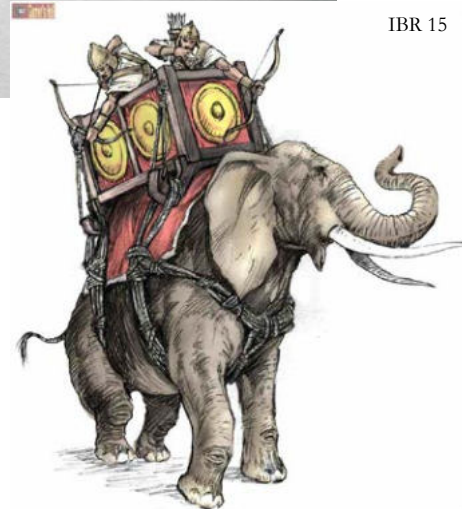
IBR 12



IBR 13



IBR 14

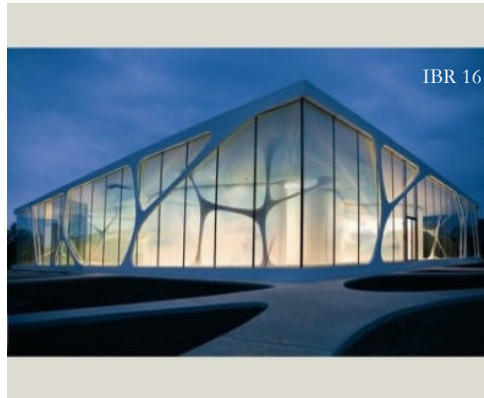


IBR 15

Mood Board

One with nature

The main purpose of this adventure touring vehicle is to explore unexplored places. That place is most of the time a natural scenic place. The presence of the vehicle in that place should not disturb the scenery. The motorcycle should blend with the background and be one with the nature.



IBR 16



IBR 17



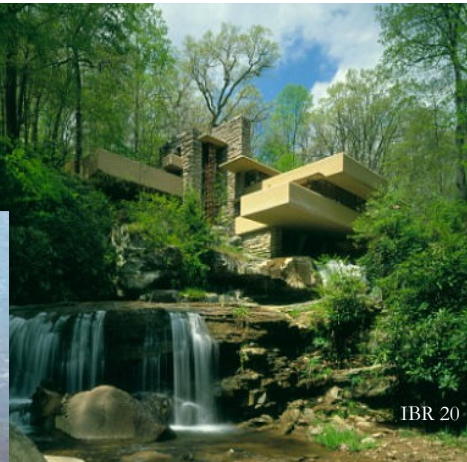
IBR 18



IBR 19

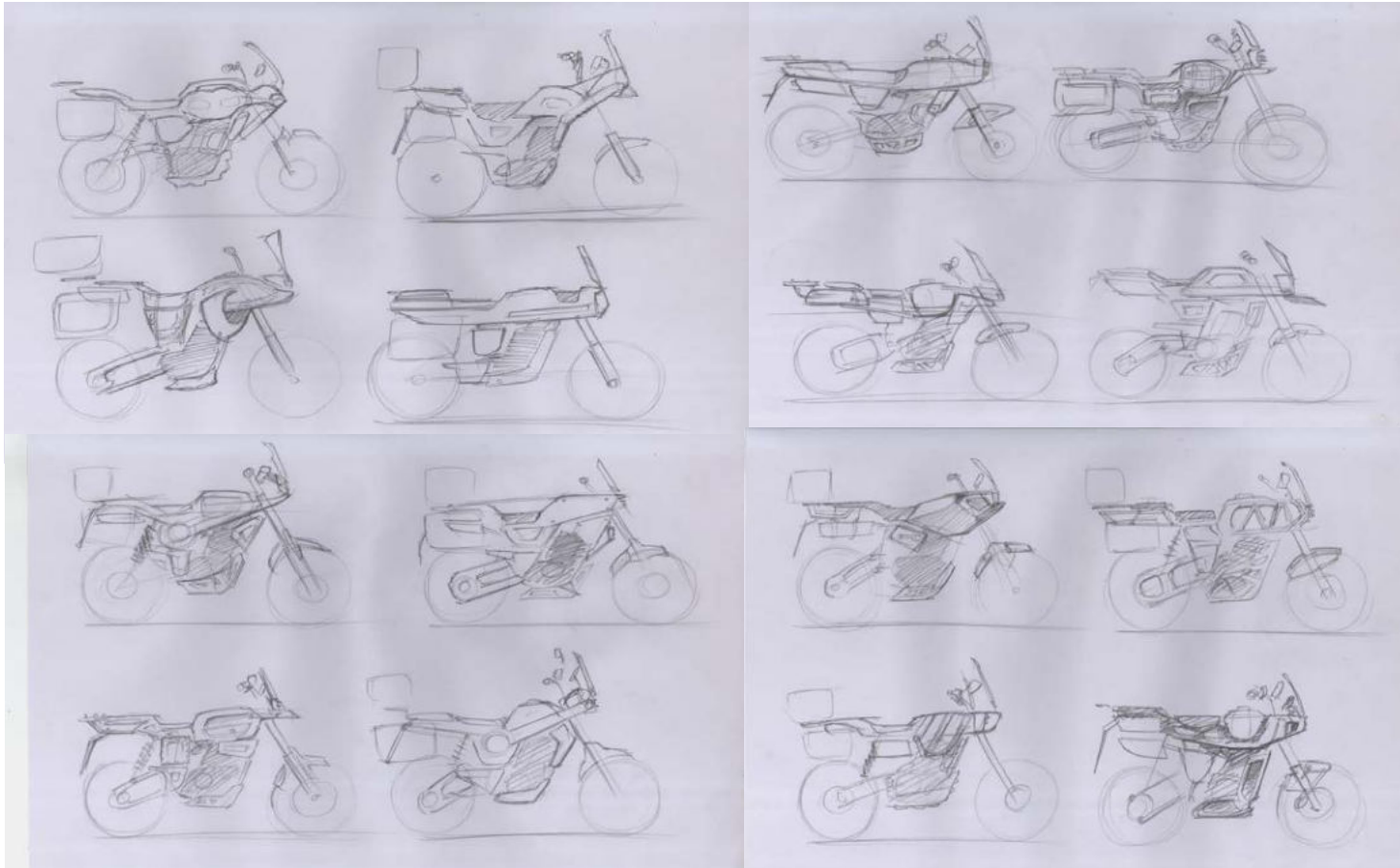


IBR 21



IBR 20

3.3 Exploratory Sketches



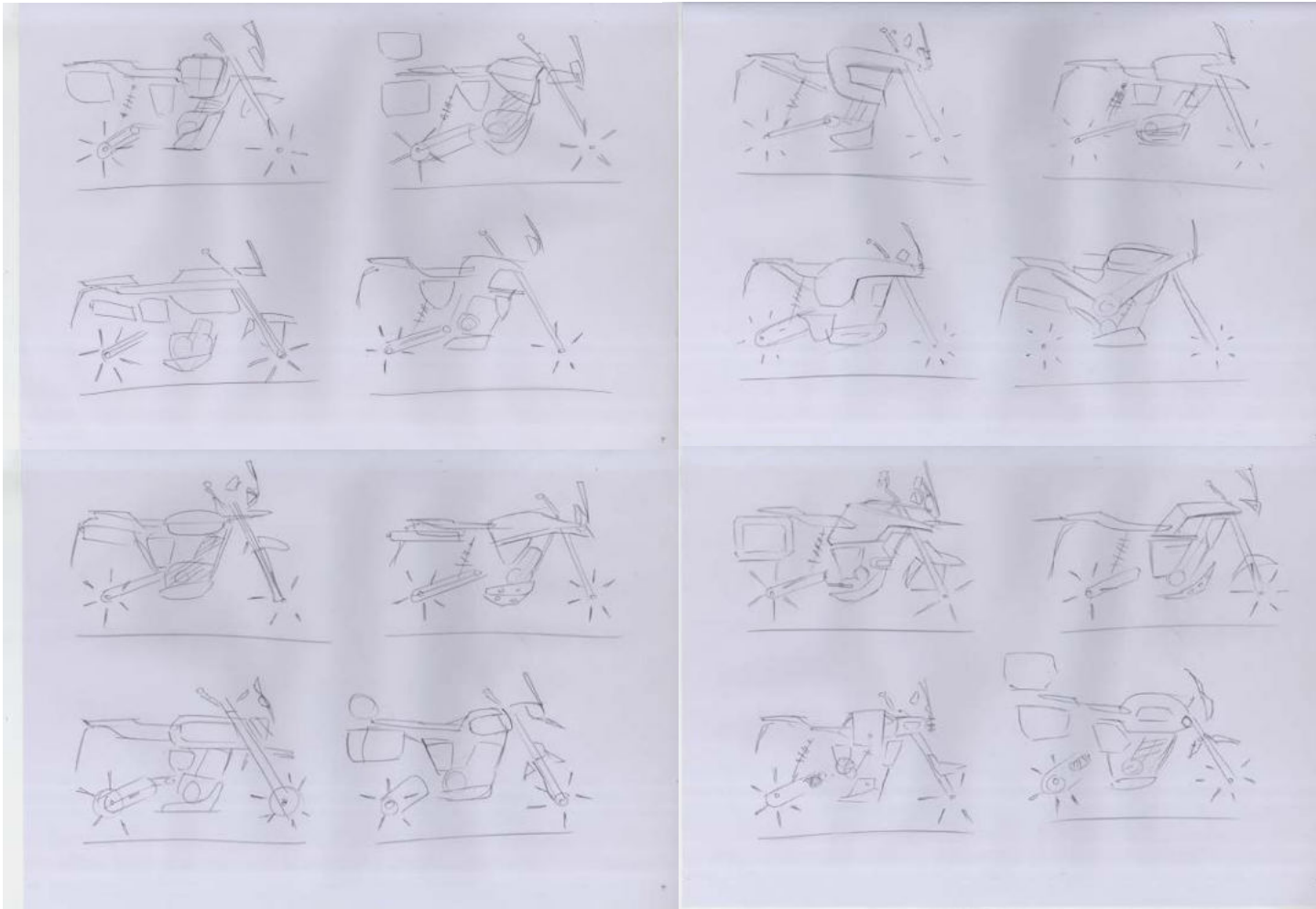
The exploration started with sketching basic volumes with the mood boards as a reference. They gave a direction towards the form to match the aesthetic intent. The initial ideations concentrated more on exploring the rugged forms. They are usually disconnected volumes with less flowy lines to give a machined feel. The major visual cues like bolts and exposed chassis members enhanced the form. Even though those detailing comes in the later part of the exploration, they are very critical in making the form rugged.

Exploratory Sketches



The exploration moved on to more integrated form. This was done to see how ruggedness can be imparted using integrated volumes and flowy lines. The visual mass is still on the tank and the headlamp area. Occasional retro treatment is given to see how can it blend with the continuous surfaces. The main observation done here was how the windshield and the tank are communicating. The longer the windshield, the stronger the integration of headlamp and fuel tank should be. The observation from existing Adventure touring motorcycles is that, the whole visual mass is in between the two wheels and slightly moved towards the top.

Exploratory Sketches



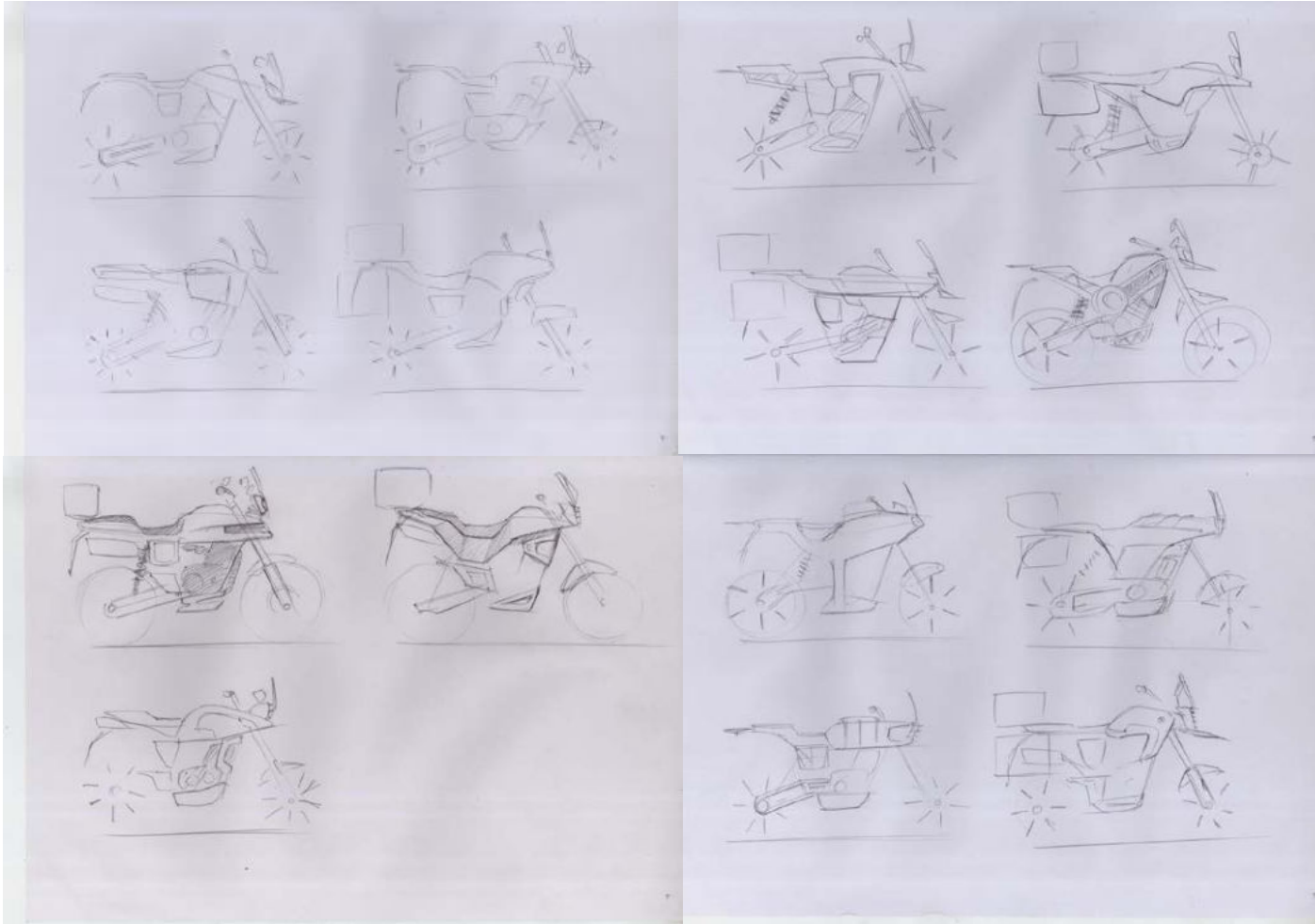
More atypical shapes are explored now. That is done using the idea of fuel tank and high level mudguard in mind. Versatile nature of the motorcycle is also explored. Distinctly highlighting the various parts and expressing their use is the idea behind showing the versatile personality of the vehicle.

Exploratory Sketches



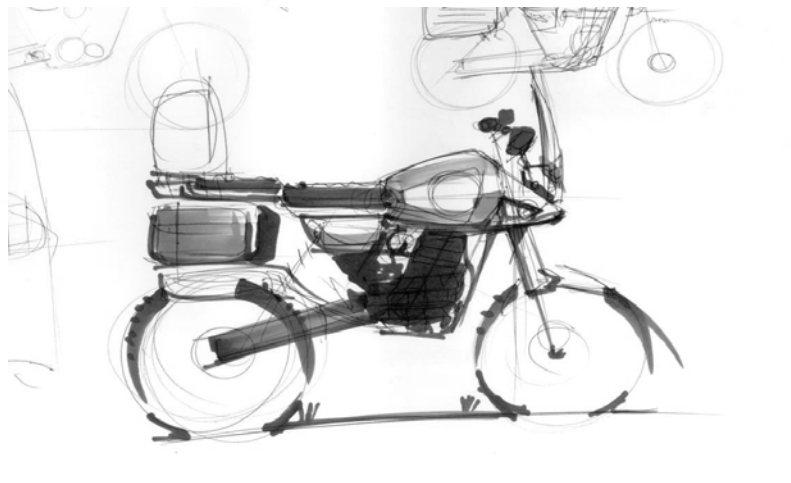
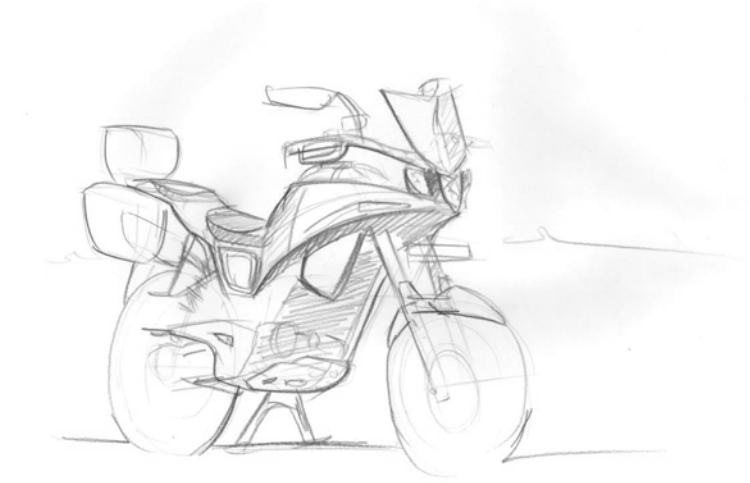
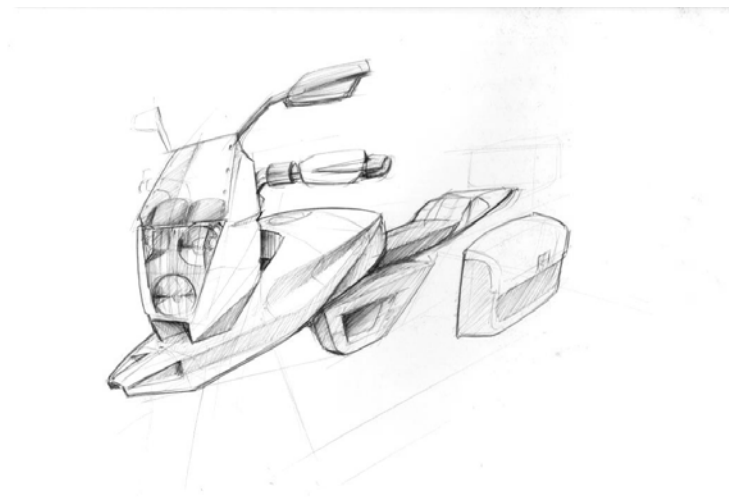
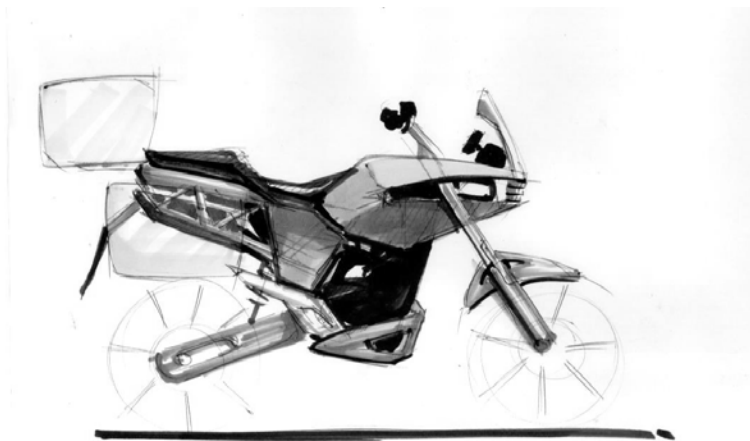
Now flowing lines and larger visual mass comes into play. The linearity of the body is also explored. The vehicle must look heavy to express its luggage carrying nature and at the same time must look directional in nature. The heavy aquatic animals were also an inspiration. They have the characteristic streamline body and at the same time bulky enough to express their massiveness. Interplay of body parts with the chassis members were also considered in this phase of ideation. Occasional use of luggage boxes were made to see how the volumes interact with the body parts.

Exploratory Sketches



Fully integrated body parts were considered. The idea is to make a couple of body parts and just mirror it. The simplicity nature is explored here. That was not giving the rugged nature of the vehicle. The same fully continuous body panels were treated with chassis member details to see whether it gave that rugged feel. The ruggedness is seen in it, but it was just because of the accessories. The accessories must enhance the rugged nature, not create it. Rectilinear lines were avoided here, it was imparting too much of rugged nature into the form. The form must reflect versatility and one with nature expressions. So occasional inspirations from nature like animals and birds were explored.

Exploratory Sketches



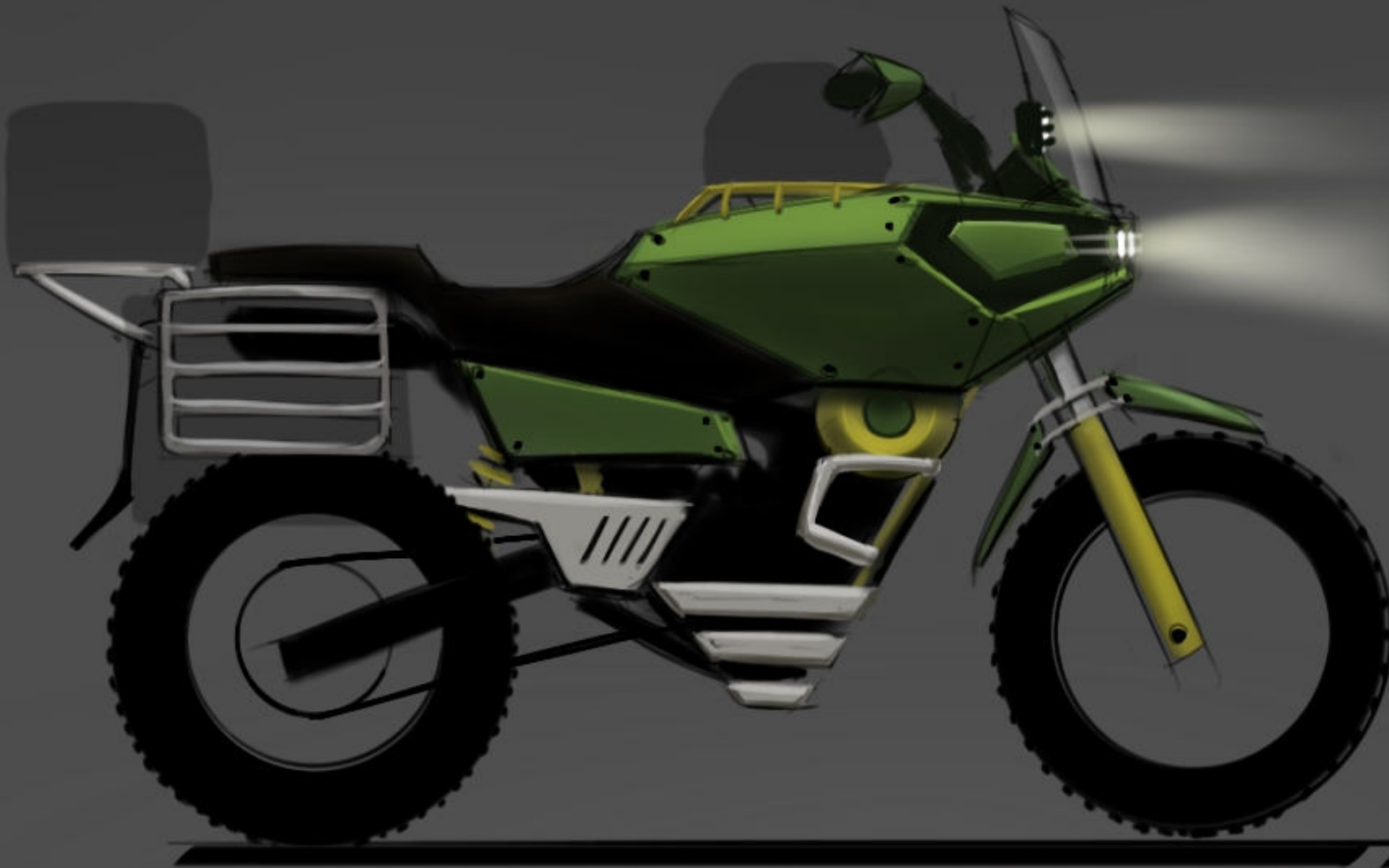
3.4 DIRECTIONAL RENDERS



DIRECTIONAL RENDERS



DIRECTIONAL RENDERS



INFERENCE FROM DIRECTIONAL RENDERS

The Directional renders were made to get an idea about the form, which kind of form to proceed with. The first render was bit more towards the edgy form. The form did not have consistency and did not give the feeling of a touring motorcycle. It gave sportier feel, that is not a desired expression. The second render was inspired from liquid and it tried to portray the fluidity of liquids. On discussing with peers and few users, the adventureness is not expressed in this. The third render was inspired from war tanks which was always a metaphor of ruggedness. The form had rugged character in it, but the ruggedness was over expressed. Usage of naked frame materials added up to the ruggedness feel. The wind protection visor was also looking weakly integrated with the form. Colour scheme was also suggesting some character in the form. It is better practice not to use colour while comparing two or more forms. From the first render, the concept of leg support gave insight into considering the ergonomics of the motorcycle. The ergonomics of the desired vehicle is studied in the following section.

3.5 ERGONOMICS

The ergonomics of the existing motorcycle were studied. An ergonomic simulator is used to check the posture of the person on that vehicle. The common observation of the posture on the adventure tourer motorcycle is that, the back is almost vertical, knee angle is large, the handlebars are usually higher than normal commuter stance.



2012 Bajaj Pulsar 150

Calculated seat height: 31.0"
Forward lean: 5°
Knee angle: 86° (smaller number means more bent)
Hip angle: 84° (smaller number means more crouched)



2013 KTM 1190 Adventure
Calculated seat height: 34.0"
Forward lean: 6°
Knee angle: 95° (smaller number means more bent)
Hip angle: 99° (smaller number means more crouched)



2013 Ducati Multistrada 1200
Calculated seat height: 33.0"
Forward lean: 3°
Knee angle: 91° (smaller number means more bent)
Hip angle: 99° (smaller number means more crouched)



2013 Kawasaki Versys 1000
Calculated seat height: 33.5"
Forward lean: 5°
Knee angle: 95° (smaller number means more bent)
Hip angle: 99° (smaller number means more crouched)



2013 BMW R1200GS
Calculated seat height: 34.4"
Forward lean: 6°
Knee angle: 96° (smaller number means more bent)
Hip angle: 99° (smaller number means more crouched)



2014 Triumph Tiger Explorer XC
Calculated seat height: 33.8"
Forward lean: 3°
Knee angle: 92° (smaller number means more bent)



2012 Yamaha Super Tenere XT1200Z
Calculated seat height: 33.1"
Forward lean: 3°
Knee angle: 94° (smaller number means more bent)
Hip angle: 96° (smaller number means more crouched)



2012 Honda Crossrunner VFR1200X
Calculated seat height: 33.8"
Forward lean: 6°
Knee angle: 93° (smaller number means more bent)
Hip angle: 98° (smaller number means more crouched)



2010 Suzuki V-Strom 1000/DL1000
Calculated seat height: 33.7"
Forward lean: 0°
Knee angle: 90° (smaller number means more bent)
Hip angle: 103° (smaller number means more crouched)



2012 KTM 990 Adventure
Calculated seat height: 34.3"
Forward lean: 2°
Knee angle: 90° (smaller number means more bent)
Hip angle: 99° (smaller number means more crouched)

source : <http://cycle-ergo.com/>



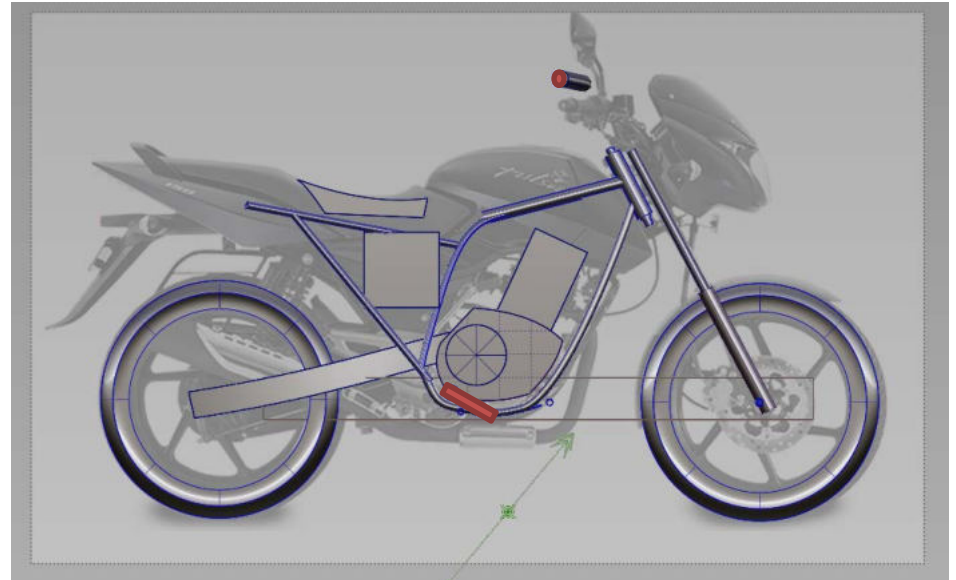
Test Rig

Since this project involves usage of existing chassis from a commuter vehicle, there must be some changes in the foot peg and handle bar position so that the person feels comfortable in any kind of terrain. A test rig is made to simulate the ergonomics of the desired vehicle. The height of the seat is taken from 50th percentile Indian male inseam length. The ground clearance of the desired vehicle is taken from the existing off-road vehicle in Indian market, Hero Impulse. The test rig is made such a way that the position of the handlebars can be varied and the foot peg position also can be varied. Engine width of 280 mm is also given to simulate the width of the vehicle. Proper cushioning is given so as to make the test comfortable, The compression of the cushion was considered so that height does not change while sitting with cushion. The handlebar position is not allowed to go in front of the rake line. The foot pegs position is also kept so as to make sure its position does not go into extreme Sports position or extreme Cruiser position. During the travel the rider might stand on the foot pegs, so it is important to consider the width factor while standing also in this test.



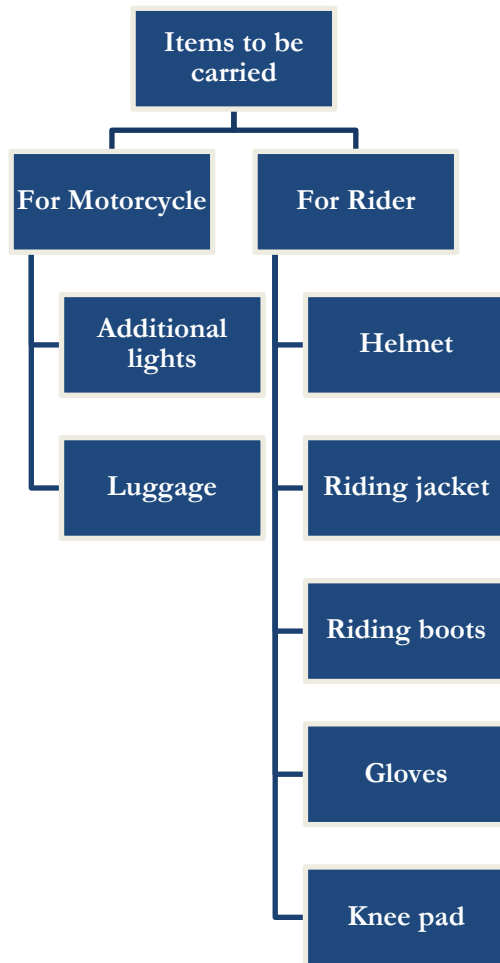
The test was conducted with 3 people, who has prior knowledge about ergonomics. The person is made to sit on the rig for half an hour with different positions. Both the foot peg and the handle bar position is varied based on the existing chassis constraints and observations made on the adventure tourer postures. The common observation made during the test is that the handle bar position for this scenario is moving higher than usual, pull back is minimal but the back tends to be straight. The foot peg position is altered towards the commuter motorcycle side, but still the problem found was, the knee angle tends to become acute as the height of the user increases.

Finalized Ergonomics



The above seen positions were fixed after the test is conducted

The optimal positions were fixed by fine tuning the angle of the knee and the elbow. The angle of the foot pegs was also given prime importance. The ergonomic triangle came out to be an upright posture triangle. The handlebars are higher than the original height and the foot pegs are moved to the front. The CAD model on the right is then taken as an underlay for further explorations and luggage configurations.

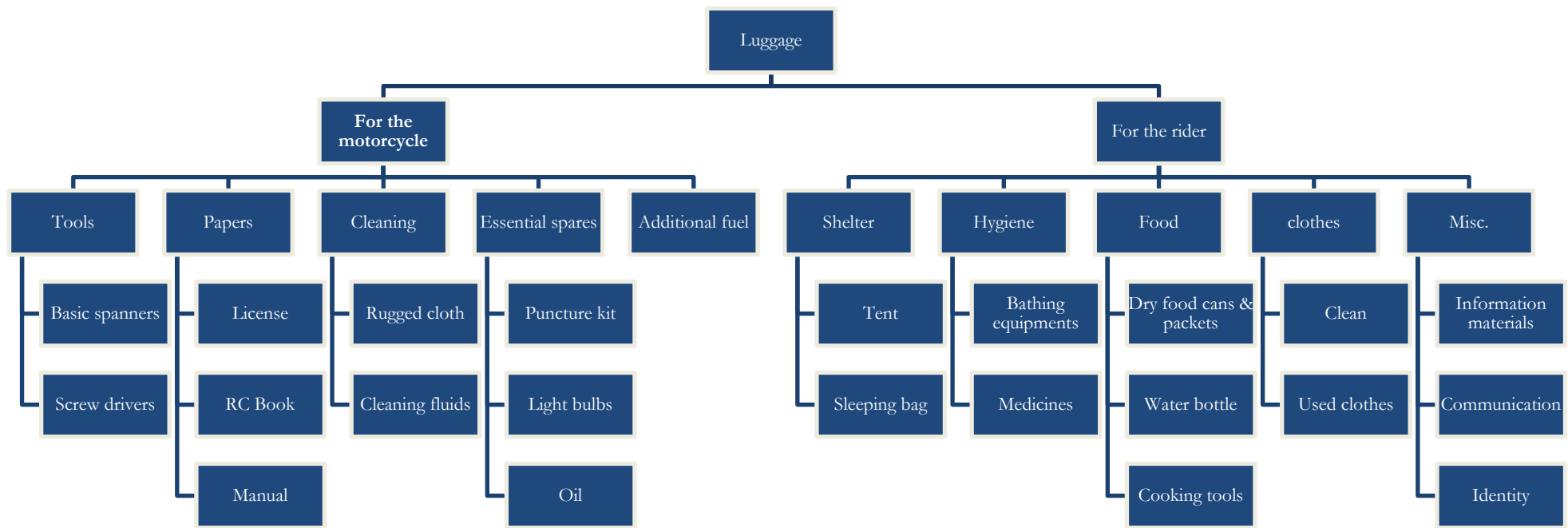


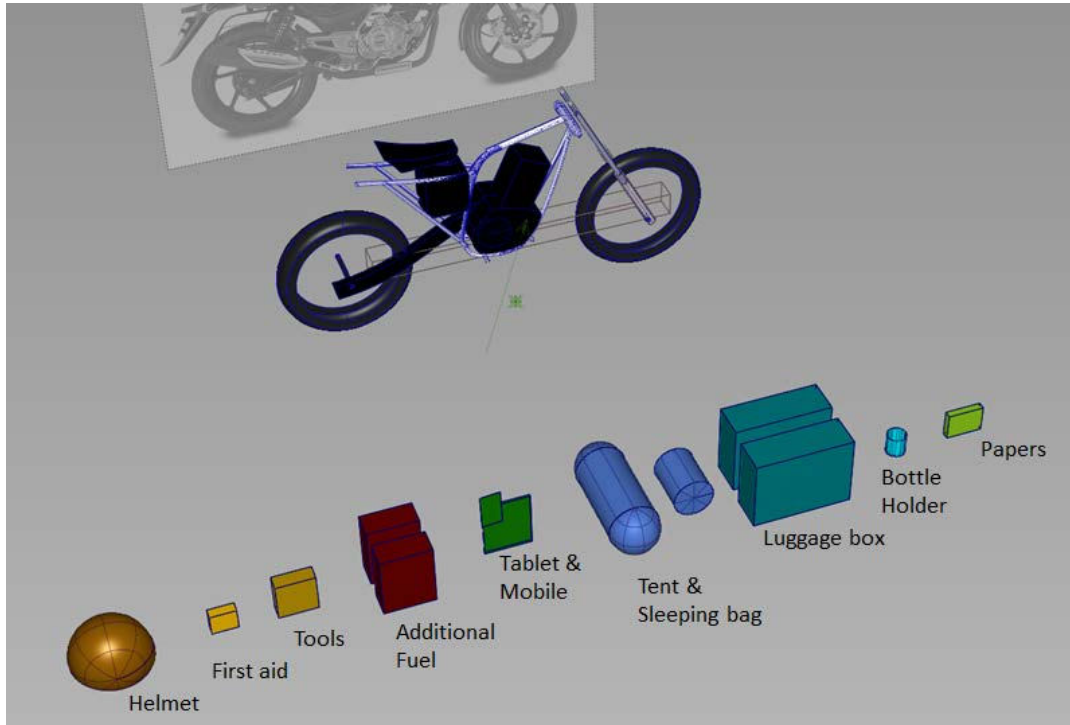
3.6 LUGGAGE

The Adventure Touring Motorcycles not just carry the rider, but also the luggage. The rider goes on for a long duration road trip, so it is very essential for him or her to carry essential supplies and tools. The problem in this case is how to make the luggage more organized on the motorcycle and make their usage more optimal.

The items carried during the tour can be for motorcycle or for the rider. The ones carried for motorcycle are usually fixed on the motorcycle itself. They are usually additional lights, spares and tools. The luggage is a general encapsulation of all the secondary items, which is further expanded into luggage related to motorcycle and for the rider.

The Luggage that adventure tourer carries can be categorized in many ways. In this case the best way to categorize is to see which ones are going into luggage box and which ones are kept outside the box. The item which goes inside the box are the ones which are not used often during the travel. The ones which are kept outside the box are the ones which are used often, or which should be kept in reach. The rider need not stop riding to take these items out from the box.





OUTSIDE THE BAG

The Following luggage are kept outside the luggage box and bags. These are essential and frequently used by the rider. Optimal space must be allocated on the motorcycle to give proper access to these and should not hinder with the riding experience.

Based on the study done at the A2Z Motorcycle Superstore and Internet research the following dimensions of the luggage that needs to be kept outside the luggage box are fixed.

Tent – 200 X 550(diameter) mm

Sleeping Bag – 200 X 160(diameter) mm

Tool Box – 180 X 150 X 50 mm

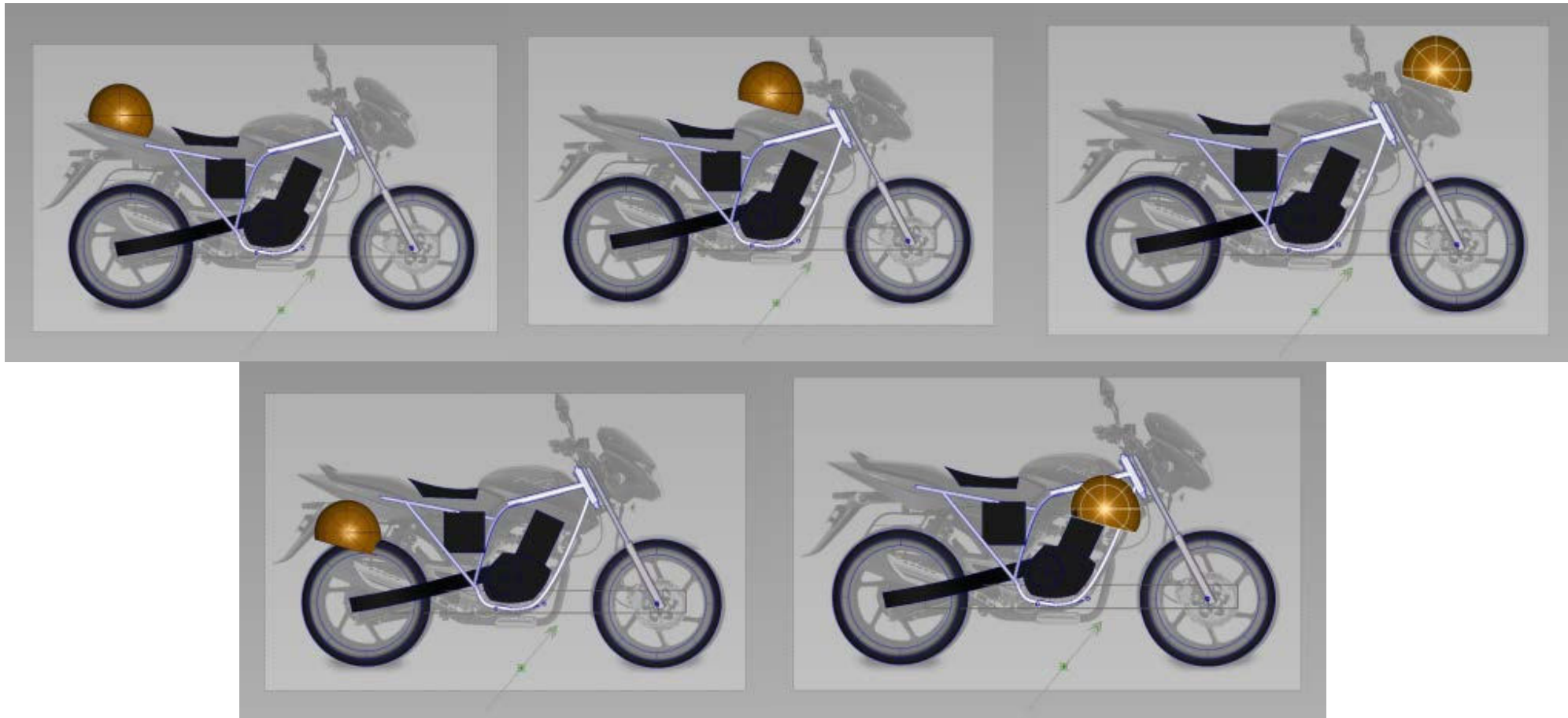
Tablet – 240 X 185 X 94 mm

Mobile Phone – 150 X 80 X 10 mm

Water bottle – 80 mm diameter

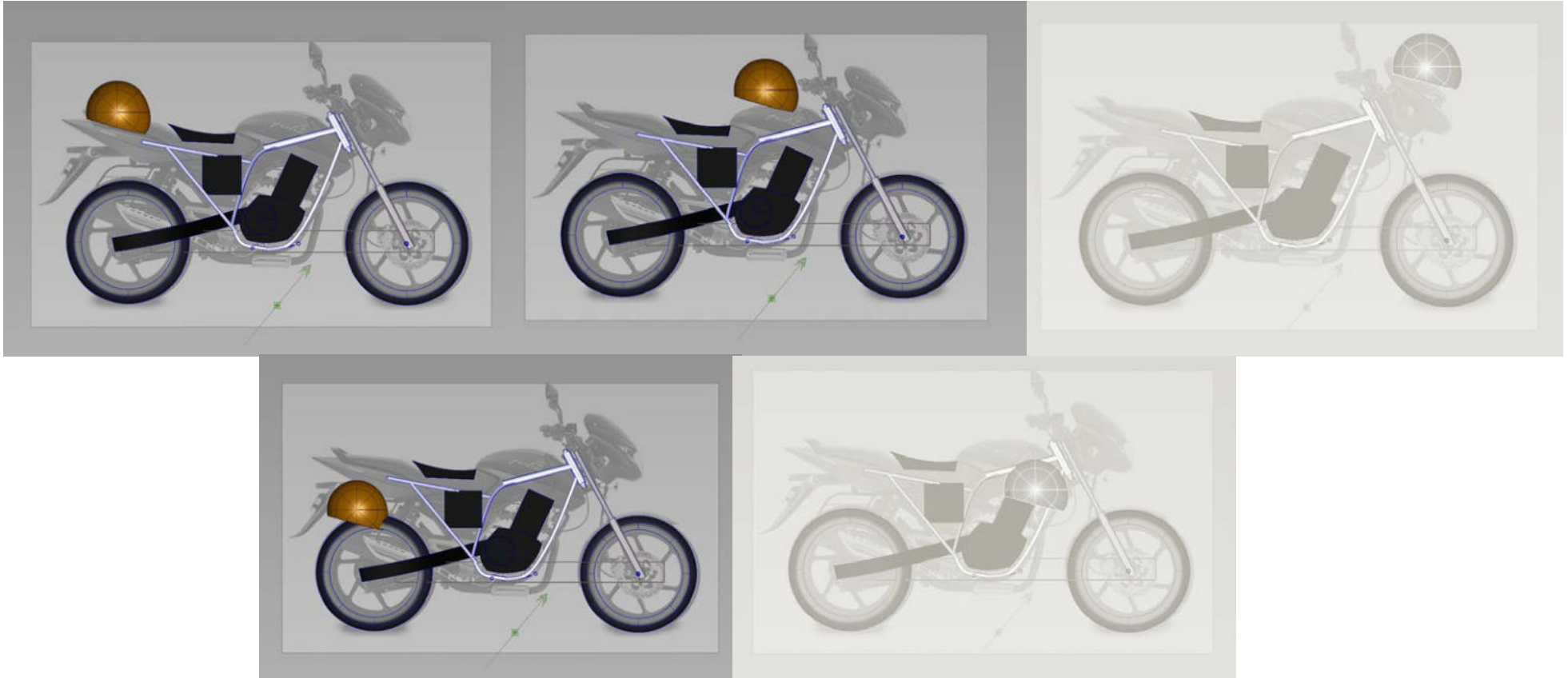
First Aid kit – 100 X 90 X 50 mm

Additional Fuel – 5 L ,shape can vary



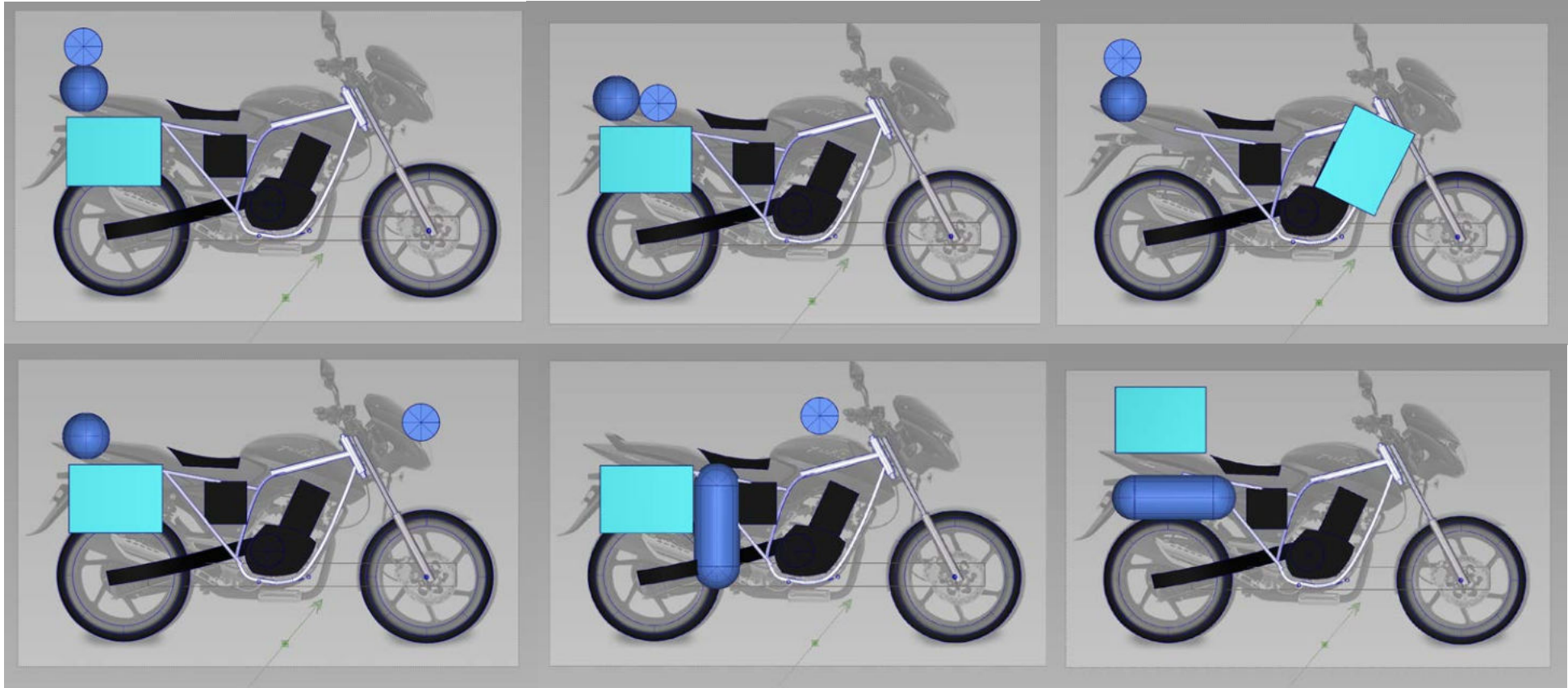
Helmet

The helmet will be kept on the motorcycle only when parked or when the rider rides it slow, for short distance travel. The priority of keeping the helmet on the bike is low. But at the same time, it ought to be locked to the motorcycle when the rider is away from the bike.



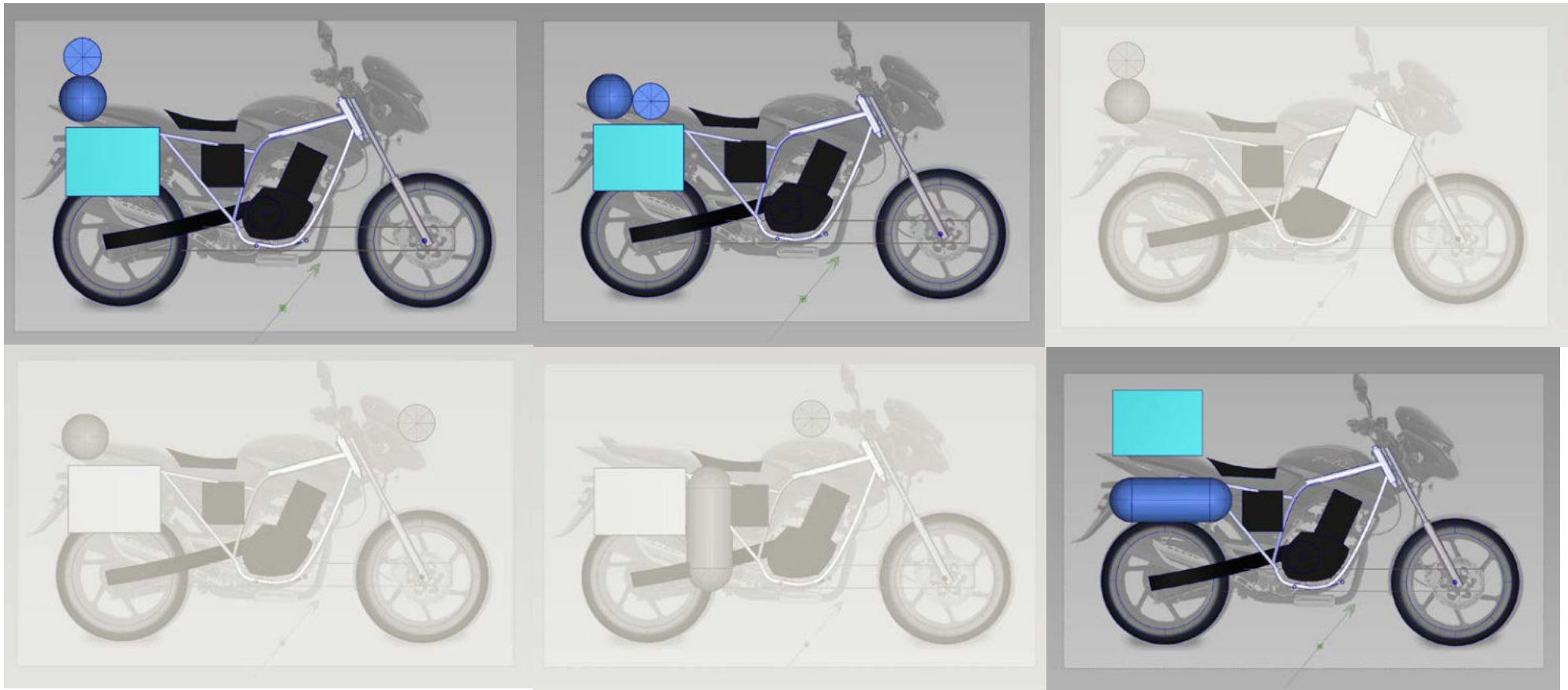
Helmet

The best positions for the helmet with locking mechanisms are the pillion rider position, over the tank or on the side of the rear wheel. Over the cowl and on the side of tank is not recommended as it obstructs the view and provides a visual imbalance to the rider.



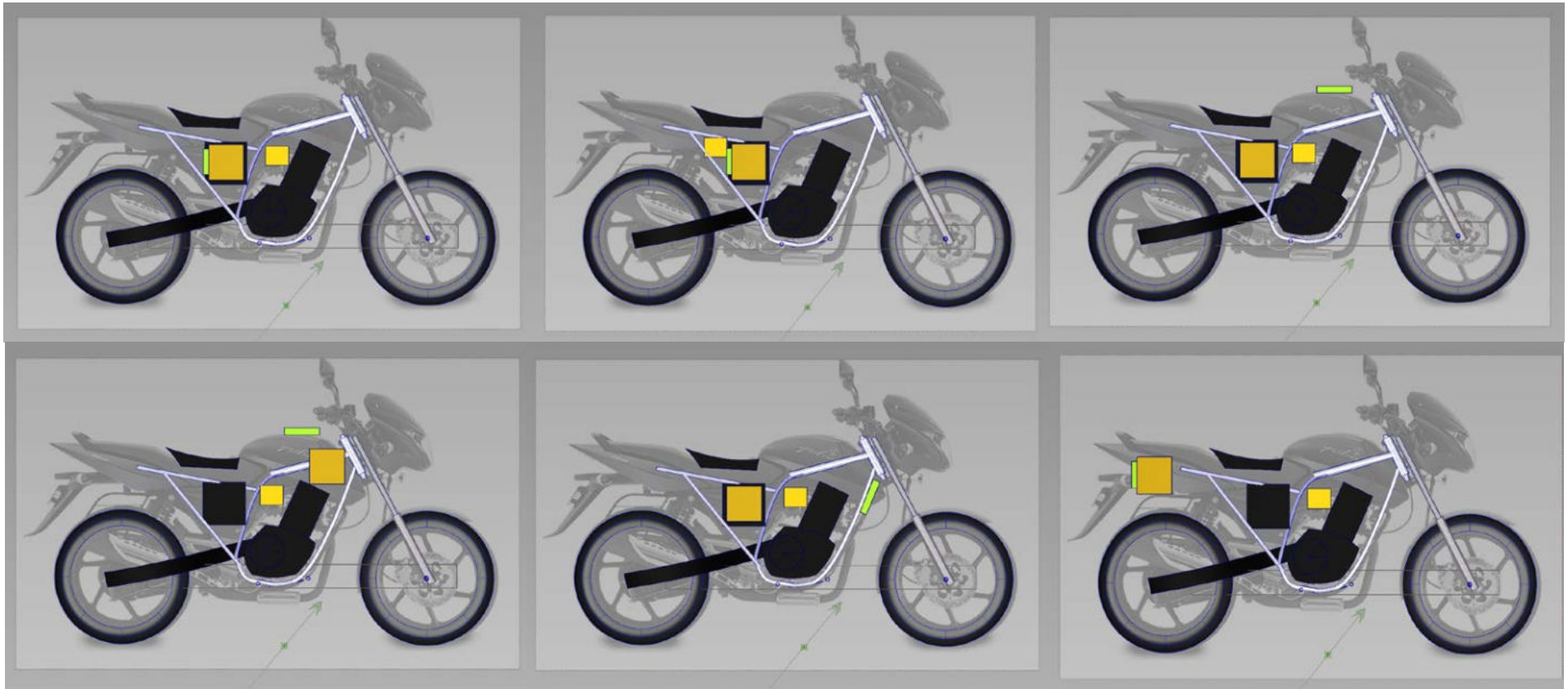
Sleeping bag + Tent + Luggage box

Sleeping bag, tent and luggage bags are grouped together because they are used only after the vehicle is parked. The rider need to park the vehicle and take these luggage out. Tent and sleeping bag is opened only while sleeping. The luggage box is opened only if necessary. The possible layouts are explored.



Sleeping bag + Tent + Luggage box

The possible and most promising layouts of these three items are highlighted here. These luggage are pushed back because the reach is not necessary during the travel. These can be taken after the vehicle is parked.



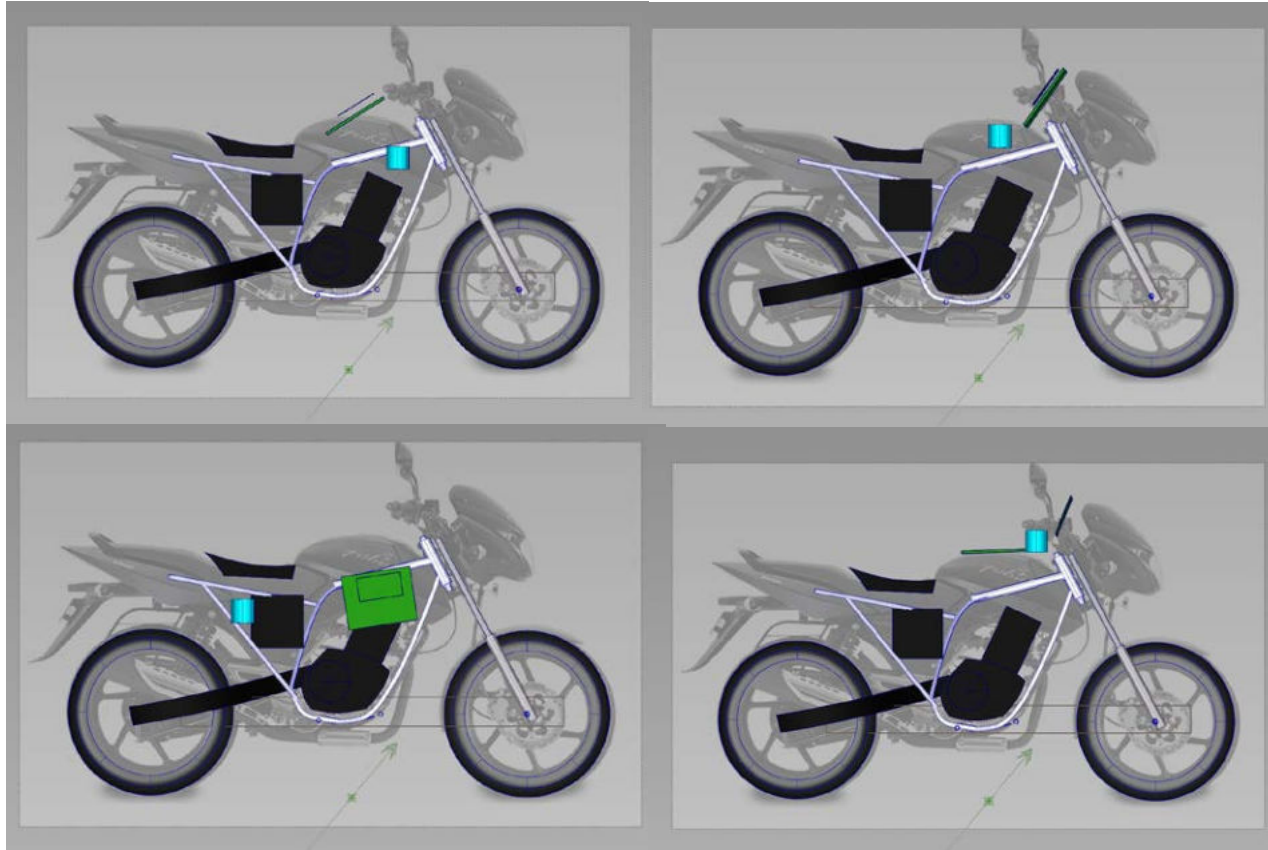
Tool box + First aid kit + Papers

The Tool box, First aid kit and papers are secondary items which will be used only in case of emergency. These got to be in obvious places and must be accessible in any kind of scenario. The first aid kit and tools need to be protected from any kind of accident.



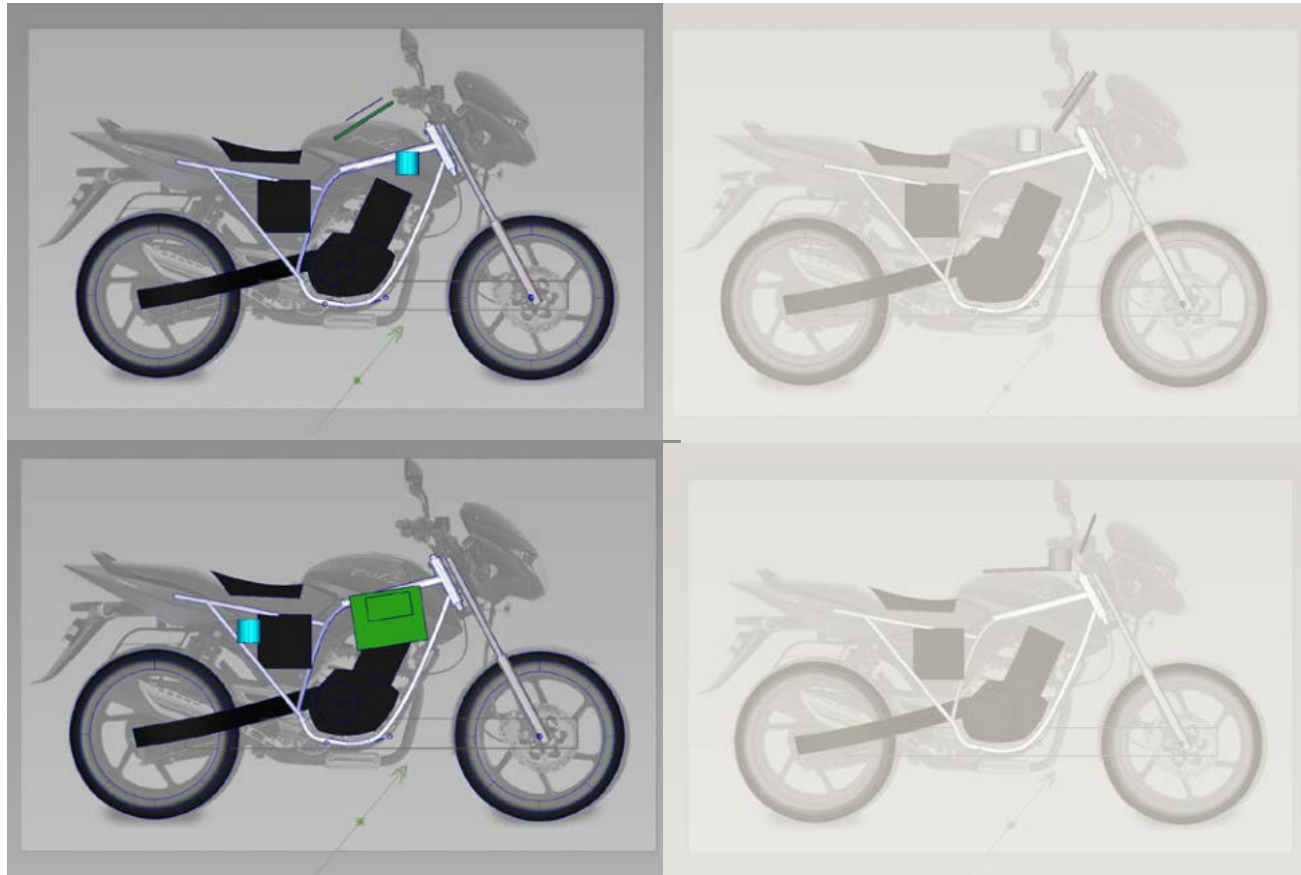
Tool box + First aid kit + Papers

The tool box is good to be located in a place nearby the engine, where it is frequently used. The first aid kit and papers is best positioned under the seat or beside the battery where the damage occurred by any collision is very less. They can be accessed easily if they are kept in these places.



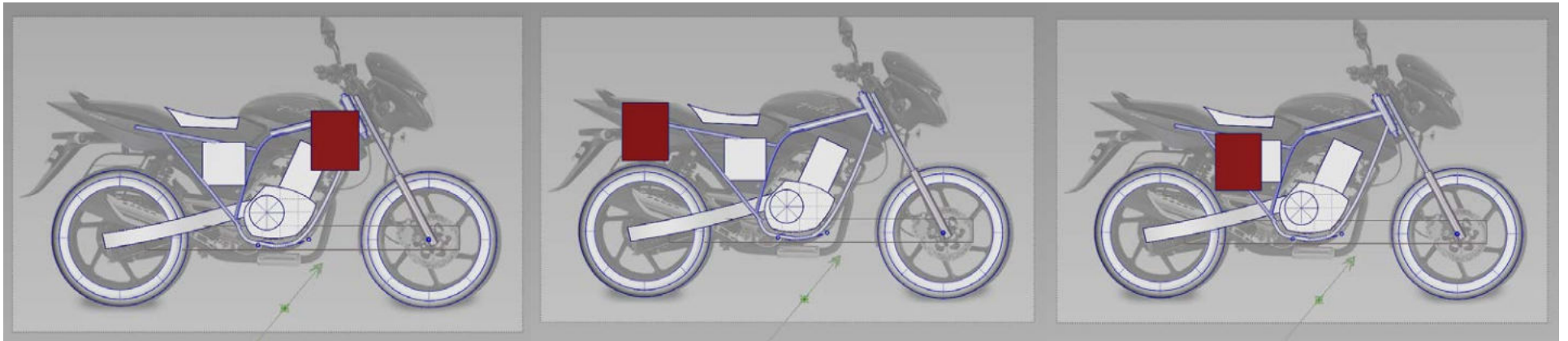
Mobile phone + Tablet + Water bottle

The mobile phone, tablet and the water bottle are the frequently used items during travel. They need to be in riders reach while riding. They should be visible to the rider so that the rider can reach in the dark also.



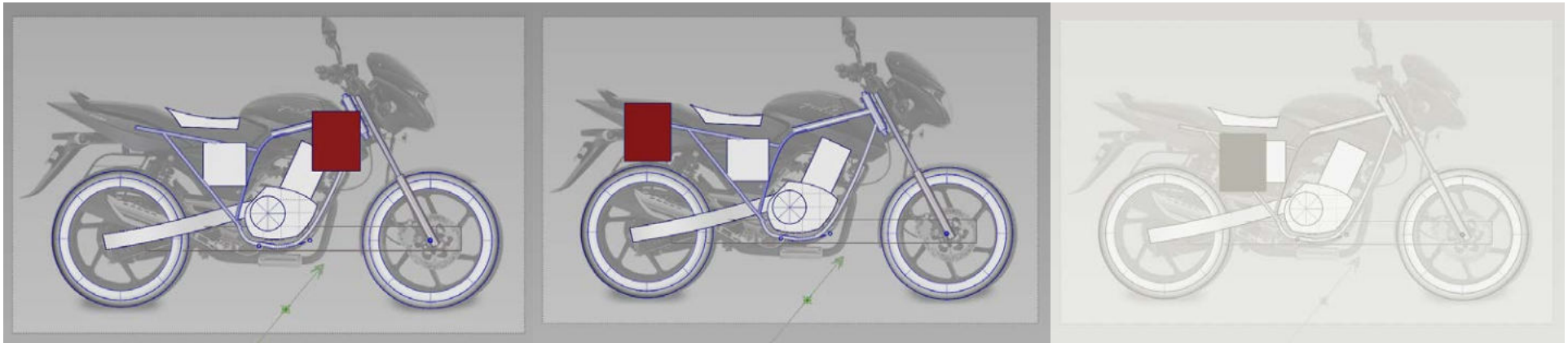
Mobile phone + Tablet + Water bottle

The best position for the water bottle and the Mobile & Tablet are highlighted. The tablet and the mobile is best positioned in front of the rider, it should have less vibrations and need to be accessed very frequently.



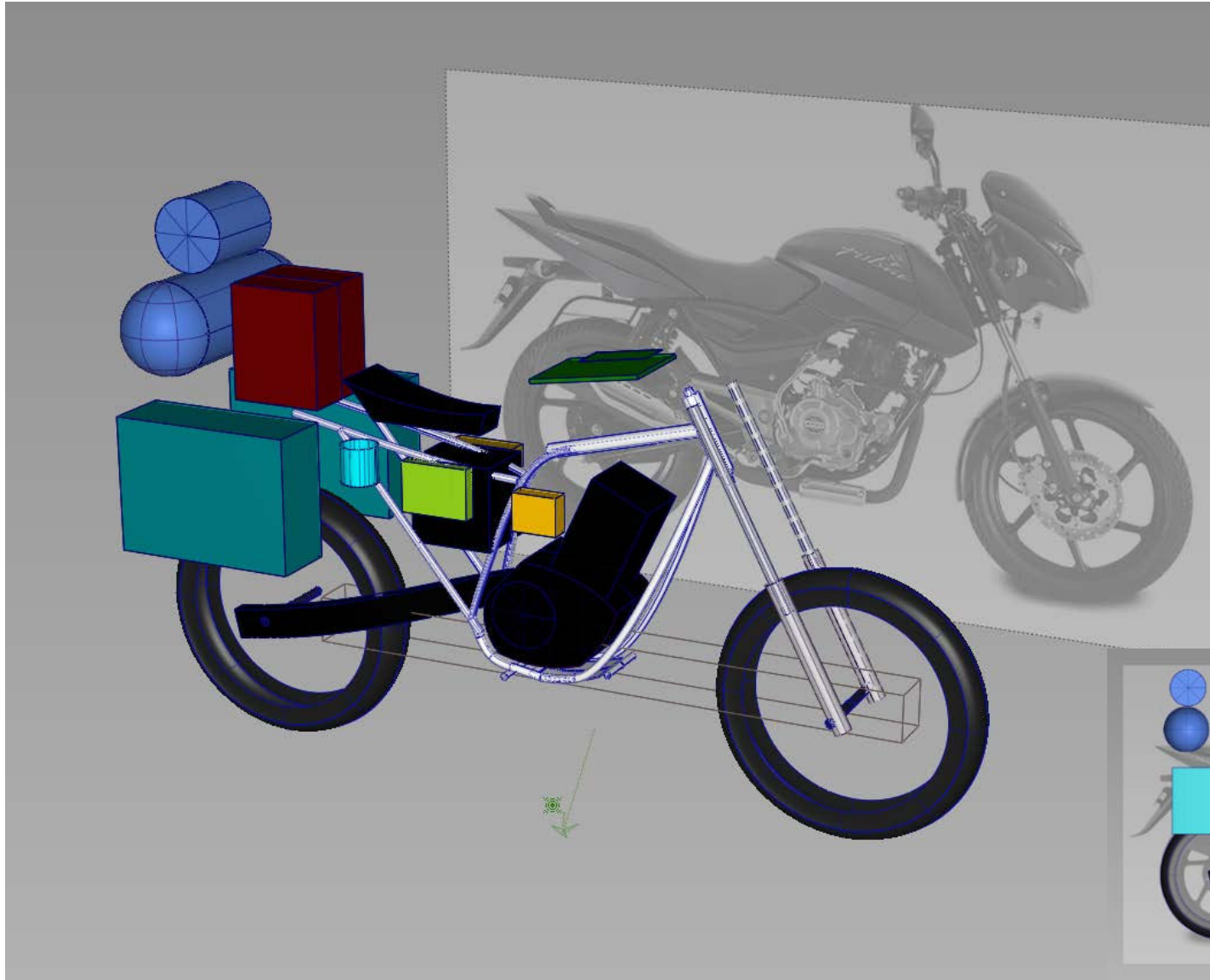
Fuel Tank

Additional Fuel tanks are important for scenarios where the petrol runs out and there is no petrol bunk nearby. The additional fuel tank comes into help during emergency and it must be refilled when necessary. It must be protected from extreme heat or high speed impact as it is inflammable.



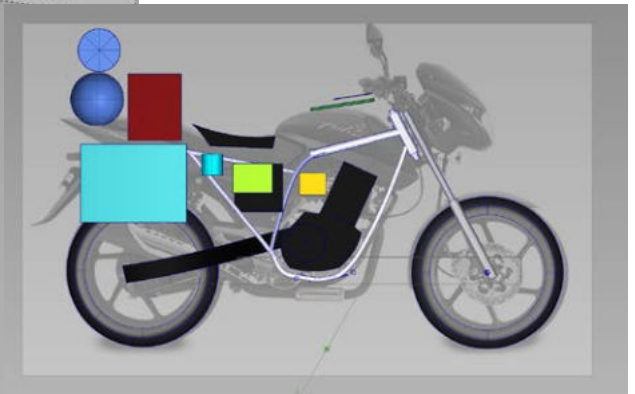
Fuel Tank

The front and the rear positions are the best for storing these additional fuel tanks. They can vary in shape, need not be cuboidal in shape all the time. They got to be raised from the ground as they might encounter with high speed stones.



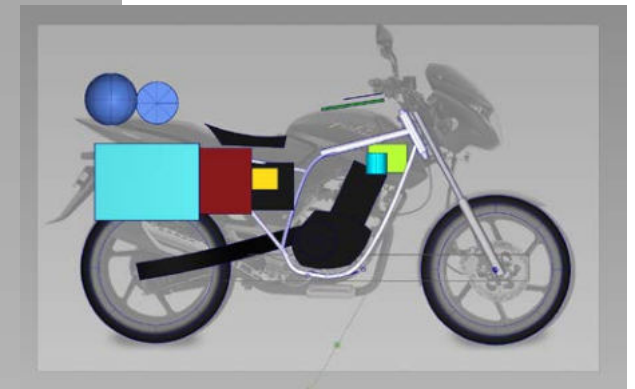
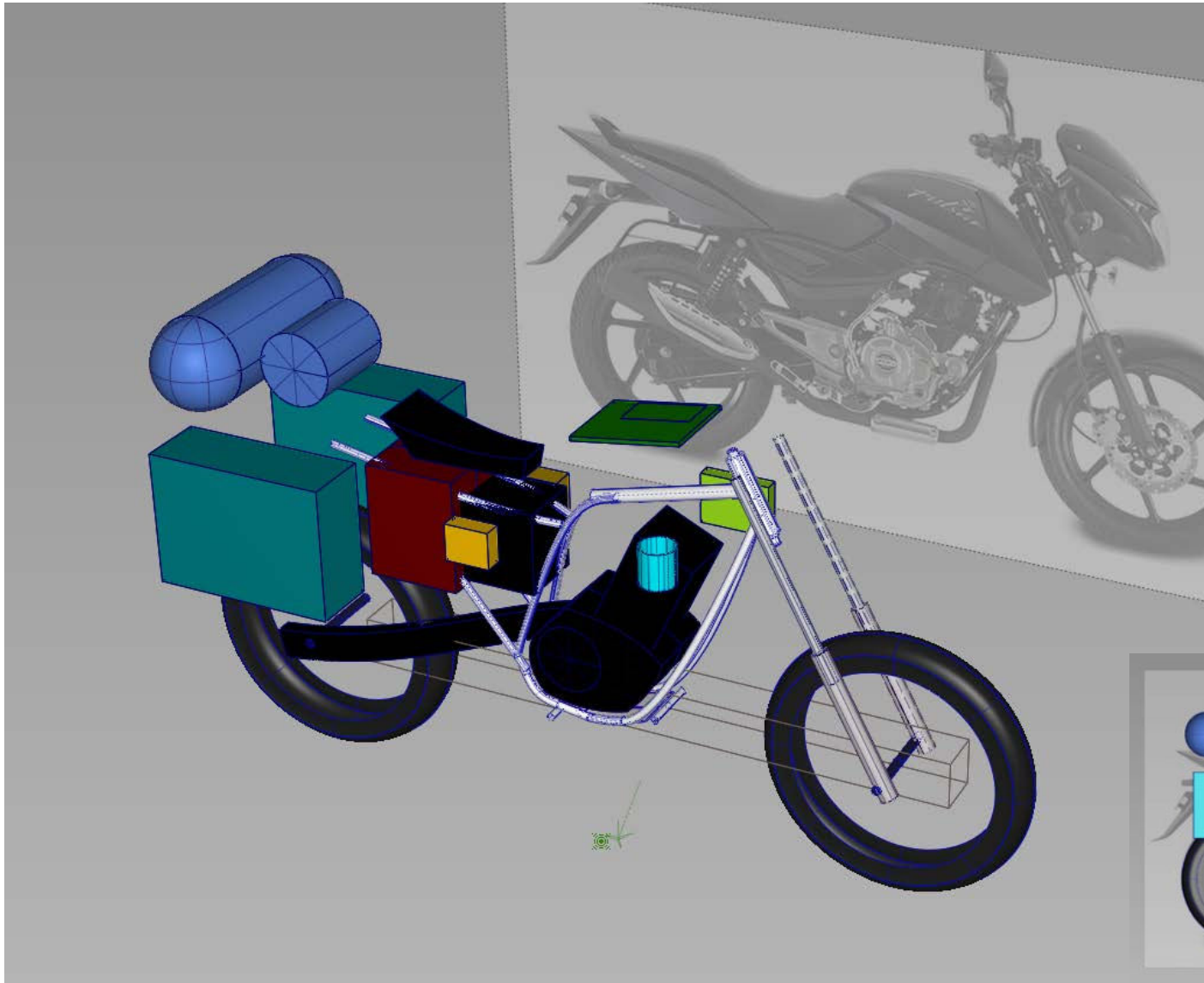
Package 3

The package 3 is made in such a way that all the luggage are moved to the rear. This is more suitable for cases which does not involve the pillion rider. This is also suitable for cases which needs less visual hindrance. And at times the wet mud will be an issue, where you don't want the front wheel to make a mess on the luggage or fuel tank. The main disadvantage of this configurations is the rear shock absorber load is increased and it will increase the swing.



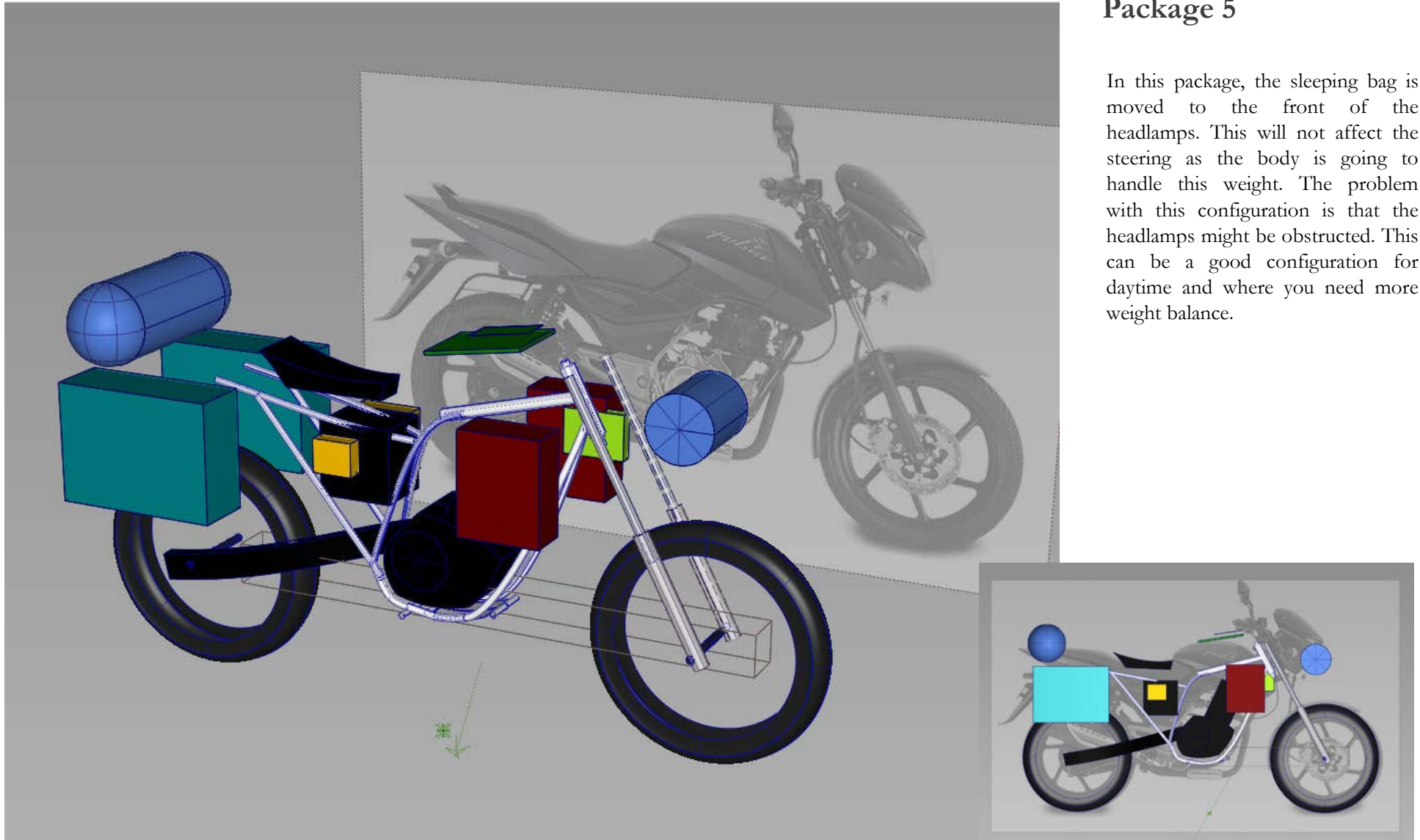
Package 4

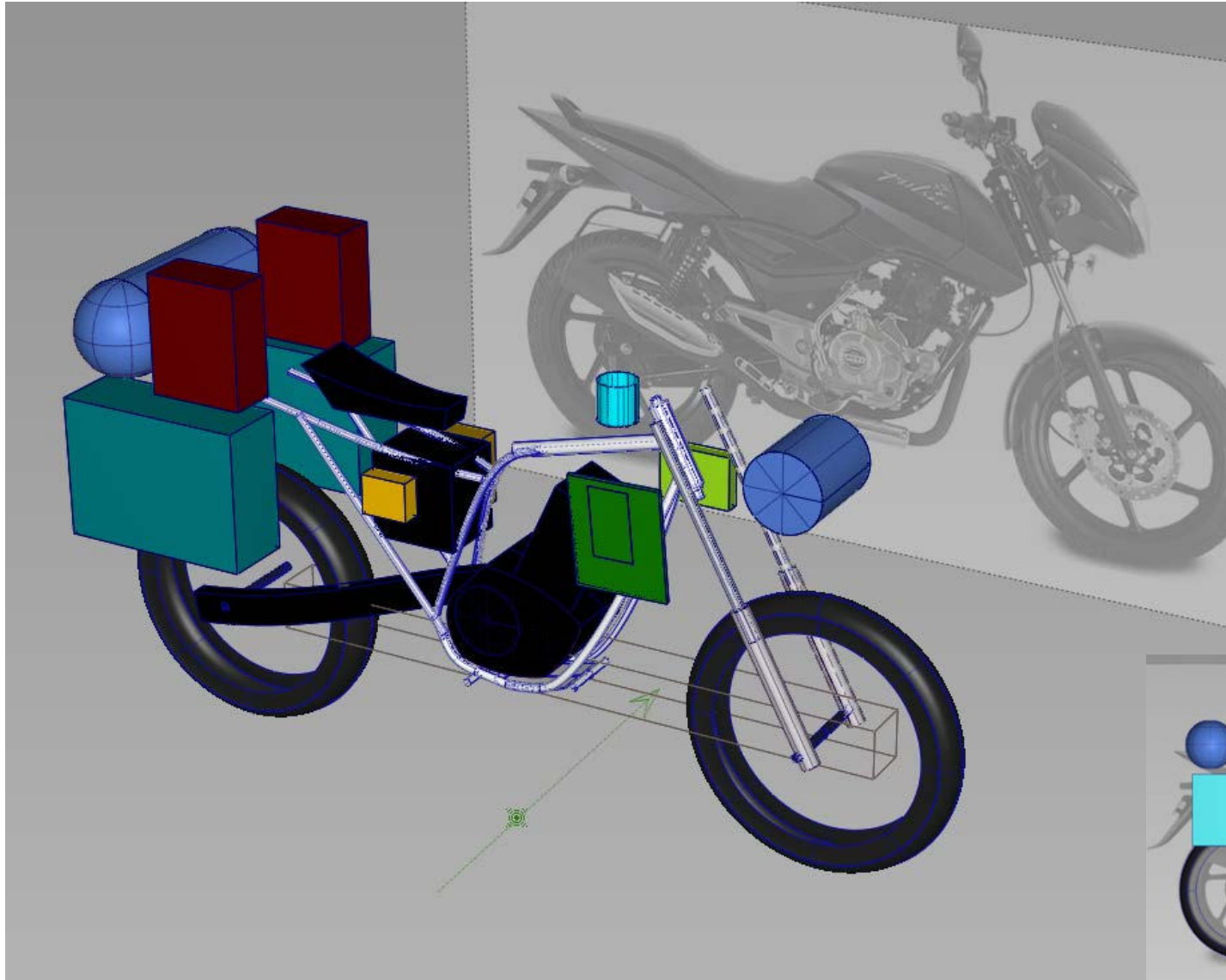
This package is similar to package 3. But the additional fuel tanks are kept under the seat just behind the battery. This will allow the rear pillion to sit comfortably and the weight is also slightly shifted towards the center. This allows more maneuverability. The papers box is moved front near the fuel tank so as to protect it from heat.



Package 5

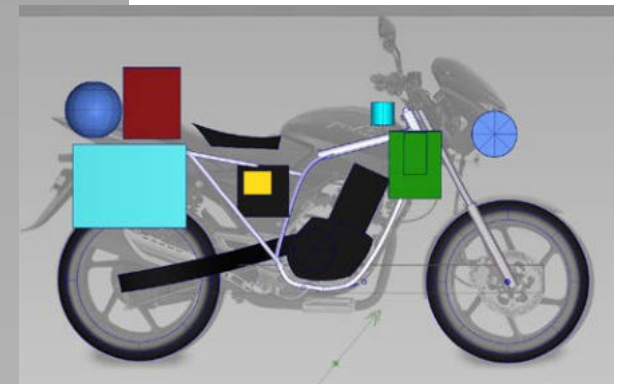
In this package, the sleeping bag is moved to the front of the headlamps. This will not affect the steering as the body is going to handle this weight. The problem with this configuration is that the headlamps might be obstructed. This can be a good configuration for daytime and where you need more weight balance.

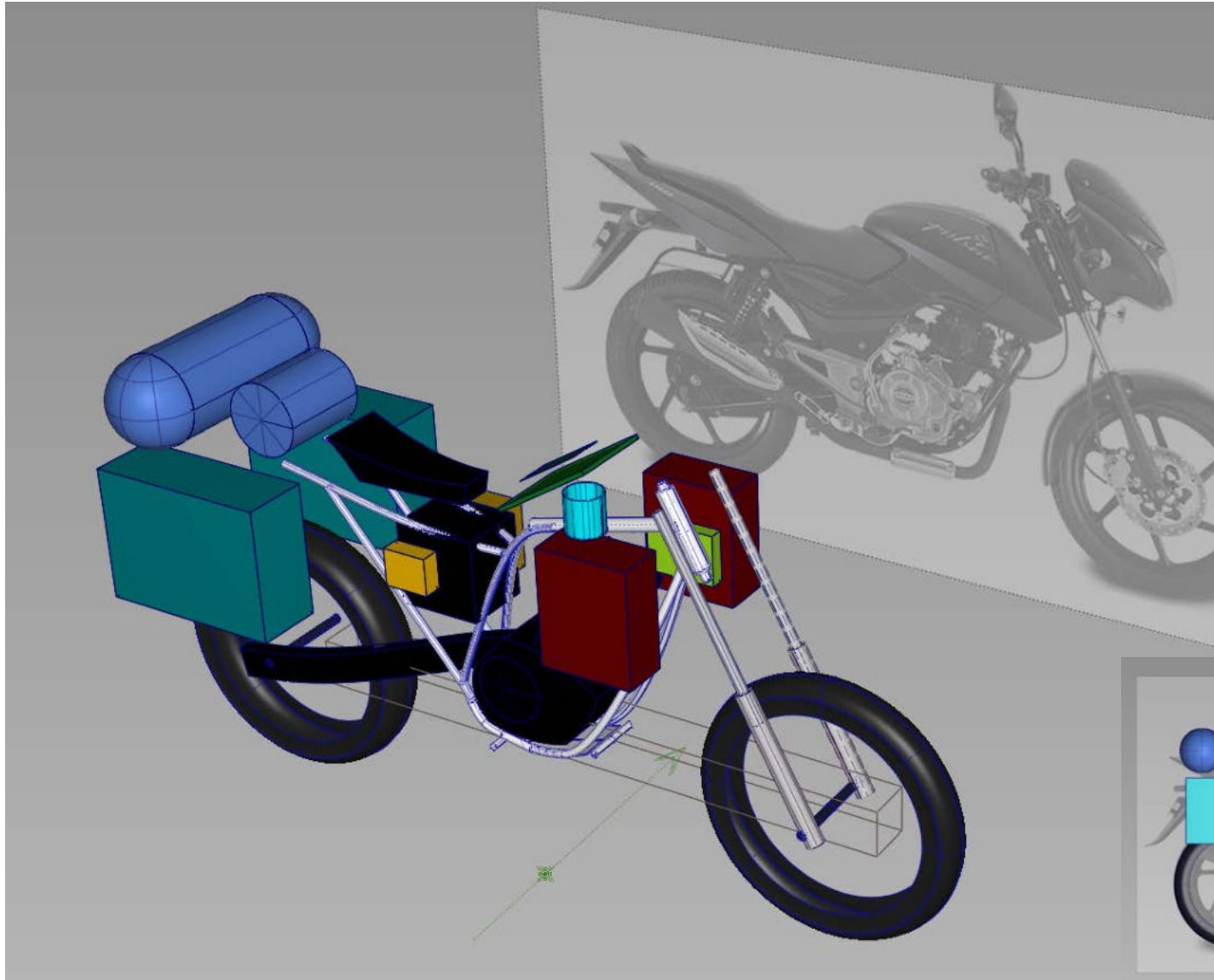




Package 6

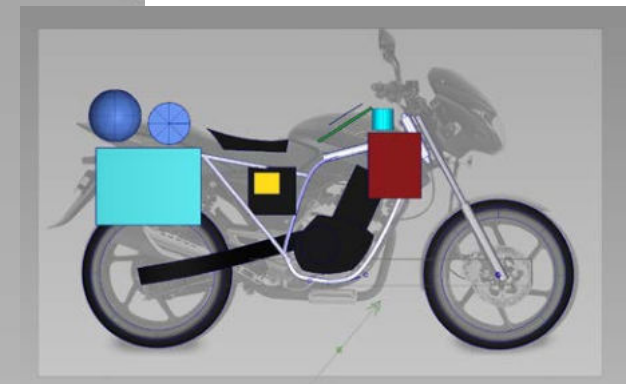
This is derived from package 5. The main focus is to reduce the weight imbalance. The additional fuel tanks are kept over the luggage box to increase road visibility. The tablet and the papers are kept beside the fuel tank to avoid hindrance of the belly while riding. This configuration will be helpful for the people who are obese and want more room for legs and upper body.





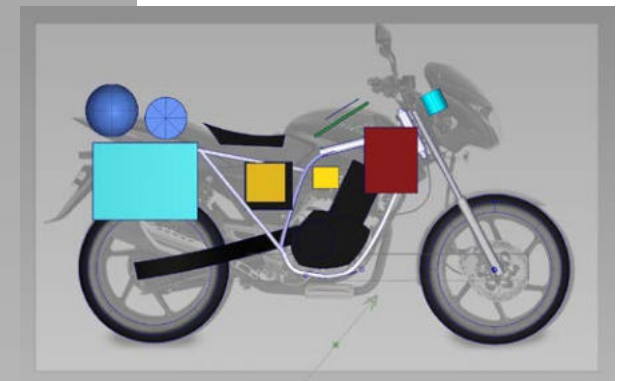
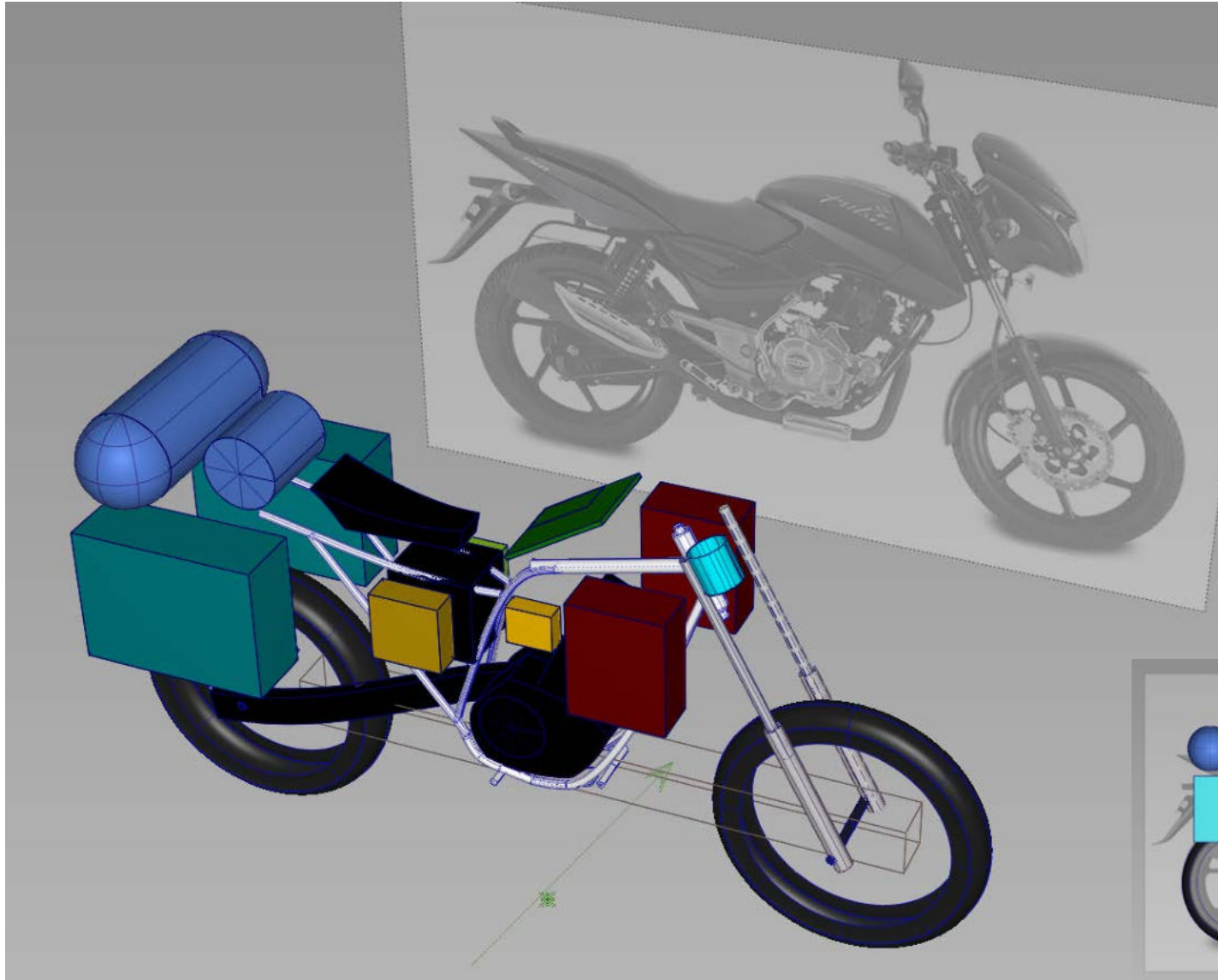
Package 7

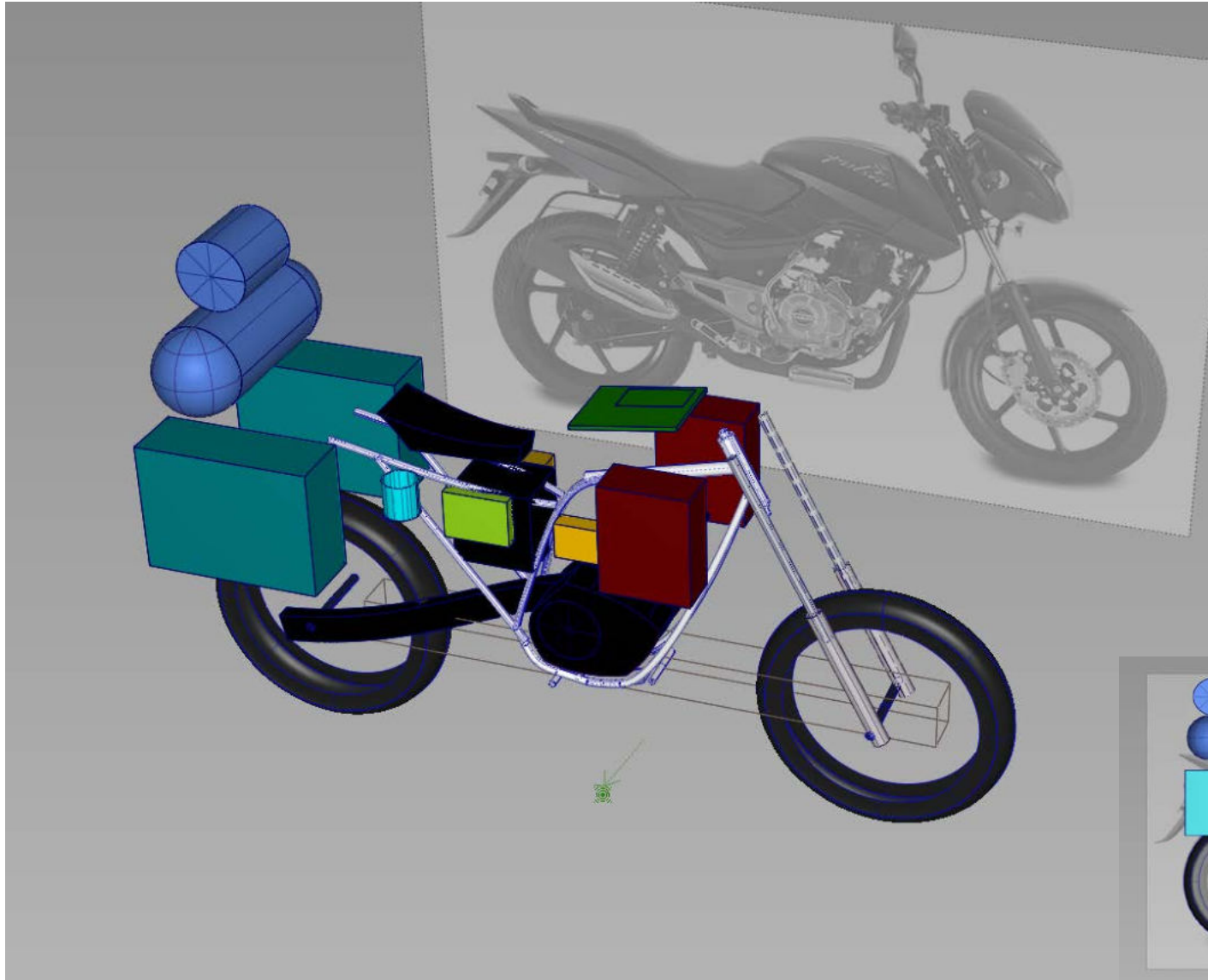
This is again similar to the first package. The height of the luggage is decreased by shifting the sleeping bag to the pillion rider seat. The papers are moved to the front between the fuel tanks to protect it from weather.



Package 8

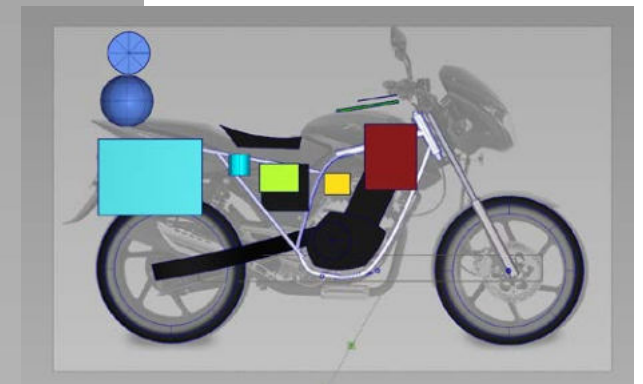
This package is derived from the previous package and elements of the first package are taken inside. The tool box is near the battery so that it will be easy for the rider to pick the tool box and repair the engine even in the dark. This reach will be better than keeping the tool box somewhere else. The first aid kit and papers are kept beside the battery so that the overall width is not more than the engine width.





FINALIZED LUGGAGE LAYOUT

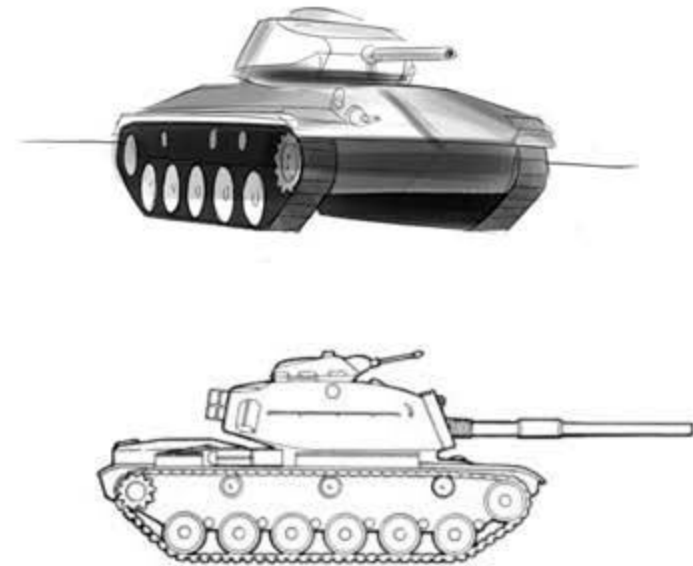
The final luggage layout is fixed. Out of all the shortlisted positions of the luggage, the optimal ones were selected. These are then considered based on the reach and the usage pattern of the rider. Package 1 is selected and will be used for concept generation.

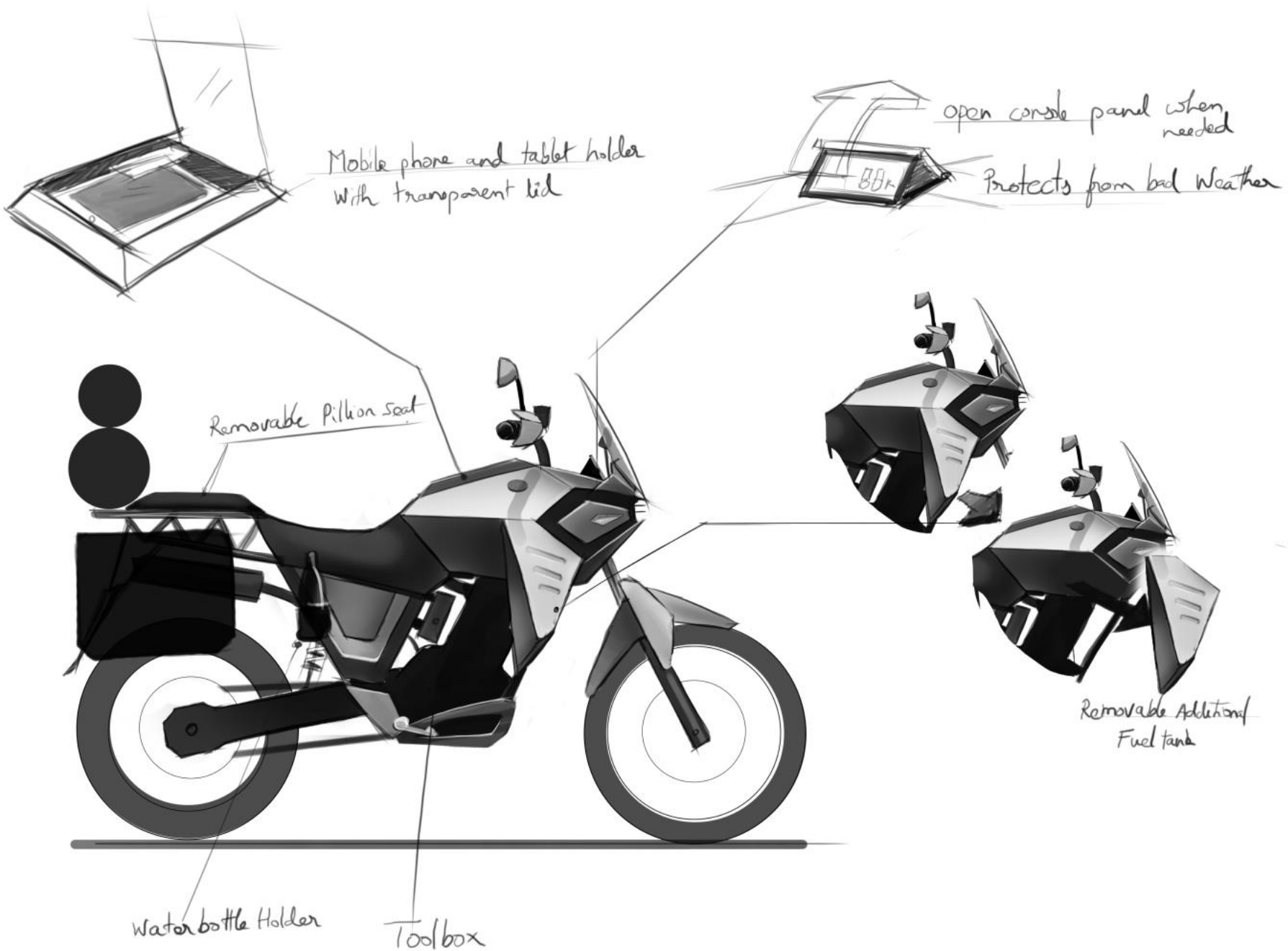


3.7 CONCEPTS

CONCEPT 1

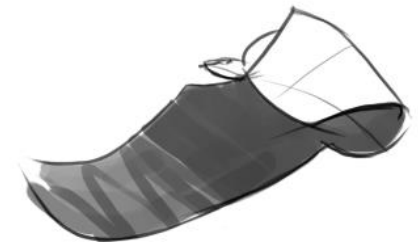
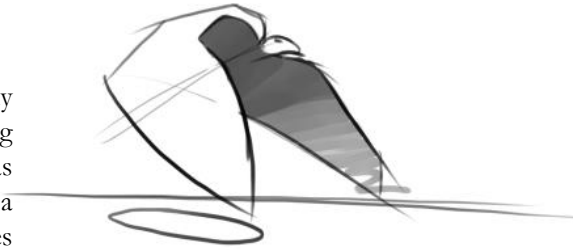
The first concept is inspired from the tanks. This is being carried from the third directional render. The Tanks can handle any kind of terrains and it is very rugged in nature. The person inside the tank feels very secured and can maneuver however he wants. The characteristic straight lines with front approach angle and departing angle of the tracks are taken as visual cues. The modularity feel of the tank also imparts a versatile character in it.

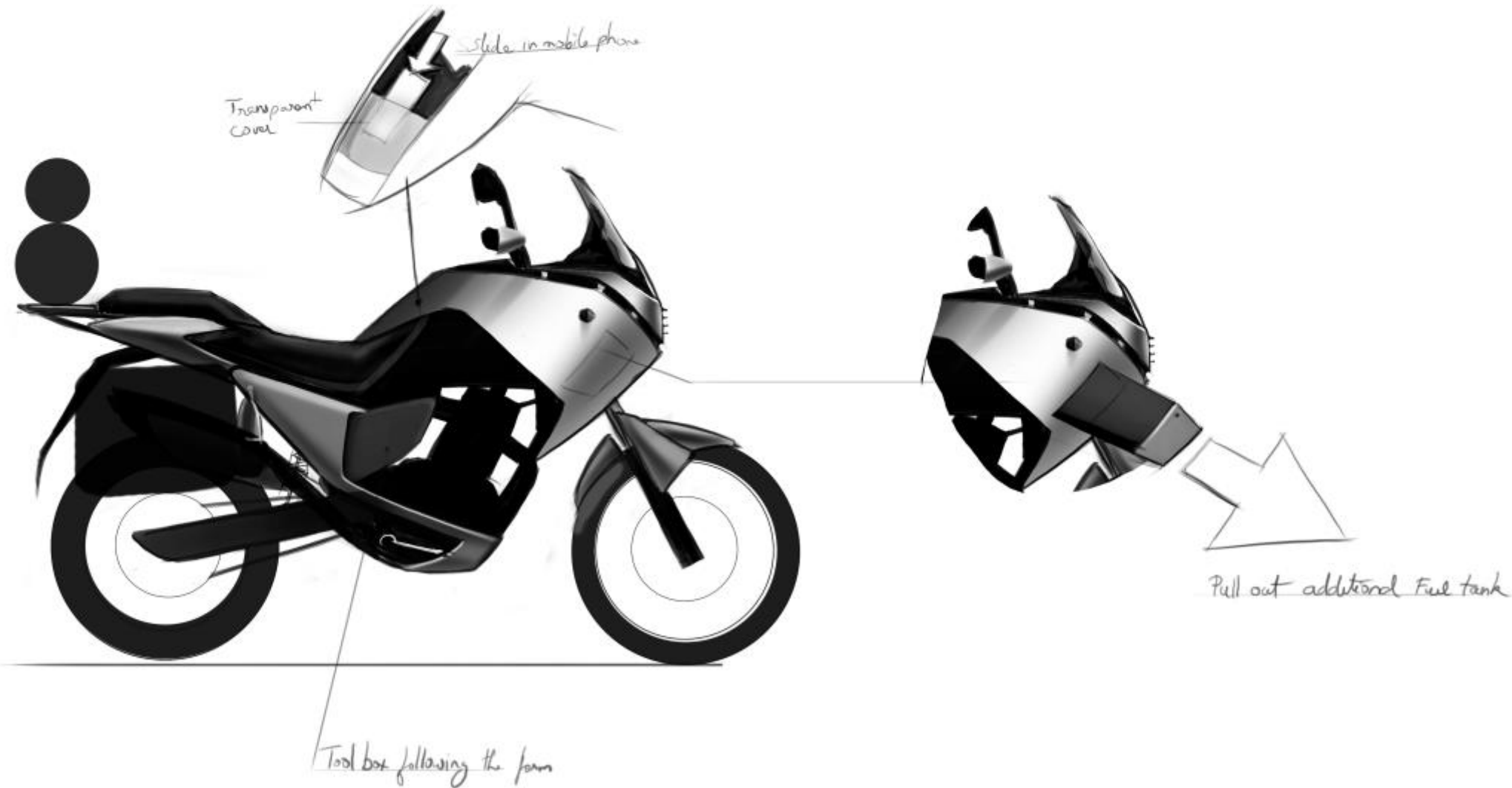




CONCEPT 2

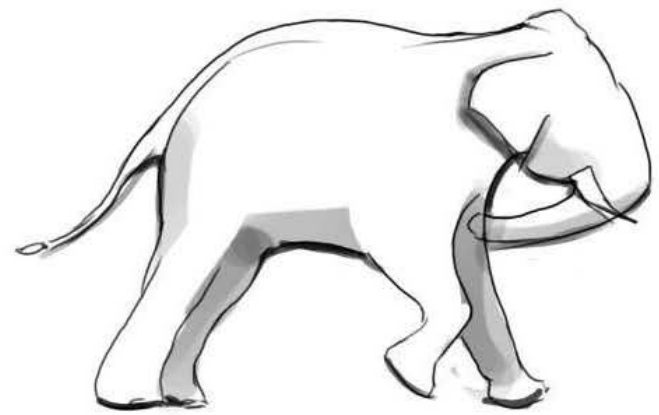
The second concept is inspired from the Vultures. Vultures are basically found in deserted areas. They are scavengers, they find their prey by flying for a long distance. The characteristic wings of the Vultures are taken as inspiration. They give a feeling of majestic-ness. The legs while catching a prey is also taken as a visual cue, as it complements the wing form and gives it a sense of dynamism.

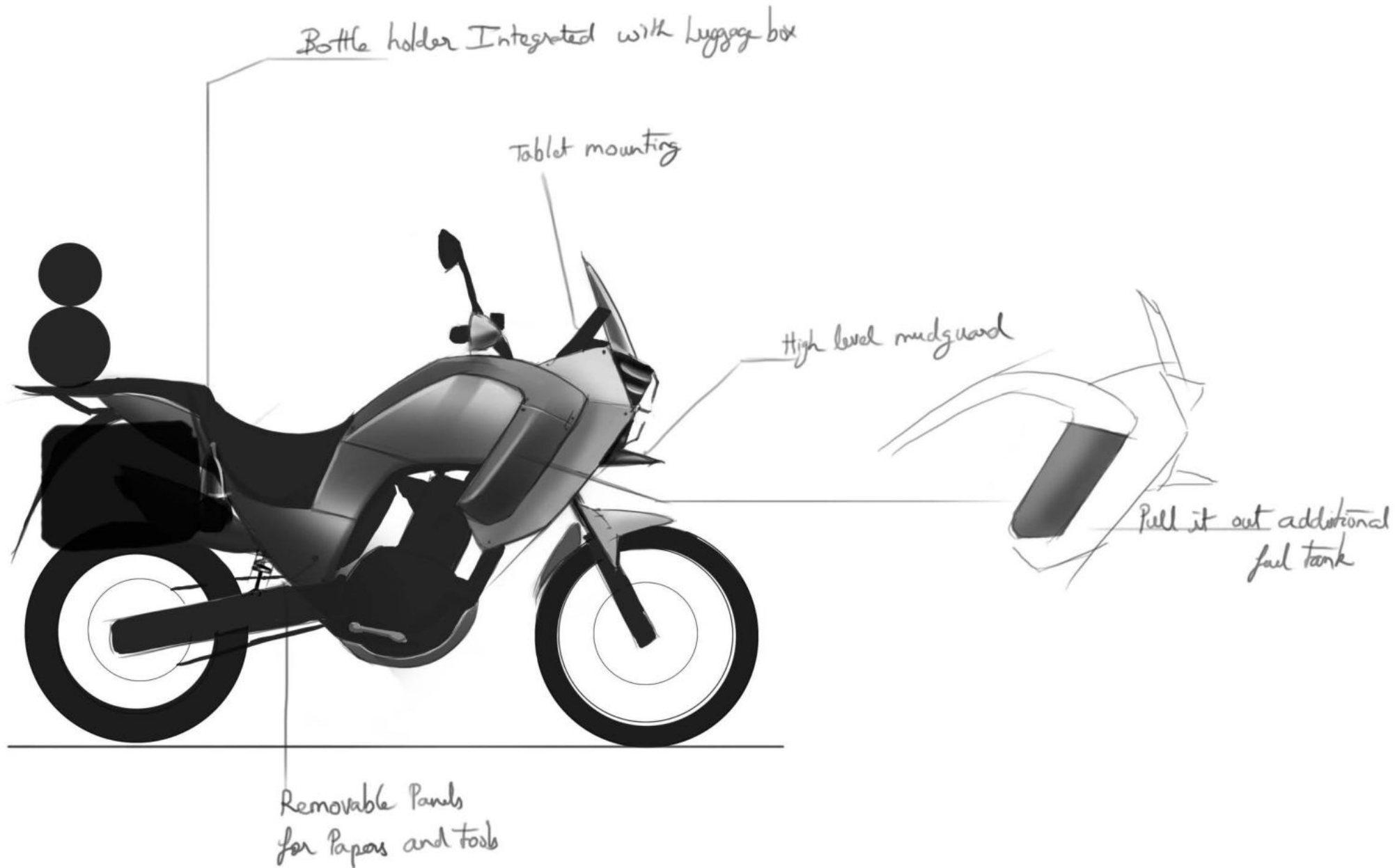




CONCEPT 3

The Third concept is inspired from safari elephants. The elephants carry people and can reach any terrain. They are visually heavy and massive in nature. The integrated form gives it a controlled dynamism feel but at the same time, the front bent head and pulled back trunk gives a dynamic feel. The cloth on the elephant and person sitting on that cloth is also taken as a visual element.





3.8 CONCEPT EVALUATION

The 3 concepts were shown to ten users and evaluated based on the following criteria. The most important ones were given more weightage of three, average ones were given a weightage of two and least important ones were given a weightage of one. They were multiplied with the actual score and the final total is obtained for every concept.



Criteria	Weightage	Concept 1	Concept 2	Concept 3
Ruggedness	3	129	90	96
Versatileness	3	114	132	84
Comfortness	3	63	123	84
Touring appeal	2	58	84	68
cruising appeal	1	18	37	34
Off roading appeal	1	42	27	33
One with nature	1	15	40	37
Total		439	533	436

Concept 2 is finalized based on the evaluation. It will be further refined and a physical model will be made.

STAGE 3

Refinement of base concept

Renderings

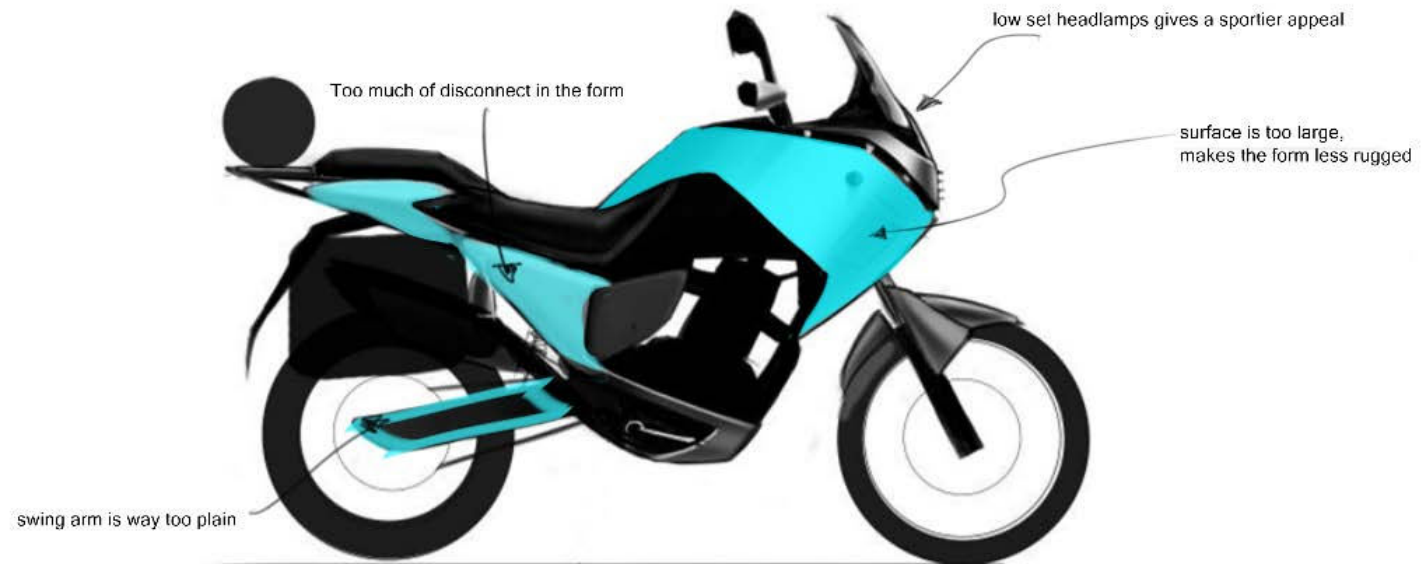
tape drawing

model making

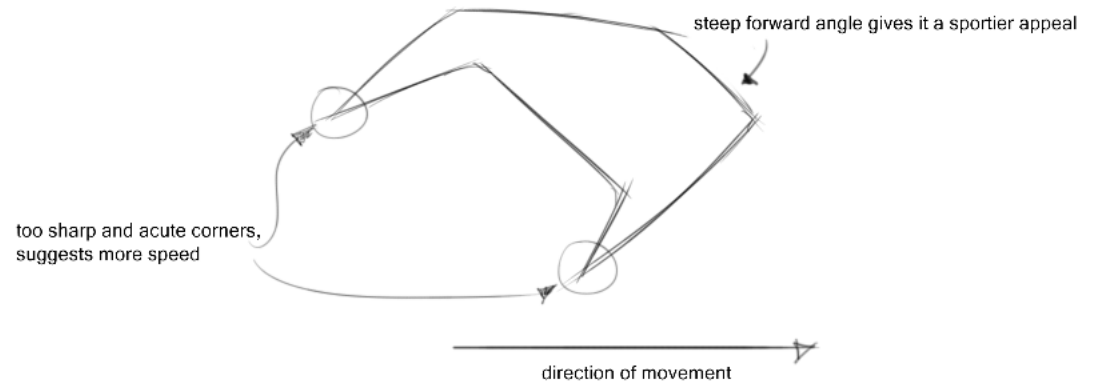
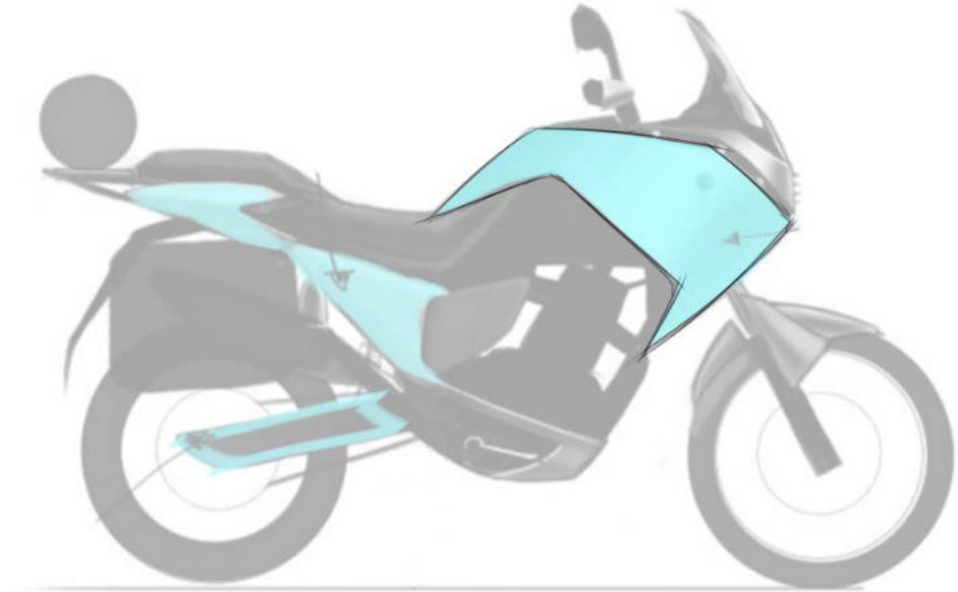
4. DETAILING & MODEL MAKING

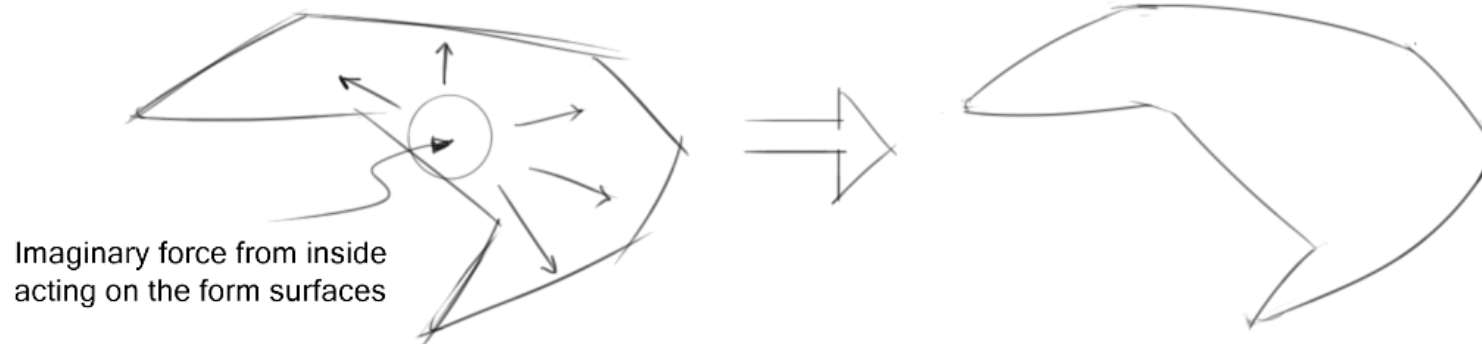
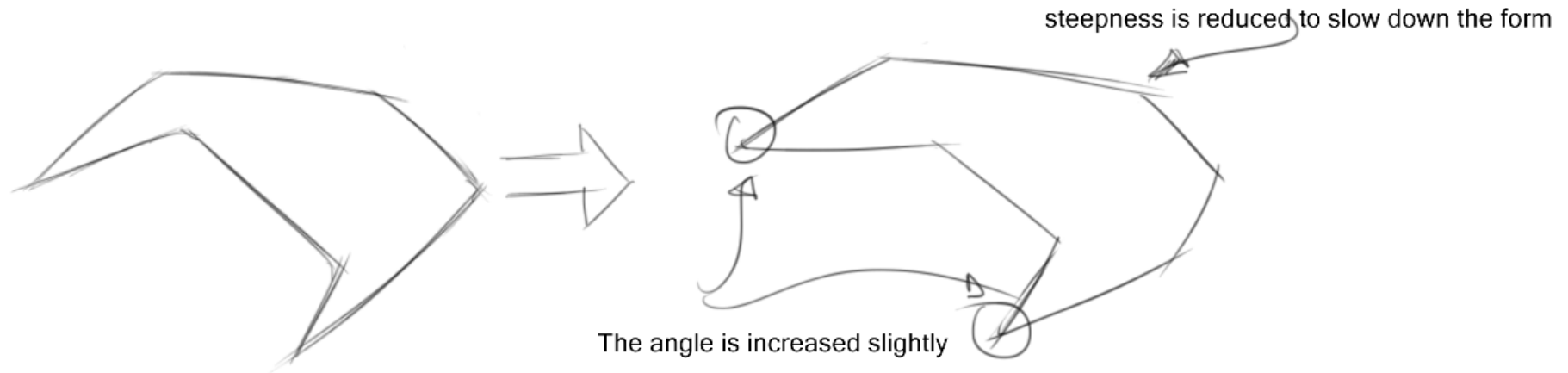
4.1 Concept refinement

The selected concept was then presented for critique. There were some points about the form itself. The main point was that the surface of the tank was too big, which made the form soft. As seen in the concept evaluation, the concept lacked some ruggedness and offroading appeal. The tank surface is one of the main factors which influence it. Other points like the other panels were feeling disconnected, swing arm does not have the character which is shown by other parts. The head lamp is also low set, which gives a fast sports bike appeal. These need to be worked upon.

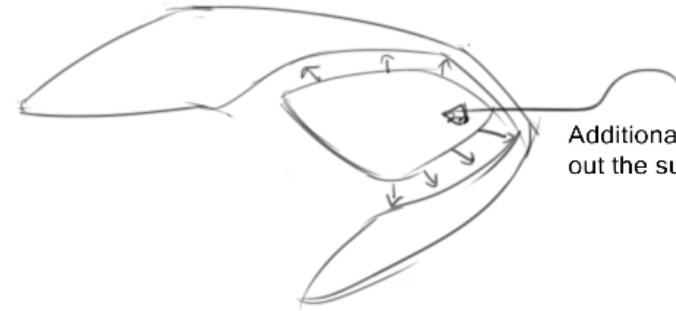
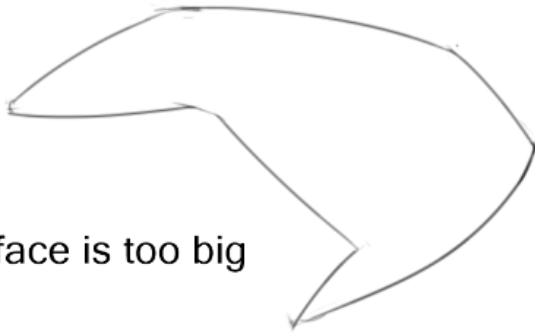


As mentioned earlier, the tank surface is too big. The form needs to be worked upon to break it down and make it more expressive. The first observation is that the tank form is more towards the sportier side. The sharp corner at the end, which has a very acute angle, gives that fast moving form appeal. The top of the form is too steep, that is front point lower than the rear point, is also enhancing the speed. As an adventure touring motorcycle, it needs to express how fast it can go. It could show that it has a lot of potential but it is always in a controlled manner. The new form is derived by these pointers observed. The angle at the rear of the form is increased slightly; the front of the form is no longer steeper but still shows a hint of speed. There is a functional component in the tank surface; there are two additional fuel tanks. Those could help breaking the large surface area. The concept of stored potential is used in making the concept more expressive. Think as if a force from inside the tank will push out the surface out. This will result in more curved lines but the corners are in place to make it feel like its controlled.





Still the surface is too big



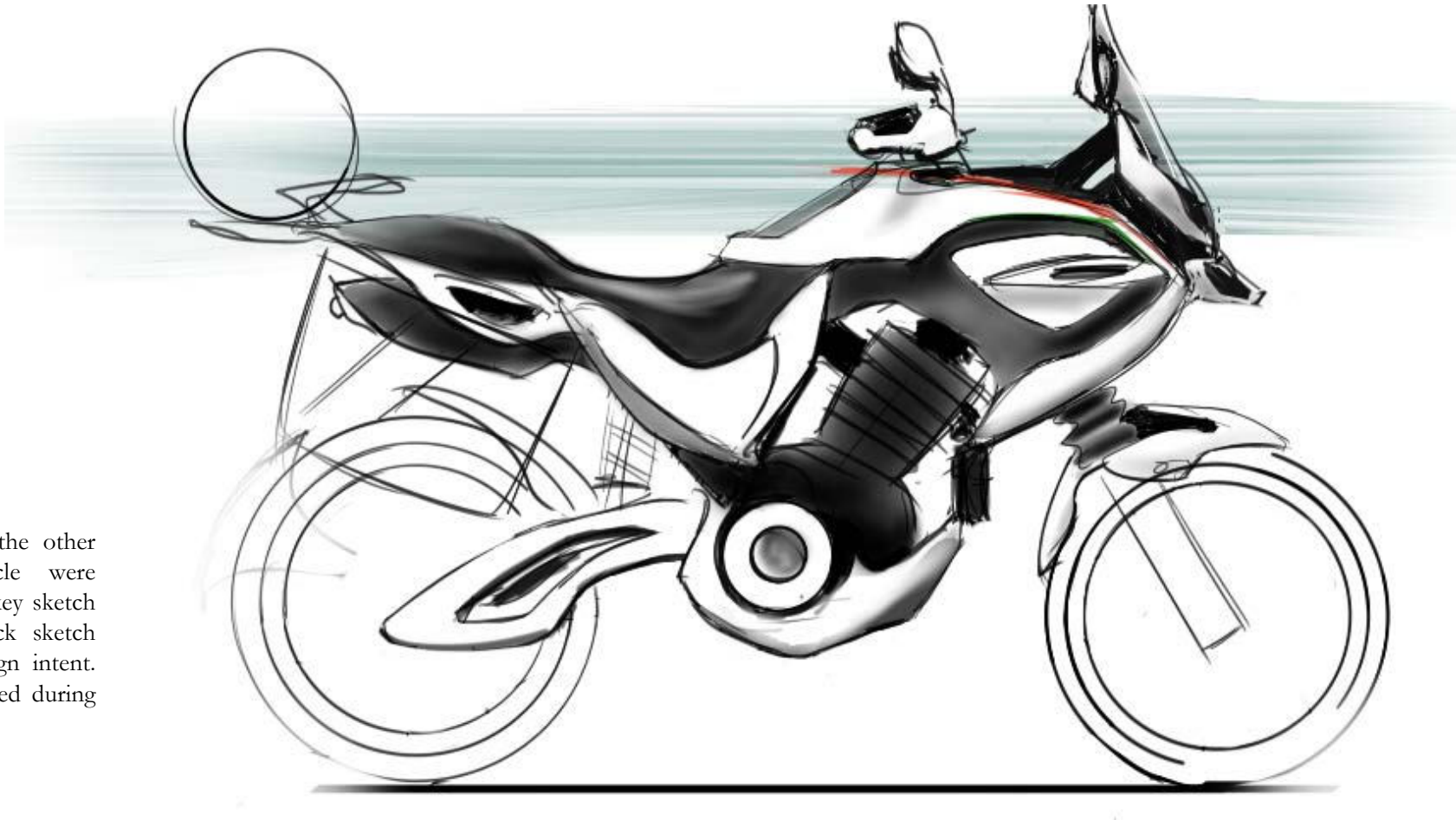
Additional fuel tank is pushing out the surface around it

Additional fuel tank is embedded on this surface.
That can be highlighted by breaking the surface

The same kind of potential is used to break down the big surface area. The additional fuel tank will be pushing the surfaces around it. Because of the force, it also creates a small lip on the edge of the cut out. Similar lip formation can be seen on the top where the transparent cover is placed. The lip formation will give an expression like the cover is trying to grow and push away the surface around it.

Key sketch

With the same idea, the other parts of the vehicle were sketched out and the key sketch is made. It is a quick sketch which shows the design intent. The lines will be refined during the tape drawing stage.

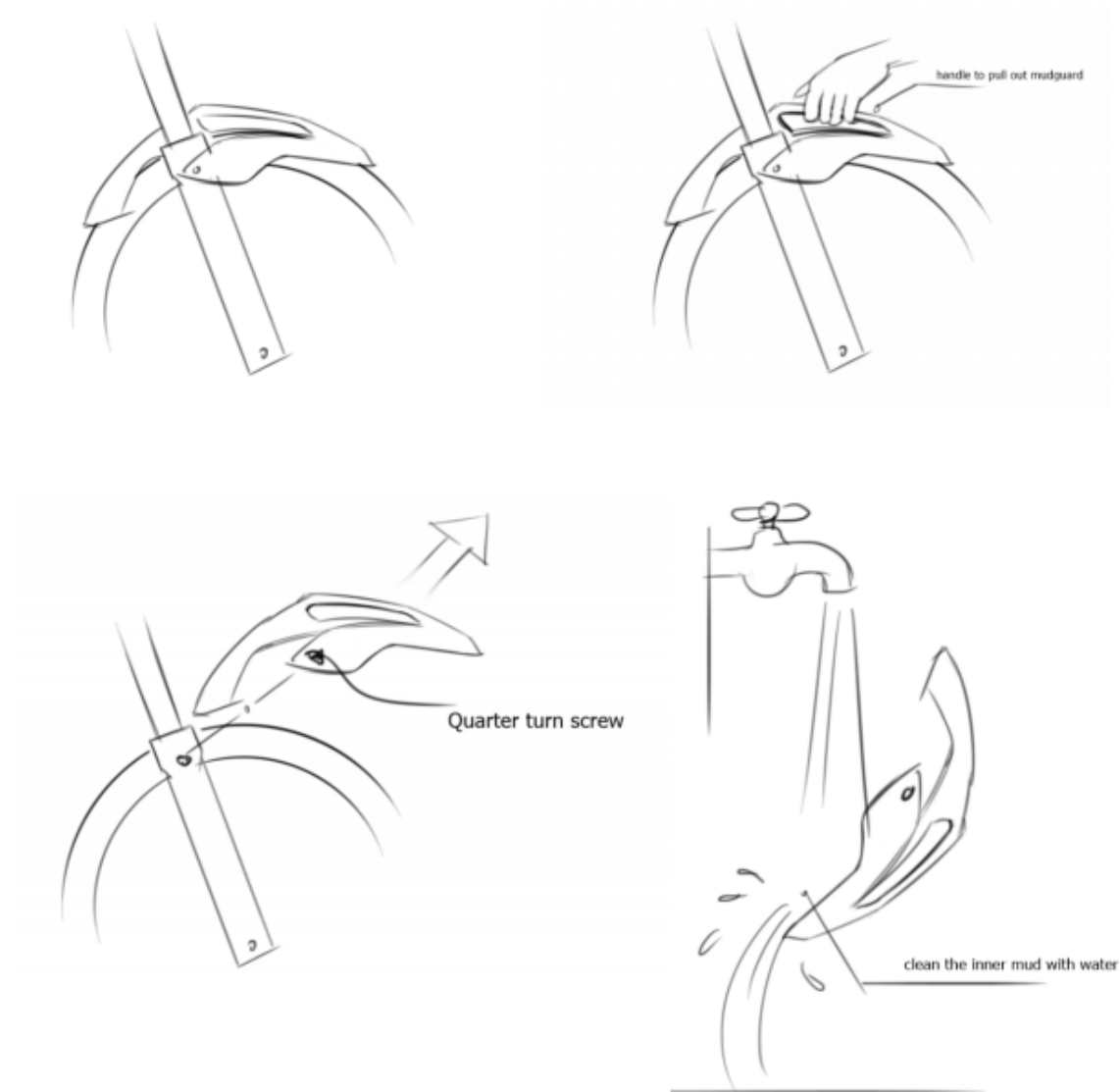


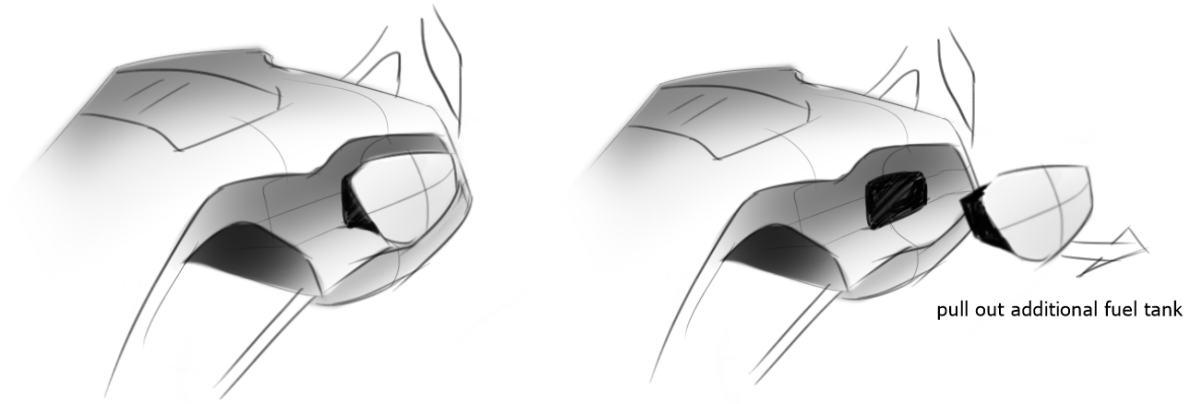
Concept renderings



Cleaning mudguard

When the user goes offroading on the tourer, there is always a lot of mud accumulation on the inner side of mudguard. Cleaning the mudguard is a tedious task. Hence to clean it effectively, it will be better to remove it. While removing, the hand cannot go on the inner side as it is dirty. A handle can be provided to remove the mudguard without getting the hands dirty. A quarter turn screw can be provided to remove the mudguard easily without any tool.

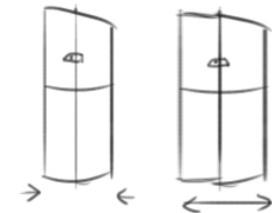
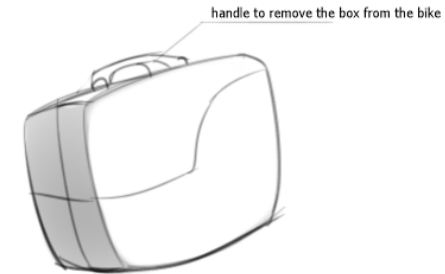




Additional fuel tank and side box

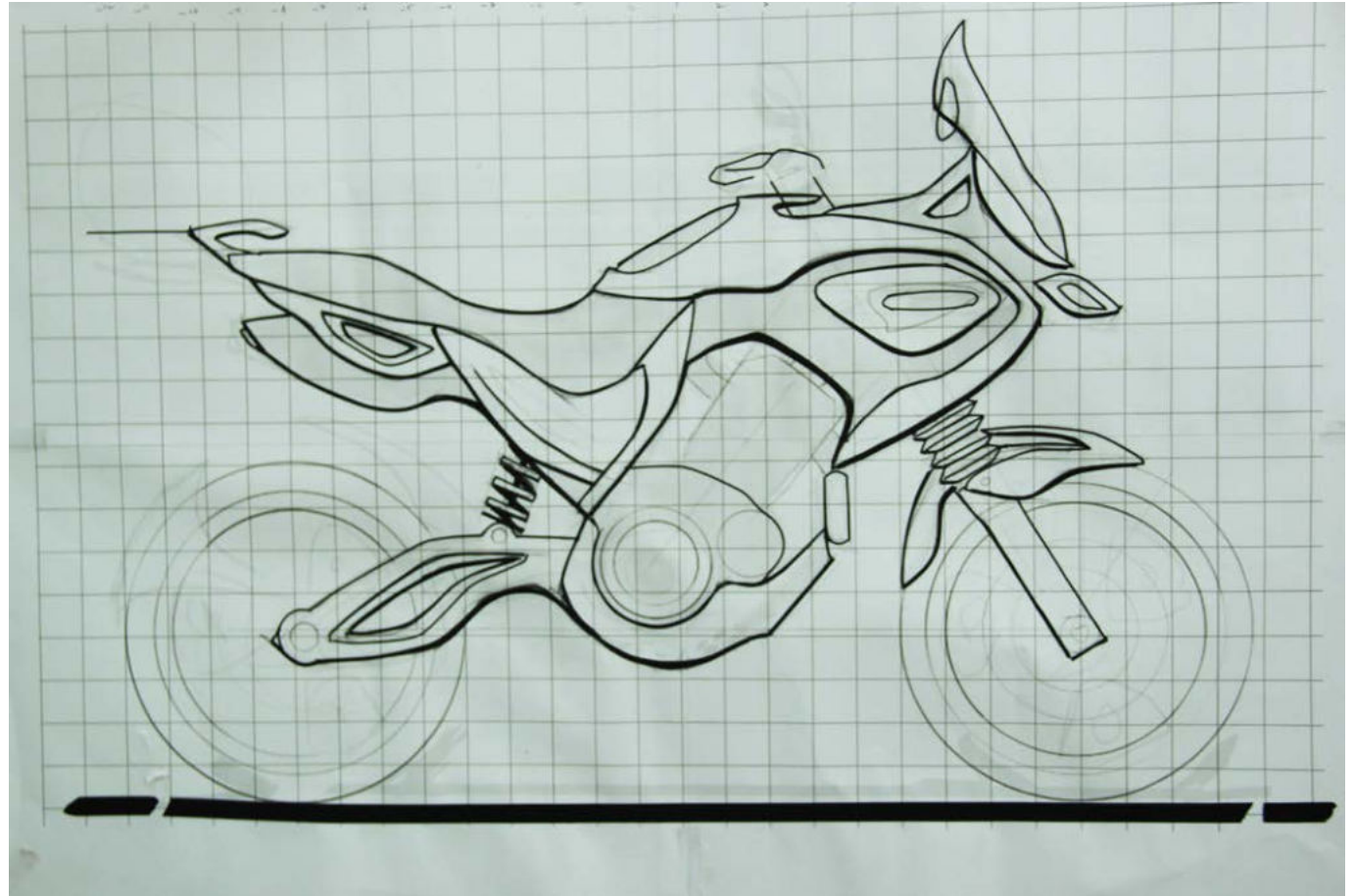
As seen in the package stage, the additional fuel tanks were placed near the actual fuel tank as that place is impact free and less heat is transmitted from engine. The additional fuel tank is also offset from the main surface as seen in the stored potential discussion. These can be removed by pulling out from both the sides. This will be locked using the key itself.

The side boxes do not have any standard size. The maximum size it can have is, it should be able to hold the full helmet. If the box has a telescopic mechanism, it can increase in volume based on the users need. The compact the box, more maneuverable the bike will be.



Tape drawing

A tape drawing is made in the scale of 1:3, since the final clay model is on the same scale. The purpose of the tape drawing is to get a clear idea about the lines, which surfaces are pushed in and pushed out. Line weight is the major element which helps in defining the surface effectively. Different line weight is given using different sized tapes. Modeling tapes do not stretch but can handle curves very well. The tape drawing is made on a 25 mm grid which could be easily translated into the clay model.

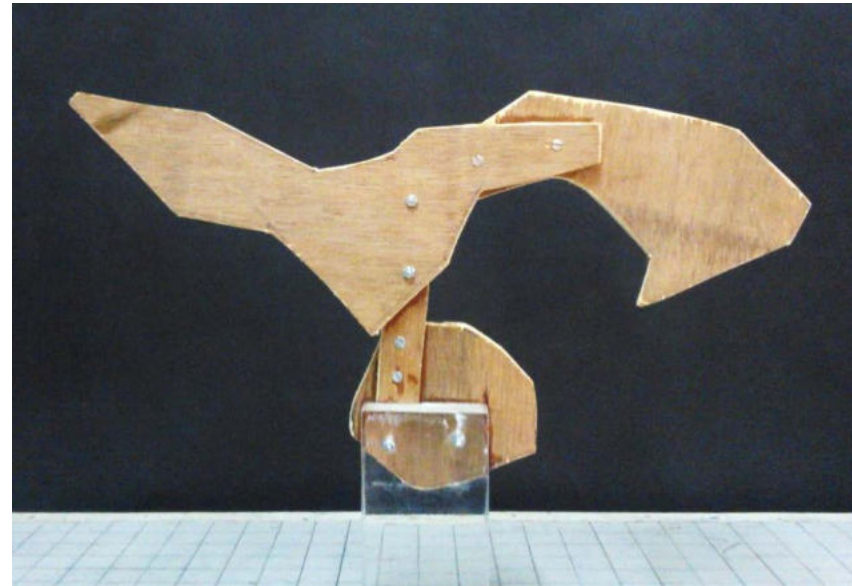


4.2 Clay modeling

Setting up the armature

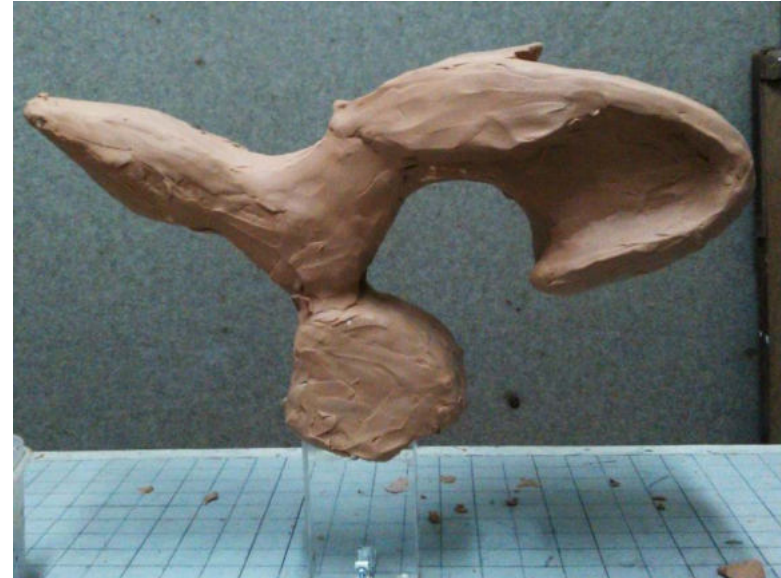
The armature is going to hold the clay in place. The armature is made by reducing approximately 10 mm from the outer boundary of the tape drawing. The inner core is made from plywood. The base part is made out of thick acrylic as it will not be visible after the completion of the model. The whole armature is fixed to a base which the same 25 mm grid that was drawn on the tape drawing. The grids are then numbered based on the center point.

Once the basic plywood armature is made, to add volume some thermocol is added on its sides. Again the thermocol is added 10 mm less than the actual boundary and an approximate shape is given to it. Once the thermocol sticks properly to the plywood, it is heated to make the surface hard. That will make the clay application easier.



Clay sculpting

Once the thermocol is hardened, clay application is started. First the clay is applied in a very thin layer so that it adheres well to the armature. Once a thin layer is formed over the core, then thicker layers of clay can be applied. But the base clay must be warm enough to make it adhere properly. A rough shape is given with hand itself while applying. Once the rough shape is done, then tools are used to give the shape. Surform tool is used to create surface definitions in a very rough way. Rakes and wires are used to impart more precise surfaces. After the surfaces are well defined, thin steels are used to refine the surface. Then fillets are given wherever it is necessary.



Final model



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IBR – Image Board Reference

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