

Design Project 3

# Design of a Transformable E-Motorcycle for 2035

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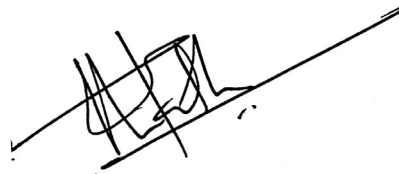
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## DECLARATION

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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.

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Mobility & Vehicle Design 2017-19



## APPROVAL SHEET

This Mobility & Vehicle Design project report entitled "Design of a Transformable E-Motorcycle for 2035", by Niketh SJ is approved in partial fulfillment of the requirement for Master of Design degree in Mobility and Vehicle Design.

Guide : Dr. Sugandh Malhotra



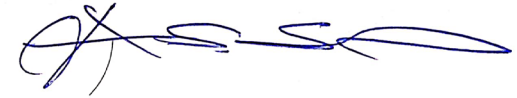
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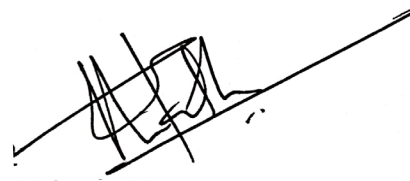
This project would not have been possible without the help from a number of people, and I would like to express my sincere gratitude to them.

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## ABSTRACT

Motorcycles have always been associated with the thrill and joy of riding. This experience varies with the type of ride, or the segment of motorcycle which is being used. Presently, users have to buy or rent out different motorcycles to have different experiences - the thrill of a high speed sports bike or the dominance and excitement of an adventure tourer. What if the bike transformed from one segment to the other on the go? What if the ride adjusted itself based on the user requirements? What if selecting different ride modes meant changing the entire geometry of a motorcycle while riding it?

This project deals with trying to find solutions for these few questions. A speculative scenario for 2035 was developed after conducting studies on the trends and development of context, technology, products, transportation systems, users & their lifestyle, etc, in the possible future. This led to the generation of a persona and a storyboard which depicts the user's lifestyle and need for the product. The transformable motorcycle was designed as a tailor-made solution for users based on his/her ergonomic needs. A motorcycle which can switch seamlessly from an urban commuter to a racer or an adventure bike with a simple voice command. A design in which the surfaces react to stimuli and vary its geometry to give the user a different feel and experience every time he rides it.

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# 01

## INTRODUCTION

# 1. INTRODUCTION

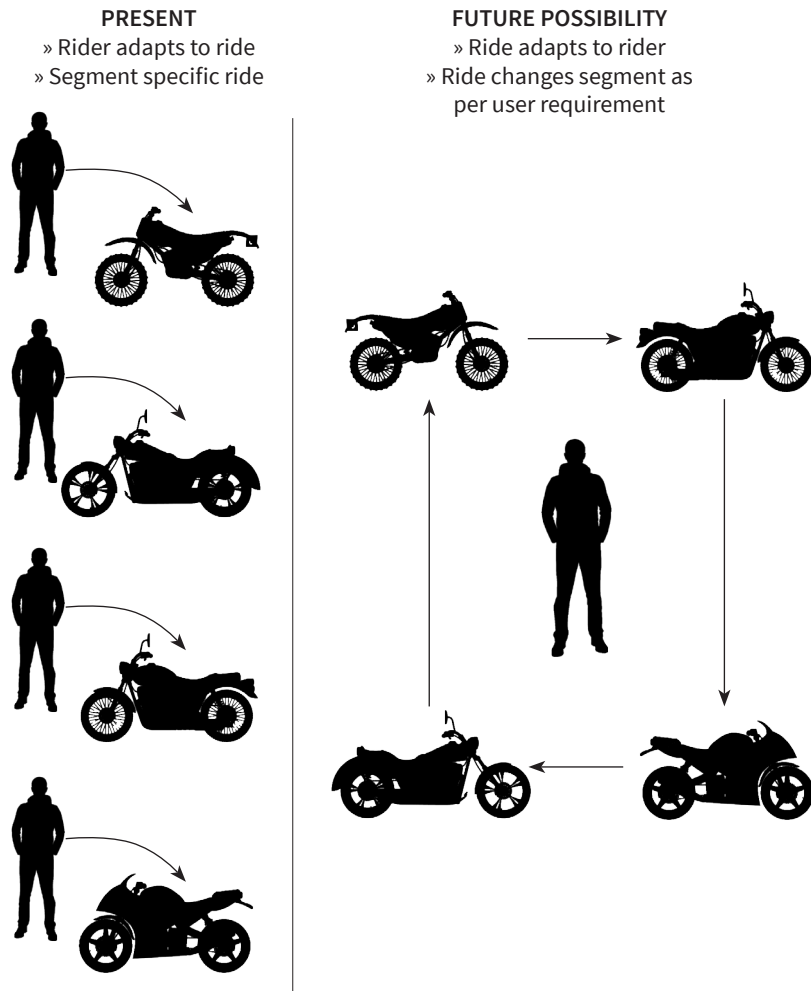


Fig 1. What if the ride adapts to the rider instead of the rider fitting into the ride? What if a single motorcycle can change from one segment to the other and serve their functions?

According to Cambridge dictionary, the word ‘**transform**’ means “*to change completely the appearance or character of something or someone*”, and ‘transformability’ is the ability to undergo said transformation. Transformability of something, or a product could be either in function or in its form and aesthetics. This makes the product more versatile and could be used for a wider range of tasks, thereby promoting multi-functionality. This flexibility is a much desired character of any product when the process of mass production and user personalization are pitted against each other. This flexibility offered can appeal to a wider range of users and offer a vast array of experiences.

While talking about motorcycles, experience has always been associated with terms like thrill, speed, enjoyment, freedom, etc. Through the years, they have developed and evolved into serving purposes such a daily commute to super-speed racing to riding rocky terrain. Based on these purposes, specific classifications or segments have evolved which specialize in serving these purposes. There are mainly six classifications of motorcycles presently - cruiser, sport, touring, standard, dual sport and dirt bike. This specialization is by means of different in riding style, ergonomics, vehicle heights, power output, etc. This being the case presently, a user can only experience a specific type of ride experience by owning a vehicle belonging to a particular segment - this offers very less versatility, and he or she has to resort to buying or renting different motorcycles to experience the other segments and ride types. Here, the rider is adapting to the ride and ride style which is highly restrictive. **What if the ride adapted to the rider? What if the ergonomics of the ride was tailor-made for each rider? What if the rider can seamlessly switch segments in a single motorcycle?**

Mass production and the manufacturing processes used in the automotive industry presently has lot of limitations and development of tailor-made solutions for users seem impractical in the current scenario. But this is going to change drastically in the near future with 3D printing, memory materials, AI systems, etc being introduced into the automotive industry. The future can pave way to a ride which not only transforms by changing the ride ergonomics, but also changes the ride visually, thereby giving the user a completely different ride experience each time. The future is also looking very bright for electric vehicles with major automotive companies moving towards that direction. The layout and requirement of electric motorcycles are different from traditional gasoline powered ones, and open up a lot of space for innovative and novel form designs. The flexibility offered by this shift is phenomenal as designs would not be centred around an engine, but rather focus more on the battery pack and motor placements (which have a different set of requirements).

This project focuses on trying to reinterpret the idea of a transforming motorcycle, where the transformation is not just an alteration in the ergonomic points (handle, seat and foot peg), but rather a complete alteration of the ride geometry - a physical interpretation of ride modes.

The research phase of this project involved understanding the history and evolution of different segments of motorcycles, how the ergonomics differ, how features differ, etc. The latest technological and design trends in motorcycles were identified and analyzed. A brief study of possible future changes in the future context, technology and lifestyle was done to develop a scenario and user profile to formulate a design brief.

# 02

## METHODOLOGY



## 2. METHODOLOGY

### Preliminary research

- History and evolution of different motorcycle segments

### Product study

- Posture and geometry - ergonomic triangle of various segments are studied and analyzed
- Understand design and technological trends in latest motorcycles and concepts

### Transformability - an exploration

- Identifying and studying techniques used in transformability in different fields like architecture, product design, etc
- Arrive at a feasible technique for transformation

### The future

- Literature study to plot the context, users, lifestyle, etc of the world in 2035

### Scenario building

- User persona generation and storyboard creation to showcase the world and activities of the user with and without the product intervention

### Design brief

### Ideation

- Volume explorations of various segments via sketches
- Exploring transformability by means of mock-ups

### Design directions

- Based on the ideation, multiple design directions are arrived at from which a direction is chosen to be furthered as the final concept

### Concept refinement

### Final design

# 03

## RESEARCH

## 3. RESEARCH

### 3.1 Preliminary research

In order to get a better understanding of transformation from one segment to the other, it is necessary to study and understand the different segments themselves. This involved looking back at the history and evolution of motorcycles, understanding the reason behind the birth of each segment, and figuring out the relevant segments which have to be considered for this project.

#### 3.1.a MOTORCYCLE & IT'S SEGMENTS

Since the advent of the Daimler Reitwagen in 1885, the idea of having powered two wheelers gained popularity. It was seen as a way to have fun with one going at high speeds - in comparison with travel speeds achieved during 1800s and 1900s, being fully exposed to nature with minimum safety and protective measures. It was seen as thrilling and exciting experience, which has seeped down through ages and exists even today. The technology, vehicle geometry, safety features, etc have all changed a lot, but the raw fun and thrill a motorcycle gives its rider is still intact. Motorcycle riding is more demanding mentally and physically, giving the user a multi-sensory experience - which driving a car can seldom provide.

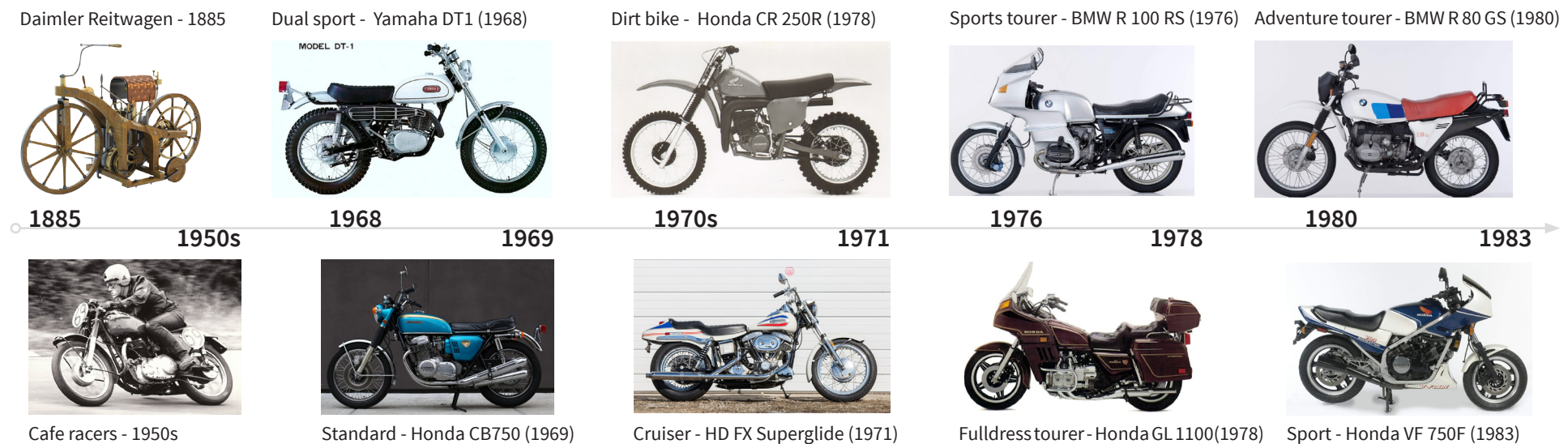


Fig 2. Segments and their beginnings

Presently there are 6 main segments: Standard, sport, touring, cruiser, dual sport & dirt, which have further specialized sub categories. Each segment serves a different function and has specific ride stances and ergonomics associated with it. Each segment and subcategory has evolved either out of the need at the time or to reignite the enthusiasm about motorcycles. For example, categories like the 'enduros' and 'cafe racers' were not introduced by manufacturers, but rather started off as custom bikes made by enthusiasts (The birth of each subcategory has been discussed in Annexure 1.1).

Motorcycles have come a long way since they were invented. The specialization and categories have grown so much in the years, that each specific purpose is being seen as catered to by a specific category of motorcycle. Although there are overlaps in segments and ride experience, the users still do not get the complete experience of each different segment by riding a single motorcycle. From the preliminary study we can conclude that the variants are mainly rooted based on 3 segments taking into consideration their evolution, the purpose they serve, the experience catered to the user, the posture, features, etc, which are -

1. Racing - Sports, sports tourer, cafe racer
2. Relaxed - Standard, cruiser, full-dress tourer
3. Off-road - Adventure tourer, enduro, motocross, scrambler, dual-sport

Of these segments, one from each classification was chosen as a stage of the transformation which the motorcycle undergoes. These are:

1. **Standard** - the relaxed stage in which the user can commute in urban areas. This will offer a relaxed riding posture for the user to traverse traffic in city areas.
2. **Cafe racer** - the racing stage, mainly chosen due to the heritage value it holds. Cafe racers were intended for rides from cafe to cafe, or in this case, city to city. It falls in between the pure sports bikes and sports tourers in posture and aggression. Although earlier cafe racers were highly demanding and taxing physically, the newer versions are far more suited and comfortable for longer rides
3. **Adventure tourer** - the off-road stage which would be suitable for trail riding and even long distance offroading. The other subsegments only are suited for short rides.

In the next stage of research, these 3 types have been further studied to get a better understanding of their ride ergonomics, features, etc.

## 3.2 Product study

A product study was conducted to analyze the trends in styling and technology and understand the ride ergonomics of the selected motorcycle segments. This would help to draft a direction in which the motorcycle design industry is heading towards in the future.

For analyzing the styling and technological trends, the most influential motorcycles and concepts from the past decade were studied. These included concepts and production models which had unconventional and novel designs. The selected motorcycles needed to have a futuristic feel to them both from technological and styling aspects

### 3.2.a STYLING TRENDS

The models chosen are date from 2010 onwards and consist mainly of electric powered motorcycles. A few gasoline powered concepts with unconventional forms have also been studied.



Fig 3. Renald Grand tourer (2010) - Retro-futuristic styling, carved mono-volume body, slender carbon fibre forks, floating seat



Fig 4. ZecOO (2012) - Anime inspired styling, hub steering, bold geometrical volume used



Fig 5. Yamaha PES1 (2013) - Conventional volume altered by giving more negative spaces, strong solid central volume



Fig 6. Lotus C01 (2014) - Retro-styled mono-volume, carbon fibre, pinstripes



Fig 7. Johammer J1 (2014) - Unconventional volume, hub steering



Fig 8. Honda NM4 Vultus (2014) - Tourer with edgy volumes, high back rest



Fig 9. Harley Davidson Livewire (2014) - Bulky volume with retro-futuristic style



Fig 10. Confederate P51 (2015) - Raw, exposed mechanism, celebrates the engineering which is used





Fig 11. BMW Motorrad Vision Next 100 (2016) - Novel styling, essence of classic motorcycles retained, reactive surfaces, unconventional volumes, self balancing



Fig 12. APWorks Light Rider (2016) - Generative design, 3D printed, extremely lightweight



Fig 13. Honda Self-balancing motorcycle (2017)- Self balancing, self driving, AI assisted, conventional styling



Fig 14. Yamaha Motoroid (2017) - Unconventional volumes and styling, AI assist, self balancing, self driving



Fig 15. Arc Vector (2018) - Bold central volume, hub center steering, floating seat



Fig 16. Husqvarna Vitpilen 701 (2018) - Novel styling, strong lines to demarcate volumes, product design feel

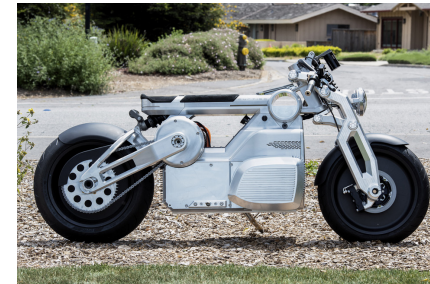


Fig 17. Curtiss Zeus (2018) - Raw styling, basic geometric volumes celebrated boldly, unique silhouette



Fig 18. Honda CB125M (2018) - Sharper volumes, unique headlamp design



Fig 19. BMW Motorrad 9cento (2018) - Unique volumes and silhouette for a touring motorcycle, integrated pannier box which can be detached



Fig 20. Husqvarna Vitpilen 701 Aero (2018) - Novel styling, strong lines to demarcate volumes, product design feel, new take on cafe racer styling



Fig 21. SIV Katana (2018) - Samurai sword inspired, simple yet bold volume, adjustable footpeg

Based on the analysis, it is evident that the brand factor and heritage of the company influences the styling a lot. Many of the futuristic models are reinterpretations or tributes to previous classic models. With the arrival of electric powered systems, the volume and surface of the main body has increased in majority of the brands. Modern surface treatments and use of new materials have breathed new life into many of the designs. Majority of the models follow the trend of having a strong, bold central volume which gives an uninterrupted surface to play around with. Although this maybe the case, models like the Vision Next 100 and Motoroid point more towards the direction in which the future might be heading to.

In short, the major take aways from this study are:

1. Unconventional surface treatments
2. Experimenting with new materials
3. Strong, bold central volume
4. More aggressive and sharp lines becoming common
5. Styling influenced by technology

### **3.2.b TECHNOLOGICAL TRENDS**

Technological advancements have not only had an influence on the features of motorcycles, but on how it looks also. New manufacturing methods, and new materials have removed a lot of limitations in coming up with new forms and surfaces. The major trends are as follows:

1. Implementation and spread of self balancing technology
2. AI riding assist and autonomy
3. Increased comfort features - handle grip and seat heater
4. Advanced safety features - ABS, rider air bag, launch control, quick/auto gear shift, traction control, LIDAR and other sensors, advanced brakes, puncture proof tyres, DRL and automatic lights, tilt control while cornering, etc
5. Introduction of ride mode selection
6. Ride by wire tech
7. Integrated GPS and tracking system
8. Inter-vehicle communication via AI systems

Both the styling and technological trends point towards a very sophisticated and technology driven future for motorcycle industry. Autonomous/semi autonomous systems will seep into motorcycles once they have become popular in other vehicle segments. These changes will drastically change the experience of motorcycle riding in the future



### 3.3.e ERGONOMIC STUDY

For the ergonomic study, motorcycles from multiple brands belonging to 3 segments - urban commuter, cafe racer and adventure tourer were studied. Brands were selected based on their global presence and popularity. This would give us an understanding of the posture and ergonomics which the riders are experiencing presently.

Urban rider

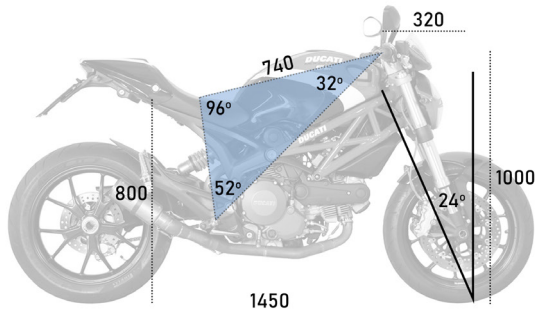


Fig 22. Ducati Monster 796

Cafe racer

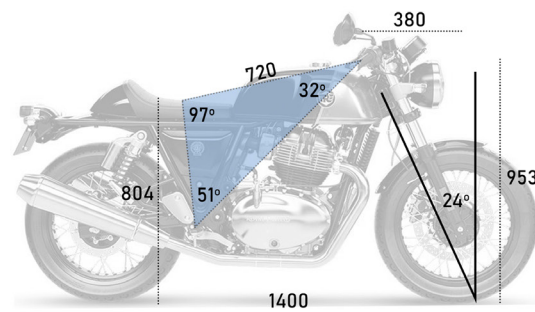


Fig 24. RE Continental GT 650

Adventure tourer

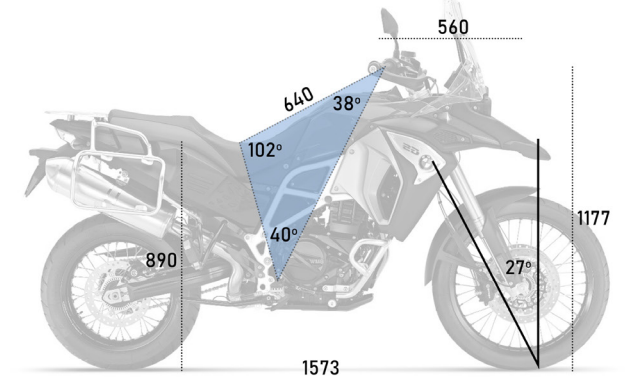


Fig 26. BMW F 750GS

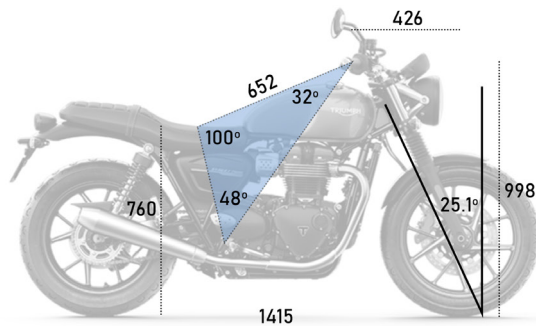


Fig 23. Triumph Street Twin

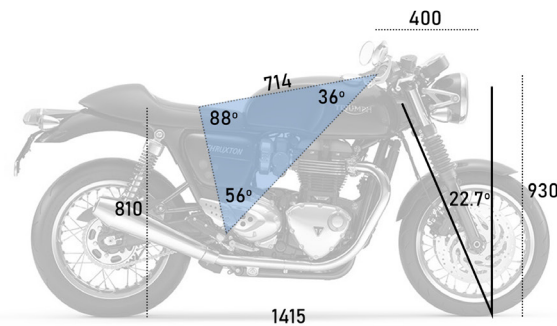


Fig 25. Triumph Thruxton

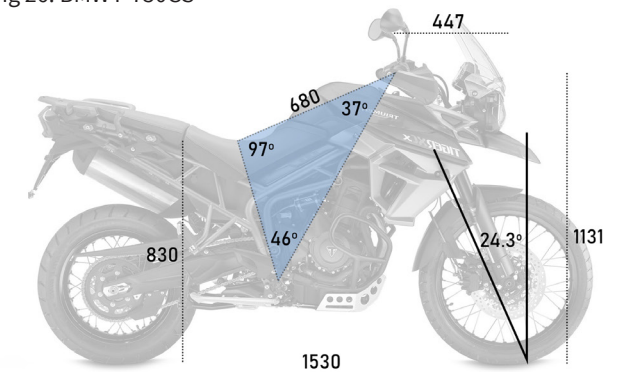


Fig 27. Triumph Tiger 800XCX

The ergonomic study gives a clearer understanding of the various factors involved in deciding the comfort factor of the ride - H point, handle position and footrest. These points vary based on the segments and can be joined to give an ergonomic triangle which defines the relationship between these 3 points. The rake angle is also analyzed, as this is a defining factor for the handling and response of the motorcycle. The rake angle stays between 22 and 25 degrees at an average, with



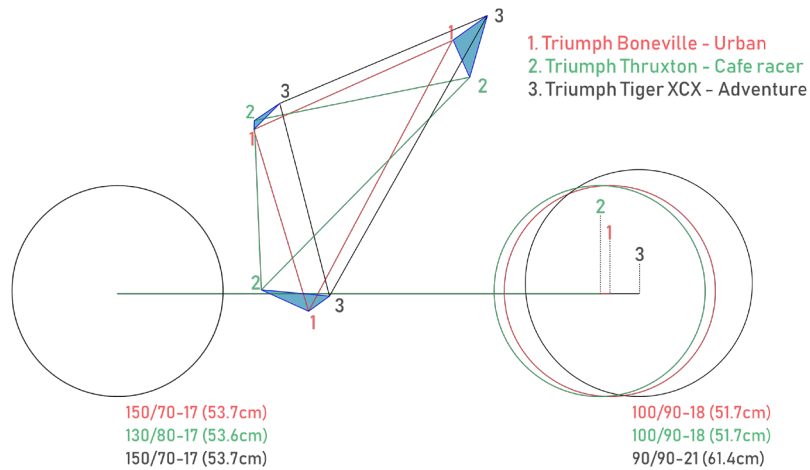


Fig 28. Ergonomic triangle comparison of Triumph line-up

very few exceptions like the BMW 750GS (27 degrees). Rake and trail determines the handling and stability of the bike on road. Larger rake angles can stabilize the bikes on road, but make it difficult to maneuver. Lower rake angles make the bikes more 'flickable', but have reduced stability in braking. Also, it is observed there is not only a stance variation, but the volume distribution is also very different between these segments.

Among these, the Triumph line-up was selected as the benchmark due to presence of a model in each segment and the brand's global presence.

The ergonomic triangles of motorcycles from each segment is superimposed to generate areas in which the each of the factors can be played around with all the while retaining ride comfort. This layout gives a basic blueprint on which the ideation can be done.

### 3.4 Transformability - an exploration

This portion of the study deals with exploring different transformable concepts in furniture, products, and architecture.

#### 3.4.a Furniture



Fig 29. Clei Doc sofa-bunk bed



Fig 30. Buolon blanc table



Fig 31. Wave cabinet by Sebastian Errazuriz

In **furniture**, components shift around to alter function and aesthetics of the product. Existing components undergo change in orientation to alter function of the product. In furniture, there are specific hinge points around which components swivel to enable the transformation.

### 3.4.b Products



Fig 32. Limbo smartphone



Fig 33. Nokia 888 concept



Fig 34. D'Light Kinetic Lighting

**In consumer products**, there is a variety of method by which products transform. In many cases, the surface of the product is capable of bending and folding to give the product a completely different function and form. In other cases, the surface maybe made up of interwoven elements which can be moved around in different orientations thereby changing the form of the product.



### 3.4.c Architecture

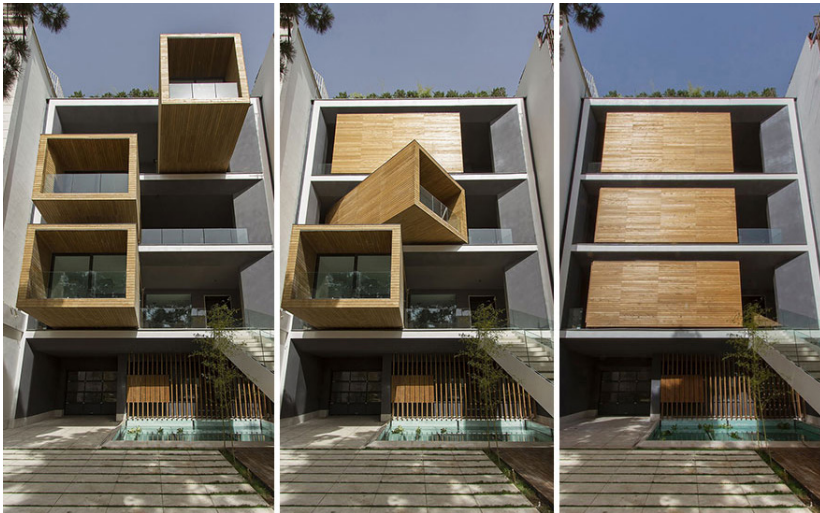


Fig 35. Sharifi-ha House by Next Office



Fig 37. Transforming roof structure at the Milwaukee Art Museum by Calatrava



Fig 36. Shading umbrellas at the Medina Haram Piazza

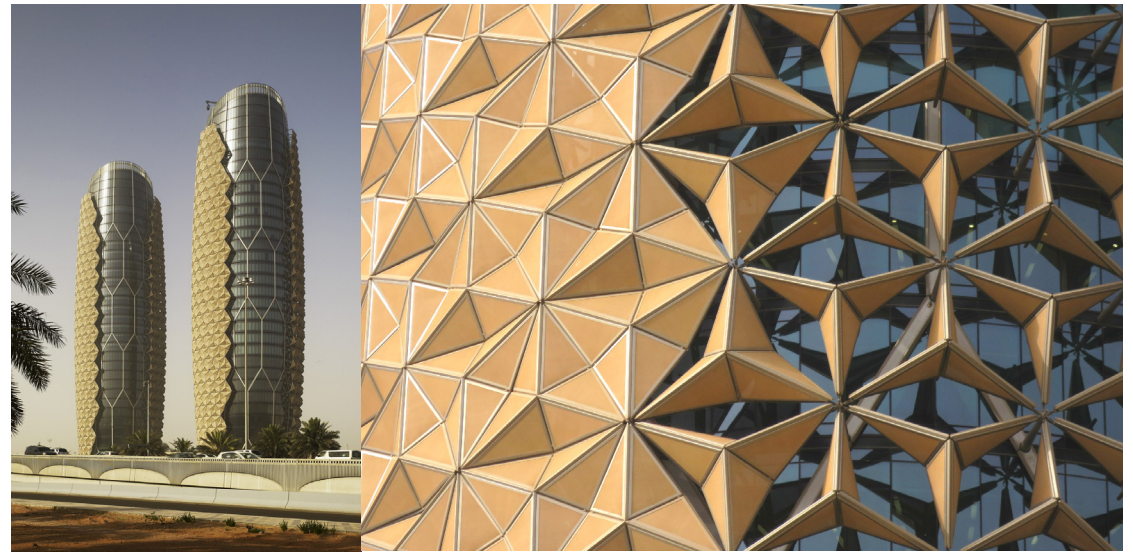


Fig 38. Al Bahr Towers by Aedas Architects with surfaces that can be opened and closed to control the amount of sunlight entry

**In Architecture**, transformation usually happens in shading devices. In many examples like the Al Bahr towers, the Medina Piazza and Milwaukee museum, there are mechanical components which move and aid the surface to fold or unravel. These surfaces are usually thin membranes which can

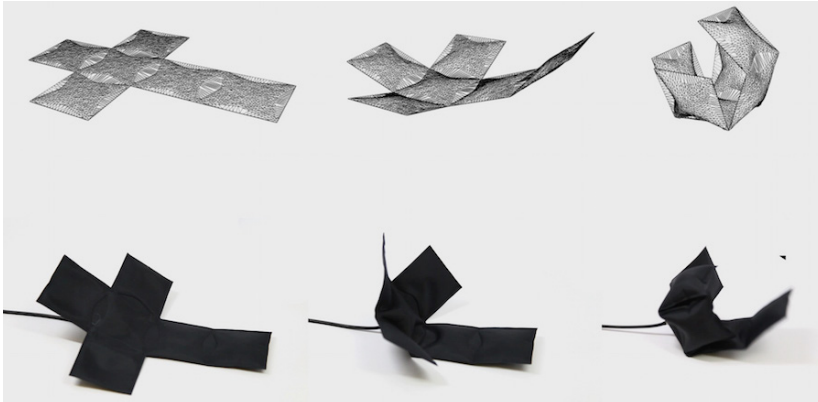


Fig 39. A 4D printed object transforming itself from a planar to a box form



Fig 40. Initial explorations of fold-ability as a transformability concept

be easily given form by using a framework. Therefore, any change in the framework would change the surface geometry. But there are also a few examples in which an entire space shifts around and transforms to give a completely new experience to the user residing in the space. The Sharifi-Ha house is such an example, where the rooms on the building facade side can swing around, not only changing the exterior look of the building, but also altering the interior spatial experience.

### 3.4.d ANALYSIS & INFERENCES

Although these three fields were considered to understand how transformability exists in our present world, the idea is not restricted to just these. From nano-tech components to huge satellites, transformability has been utilized to achieve multiple sets of functions. The major factors which a transformable concept should satisfy are :

Flexibility in application and function

Modifiable appearance and geometry

Adaptable shape and size

Once these factors are satisfied, the transformable concept can be deemed an effective and efficient. And from the products studied here, one can understand that transformability can be achieved using two methods

- i) Collapsible or movable mechanisms
- ii) Material with alterable surface property

4D programmable materials which will be readily available in the future is something which can be used as a bridge between both the aforementioned methods. These materials can twist, fold and unravel based on commands given to them. These materials do not require a structural system to bring about the geometrical change. To understand how these materials can be used effectively in a transformable motorcycle concept, several explorations and iterations were done using scale models, where paper was used to mimic the 4D material.

From the explorations it was understood that although fold-ability which can be brought about by 4D materials seem feasible in certain areas, it cannot be used in many places where structural capabilities are required. Therefore a combination of fold-ability with a movable mechanism can to be implemented to achieve a much more efficient result.





Fig 41. Hyperions by architect Vincent Callebaut - an energy positive eco-neighborhood proposed for Delhi NCR, India



Fig 42. Vertical farming done by Farm.One in Manhattan, New York, USA

### 3.3 The Future Scenario

Predicting the future is next to impossible, but there are ways in which possible scenario can be developed by studying advances in fields which has the potential of influencing the future. All these advances can be categorized broadly into 3 categories :

Environment

Human

Technology

#### 3.3.a ENVIRONMENT

In the possible future, nature and environment will be seen as the most important things to be protected as conserved as it directly affects the existence of humans. In the United Nations Sustainable Development plan for 2030, factors like fight against global warming and adverse climate change, conservation and improving quality of life for all organisms both on land and under water have been given utmost importance.

There will be a huge push to promote clean, green and renewable energy sources, thereby reducing or completely discarding the requirement for fossil fuels. Similarly, focus will shift towards renewable and biodegradable materials. Bionics and biomimicry will become a major source of inspiration for development in all fields - learning from nature.

With an increase in population to 8.8 billion people, and 60% of them living in urban areas, housing and accommodation needs will skyrocket. Due to limited land area in urban areas, cities and even green spaces will start to grow vertically. The concept of farming will change, with artificial and vertical farming methods coming into play. Genetically modified seeds which guarantee more yield will be introduced to solve food problems.

With shift to renewable and eco-friendly energy sources, pollution and CO<sub>2</sub> content in the atmosphere would reduce drastically, curbing global warming. This would mean that nature and environment could be enjoyed more and aid in promoting a healthy lifestyle for humans with a sense of coexistence with all living organisms.



Fig 43. Bionic prosthetic arm created by DARPA



Fig 44. Nextage humanoid robot from Kawada Industries - job automation will create a major shift in job profiles available for humans

### 3.3.b HUMAN

Change in job profiles due to widespread automation will create a major shift in the economy. Manual labour and repetitive tasks will be taken up by robots and machines, creating a huge shift towards job profiles in which human intervention is unavoidable - eg, creative, consulting, imaginative, intellectual professions.

With 3D printing becoming prevalent in the manufacture industry, bespoke and tailor-made products will be readily available. Self cleaning materials, automation, advanced HMI, etc increases convenience of use and makes life easier. Products will behave and function based on the user who is handling it, with having presets and advanced user recognition systems.

Smart clothes and tech implants will closely monitor health and also enhance human performance. This will mean that humans will be at peak physical health, but the same cannot be said about mental health. WHO has predicted that by 2030, depression will be the leading cause of disease burden at a global level. Since the users will be surrounded by screens and other media systems like AR, VR and even contact lens which serve as a display unit, they will always be sedated by visual media, advertisements, etc. There will be a critical need for the users to connect back to nature and experience the world in a real sense and not virtually.

Social connections would be suffering as people would prefer connecting virtually rather than physically. There will be a huge drop in marriage numbers, as the young generation would prefer to have a live-in relation, or stay single. There will be a spread in multiculturalism as the global connection between regions become stronger.

With more products turning into services, the idea of ownership of certain types of products will become obsolete. These services will be availed based on subscription and a different class based system will emerge, solely on the basis of economical status. That being said, highest percentage of global population will fall into the middle class income group (presently \$16100 as minimum annual income for a family of four members).

Physical labour will have assisted systems like exo-suits or muscle enhancements. Prosthetics would change into completely user specific and will start replicating touch sensitivity, even providing extra features like switchable modules for different activities, enhancements, etc and will be able to completely replace the missing body part. Being assisted always and having everything available on-click will mean that the human temperament and behaviour will change drastically. The attention span and patience may reduce to great extent causing them to get bored easily. This would mean that they will require products and services which can keep up with change and can change based on user needs whenever required.

All this boils down to the concept of customization, user specific tailor-made designs which can be done by the user itself with the aid of AI and other assisting technology.





Fig 45. Facebook is trying to create a brain-computer interface without any invasive implants.

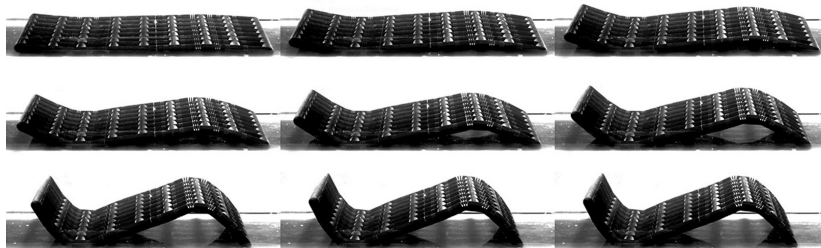


Fig 46. 4D programmable material being developed by MIT



Fig 47. 3D printed office building in Dubai, UAE

### 3.3.c TECHNOLOGY

Technology is something which is growing and advancing at an exponential and alarming rate and forms the base of growth in all fields mentioned in the previous categories. In the near possible future, technological advances may completely remove the gap between man and machine. With advanced research and study being conducted into developing a better ‘brain-computer’ interface, controls and commands may be thought driven in the future. Advanced AI systems will be in charge of controlling a lot of systems on the human level and also in a city level. Smart homes with a responsive AI will ensure that the user is comfortable always while also optimizing the energy requirements. AI systems will be assisting the transportation, health and education sectors making them more centralized, interconnected, efficient and environmentally smart.

When talking about the field of healthcare, health monitoring implants, and IOT enabled intelligent clothing will keep tabs of user health and inform him of any diseases or ailments well beforehand. Advanced bio-printing techniques would come into play where fully functional organs and tissue can be 3D printed ready-to-use. Healing bays and fully automated operation theatres will become a common sight in all hospitals and healing centres speeding up the entire process of diagnosis, medication, and surgery.

In the manufacturing industry, new techniques and materials will come in which would help for faster manufacture with very less resource wastage. Presently, 3D printing technology has completely changed the face of manufacturing and production industry, therefore one can only assume that this technology would be adapted on a larger scale in a much efficient manner to create customized products. Programmable 4D materials which are in a developmental stage presently will be used widely in the future. This opens up a lot of possibilities of developing products and surfaces which can change based on time or as a reaction to some stimulus. More structural materials will come into play, where the materials itself will be strong enough to take loads thereby making the requirement of structural members are structures obsolete. Generative design is one of the many ways which are being used presently to create structures efficiently, where the best structure is designed with the aid of computers. Further into the future, generative designs may become prevalent, as it consumes less material and resources than traditional structural systems, thereby reducing time and resource wastage drastically. The construction industry would become a part of the entire manufacturing chain, where construction of structures would be mainly done by using preset modular pieces, or by 3D printing. This makes construction easier and faster and reduces the idea of permanency, making the buildings detachable or transformable.



Fig 48. A passenger experiencing the autonomous drive mode in Tesla Model S

In the transportation industry, services like Hyperloop and ET3 will open up new possibilities for faster and more efficient hi-speed public transport. Technology like cryo-levitation and mag-lev will not only be used in public transport, but will also start seeping down into personal transportation vehicles. Personal and shared transport pods which travel in a particular route will reduce the dependency on personal transportation devices, thereby freeing up roads more. Vehicles will achieve higher levels of autonomy in the near future and will change the experience of personal travel in a very strong manner. The roads being dominated by autonomous vehicles would create a much more stream lined traffic flow as the vehicle AI are always communicating with one another and also with the traffic systems. This would definitely reduce the number of accidents and vehicle crashes whereby improving and ensuring the safety of users. Personal mobility devices like micro-mobility products and jet-packs may come in the near future, which can be used for recreational purposes or in areas where larger vehicles are restricted. Similarly, the field of space travel will also advance much more with companies like Tesla and Virgin Atlantic moving ahead with the idea of commercializing space travel. Tesla has their Space-X program up and running with the goal of taking people to Mars. The entertainment industry will be taken over by augmented and virtual reality concepts, and the idea of having physical screens will be trumped by holographic projections and eye lens itself serving as screens. Advancement in haptic technology will aid the users in interacting with the virtual environment with the same physical feedback and experience one would have in the real world.

### 3.3.d INFERENCE

This study gives one an idea and direction in which the future is heading to. Based on the time period being considered in the future, this study helps one build a feasible scenario by shedding light on the possibilities of the context, user, and products.

Based on the possible projections understood from the study, one can realize that the future user will be more inclined towards having products which are very specific to them, and the experience each user will have while using them will also be very unique. The need for customization and need to have a new experience every time shows that the idea of having a transformable motorcycle is very feasible in this possible future scenario.

# 04

## SCENARIO



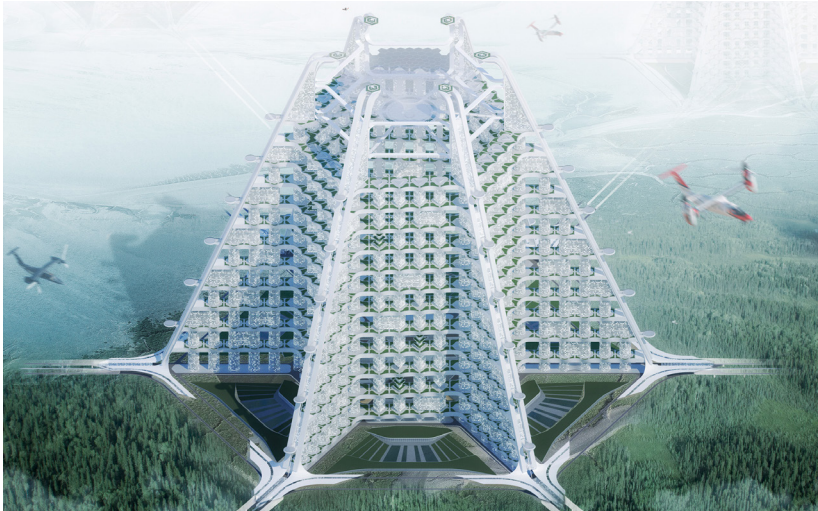


Fig 49. Cities greener and growing vertically



Fig 50. Increased dependency on clean energy



Fig 51. Drone delivery systems



Fig 52. Interconnected autonomous transportation systems

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## 4. SCENARIO

Based on the study on the possible future, a scenario is built up which will form the context for a small storyboard showing the activities of the user and his possible interactions with the motorcycle. This would eventually help in moulding a design brief based on which the design process can start.

The year 2035 has been set as the scenario for the product as this was seen as a feasible period for realization of such a product.

The scenario has been developed considering 4 factors - context, product, user, transport.

### 4.1 Context : 2035

- Global population crosses the tally of 8.8 billion people
- 60% of this global population settled in urban areas
- Evolution of megacities
- High dependence on clean energy
- Biomimicry and nature inspire majority of products
- Intelligent materials, high tech alloys, etc used in manufacture – 4D materials which changes with time and respond to stimuli
- Rise in use of public transport facilities like super fast trains, transport pods, shared vehicles for commute – public transport becomes faster and cheaper



Fig 53. Increased dependency on clean energy

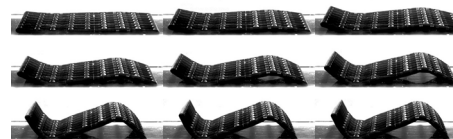


Fig 54. Increased use of 4D printed materials



Fig 55. Super hi-speed highways



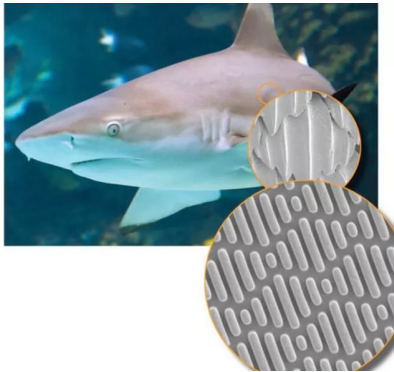


Fig 56. Huge influence of bio-mimicry

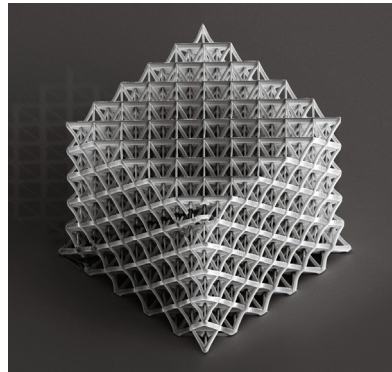


Fig 57. Use of advanced nano tech



Fig 58. Mag-lev tech becomes common



Fig 59. User based settings for products

## 4.2 Products : 2035

- Advanced AI and IOT connected products
- Products will detect user palm print/DNA and only registered users can operate/use it
- Natural materials infused to create new materials which are eco-friendly
- Advanced nano-tech used in product industry
- Products become more compact but has more features
- High level of customizability and personalization
- Heavy influence of bionics and biomimicry on designs and functions
- Self made products using 3D printing
- Self healing materials introduced - high durability and longevity
- IOT enabled apparels keep tabs on user comfort and keeps users connected
- Wireless charging even for electric vehicles becomes common
- Robot servants and assistants become common



Fig 60. Wireless charging feature enabled in all products

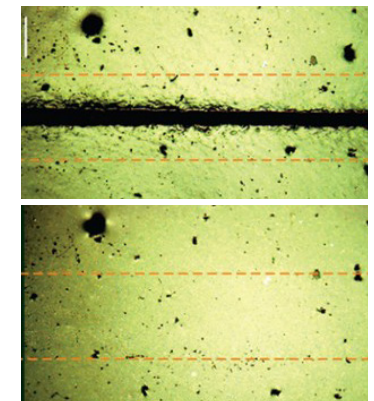


Fig 61. Self-healing materials



Fig 62. Robot servants become common

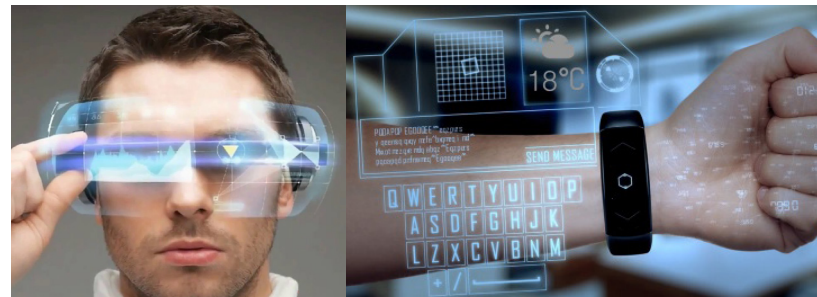


Fig 63. Wearables and implants become common



Fig 64. Wearables and implants become common





Fig 65. People are digitally connected, but lack physical connections



Fig 66. Enhancements and exo-suits help increase the physical strength barriers

Project 3: Design of a Transformable E-Motorcycle for 2035

## 4.3 Users : 2035

- Rise in unmarried population
- Need for high level of customizability required in products – pre-production and post-production customization
- Personal vehicles used more for recreational purpose by enthusiasts and have minimal use as commuters
- Products become extension of user and his personality
- Open source files available for user to customize and print own products
- Implants become common – health, diet monitoring, enhancement implants , etc
- Highly stressed generation
- Advanced prosthetics and assistance in physical activities
- Engulfed by AR-VR screens - becomes very important part of lifestyle
- High quality of life - better health and life expectancy
- Life eased by autonomous systems
- High dependency on virtual personal assistants



Fig 67. Tailormade products available for user



Fig 69. Heavy use of AR/VR in day to day life

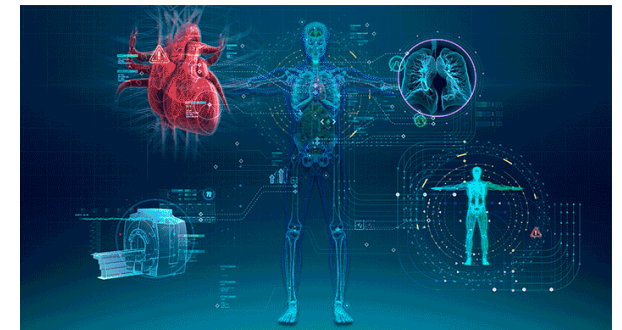


Fig 68. Implants continuously monitor user health

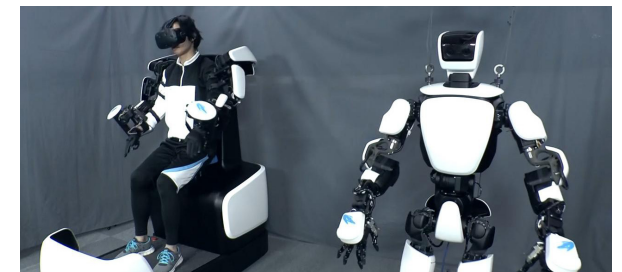


Fig 70. Introduction of body surrogates

## 4.4 Transportation : 2035

A visual study using an image collage was done to get a glimpse of the type of transportation systems which will be present in the scenario. These include many concepts which have been designed and developed by some of the prominent industry leaders in automotive and transportation design.

### 4.4.a Three wheelers

Three wheelers would serve as a mode of personal transport for one or two passengers at a time. These take up more space in comparison to 2-wheelers and will offer a mixed experience while driving - neither a car, nor a bike.



Fig 71. Toyota I-road



Fig 72. Honda 3R-C concept

### 4.4.b Pods

Transport pods will become a common sight in the near future. These can be personal pods or shared pods. There are multiple concepts which surround the idea of pods - individual pods and pods which can attach to one other to create a chain, similar to a tram or train

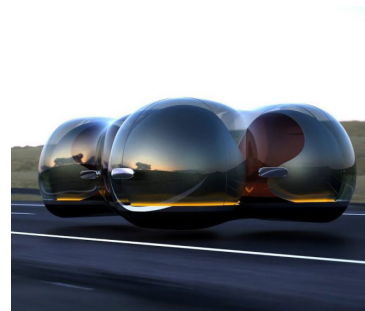


Fig 73. Renault Floating Pod



Fig 74. GM En-V pod



Fig 75. E-pod by NEXT Future Transport.



#### 4.4.c Four wheelers

Four wheelers would turn more luxurious and would cater to both personal transportation needs and also as shared mobility devices. The interior experience would change drastically as majority of vehicles would be self-driven.



Fig 76. Icona Nucleus concept



Fig 77. Icona Nucleus concept - interior



Fig 78. BMW Vision Next - interior



Fig 79. Mercedes Benz Biome concept



Fig 80. Renault Trezor concept

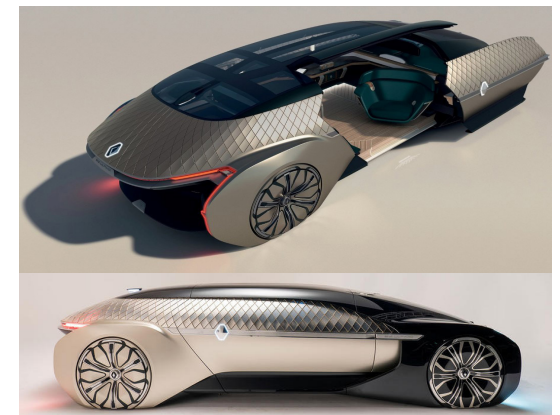


Fig 81. Renault EZ-Go shared mobility concept



Fig 82. TerraFugia TF-X concept flying car



Fig 83. BMW Hoverbike



Fig 84. Autonomous air taxi concept from Airbus



Fig 85. Lilium Air taxi

#### 4.4.d Aerial vehicles

Along with road going vehicles, the future will also have several aerial vehicles serving as personal and shared transportation options.

#### 4.4.e Public transportation

Mass public transportation will have a well interconnected system consisting of ride share vehicles, hi-speed train systems, hyperloop, etc



Fig 86. A ride sharing concept from Toyota



Fig 87. Suspended pods



Fig 88. Straddling bus concept



Fig 89. Hyperloop

The scenario gives us a brief look into how the world would possibly look in 2035. It presents us with an exciting set up to introduce a transformable motorcycle which enriches the travel experience of the rider.



## 4.5 Storyboard

The scenario gives a context for development of a user persona and a storyboard showing the life of the user. The storyboard in this case deals with a pre-intervention and post-intervention story where one can see how the product changes the lifestyle of the user.

### 4.5.a User Persona

Jacob is part of the Generation Alpha (people who are born between 2005 and 2025). He is adept with technology and is primarily invested in a consulting/creative job. Presently he lives a very sterilized life which is taken up mostly by time spent in his residence and in his office. He uses implants, wearables and IOT connected smart clothing to keep tabs on his health and stay connected. He prefers customization in everything and wants products and services tailor-made for him. He has a motorcycle which he uses for long rides, but is not suitable as a daily commuter. He wants to break out of his sedentary lifestyle and explore, while making a strong statement about himself. He wants more thrill and adventure in life. He is unmarried, likes spending time with his friends, but mostly likes to explore and enjoy highly personal time as he is introverted.

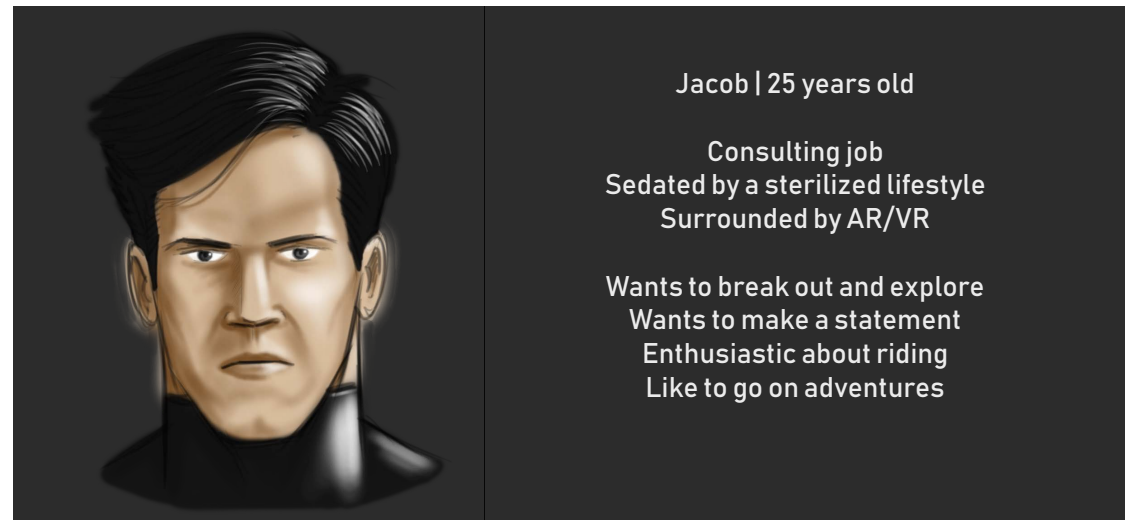


Fig 90. User Persona

#### 4.5.b Pre-intervention

His profession requires him to travel regularly to multiple sites within and outside the city. For the rides outside the city he uses his motorcycle as the speed regulations are eased and he can enjoy the ride freely. He wants to enjoy a similar riding experience for his daily commute also, while staying within the speed limits. But since his motorcycle is designed specially for hi-speed long rides, he finds it very uncomfortable for his daily commute. The ride posture and ergonomics is in such a way that it is highly unsuitable for the urban scenario. Furthermore, he likes to do a bit of trail riding and offroading sometimes, and here again, his hi-speed motorcycle is highly uncomfortable and not up to the task. He has to rent out or borrow a motorcycle to enjoy offroading and trail riding, but after a point, it becomes too much of a effort to always borrow or rent out.

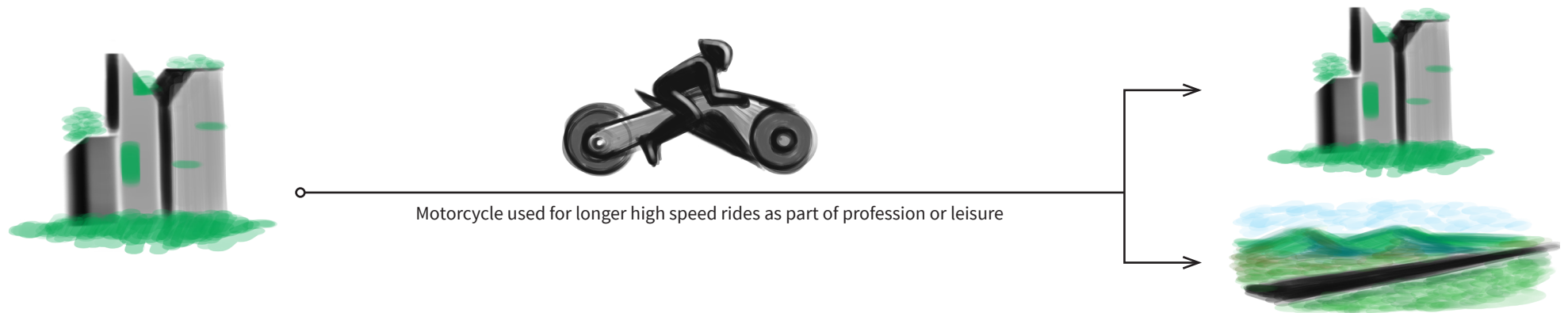


Fig 91. Hi-speed motorcycle owned by the user is highly inconvenient in an urban commuter setting



Ride ergonomics of the hi-speed motorcycle is highly uncomfortable in a start-stop style urban commute.



Fig 92. Daily routine of the user

Due to the lack of versatility of the motorcycle, Jacob resorts to ride sharing and public transportation for his commuting needs. The daily routes are fixed and he has become bored of this repetitive routine. This forces him to lead a very monotonous life, which is filled with boring commute and an overload of AR and VR ads and information. He doesn't find screens entertaining anymore, as his profession also deals with continuous AR/VR activity. This lifestyle slowly starts sedating him and he feels like he is stuck in a limbo and wants to break out of it.



#### 4.5.c The intervention

A possible solution to Jacob's problem is the use of a transformable motorcycle.

This would satisfy his needs of daily commuting, hi-speed intercity rides and also the occasional offroading and trail riding.



Fig 93. Daily commute enriched by the motorcycle - user can pick his own routes for daily commute



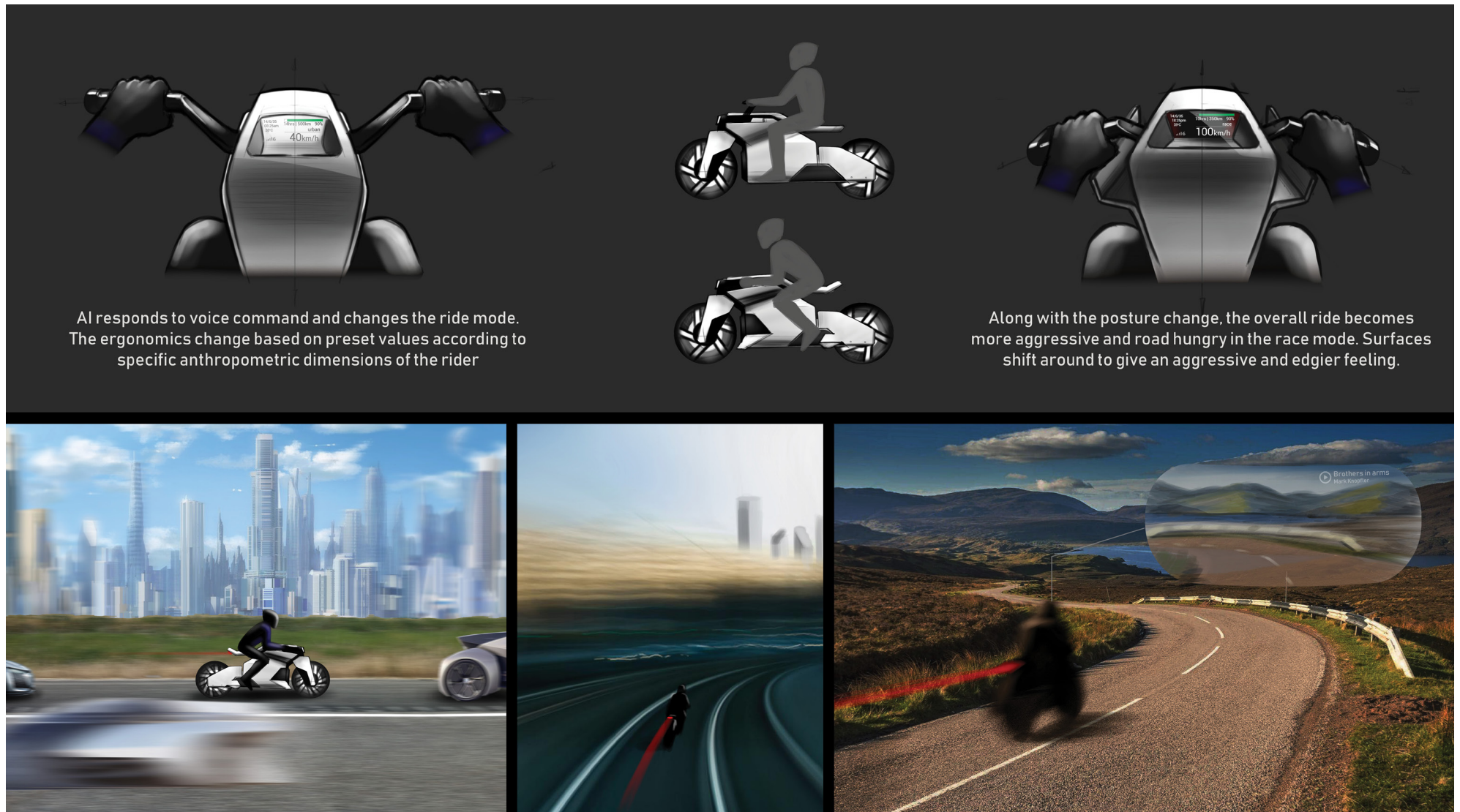


Fig 94. The switch from urban to racing mode is seamless and offers a new experience

The ride adapts to Jacob and is customized based on his ergonomic requirements. It's not only comfortable and compact for commuting inside the city, it becomes a ride companion for high speed intercity travels and long rides.

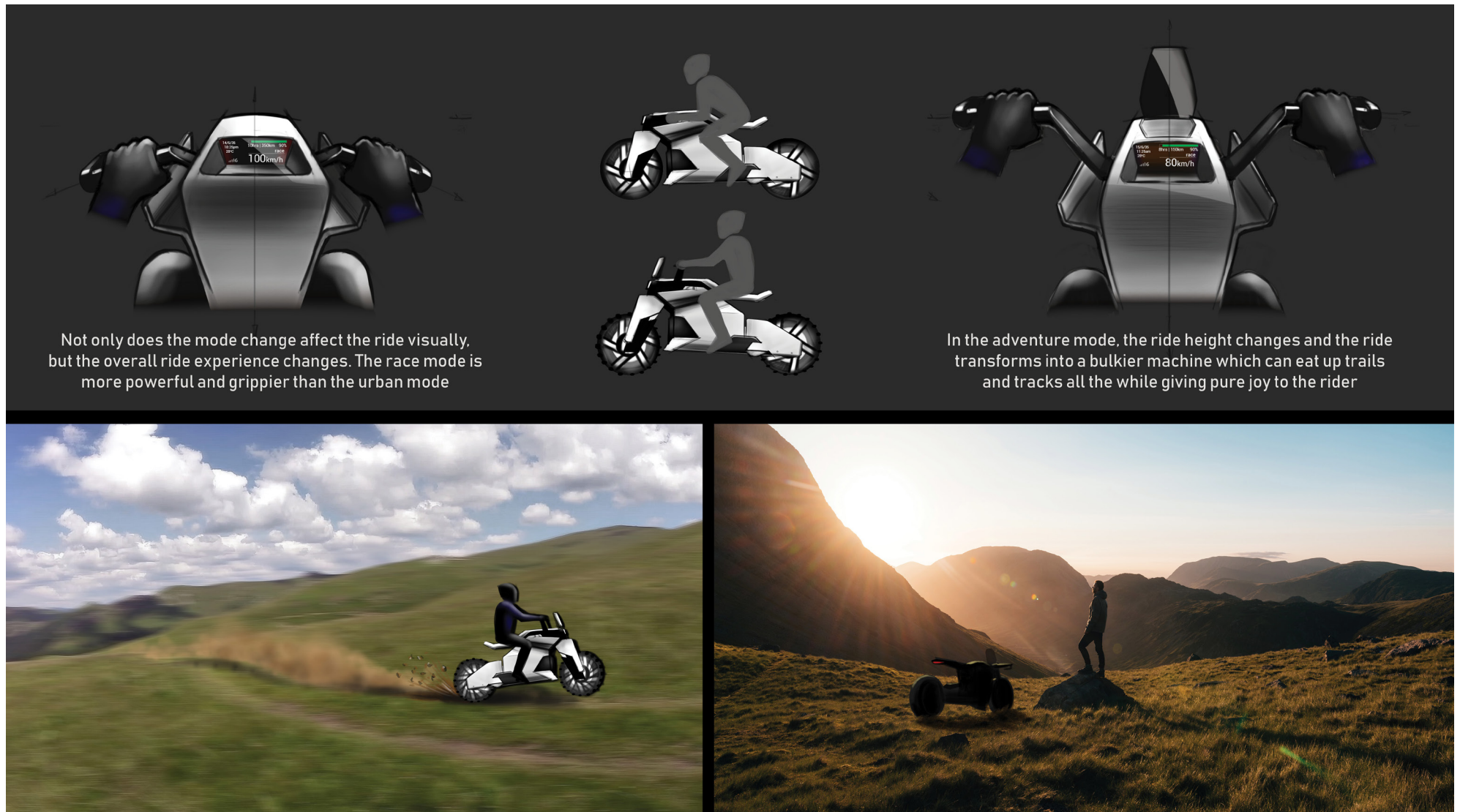


Fig 95. The off-road mode offers a way to have an adventurous time with child like fun

The motorcycle also satisfies the user's need to go off the road occasionally to have fun and get completely cut-off from the rest of the urban setup.

# 05

## DESIGN BRIEF

## 5. Design brief

Conceptualize and design a transformable electric motorcycle for a youngster residing in an urban scenario in 2035. The motorcycle should be able to alter its geometry to offer multiple ride modes and experiences to the user with features like:

- Variable wheelbase and ride height
- Shifting ride posture with alteration in position and geometry of seat
- Variable handlebar height, width and reach
- Dynamic changes in geometry of bike to give the visual and physical experience of the transformation or mode change - shift in tank geometry, change in style and look of info-graphic screen, different audio feedback to mimic engine noise, etc

The motorcycle will have single seating and is targeted at young professionals working in creative and consultancy fields, living in a metropolitan area in 2035. They enjoy riding a motorcycle for daily commute, take long distance trips as part of work and leisure, and like to go exploring and trail riding whenever they can.

Exterior design of the motorcycle should reflect the personality and lifestyle of the rider - Edgy and dynamic



# 06

## IDEATION

## 6. Ideation

### 6.1 Pre-ideation

A pre-ideation was done to understand and explore volumes based on the design brief.

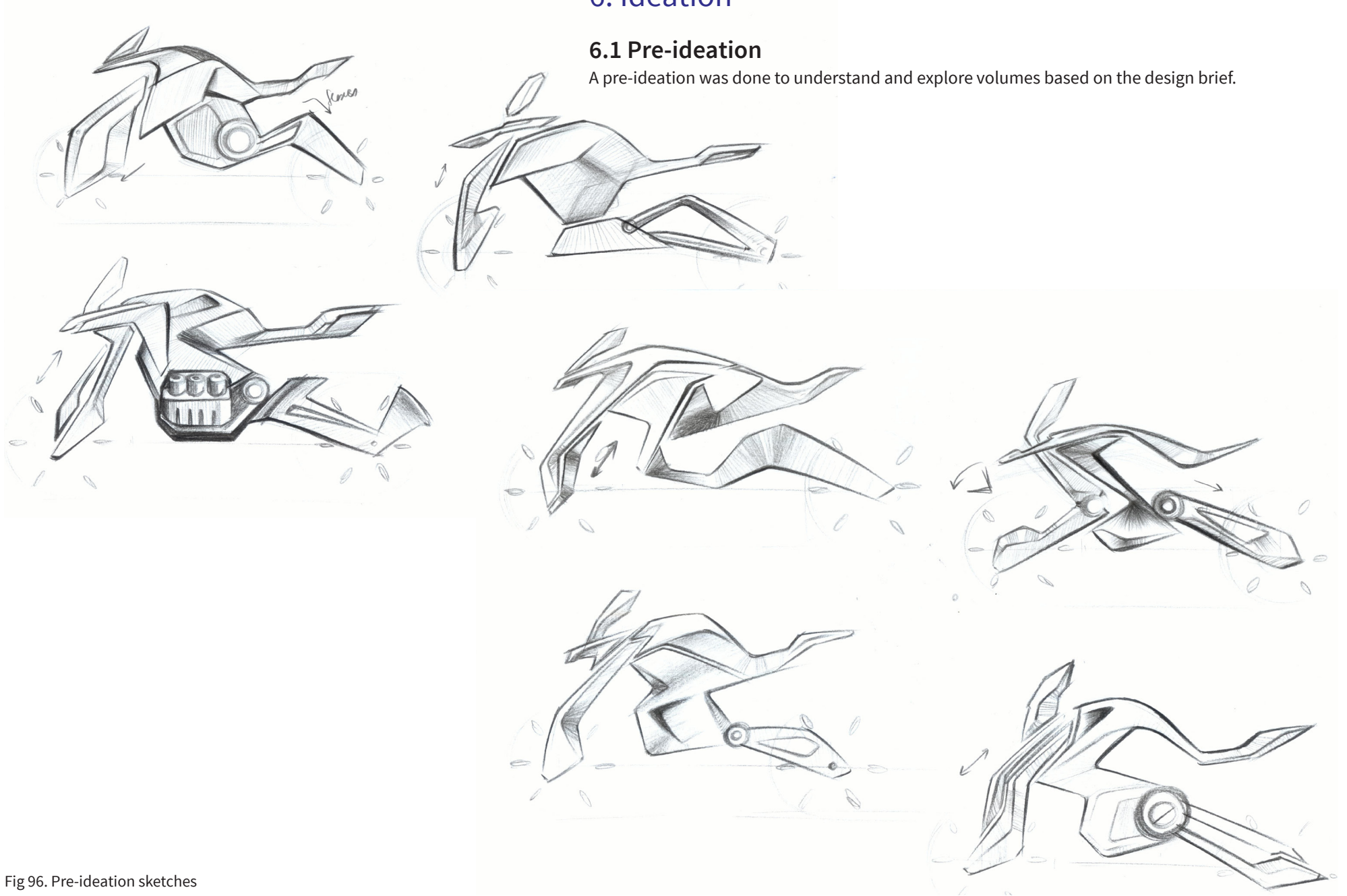


Fig 96. Pre-ideation sketches

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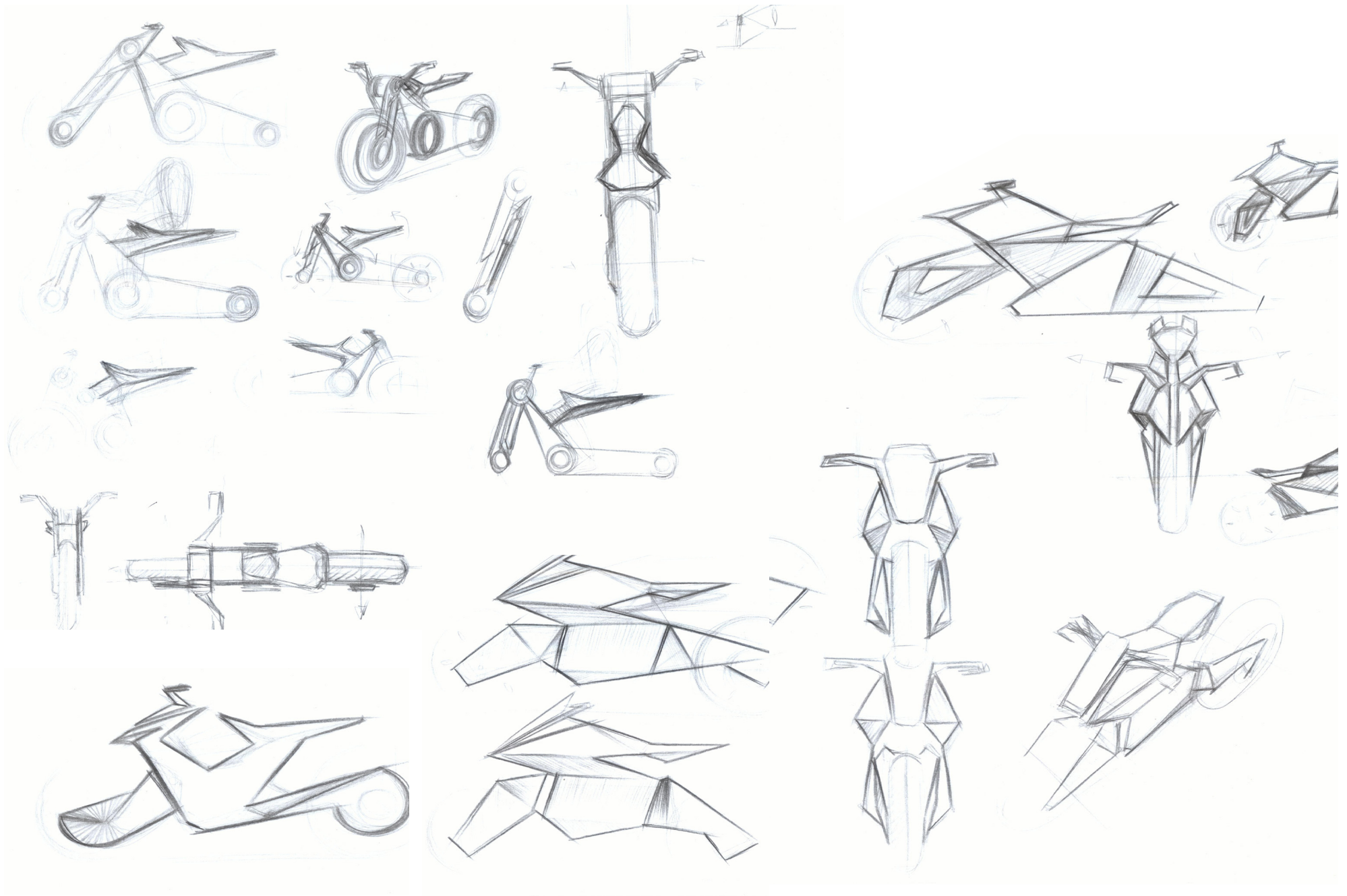


Fig 97. Pre-ideation sketches

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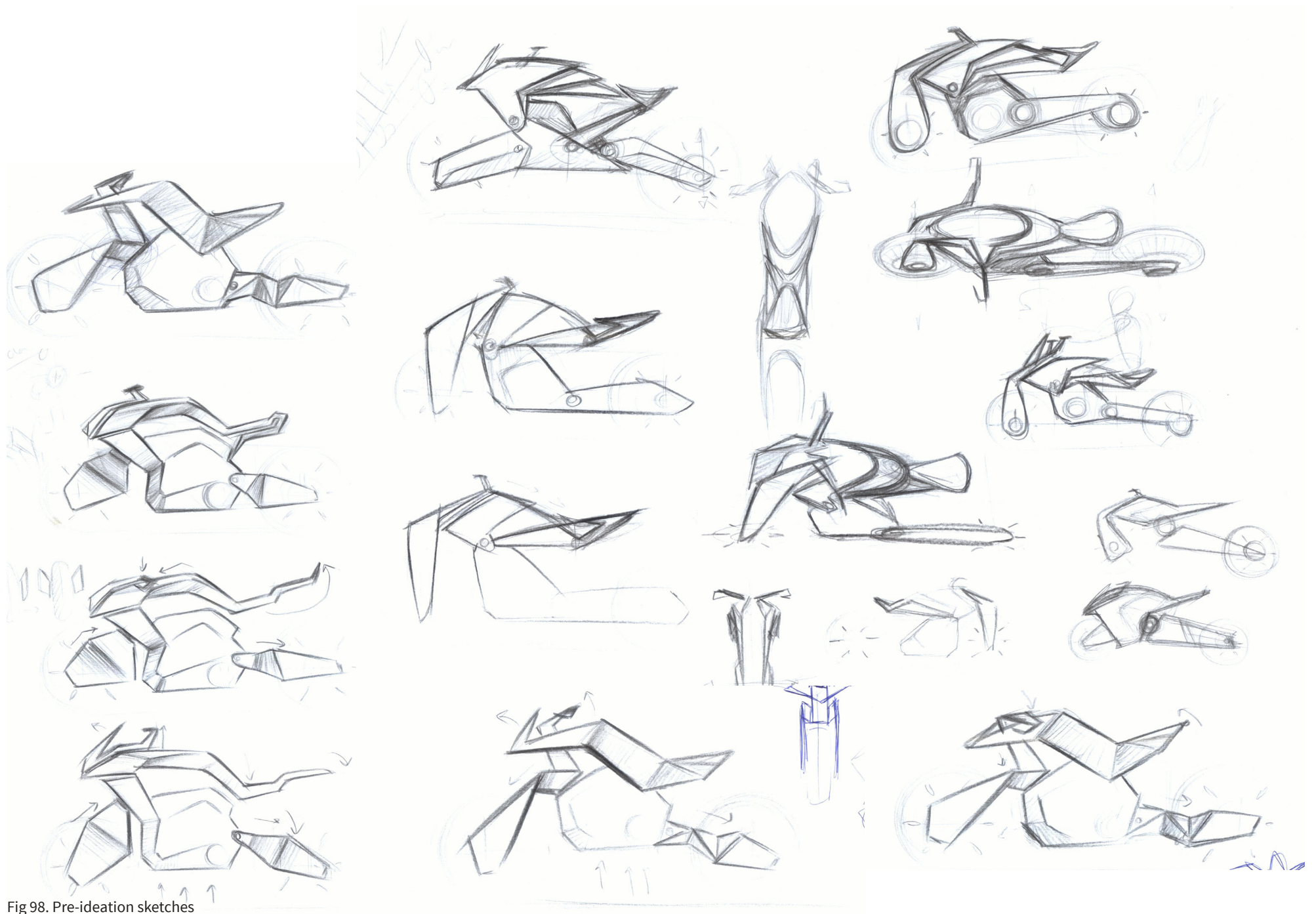


Fig 98. Pre-ideation sketches

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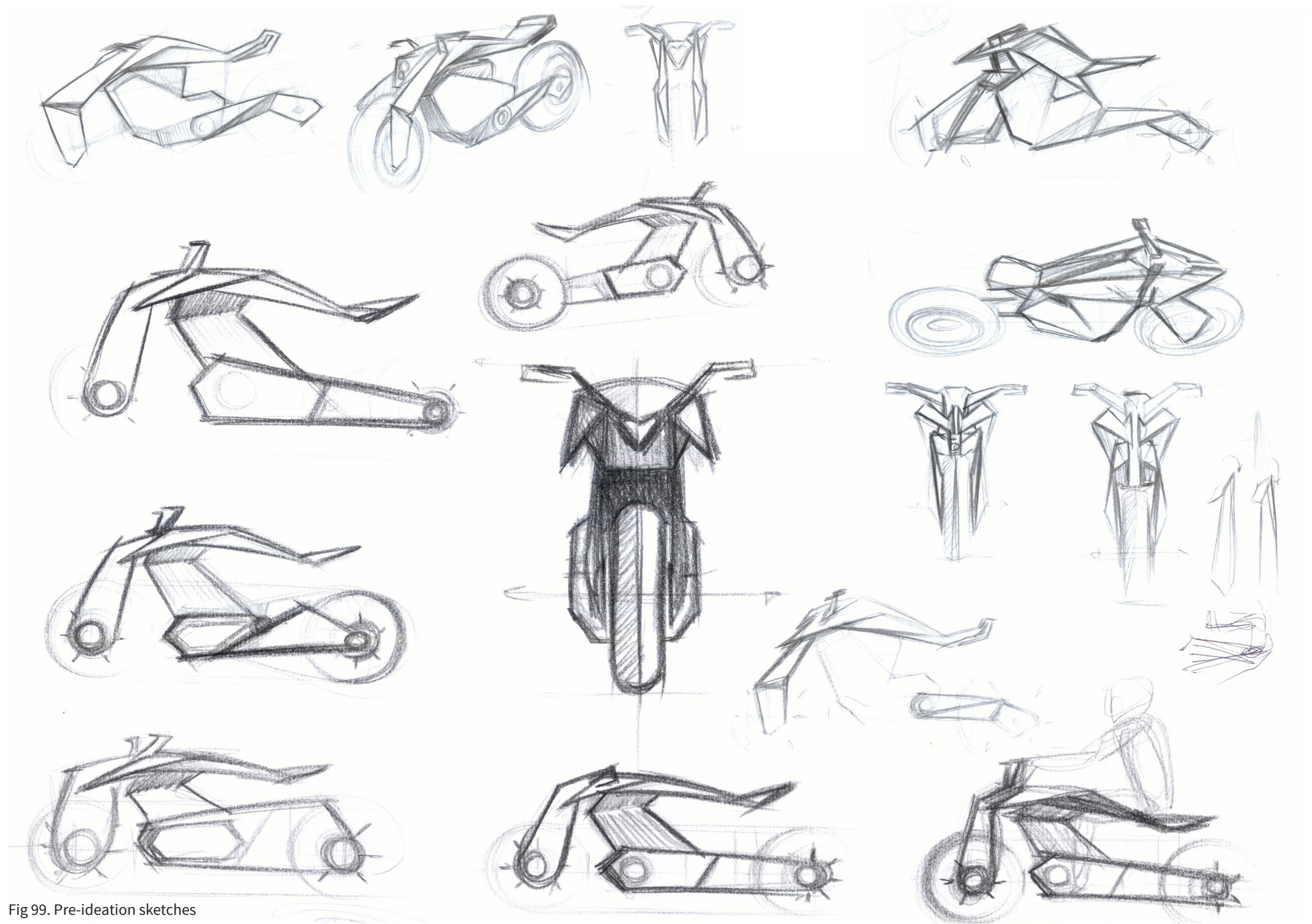


Fig 99. Pre-ideation sketches

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## 6.2 Ideation

The main aim was to achieve transformability, not only by shifting the ergonomic triangle, but include the entire geometry of the bike so that the user gets a complete new ride experience when he shifts from one mode to the other. Multiple directions were explored and then the most feasible ones were shortlisted to be taken further.

### 6.2.a Concept 1 - Active surfaces

This concept explored the possibilities by which active and programmable surfaces could transform to give the different ride modes. The biomimetic design was inspired from the movement of a human hand. The active surfaces mimic the action of a hand movement, where the bones are replaced by surfaces. These surfaces shift around to initiate the transformation.

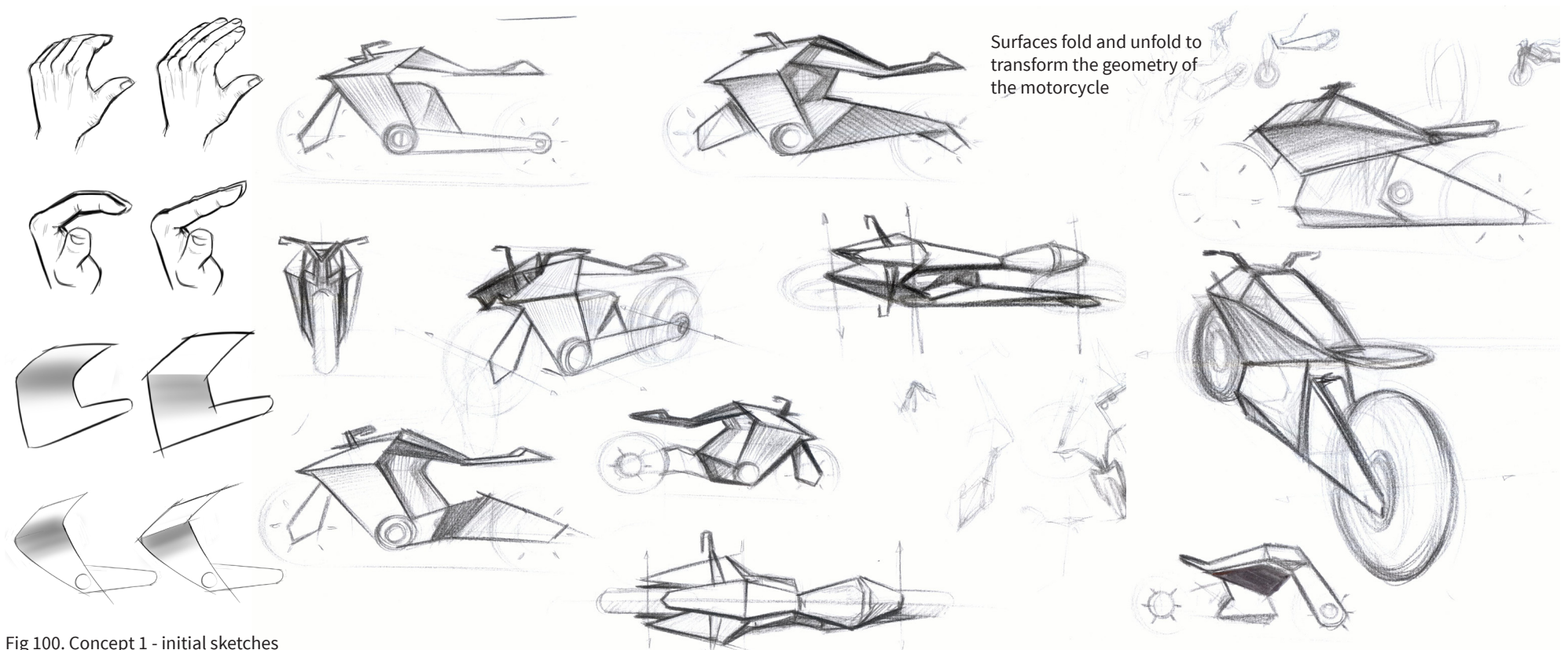


Fig 100. Concept 1 - initial sketches



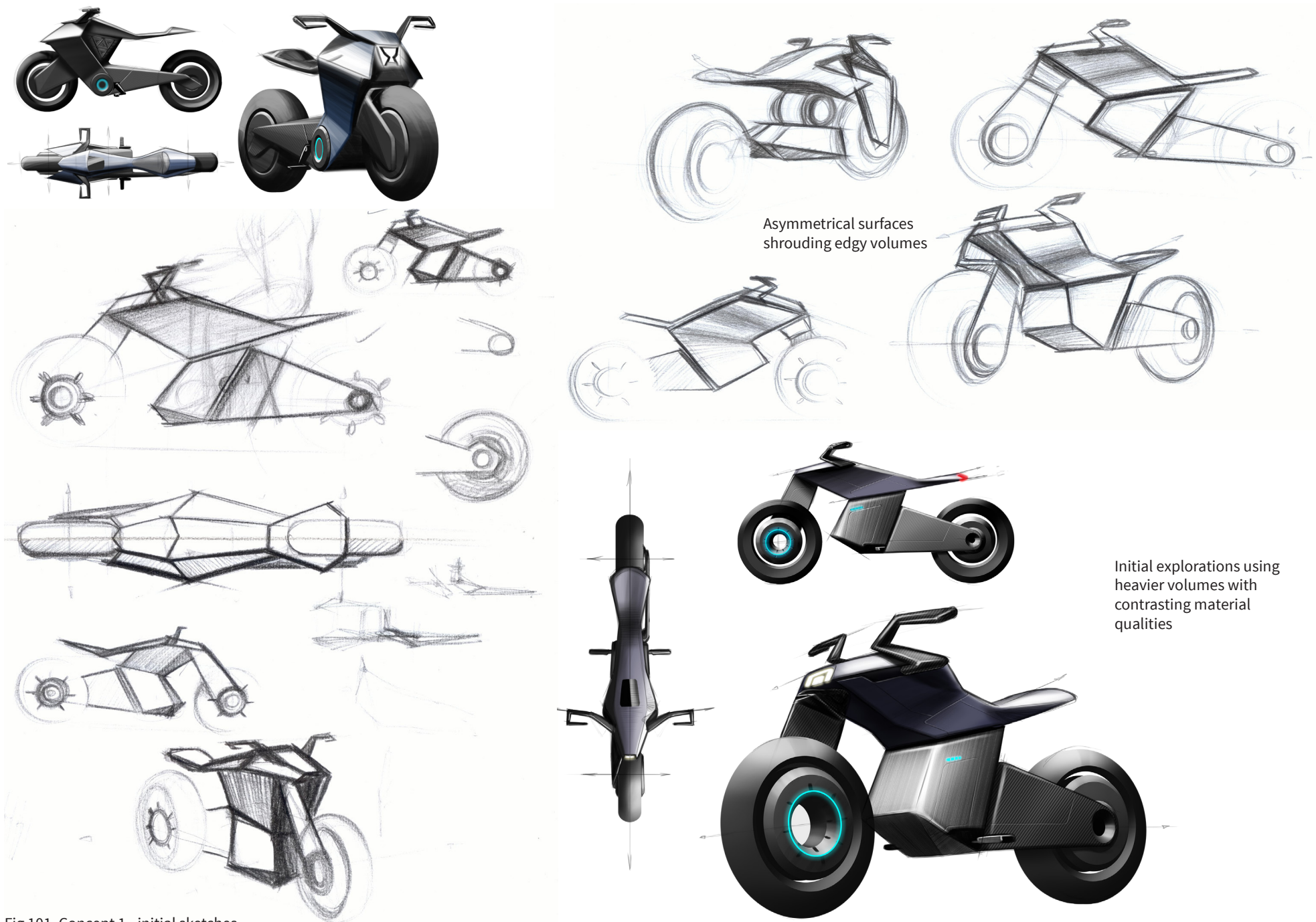


Fig 101. Concept 1 - initial sketches

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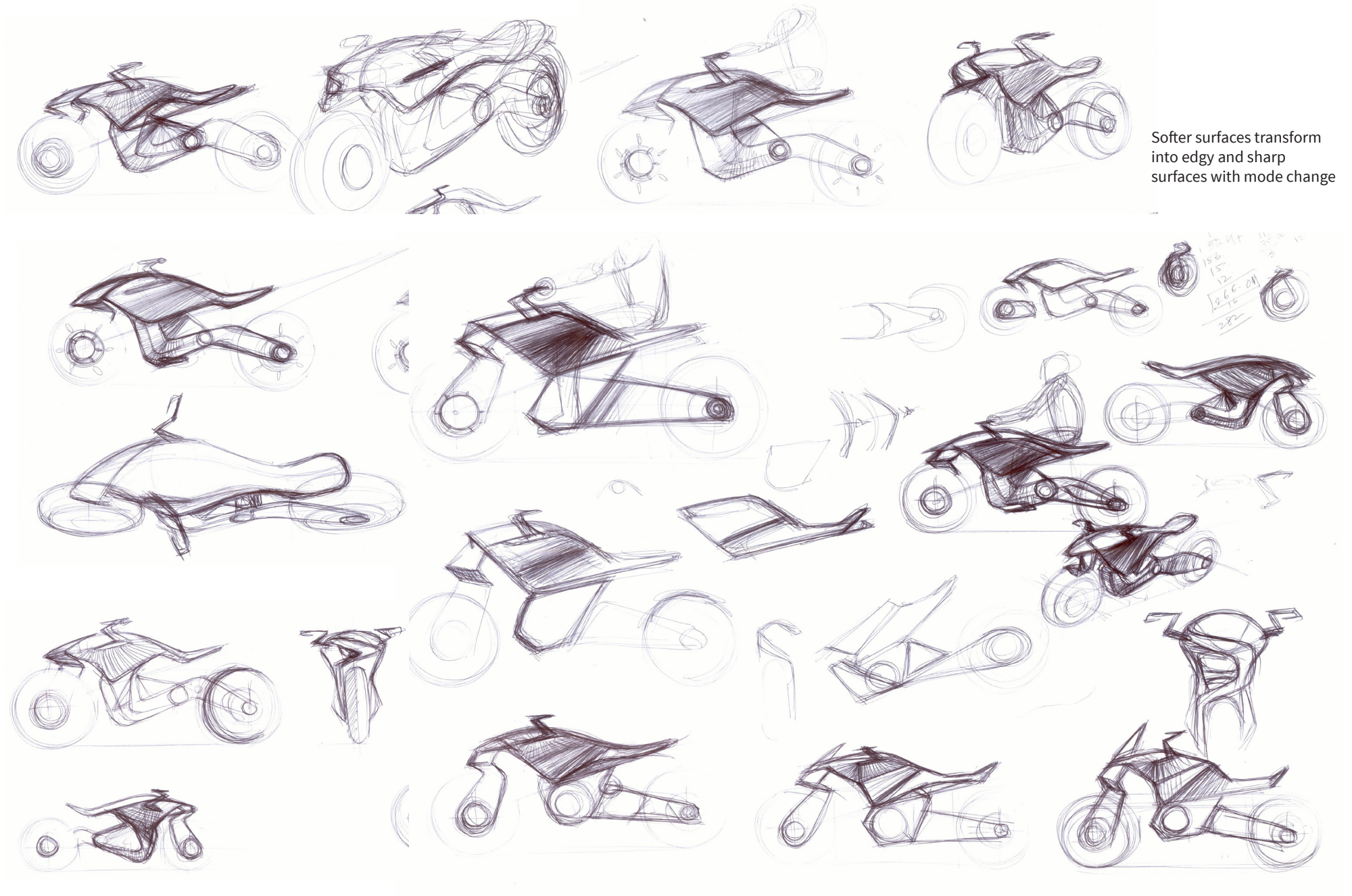


Fig 102. Concept 1 - idea refinement

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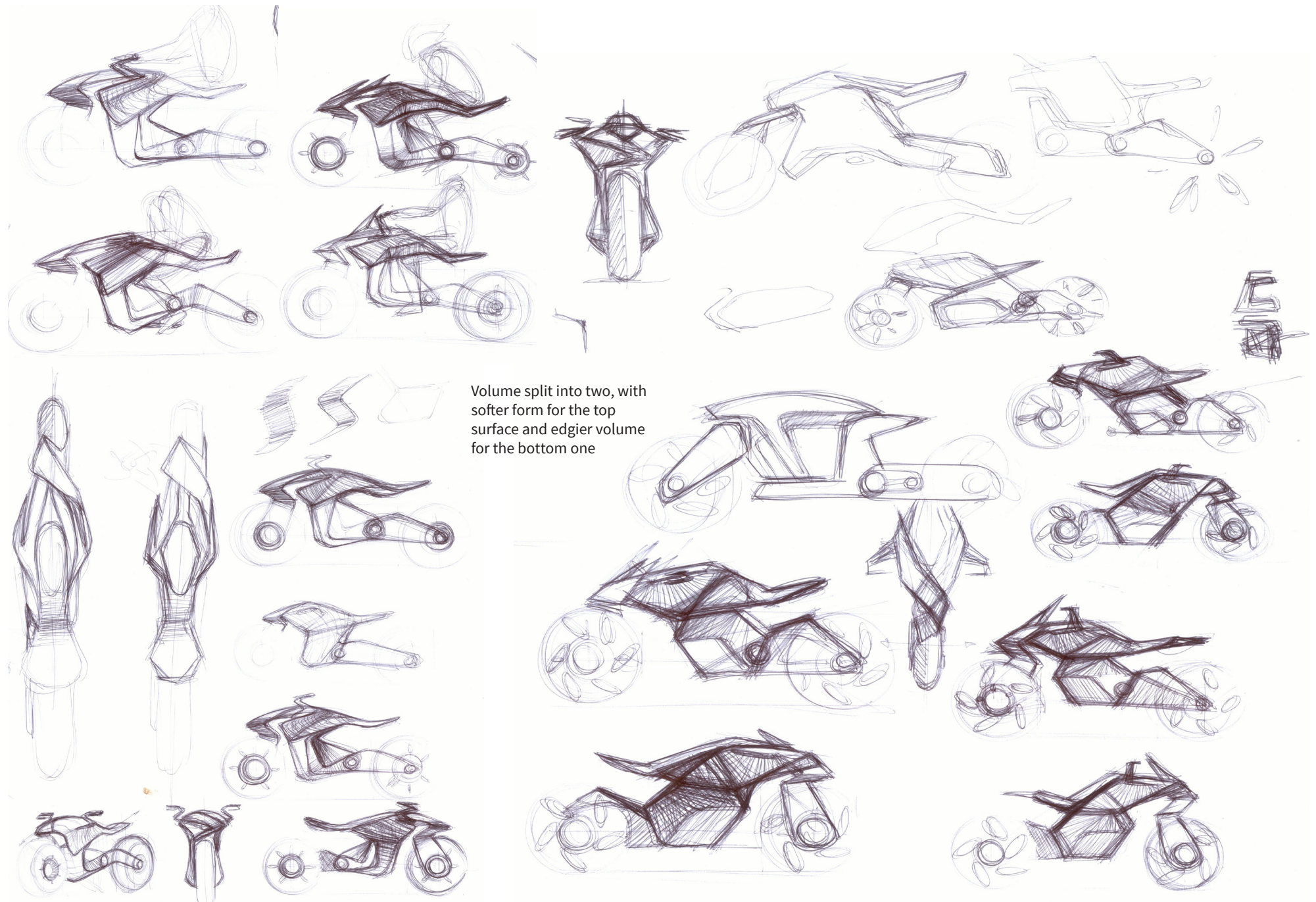
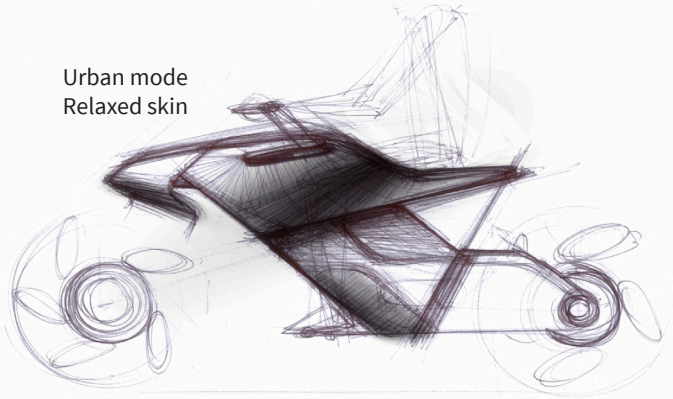


Fig 103. Concept 1 - idea refinement

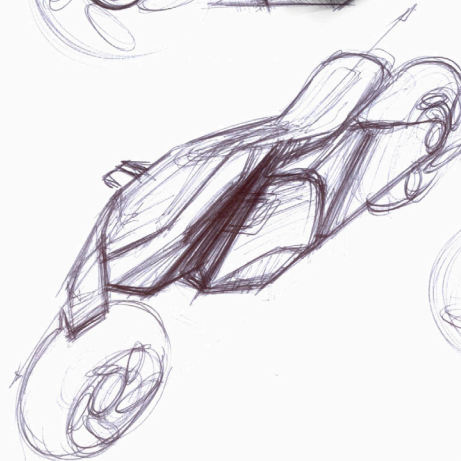
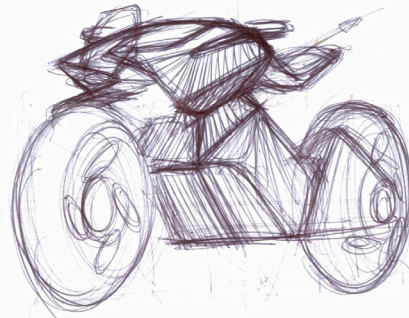
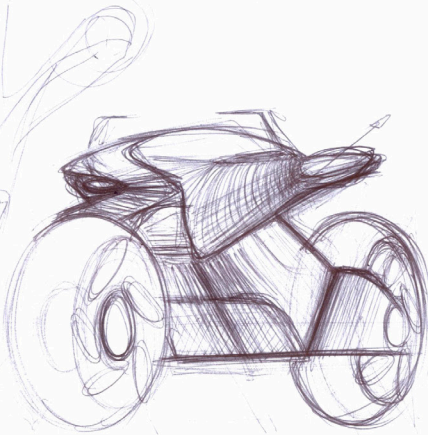
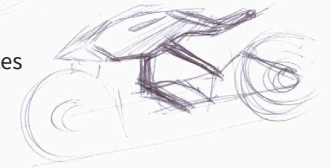
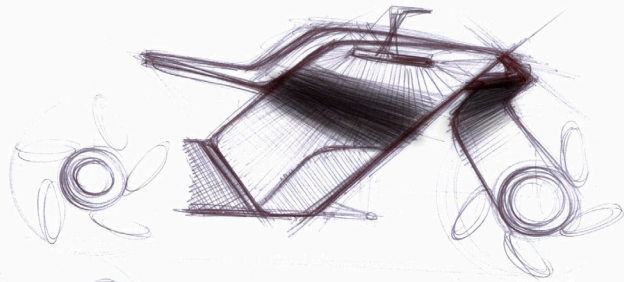
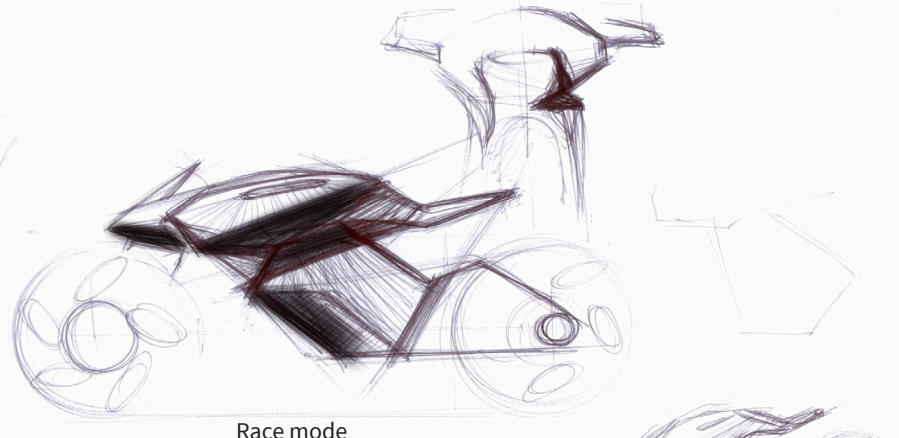
Project 3: Design of a Transformable E-Motorcycle for 2035



Urban mode  
Relaxed skin



Race mode  
Skin folds creating sharper surfaces  
and gives a much for aggressive  
feeling



Off-road mode  
The seat drops and skin  
expands a bit to give a  
feeling of increase in  
volume - making it feel  
more dominating

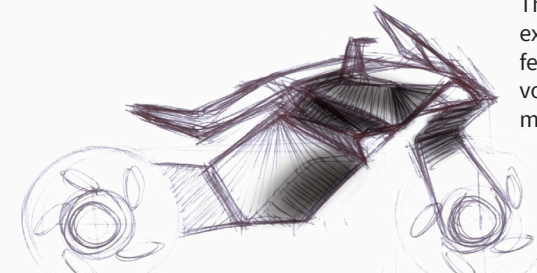
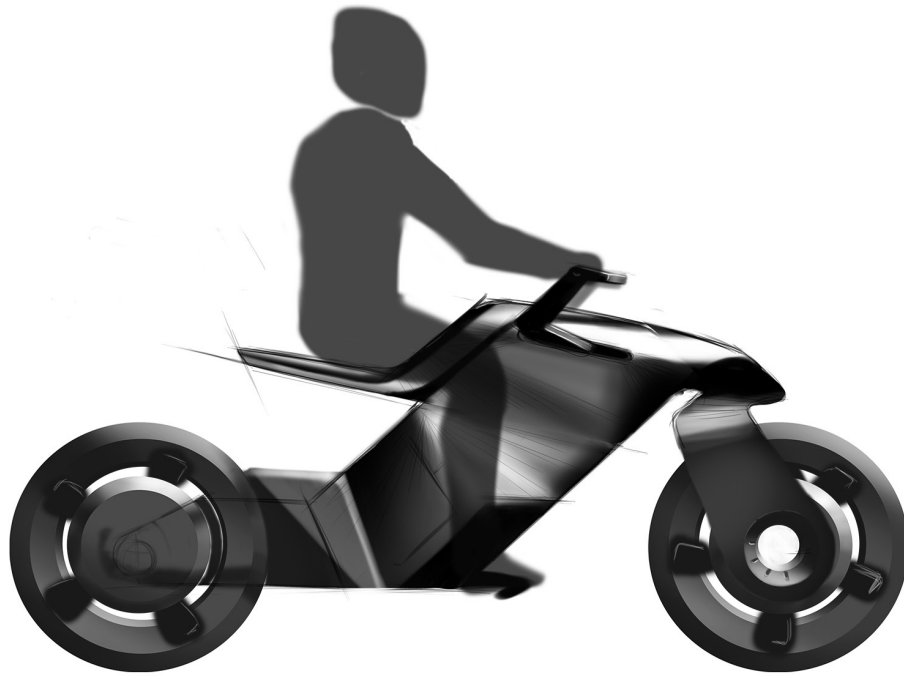


Fig 104. Concept 1 - idea refinement



**Concept 1:**  
**ACTIVE SKIN**

Asymmetrical design with  
active surfaces that fold  
and unfold to propagate the  
transformation

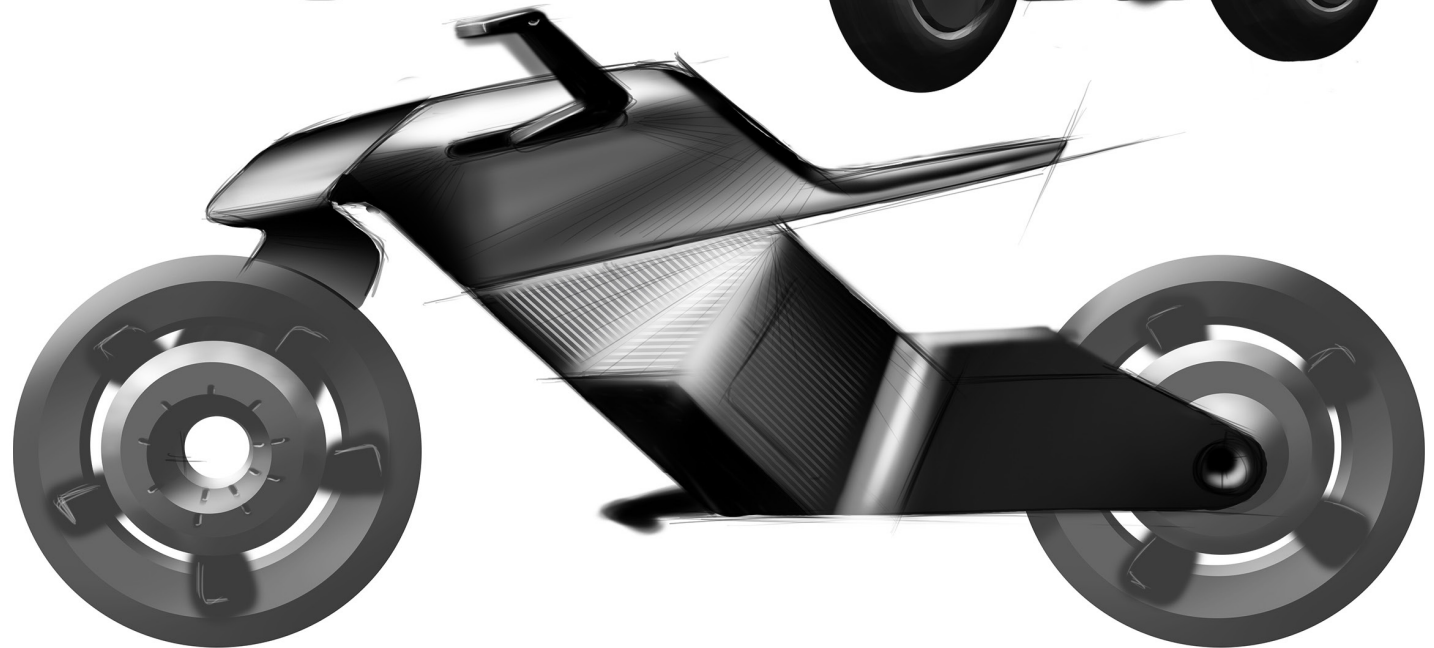
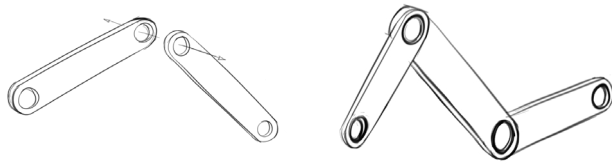


Fig 105. Concept 1 - Final sketch

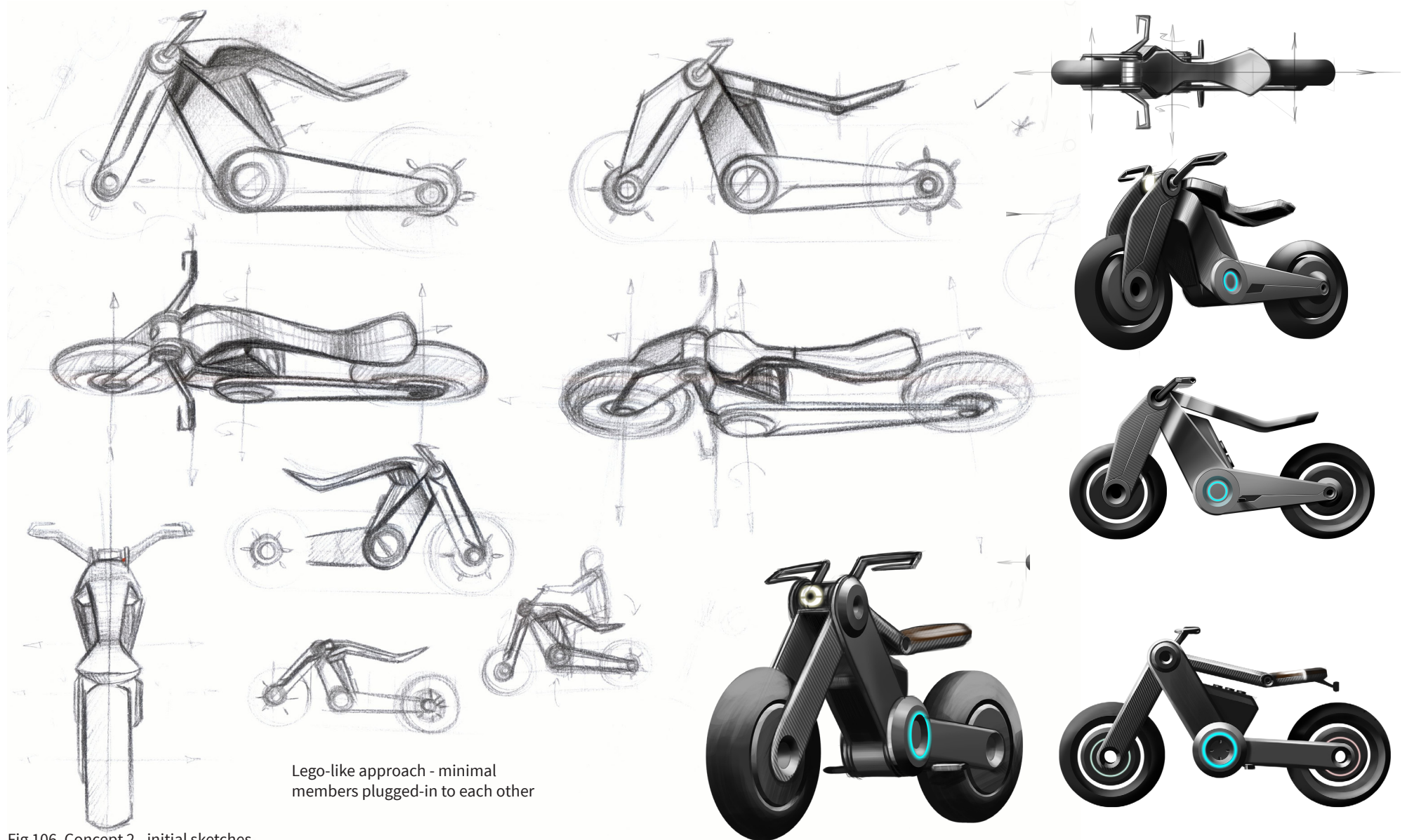
Project 3: Design of a Transformable E-Motorcycle for 2035





## 6.2.b Concept 2: Raw & Mechanical

In this concept, the idea of a bare-bone and naked concept was explored. The transformation happens at pivot points which are showcased evidently giving a very analogous feel to the design. This idea celebrates the transformability of the bike without hiding it behind skins.



Lego-like approach - minimal members plugged-in to each other

Fig 106. Concept 2 - initial sketches

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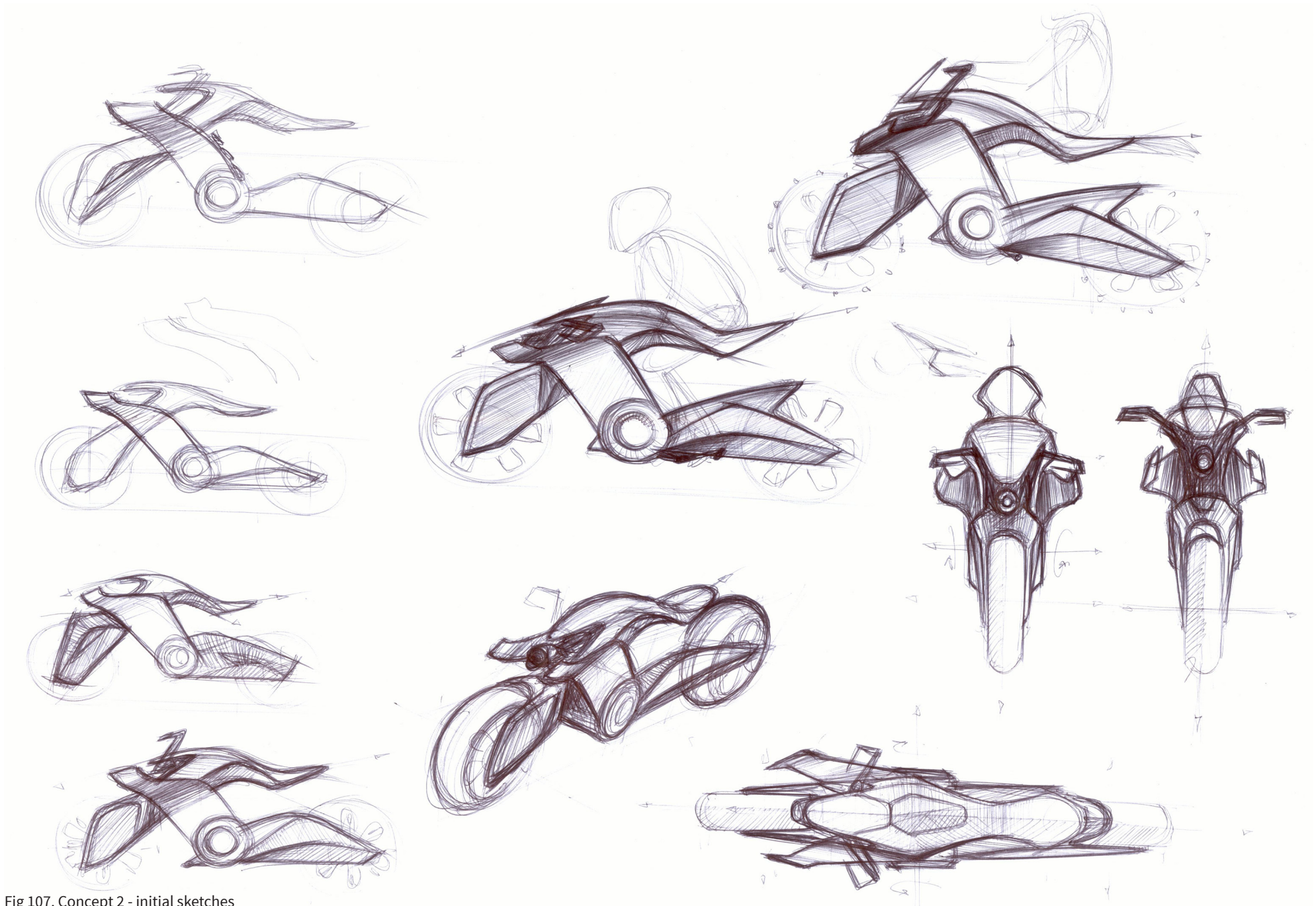


Fig 107. Concept 2 - initial sketches

Project 3: Design of a Transformable E-Motorcycle for 2035



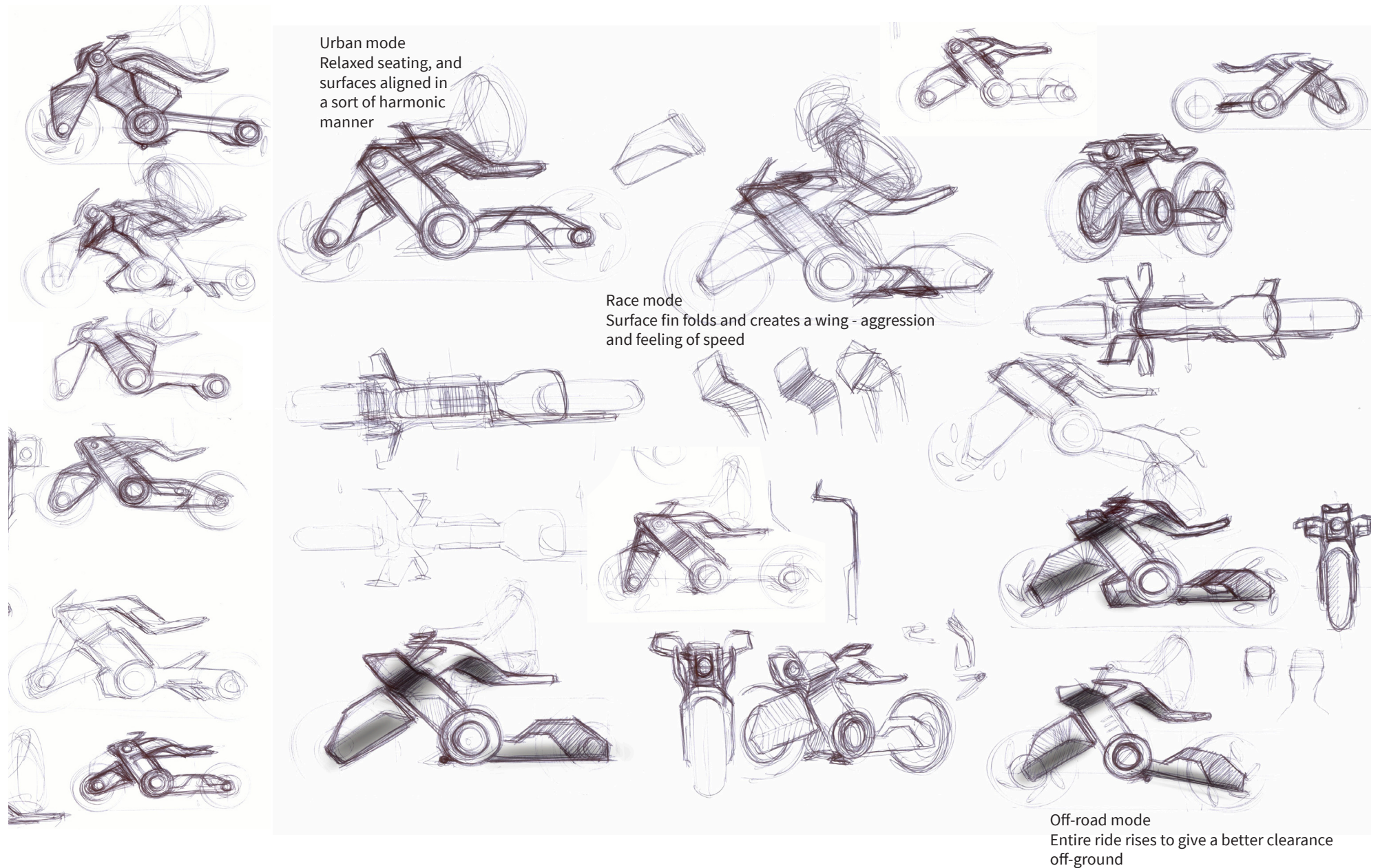
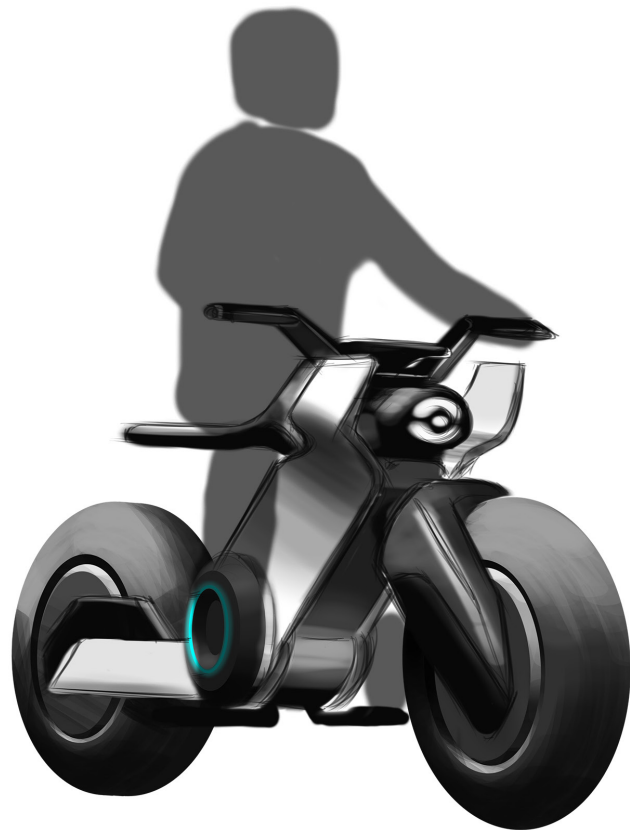


Fig 108. Concept 2 - idea refinement

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## Concept 2: BARE BONES

The raw structure has minimal surfaces giving a very analogous and mechanical feel to it. The central pivot is emphasized in an attempt to celebrate the idea of transformability

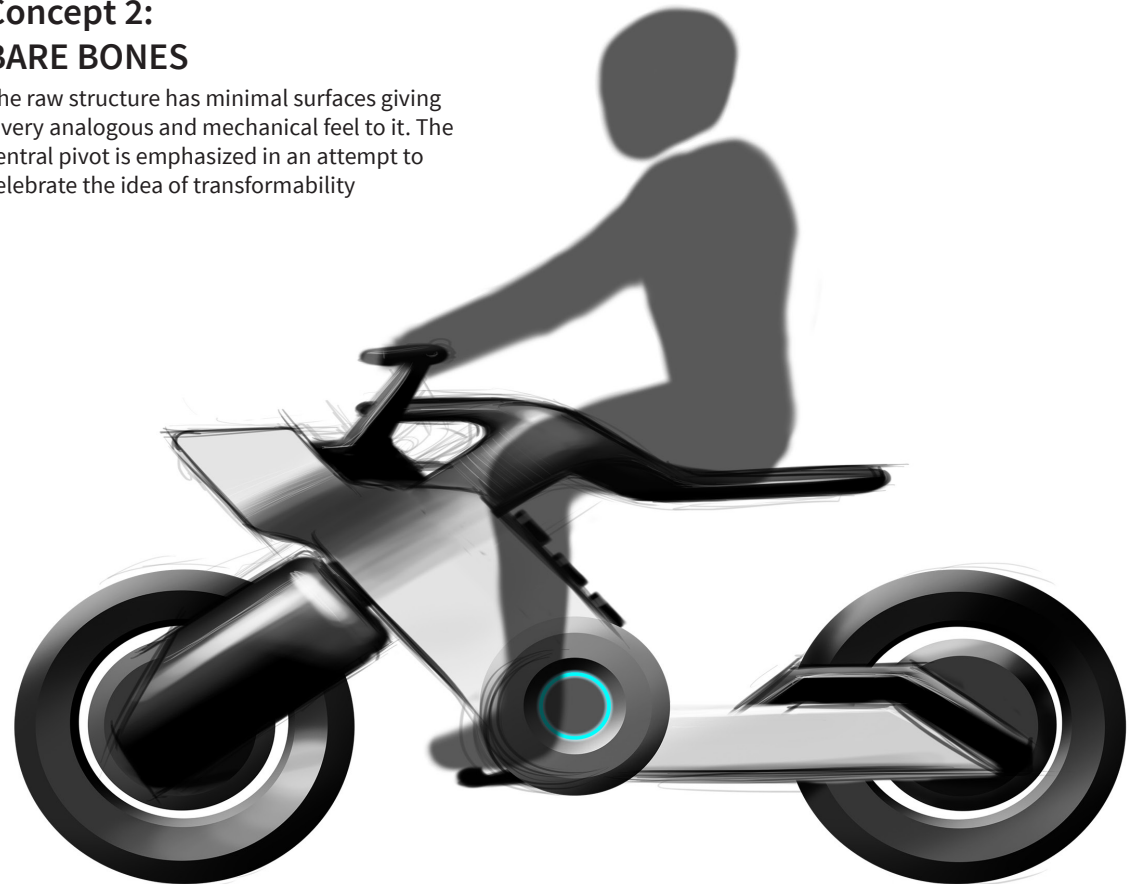
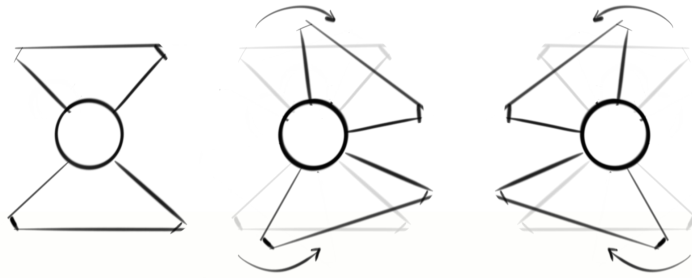
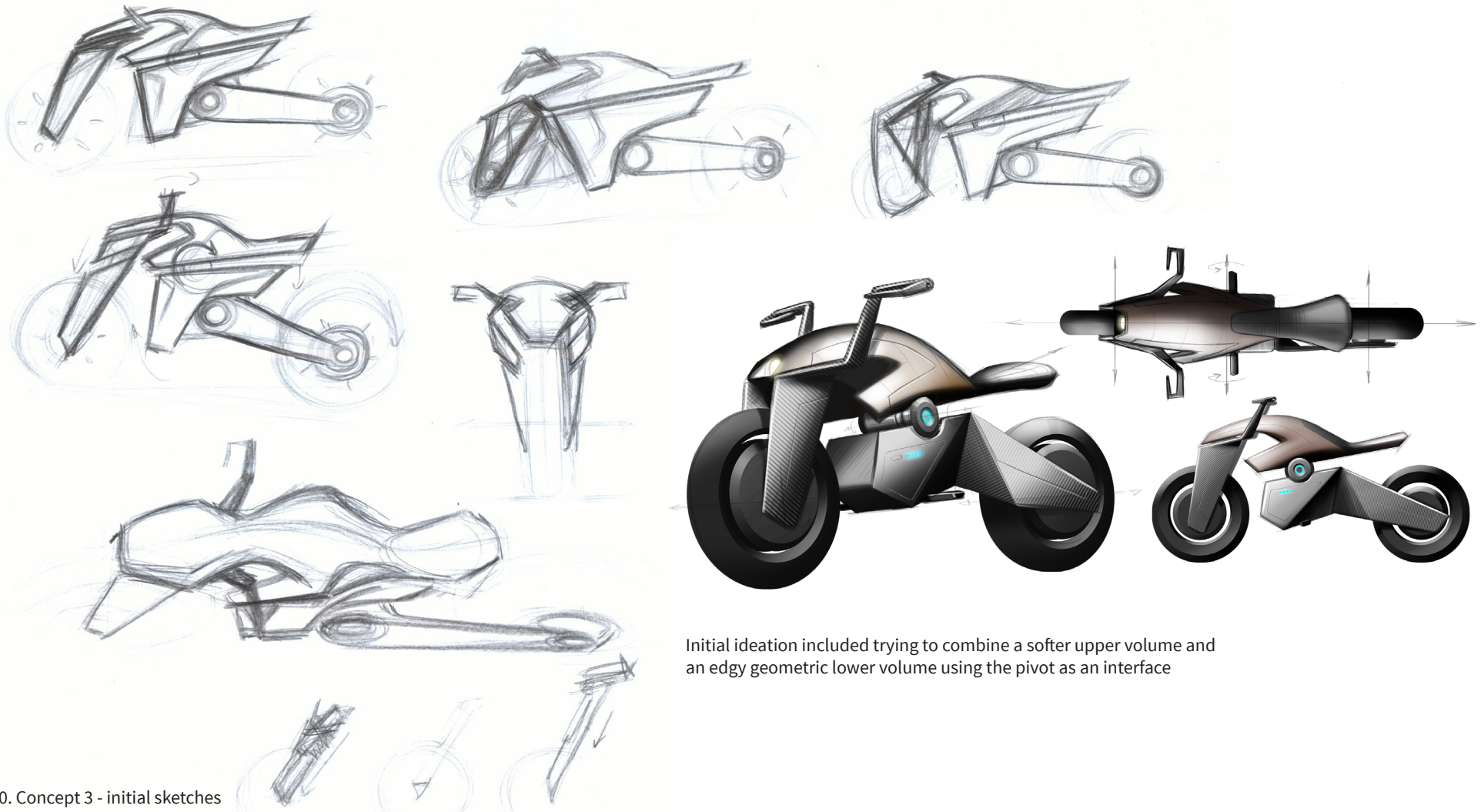


Fig 109. Concept 2 - Final sketch



### 6.2.c Concept 3: Centre pivot

In this concept, an attempt has been made to explore transformation by using a pivot to separate the upper and lower volumes of the bike. This enables the bike to undergo transformation by using minimum pivot points unlike Concept 2



Initial ideation included trying to combine a softer upper volume and an edgy geometric lower volume using the pivot as an interface

Fig 110. Concept 3 - initial sketches

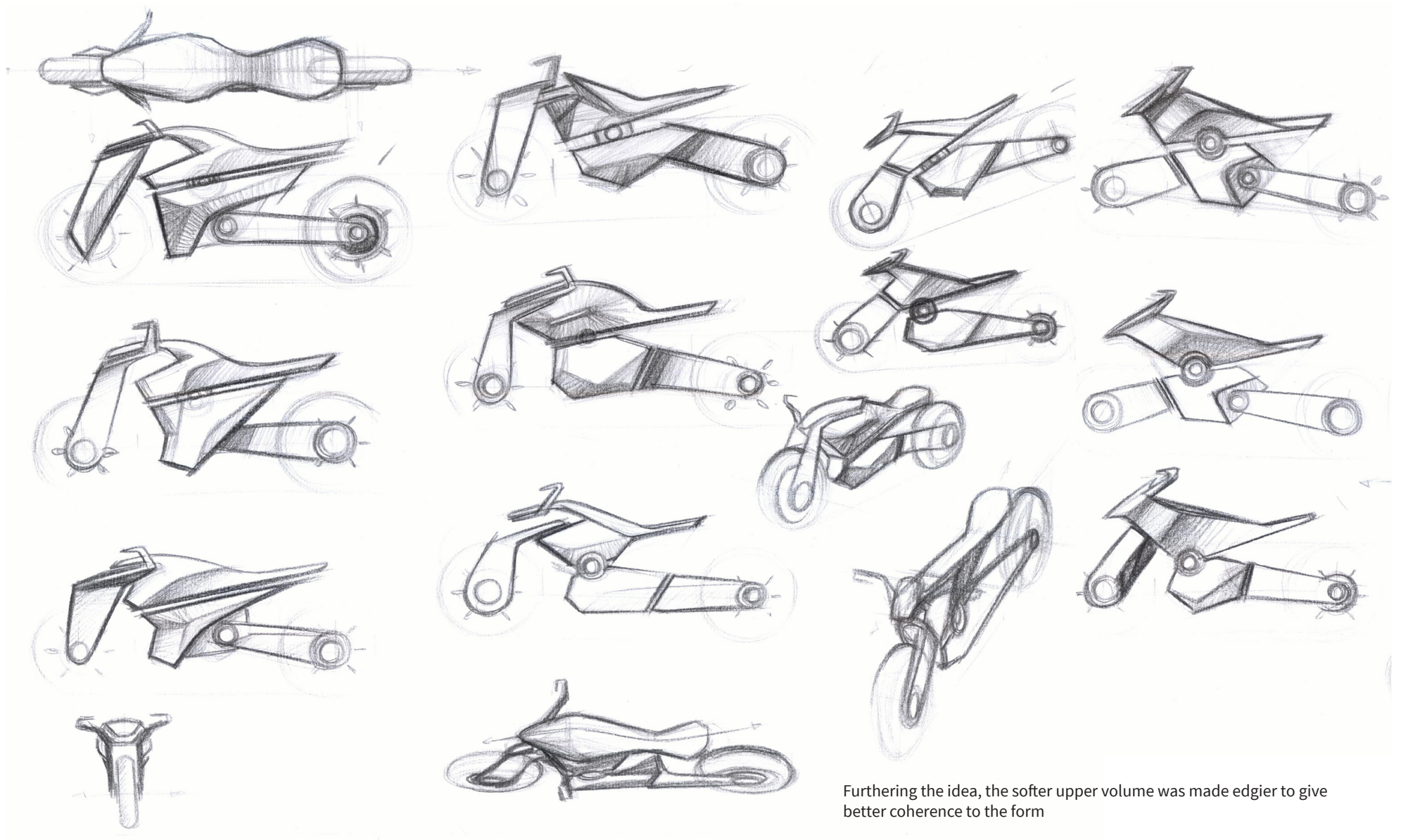


Fig 111. Concept 3 - initial sketches

Project 3: Design of a Transformable E-Motorcycle for 2035



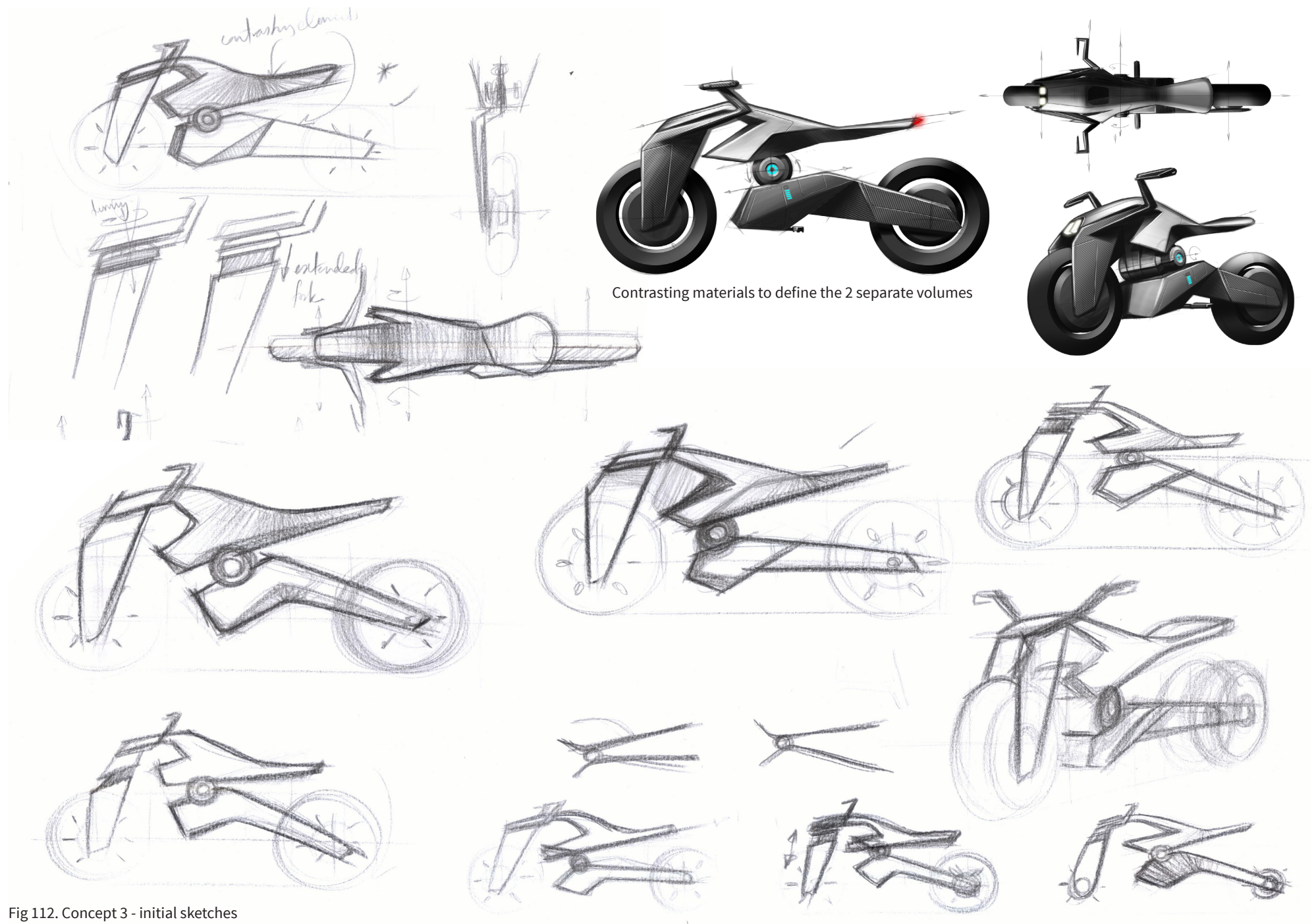


Fig 112. Concept 3 - initial sketches

Project 3: Design of a Transformable E-Motorcycle for 2035

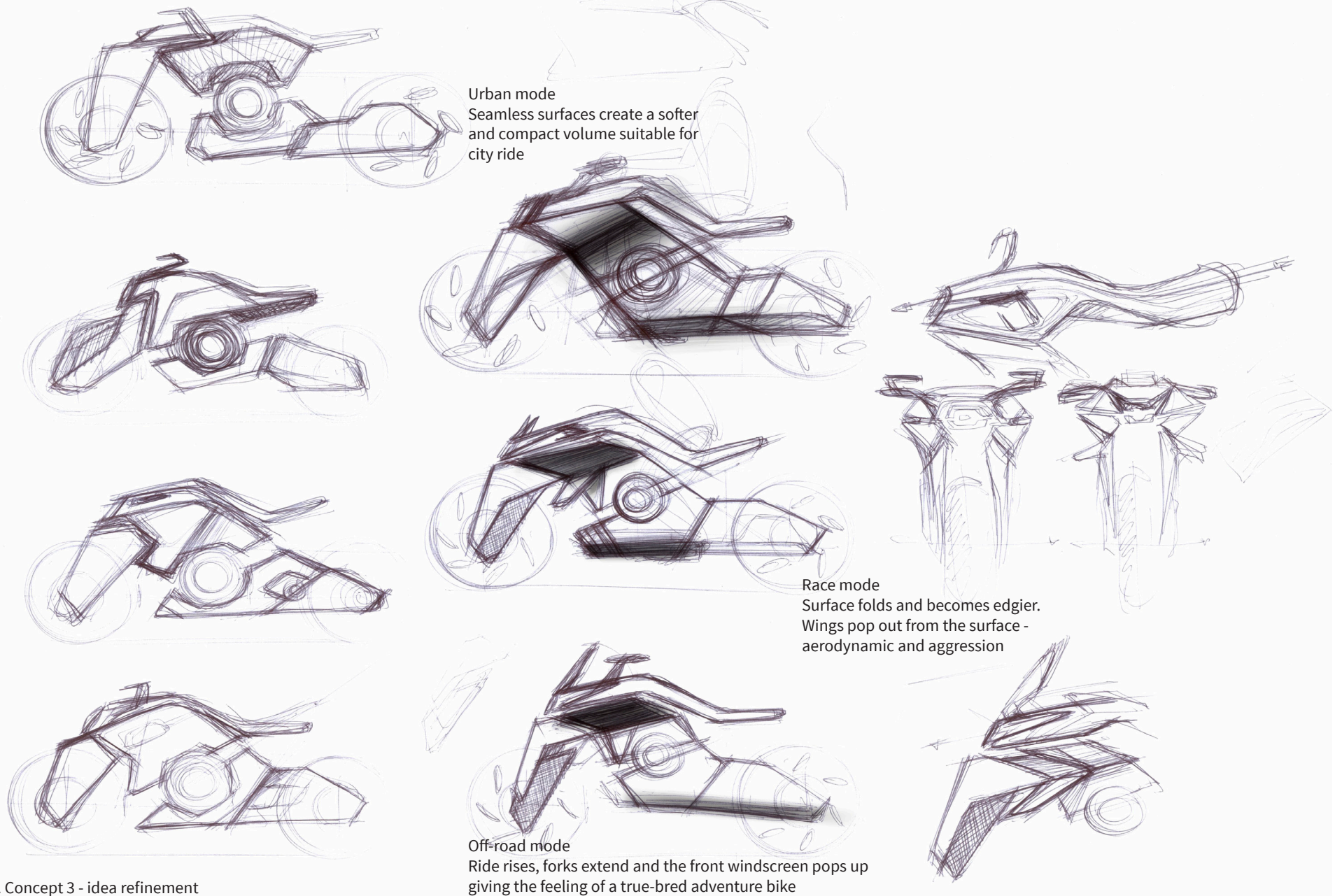


Fig 113. Concept 3 - idea refinement



### Concept 3: CENTRAL PIVOT

The central single pivot enable the bike to undergo transformation to satisfy ergonomic needs of all 3 ride modes without making major local transformations

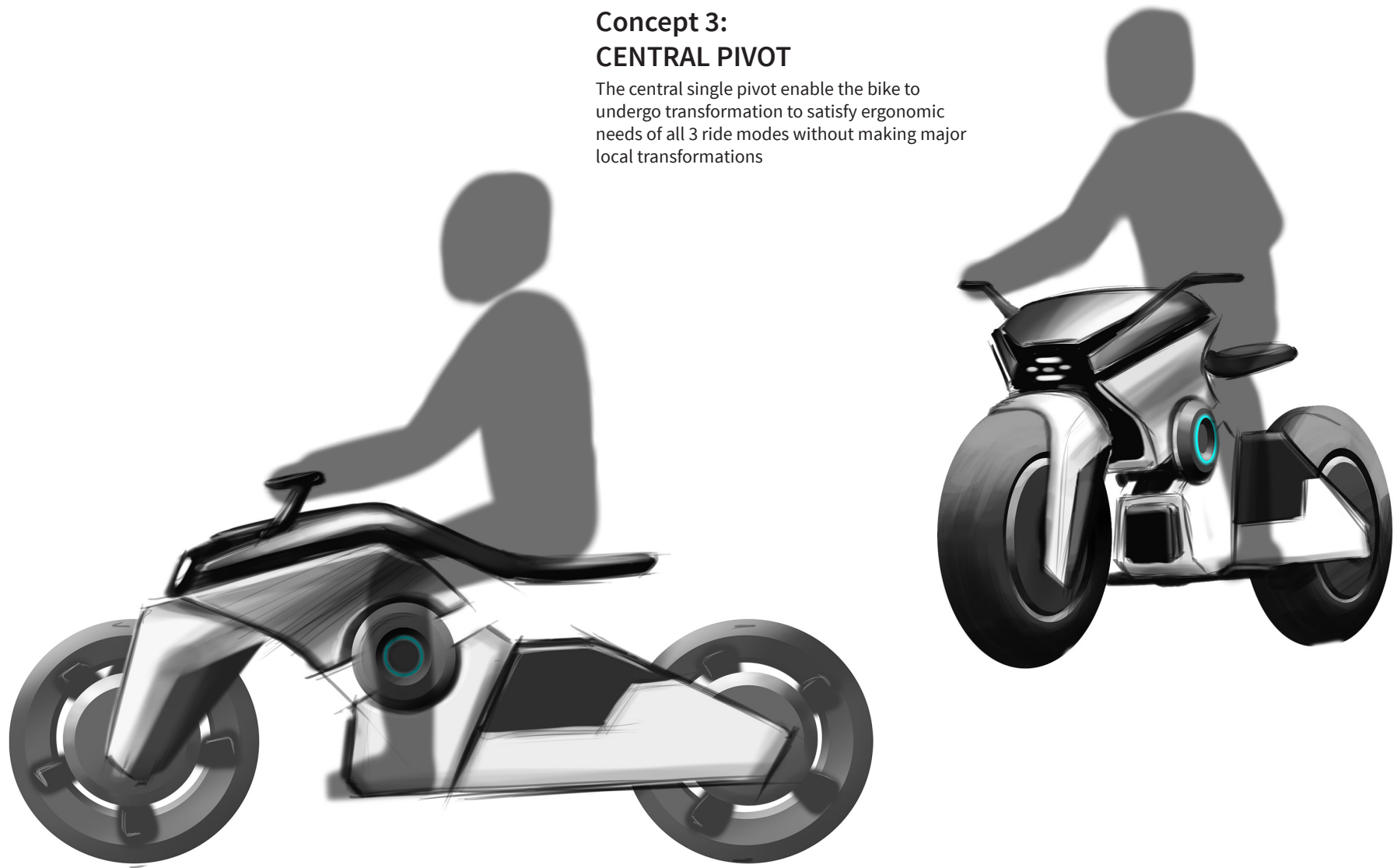
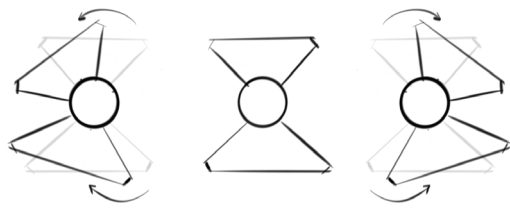
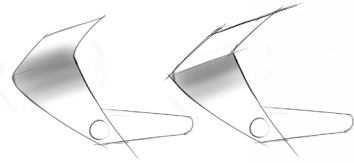


Fig 114. Concept 3 - final sketch





+



#### 6.2.d Concept 4: Active surfaces + central pivot

The fourth concept deals with exploring the possibilities of achieving transformation by combining the concepts explored in direction 1 and direction 3. Active surfaces contribute to the local transformation which enhances the experience while the major ergonomic changes is taken care of with the transformation done by the central pivot.

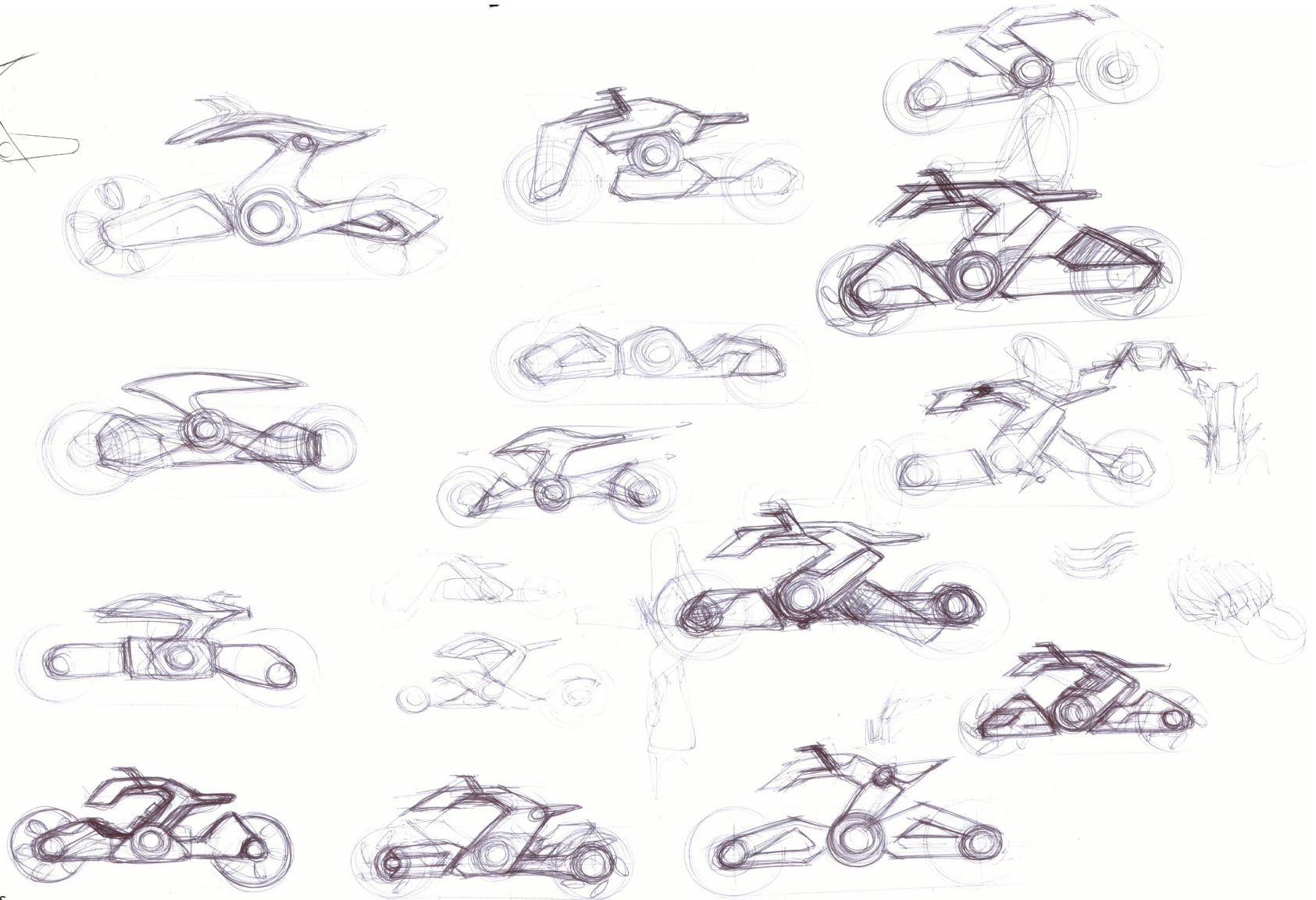
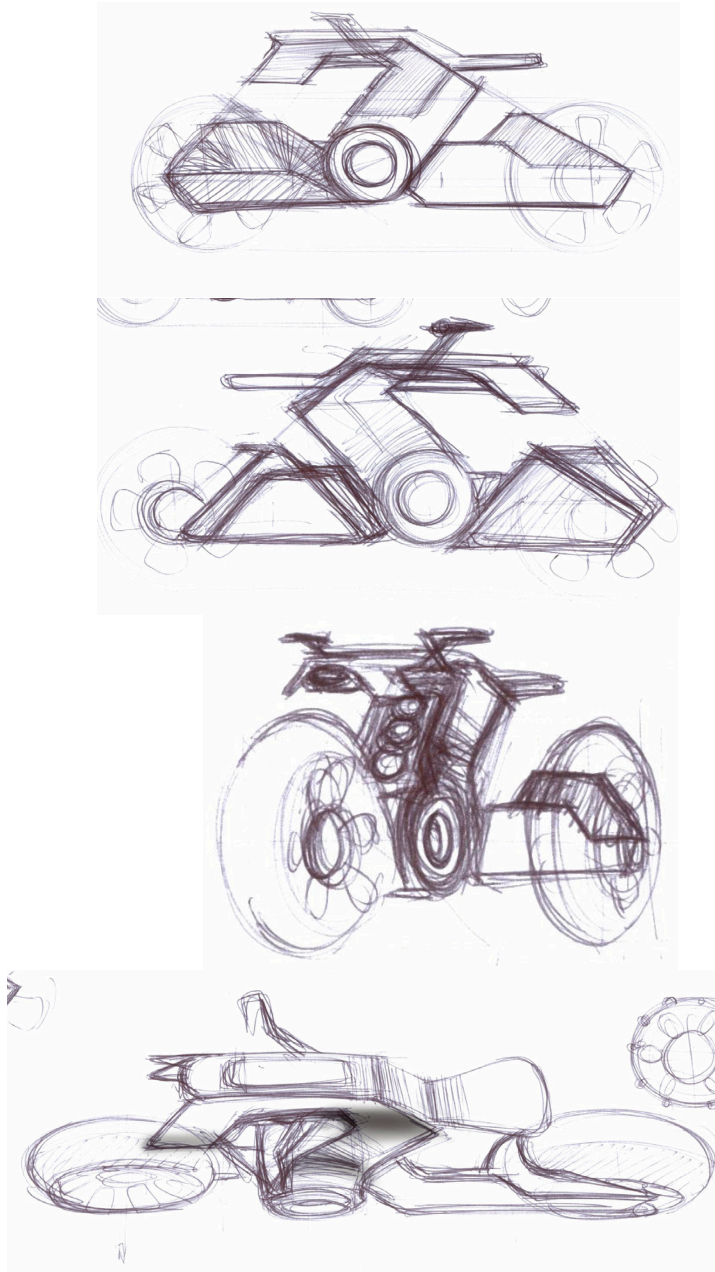
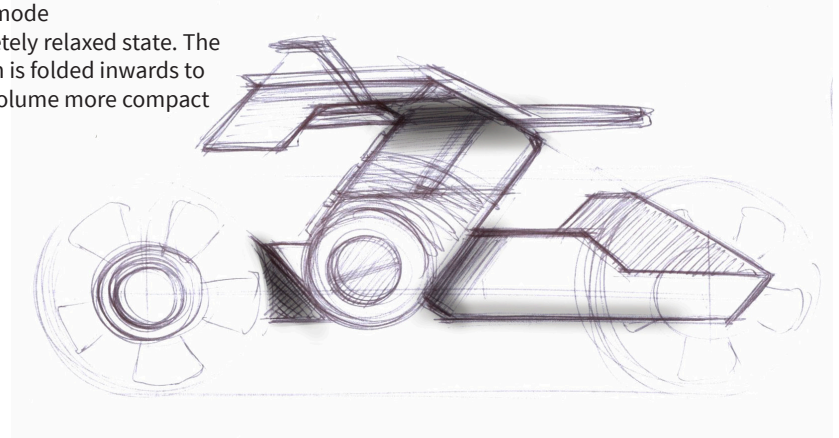


Fig 115. Concept 4 - initial sketches



Urban mode  
Completely relaxed state. The front fin is folded inwards to make volume more compact



Race mode  
The rider stance completely tilts, making the posture highly aggressive. The fin opens out like a sharp wing

Off-road mode  
Ride tilts back making the front appear much larger for the rider. The fin becomes flat and adds to the perceived volume

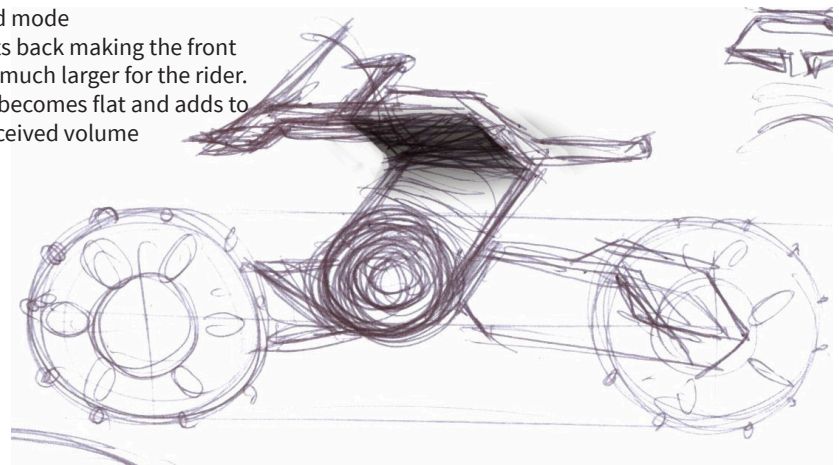


Fig 116. Concept 4 - idea refinement

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#### Concept 4: ACTIVE SKIN + PIVOT

This direction uses the best of direction 1 and 3 to arrive at a feasible solution.

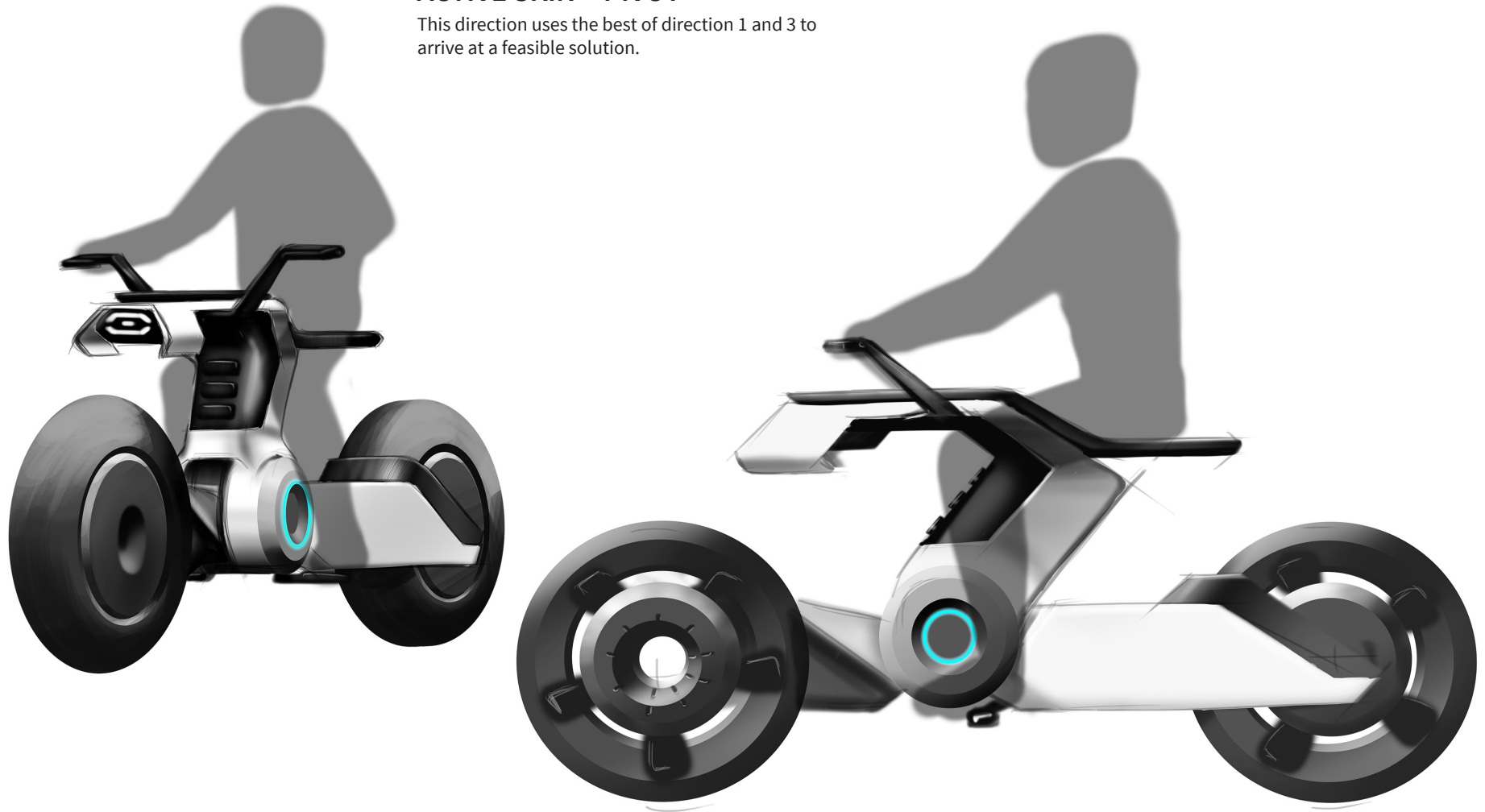


Fig 117. Concept 4 - final sketch



### 6.2.e Concept Evaluation

A peer review was done to evaluate the concepts based on certain criteria. This provided a credible comparison between all four concepts and the best of the lot was picked to be developed into the final design. The results came out after interaction with 10 reviewers.

#### Criteria

1. On a scale of 1-5, rate how much do you feel and anticipate that it looks like this design would transform
2. On a scale of 1-5, how futuristic do you think this design is
3. On a scale of 1-5, how much would you like to ride/enjoy riding this?
4. On a scale of 1-5, how satisfied are you with the transformation?

#### Concept 1

11

17

9

14

#### Concept 2

15

**22**

21

19

#### Concept 3

19

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**22**

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#### Concept 4

**29**

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26

**30**

From the evaluation, it was understood that concept 4 was the most promising one to be further developed and refined.

## 6.3 Design development

Based on the evaluation, concept 4 was selected to be developed and styled further.

### 6.3.a Mood board

The mood board comprised of images which would symbolize the 'edgy' and 'dynamic' nature of the young generation in 2035.

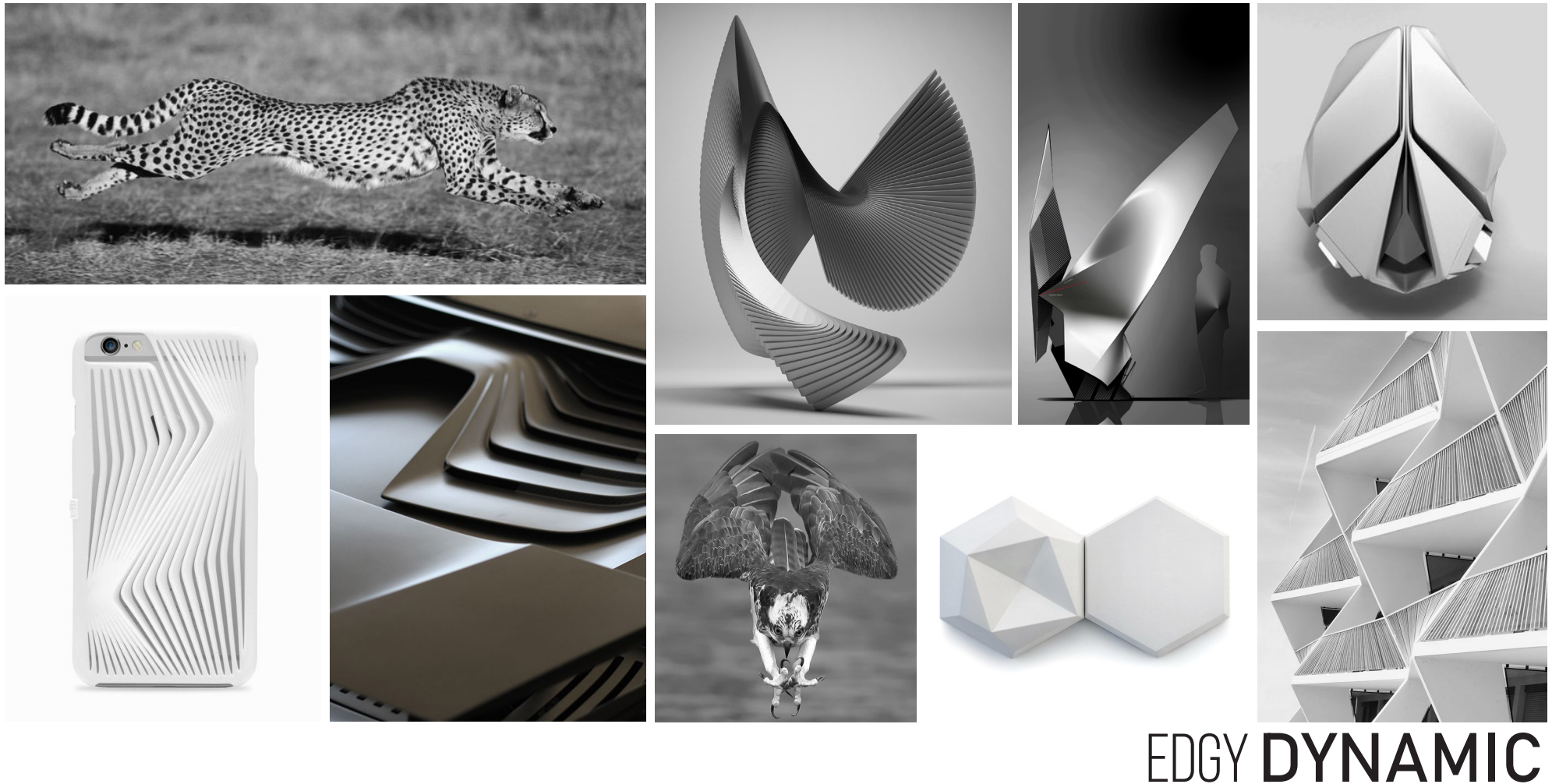


Fig 118. Mood board

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### 6.3.b Form styling

Taking inspiration from the mood board, the finalized direction is developed and styled.

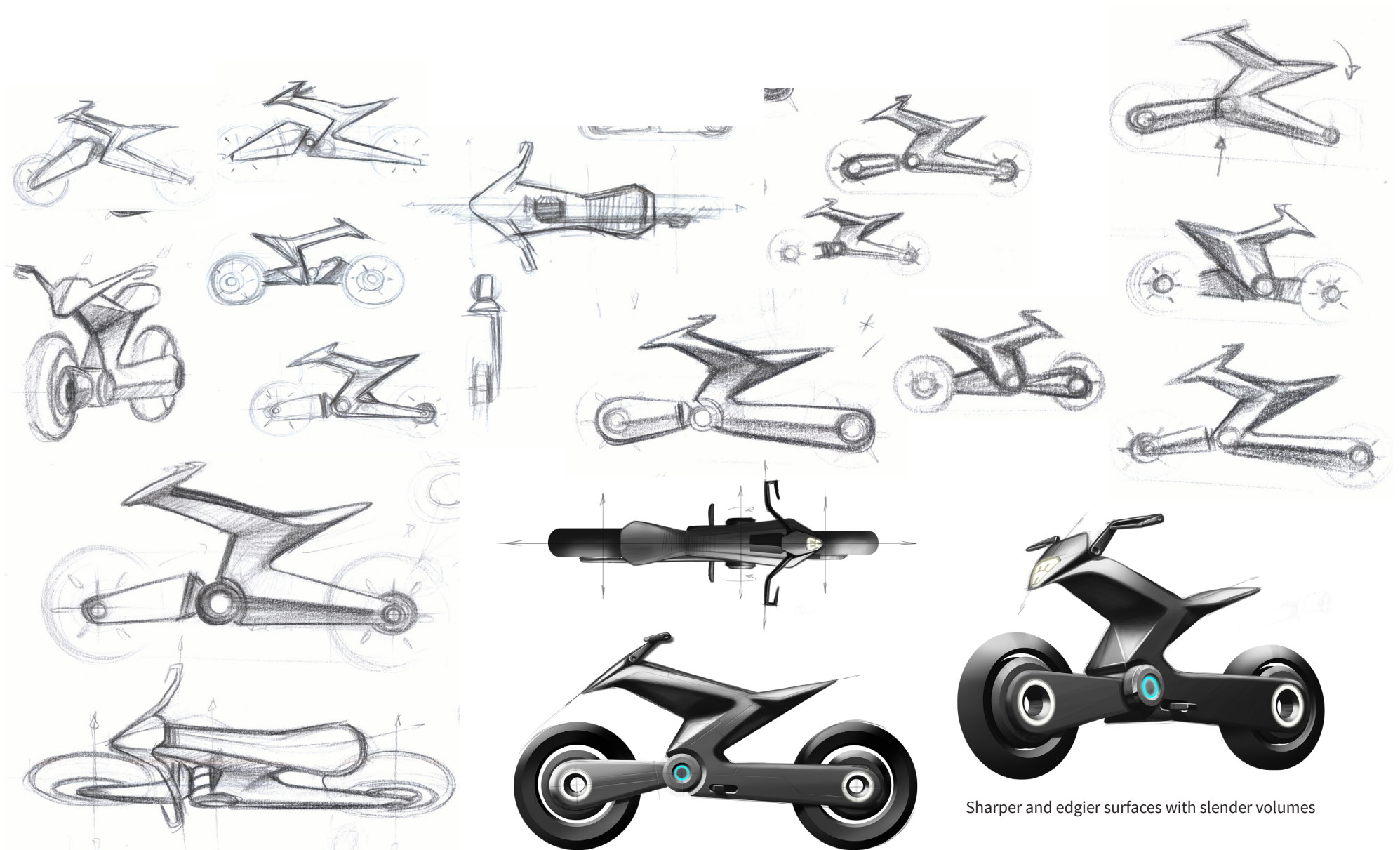


Fig 119. Initial sketches

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Sharper and edgier surfaces with slender volumes



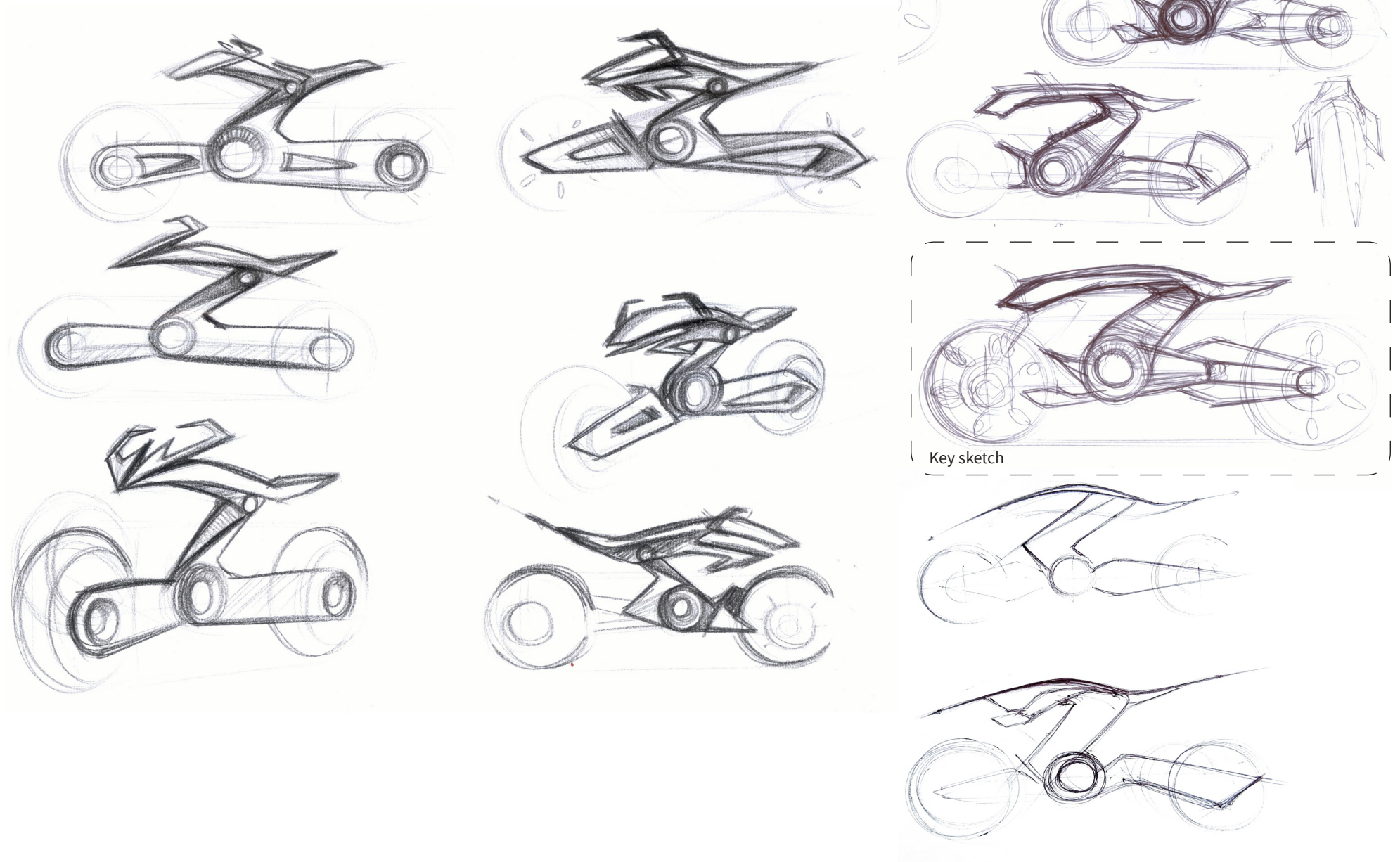


Fig 120. Initial sketches

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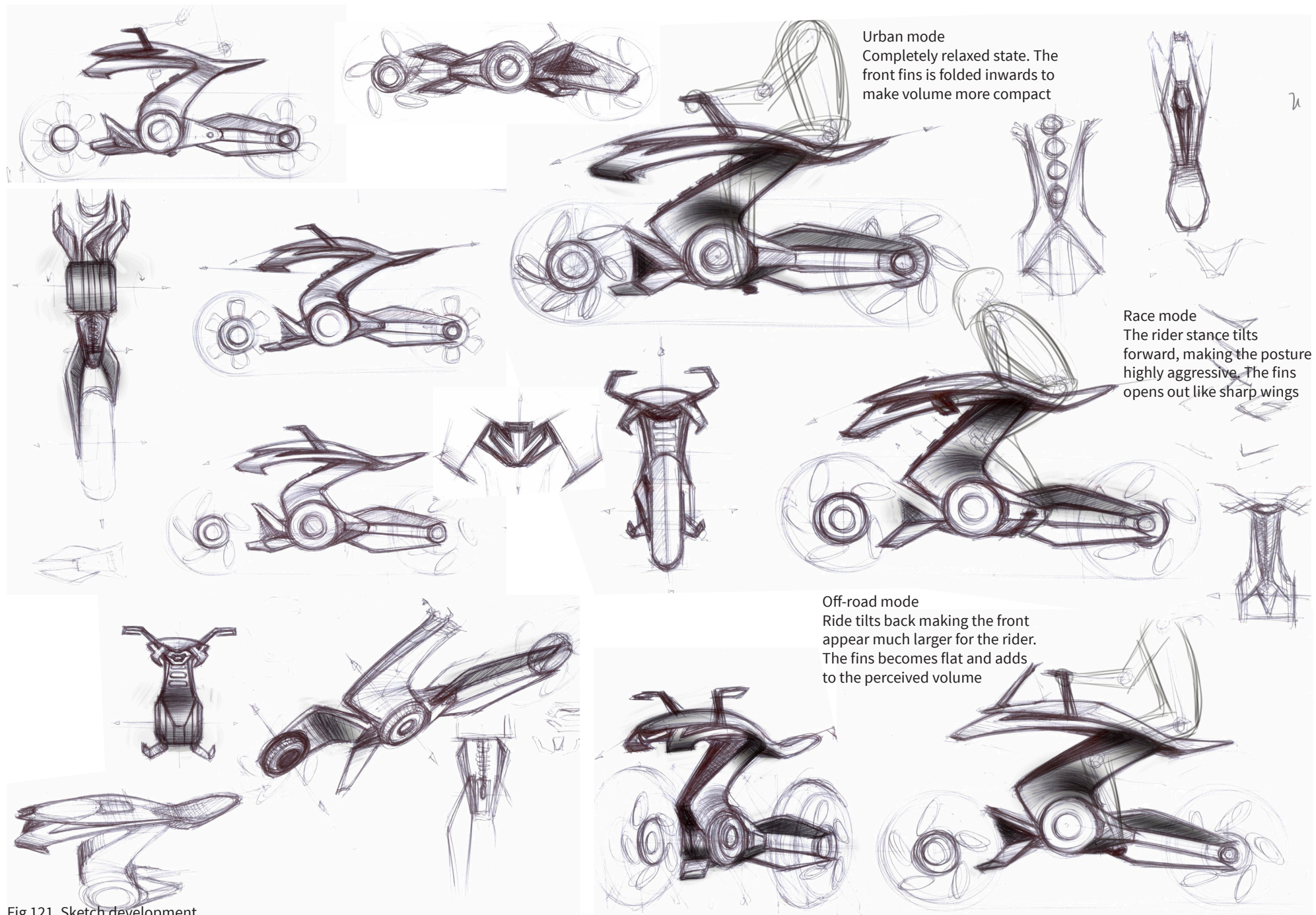
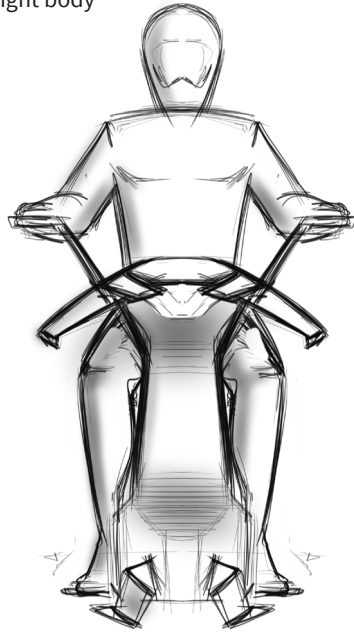
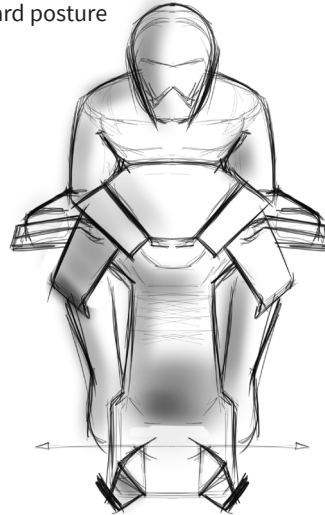


Fig 121. Sketch development

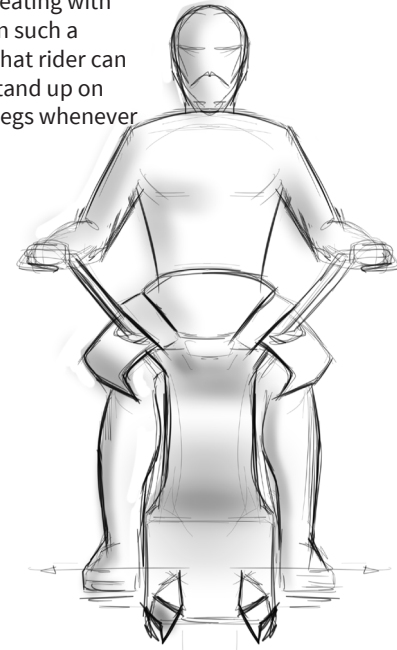
Urban mode  
Relaxed seating  
with upright body  
posture



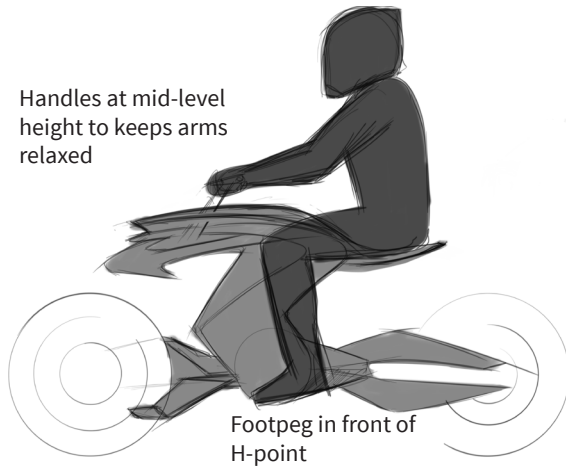
Race mode  
Aggressive with a  
lean forward posture



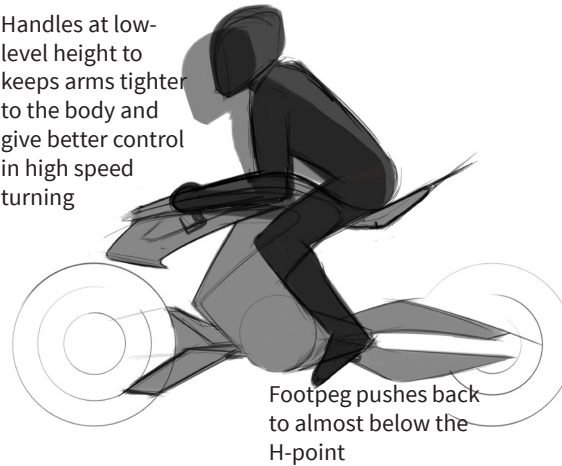
Off-road mode  
Upright seating with  
posture in such a  
manner that rider can  
quickly stand up on  
the footpegs whenever  
required



Handles at mid-level  
height to keeps arms  
relaxed



Handles at low-  
level height to  
keeps arms tighter  
to the body and  
give better control  
in high speed  
turning



Handles at high-level  
height to keeps arms  
to account for the  
rider standing up and  
riding during off-road  
sessions

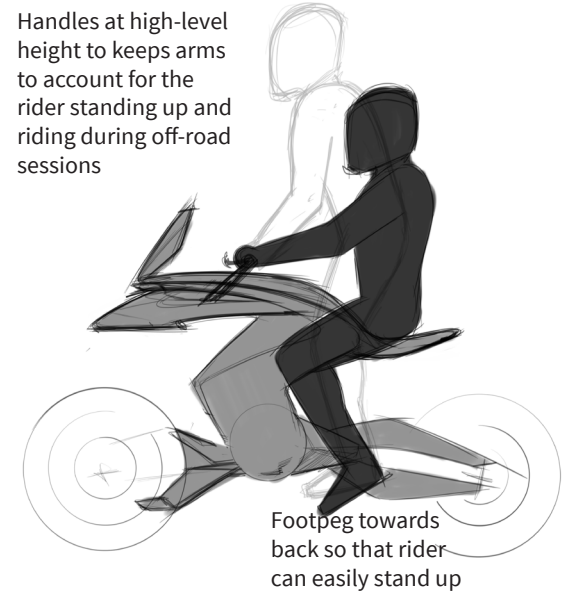
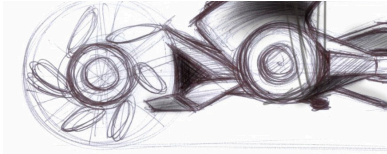


Fig 122. Sketch development - riding experience

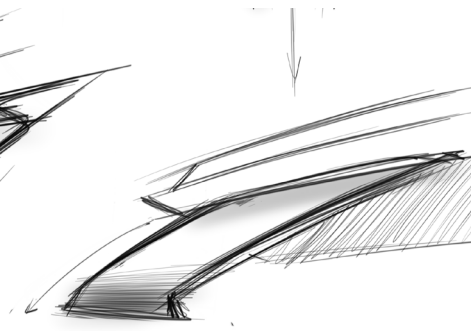
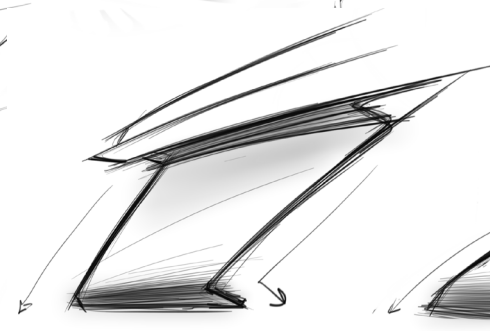
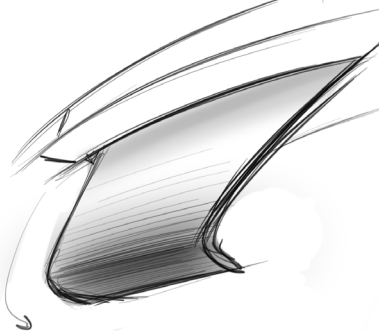
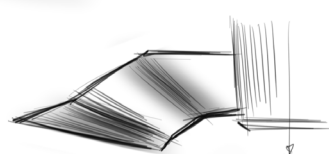
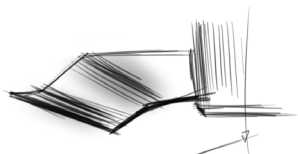
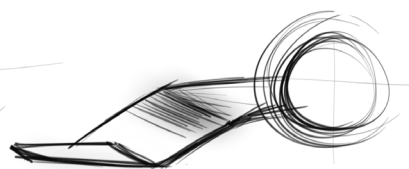
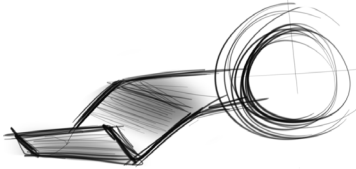
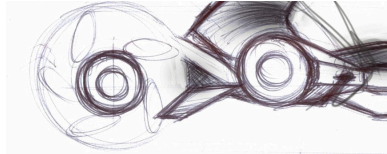
Project 3: Design of a Transformable E-Motorcycle for 2035



Urban mode  
Lower fin folded inwards



Race mode  
Fins deploy



Urban mode  
Upper fin folded inwards

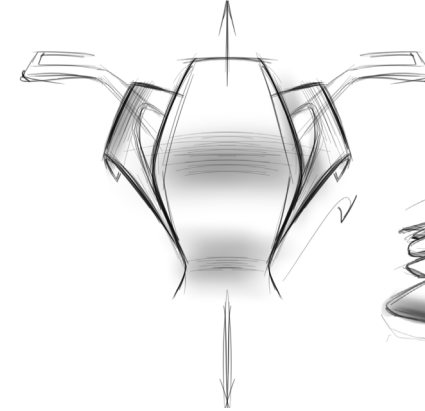


Race mode  
Fins deploy

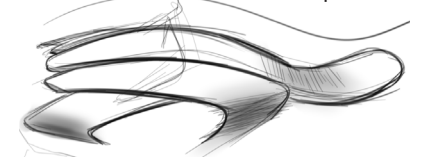


Off-road mode  
Fins open out further to increase visual volume

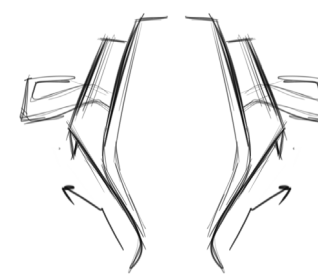
Urban mode  
Tank volume softer and more compact



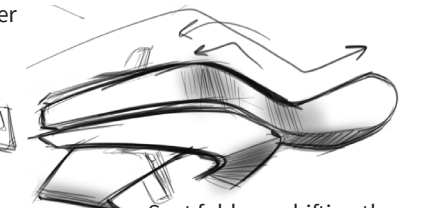
Seat in a relaxed posture



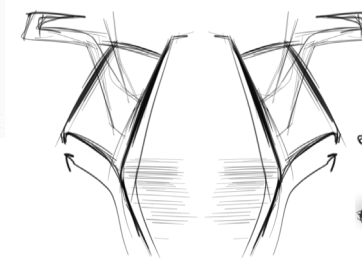
Race mode  
Tank volume sharper and edgier



Seat folds up shifting the rider to a lean-forward posture



Offroad mode  
Tank volume edgier and broader



Seat goes back to the relaxed posture

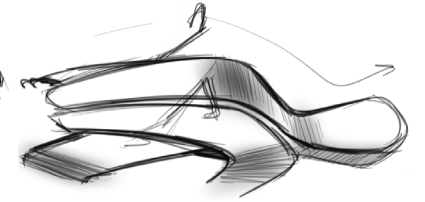


Fig 123. Sketch development - local transformations

## 6.4 Final concept

### 6.4.a Urban mode



Fig 124. Urban mode - perspective view

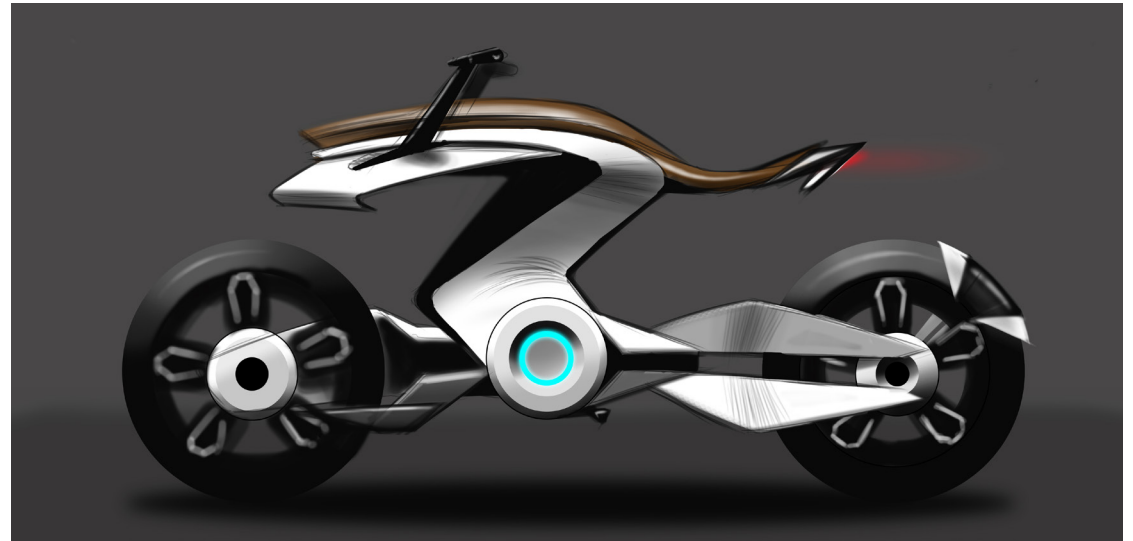


Fig 127. Urban mode - left side view

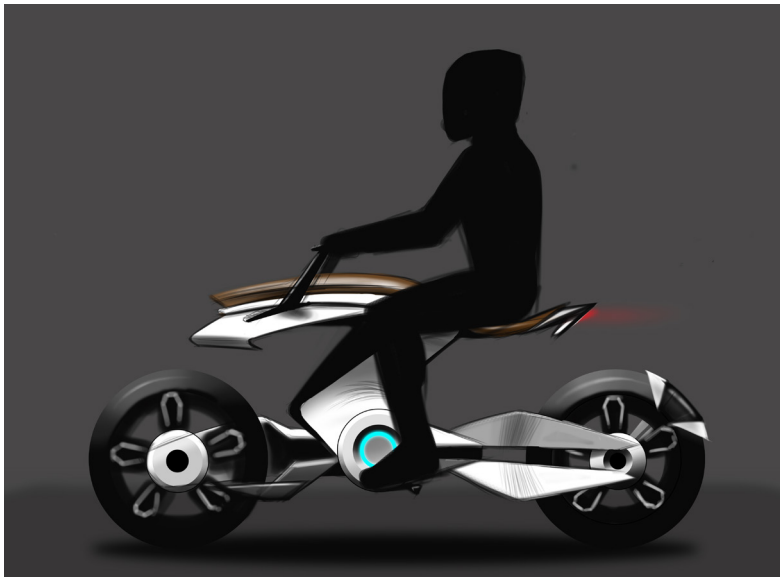


Fig 125. Urban mode - ride posture

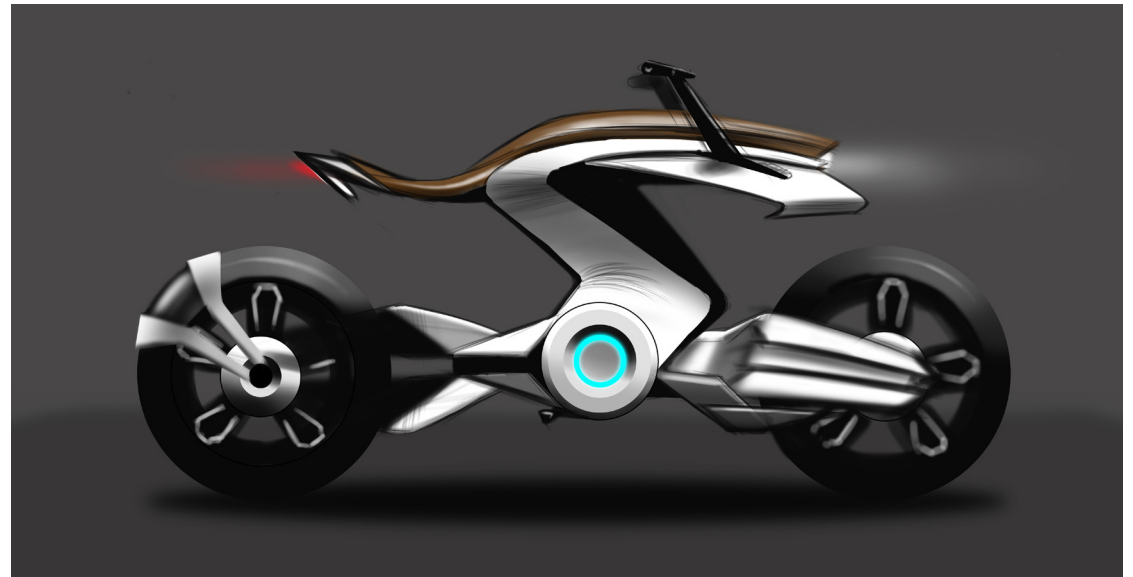


Fig 126. Urban mode - right side view

#### 6.4.b Race mode

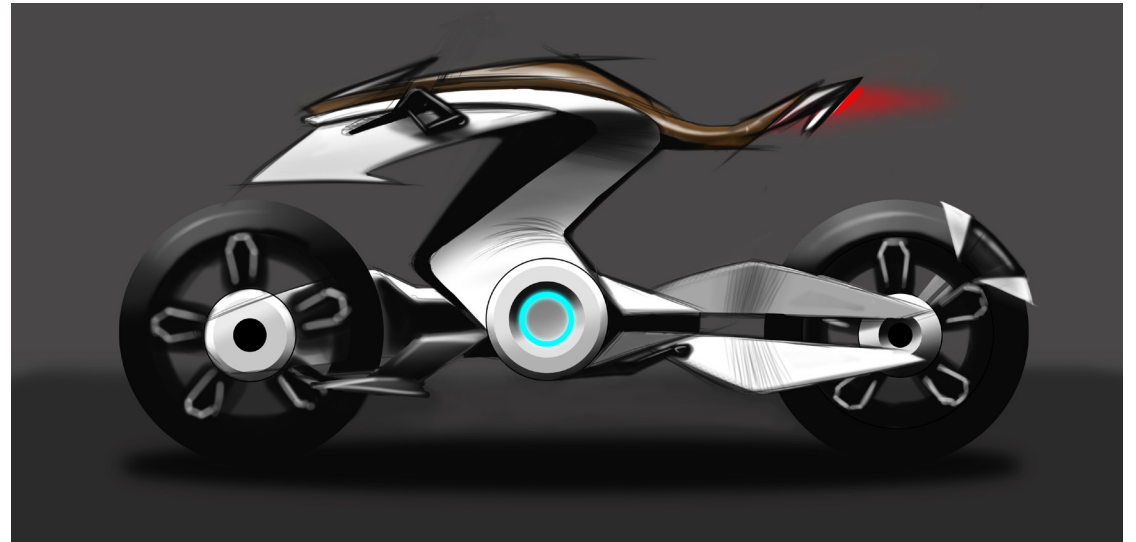


Fig 129. Race mode - left side view



Fig 128. Race mode - ride posture



#### 6.4.c Off-road mode



Fig 130. Off-road mode - ride posture

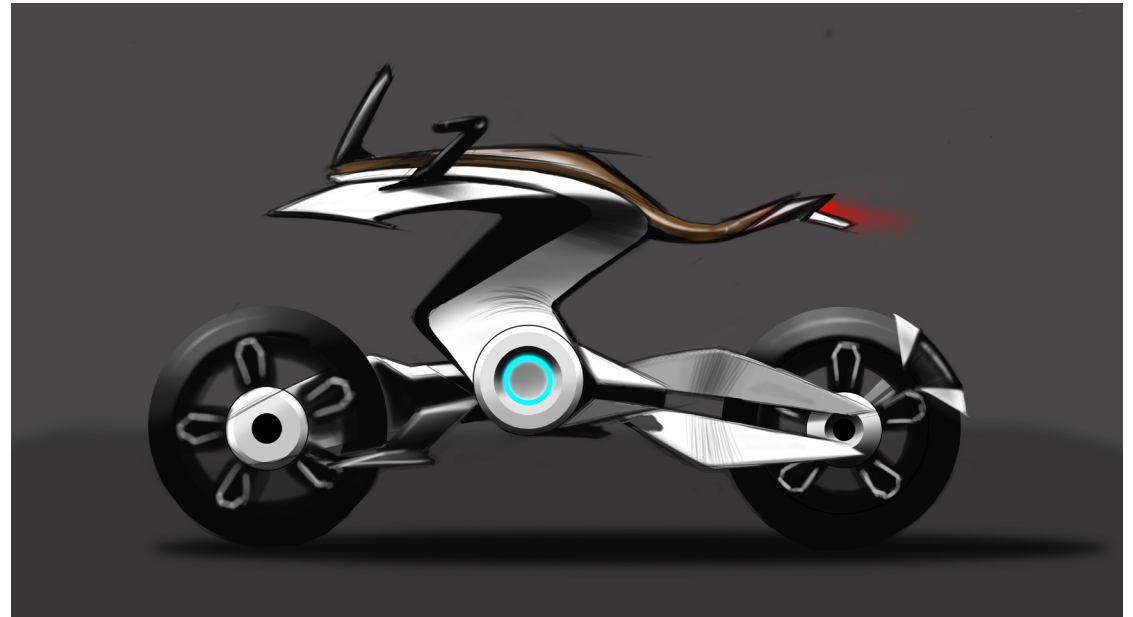


Fig 131. Off-road mode - left side view

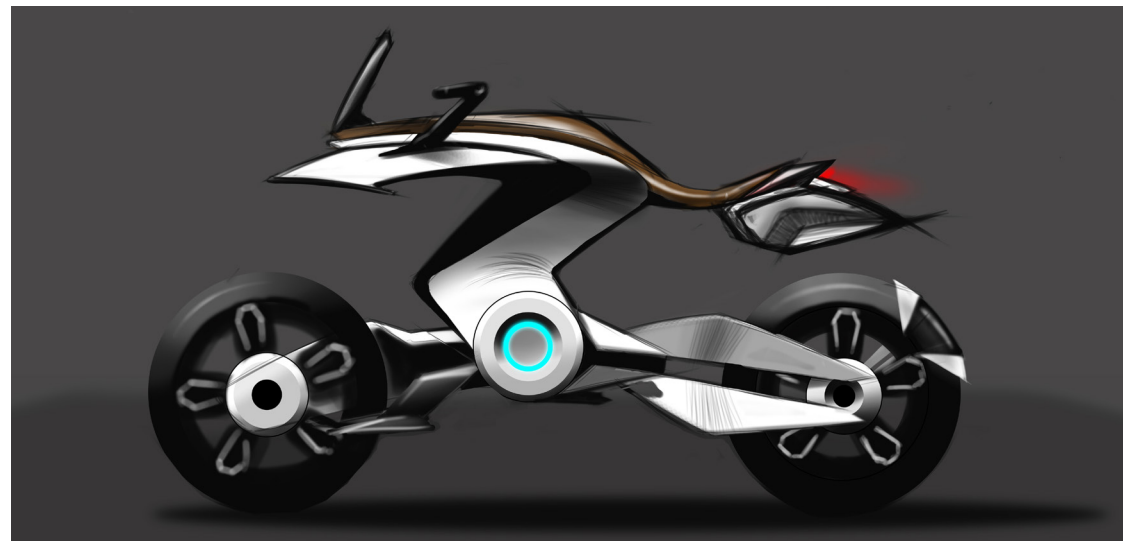


Fig 132. Off-road mode - optional pannier for storage

#### 6.4.d Customizability

The surface pieces are modular that they can be customized and changed as per user requirements. With 3D and 4D printing becoming very common, even the user himself can customize the design and print themselves.

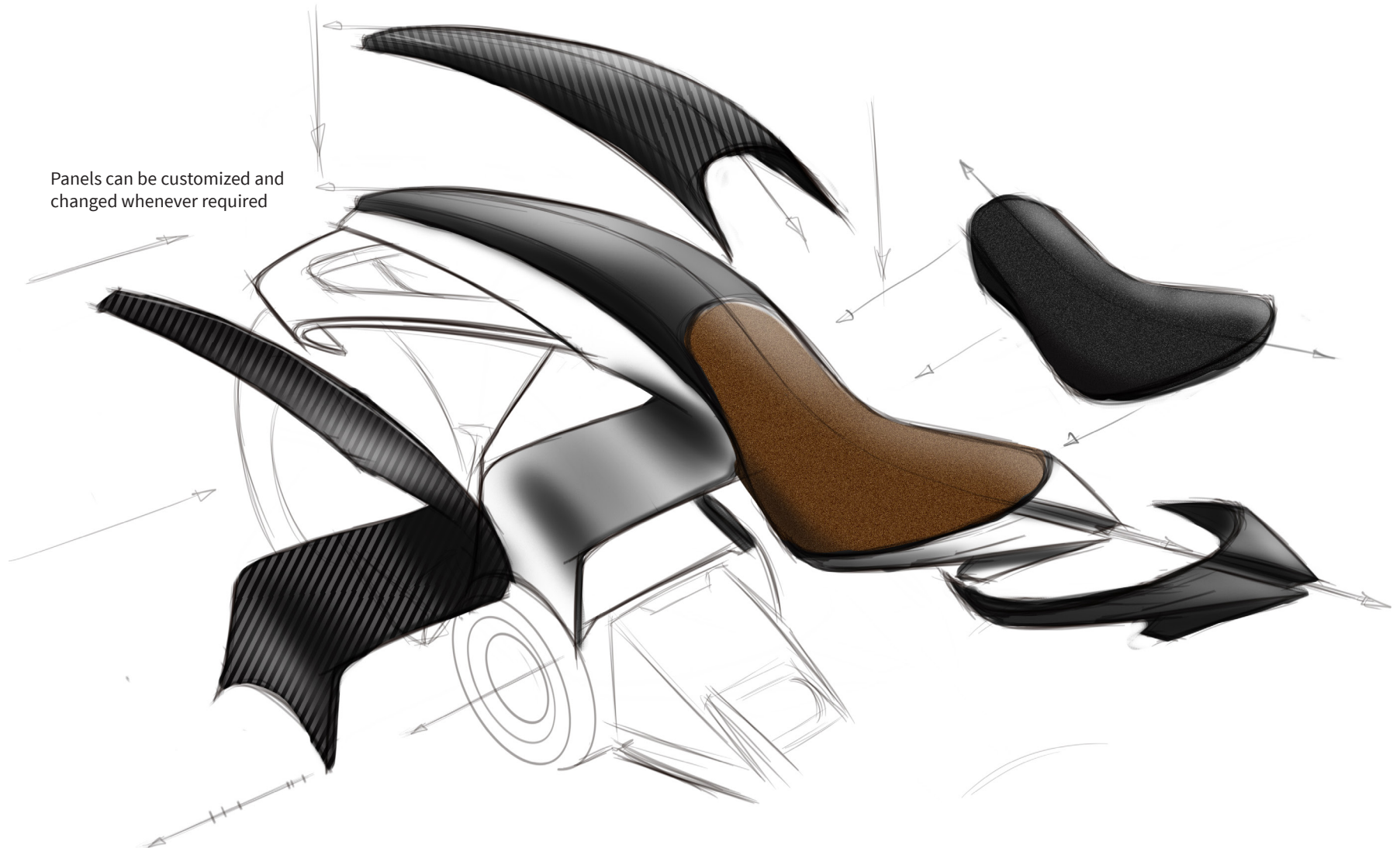


Fig 133. Customizable parts

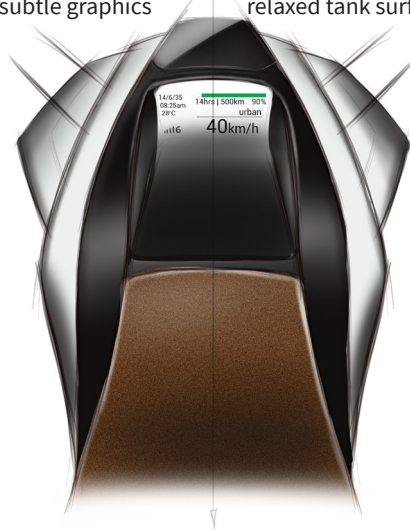
### 6.4.e Screen experience

With changes in the ride mode, the visuals which the user experience is also very important to the ride experience. With each mode change, the orientation of the display changes to suit the ride ergonomics, and the screen design also changes.



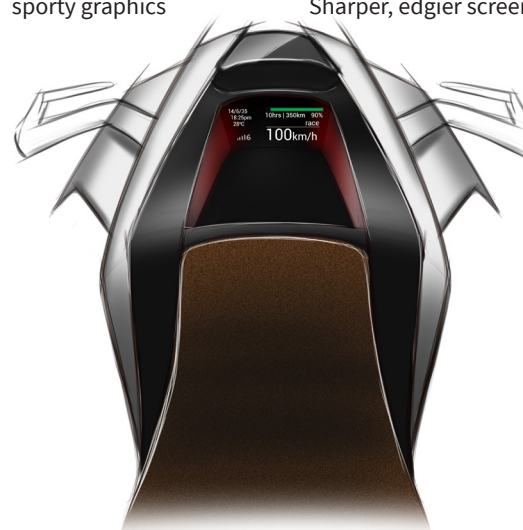
Lighter screen colour  
with subtle graphics

Gradually curved  
screen to match the  
relaxed tank surface



Dark theme with  
sporty graphics

Sharper, edgier screen



Dark theme  
retained, but  
graphics change

Sharper, edgier  
screen

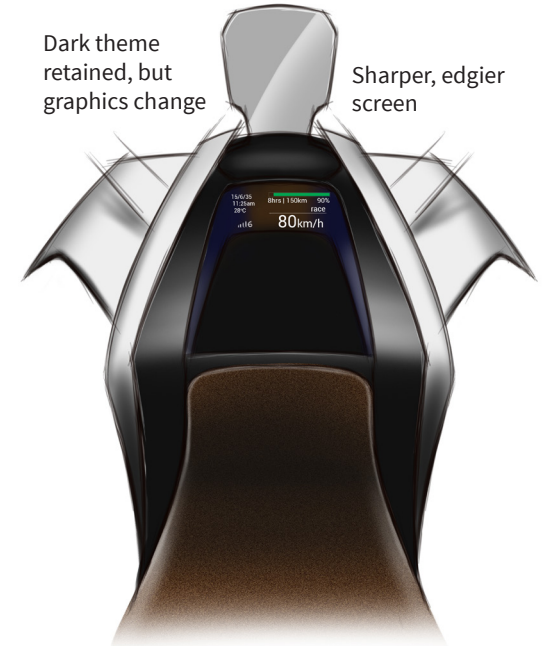


Fig 134. Display screen - urban mode

Fig 135. Display screen - race mode

Fig 136. Display screen - offroad mode



## 6.5 Final Layout and Packaging

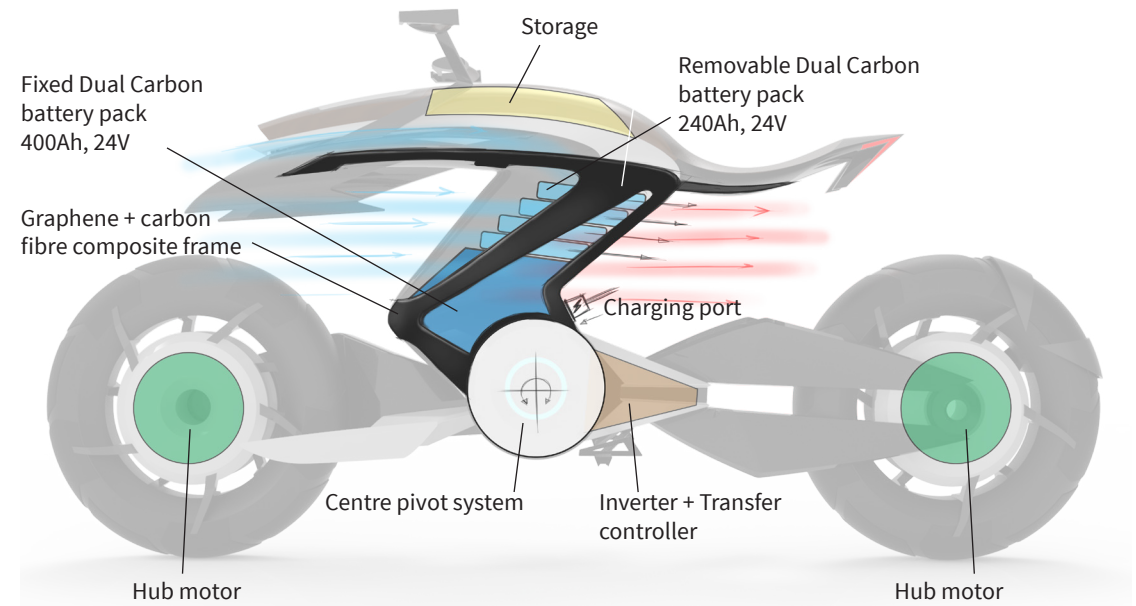


Fig 137. Final layout showing the placement of various components

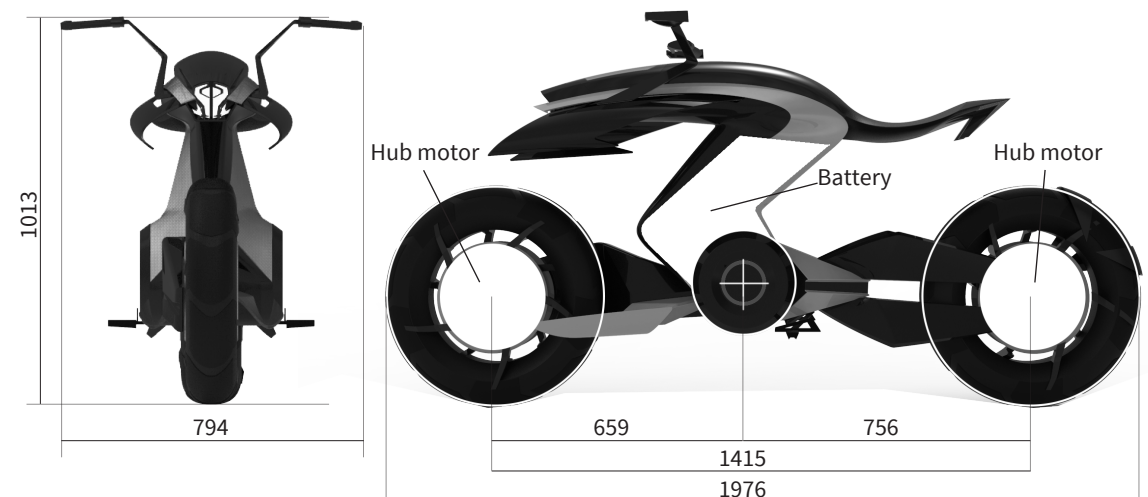


Fig 138. Schematic package

# 07

## FINAL DESIGN

## 7. Final design

### 7.1 Urban mode

This mode features a relaxed seating posture and is compact enough to be maneuvered through city traffic. The handle bar position keeps the arms relaxed, while the footpegs contribute further to the relaxed posture. The upper and lower fins are folded to give a compact form which feels like its been restricted from unfolding and reaching its full potential.

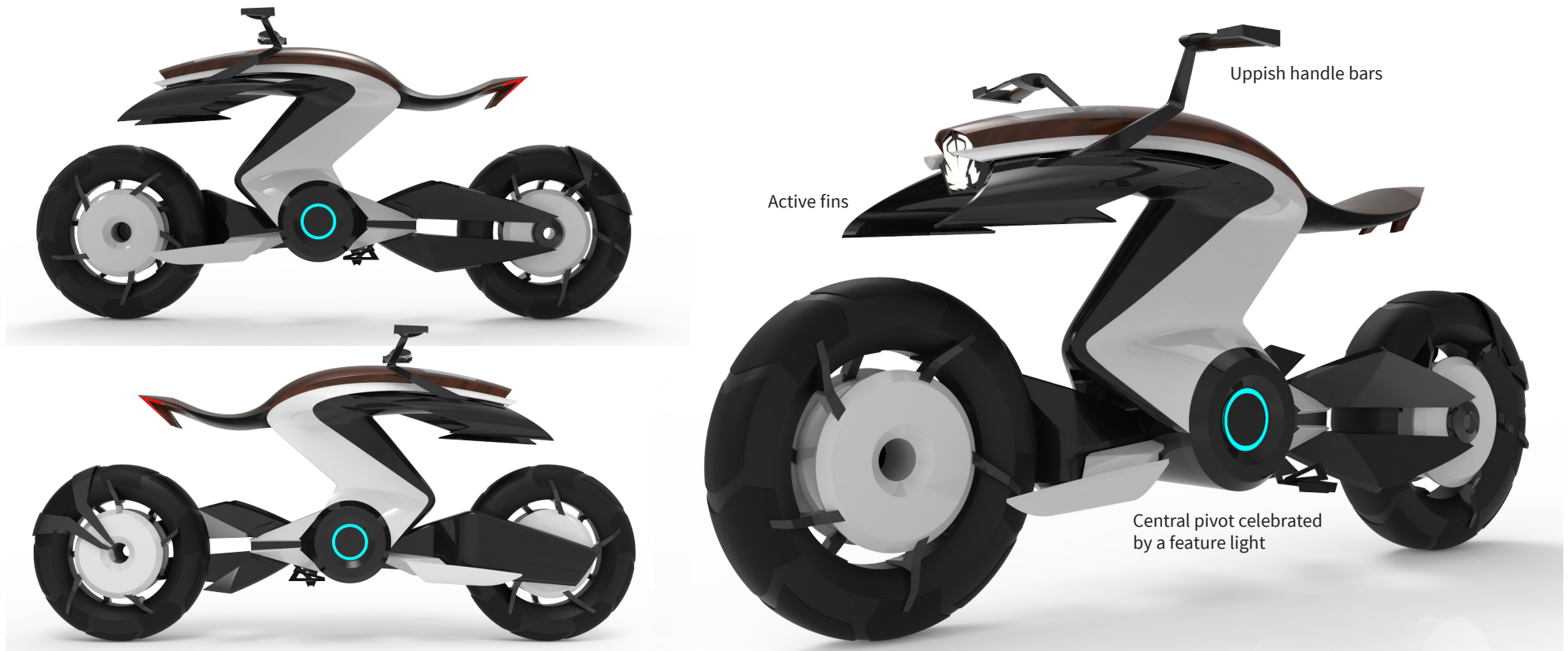


Fig 139. Urban mode



## 7.2 Race mode

The race mode has a much more aggressive ride stance. The rider leans forward with the handle bars dropping down and footpegs moving backwards. The wheelbase increases with the swing-arm moving a little backwards. The upper and lower fins straighten out giving an aggressive jet-fighter feeling to the whole bike.

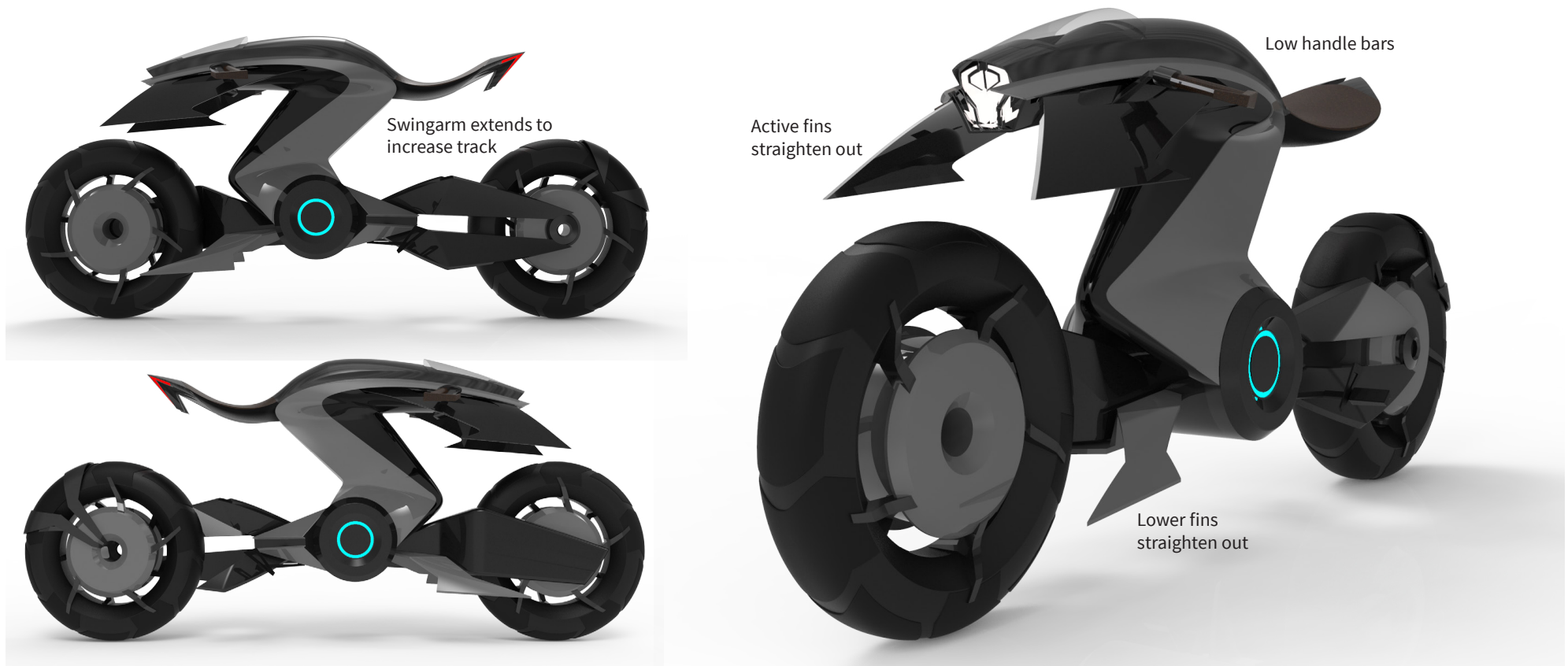


Fig 140. Race mode

### 7.3 Off-road mode

The ground clearance increases with the front and rear arms moving towards each other around the central pivot. The handles are slightly uppers to give the rider an erect seating posture. The footpegs are placed in such a way that the rider can stand up easily whenever required. The upper fins folds and twists in such a way that the rider feels the overall volume of the tank has increased. The studs in the active tyres pop out to give a better grip in offroad conditions.

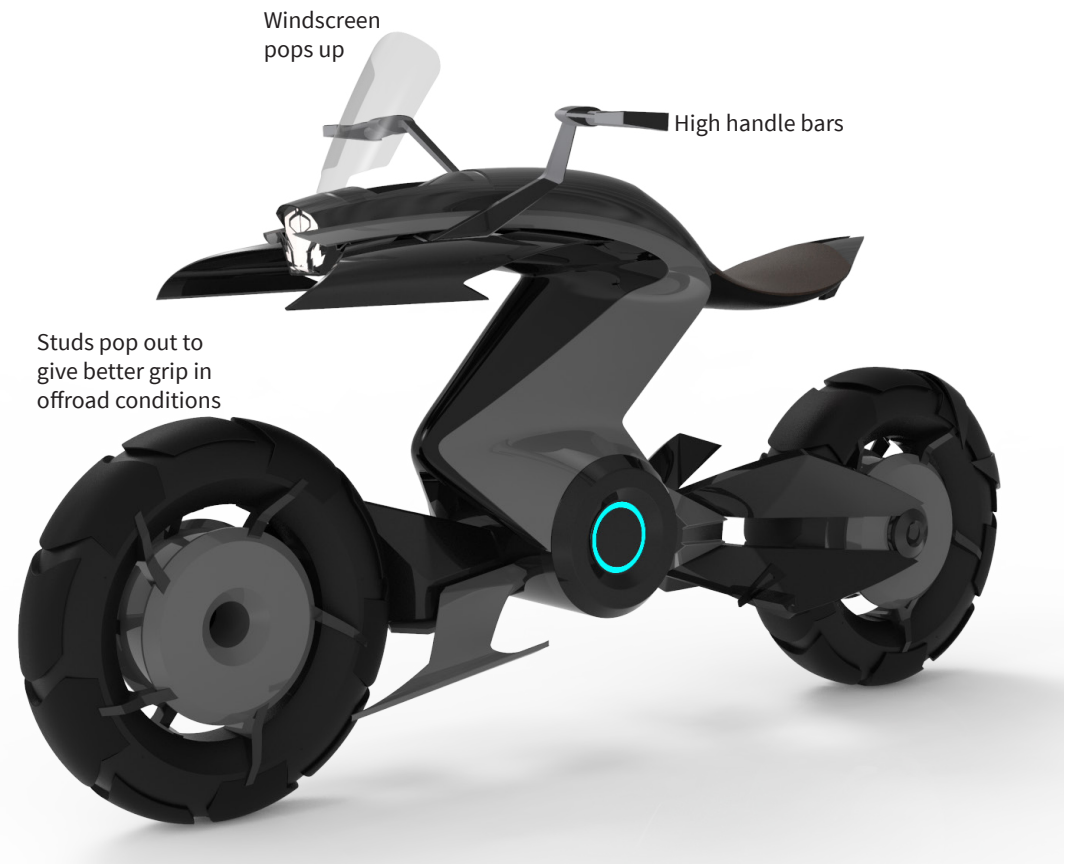
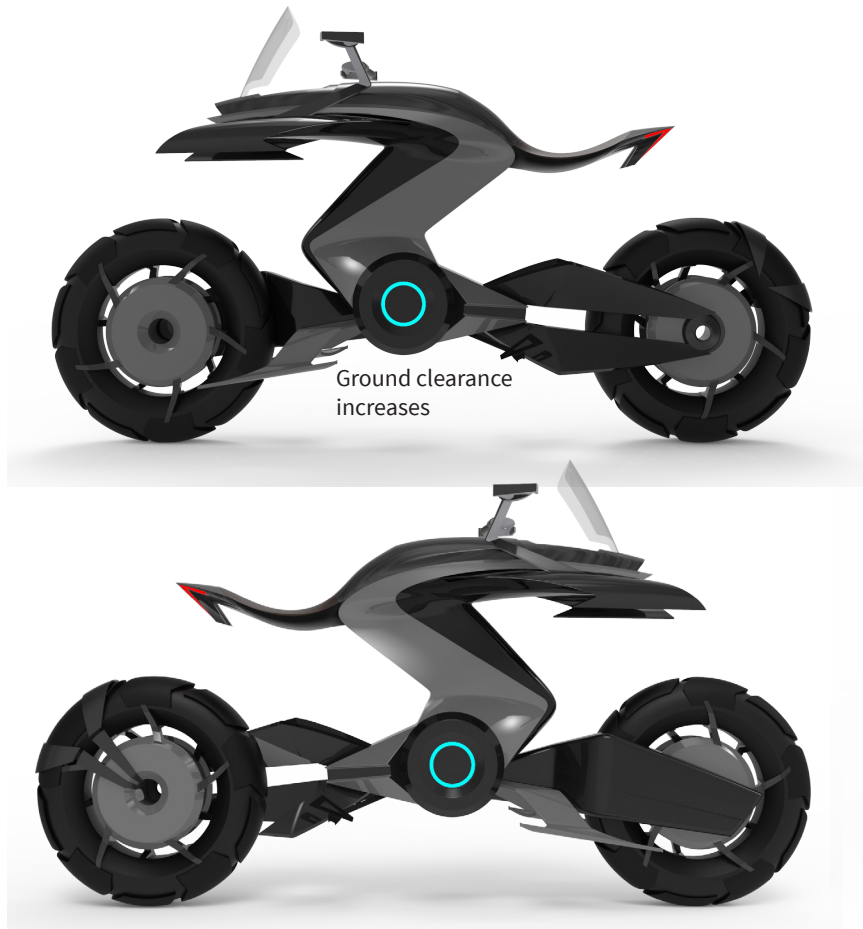


Fig 141. Off-road mode

## 7.4 Ride ergonomics

The ride ergonomics of the 3 modes are completely different. The transformation happens in such a way that each mode gets its correct ride posture.



Fig 142. Urban mode



Fig 143. Race mode



Fig 144. Off-road mode



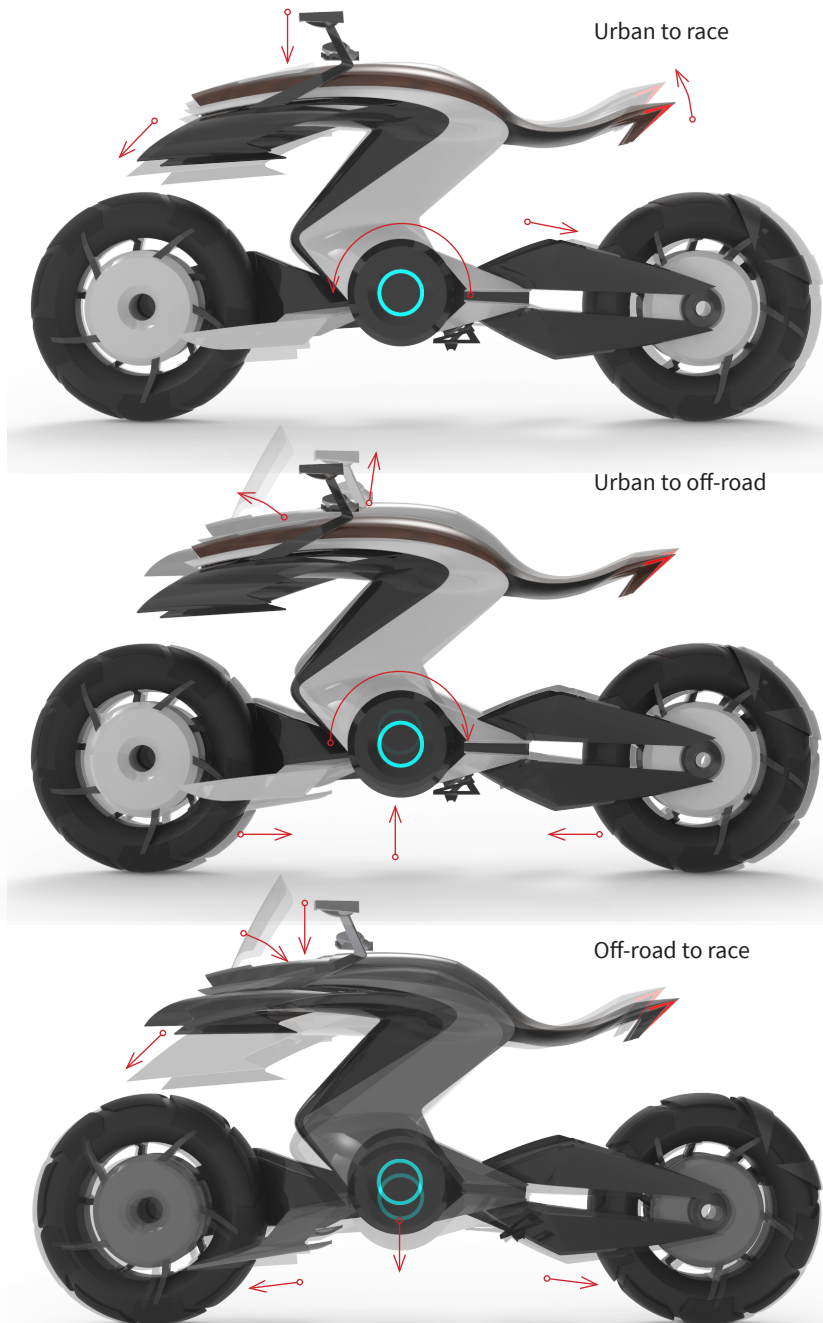


Fig 145. Transformations from mode to mode

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## 7.5 Transformation

The design features major transformations which occur by the body rotating around the central pivot and local transformations happen by means of active surfaces folding, unfolding, twisting, etc.



Fig 146. Different handle positions and transformation of upper fin in different modes - Urban, race, off-road

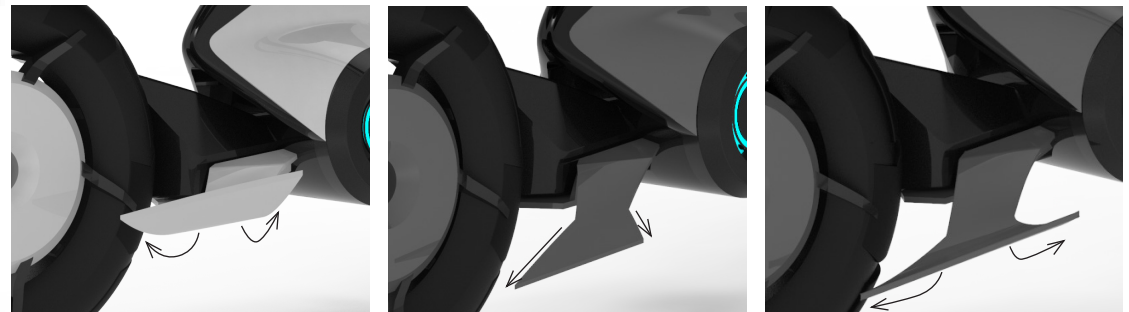


Fig 147. Transformation of lower fin in different modes - Urban, race, off-road



Fig 148. Transformation of the rider seat in different modes - Urban, race, off-road

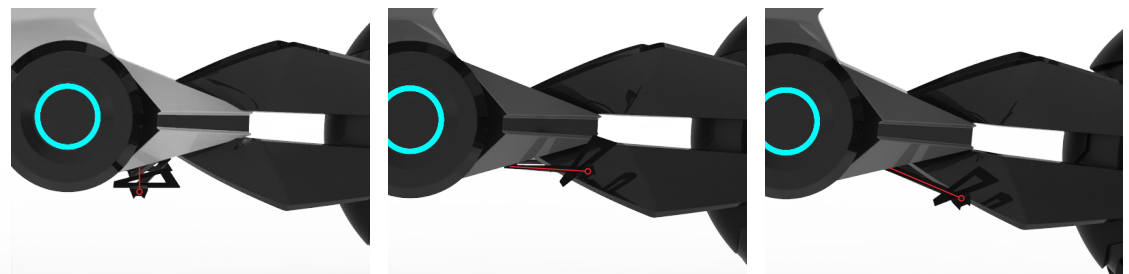


Fig 149. Position change of footpeg in different modes - Urban, race, off-road

Tyre tread for urban and race modes

Tyre tread for off-road mode

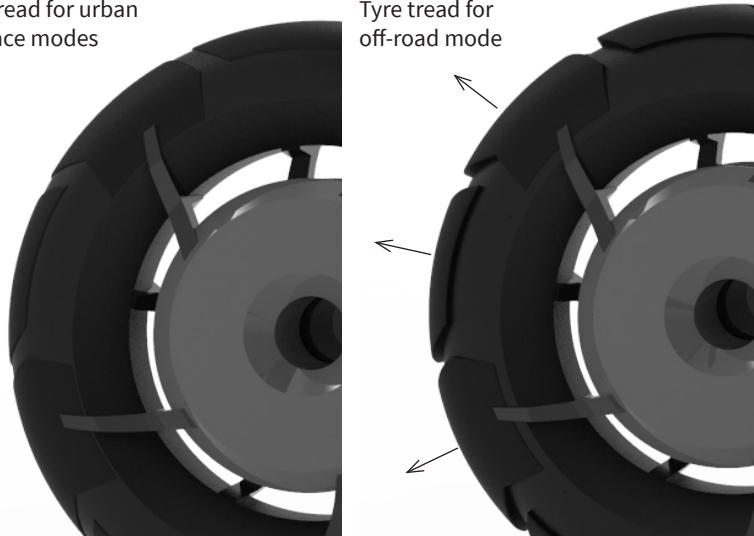


Fig 150. Tread sections pop out to increase grip while using off-road mode

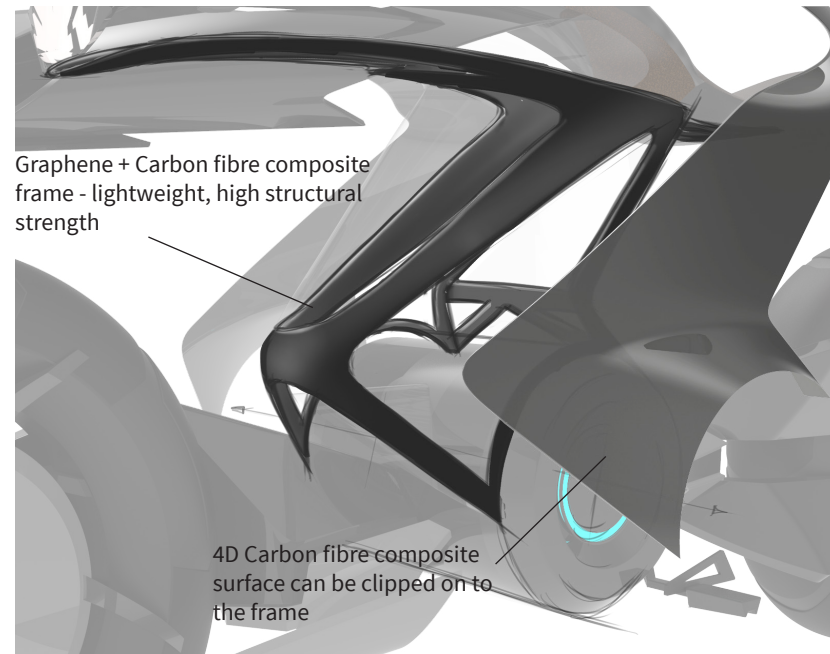


Fig 151. Details of the lightweight structural frame

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## 7.6 Details

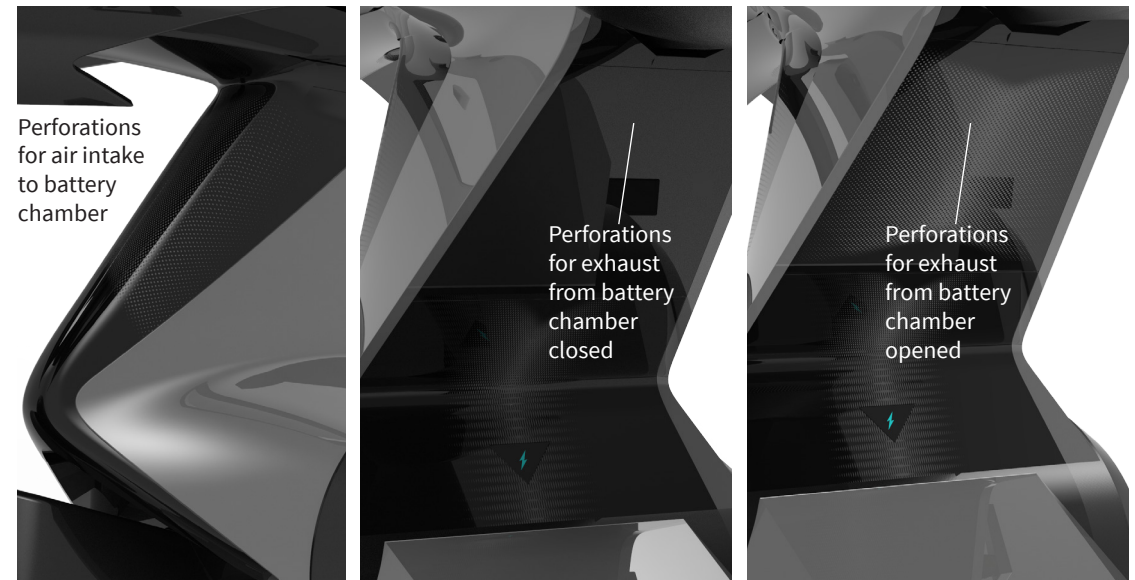


Fig 152. Air intake and exhaust perforations for battery cooling open up only when bike is switched on



Fig 153. Back panel opens up for access to batteries

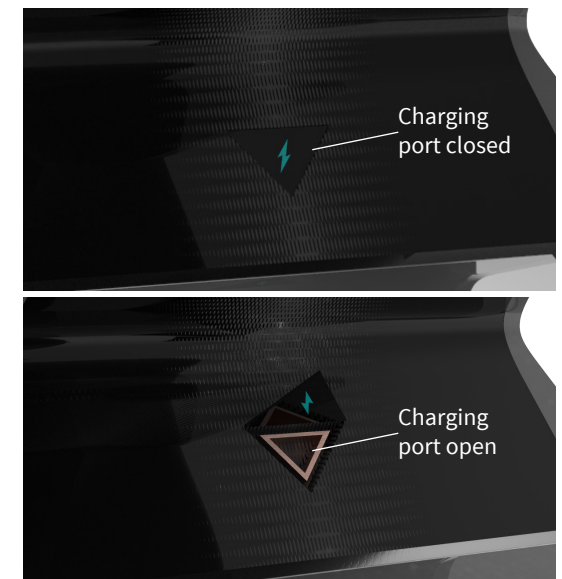


Fig 154. Charging port present on the rear side

## 7.7 Customizability

The surface panels can be easily snapped on to the frame, thus making it extremely easy for the user to customize the vehicle as per his/her needs.



Fig 155. Various options which can be achieved via customization





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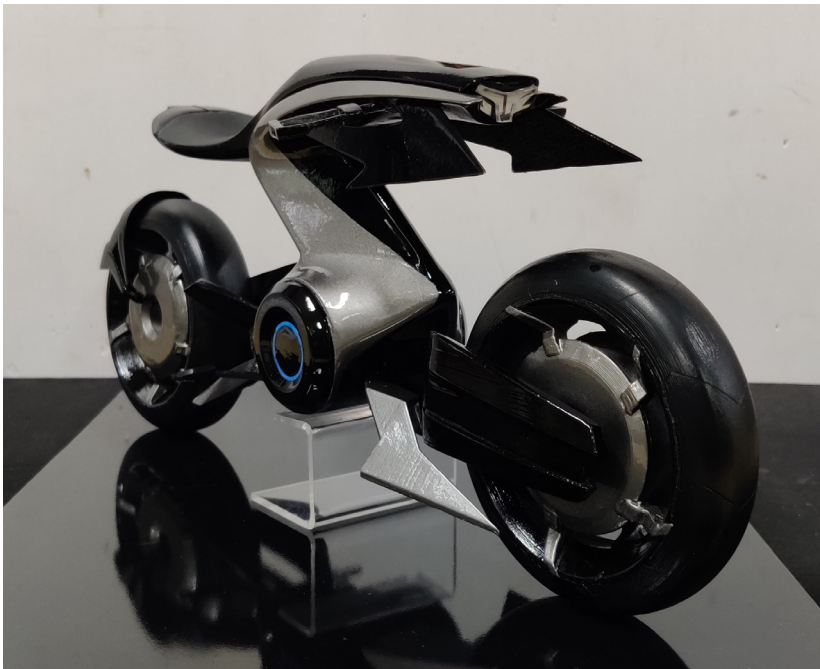
08

FINAL MODEL

## 8. Final model







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Project 3: Design of a Transformable E-Motorcycle for 2035

# 09

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# 010

## ANNEXURE

## 10. ANNEXURE

### 10.1 History of motorcycle & segments

Although Reitwagen is seen as the forerunner of modern motorcycles, the 1894 Hildebrand & Wolfmüller motorcycle is the first series production model, and the first to be called a “motorcycle”. Once this was achieved, several other companies started popping up in Europe with ideas of creating newer versions and models of motorcycles. Among these were Peugeot Motorcycles, Royal Enfield, Triumph, Norton and BSA which all started between 1898 and 1910. A similar story was unraveling in the USA with companies like Indian Motorcycles and Harley Davidson which came in 1901 and 1903 respectively.

It was during the first World War, that motorcycles manufacture boomed. Motorcycles were used as messenger and personnel carriers since they could tackle tougher terrain at much higher speeds and at very less cost. It was during this time that the first ‘modern motorcycle’ came out - The Triumph H or the ‘Trusty Triumph’ was a 550cc 4 stroke motorcycle with a 3-speed gearbox and belt transmission came out in 1915 and was widely used in WW 1.

In 1920 that Harley Davidson claimed dominion over the industry as the largest motorcycle manufacturer, with sales spanning over 67 countries. Due to the popularity of motorcycles growing during the post war period, newer companies started forming all over the world. BMW Motorcycles came to the scene in 1923 with their iconic boxer engine layout and has become one of the forerunners in the industry since then.



Fig 156. Daimler Reitwagen - 1885



Fig 159. Hildebrand & Wolfmüller - 1894



Fig 157. Triumph Model H - 1915



Fig 158. BMW R32 - 1923



Fig 160. A group of young riders on their cafe racers - 1960s Rockers in London



Fig 161. Ducati 250 OHC Scrambler - 1963



Fig 162. Yamaha DT 1 - 1968

### The Cafe Racer - 1950,60s

Post World War 2, in the USA certain clubs started forming with members labeled as ‘bikers’ who sought riding together as a means of continuing the camaraderie initiated during the war. Meanwhile in Europe, companies were more focused on coming out with practical and economical transportation, but there was a huge group of young motorcycle enthusiasts in London who were still smitten by the idea of speed and thrill in riding. This gave birth to the ‘cafe racer’, which was basically a lightweight, powerful motorcycle optimized for speed and control rather than comfort. It was used to ride short distances, mainly from cafe to cafe, hence the name cafe racer.

During the 1950s, Japanese companies like Honda, Yamaha, Suzuki and Kawasaki started coming up with motorcycles. Being cheaper and better engineered than European and American motorcycles, Japanese companies started grabbing large majority of the market share, which caused many European motorcycle companies to go bankrupt.

### The Scrambler - 1950, 60s

By 1940s, development of better roads influenced the motorcycle industry and led to development of heavier and road oriented motorcycles. During 1950-60s, many European manufacturers came up with customized versions of their lightweight motorcycles to grab more customers and improve sales. These were called ‘scramblers’, and usually had knobby tyres and high mounted or up-swept exhausts for off-roading purpose.

Scramblers are a very popular segment even today with companies like Ducati, Triumph, BMW, Norton, Indian, Moto Guzzi, etc still producing them.

### The Dual Sport Motorcycle - 1968

In 1968, Yamaha introduced the DT1, which gave birth to a new segment called the ‘dual sport’ which could be used for both on-road and off-road purposes. The DT1 had a 250cc single cylinder engine with block pattern tyres and high ground clearance. The DT1 is also hailed as the world’s first ‘dirt bike’. Several manufacturers tried experimenting with this segment by making the bikes more heavyweight but resulted in them losing their ‘dirt worthiness’ and lost popularity among enthusiasts.

It was in 1990, with the DR350, Suzuki rekindled the flame of light-weight dual sport motorcycles satisfying its enthusiasts. The Suzuki motorcycle had a 350cc single cylinder engine with a 6-speed transmission.





Fig 163. Puch 175 Enduro - 1973



Fig 164. Honda CR 250R - 1978



Fig 165. Harley Davidson FX Superglide - 1971

## The Enduro - 1970s

Although Enduro riding competitions used to happen as early as 1913, where customized bikes were used, factory made 'enduro' class motorcycles only appeared in 1970 as a reaction to the production of the dual-sport motorcycles.

Enduro class motorcycles are purely road-legal off-road bikes, used for long-distance and cross country rides. These were super light-weight yet tough motorcycles. They usually have a 2stroke engine between 125cc & 350cc or a 4stroke engine between 195cc & 650cc. Present day enduros are included under the dual-sport category itself

## The Motocross bike

The initial motocross bikes existed as early as 1920s, with origins similar to the enduro bikes. Later, when motocross became an established sport post WW2, pure motocross bikes started to emerge.

Motocross bikes have smaller fuel tanks, and are intended for short races only. They have longer suspension travels and are meant purely for off-road purposes. Motocross bikes are not road legal as they are stripped off of headlights, tail-lamps etc, thereby making it lighter and faster for improving speed.

Modern day motocross bikes have a 'banana' seat which helps the rider seamlessly shift between seating positions and standing position. There are multiple sports which have been derived from Motocross including Freestyle, Supercross, etc.

## The Cruiser - 1971

By 1970s, 2-stroke motorcycles were becoming a craze in Europe, whereas Harley managed to churn out its heavy bikes in America piggybacking on its unique product range and nationalism-driven customer base.

In 1971, Harley came out with the first mass manufactured cruiser bike. Although 'choppers' existed before this, the Harley Davidson FX Super glide was the first official cruiser bike rolled out by an OEM. This motorcycle had a laid back seating, with high handle bars, a 1200cc 4-stroke engine and was marketed as a long-ride friendly motorcycle. Although it didn't manage to succeed at first, the later models grabbed a lot of attention and formed the base for the cruiser line-up from Harley.

Presently all major motorcycle companies have their own line-up of cruiser models and they range usually from 750cc to 2500cc.



Fig 166. BMW R100 RS - 1976

### The Sports tourer - 1976

The BMW R100 RS is the first motorcycle to have a frame fixed full fairing. This 998cc bike had a 4stroke boxer engine and gave birth to the Sport touring segment as it had a different fairing compared to other touring motorcycles.

Sports tourers have the performance of a sports bike and has the capabilities of a tourer bike giving a better ride comfort suitable for long rides. Sports tourers are mainly meant for road riding and not off-roading. They have a larger fairing and windscreen compared to sports bikes as they have a much more upright seating position. Present day sports tourers are also fitted with panniers and other storage spaces to help the rider carry more luggage.



Fig 167. Honda GL 1100 - 1980

### The Full-dress tourer - 1980

Full dress tourers are largest of the tourer segment. They have larger fairing and come with integrated pannier and luggage storage spaces. They have a much larger engine capacity and have better and more comfortable seating space provided for the pillion.

The Honda GL 1100 also known as the 'Goldwing' was the first full-dress tourer motorcycle. It revolutionized the idea of touring by giving superior storage capacity and ride comfort. The Goldwing series is still in production with the GL 1800 and have features like electronically adjustable suspension, forward and reverse 'walking' mode, throttle by wire, 4 ride modes, traction control, heated hand grips, saddle heating and airbags.



Fig 168. BMW R80 G/S - 1980

### The Adventure tourer - 1980

The third classification under the tourer category, and also falls under the dual-sport category. They have spoke wheels, higher ground clearance, attachable pannier boxes, skid plates, and road-legal knobby tyres.

The first ever adventure tourer motorcycle was the BMW R80 G/S. It had an 800cc engine with a shaft drive. This motorcycle was the precursor to the world famous G/S series of motorcycles manufactured by BMW. The boxer engine design has been retained, although a lot changes in styling and features have come about. The latest version, the R1250 GS has a massive 1254cc engine and has features like ride by wire, different ride modes, dual channel ABS, heated hand grips and saddle. The present day styling features a very dominant beak structure (prominent in adventure tourers of all manufacturers), which serves a dual purpose of aesthetics and function (air channeling, and stopping dirt/debris from hitting the rider while riding).



Fig 169. Honda CB750 - 1969



Fig 170. Honda VF 750F - 1983

### The Standard motorcycle

Although there is no specific era mentioned which specifies the origins of this category, it is often associated with the 1970s Japanese motorcycle designs.

This category has a seating posture which sits between the cruiser and the sports category. They are general purpose motorcycle with an upright riding position and do not usually have fairing or windscreens due to which they are often referred to as naked bikes.

### The Sports bike - 1983

Sports bike is a term which refers to motorcycles optimized for speed, handling and braking. These hi-speed bikes existed since the day motorcycles were used for racing purposes, but the precursor to the modern sports bikes is known to be the Honda VF 750F - a faired version of the Honda CB750. These specialized bikes have a low height handle bar position and higher foot-pegs which bring the body closer and make the volume much more compact. The rider has a lean-forward posture which places the weight over the tank of the bike. The fairing was added to increase aerodynamics and give more stability to the bike at higher speeds. Presently, the fastest sports bike is Kawasaki Ninja H2R which has recorded a highest speed of 401 km/h.



