DEP702

DESIGN PROJECT - 2 REPORT

Project Title: **Compact Human-powered Watercraft**

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Approval Sheet

The Mobility and Vehicle Design project report titled - "Compact Human-powered Watercraft", by Pratik Bansode is approved in partial fulfillment of the requirements for a Master of Design degree in Mobility and Vehicle Design.

Approved by

Guide:

Co-Guide:

Chairperson:

Internal Examiner:

External Examiner:

Declaration

This is a declaration that this M.Des Project report titled Compact Human-powered Watercraft submitted to IDC School of Design, IIT Bombay contains my original ideas and my own words. The report adheres to all principles of academic and research ethics and no data provided has been misinterpreted, or falsified. It is understood that violation of the above will cause disciplinary actions by the institute and can also lead to penal actions from the sources that have not been appropriately cited or from whom proper permission was not taken.

Pratik Bansode
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December 1, 2022

Acknowledgment

I would like to express my sincere gratitude to IDC School of Design, the Head, the Course coordinator, and our professors, Prof. Sugandh Malhotra and Prof. Nishant Sharma for their kind support and encouragement throughout the project. I would like to thank my guide, Prof. Sugandh Malhotra, for his constant guidance and support throughout the course of this project. I also thank Mr. Harsh Kamble for his valuable feedback and insightful comments that guided me in the right direction.

I am grateful to my family and friends who provided me with moral support and encouragement that kept me motivated throughout the duration of this project.

Abstract

The design project aims to address the limitations of current watercraft used for eco-tourism in mangrove forests. The challenge is to create a compact, manually-operated watercraft that can maneuver through shallow waters and dense mangrove areas, allowing tourists to explore these unique environments more efficiently. The proposed watercraft should have a smaller footprint and stable design to navigate around obstacles like rocks and roots. It should also be easy to operate, ensuring a minimal learning curve for users. With the ability to be used during both low and high tides, this innovative watercraft aims to enhance the eco-tourism experience, providing visitors with a closer and more immersive encounter with the diverse wildlife and beauty of mangrove forests.

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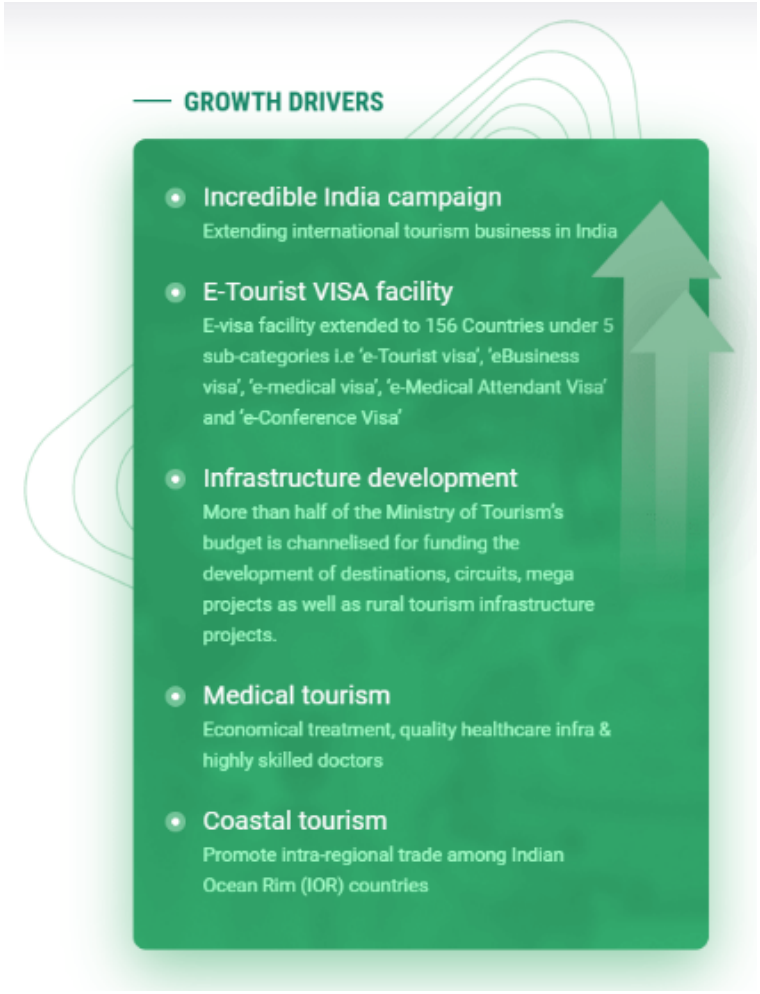
1. Introduction

Mangrove forests act like a sentinel that protects the coastal region against tsunami waves or hurricanes. The roots of these trees form a densely interconnected structure that brakes down the waves and decreases the force of impact by absorbing the energy of the waves. Mangroves are home to a lot of creatures from beautiful and majestic birds to fishes and crabs. Mangroves also play an important role in balancing the ecosystem by preventing soil erosion. Mangroves have aerial roots that extend vertically from the soils surrounding the trunk. These roots enable the mangroves to breathe in habitats that have waterlogged soil.

Mumbai's mangroves boast a history older than the city itself. It was the British who, upon realizing the strategic and commercial importance of the islands of the Arabian Sea, ordered the clearing of the mangroves that rimmed the once-separated islands to create a continuous land mass then known as Greater Bombay. Today, many of these mangroves have disappeared and only a few remain. These can be spotted along locations such as Vasai Creek, Thane Creek, Manori, Malad, Mahim, Bandra, Versova, Sewri, Mumbra–Diva, Gorai, and Ghodbunder. These mangroves also provide income for a lot of fishermen.

Thane Creek one of the mangrove forests in Mumbai has been deemed a Flamingo Sanctuary. Thane Creek has semi-diurnal tides, which means the tides change from high tide to low tide in 6 hours. So throughout the



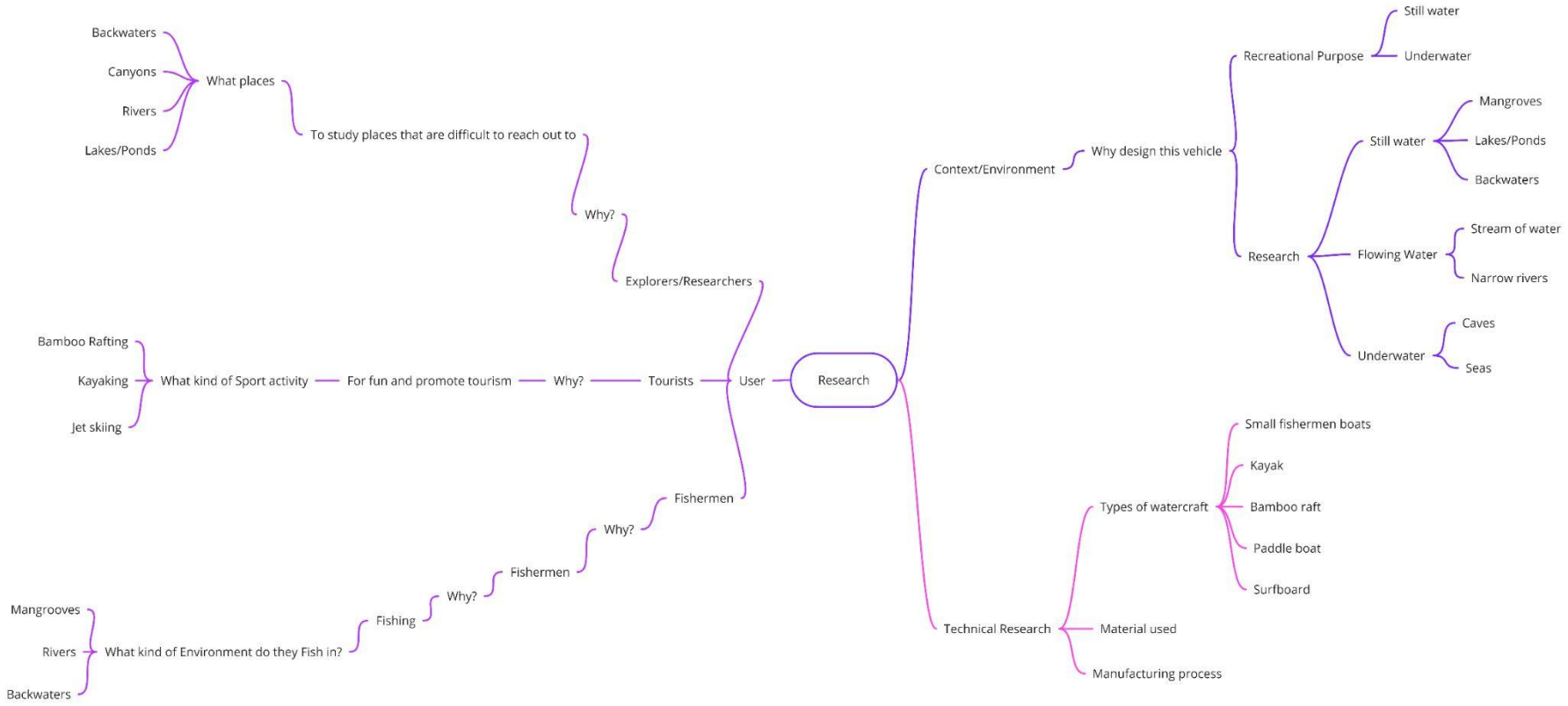
1.1. Tourism Growth in India

day, two cycles of the ties occur. The highest of the high tides goes to 14.5 ft and the lowest of the low goes to 0.9 to 3.15 ft.

Mangrove Cell wishes to build a recreational space around the mangroves that would attract more visitors. Tourism in India is growing significantly in the sector of eco-tourism. The government invests a lot of money into eco-tourism, and recreational activities to spread awareness of the environment.

In India, the tourism industry's direct contribution to the GDP is expected to record an annual growth rate of 10.35% between 2019 and 2028. By 2028, Indian tourism and hospitality are expected to earn US$ 50.9 billion as visitor exports compared with US$ 28.9 billion in 2018. The industry is also looking forward to the expansion of the e-Visa scheme, which is expected to double the tourist inflow in India.

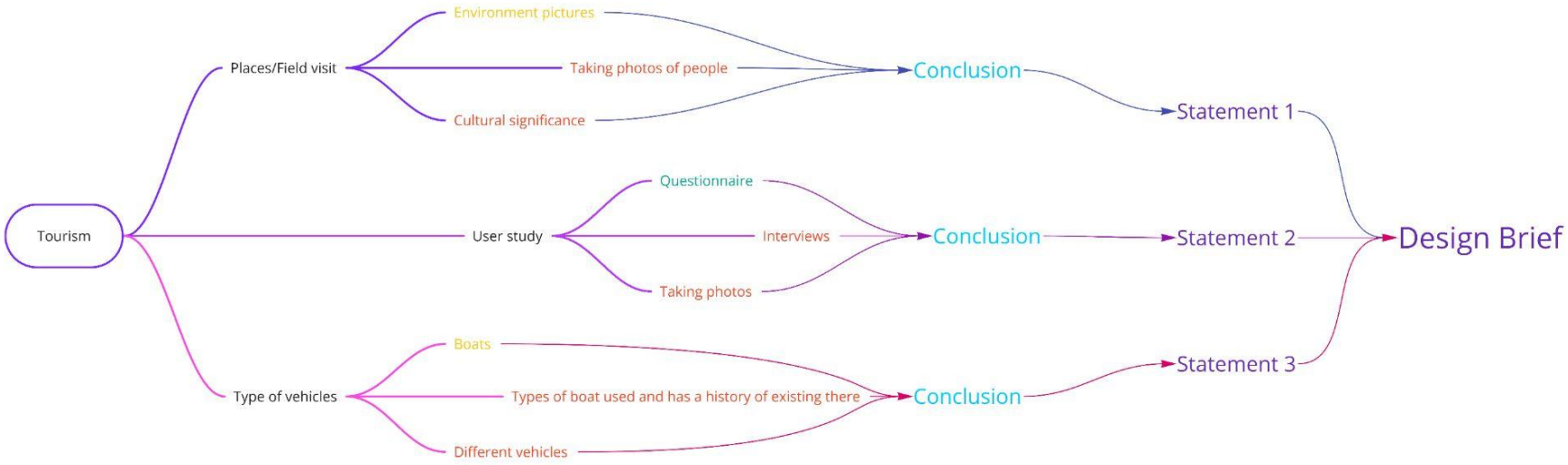
2. Design methodology



Flow Chart. 2.1. Research Process

The research process was conducted in three parts, 1. Context/Environment Research, 2.User research, 3.Technical/Product research. Then this research was further divided into various different parts asking why, where, who, what, and how. These questions were answered in the process itself. Throughout the process of interviewing & collecting images, some insights were collected and through these insights, a Design brief was made. After Brief a user persona was created to have a set direction as to whom the product was going to be made. With the user persona set in place, the first set of ideations was made to explore the possibilities of what and how the problem could be solved.

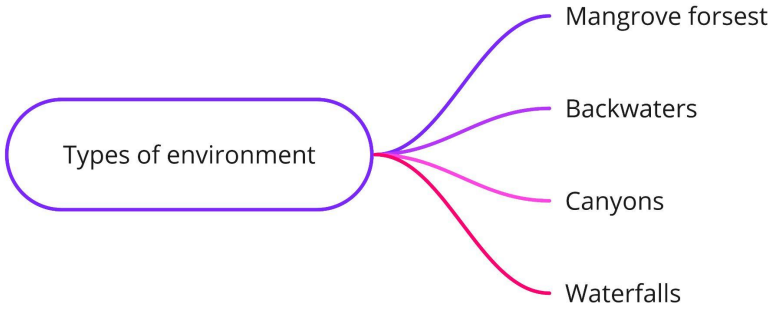
Then the packaging of the vehicle was made by taking the 95th and 50th Percentile as reference points and the vehicle was developed around these dimensions. A mood board was made after this process. Then the concepts were further explored and some new ideas were created. The external forms were explored. Finally, the concepts were shortlisted and one concept was finalized. A 3D model was made using Blender to further envision the product. In the end, a prototype was created.



Flow Chart. 2.1. Design Brief.

3. Research

The research process started with considering a bunch of various different environments. Starting from studying canyons to different types of lakes and narrow rivers that flow inside caves and mangroves. All the environments were narrow and difficult to explore because of the lack of specialized transportation. Pictures of these environments were collected by going at the spots and also through satellite images from google earth.



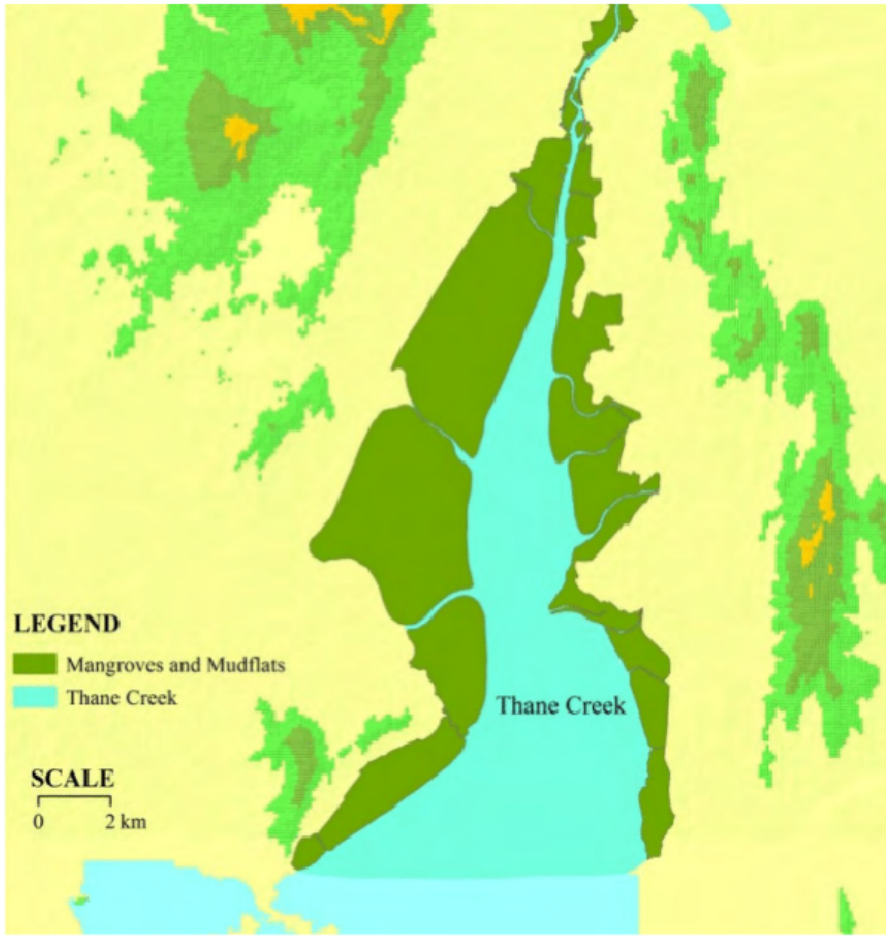
Flow Chart. 3.1 Types of environment

3.1 Types of Environments

Finally, mangrove forest was to be the direction that was selected as tourism around these hotspots were increasing and environmental awareness was being spread by the government.

3.1 Context Research

Mangroves have become a tourism hotspot and these also help the local community as it becomes their source of income. But to travel through the Mangroves there are no specific vehicles in the market that will allow a more efficient ride through the dense mangrove forest area.
In the beginning, there were two ways to look at this project one idea was to make a watercraft for the local fishermen and the other was to make a service system that people will be able to access when they go to these environments.
Thane Creek is rich with mangroves surrounding the place. Thane Creek is an inlet shoreline of the Arabian Sea that isolates the city of Mumbai from the Konkan region. The creek is divided into two parts. The first part lies between Ghodbundher and Thane, and the second part lies between the city of Thane and the Arabian Sea. The density of mangrove trees is the highest in Thane Creek (30 trees/25 m 2) followed by other creeks (9.5 to 28.5 trees/ 25 m 2). Among the mangrove species available in Maharashtra, Avicennia marina, Sonneratia alba, and S. apetala are the dominant species grown in Airoli and Vashi Creek of Thane district. The tides in Thane Creek is semidiurnal tide where the tides go from High tide to Low tide in a matter of 6hrs. The highest of the High tides go up to 14ft high and the lowest of low ranges from somewhere around 1-3.5ft. Thane Creek is home to various different species of birds from rare birds to some unknown birds, with Flamingos being the center of attraction amongst the tourist.. The Maharashtra Government has declared the area along the western bank of Thane Creek as the "Thane Creek Flamingo Sanctuary".



3.2. Thane Creek

3.3. Current Route

The Marine and Coastal Biodiversity Centre provides boat rides around Thane Creek where the passengers are able to experience the thane creek through the mangroves and see the flamingos and other birds. This place is common for photographers that like to capture birds through the eye of their lenses. The boating route starts from Airoli goes up to Vashi and comes back to Airoli. The boating costs from Rs.396 for 24-seater boats

to Rs.6600 for Premium boats. The costs change on the weekend being more expensive on the weekend.

The boats that are used at this place are a 24-seater motorized boat that takes the passengers through the mangroves in a 30-minute ride, Another one is a speed boat that can sit 6-7 people at one time. The biggest problem with these boats was that they were only capable to travel outside the mangrove forest area and not through the trees. As shown in the image _____.

3.3. Current boats used.

3.4 Areas that the current boat cannot enter.

A lot of birds nest in these spots in particular and no vehicles are able to go in these places. One other way to explore is by mangrove boardwalks. These boards stretch through the mangrove and surround the place. But these boards are placed in a certain place and restrict the explorers from truly exploring the beauty of mangroves and experiencing nature in a better way.

3.4 Mangroves

3.5 shallow waters

3.6 Boardwalk

Field Study

3.7. Abandoned Boats during low tides

A lot of the boats are non-functioning during the low tides and during the monsoon season, no boating activity is done as the tides are very frequent and unpredictable. For these boats to get into the water people need to push them and get them to get them working, this is not very efficient, especially for the tourists, as they might have to get into the marshy lands just to put the boat in the water.

3.2 User Research

Questionnaire

For Users

How did you get to know about this place?

What all activities are available?

How many activities have you tried?

Which one was your favorite?

If we make a vehicle would you be interested in buying it?

What kind of activities is available here that is currently not available anywhere else?

What kind of activities would you wish were available here that are available at other places?

If you could design a water activity what would you want it to be?

How was your experience?

What all problems occurred while using the boat or the watercraft?

Was it difficult to paddle?

How different is it from a cycle, bike, or car (whatever is relevant)?

Does it take a lot more effort to paddle by hand than with feet?

Were you afraid of water at any point in time?

If yes then why?

Have you visited any other similar places to this?

What were those places? How was the experience there?

Have you tried rafting in a river or a canyon?

Would you like to visit one of these places?

If there was a personal vehicle that you could take to places like this for having fun would you buy it?

Or would you like to have a service system where you are able to rent the vehicle for a said time period?

How often do you go out on trips like this?

At any point did you feel that the boat would topple?

Would you want to have a two-person vehicle or a single person?

Would you want to be able to carry the vehicle around?

Would you prefer it to be completely human-powered, Or would you like to have it be electric-assisted?

Which one do you feel was more cost-effective, meaning which one was the one that you would like to come back to?

What different kinds of boats have you driven?

For Service Provider

When was this service started?

What all activities do you provide?

How long have you worked here?

Do you know other places that provide these kinds of services?

What all activities are here that are not available at other places?

What all activities are at other places that you would like to bring here or are planning to bring?

Was there any trouble caused by the customers?

Was there any emergency situation that you ran into?

How was the situation handled?

If we designed a vehicle for fun activity would you provide this service too?

How are the working hours divided?

At what time does the service close?

What is the best time of the year to visit these places?

What activity would you recommend for a person that has never done this before?

How is the customer's safety taken care of?

What activity is preferred by the customer?

In terms of - what is it that they enjoy more? What sells more tickets?

What is the cost of the activities?

What other places are there in Mumbai and elsewhere that you know about that provide these kinds of services?

What is the age limit for a customer?

Is there any other factor that is considered before a person enters the watercraft?

What is the age group that you see the most?

How are the boats maintained?

What if something breaks down how is the situation handled?

When were these boats made?

Where did you buy these boats from?

What was the cost of one unit?

How are these boats made?

What is the material that is used to make this boat?

Does this service create pollution?

Were there any customers that visited multiple times?

What is the peak time of the year for these services?

What happens to these vehicles during the off-season?

Where are these boats stored?

How are they transported from one place to another?

What if the vehicle is so small that you are able to carry it as a single person?

Would it help if it is small and compact in terms of storage?

Do people prefer group activity or individual activity?

Why do you choose these activities?

What different kinds of boats have you driven?

Which one is your favorite water activity to do?

3.3 Product Research

Flow Chart. 3.1. Potential water vehicles.

3.3.1. Current Vehicles in the Market

There were many different vehicles in the market that were used by people to explore the water bodies. The vehicle was studied to find out the possible areas of intervention. A lot of these vehicles were paddle driven. Some of the vehicles used different types of mechanisms to propel the vehicle.

The main two portions of the vehicle were studied the seating position of the rider and the propulsion system that could be used. In the mangroves, there is a big possibility of the propeller getting stuck in the roots of the trees. Also, the waters surrounding these types of environments are shallow.

For boating in mangroves, fisherman boats were used in a lot of places. These boats were used by the locals to gather fish and other natural resources. For boat trips around the mangroves, the same fisherman boats are used. In certain parts of Kerala, Vanchi boats are used by the locals. Kayaks are used as a recreational vehicle to explore lakes and in some cases to explore the mangrove forests.

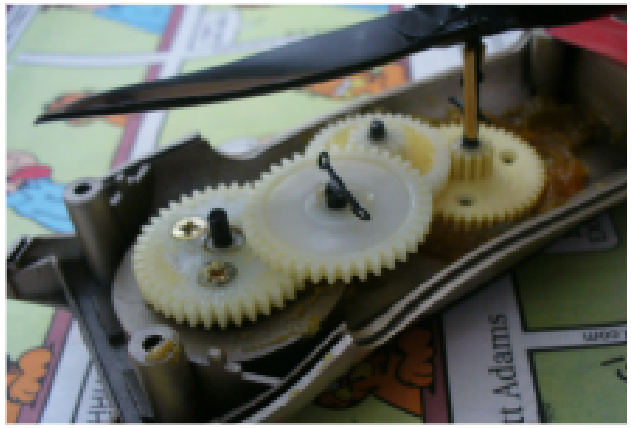
3.8. Coracle

3.9. Bumper boat

3.10. FRP Boat

3.11. Kayak

3.12. Vanchi boat



3.13. Swamp boat

3.14. Mechanism

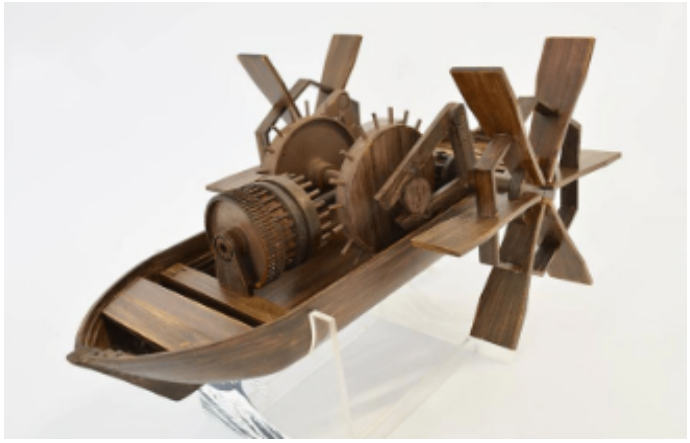
3.15. Hand-powered fan

3.16. Swamp boat

3.17. Catamaran

3.1.2. Possible Propulsion Mechanism 1

One possible way to Propel the vehicle was to have a mechanism that could blow the wind from the rear of the vehicle and that would move the boat forward, like the one that is used in swamp boats this could mean the propeller wouldn’t have to be submerged in the water, and it wouldn't get stuck in the roots of the vehicle. This would use a pedal mechanism that would help turn the blades and move the vehicle ahead. With a gearbox the effort required could be reduced.



3.17. Da Vinci Paddle Boat

3.1.3. Possible Propulsion Mechanism 2

Another method could be using a water wheel. This mechanism was made by Leonardo da Vinci. Combining this with a Tractor triller mechanism would help propel the vehicle in the shallow waters and also mudflats. This could also use a pedal mechanism.

Benchmarking

Manta-5 Hydrofoiler

Weight - 31 kg
Dimensions - 1370 x 1980 x 2190 mm.
Capacity - 100 kg
Material - Carbon Fiber Foil + Aluminum Quarter 6061-T6
Motor - IPX8 rated electric motor 460 watts of pedal assist power
Battery life - 4 h
Battery - Lithium-ion;
Battery Capacity: 882 Wh 48V 110/240V AC input

Ceclo Funx2

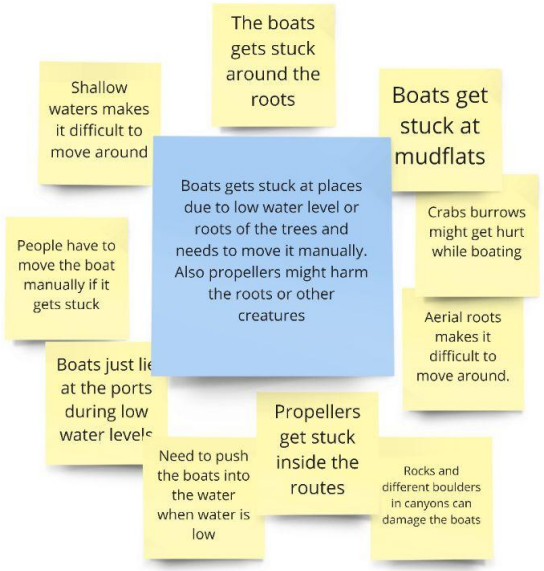
Weight - 58 kg
Dimensions - 3200 x 2100 x 680 mm.
Capacity - 228 kg
Material - Catamaran 0.9 mm PVC + Aluminum frame
Motor - 500 watts
Battery life - 3 – 6 h
Battery - 25.9 V • 15,600 mAh • 333 Wh

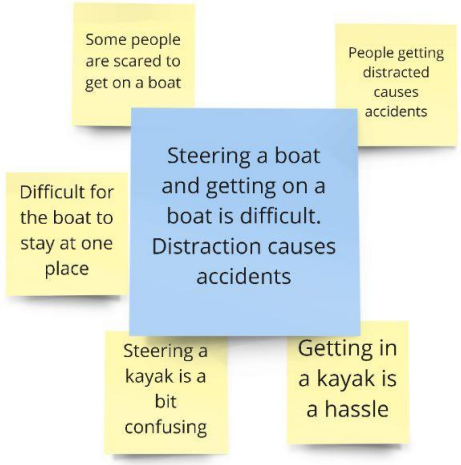
Schiller Water-cycle

Weight - 82.5 kg
Dimensions - 3800 x 1600 x 1220 mm.
Capacity - 140 kg
Material - Anodized Aluminum with T6 welds

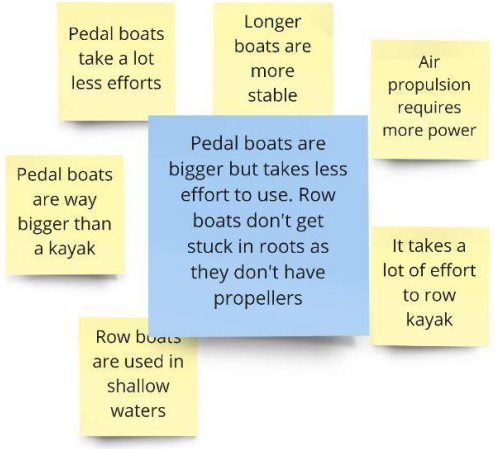
Weight - 27 kg
Dimensions - 2320× 1500× 1880 mm
Capacity - 120 kg
Material - high-density polyethylene frame
Fitness has mostly the same specs, although it allows users to switch between four different motors (ranging from 150 to 250 watts), depending on how much of a workout they want.
Battery life -

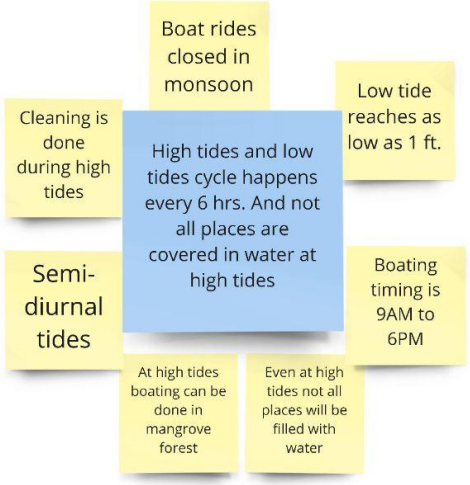
3.4. Insights

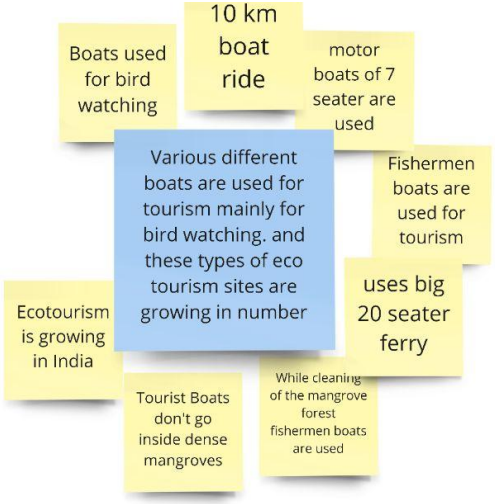

The boats gets stuck around the roots
Shallow waters makes it difficult to move around
Boats get stuck at mudflats
Boats gets stuck at places due to low water level or roots of the trees and needs to move it manually. Also propellers might harm the roots or other creatures
Crabs burrows might get hurt while boating
People have to move the boat manually if it gets stuck
Aerial roots makes it difficult to move around.
Boats just li
at the ports during low water level
Propellers get stuck inside the routes
Need to push the boats into the water when water is low
Rocks and different boulders in canyons can damage the boats


Some people are scared to get on a boat
People getting distracted causes accidents
Steering a boat and getting on a boat is difficult. Distraction causes accidents
Difficult for the boat to stay at one place
Steering a kayak is a bit confusing
Getting in a kayak is a hassle


It is difficult to walk in marshlands
Fishermen use makeshift boats made from thermocol
Cleaning of mangrove is done by walking on marshlands
Livelihood of local depends on getting in a mangrove and walking in marshland becomes for fishing, wood, honey. Some fishermen use makeshift boats
People collect wood and honey from mangrove forests
Livelihood of fishermen living near mangroves depend on it
Two people are required while fishing


Pedal boats take a lot less efforts
Longer boats are more stable
Air propulsion requires more power
Pedal boats are bigger but takes less effort to use. Row boats don't get stuck in roots as they don't have propellers
Pedal boats are way bigger than a kayak
It takes a lot of effort to row kayak
Row boats are used in shallow waters


Boat rides closed in monsoon
Low tide reaches as low as 1 ft.
Cleaning is done during high tides
High tides and low tides cycle happens every 6 hrs. And not all places are covered in water at high tides
Semi-diurnal tides
Boating timing is 9AM to 6PM
At high tides boating can be done in mangrove forest
Even at high tides not all places will be filled with water


Boats used for bird watching
10 km boat ride
motor boats of 7 seater are used
Various different boats are used for tourism mainly for bird watching. and these types of eco tourism sites are growing in number
Fishermen boats are used for tourism
uses big 20 seater ferry
Ecotourism is growing in India
Tourist Boats don't go inside dense mangroves
While cleaning of the mangrove forest fishermen boats are used

3.5. Conclusion

With the different inputs from the interviews and the insights that were collected throughout the research process. Some problems were identified in the vehicle that is currently available in the market. Intervene in the problem that was identified was the next step in the process.

A lot of the problems circle around the vehicle not being able to perform to its full potential, due to the environmental conditions or the weather that would not allow the vehicle to operate.

4. Design Brief

4.1. Problem Statement

Eco-tourism is growing in India. Mangrove forest is an attraction to many visitors, especially for bird watching and experiencing these forest areas. The Boats however that are used for tourism carry at most 20 people and thus these boats are incapable of going into these forest areas because of their massive size. A lot of these boats lie on the shore or on the port during low tides.

To design a compact manually-operated watercraft, that can go into mangrove forests and shallow water.

It should be compact enough to maneuver around obstacles like rocks and roots. It should have a smaller footprint so that it can go in the dense areas of mangrove forests.

The learning curve of the user should be minimum. Getting in and out of the boat should be easy. It can be used during low tides and high tides.

It should be stable. The propellers of the watercraft should be positioned in a way it allows movement on the mudflats.

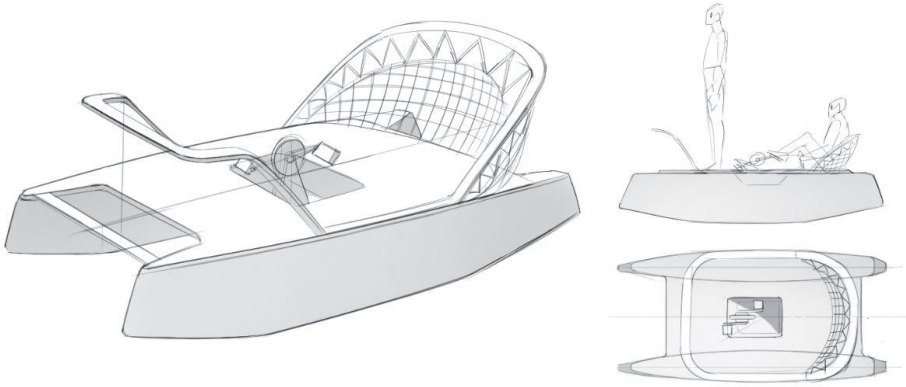
5. User Persona

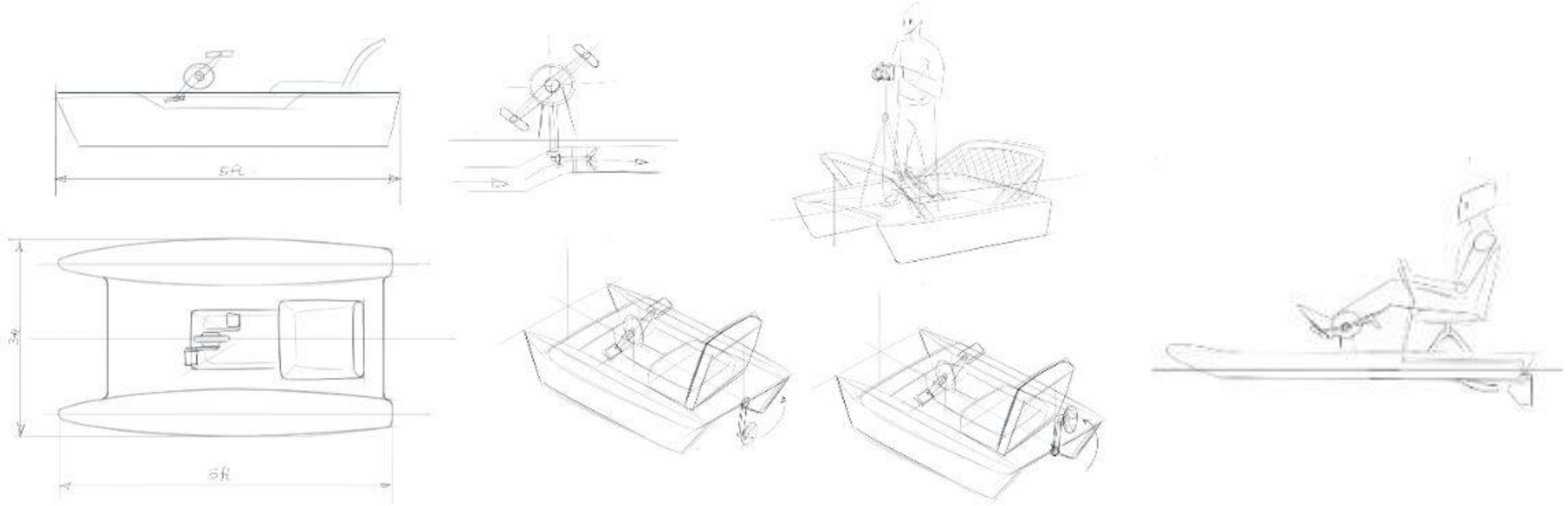
5.1. User Persona

6. Explorations

6.1. Exploratory direction 1

Various different directions were explored to intervene in the problem that was discovered through the insights that were collected from the research, and that would satisfy the Design Brief. The other was a recumbent sitting position where the rider would sit in the vehicle like how they sit in a car. This would have a seat and a backrest that would be mounted upon the hull of the boat. The hull of the boat was also explored from a surfboard kind of board to pontoons/floaters that could be inflatable.





6.2. Exploratory direction 2

There were basically two directions for the solution, and it depended upon the sitting position of the rider. The rider's position could be one sitting on a bicycle where a frame would be mounted on top of the hull and they would have been able to ride it the way one would ride a bicycle, but on water. A catamaran or a multi-hull system would make the vehicle more stable. So it would be easier to get on and off the board without people being afraid of the boat toppling over.

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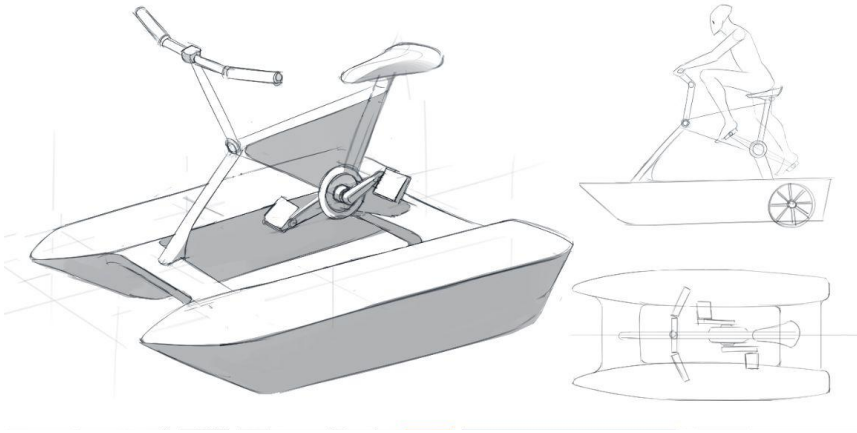
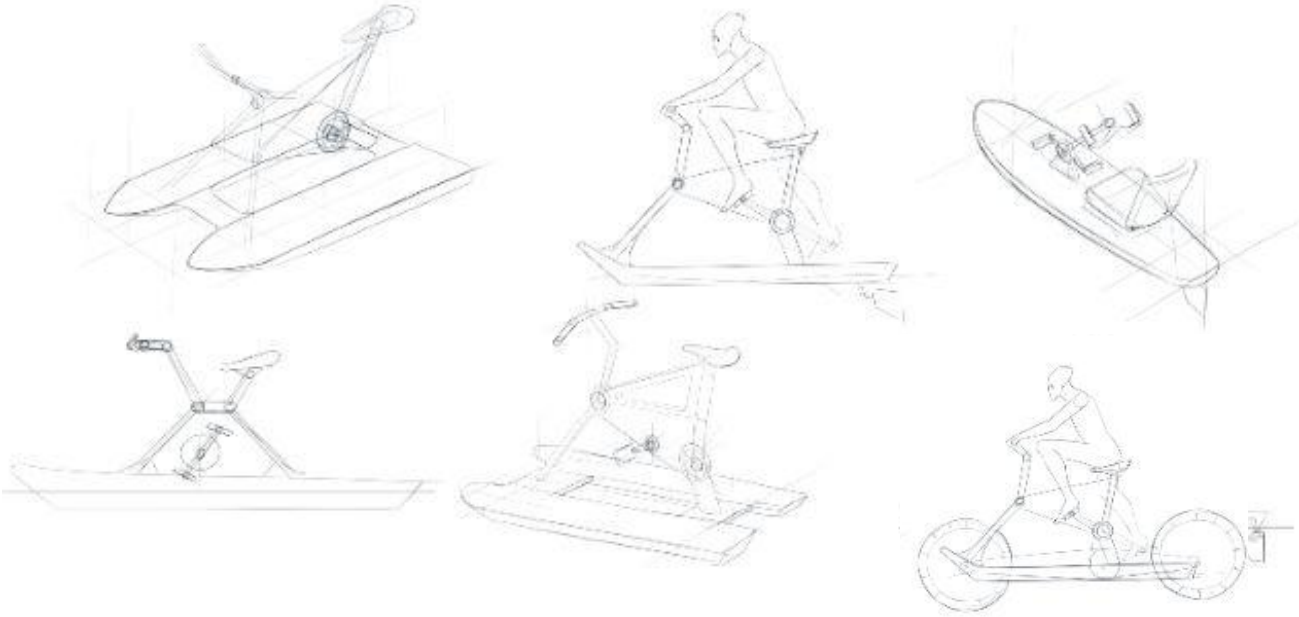
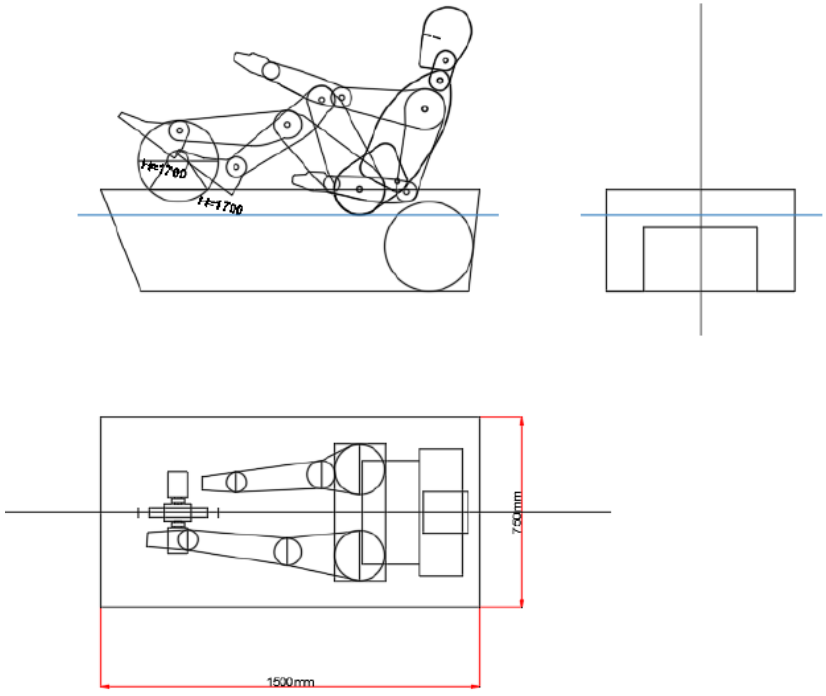


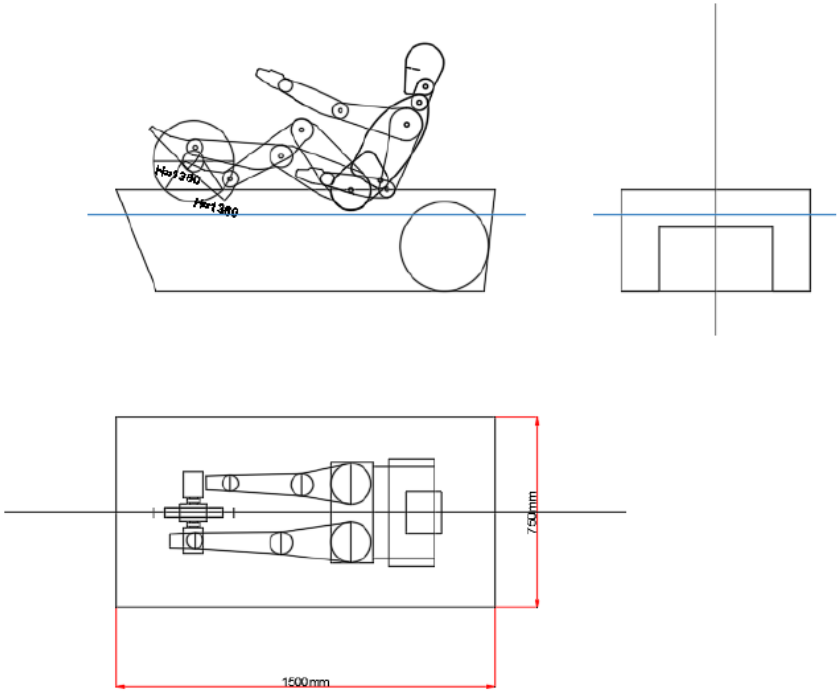


7. Layout

95th Percentile

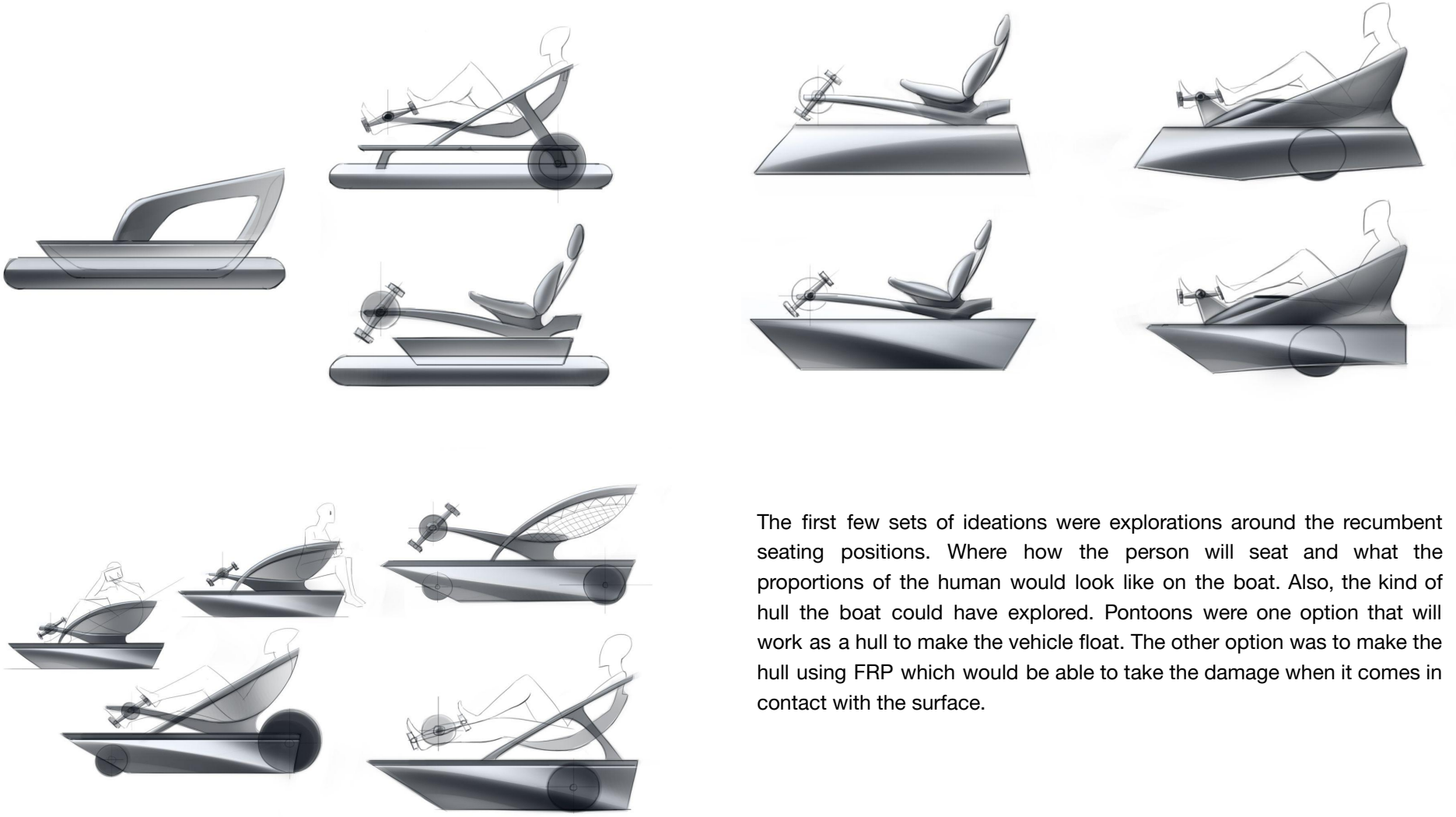


50th Percentile



8. Moodboard

9. Ideations



The first few sets of ideations were explorations around the recumbent seating positions. Where how the person will seat and what the proportions of the human would look like on the boat. Also, the kind of hull the boat could have explored. Pontoons were one option that will work as a hull to make the vehicle float. The other option was to make the hull using FRP which would be able to take the damage when it comes in contact with the surface.

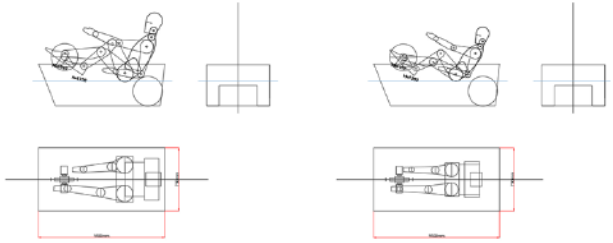
10. Concept ideations

10.1. Direction 1

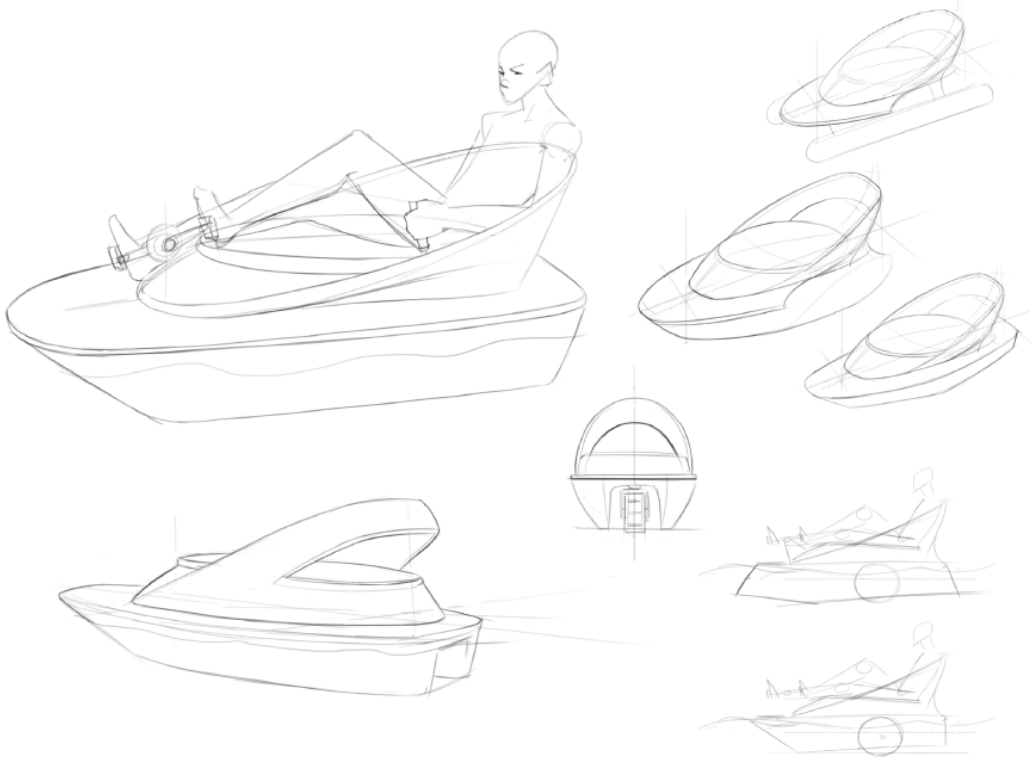
Mood Board

95th Percentile

50th Percentile



CAD Drawing



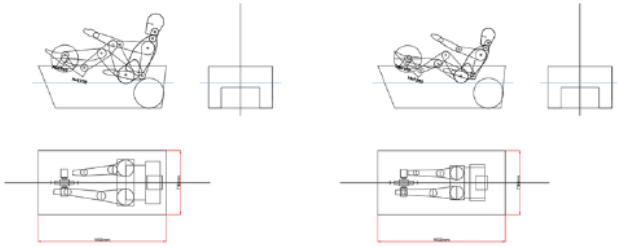
First set of ideations was done based on a seating position where the h-point of the rider was above the surface of the water. And the seat was covered by an outer structure to provide safety for the rider.

10.2. Direction 2

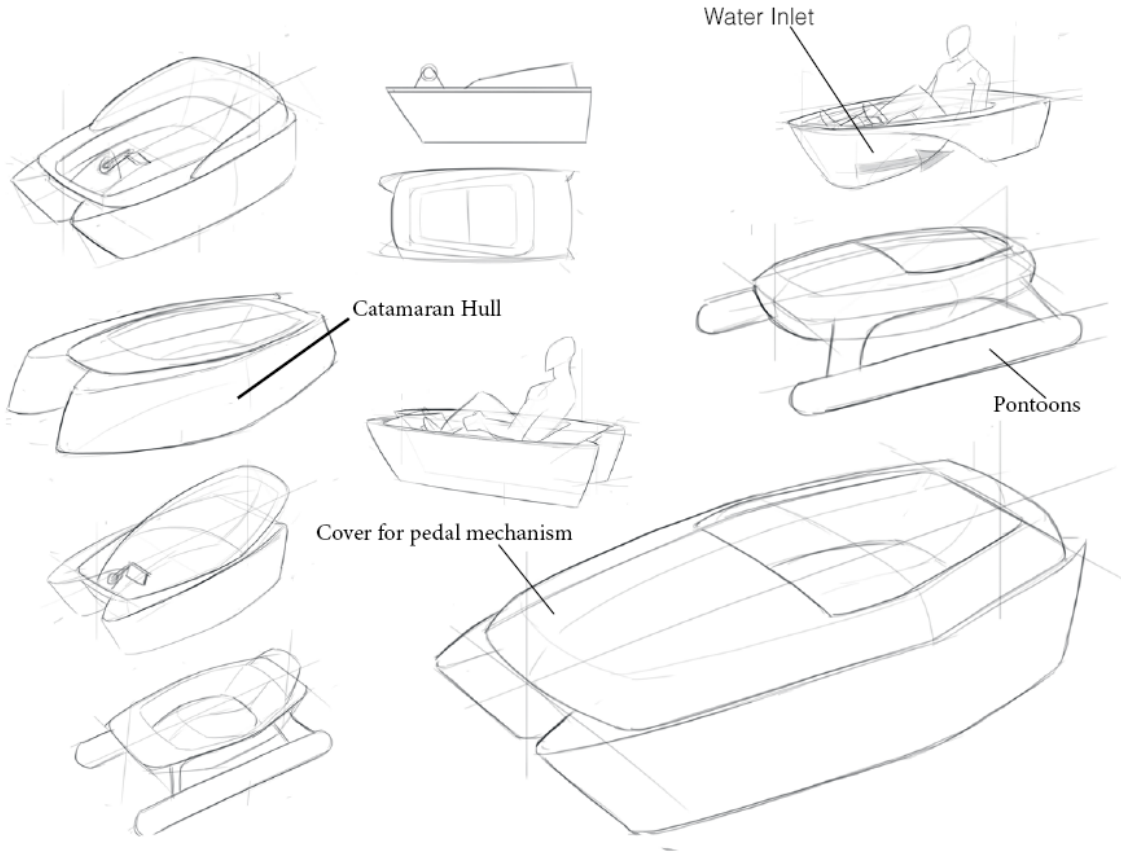
Mood Board

95th Percentile

50th Percentile



CAD Drawing



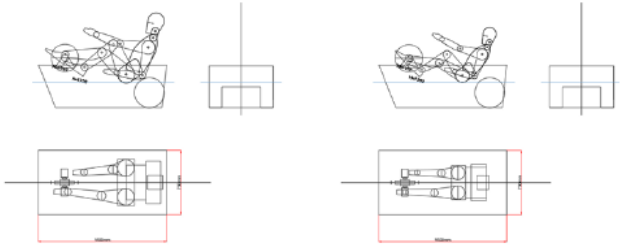
In the second direction a panel would house the mechanism.

10.3. Direction 3

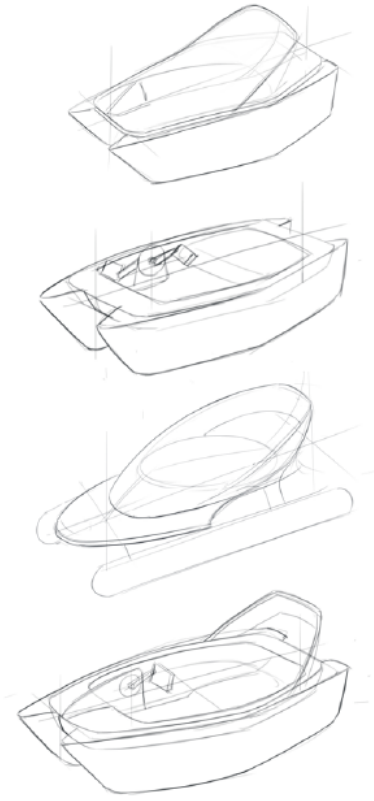
Mood Board

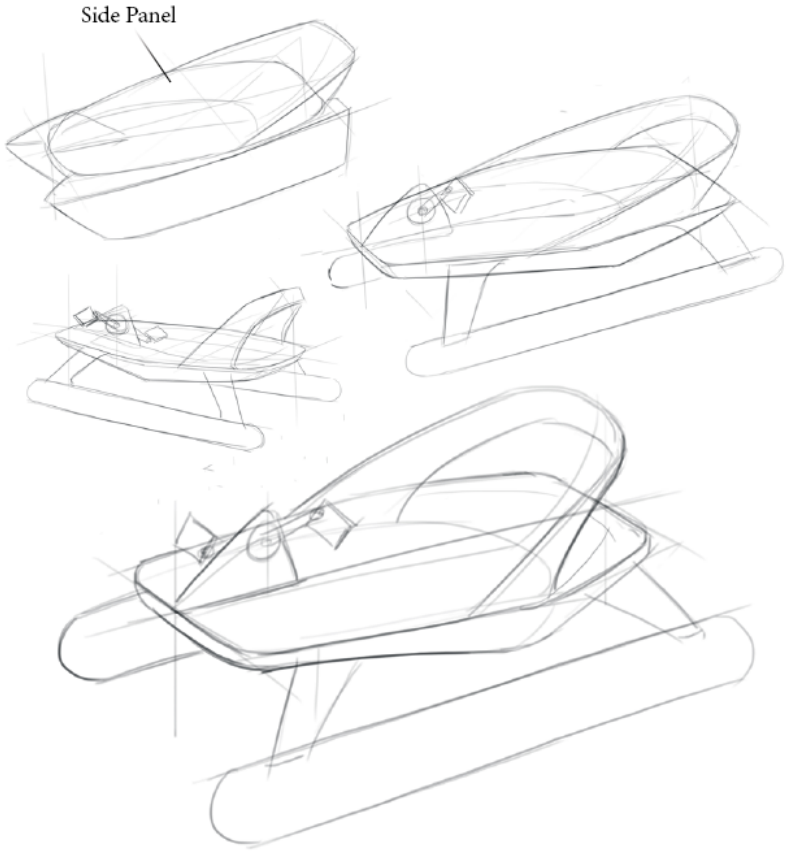
95th Percentile

50th Percentile

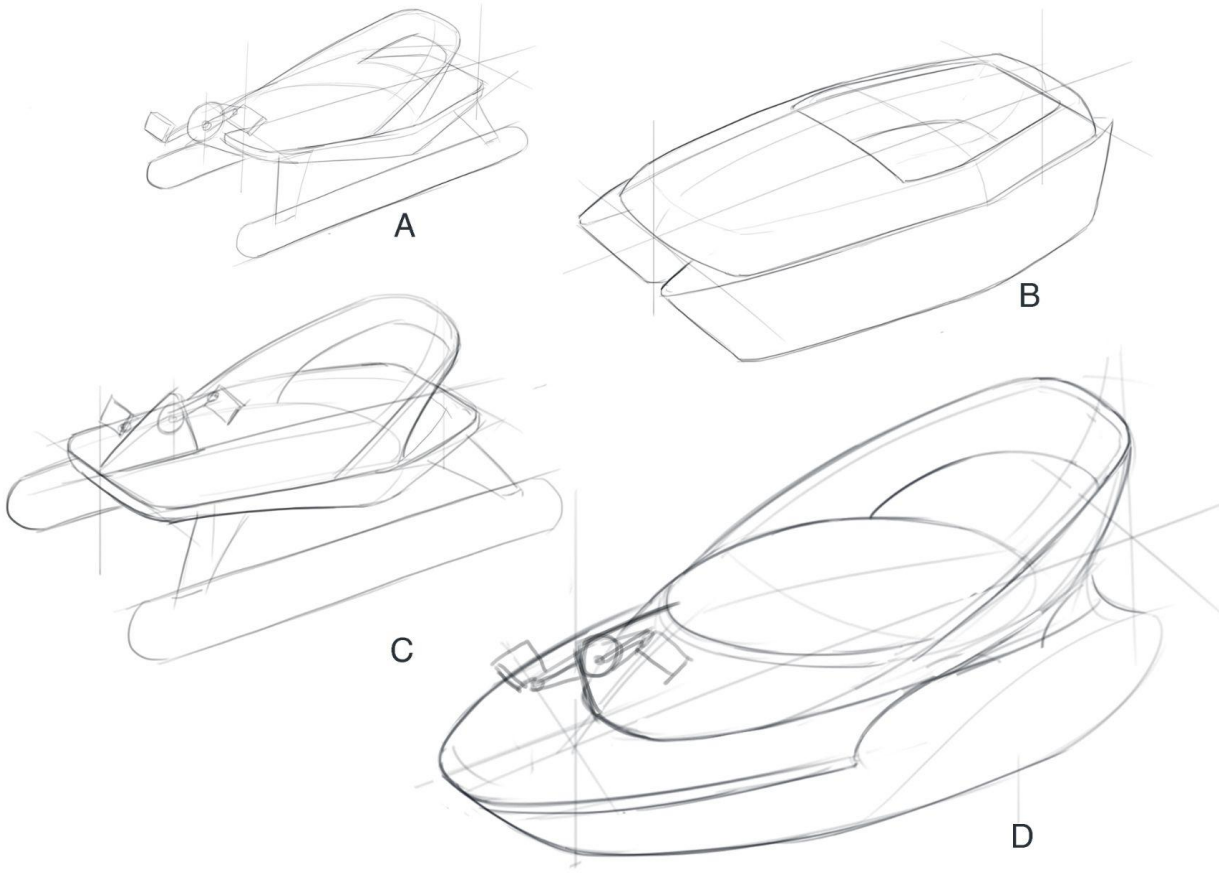


CAD Drawing





In the 3rd direction the rider would be seated on the board and the rider would pedal the boat.



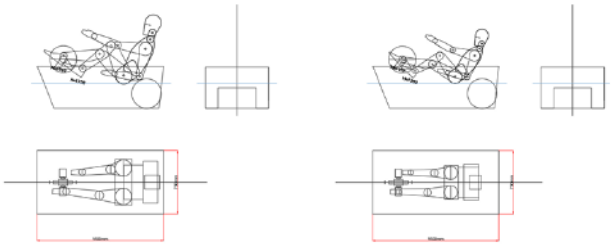
The concepts that were selected to further develop the form of the vehicle. Concept D was taken forward and the elements of the other concepts were explored in the form exploration process.

10.4. Form Exploration

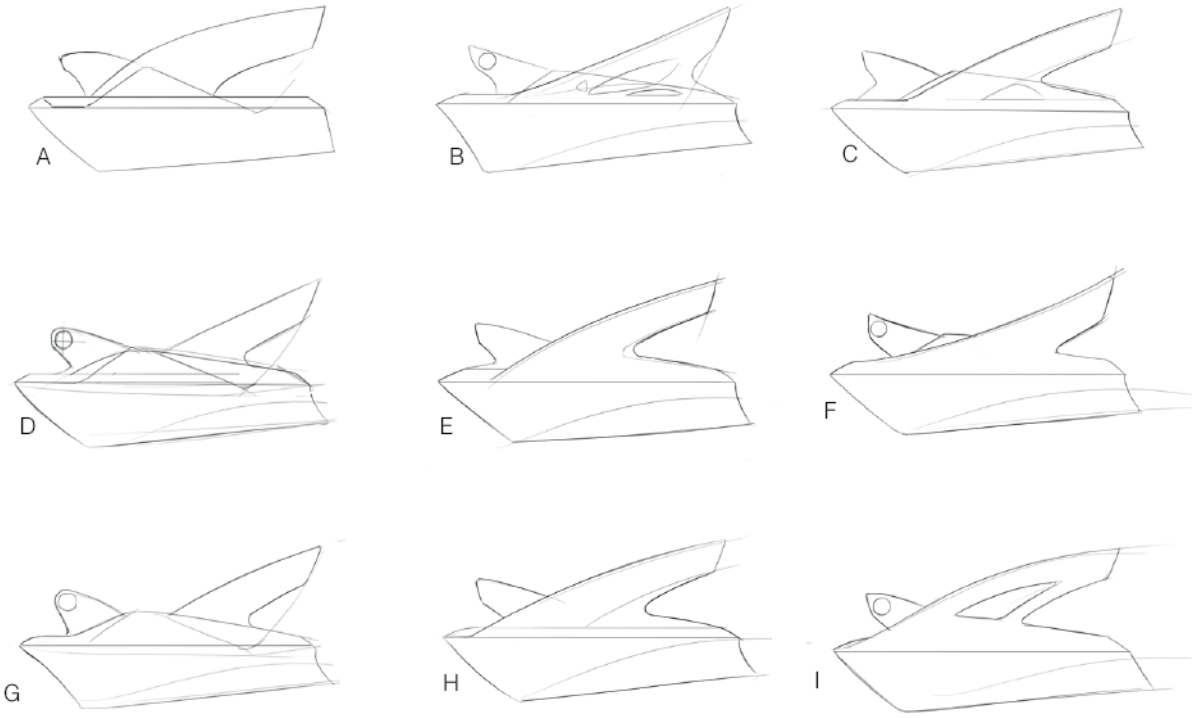
Mood Board

95th Percentile

50th Percentile



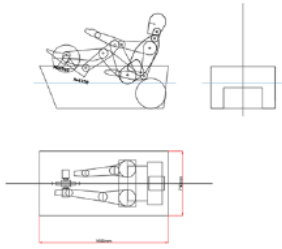
CAD Drawing



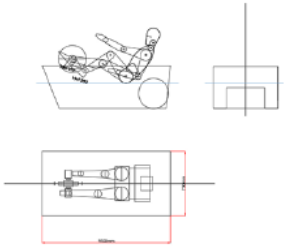
Started with exploring the geometry of the vehicle by creating a silhouette of the vehicle based on the key works that were set in the mood board.

Mood Board

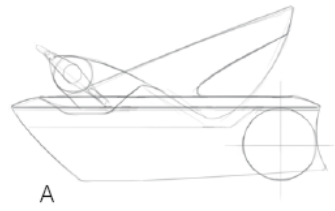
95th Percentile

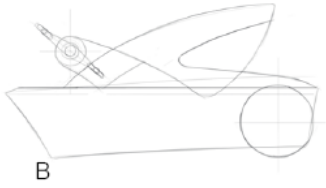


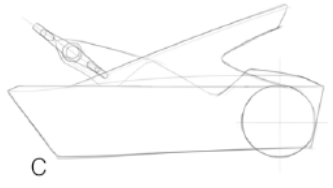
50th Percentile

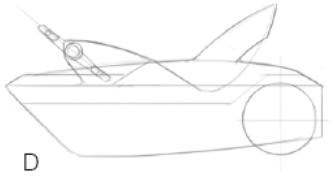


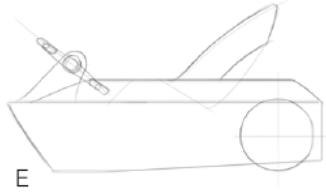
CAD Drawing

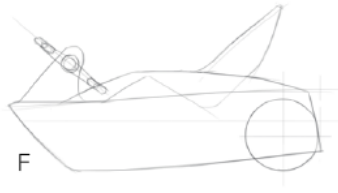


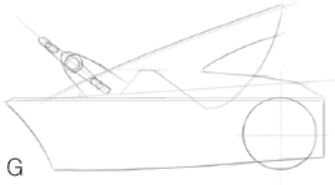


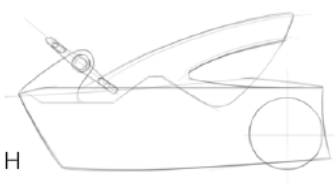


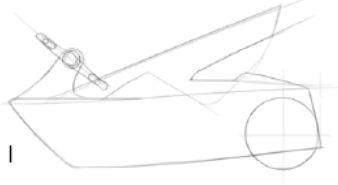








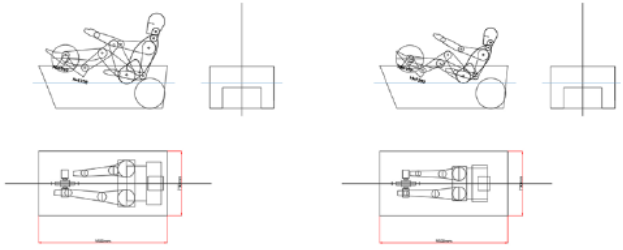




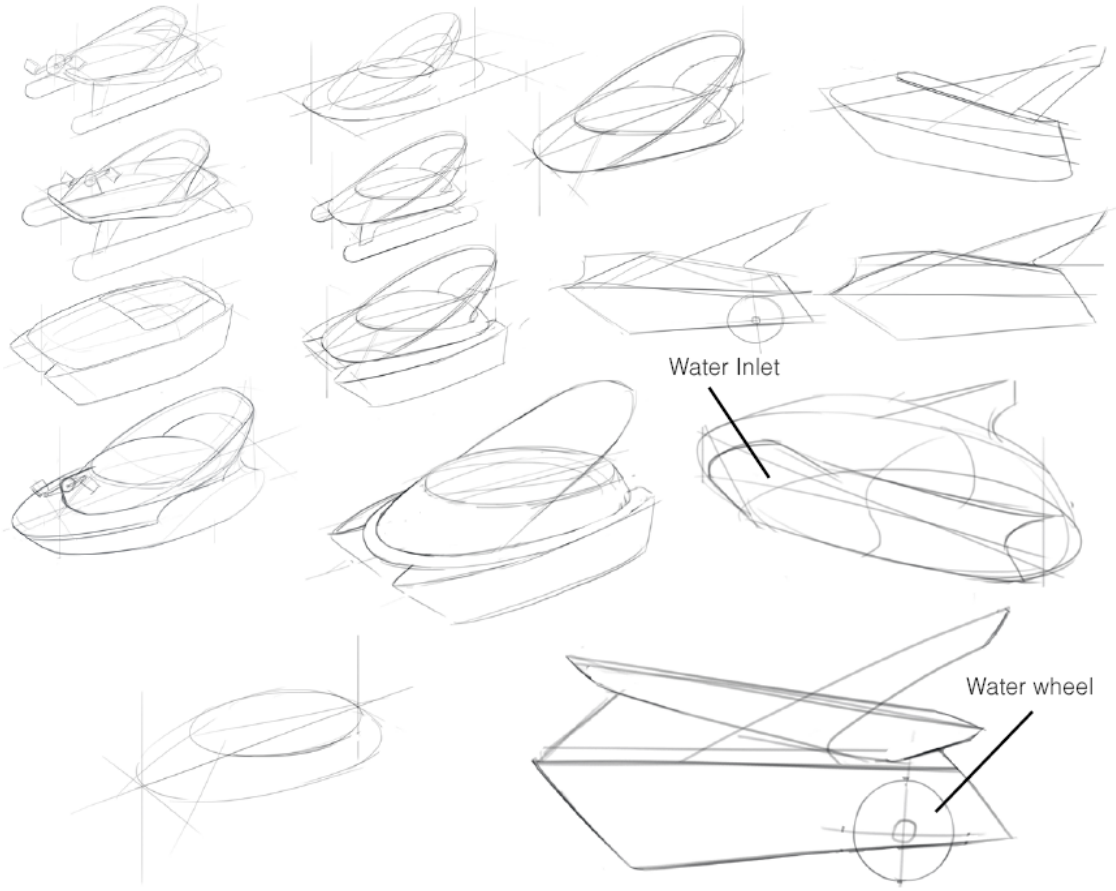
Mood Board

95th Percentile

50th Percentile



CAD Drawing

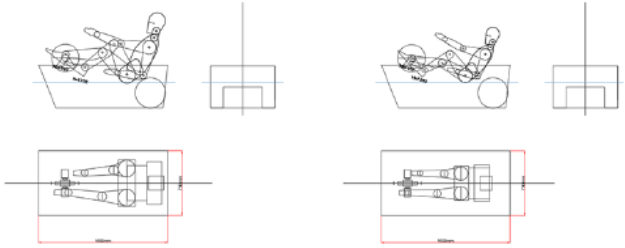


The forms were further developed in the 3D space to further envision the form of the vehicle.

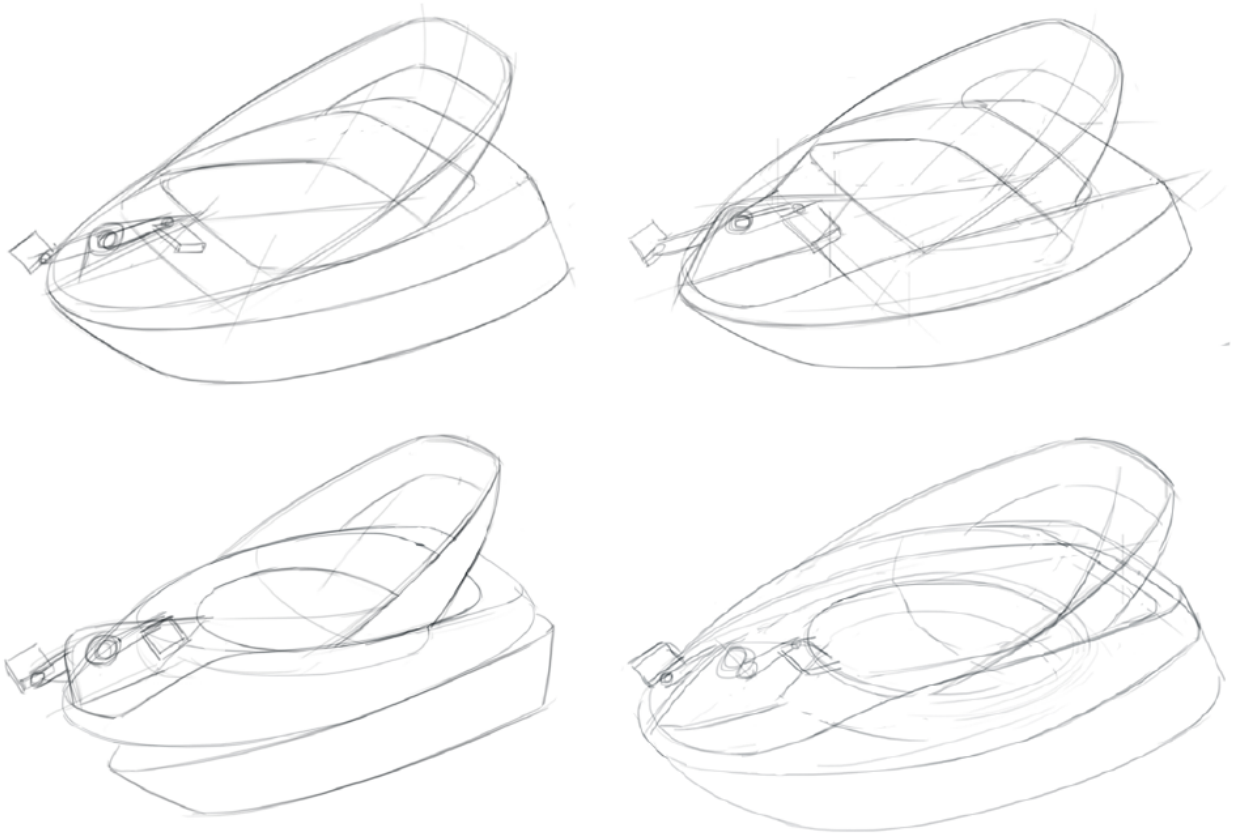
Mood Board

95th Percentile

50th Percentile



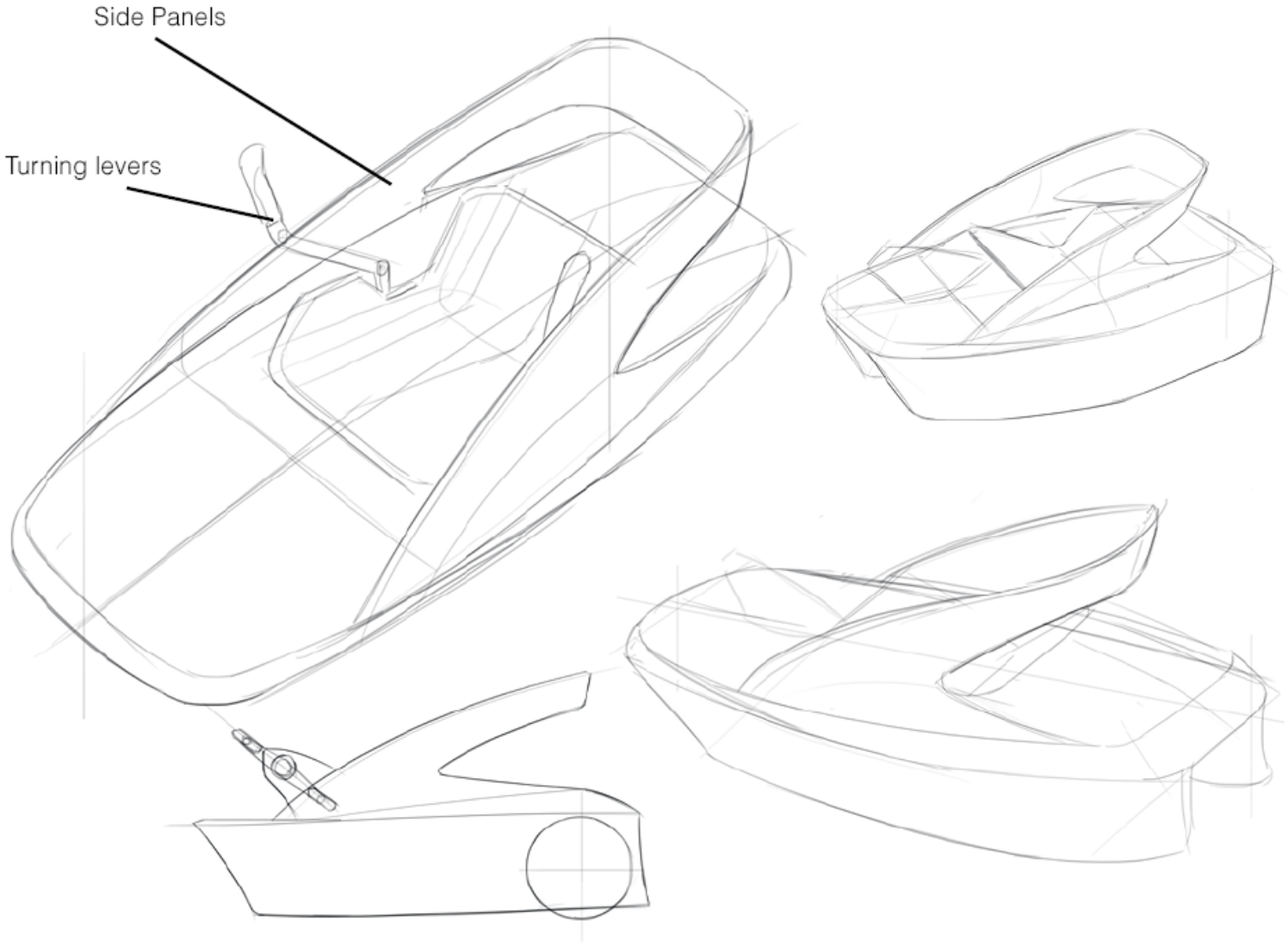
CAD Drawing



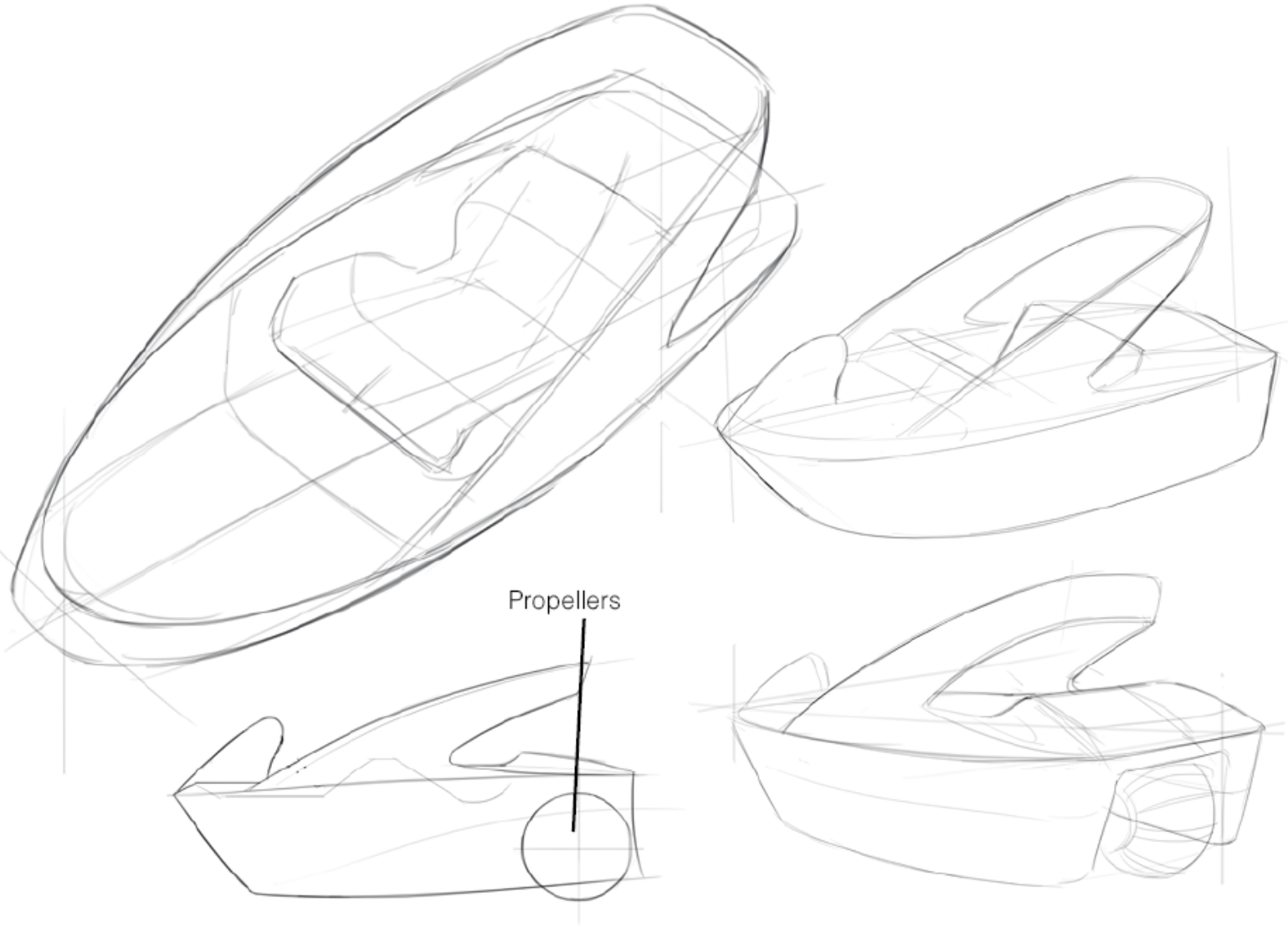
These were the four forms that were selected to develop the concepts of
for the final design.

11. Concepts

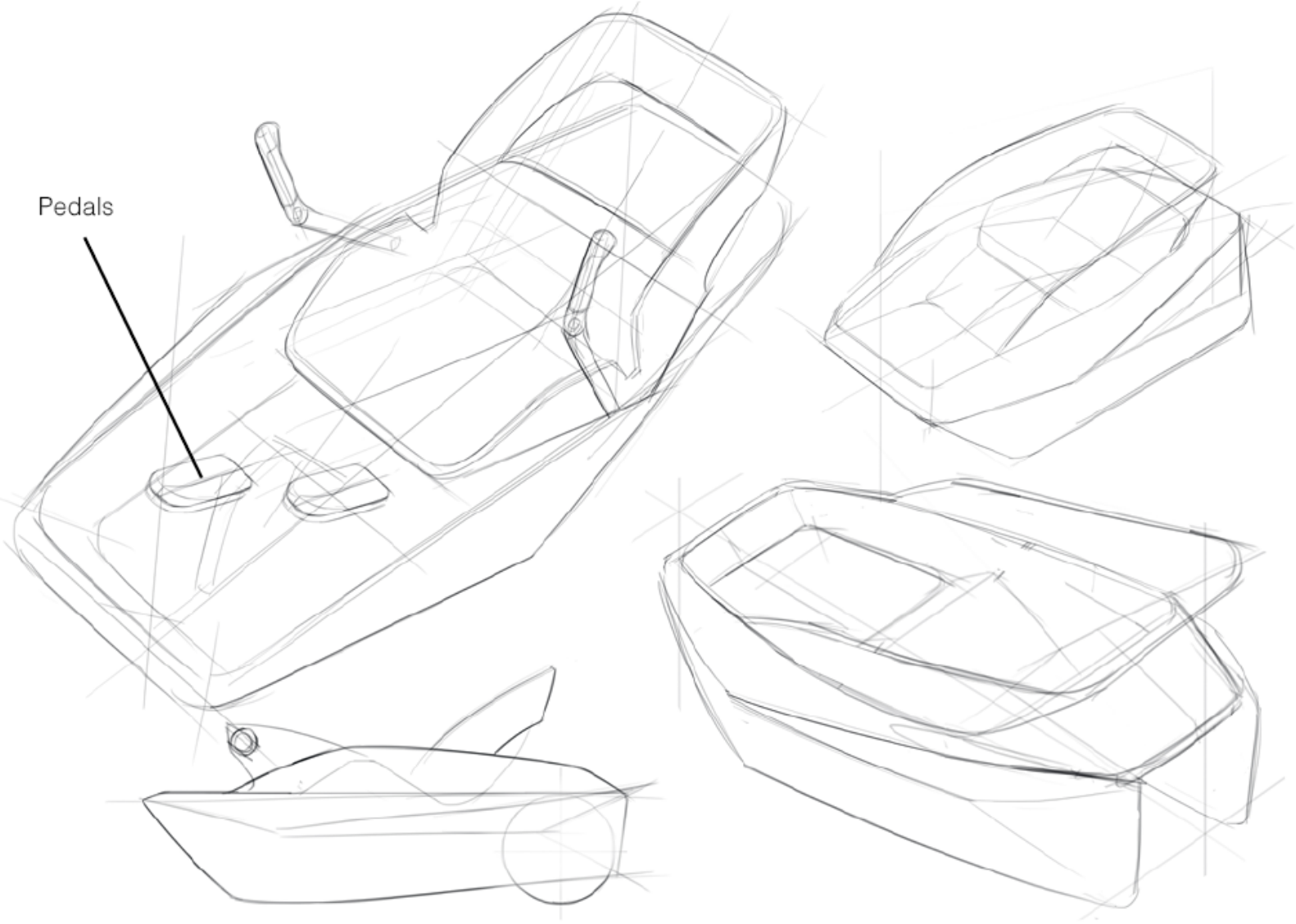
11.1. Concept A



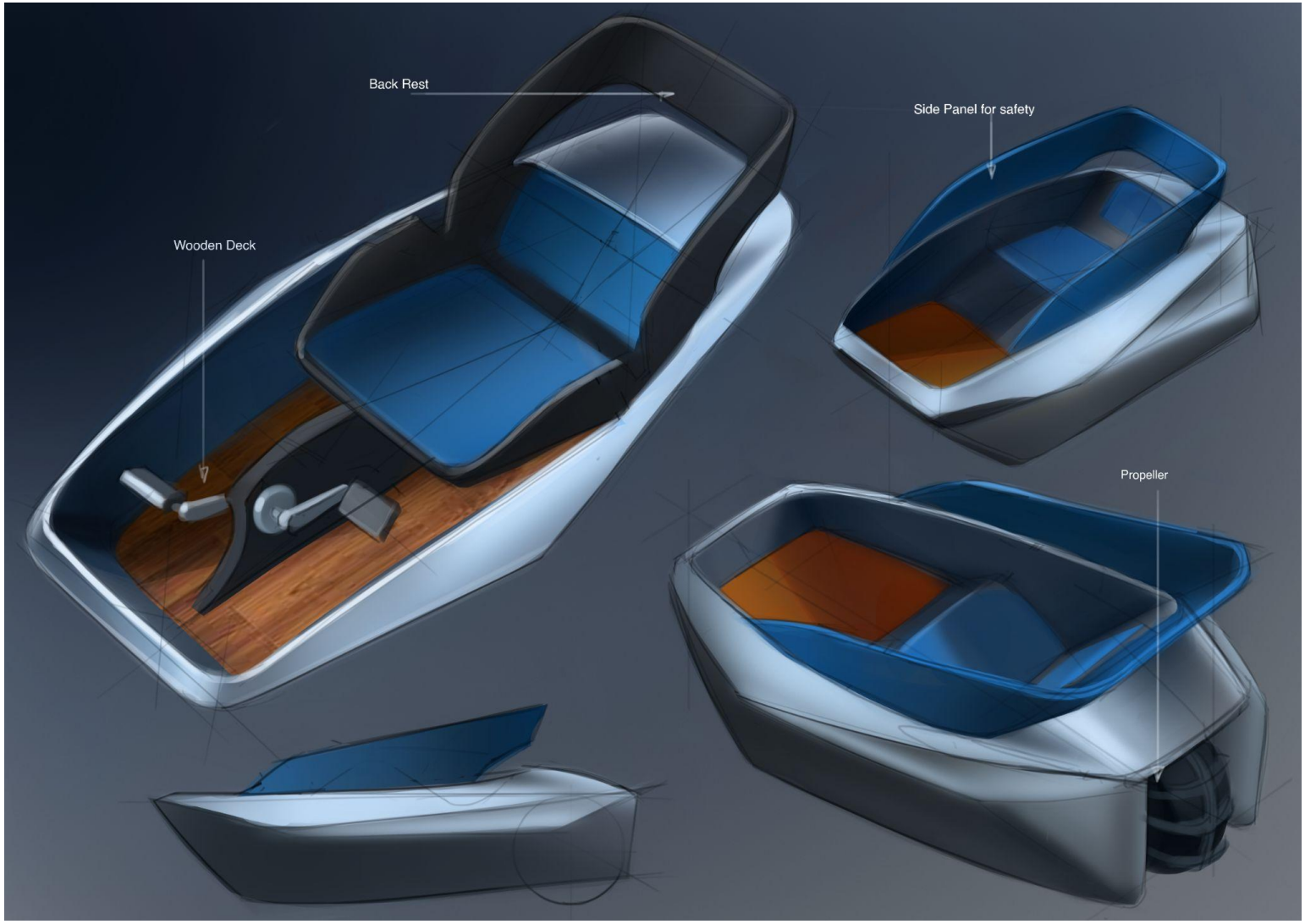
11.2. Concept B



11.3. Concept C



12. Final Concept



13. 3D model

14. Prototype

15. References

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