

Water taxi for inland water ways-Kerala

Design project III

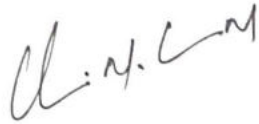
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Declaration

I declare that this written submission represents my ideas in my own words, and where other's ideas or words have been included, I have adequately cited and referenced the original source. I also declare that I have adhered to all principles of academic honesty and integrity and have not falsified, misinterpreted or fabricated any idea/data/facts/sources in my submission. I have understand that any violation of the above will be cause for disciplinary action by the institute and can invoke penal action from the sources from which proper permission has not been taken, or improperly cited.

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This Mobility & vehicle design project report entitled Water taxi for inland water ways - Kerala, by Unni Mohan M is approved in partial fulfillment of the requirements for Master of Design degree in Mobility and vehicle design.

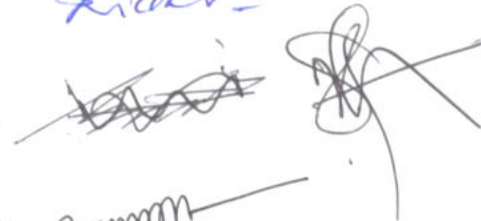
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Date:

Place:

Acknowledgement

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Unni Mohan M

Date

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01 Genesis

Article



<http://www.scorpiogenius.com/2009/08/ts-canal-passage-through-time.html>

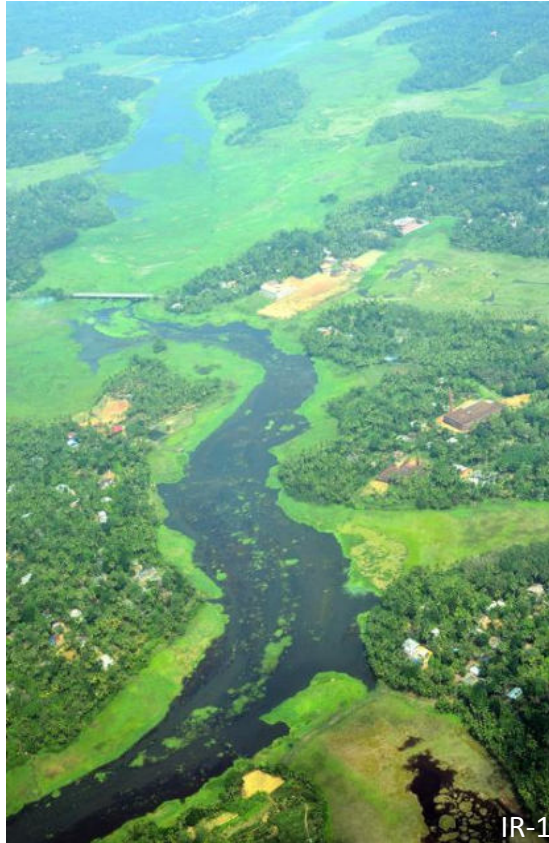
Chief Minister V.S.Achuthanandan and officials visiting the tunnel as part of works related to National Waterway III.

This article generated great interest in me to read more about water way and related stories.

Stories from grandmother

Stories about her father doing coir business from Varkala to cochin through Travancore shornoor (TS canal) and her trips in the same were inspiring.

1.1 Initial study



IR-1

- There are 67 navigable rivers in the state.
- Peculiar feature of Kerala -Canals link the lakes and backwaters to form an uninterrupted inland water navigation system from Thiruvananthapuram to Vadakara - a distance of 450 kms.

- The T S (Travancore - Shornur) Canal, build in 1880, was the main water transport route from Trivandrum to Cochin and beyond till 1950s.
- Was the main trade route specially to transport spices and grains to the ancient port of Kollam.



IR-2

02 Research

2.1. Inland Water Transport

2.1.1. Description

2.1.2. Cost-effective and eco-friendly option

2.1.3. Notable Inland waterway around the world.

2.1.4 Inland vessels

2.2 Inland water ways in India

2.3 Inland Water ways-Kerala

2.3.1 Historic relevance

2.3.2 Present scenario

2.3.3 Future potential

2.4 Kerala Naval architecture\icons

2.4.1 ChundanVallam

2.4.2 Kettuvallam

2.1 Inland Water Transport

2.1.1 Description

- A body of water, such as a river, canal or lake, is navigable if it is deep, wide and slow enough for a vessel to pass.
- Inland Water Transport Systems- is used for centuries in countries including India, China, Egypt, the Netherlands, the United States, Germany, China, and Bangladesh.
- In the Netherlands, IWT handles 46% of the nation's inland freight; 32% in Bangladesh, 14% in the United States, and 9% in China.
- Waterways are the cheapest means of transport. They are most suitable for carrying heavy and bulky goods. It is a fuel-efficient and environment friendly mode of transport.



2.1.2

Cost-effective and eco-friendly option

- IWT developed along existing rivers, canals and waterways-no question of land acquisition.
- The per km cost of development of a waterway is insignificant compared rail or highway.
- The maintenance cost of a waterway is also less.
- The time taken to develop waterway routes is negligible.
- IWT more environment-friendly than either road or rail.
- Congested roads and indisciplined drivers - accidents on highways.
- The least hazardous mode of transportation.

2.1.3

Notable Inland waterway around the world

Venice



- Venezia is a city of small islands, enhanced during the Middle Ages by the dredging of soils to raise the marshy ground above the tides.
- The resulting canals encouraged the flourishing of a nautical culture which proved central to the economy of the city.
- Today those canals still provide the means for transport of goods and people within the city.
- The main public transportation means are motorized waterbuses.

Bangkok - Thailand



- Although much diminished from their past prominence, water-based transport still plays an important role in Bangkok and the immediate upstream and downstream provinces.
- Several water buses serve commuters daily.
- Long-tail boats operate on fifteen regular routes on the Chao Phraya, with an average of 2,889 passengers per day.
- Passenger ferries at thirty-two river crossings served an average of 136,927 daily passengers.

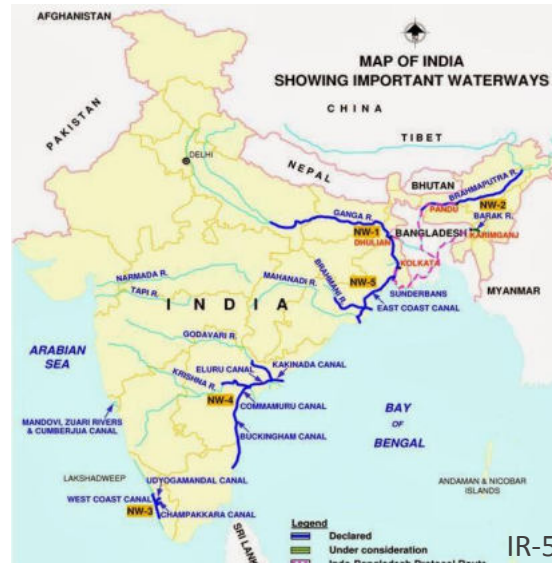
2.1.4 Inland vessels

- Inland vessels are usually less sturdy than ships built for the open seas, with limited navigational and rescue equipment,
- Not to survive the high winds or large waves characteristic to large lakes, seas or oceans.
- They can thus be built from light composite materials.
- They are limited in size by width and depth of the river as well as the height of bridges spanning the river.
- They can be designed with shallow drafts.,
- Ferryboat is often used to cross a river, Riverboat is used to travel along the course of the river.
- A passenger ferry with many stops, such as in Venice, Italy, is sometimes called a water bus or water taxi.



2.2

Inland Water ways-India



Waterways declared as the National Waterways-

1. The Ganga river between Allahabad and Haldia- N.W.-1.
2. The Brahmaputra river between Sadiya and Dhubri (891 km)- N.W.-2.
3. The West-Coast Canal in Kerala (Kottapurma-Komman, Udyogamandal and Champakkara canals-205 km) – N.W.-3.
4. Godavari & Krishna rivers & Canals between Kakinada and Puducherry (NW-4.)
5. The East Coast Canal stretch along with Brahmani and Mahanadi delta river system is defined as NW-5.
6. Barak river from Bhanga to Lakhipur(121 km) in the State of Assam.

- Inland navigation waterways of 14,500 km in length.
- 3,700 km are navigable by mechanized boats.
- In India, only 0.15 per cent of domestic surface transport is done through this route.
- Roads and railways continue to be the bulk carriers

2.3

Inland Water ways-Kerala

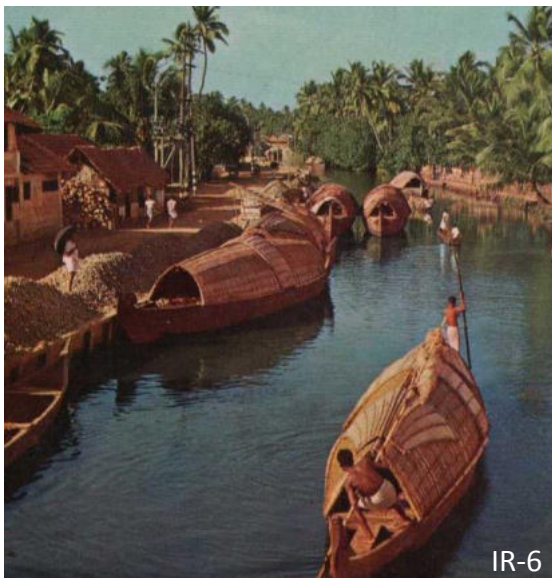
2.3.1 Historic relevance

- Kerala backwaters chain of brackish lagoons and lakes lying parallel to the Arabian Sea coast
- The network includes five large lakes linked by canals, both manmade and natural, fed by 38 rivers.
- The backwaters have a unique ecosystem - freshwater from the rivers meets the seawater from the Arabian Sea.
- Salt water from the sea is prevented from entering the deep inside, keeping the fresh water intact for irrigation purposes.

- Canals link the lakes and backwaters to facilitate an uninterrupted inland water navigation system from Thiruvananthapuram to Vadamakara, a distance of 450 kms.
- Kuttanad in Alappuzha district alone has more than 20 per cent of India's total length of waterways.

The Varkala canal.

- The Varkala canal runs parallel to the Arabian Sea and NH 47. This canal was built by linking the natural water bodies. The conditions of the canal do not allow navigation now.
- The two tunnels are the main features along the stretch of Varkala canal, constructed at a great cost by the Travancore Government and opened in 1881.
- One of them is nearly half a mile in length, bored through the cliffs linking the waterways on either side and establishing through-water communication between Trivandrum and Quilon.



The Varkala tunnel

Magnificent feat of Engineering - The Varkala tunnel.

- The 722-m-long Sivagiri tunnel and the 355-m-long Chilakoor tunnel in the stretch are the main bottlenecks in the waterway.
- The Sivagiri tunnel, completed in 1880, is reported to be the only one of its kind in Asia.
- It was given a facelift in 1942.
- The tunnel was navigable till 1970.
- The National Transportation Planning and Research Centre (Natpac) has suggested several improvements for the tunnel at Varkala to commence boat services.
- The tunnel rises to a height of five meters, siltation restricts the air draft to only 1.3 meters now.



IR-9



IR-8

Present Scenario

- The West Coast Canal from Kottapuram to Kollam was declared as National Waterway No.3.
- National Waterway (Kollam-Kottapuram stretch of West Coast Canal and Champakara and Udyogmandal Canals) Act 1992 (33-F of 1992) and notified on 1st Feb. 1993.
- From Kottapuram to Kollam including Champakara and Udyogmandal canals has a navigable length of 205 kms. 312 Navigational aids comprising of navigation buoys and solar operated navigation lights and 18 beacon towers.
- This is the first National Waterway in the country having 24 hours navigation facilities in the entire stretch.

Date of declaration	February, 1993
NW-3 consists of	
West coast canal (Kottapuram - Kollam)	168 km
Udyogmandal canal (Kochi Pathalam bridge)	23 km
Champakara canal (Kochi - Ambalamugal)	14 km
Total length	205 km
Sea opening- 4 no's	Munambam, Kochi, Kayamkulam and Neendakara
Tidal influence	About 0.70 m to 1.00 m rise during high tide

Obstacles
Narrow portions

Lock gates at Thanneermukkom, and Thrikunnapuzha

Alappuzha – Kollam stretch



Kerala Shipping and Inland Navigation Corporation Ltd.

Activities Transportation of bulk raw materials, petroleum products and water cargo through inland waters.

Operation of ferry services to the islands around Kochi.

Docking and repair of marine vessels.

Construction of wooden and steel inland water crafts.

KSINC is engaged in the fields of transportation of passenger and cargo through the inland waterways of Kerala, Backwater tourism and construction and maintenance of small vessels and crafts.

The company carries bulk materials, petroleum products, potable water, acids etc. through its fleet of barges.

For tourists it operates a number of tourist boats and speed boats, including the luxurious "Sagara rani", which is the only vessel of its kind at Kochi.

Projects

Construction of House Boats

Catamaran service

Dredging

Waterway linked Tourism

Water Sports

Navigation Training Center.

Kerala State Water Transport Department

Governmental agency that regulates the inland navigation systems in the Indian state of Kerala and provides inland water transport facilities. It stands for catering to the traffic needs of the inhabitants of the waterlogged areas of the districts of Alappuzha, Kottayam, Kollam, Ernakulum, Kannur and Kasargode. The department is headed by the State Minister in charge of transportation.

The department is based at Alappuzha and operates a good number of passenger services in the district. Typically, the boats operated by them can carry up to 100 passengers. Even through it is a commercial department, its functioning is like a service Department, ever since Transportation came under Essential Service in Kerala. The Department transports about 150 lakhs of passengers per annum using Wooden/Steel and fiberglass passenger boats.



IR-12

Boat Capacity - 50 to 150 passengers
(wooden boats)

Speed of operation - 10 to 15 km per hour

Boat Size- Length: 20 to 35 meters, Width: 3 to 4.5 m, Depth: 2 m

Empty Weight - 5 to 15 tons

Crew per boat - 5 max.



IR-11

- The Kuttanad area of Alappuzha, which was ill-connected by road until a few years back, had only these boats for their commute.
- The boat has about 4 crew members including a Driver, a navigator, a person to tie the boat at stops, and a conductor locally called as a "Master".
- The Navigator sits inside this cabin. He has a star wheel to control the direction of the boat.
- He communicates with the Driver, who sits towards the middle of the boat, with the help of a bell.
- The third person in the crew jumps out of the boat every time the boat reaches a jetty for a stop.

A host of issues

- Opposition to dumping of slush dredged out from water bodies. As per norms, NW III must have a two-meter depth and 32-metre width so that even huge barges that transport 600 tones of goods may safely use them.
- Land owners on either side welcome depositing of sand on their premises, but are opposed to depositing of slush.
- Fishing nets erected illegally on water bodies too stifle the movement of boats.



• Lorry lobby

The lorry lobby is instigating protests to stifle the development of NW III and coastal waterway, since shifting to cheaper, safer and eco-friendly water transport will affect their business.



Tourism

- Kerala was placed among the '50 destinations of a lifetime' by National Geographic Traveler in a special collectors' issue released just before the turn of the millennium.
- The kettuvallams (Kerala houseboats) in the backwaters are one of the prominent tourist attractions in Kerala. More than 2000 kettuvallams ply the backwaters. Kerala government has classified the tourist houseboats as Platinum, Gold and silver.
- Thatched roof covers over wooden hulls, 100 feet (30 m) in length, provided protection from the elements. The houseboats have become floating cottages having a sleeping area, with western-style toilets, a dining area and a sit out on the deck. Ketuvallams are motorized but generally proceed at a slow speed for smooth travel.



2.3.3 Future Potential

- 74 km Kovalam- Kollam stretch of the waterway is included as a part of the Smart Waterway project of the Central Govt.
- Works for widening the canal to 14 meters and to a depth of 2.2 m and restoration of the Sivagiri tunnel to complete the linking of the stretch to the National Waterway have started.
- Roads are clogged, railways are overburdened, water transport as an alternative reduce the nightmarish congestion on roads.
- It will also be far more economical than widening the existing roadways or building new roads in the densely populated state.

The Theerapadham Project envisaged by the authorities in the late 90s planned to convert the urban stretch of the TS Canal into a waterfront haven.

Theerapadham project could well and truly take off once the waterway project is successful.

The canal presently runs almost parallel to the NH Bypass and the NH 47 , throwing up an exciting prospect of a waterfront boulevard on the lines of those in Amsterdam or Copenhagen.

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Kerala Govt plans movement of petro products thru waterways

<http://www.thehindubusinessline.com/news/states/kerala-govt-plans-movement-of-petro-products-thru-waterways/article5579018.ece>

KOCHI, JAN. 15:

In the wake of rising road accidents involving petroleum tanker lorries, the Kerala Government is seriously considering movement of petroleum products through waterways.

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TODAY'S PAPER » NATIONAL » KERALA

KOCHI, November 27, 2013

Protesters against highway widening show no work done on acquired land

Kerala has narrower National Highways compared to other parts of India. Kerala is the only state, other than Goa, which has requested for narrower highways in the state. While National Highways are being upgraded to 45-meter-wide, Kerala state government has requested NHAI to reduce the width of National highways in the state to 30-meters.

2.4

Kerala Naval architecture \ icons

Chundan Vallam - Speed and performance



IR-13

Chundan Vallam (Beaked Boat), known to the outside world as Kerala snake boats, are one of the icons of Kerala culture used in the Vallamkali (boat race).

- Traditionally each boat belongs to a village.
- Only men are allowed to touch the boat, and barefooted.
- They are controlled by 4 helmsmen, 25 singers and about 100-125 oarsmen who row in unison to the fast rhythm of the Vanchipattu (song of the boatman).
- The Snake Boat Race of Kerala boasts of being the largest team sport in the world is a magnificent fiesta that brings alive the tranquil backwaters.

- Based on an ancient scripture **Sthap Athya Veda**.
- About 83 feet length & 6 inches thick long wooden planks are used for the construction of the hull.
- The boats is 158 feet long and holds 107 men.
- Head & tail will project 5 & 3 feet above the water level. 64 seating compartments - represent the 64 art forms.
- 4 Master oarsmen (representing 4 vedas) are seated at the head of the boat, with large controls the direction of boats.
- Boat is coated with animal fat boiled with lime but the inside is usually smeared with fish oil.
- In order to make the boat slippery in water, coconut shell carbon, eggs & fish oil are used.



IR-14

Kettu Vallam - Luxury and comfort

- The original kettuvallams were used to transport rice and spices about 30 tons, from Kuttanad to the Kochi port.
- Present day houseboats are huge, slow moving exotic barges used for leisure trips.



Features

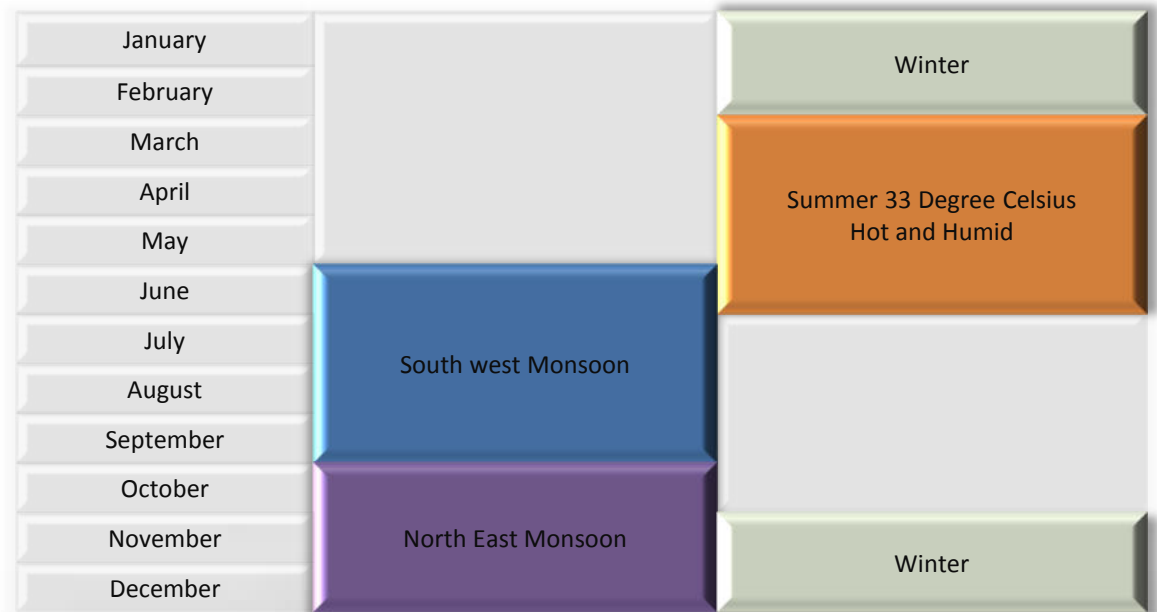
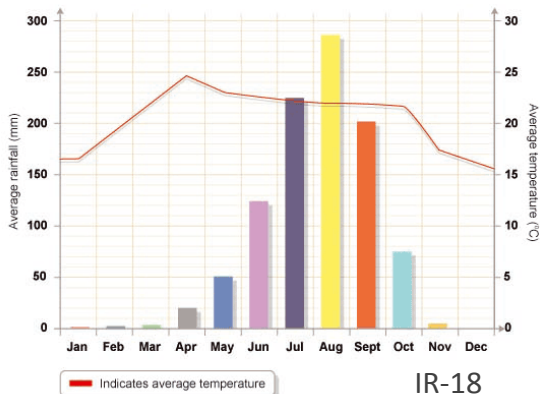
- The kettuvallam is held together with coir knots. The boat is made of planks of jack-wood joined together with coir.
- This is then coated with a caustic black resin made from boiled cashew kernels.
- A portion of the kettuvallam was covered with bamboo and coir to serve as a restroom and kitchen for the crew.
- In Alappuzha alone, there are as many as 500 houseboats.
- Bamboo mats, sticks and wood of the areca nut tree are used for roofing, coir mats and wooden planks for the flooring and wood of coconut trees and coir for beds.
- For lighting though, solar panels are used.



2.6

Climatic conditions

- Kerala has hot and humid climate during April-May and pleasant, cold climate in December-January.
Summer extends from the month of April to June. During this period the temperature reaches to a maximum of 33 degrees centigrade.
- South West Monsoon that starts pouring in the month of June and continues till September, with the increase in humidity.
- The North East Monsoon begins in the month of October and stops at the end of December.
- Occasionally very little rainfall accompanied by thunder and lightning takes place in the northern region of the state.
- Highest rainfall is received by Kottayam during this winter season.



Takeaway from research

Observations

- Native and gifted waterways.
- Historically water ways were life line for people movement and also for goods.
- Economical and environment friendly.
- NW-3 runs almost parallel to NH-47.
- Varkala tunnel and canal are magnificent feat of engineering.
- India's first NW to become 24hrs operational.
- Highly used for tourism.
- Kerala has two iconic navel architecture- Chundan Vallam and Kettuvallam.
- State water transport dept. active but localized to small part.
- Strong presence of monsoon in the state.
- Comfortable and refreshing travel experience.
- Works ongoing for elongation of water way from kollam to Trivandrum.
- Many govt. projects on maintenance and development.

Comments

- Water travel experience remains same in terms of ride comfort but in road transport, surface condition matters.
- Road going experience is never beautiful as water ways.
- Congested and accident prone National highways.
- Over burdened railways.
- Unlike other NW, Nw-3 has combination of rivers and lakes (which keeps floods under control and remains operational almost all seasons).
- Kerala highways are only 45 m compared to national width of 60m. Protest at many part restricting it to go beyond 30m width.
- Current water transport vessels are large and slow (average speed of 15 km/hr.).
- Family privacy (trains offers best travel comfort, but lacks privacy, especially for family).
- Water ways, a sensible transportation model for densely populated Kerala.

03 Field study

3.1

Long distance journey

Alappuzha - Kollam/Kollam-Alappuzha
backwater cruise

Journey time 8 hours

- Departure: 1030 hrs. from DTPC boat jetty.
- Fare: Rs 300 per head.
- No of seats- 80.

The trip

The road trip to kollam to Alleppey would take about 2 hrs., but to get inside Alleppey town another half an hour is required.

The journey though 8 hours was refreshing. Relaxed journey unlike scary national highways which are slow and accident prone.

Observations.

1. Only two halts-one for lunch and other for tea.
2. Toilet inside the boat is convenient.
3. Upper deck highly preferred by travelers.
4. During Initial hours, travelers enjoyed scenic beauty.
5. As time passed, tourists moved into reading book and other activities.
6. Strong sound and vibration from diesel engine filled the cabin.

7. Smell of oil, diesel and occasional entry of smoke in the cabin.
8. Seat comfortable for 8 hrs.
9. Airy feel of cabin was inviting.
10. Water cooled engine.
11. No night trips (excessive reflection from the water surface).





Observations.



Boat roll while ingress and egress.



In narrow channel, boat tends to move and hit the walls.



Bored with lengthy travel.



Waves from other boats affects the ride.



Designed and build by state government.

3.2

Regular ferry service



Small size of vessel could improve average speed.



Size seems good for speed and crowded parts of waterways.

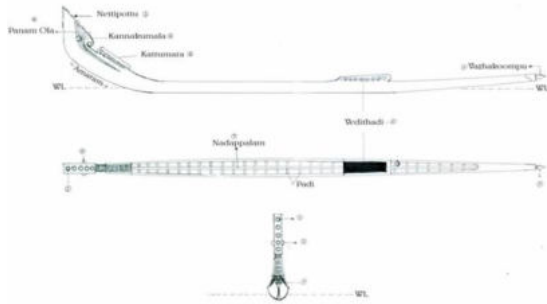


1. People travelling uses ferry as the prime means of transport.
2. Boat never has a complete stop, by propelling forward and reverse the boat is brought near jetty.
3. People starts moving out with or without the help of staffs.



3.3

Study of Chundan vallam



Observations

- Crafted by hand.
- Centre part is first constructed in inverted position with the help of jigs.
- Tail design is made at the end and is left with the creative mind of master at that point of time.
- Rear has to look like a snake with head held high. This gives visual dominance to the boat. Visually rear looks heavy.
- The tall rear helps the master oarsman to command the boat with fine control.
- Rear is enriched with fine craft work and brass ornamentation.



Chundan Vallam

Observations



3.4

Takeaway from Field study

Observations

Long distance journey

- 6.5 hrs. for a distance of 86 km.
- Tiresome because of sound and vibration of diesel engine.
- Boats does not give a feel of safety from outside, presence of life jackets inside gives confidence.
- Rolling of boat while ingress and egress scare first time travellers.
- Toilets in side a must, as unlike roads the cannot be stopped near banks easily.
- It could easily penetrate inside town.
- Reflection from water-less night trips.
- Boats never have a complete stop.
- Speed equivalent to 12km/hr.
- Small size boats could move through house boats and other vehicles easily without slowing down.

Short distance journey-

Used by people as the only source of transport, the journey and travel experience has become a part of culture for the users.

Comments

- Lengthy journey.
- Great visual experience .
- Boats has been associated with the fear of capsizing.
- Rolling of boat not very inviting.
- Passengers finds difficulties with ingress and egress.
- Engine could be isolated from cabin.
- Roads towards district capital are heavily clogged, boats have an advantage here.
- Solution for night journey.
- Boat journey can offer better privacy compared other means of transport.

04 Vehicle idea

Indicators to a new vehicle.

- Time spent in travel should be actually spent for it in comfort - Congested roads and over crowded railways.
- Idea about a vehicle which can be hired to travel long distance in water and offers better privacy and space especially with family.
- Vehicle which can offer better space for passengers especially for travelling long distance. Road vehicles have space limitations (other than custom build). Railways cannot offer personal space or privacy.
- Water vehicle can offer better space than road vehicles and better travel experience than trains.
- A big mpv in water.
- Other than railways, a vehicle going experience reminds us about the presence of engine or propulsion system.

Vehicle idea

A fast water vessel which can be hired for long distance travel?

Examples around the world?

The answer to above brings in water taxi.

Water taxi



05 Benchmarking

Water taxi

- A water taxi or water bus, also known as a **commuter boat**, is a watercraft used to provide public transport, usually but not always in an urban environment.
- Service may be scheduled with multiple stops, operating in a similar manner to a bus, or on demand to many locations, operating in a similar manner to a taxi.
- A boat service shuttling between two points would normally be described as a ferry rather than a water bus or taxi.
- The term water taxi is usually confined to a boat operating on demand, and water bus to a boat operating on a schedule.

5.1

Water taxis around the world

San pedro water taxi

- The boats are designed for speed from Chetumal Quintana Roo Mexico and San Pedro.
- The seats are completely padded with back-rest, head-rest and hand-rest.
- The boats can carry a sixty passengers.
- High definition TV.
- Behind every seat are motion sickness bags and safety cards. Stewardess onboard assists.
- A small/light snack is served to all passengers.

- The boats are completely covered and are powered by three 250 HP Yamaha out board four-stroke engines. This makes the ride vibration, smoke and noise free. Standard on all vessels are GPS, VHS Radio, Compass, Trim-tabs to stabilize boat whilst under way and life jackets for each passenger.



IR-27



IR-26

Dubai -Water taxi



- Dubai Creek to Jumeirah and back .
- The Roads and Transport Authority offers special family packages as well as scheduled daily trips.
- Air-conditioned and metered water taxis,
- Costs around Dh550 for a one-way trip.
- With a cruising speed of 25 knots and top speed of 35 knots.
- The taxi can seat 11 passengers and has 18 stations.



Hydrogen-powered ferry service - Bristol

Hydrogenesis

- The 11m-long steel boat driven by fuel cells.
- The only sound is the hum of the gears changing and the gentle splash of water).



<http://www.theguardian.com/environment/2013/jul/18/hydrogen-powered-ferry-service-bristol>

Cape Water Taxi

Owned by Seahorse Charters, The Cape water taxi provides local residents and visitors of Lewes, Rehoboth and Dewey a comfortable, safe, affordable, hassle-free way to travel up and down the coast. The services provide an alternative way to experience the wonders of the scenic area without having to fight heavy traffic and congestion of roads.



<http://www.capewatertaxi.com/>

The Beirut Water Taxi



The Beirut Water Taxi Project will help reduce Lebanon's traffic worries, carbon emissions and reduce stress levels among commuters, says its creator Dr. Khaled Ahmad Taki.

Yellow Water Taxis Sydney Australia



- Yellow Water Taxis are capable of holding up to 16 persons.
- All-Weather vessels, that can be used either open or closed.
- Taxis are plentiful and can be flagged down most anywhere, though are easily found in taxi racks throughout the city.
- For short trips with a big family, cheaper than public transport.

<http://www.yellowwatertaxis.com.au/>

Yellow Boats -The Water Taxi

- The best way to get around (Ft Lauderdale) is on the Water Taxi, which will zip up and down the Intracoastal Waterway and New River all day.
- The fleet includes 12 vessels ranging from intimate Old Port Class open air boats, ideal for small groups, to the Island Class 65 ft twin diesel Island boats, with climate controlled cabin, full liquor bar, accessible restroom, 200 passenger capacity, 20 knot top speed and premium audio system.



Vivada Inland waterways Limited

- Largest inland waterways company in India.
- The main operations are controlled from Kolkata, which is the main hub for Inland Water transport in National waterways 1 and National Waterways 2.
- The water taxi provides a wonderful opportunity for boating on the Hooghly.
- It starts its venture from the Millennium Park, which is located at the heart of Kolkata.



5.2

Other examples of interest

Cabin cruiser

- A **cabin cruiser** is a type of power boat that provides accommodation for its crew and passengers inside the structure of the craft.
- A cabin cruiser usually ranges in size from 25 to 45 feet (7.6 to 13.7 m) in length, with larger pleasure craft usually considered yachts.
- Many cabin cruisers can be recovered and towed with a trailer and thus easily stored on land, which reduces maintenance and expense. These craft are generally equipped with a head (toilet), a galley, and at least one berth.
- Most cabin cruisers usually have a small dining area and some have a cabin to the rear of the cockpit, with a double bed.



- Some cabin cruisers are equipped with heating, air conditioning, and power generators. Most also have water heaters and shore power electric systems.
 - The cabin cruiser provides many of the amenities of larger yachts, while costing much less and normally being fully operable by the owner.
 - Cabin cruisers are generally able to handle the water well because of their size and give a stable ride.
 - They are generally spacious in the cockpit.
- A **pontoon** is a flotation device with buoyancy sufficient to float itself as well as a heavy load. A **pontoon boat** is a flattish boat that relies on pontoons to float.
 - Pontoons may be used on boats, rafts, barges, docks, floatplanes or seaplanes. Pontoons may support a platform, creating a raft.

Pontoon boat



Yacht



- A **yacht** is a recreational boat or ship.
- In modern use the term designates two rather different classes of watercraft, sailing and power boats. Yachts are different from working ships mainly by their leisure purpose, and it was not until the rise of the steamboat and other types of powerboat that sailing vessels in general came to be perceived as luxury, or recreational vessels. Later the term came to encompass motor boats for primarily private pleasure purposes as well.
- Yacht lengths generally range from 10 meters (33 ft.) up to dozens of meters (hundreds of feet). A luxury craft smaller than 12 meters (39 ft.) is more commonly called a cabin cruiser or simply a cruiser. A superyacht generally refers to any yacht (sail or power) above 30 m (98 ft.) and a megayacht generally refers to any yacht over 50 meters.



Catamaran

- A catamaran is a multihulled vessel consisting of two parallel hulls of equal size.
- A catamaran is geometry-stabilized, derives its stability from its wide beam, rather than having a ballasted keel like a monohull. Being ballast-free and lighter than a monohull, a catamaran can have a very shallow draught. The two hulls will be much finer than a monohull's, the reduced drag allowing faster speeds.
- The limited heeling means the ride may be more comfortable for passengers and crew, although catamarans can exhibit an unsettling "hobby-horse" motion.

Features

- Catamarans, specifically the multi-hulls, are normally faster than single-hull boats for two reasons : less drag, more power.
- The major increase in speed over a monohull is due to the hull shape. Catamarans make use of needle like hulls which significantly reduce wave drag.
- Catamarans are typically lighter and thus have less displacement (weight). They don't require a keel counterweight since righting moment is derived from the spacing between multiple hulls.
- Catamarans have a wider beam (the distance from one side of the boat to the other), which makes them more stable and therefore able to carry more sail area per unit of length than an equivalent monohull.

- A catamaran is most likely to achieve its maximum speed when its forward motion is not unduly disturbed by wave action.
- This is achieved in waters where the wavelength of the waves is somewhat greater than the waterline length of the hulls, or it is achieved by the design piercing the waves.
- Thus catamarans are especially favorable in coastal waters, where the often sheltered waters permit the boat to reach and maintain its maximum speed.

Passenger transport

- The use of catamaran for high-speed passenger transport was pioneered by Westermoen Hydrofoil in Mandal, Norway, who launched the *Westamaran* design in 1973.

- The Westamarans, and later designs, some of them consisting of a catamaran hull resting on an air cushion between the hulls, became dominant for all high-speed connections along the Norwegian coast. They could achieve speeds comparable to the hydrofoils that it replaced, and was much more tolerant of foul water and wave conditions.
- High-speed Stena (HSS) is the world's largest fast ferry, traveling at a speed of 46 mph, although it is capable of doing over 70 mph.



IR-41

F1 Powerboat

- F1 racing uses tunnel hull catamarans that are capable of both high speed and exceptional maneuverability.
- Overall, the boats weigh 390 kg.
- They are 6 meters long and 2 meters wide using of carbon fiber and Kevlar.
- The tunnel hull design creates aerodynamic lift due to a 'wing' formed by the deck and under surface of the hull. only a few inches of the boat touch the water, leading to the high speed.
- F1 boats are powered 400 horsepower at 10,500 rpm.
- This engine can propel the boats to 100 km/h two seconds and to a maximum speed of over 250 km/h.



Solar catamaran Solon C60



- With a length of almost 18 meters and a width of 7 meters, the Solon is driven by two electric motors, which speed the Catamaran to a maximum speed of up to 15 mph.
- With sunny weather the solar panels on the roof guarantee, the ability to run indefinitely.
- The shape of the ship was optimized under bionic aspects.
- The double hulls contain a tunnelled propeller system, which guarantees a high efficiency propulsion and thus takes much less surface water in. Additionally, it protects the propeller from touching the ground.



Planet Solar



- The largest solar-powered boat in the world.
- The vessel was designed by LOMOcean Design, built by Knierim Yachtbau in Kiel, Germany, and launched on 31 March 2010.
- In May 2012, it became the first ever solar electric vehicle to circumnavigate the globe.
- The 31-meter boat is covered in over 500 square meters of solar panels rated 93 kW, which in turn connect to one of the two electric motors in each hull.
- There are 8.5 tons of lithium-ion batteries in the ship's two hulls.
- The boat's shape allows it to reach speeds of up to 14 knots.
- The hull was model tested in wind tunnels and was tank tested to determine its hydrodynamics and aerodynamics.



06 Vehicle Image

6.1

Inputs for the new vehicle

A water taxi

- Hired for long distance travel in NW-3.

Size

- Big enough for comfort and
- small enough go fast maneuver around.

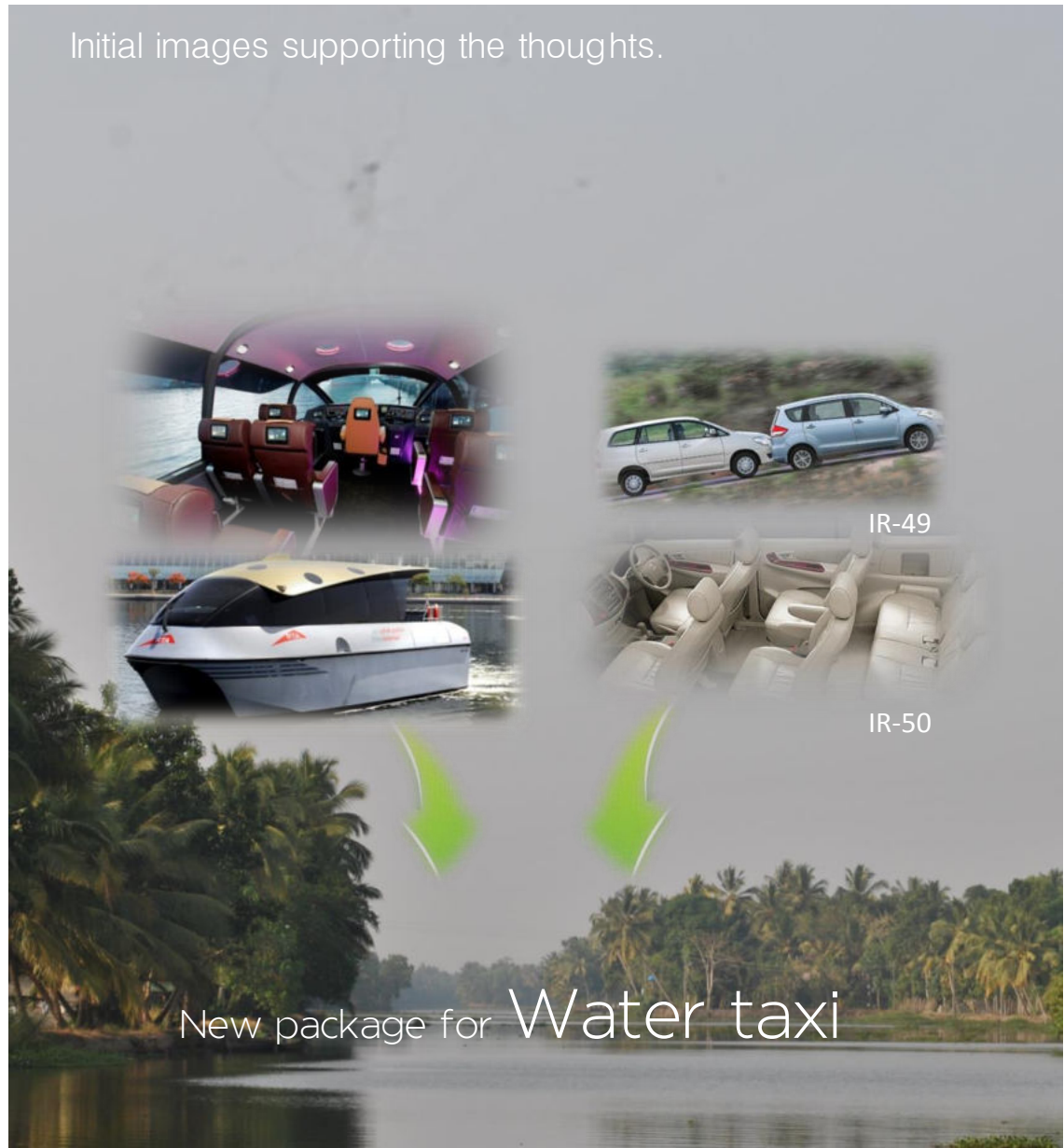
Travel experience

- Comparable or even better to a good road travel experience.
- Advantages of inland waterways (de congested and comfortable).
- Speedy enough to attract road users.

With

- navigational aids for night and safety
- Good seating,
- privacy,
- spacious cabin,
- facilities (toilet, luggage).

Initial images supporting the thoughts.



6.2 Water taxi to

Users-

- Family hiring mpv or taking personal vehicles.
- Tourists-domestic and international.
- Business trips.

Experience-

- Can be related to a comfortable mpv experience (comfortable road experience which can be hired by masses.)
- with better space ,privacy and comfort (than rail and road)

Distance and speed-

- Average distance between district capitals along NW-3 is 70 km (total distance of 250 km).
- Average speed equal to or greater than NH-47 which runs parallel to NW-3 .

6.3 Additional inputs

Discussion and feedback from guide.

- Good over night travel experience (seating + light experience).
- Ingress and egress during rains.
- Feel of safety without being loud.
- Interior seat configuration-
 - flexible
 - interactive,
 - relaxing for sleeping,
 - conferencing,
 - individual entertainment.
- Idea about isolating engine.
- Separating driver from cabin.

07 Design considerations

7.1

Boat architecture selection

Roominess

- The cockpit, is usually huge, since it spans over both hulls. Light and spaciousness,
- As a result of this roominess, a catamaran rarely feels crowded.

Stability

- Catamarans have a phenomenal stability:
- They do not heel under way and do not roll at anchor, no seasickness.
- Stability is also a good factor for elderly people and/or first time traveler..
- Catamaran excellent impression for their first cruise

Speed & maneuverability

- Catamarans are faster under power or sail. than a monohull.
- Catamarans have shallow drafts.
- The phenomenal maneuverability of the cats. With 2 engines spread apart, pivot around the boat's central axis and without rudders.

Catamaran Cons

- Does not convey feeling of sailing.
- anchoring a catamaran can be more difficult, as have more windage.

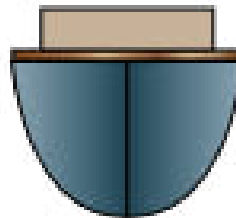
Monohulls



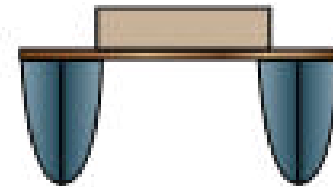
Catamarans



Monohull



Multihull Catamaran



IR-52

7.2

Constraints -Dimension



The Varkala Tunnel is only five meters wide, while the standard width of the National Waterway is 14 meters. Reversible head lock designed to control currents or water levels in either direction. The usable dimension appears to be 45m by 8.40m



- A Kerala houseboat is on an average 70 feet (21.3m) long boats with 15(4.5m) feet width in the central section.
 - The standard width of the National Waterway is 14 meters.
- Average width of house boat -4.5m.

Taking a scenario of going through two house boats on 14m NW-3 stretch,
Space available after giving 1 m tolerance.
 $14 - (4.5+1m + 4.5+1m) = 3m$

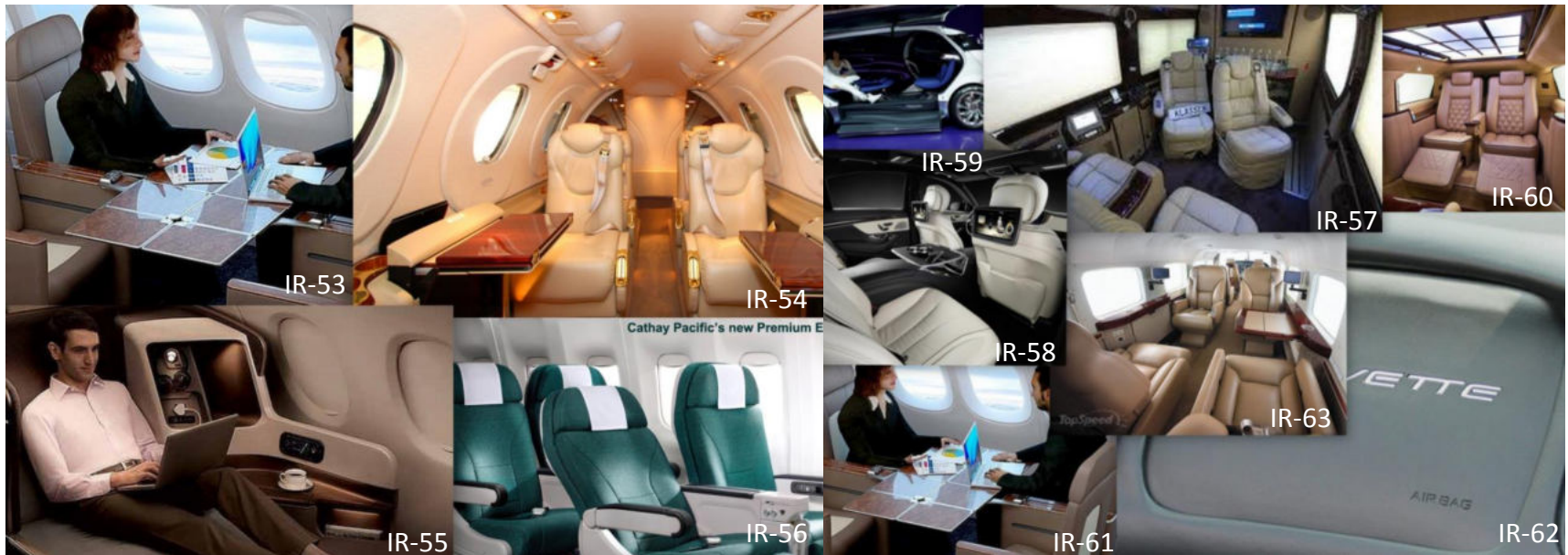
Varkala tunnels are only 5m in width.

Taking above factors into account-
3m exterior dimension is considered.

7.3 Seating.

Considerations-

- Good over night travel experience (seating+light).
- Feel of safety without being loud.
- Interior seat configuration-flexible
interactive,
relaxing for sleeping,
conferencing,
Individual entertainment



Based on desirable features and taking an external dimension of 3m, seating is taken as 7 (6 users+ driver) for initial exploration.

7.4 Speed

Roads are two line for most of the stretch.
Two line roads are prone to accidents.

- NW-3 runs parallel to NH-47.
- NW-3 is empty considered to NH-47 except near kuttanad where lake are filled with slow moving houseboats.
- Width of water body are many times larger than road for most of the parts.



BY Road - NH-47
Drive from Trivandrum
to cochin
Distance =220Km
Time taken = 5hrs30min
Average speed=40Km/h

Water taxi with average speed 40
or more make a tempting choice

7.5 Propulsion

Catamarans with two engines and two
propeller

With 2 engines spread apart, catamarans can
pivot around the boat's central axis and
without rudders ,making it extremely
maneuverable.

If electric propulsion is considered-battery and
electric motor can be place in the floats
allowing isolation and advantage of space.



Catamarans with single engines and single
propeller.

By allowing propeller to change angle, handling
can be greatly improved .



To explore both for initial ideation

7.6 Navigation aids



- **Navigation Lights:**
Navigation Lights enhance the visibility of boat at night, during reduced visibility such as fog or rain.
- **Radar**
Radio detection and ranging -shows what's out there and how far away it is.
- **Horn**
- **Magnetic Compass:**
A compass is a navigation aid for the boat operator to indicate direction. The needle in a magnetic compass will point to the magnetic north.

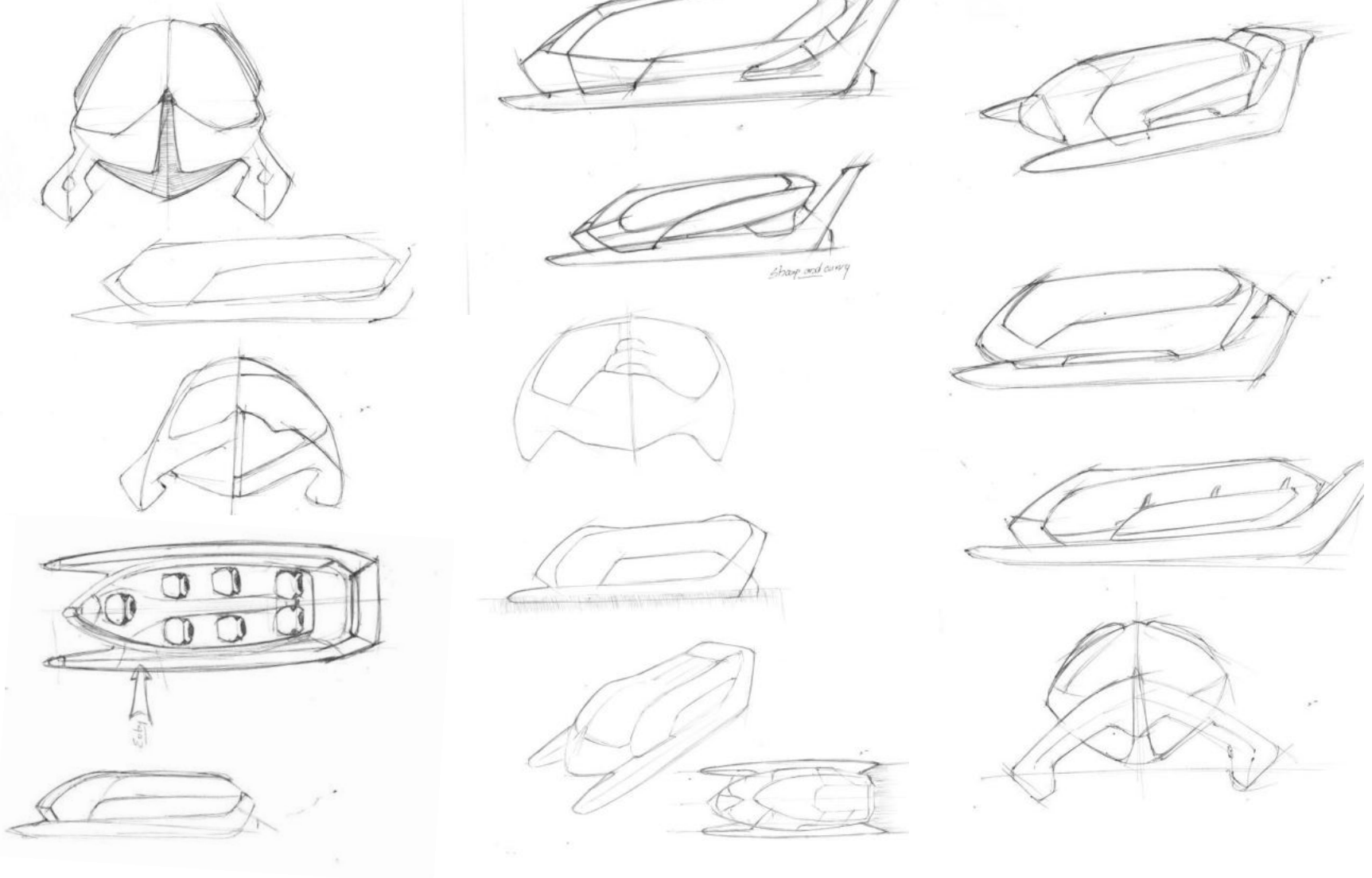
Single digital display for all indication and warning sinages.

7.7 Safety and features



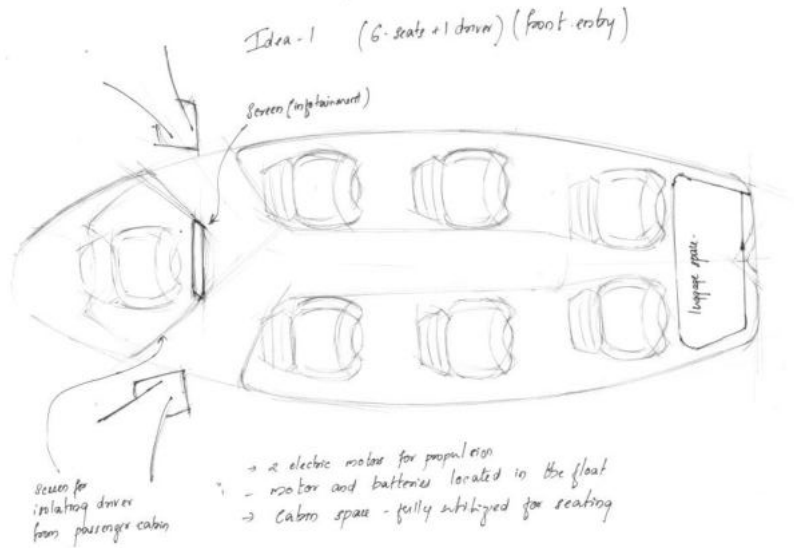
08 Sketches

Free explorations



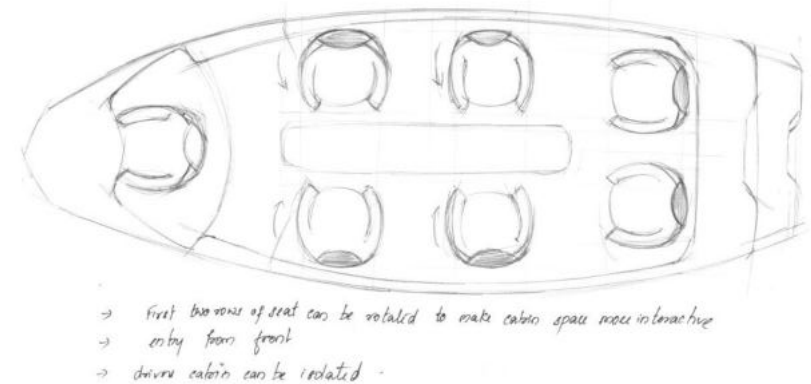
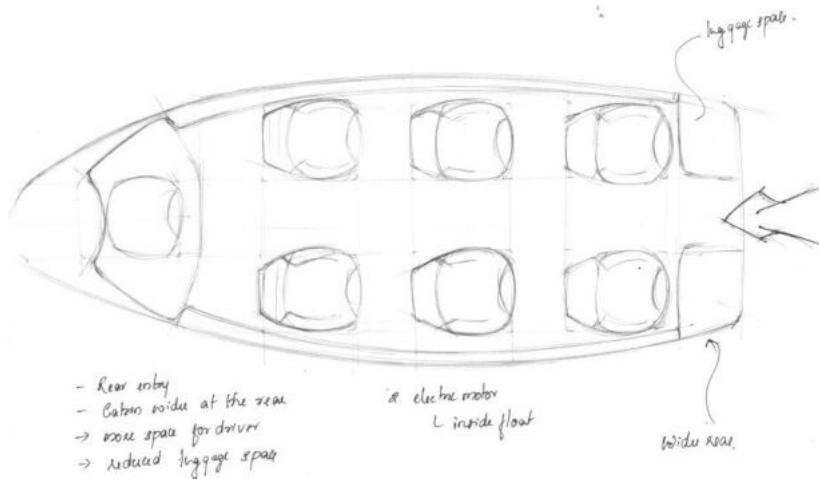
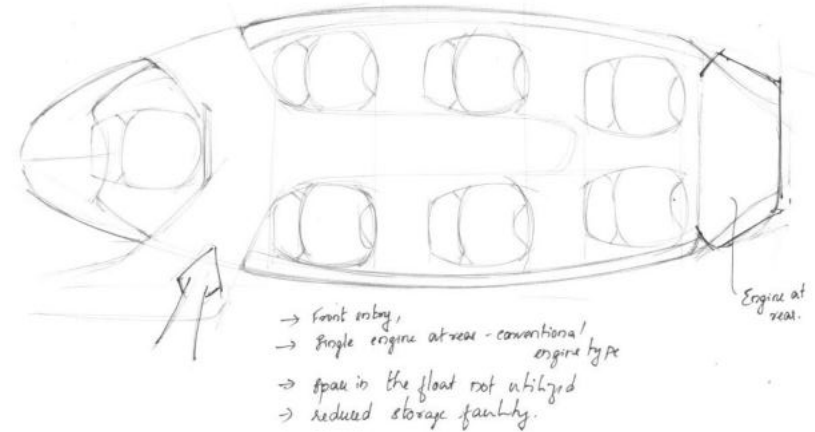
08 Sketches

Free explorations



Ideations for seating and doors.

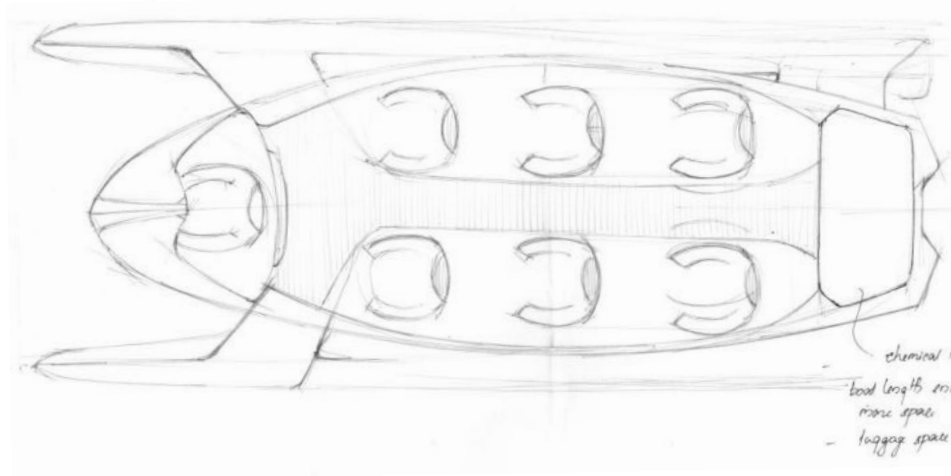
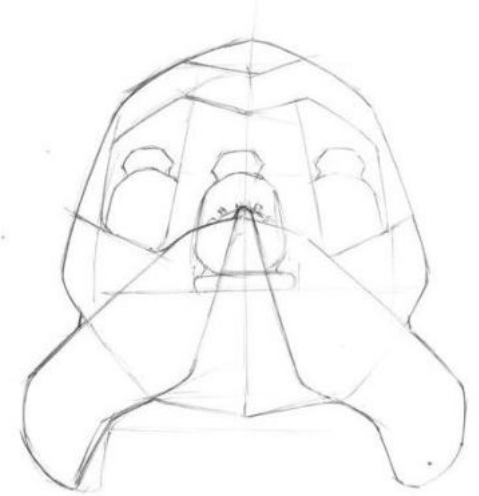
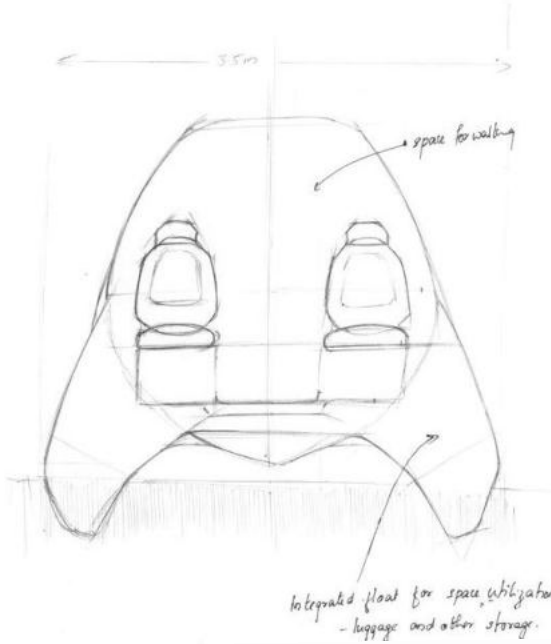
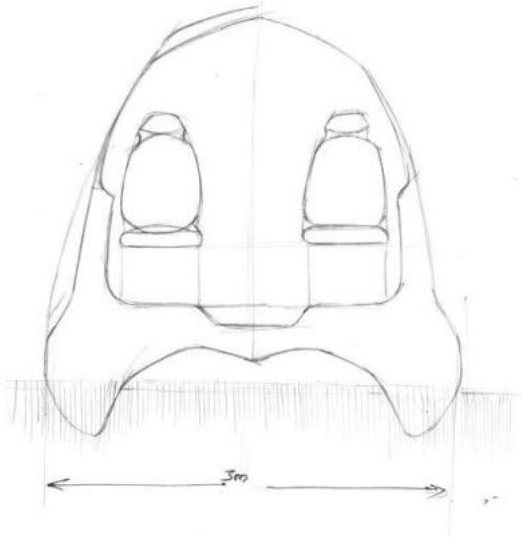
Idea - 3



08 Sketches

Free explorations

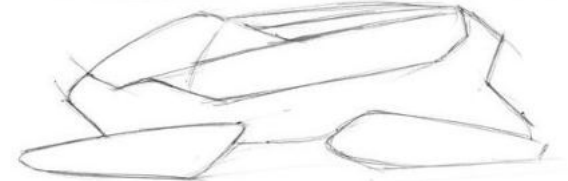
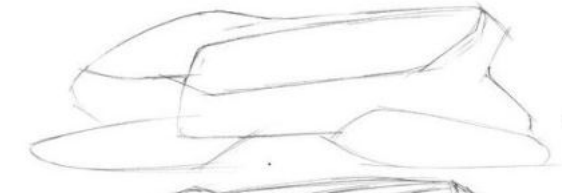
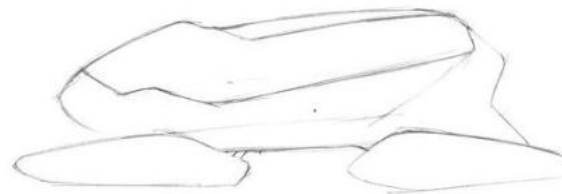
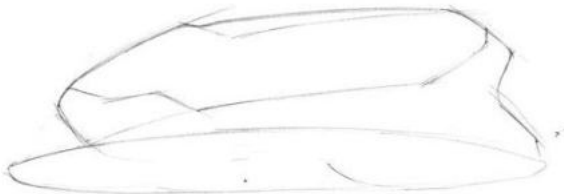
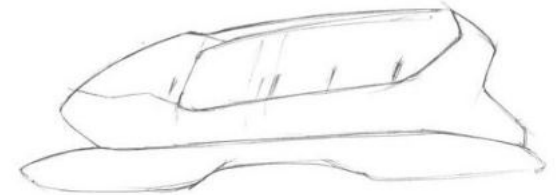
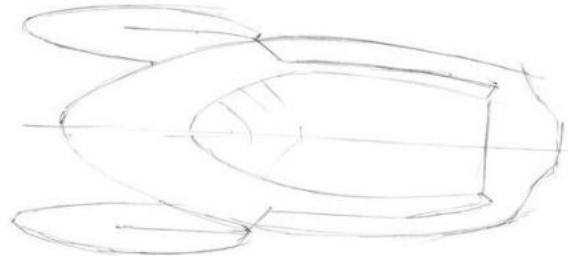
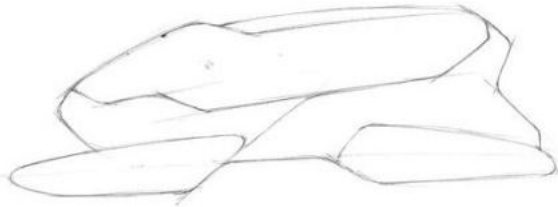
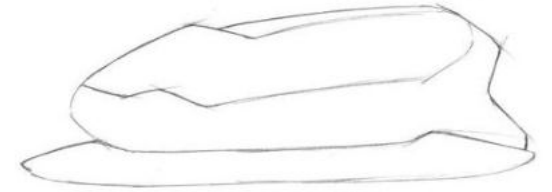
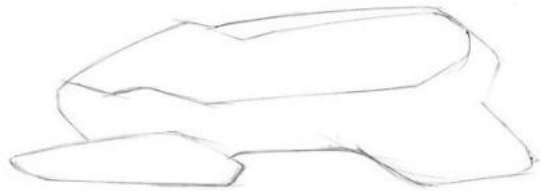
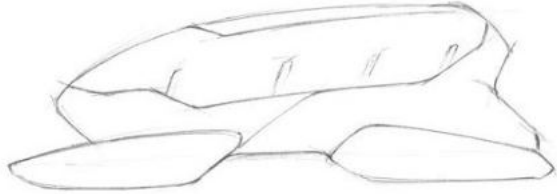
Ideations for seating - front view



08 Sketches

Free explorations

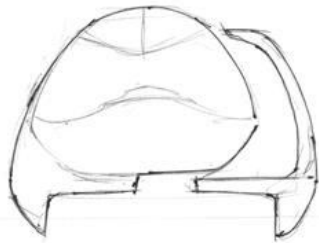
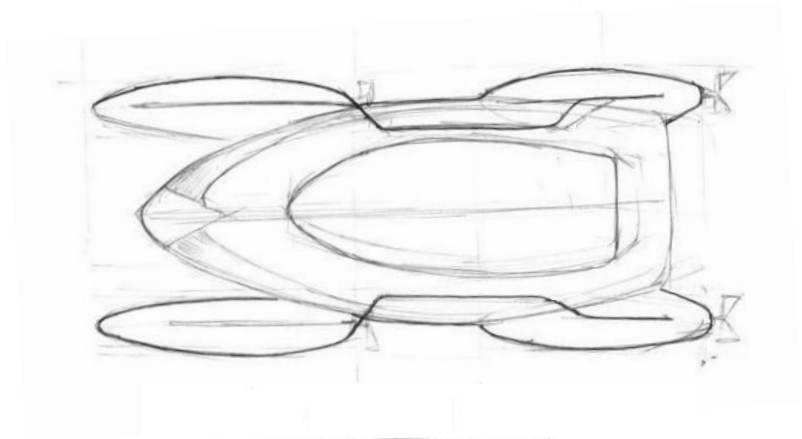
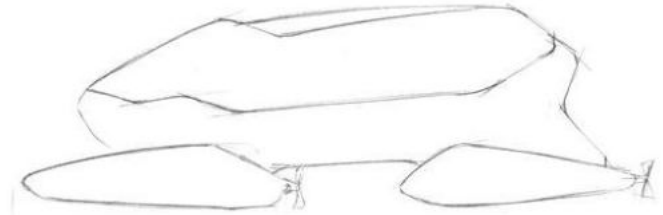
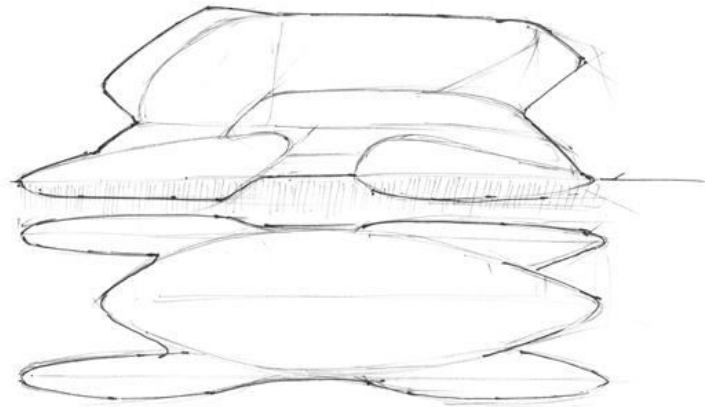
Ideation on float design



08 Sketches

Free explorations

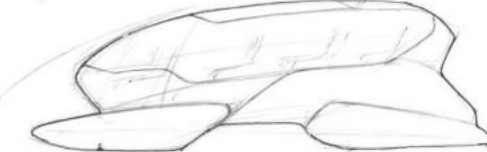
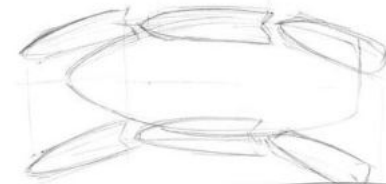
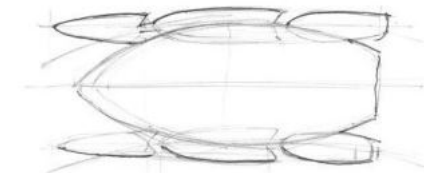
Ideation on float design



Reducing float area



flexible floats



09 Design brief

Intent-

Design of water taxi for Kerala inland water ways.

Offering-

Comfortable long distance travel experience for 6 adults plus driver.

Cabin

Offers-

privacy, space, comfort and facilities(toilet)
Interior seat configuration-
flexible
interactive.

Specifications-

- Catamaran architecture
- Design allows comfortable ingress and egress.
- Protection from rain.
- Single person control.
- Average cruising speed of 21knots (40km/h) or above.

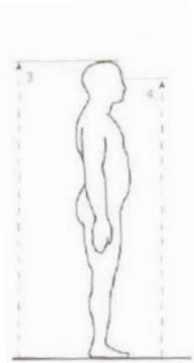
Aesthetics-

- Taking design clues from naval architecture icons.
- Feel of safety without being loud.

10 Human factors

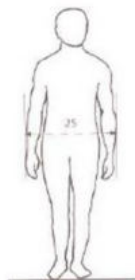
10.1

Anthropometric data



Stature

	5th	50th	95th
Male	1537	1648	1781
Female	1429	1517	1632



Max body width-relaxed

	5th	50th	95th
Male	415	503	619
Female	391	464	599

Space for walking ,sitting(reclined) and movement to toilet has to be considered while designing interior space.

The approach in the design is to focus on defining interior environment by allotting proper space for relaxing, movement and storage of personal baggage. Once interior is set and defined exterior volume around the cabin is decided.

Design from Inside to Outside

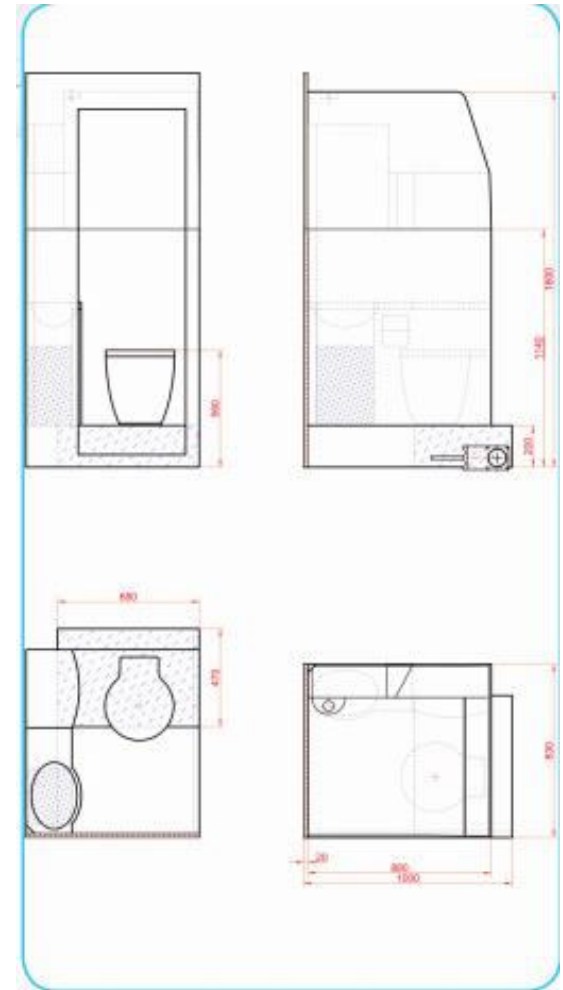
10.2 Facilities-Toilet.

For long distance cruising by water , toilet onboard is inevitable as the vessel cannot be brought near shore easily .Also infrastructure along the NW-3 is highly undeveloped.

Taking clues from toilets used in long distance buses for dimension and facilities,glova bus toilet is chosen as the reference .

Dimension of the toilet is 930 x 850 x 1.800 mm, the height is variable

GLOVA Bus toilets



10.3

Cloths and body language



IR-76



IR-77

Considerations

- Traditional dressing style includes sari for ladies and mundu for gents.
- Western dressing style is prominent with current generation ,but senior citizen and women in the state still goes with traditional dressing.
- Body parts exposed in sari for women- material for seat has be carefully chosen, good resistance to sweat and comfortable for body
- Since one hand is used to hold mundu and sari while walking, some support for holding while boarding the boat has to be considered. This becomes important as the boat rolls while ingress and egress.



IR-78



IR-79



IR-80



IR-81



IR-82



IR-83

10.4 Bench marking -Dubai Water Taxis



Water Taxi (Technical specification):

- Hull : Catamaran.
- Length : 10.8 meters.
- Width : 4.1 meters.
- Speed : 35 knots (65 Km/hr.).
- Engines : Water Jet.
- Number of passenger : 11 passengers.
- Number of boats : 10 boats for phase 1.

Water Taxi (Seat Features):

- Seats with features equivalent to business class in planes.
- Seat decline to the back with 45 degrees.
- Seats are foldable by 20% to create room for passengers with special needs including the entry and exit of the wheelchairs.

- All seats equipped with life jacket in the bottom of the seat belt as specified in International Convention for the Safety of Life at Sea (SOLAS).
- Built by the Damen shipyard in the Netherlands.

Water jet propulsion

Powered by a pair of Kamewa FF310 waterjets built by Rolls-Royce at Kokkola in Finland.



Features

- Produces less noise and vibration.
- Ability to accelerate, reverse, stop and steer is excellent.
- Higher efficiency with speed.
- No overloading of engine, lesser breakdowns and increased life cycle.

Main components are: pump and nozzle. Pump is generally driven by a shaft from a diesel engine or gas turbine, to draw water through a sloping intake duct under the vessel's hull.

High pressure water from the pump is discharged through an aft-facing nozzle to move the vessel forward.

11 Propulsion

Types

1. Conventional IC engines

Most widely used method of propulsion in marine industry.

2. Electric propulsion.

Electric propulsion is also accepted as a potential source in marine industry. Some examples in this area are-

Solar catamaran Solon C60



Planet Solar



Hydrogen-powered ferry service - Bristol



Electric propulsion is faced with the problem of energy density.

Solar power cannot be considered as the prime source of power.

The energy storing capacity of batteries for a long distance service is also a matter of concern.

The option of electric propulsion makes more sense when it is considered as an auxiliary propulsion taking examples from hybrid cars which are becoming popular in present time.

Day time solar energy can be harnessed from overhead panels and used to give auxiliary propulsion.

3. Hybrid-IC plus electric

A combination of IC engine and electric propulsion. Energy for electric propulsion can be obtained batteries which are charged by solar power or some sort of energy recovery or regeneration. In this case IC engine acts as primary propulsion system.

11.1

Conventional IC engines

11.1.1

Engine-Inboard or outboard ?

Inboard motor is a marine propulsion system, where engine is enclosed within the hull of the boat, usually connected to a propulsion screw by a driveshaft.

Outboard motor - consisting of a self-contained unit that includes engine, gearbox and propeller or jet drive, designed to be affixed to the outside of the transom.

Most common motorized method of propelling small watercraft. As well as providing propulsion, outboards provide steering control, as they are designed to pivot over their mountings and thus control the direction of thrust.

To eliminate the chances of hitting bottom with an outboard motor, the motor can be tilted up to an elevated position either electronically or manually. This helps when traveling through shallow waters where there may be debris that could potentially damage the motor as well as the propeller.

Inboard motor



Outboard motor



Outboard motors advantages

Size and Space: Outboard motors gives the vessel more spacious interior.

Handling: Steering an outboard boat means turning the entire engine, either directly or with a steering wheel. Outboard boats handles much better going backward than inboard boats

Low Speeds: Another advantage of the outboard motor is handling at low speeds. Outboard boats can turn effectively with or without power, which makes low-speed maneuvering and docking easy.

Acceleration: If the propeller is located in turbulent water created by this current, acceleration and fuel efficiency are reduced. However, many outboard motor designs place the propeller farther back, outside the boat's turbulence. This provides improved acceleration and better fuel efficiency.

Engine Lift: One of the biggest benefits of the outboard design is that the entire motor can be lifted out of the water when not in use.

Maintenance: Being able to lift the whole engine out of the water also makes maintenance easy. Operators can reach the motor from inside the boat and access the whole system while the boat is on a trailer.

Portability: Many smaller outboard motors can be easily detached and moved from boat to boat or put in storage.

Cost: Outboard motors are more affordable and that the motor itself is cheaper to replace.

11.1.2 Outboard in cats

Single or double outboard engines ?

Inputs from forums and blogs

1.http://www.wmi.org/multi_boards/catamarans/T57.htm

With twin motors the benefits - easy maneuvering, safety if one motor has a problem, twin charging of batteries etc.,

Also with twins motors running at half throttle will be faster and less strain on engines than one higher hp doing the same revs.

Fuel saving is negligible.

Cavitation problem of single propeller in cat and with load

2.http://www.worldcat.com/site/benefits_

Double engine increases reliability .the picture shows a cat propelled by single engine.



3.<http://coastanglermag.com/blog/2010/11/twin-vee-catamarans/>

Most catamarans are powered with twin engines to maximize engine efficiency, i.e., one engine behind each hull. The area between the hulls is usually full of aerated water and a single engine prop has trouble getting a good grip on the water.

4.<http://shuperboats.com/info/motor-katamaran-en.php>

Maneuverability -Power catamaran is superior to any, even the twin-engine monohull , simply because the catamaran engines are much further apart.

5.<http://www.boatdesign.net/forums/boat-design/anti-cavitation-deflector-cat-35304.html>

For high speeds two engines are required for cats, one behind each hull. To make single center propeller effective in cats some modifications are required.



11.1.3

Waterjets Vs. Propellers

Inputs from forums blogs and internet research

1.file:///C:/Users/MVD%202/Downloads/Waterjets VsPropellers.pdf

For speeds up to 25 knots, propellers are more efficient than jets.

For 28-30 knots, use waterjets. Jets will not be effective on a heavy craft.

Waterjets; Pros; maneuverability, protected, safety, less stress on engine/transmission.

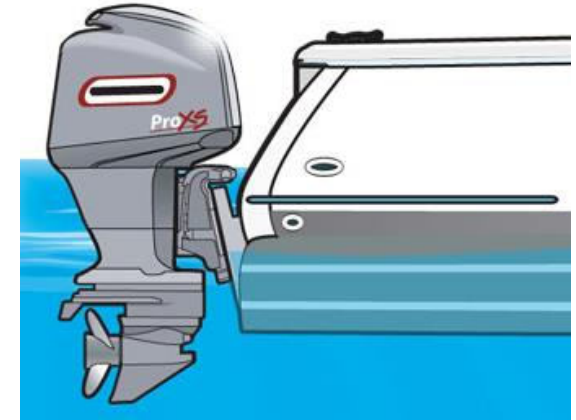
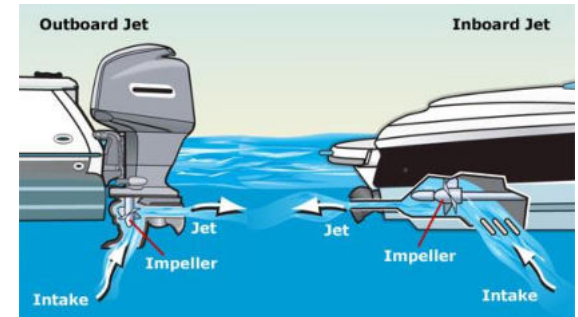
Waterjets; Cons; cost, lower efficiency at low speed.

Propellers, Pros; cost, higher efficiency at low speed, less on board systems.

Propellers, Cons; vurnable to external damage, less safe with casualty in water, less kind to transmission and engine.

2.<http://www.yachtforums.com/forums/technical-discussion/4470-jet-drive-vs-prop.html>

A study in 1992 conducted by Naval Architects Donald Blount and Robert Bartee revealed that a propeller-driven boat will have a hull efficiency of 92%, while the water-jet driven boat will have a hull efficiency of 110% at speeds over 25 knots. A propeller puts a heavier load on the engine. Overload on the engine leads to premature engine failure.



A water jet protects the engine from changes in boat weight. It presents a predictable load to the engine.

Water jet systems typically are more reliable than propeller systems because they are less complex and the engines are protected from overloads more adequately.

11.1.4 Engine -power

Taking reference from some examples

1. San Pedro Water taxi



- These boats are designed for speed and especially to conduct runs to and from Chetumal Quintana Roo Mexico and San Pedro.
- Powered by three 250 HP Yamaha out board four-stroke engines.
- Seated capacity of sixty passengers.

2. Premier 250 Intrigue



Length Overall	7.75 m	Dry Weight	1,338 kg
Beam	2.59 m	Tested Weight	1,778 kg
		Fuel Cap	87 L

- With a single Yamaha F250 propels to a top speed at 6250 rpm of 39.2 mph, burning 21.55 gph giving a range of 87 miles.
- Cruise at 3000 rpm and 17.2 mph reduces the fuel burn to 4.7 gph giving a range of 175 miles and an endurance of 10 hours.
- Top speed for the Premier 250 Intrigue is 39.2 mph (63.1 kph).

3. Ecstasy range from Samudra shipyard, Kerala



Speed in Knots		Main Particulars	
HP	With 8 Pax/560kg	Length	6.8 M
70	20-22	Beam	2.2 M
100	25-28	Depth	1.1 M
150	30-32	Draft	0.33 - 0.45 M
200	34-36	Power	70 - 300 HP
225	38-40	Seating	8 Persons (incl. Driver)
250	40-42		
300	42+		

Engine power and dimensions

From above examples 250hp engine is good enough to take a payload of 8 people and boat weight of 2 tones.



Dry Weight	276 kg
Mounting Centers	28.6"
Steering Angle (maximum)	32° from center

Outboard propeller drive can be converted to jet drive with some reduction in efficiency. The conversion guide from Yamaha is

Jet power conversion guide	
Propeller shaft Hp	Jet Pump HP
150	105
115	80
90	65
60	40
40	30

Catamarans with twin outboard performs better than with single engine. Two 105 Hp outboard jet drive or two 115Hp propeller drive outboards can be considered for propulsion.

Dimension reference



11.1.5

Concluding IC engine specifications

Based on the studies on IC engines on catamarans it has been concluded to proceed with two jet drive outboard engines. For dimension and other specifications Yamaha 105 jet drive has been selected for concept development.

- Engine placement - Outboard
- Engine number - Twin engine catamaran
- Propulsion type - Waterjet outboard
- Engine power - 2*105 Yamaha jet drive

11.2 Electric propulsion.

Successful electric propulsion model in catamaran design has electric motor and batteries placed in side hulls. Thus the middle platform can be entirely considered for cabin design.

11.3 Hybrid propulsion.

Combination of IC engine as primary propulsion and electric power as auxiliary source. Placement of batteries and electric motor on floats and IC as outboard engine, the center platform can be entirely used for cabin design.

12 Concept Development

12.1

Drive and propulsion inputs

Catamaran type architecture with the center platform joining two hulls can be entirely used for cabin design as the propulsion units are either out board or placed inside floats.

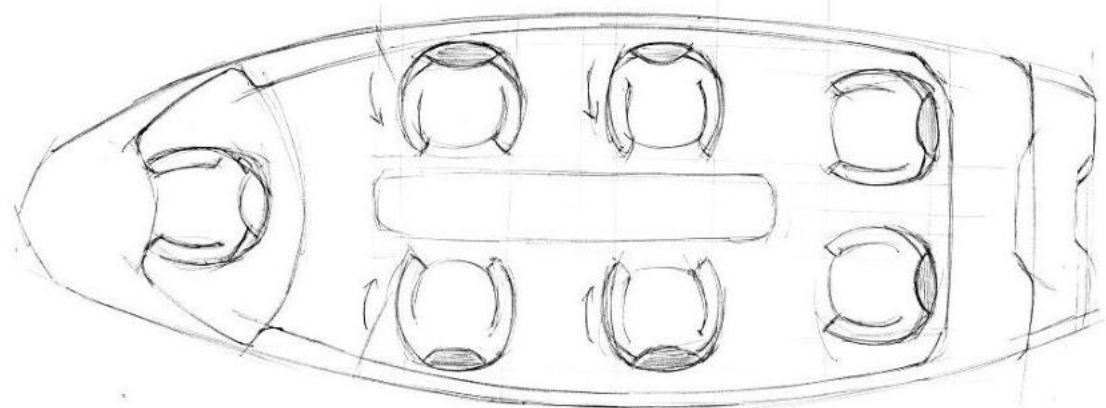
From initial ideation on seating, the following layout is selected .

The layout has doors kept on either side of cabin behind divers seat and toilet at the rear end of cabin.

12.2

Seating layout

This layout is selected from space point and also on the consideration that the vehicle is single person controlled. Door being in front helps driver to have better visibility of people movement during embark and disembark. The rear part can be used for storage and toilet facilities.



- First two rows of seat can be rotated to make cabin space more interactive
- entry from front
- driver cabin can be isolated

12.3

Luggage placement

Following scenarios are considered for travelers in water taxi.

- Family
- Business trips
- Domestic and international tourists

Two bags are considered for a each passenger.

Shoulder bag or hand bag as a cabin bag and a trolley bag or duffle or rucksack as the other bag.

For space exploration maximum dimensions are considered from each group.

Weight of shoulder bag is expected to be around 7kgs and that of trolley bag to be around 20kg.



Baggage-luggage consideration

Group-1

VIP i3 01 Laptop Backpack

Dimension (cm) (LxHxW)
33 x 40 x 21



IR-89

Hand bag

Dimension (cm):
43 x 22 x 11.4 (LxHxW)



IR-90

Group-2

Wild craft-rucksack

Dimension (cm) (LxHxW)
33 x 78.7 x 25.4



IR-91

VIP Diva II Check-in Luggage

Dimension (cm) (LxHxW)
37 x 56 x 28



IR-92

Duffel bag

Dimension (cm) (LxHxW)
76.2 x 30.4 x 30.4



IR-93

Dimension (cm):
62 x 46 x 34 (LxHxW)



IR-94

12.3.1

Explorations on luggage packaging

Dimension of luggage taking maximum values from examples studied are

Group-1
43cm*40cm*21cm (L*H*W)

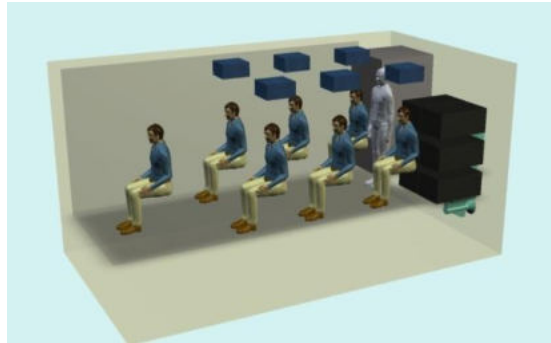
Group-2
78cm*46cm*34cm(L*H*W)

Using the above dimension multiple arrangement for luggage are tried out as shown.

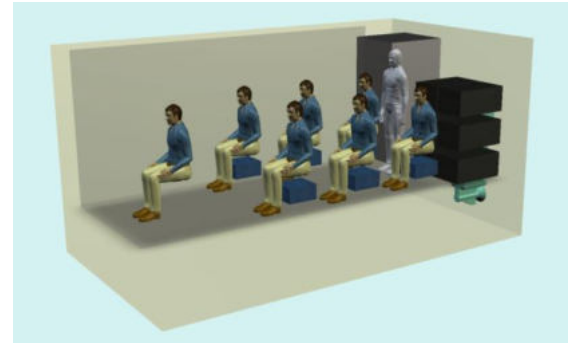
Packaging 3-b among the lot seems to be better in many aspects-

- luggage near to customer,
- easy access,
- easy placement,
- maximum utilization of width.

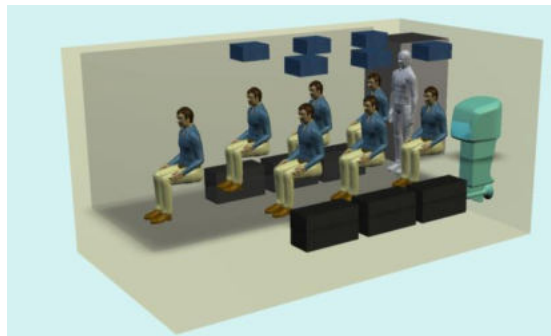
Luggage packaging -1-a



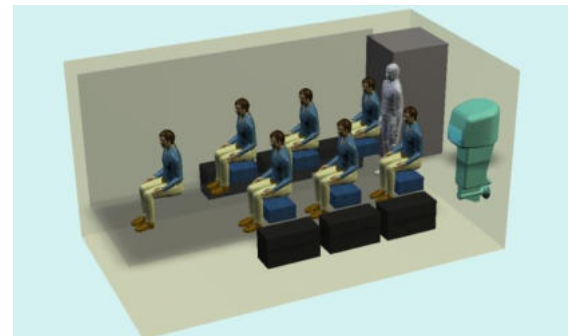
Luggage packaging -3-a



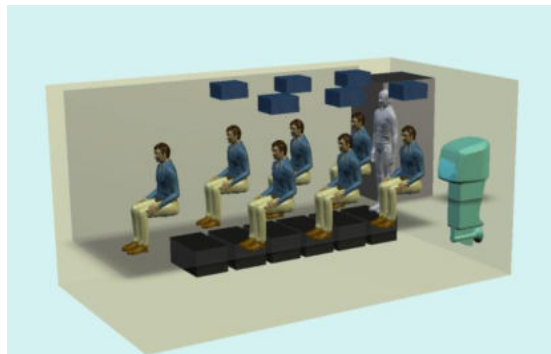
Luggage packaging -1-b



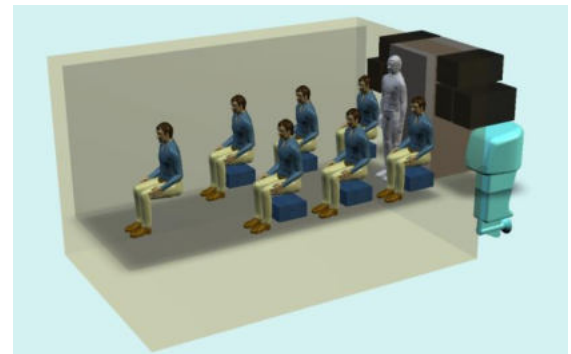
Luggage packaging -3-b



Luggage packaging -2



Luggage packaging -4



12.4

Embark and disembark

Jetties are required for the "landing" of cargo and for the people to embark and disembark. These are typically constructed on water, a simple square concrete platform on piles, with two levels to cater for water level variations. Three meter wide jetties are provided for berthing public ferries with a capacity to take 50-60 passengers. Private boats, which usually accommodate one family or about three to four persons at a time, use the two meter wide jetties for servicing. The jetties are also designed taking into account the different types of water levels that they encounter. For this, steps are provided at four different levels:

- one step at -30cm (30cm below ground level) for high water level,
- one step at -1.2m for low water level,
- and two steps at -60cm and -90cm respectively for intermediate water levels.
- These water levels for the jetties apply to all kinds of boats serviced by the jetty terminal.



Floating Jetty

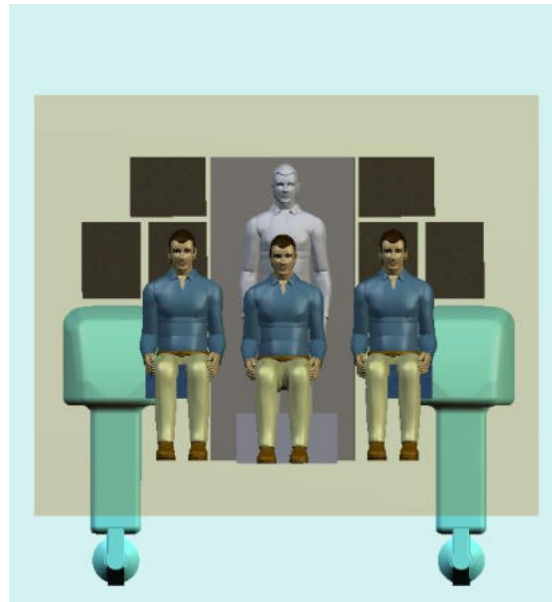
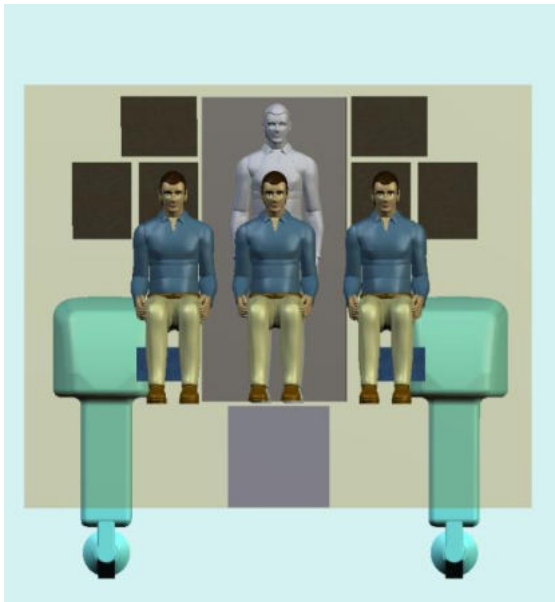
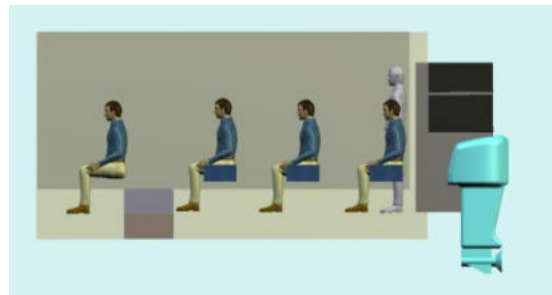
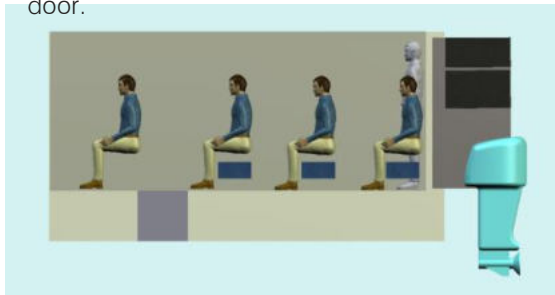
Floating Jetty dimensions

Length	20 Ft
Breadth	15 Ft
Depth	1 M
No of Floaters	2 No's
Platform size	300 Sq.
Engine	40/60 HP OBM
Handrail Height	90 CM



12.4.1 Platform height

Platform height inside can be lowered to bring down the overall height of the catamaran. Taking clues from stair height of 7 inches, platform can be lowered by around 15cm. Also instead of lowering entire platform inside the center pathway can be lowered. Seat can be mounted at the same level as the door.



12.4.2 Door ideations

Considerations-

1. Dressing pattern - With sari and mundu , one hand is used for holding the dress especially while walking.
2. Boat rolls - Boat never has a complete stop. While moving into or out of boat, rolling of boat is disturbing especially for females. Some holding mechanism while moving in and out will be of great help for first time users.
3. Jetty height - Jetty height is variable with different place and also with climate. Adjustability of boat height or part of boat can be considered.
4. Rain - Movement of people in and out of boat while raining. Gullwing doors can be a savior till the time passenger opens umbrella.

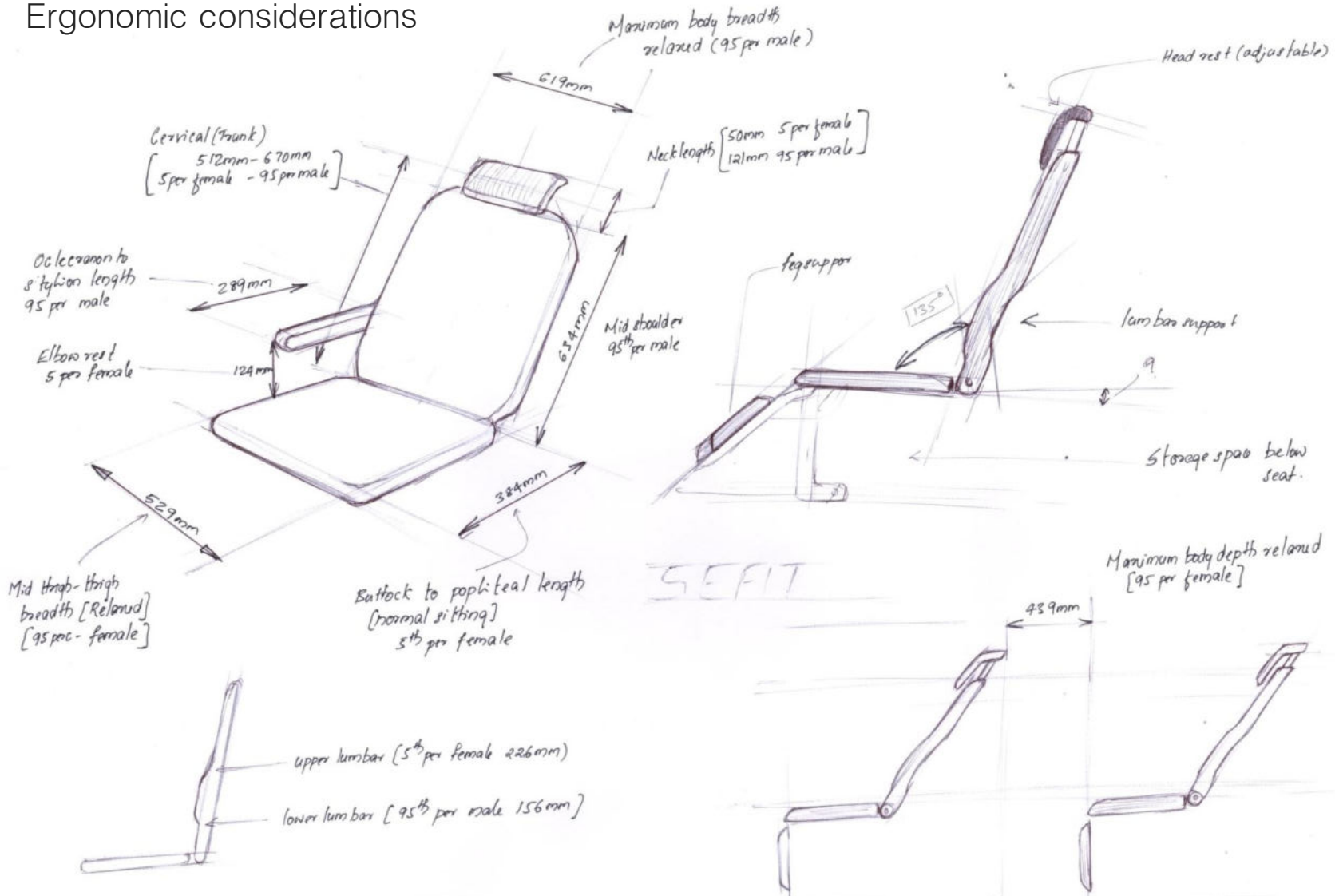
12.4.3 Hand rail(Inside and outside)

For comfortable movement of people inside the boat hand rail has to be provided from door to the toilet.

Some sort of foldable hand rail can be considered with door which projects out of boat when door open, to help people to move inside boat with one hand as the other hand is expected to be engaged for holding sari or mundu.

12.5 Seat design

Ergonomic considerations

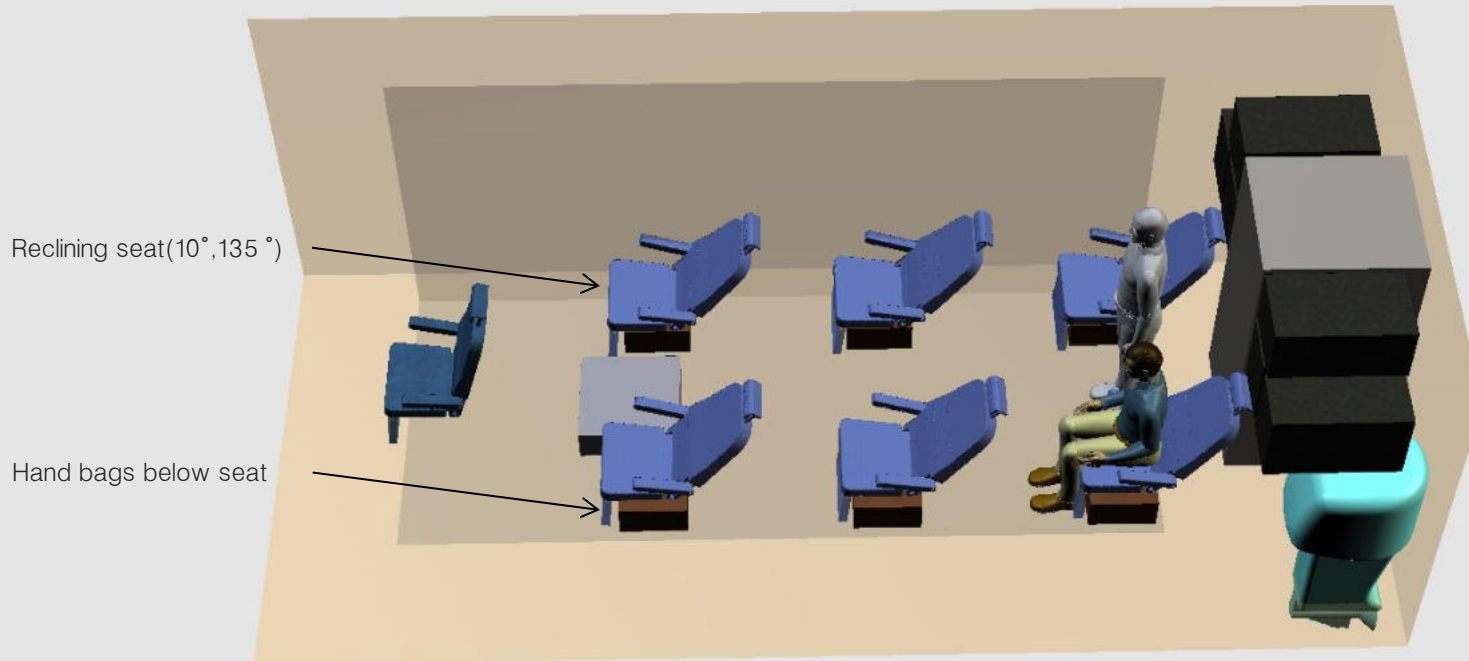


Reference -Indian anthropometric dimensions for ergonomic design practice - Debkumar Chakrabarti ,NID

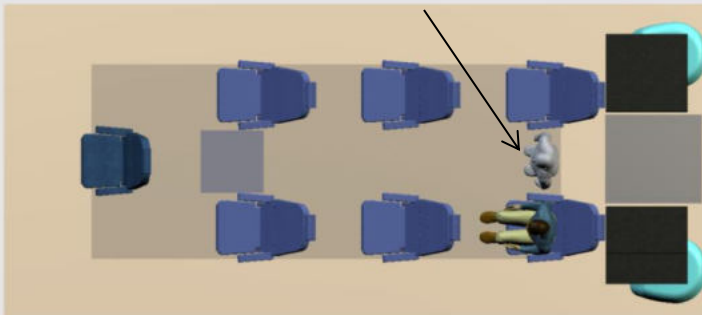
Seat design based on ergonomic inputs



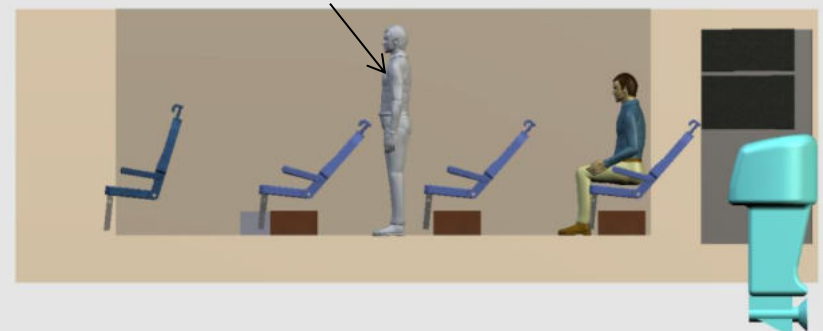
12.6 Defining interior space



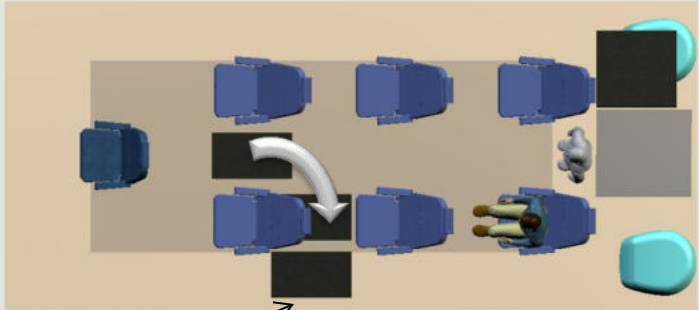
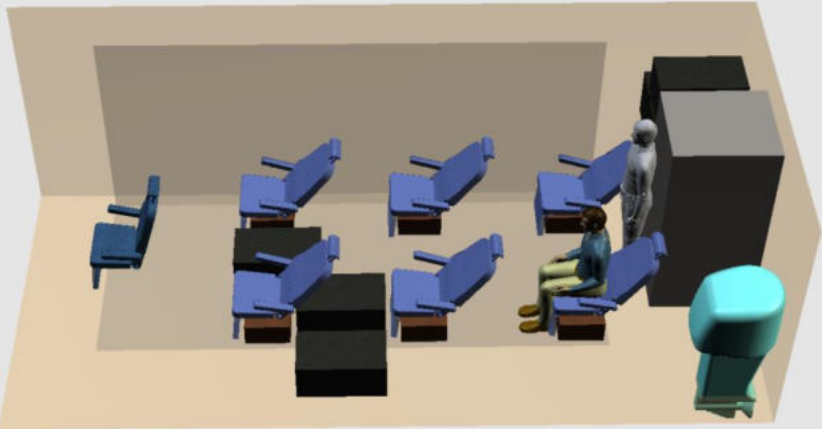
Space between seat for movement
(619mm Width 95 percentile Indian male)



Passenger can stand from his seat without disturbing other(keeping width as 439mm (95 percentile Indian female))

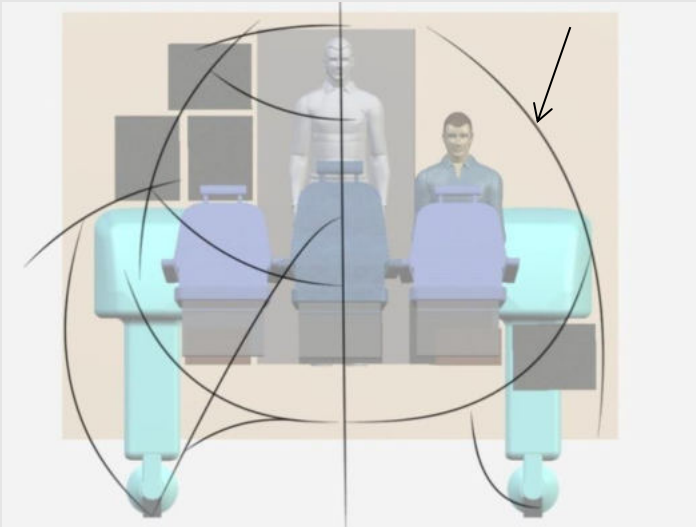
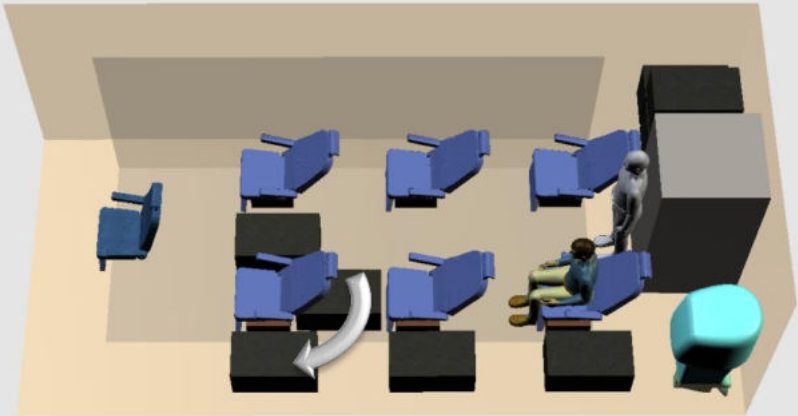


Alternate luggage arrangement



Luggage bag movement, (bags to side)

Roof lines changed by relocating luggage

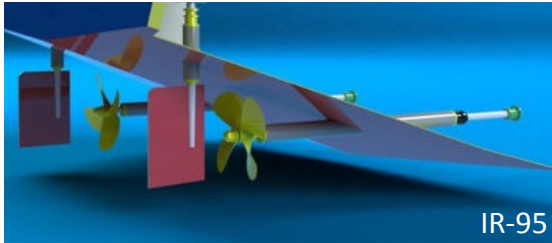


12.7 Braking

Mostly braking is done by cutting the throttle as the surface friction provided by water provides good stopping resistance.

For quick braking

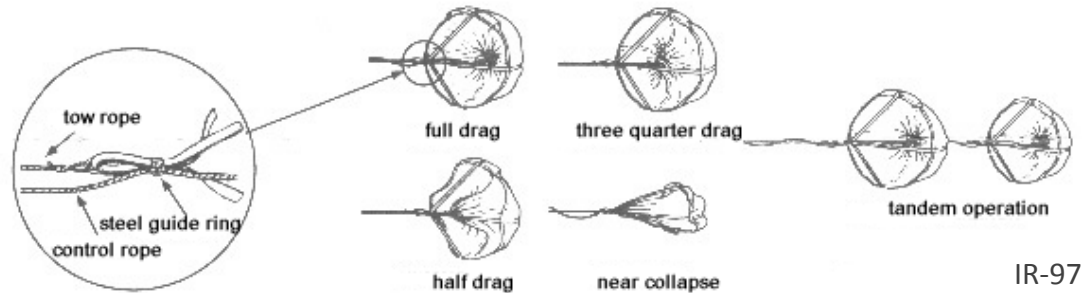
- reversing of propeller
- parachute brakes



Paratech Boat Brakes



Paratech boat brakes visually explained



Strong presence of water hyacinth in Kerala inland waterways eliminates the choice of parachute braking



12.8 Other inspirations for float design

Catamarans design are always associated with rigid floats. Observing movement of fish, flexible floats design can be considered for better control and flexibility of movement.

Movement of turtles gives inspiration to multiple floats which can be steered in water .



13 Regulations

Govt. regulations

<http://www.keralaports.gov.in/inlanddocument.htm>

13.1

LIFE SAVING APPLIANCES

Class I -Passenger vessels, Ferry launches and boats;

Requirement for Vessels of Class I

- Sufficient number of life rafts or buoyant apparatus to accommodate at least 50% number of passengers and crew on board.
- One life jacket for 50% of the passengers and crew on board.
Life jacket for child, for 10% of total number of persons certified to carry. For the purpose of this rule, child means persons weighing below 30 kg.
- At least four life buoys for vessels up to 25 meter length, six life buoys for vessel 25-45 meter length and eight life buoys more than 45 meter length. At least two of the lifebuoys supplied shall be equipped with self igniting light if the vessel navigates at night.
- All boat crew shall possess sufficient training in rescue work in addition to artificial respiration and first aid.
- All boats shall have headlights or Search lights, hand torches and emergency lanterns.

- Boats shall be sturdy and maintain rigid standards . The under water material should be sound, strong and sea worthy.
- In small vessels one pair of oars shall be kept in readiness for use in the event of power failure.

Class IV -Pleasure crafts and adventure vessels.

Requirement for Vessels of Class IV

- Every vessel of Class IV up to 10 meter in length shall carry life jacket for each person. Vessel above 10 meter shall carry sufficient life raft or life buoys for all persons on board.
- All vessels of Class IV shall carry at least two Life Buoys of which one to be of self igniting type if the vessel navigates at night.
- For small vessels where buoyant apparatus could not be accommodated, 100% buoyancy by way of life jackets and life buoys shall be provided.

13.2

Inland Vessels fire fighting equipment

- All inland vessels shall be provided with an approved type of fire appliances.
- Minimum one hand operated fire pump in every vessel exceeding 6 meter in length;
- Minimum one Portable Dry Power type fire extinguishers in every vessel having a large electrical installation.

13.3

INLAND VESSELS CONSTRUCTION

HULL CONSTRUCTION

The Structural strength of every vessel to which these rules apply shall be sufficient for the service for which the vessel is intended.

Hull side Valves and Fittings

- All waterway inlet and overboard discharge pipes shall be fitted with valves or cocks secured direct to shell plating or water boxes.
- All valves and cocks are to be of bronze or other approved material.
- Gratings having adequate net area are to be fitted at all openings for water inlet valves.
- Waterway inlet and discharge valves and cocks are to be fitted in easily accessible positions.

Deck openings,Hatch comings.

All openings in deck shall be well designed and capable of being effectively closed water tight. Hatch comings shall be provided with hatch covers of adequate strength and shall be capable of being battened down.

Height of Sides and Rails.

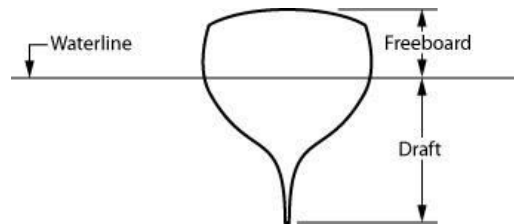
- In open vessels the top of the gunwale, covering board or wash strakes, or the upper edge of the half deck at side as the case may be, shall not be less than 75 cms above the flooring boards in the case of vessels 6 m in length or less, and not less than 90 cms in the case of vessels 12 m in length or more.
- From lengths between 6m and 12 m, the height shall be in proportion. Decked vessels shall be provided with bulwarks or rails not less than 1 m in height and the rails shall not be more than 22.5 cms apart unless strong netting is provided.

Water closets

Vessels which ply by day on voyage not lasting more than six hours, there shall be one latrine for every 200 passengers .

13.4 Freeboard

- In case of passenger vessels when the vessel is loaded with weights representing the full number of passengers and crew at 65 kg for each person, and when all necessary fuel is on board, the clear height of the side above water, at the lowest point, is not less than **38 cms for vessels 6 m in length or less**, and 76 cms for vessels 18 m, in length and over.
- For lengths between 6 m and 18 m the height shall be in proportion.
- Vessels permitted to ply during foul season shall be required to have freeboard 1.5 times as of that calculated.
- Floorings shall be provided throughout the vessel. It shall be removable to allow for cleaning and inspection and shall allow rapid drainage of water to the bilges. Drain plugs in the skin of the vessel shall not be permitted.



http://www.otenmaritime.com/_/rsrc/1264398146493/stability/reserve-buoyancy-freeboard-and-trim/mlr11_s1_f13_co%20%5BConverted%5D.jpg

13.5

OTHER ACCESSORIES

Anchors & Cables etc.

- Every inland vessel shall be provided with at least two anchors and chain cable.
- In addition every vessel shall be provided with at least one hand lead line 15 fathoms in length with lead of at least 3.2kgs weight provided that small vessels plying in shallow waters may be provided with a depth measuring pole or rod suitably marked.
- Every open vessel shall be provided with at least three oars, three rowlocks and two efficient boat hooks. Every vessel shall be provided with at least two heaving lines.
- Appropriate communication and navigation equipment like compass, binoculars, wheel indicator, bridge engine control, public address system, mobile phone etc. shall be provided as specified by the surveying authority.

14 Other data

Tunnel

All cats have one, although some are specifically called the tunnel hull. It's the space between the two hulls and the underwing or bridge deck, and is relied upon for lift.

Slamming

Occurs when a wave is trapped inside the tunnel and hits the underwing. A lightweight, good design, and sustained speeds prevent slamming.

Sneezing

Exclusive to cats, it's a spray from the front of the tunnel back into the boat. Air compresses the water and creates a cushion. The air cannot escape out the back of the tunnel and thus is forced forward. Poor design and /or balance usually cause sneezing, and weight can sometimes be a factor.

Banking

The lateral attitude of a vessel, applicable to moving vehicles as well. V-hull boats, bicycles, and motorcycles bank into a turn. Powered catamarans on the other hand, are more similar to cars. They tend to bank out of the turn, and it takes a little getting used to.

Out board engine mounting should have freedom to be lifted as per load and also to change inclination to prevent trimming effect as explained in images on right.

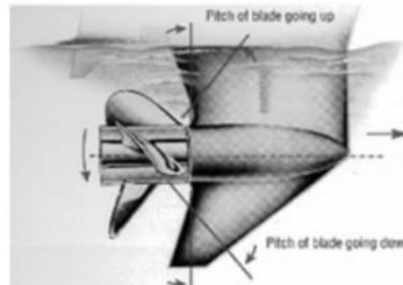


Figure 7-22 Trimmed parallel to water surface. Little or no steering load.

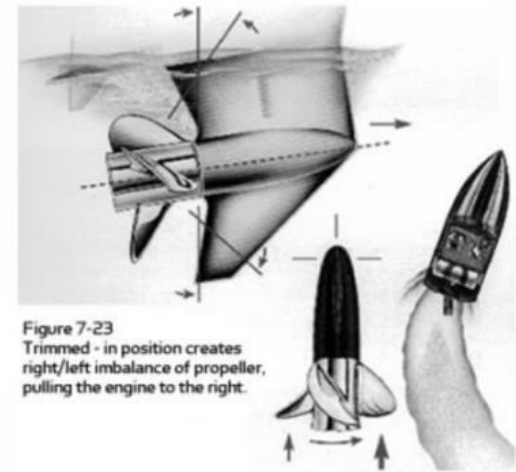


Figure 7-23 Trimmed - in position creates right/left imbalance of propeller, pulling the engine to the right.

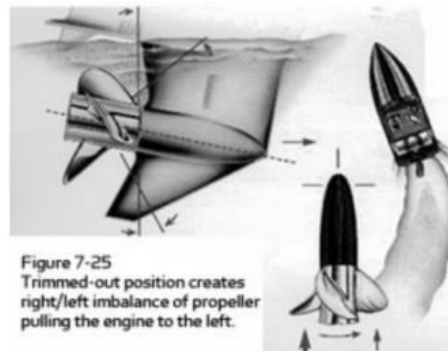
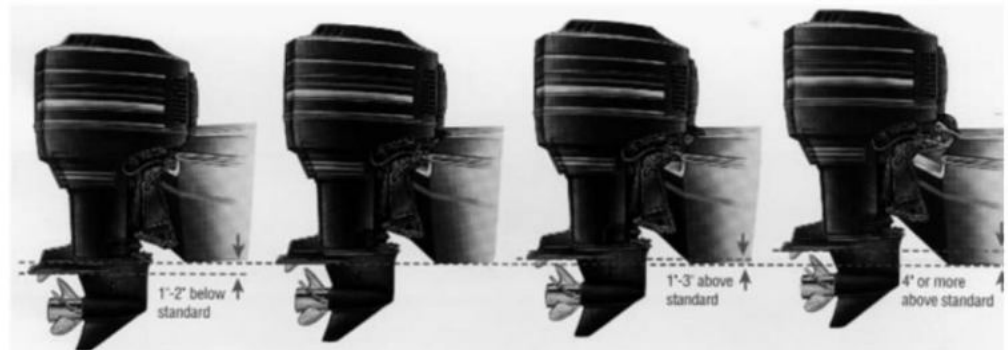


Figure 7-24 Trimmed - out position creates right/left imbalance of propeller, pulling the engine to the left.



Work application heavily loaded, slow speed

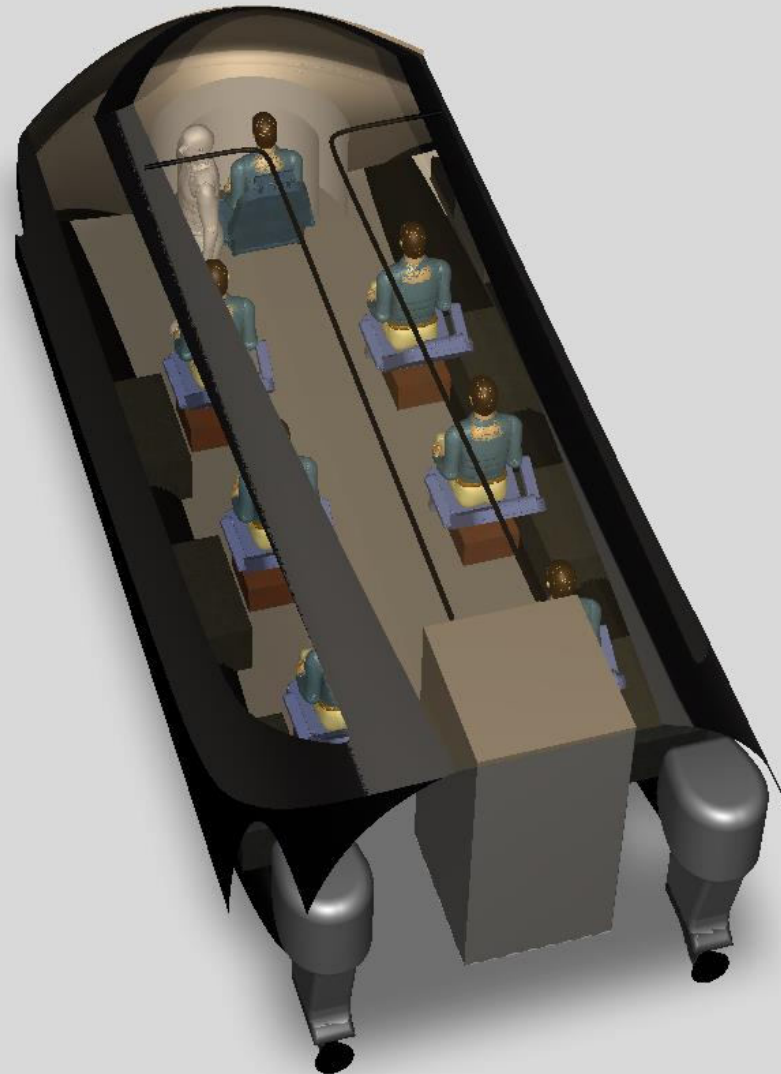
Normal duty: average speed installation

Sport application: sport and ski

High-performance application: maximum speed is primary consideration

15 Concepts (float and propulsion)

15.1 Concept-1 2-Outboard IC propulsion

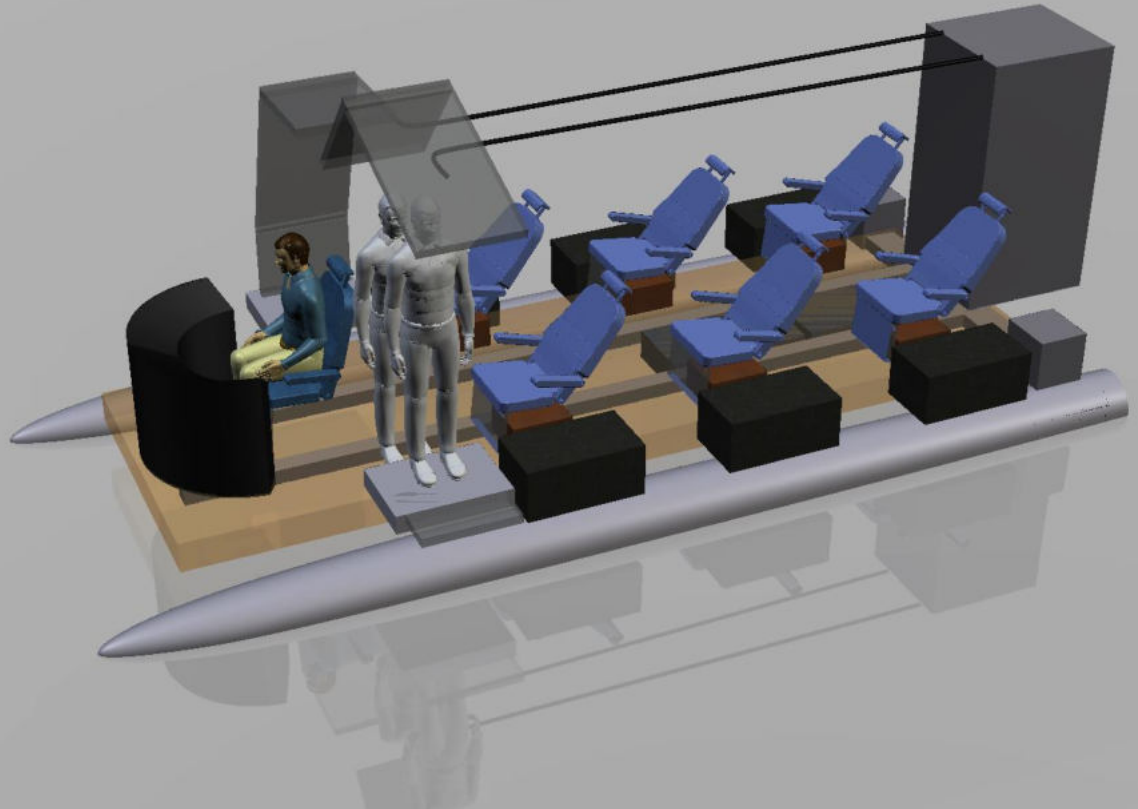


This concept has two outboard IC engines placed behind each floats. Layout is inspired from conventional catamaran architecture. Each floats can be separately steered to give good handling.

15.2 Concept-2

Electric propulsion in two floats

Concept 2 has two electric motor powering two propeller placed in each floats. The batteries and motors are packed in floats. Reference to this layout is from Planet solar.



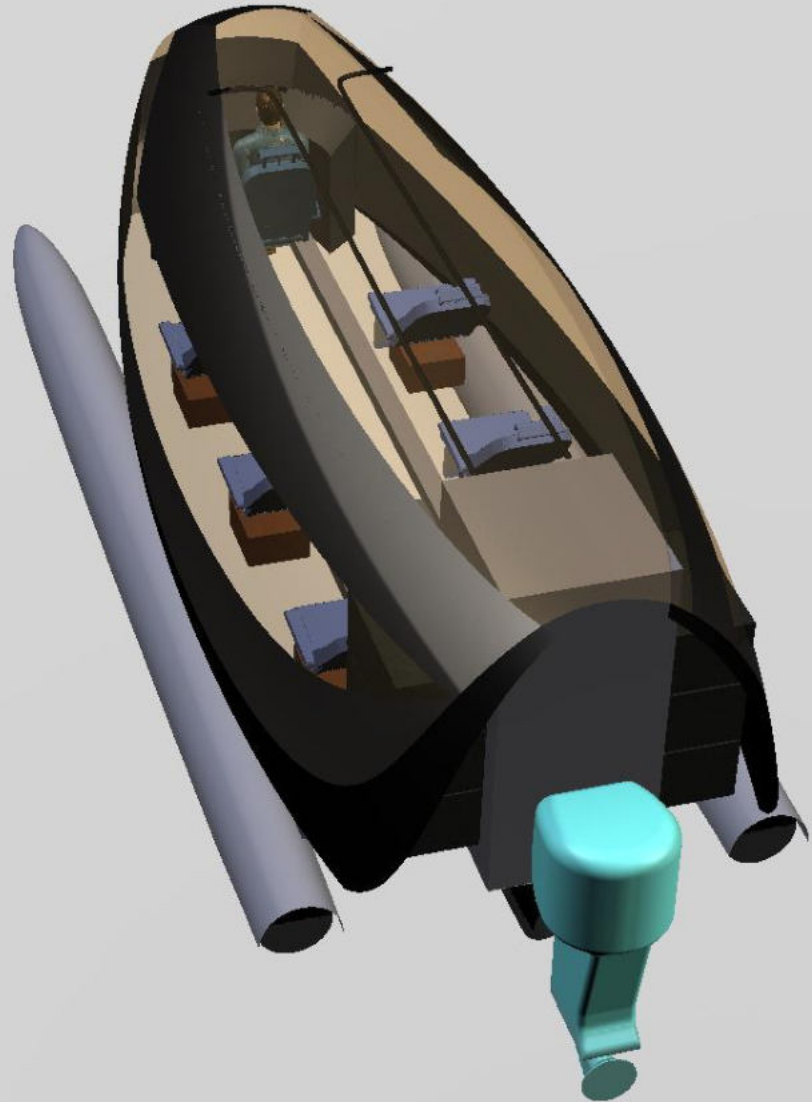
15.3 Concept-3

Hybrid - IC outboard and two electric motors

This hybrid concept has electric propellers in each floats in addition to single IC outboard at rear.

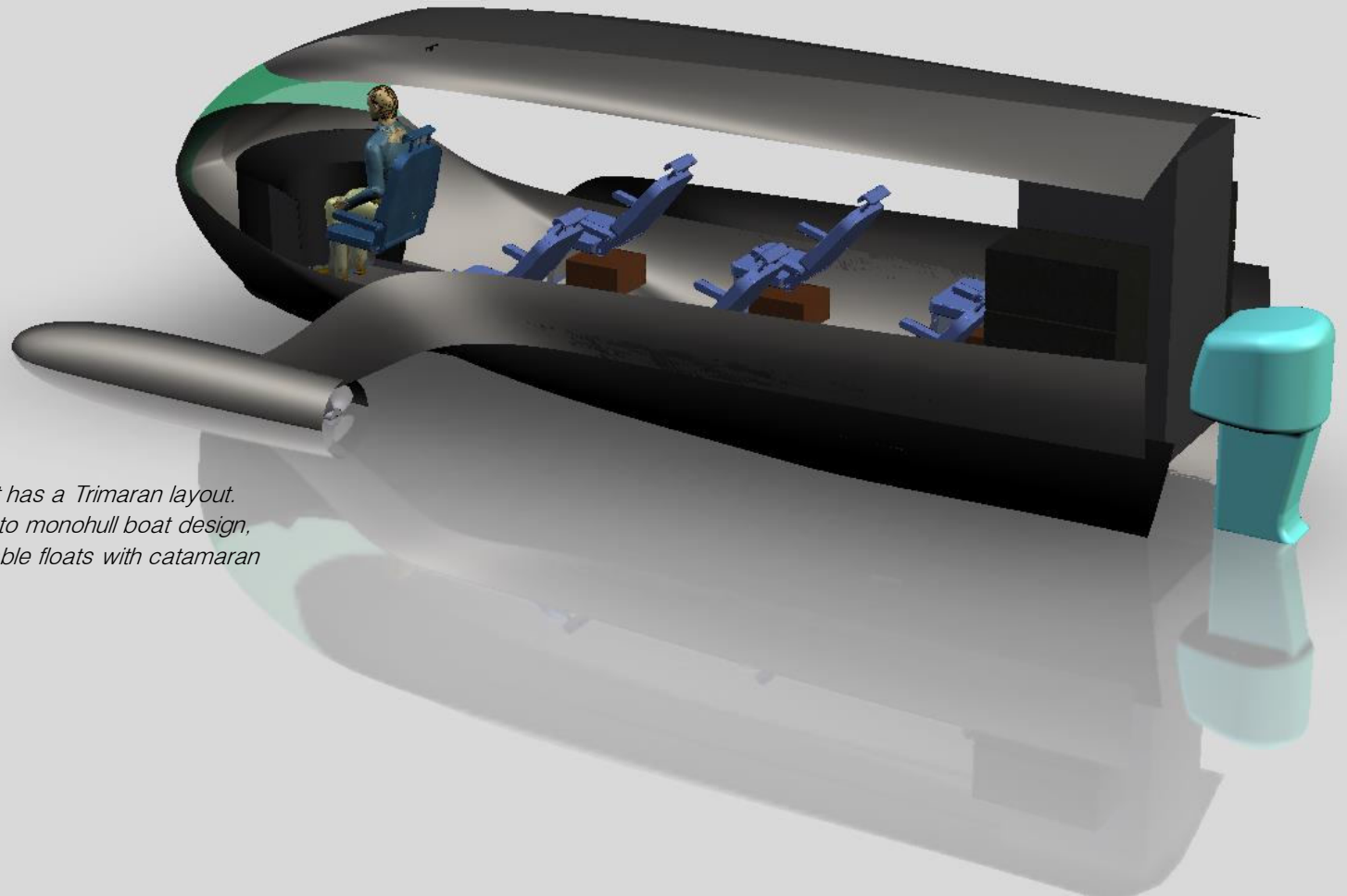
IC outboard provides main thrust. Electric propulsion is considered as auxiliary source. Electric propellers can help when going through narrow sections or during embark and disembark.

Charge for electric propulsion can be generated from solar panels place on the roof.



15.4 Concept-3.1

Hybrid - IC outboard and two electric motors

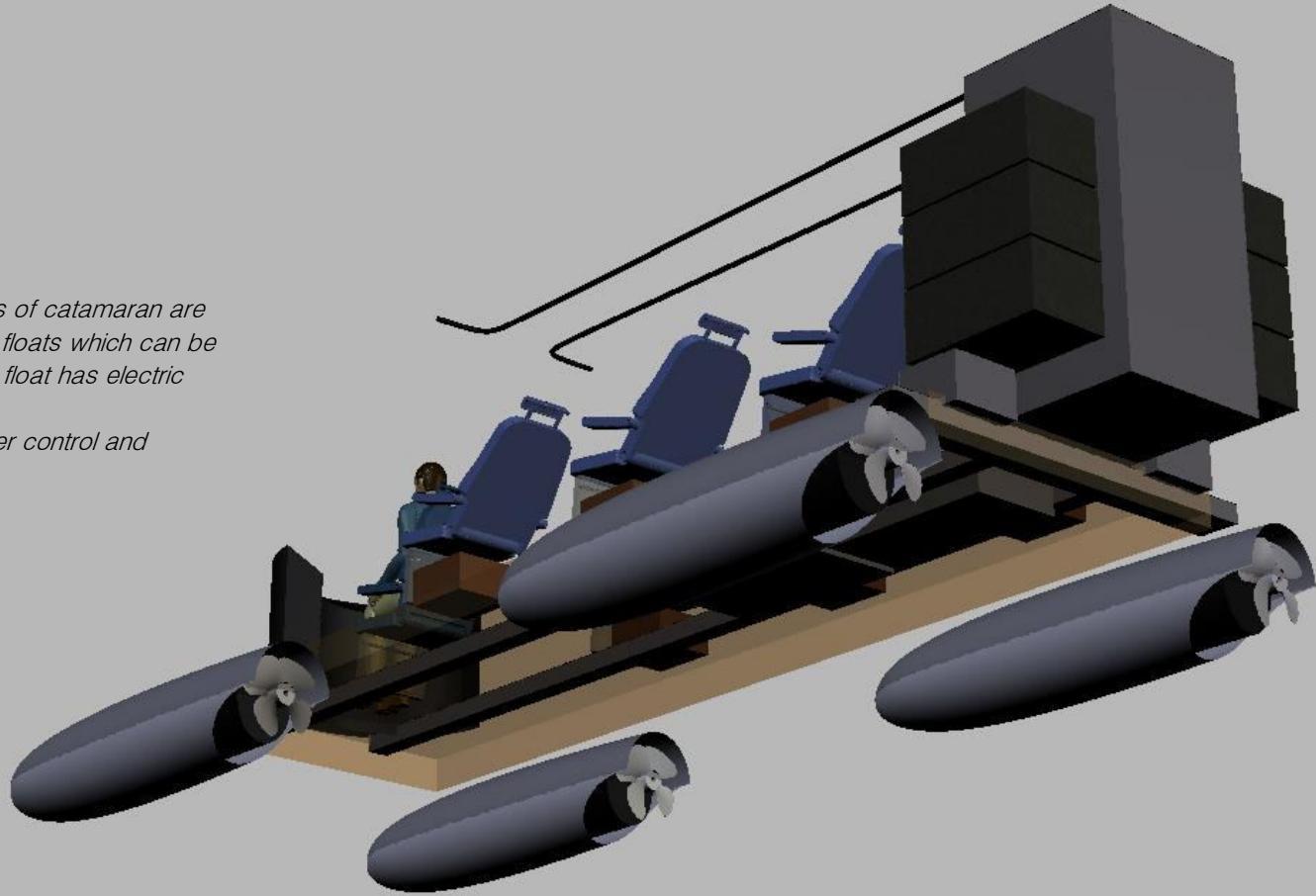


*This hybrid concept has a Trimaran layout.
Rear part is similar to monohull boat design,
but front has steerable floats with catamaran
layout*

15.5 Concept-4

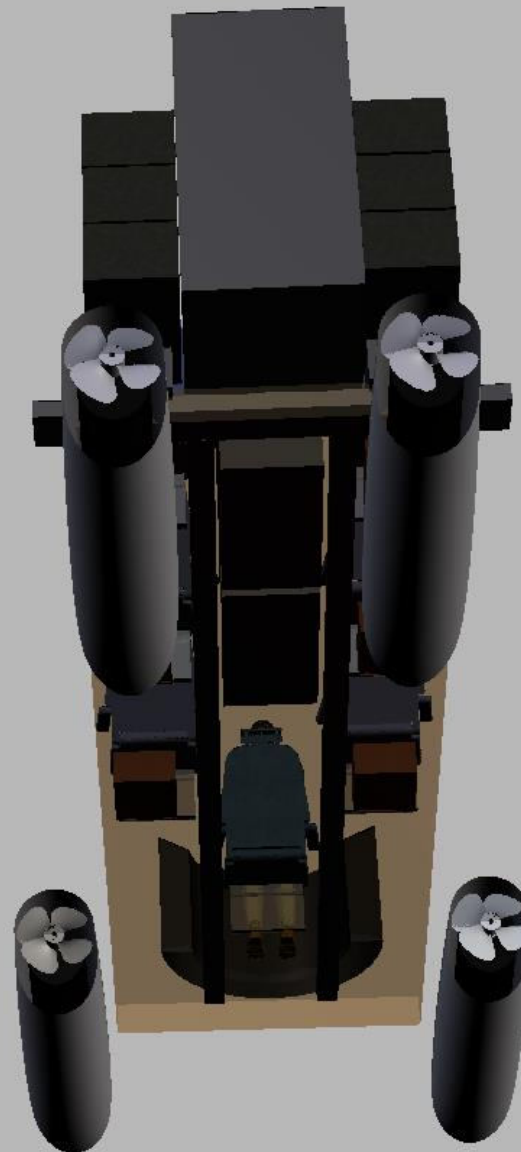
Four electric motors on four floats

In concept-4, regular floats of catamaran are replaced with 4 separate floats which can be steered individually. Each float has electric propulsion. These floats help in better control and braking ability.



15.5 Concept-4

Four electric motors on four floats

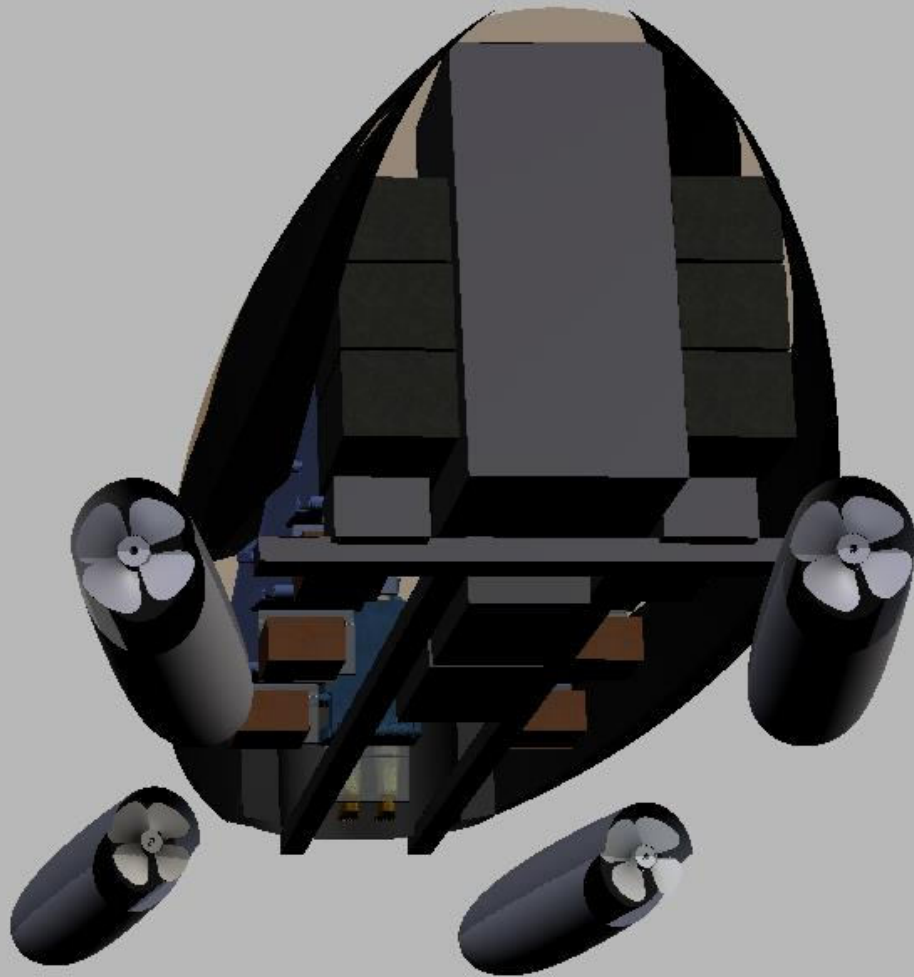


Variation of concept-4 with rear floats placed near to body to avoid disturbed water from front propellers.

15.5 Concept-4

Four electric motors on four floats
Float helping in steering

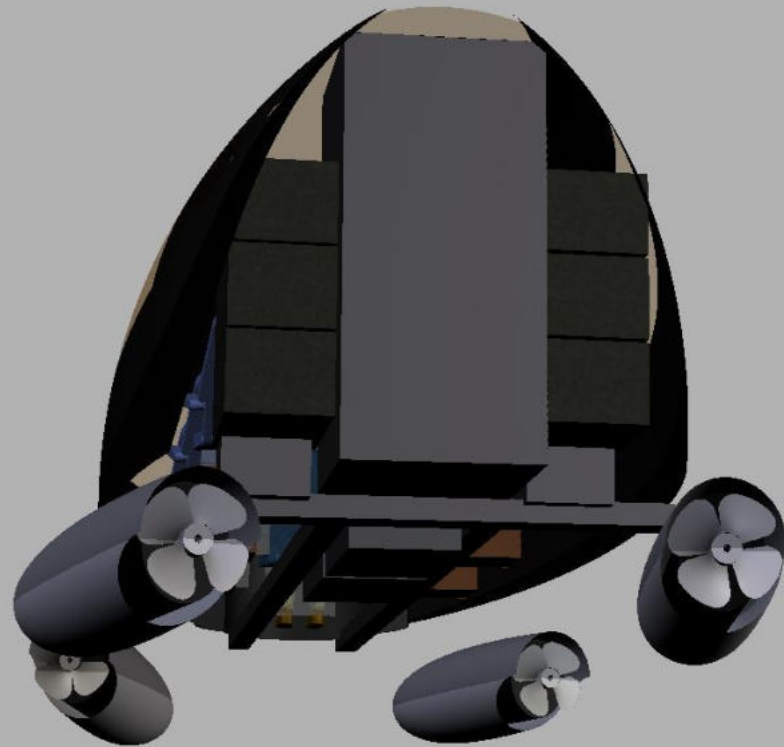
Steering to left with a shorter turning circle and predictable handling.



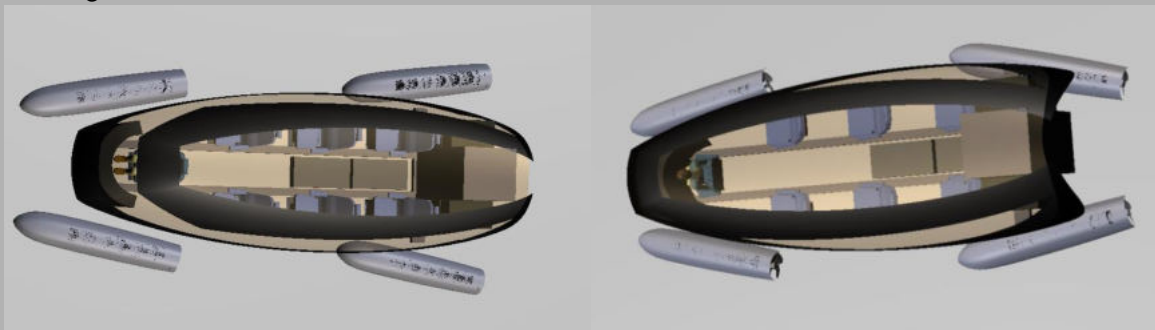
15.5 Concept-4

Four electric motors on four floats
Float helping in braking

*Braking with the help of floats.
Energy used for normal braking by reversing
the propellers can be saved.*



Braking



15.6 Concept-5

Fully flexible float design



Fully flexible float design with electric propulsion.

15.6 Concept-5.1

Flexible float design



Semi flexible float design with electric propulsion.



16 Ideations Interior

16.1

Seating

Three scenarios

1. Family
2. Business trips
3. Domestic or international tourists

The seating layout can give a feeling of being connected together. At the same time seating can also be distinct in terms of comfort and personalized feel.

Design of panels around the seat, color theme and lighting can help in satisfying above need.

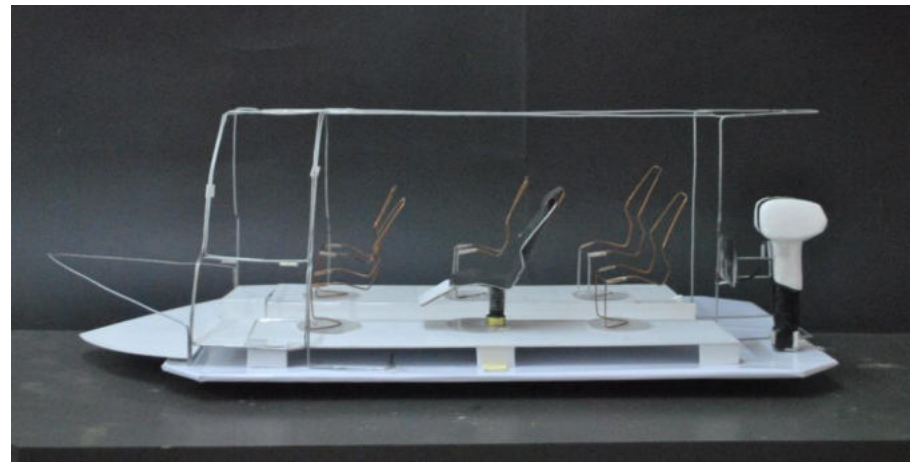
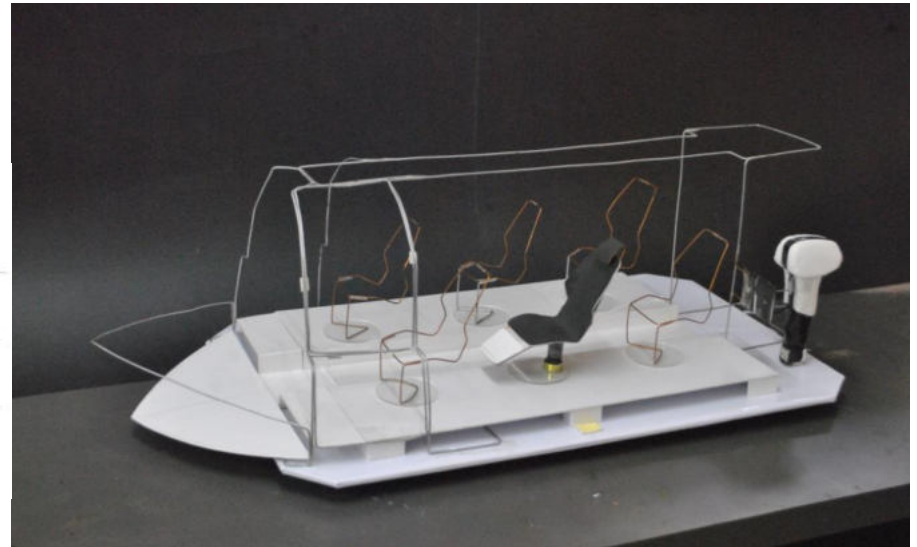
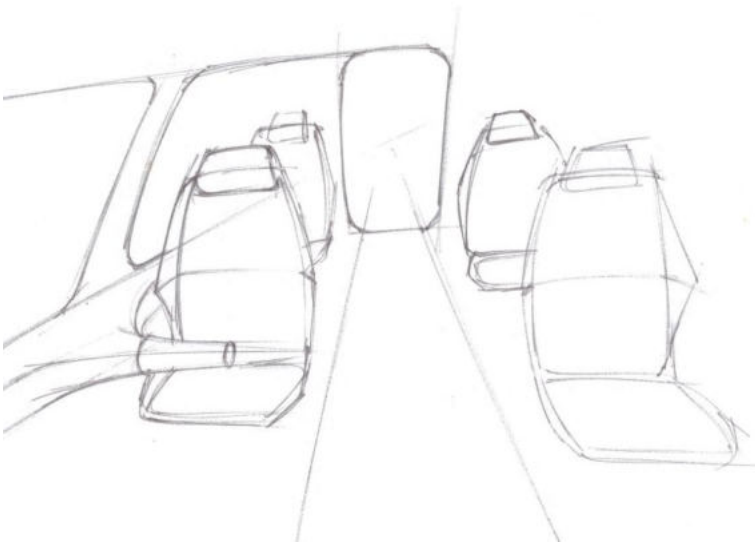
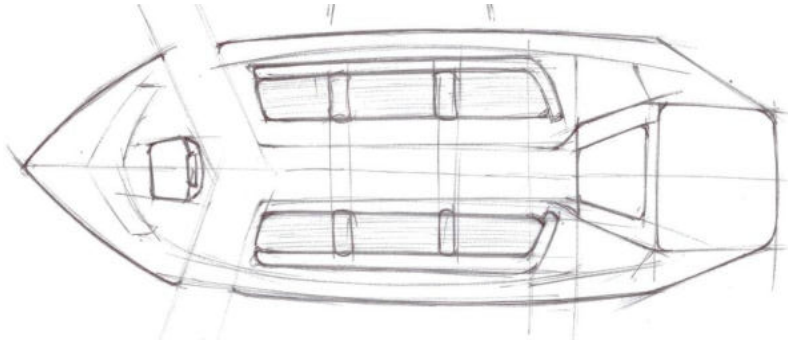
Porsche-Panamera has center console continuing till the rear seat bringing a feel of connected together.

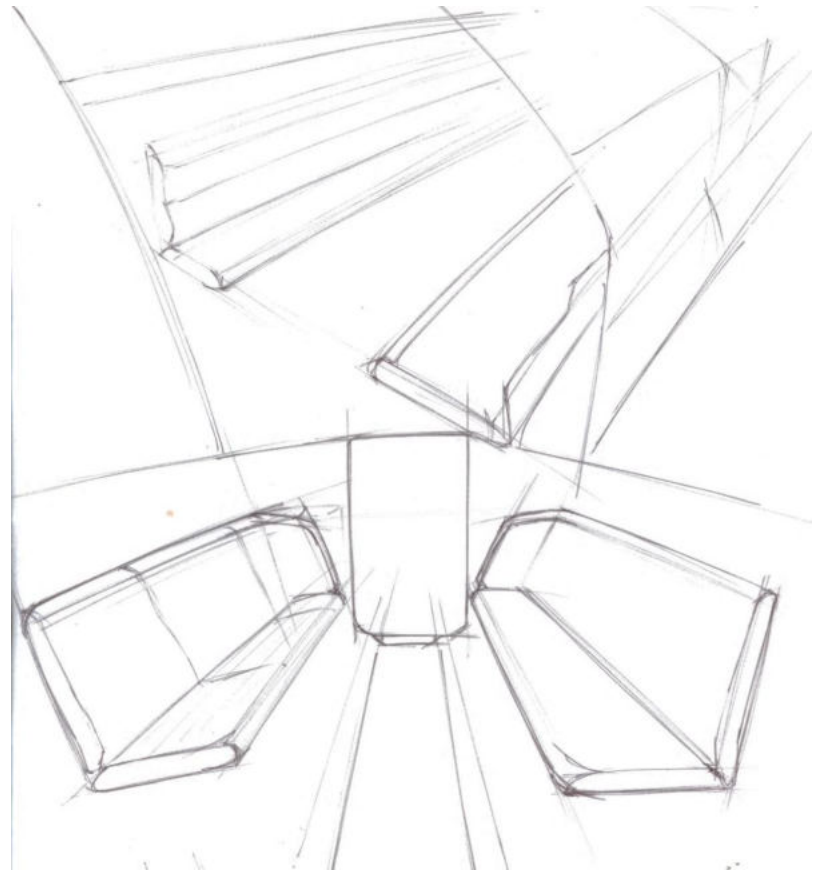
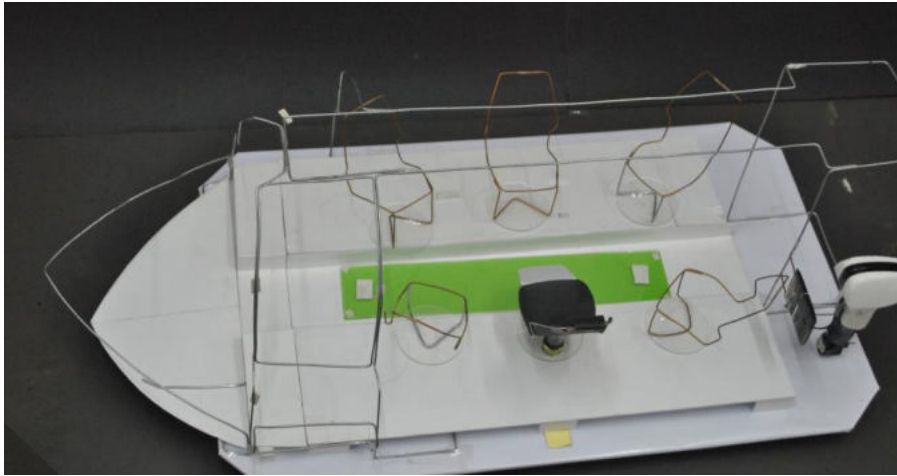
Other image inspiration for seating



Seating ideations

For better understanding of interior space a scaled wireframe model of interior is made.



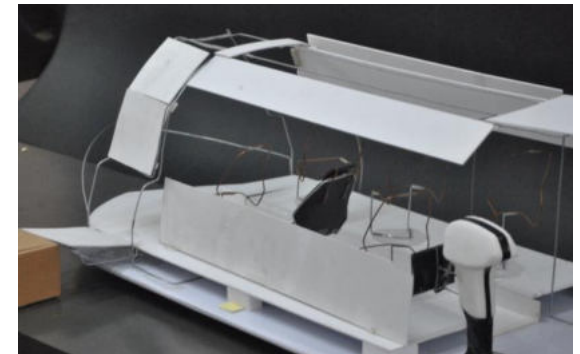
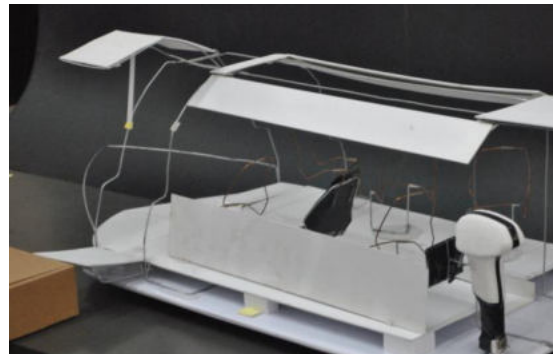
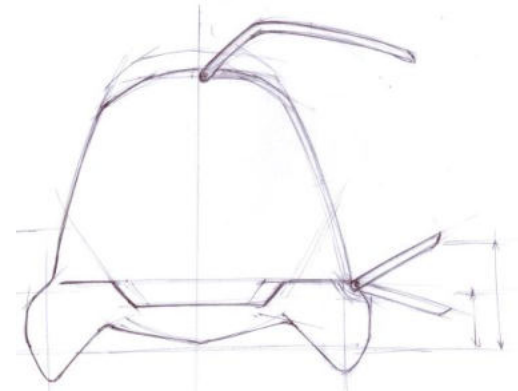
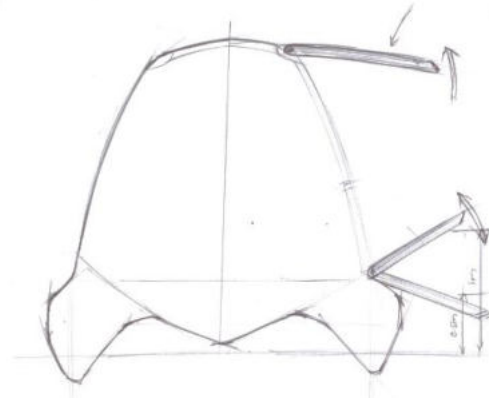
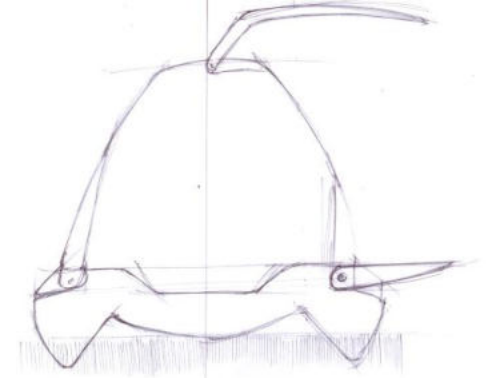
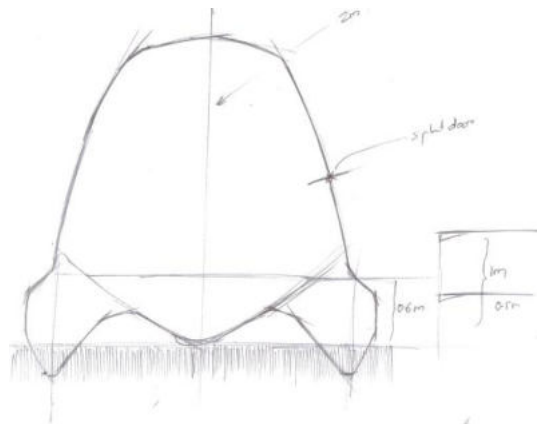
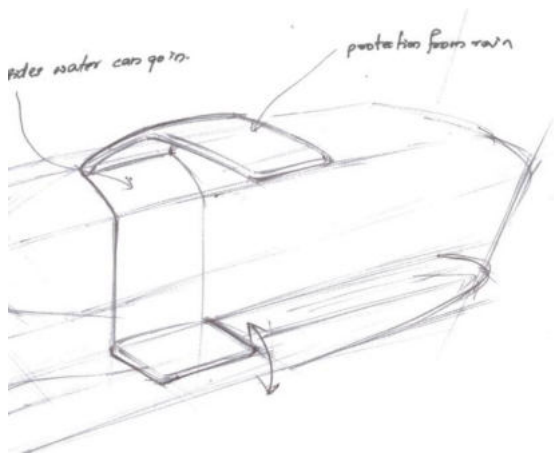


16.2 Door

Taking clues from traditional house boats ,top part of door can be designed to open like gullwing doors. The lower part of door is rotated to match with jetty height.



Top gullwing door



16.3 Hand rail.

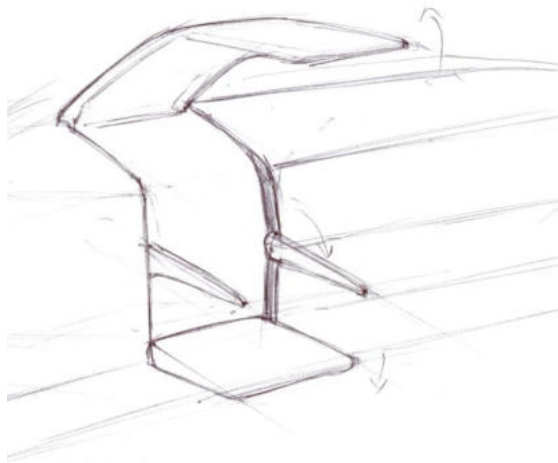
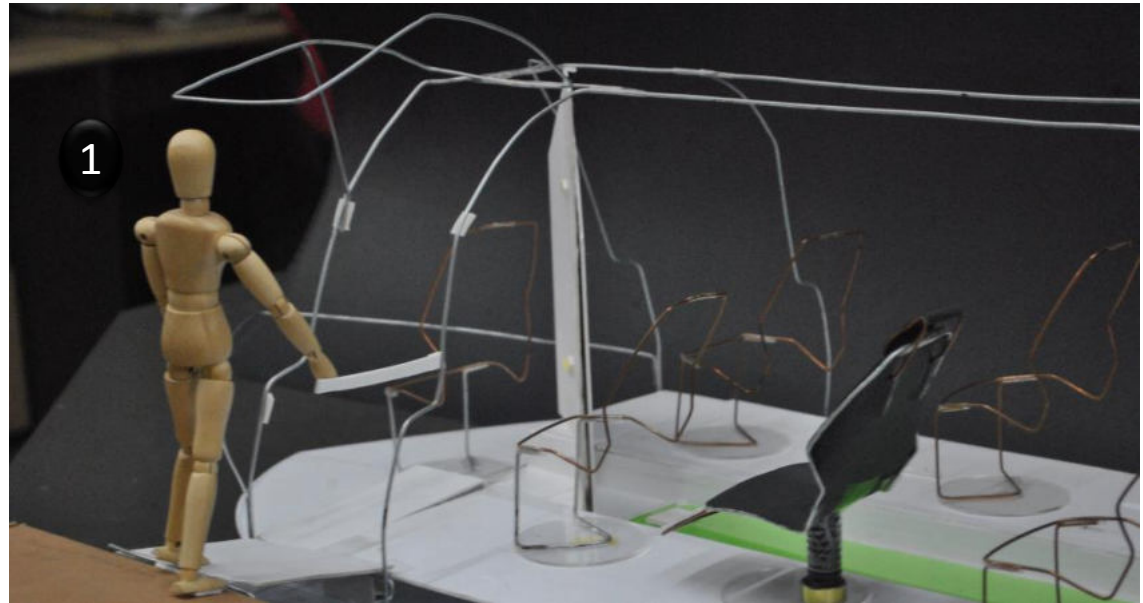
Since boats never have a complete stop, hand rails are helpful for passengers during moving in and out, and also for movement inside the boat. The picture shows some ideation for hand rail.

Picture 1 shows a hand rail coming outside the vehicle to help the passenger to embark.

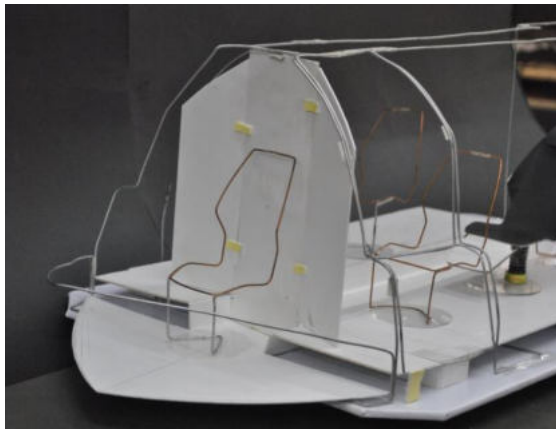
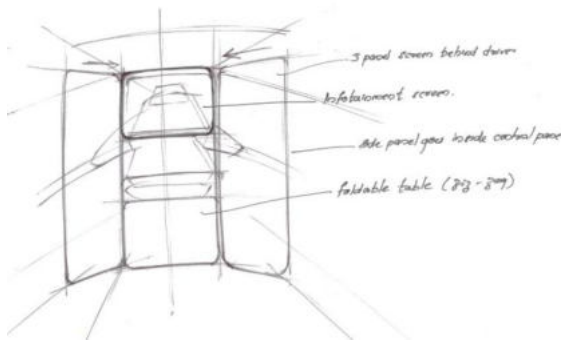
This helps in ingress using one hand.

This handle can also be a gesture for inviting inside.

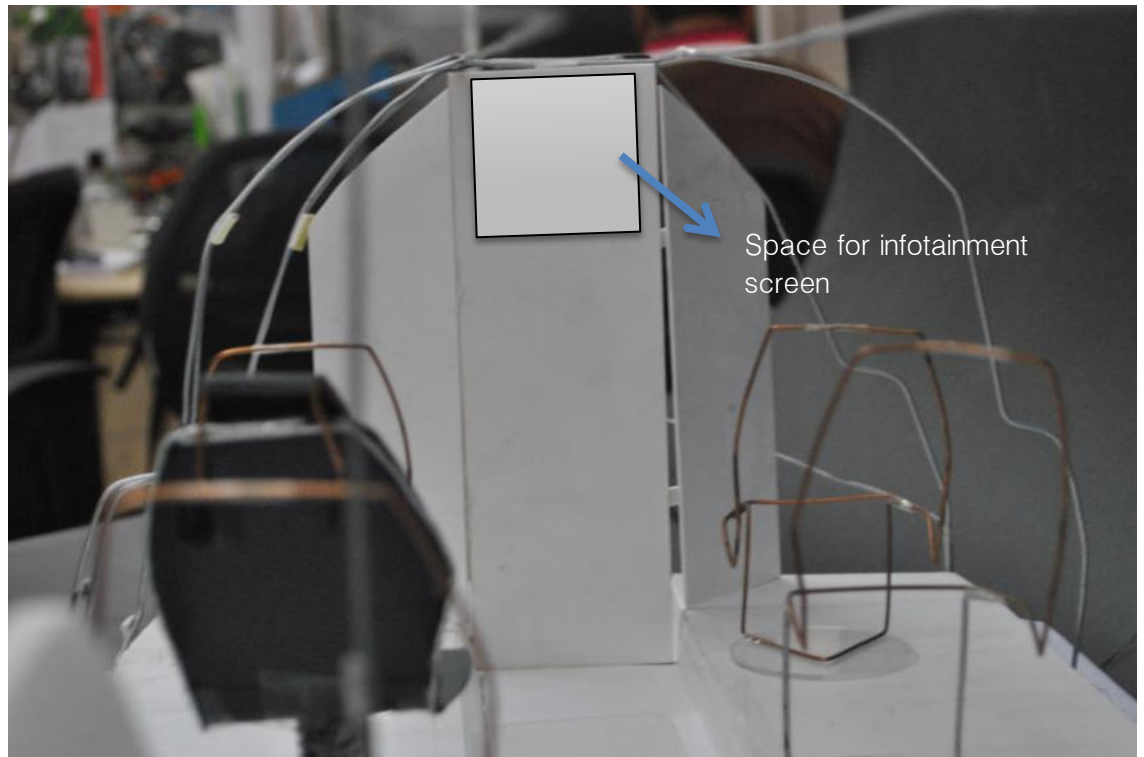
Picture 2 shows hand rail inside cabin to help passenger movement inside.



16.4 Cabin isolation and infotainment

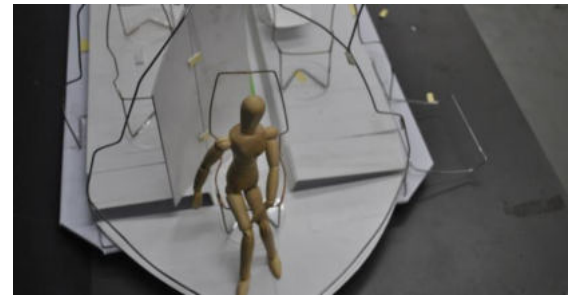
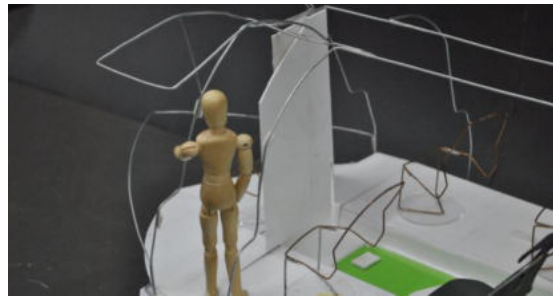
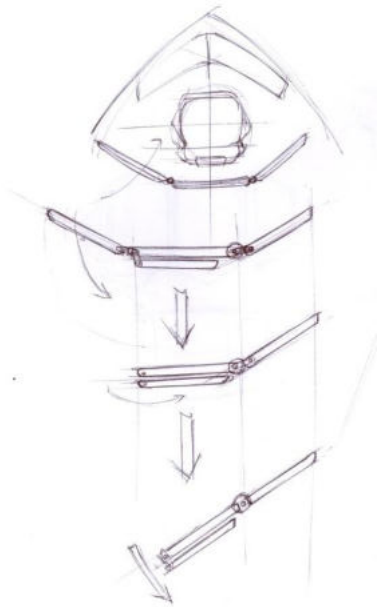


3 panels separates driver from cabin. Side panels can slide /folded inside middle panel.

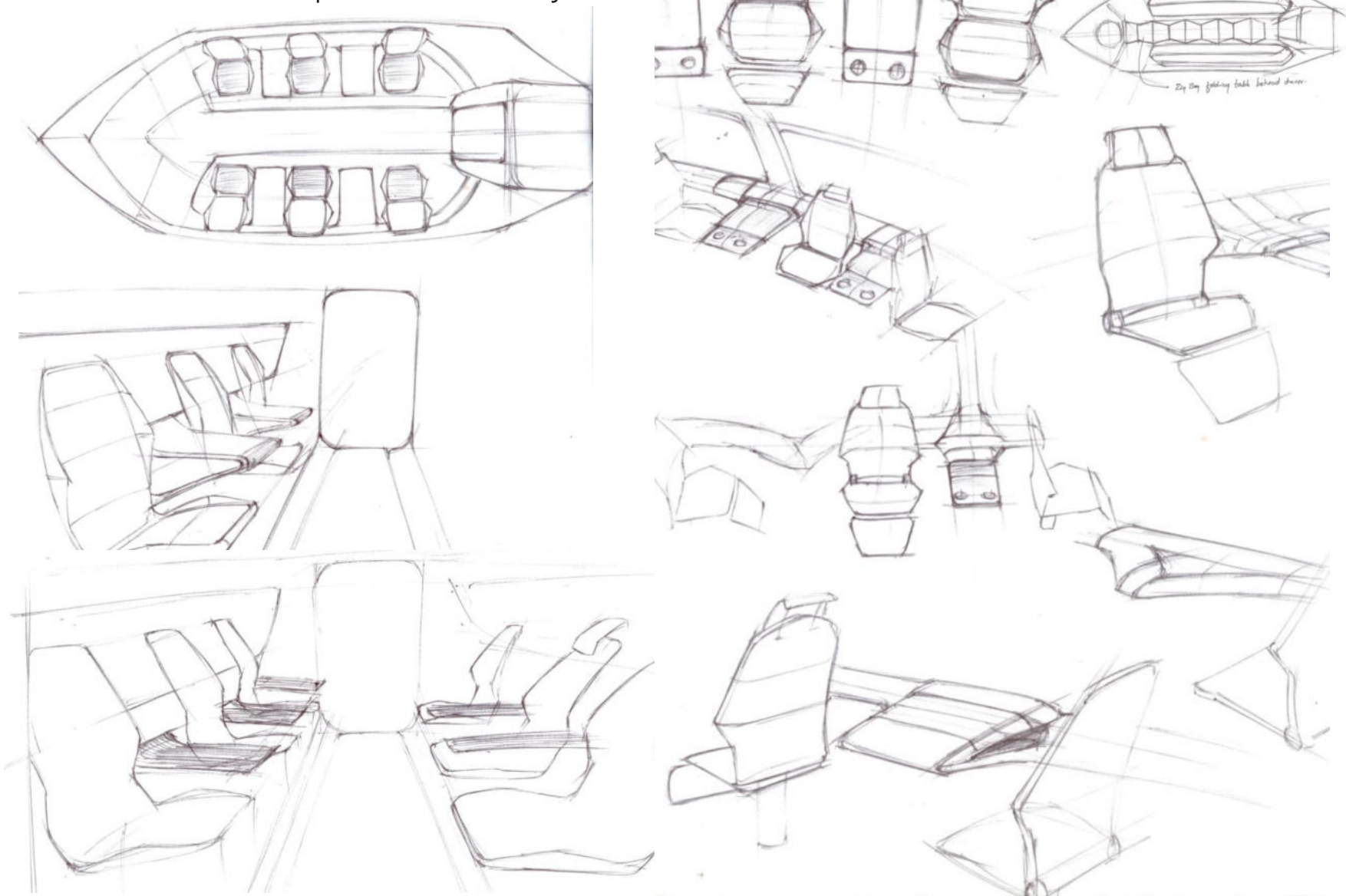


16.5 Driver movement

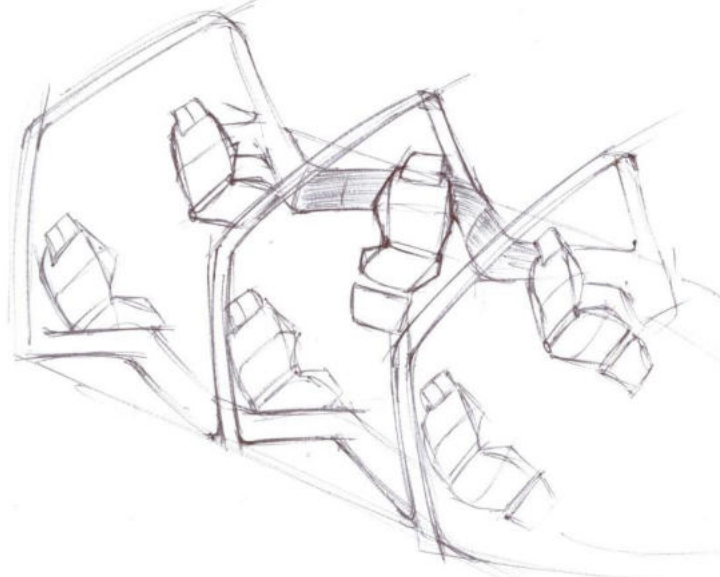
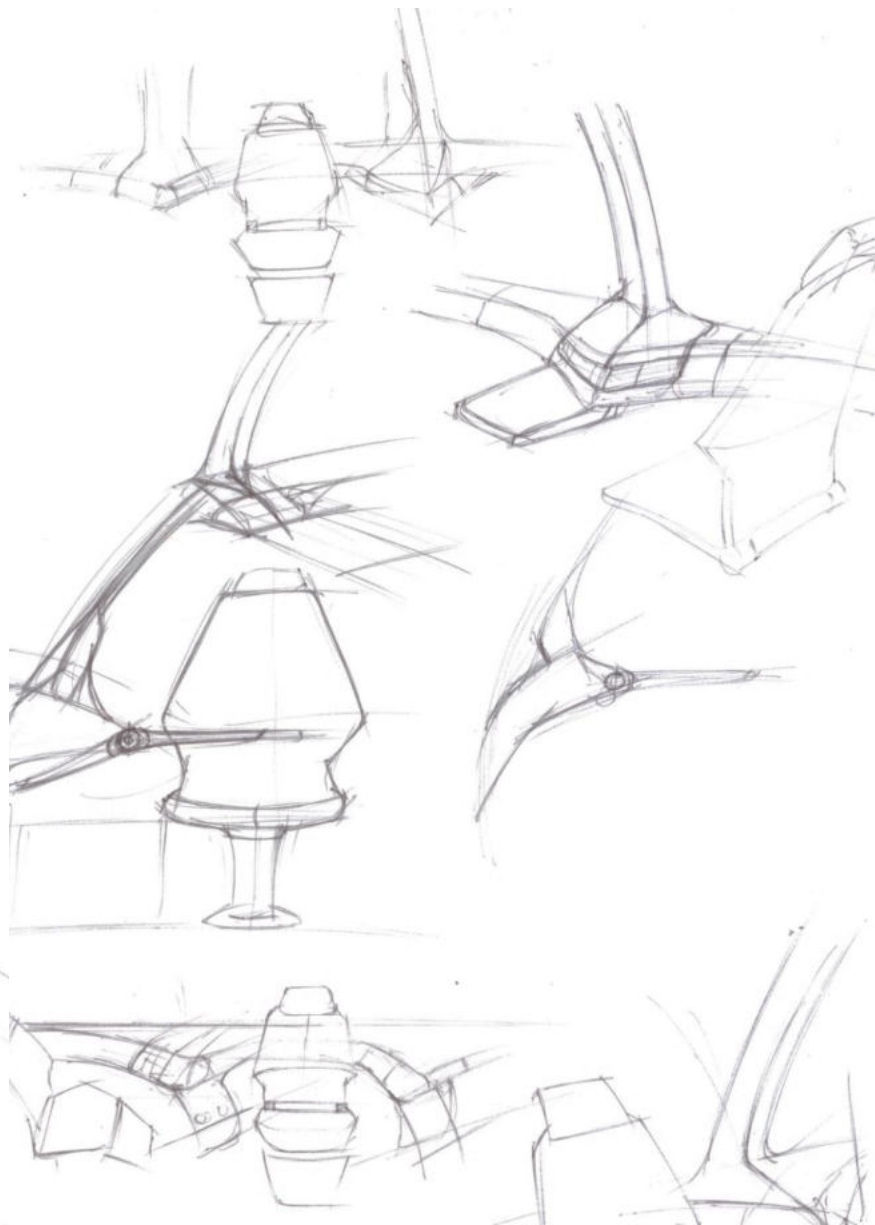
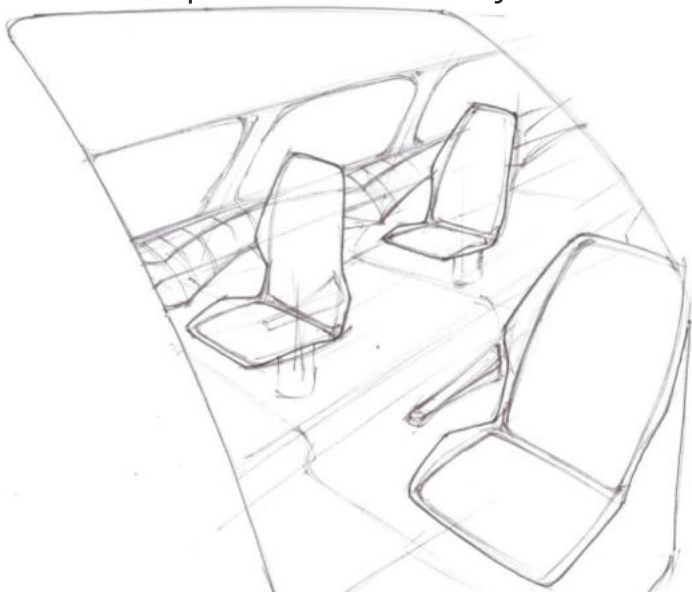
The pictures shows movement of driver from side door to the cabin. One of the side panel slides/folds into middle panel and the middle panel opens to provide room for driver movement as shown in sketch.



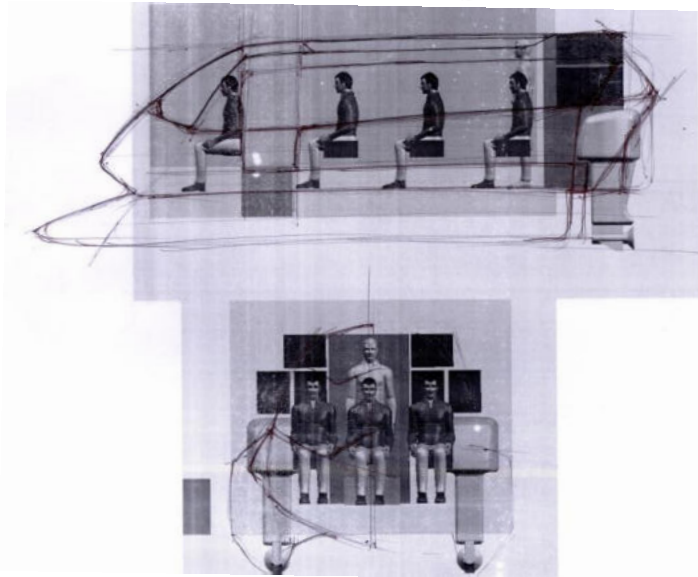
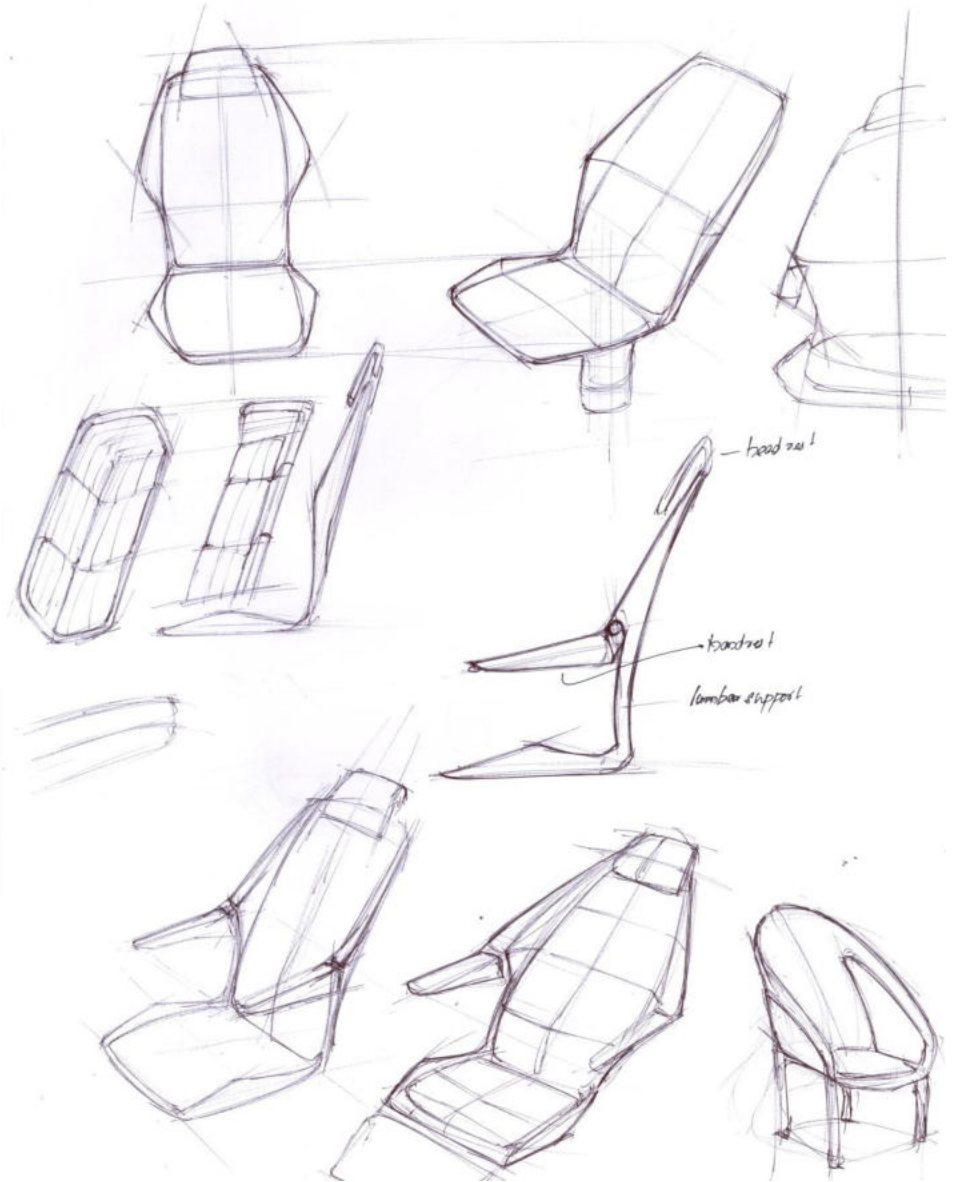
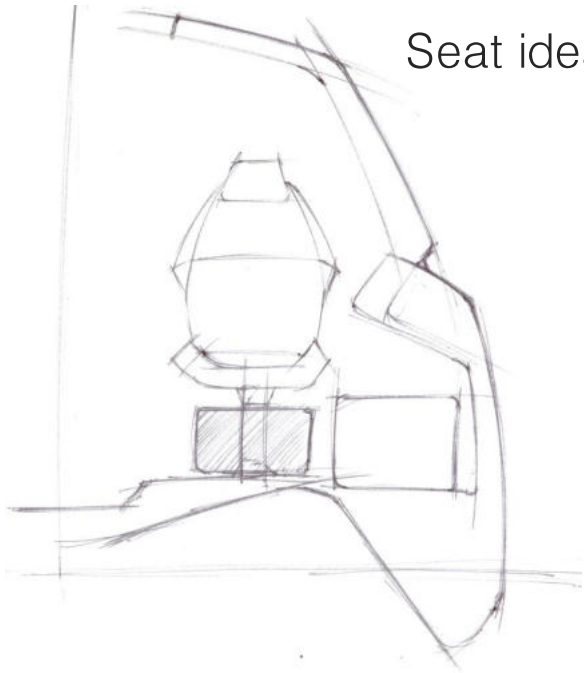
16.6 Interior panels and tray



Interior panels and tray

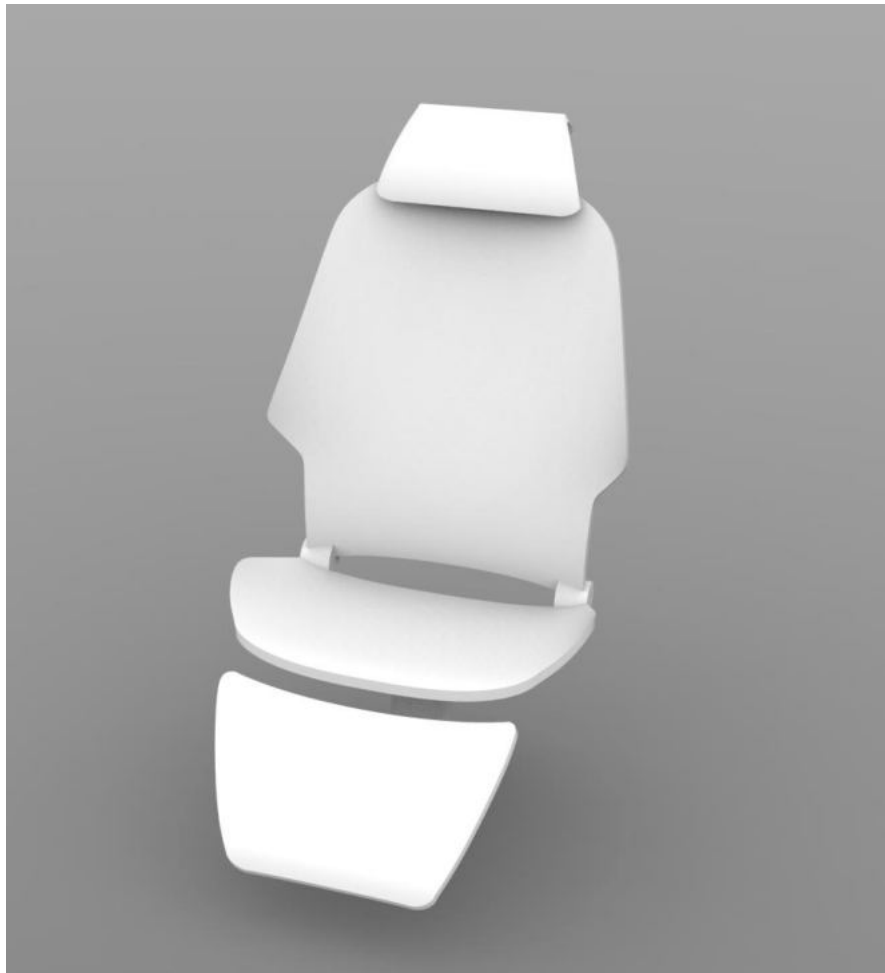


Seat ideations

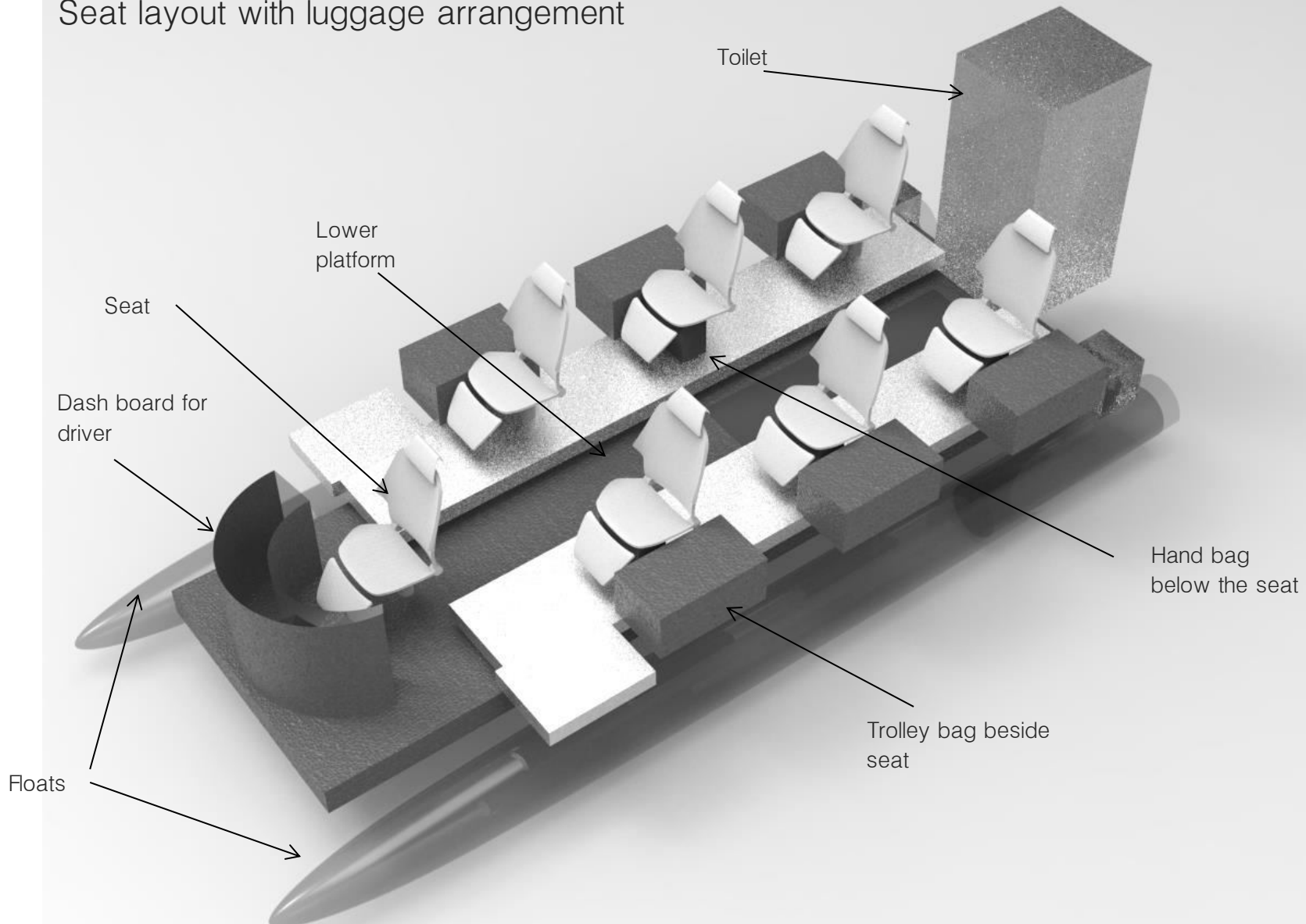


Ideation in CAD

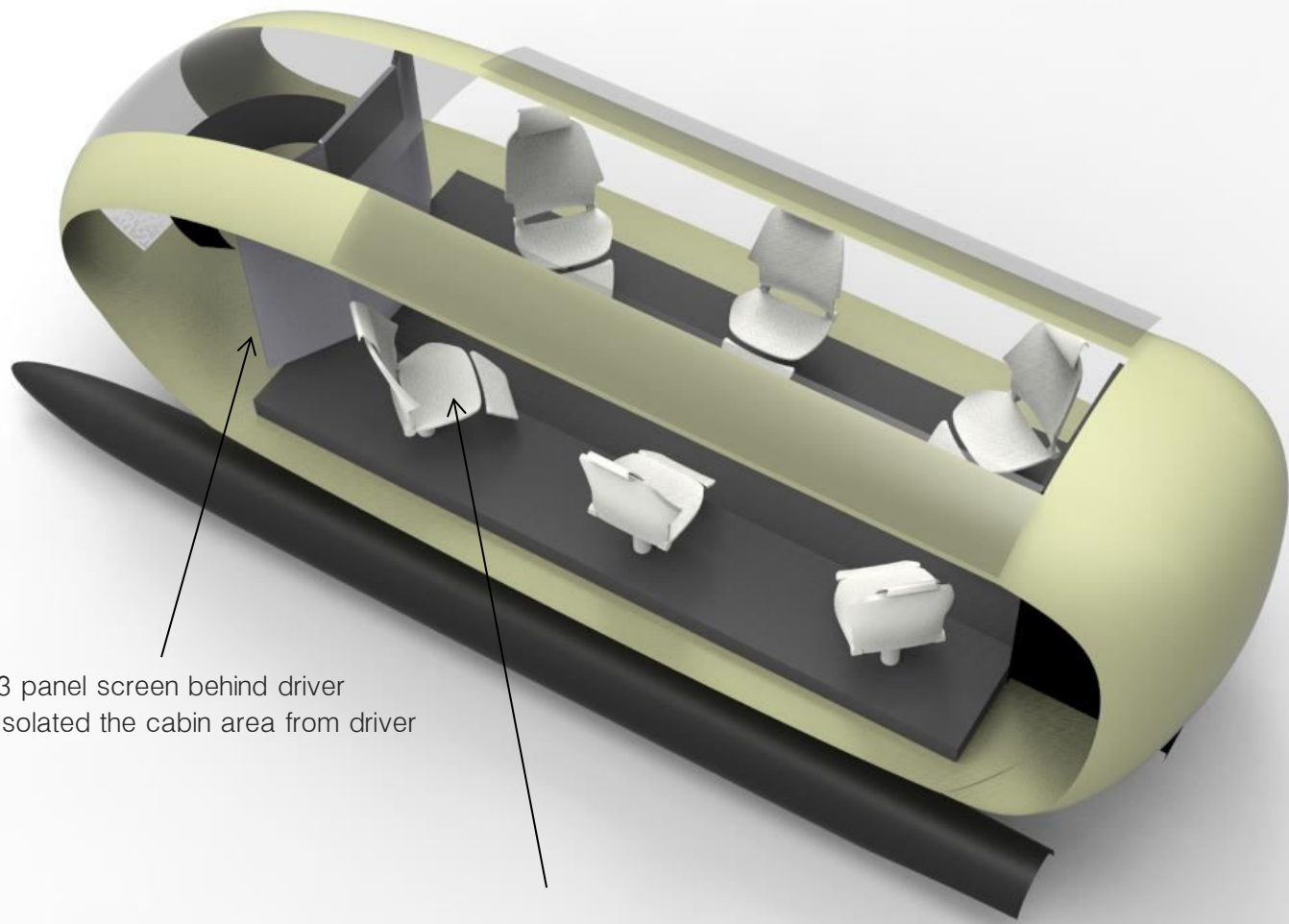
Seat



Seat layout with luggage arrangement

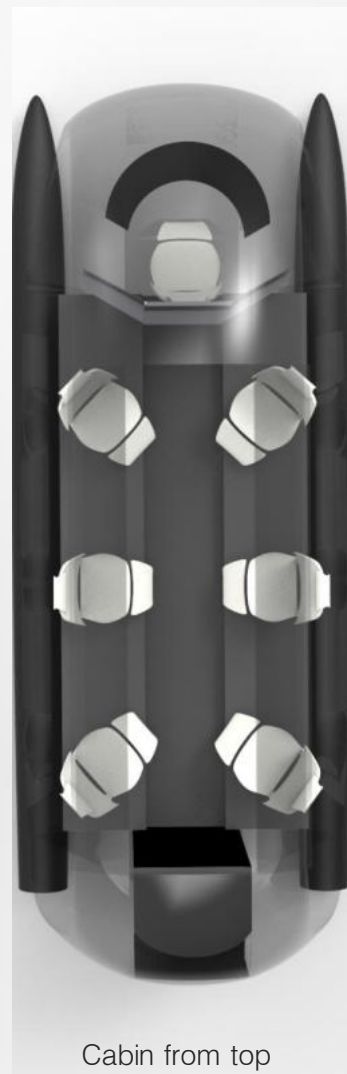


Seating flexibility



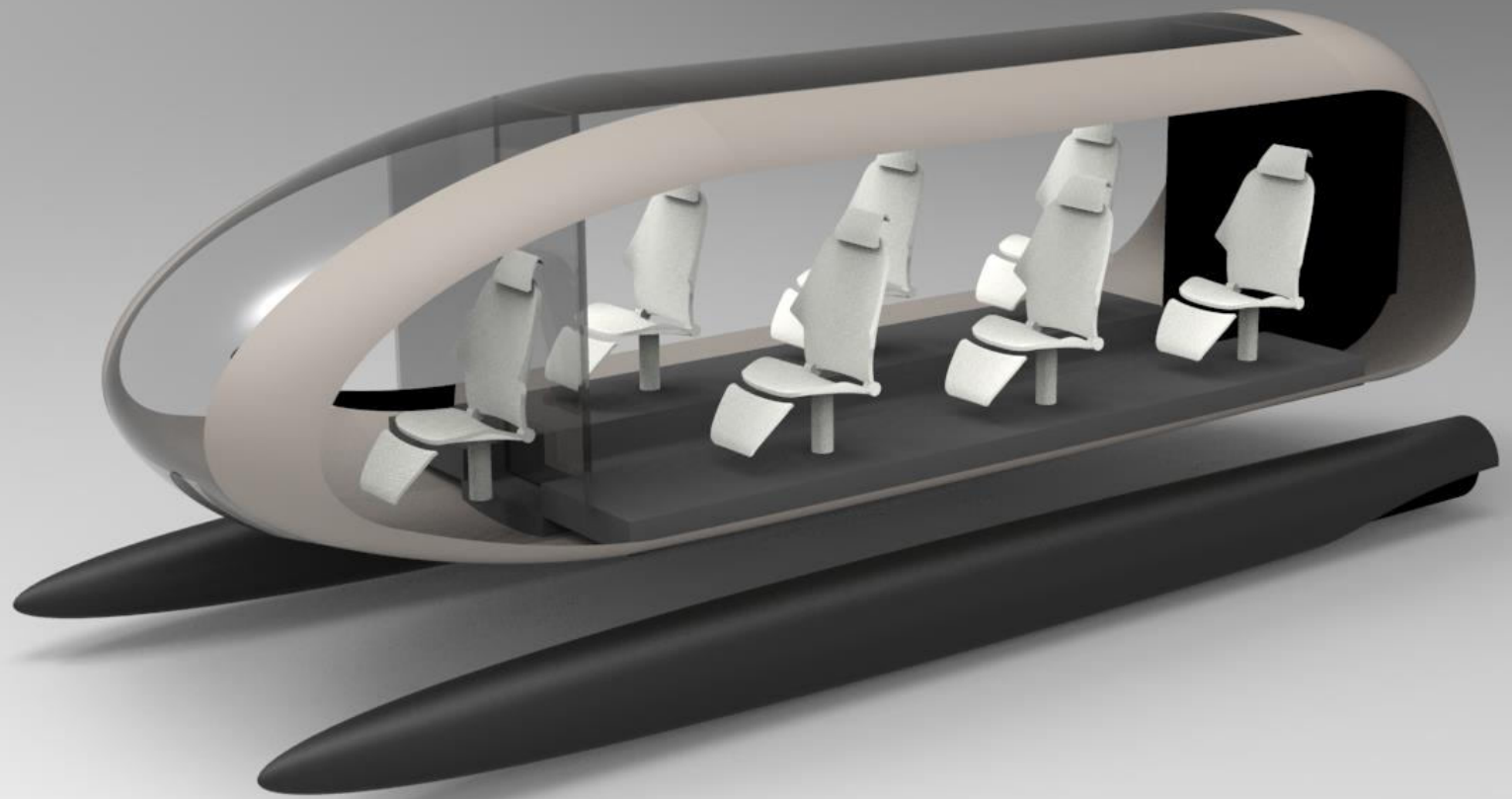
3 panel screen behind driver
Isolated the cabin area from driver

Seats can be rotated to make
cabin space more interactive

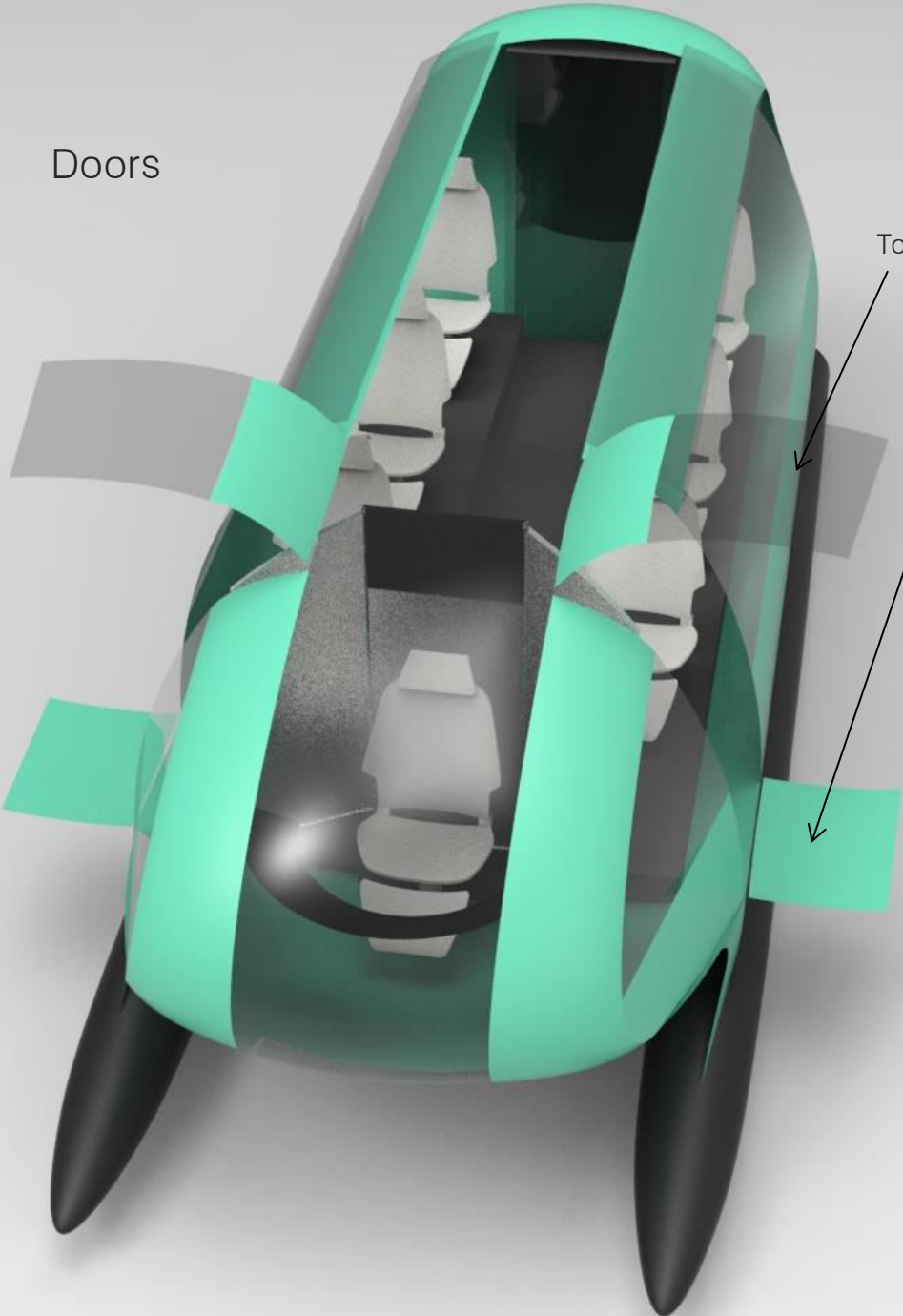


Cabin from top

Defining exterior volume



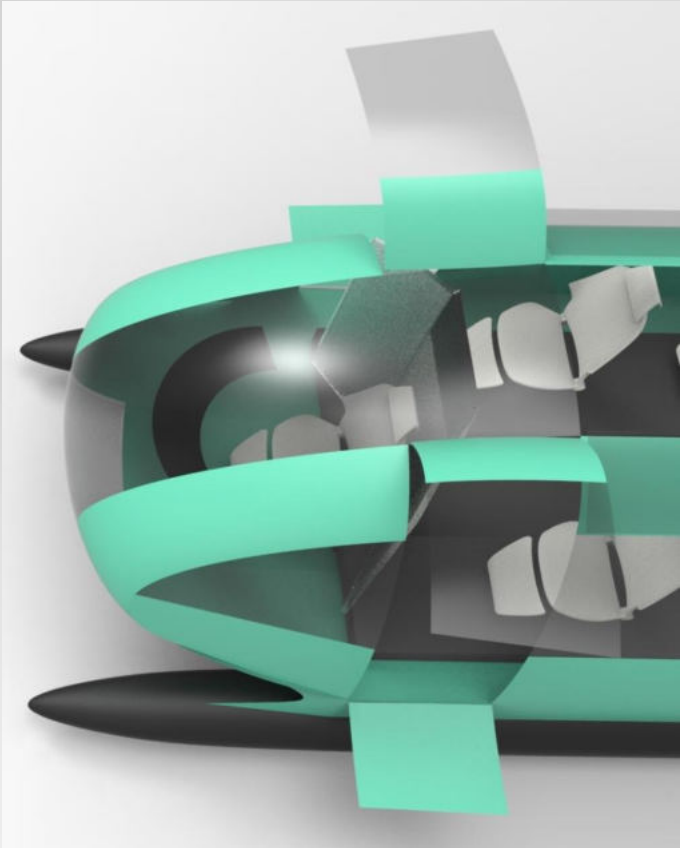
Doors



Top part of door opens like gullwing door



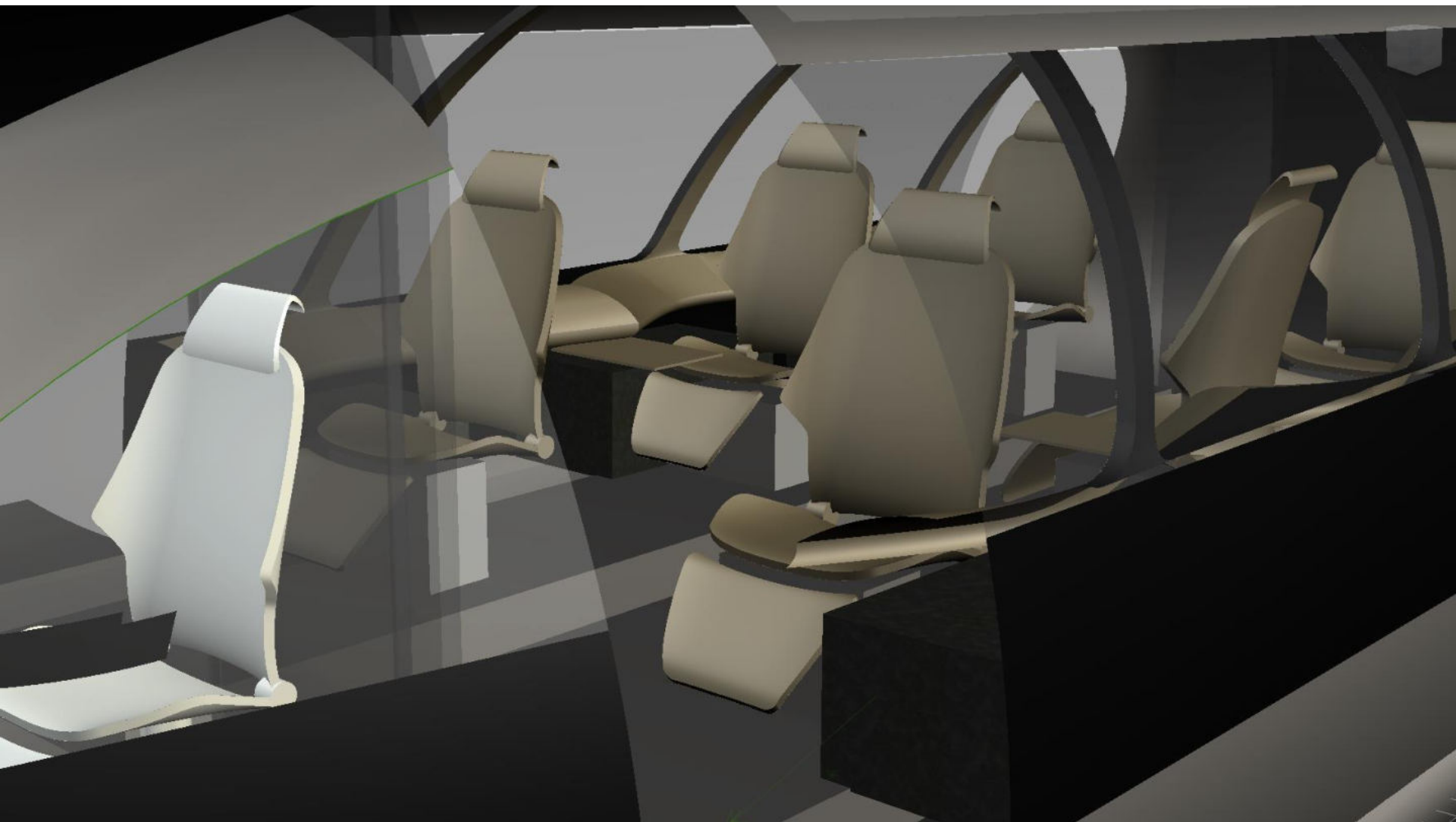
Lower part of door aligns with jetty height



Infotainment



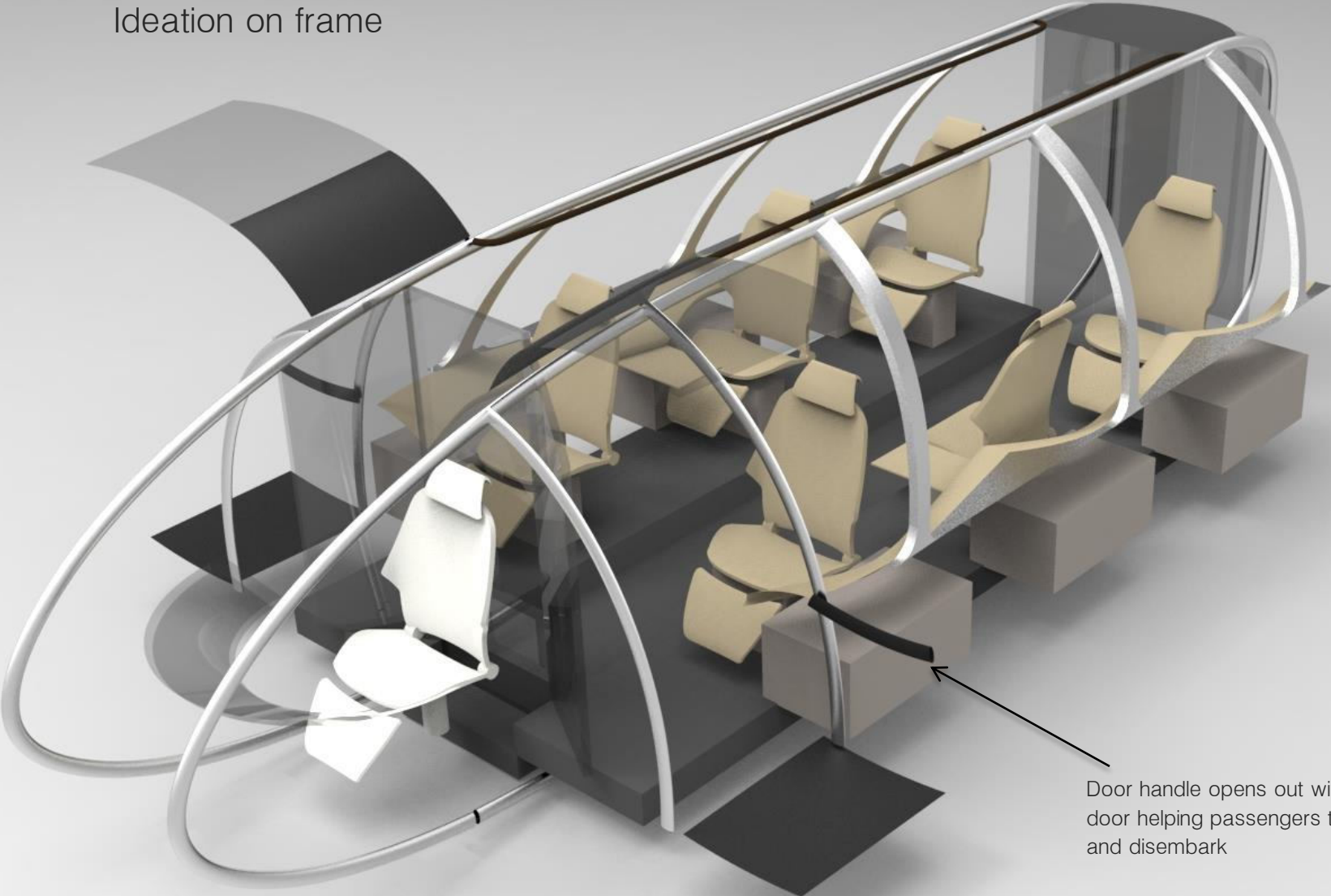
Interior view



Interior

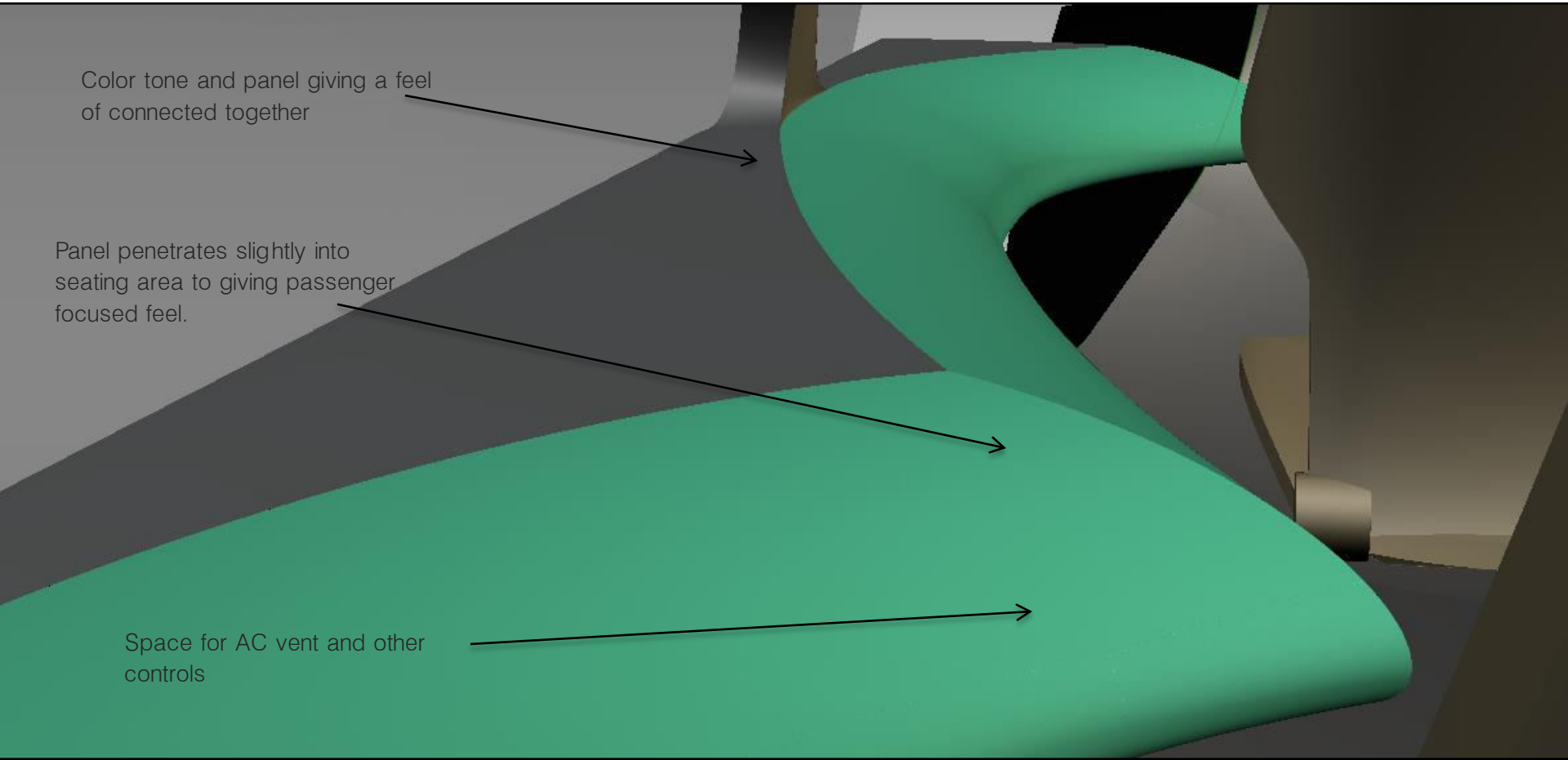


Ideation on frame



Door handle opens out with the lower door helping passengers to embark and disembark

Console in front of seat.



Color tone and panel giving a feel of connected together

Panel penetrates slightly into seating area to giving passenger focused feel.

Space for AC vent and other controls

17 Design inputs

For better understanding about exterior design Dr. Dileep K Krishnan from ship technology from Cochin University of Science and Technology was approached with works till date.

Professor was kind enough to spent good quality time on discussions and feedback.

Inputs from the discussion

17.1

Route constraints NW-3

- Length \geq 38m
- Breadth \geq 8.5m
- Draft \geq 1.5m
- Air draft \geq 4.5m

With length of about 7m , width of 3m and height of about 2.6m the current dimensions fits well within the dimensional constraints of the route.

17.2

Catamaran Floats can be

- Normal semi submersible floats
- Fully submersed floats

17.3

Hull Materials

Current materials of choice

- Steel
- Aluminum
- FRP
- Wood

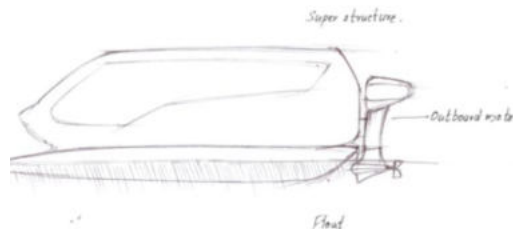
From the above list Aluminum and FRP seems light weight options.

All fitting should be light weight.

Super structure -Structure part of boat above floats.

For construction of super structure FRP or any other light material can be used. Multi layer fabric stretched on aluminum frame can be considered for a lighter super structure.

Fabric strengthened with FRP resins can be considered for roof and other parts of super structure.



17.4

Weight of the catamaran.

- Though govt regulation specifies weight of 65kg per person, 75 kg is normally taken for design calculation.

With a seating capacity of 7 persons

,passenger weight comes around **525kg.**

- Luggage weight for each user is taken around 27kg(20kg(trolley bag)+7kg(hand bag)),bringing total luggage weight to **189Kg.**
- Outboard engine weight for 115hp comes at 190Kg. With two engines total engine weight comes to **380Kg.**

Total weight of boat= Occupants+ luggage +Engine + Support systems + Material weight of catamaran.

Support system includes AC compressor, batteries and water storage for toilet.

Material weight of Catamaran= Float+ super structure + Interior

Approximate factor for FRP shell weight is 13kg per sq.m

FRP body requires stiffeners, which will add 40% to FRP body weight.

17.5

Resistance.

Resistance of a floating body in motion has

- frictional resistance (R_f) and
- residual resistance (R_r)

Frictional resistance is that which occurs between the hull and the water while the residual resistance is the sum of all other resistances of which wave-making, form, and yaw are the most important. Other forces come into play under special circumstances (air resistance due to headwinds and energy losses due to pitching) are rarely serious design considerations.

Frictional Resistance

$$R_f = 0.97 \times C_f \times S_w \times V^2$$

where: R_f = Resistance

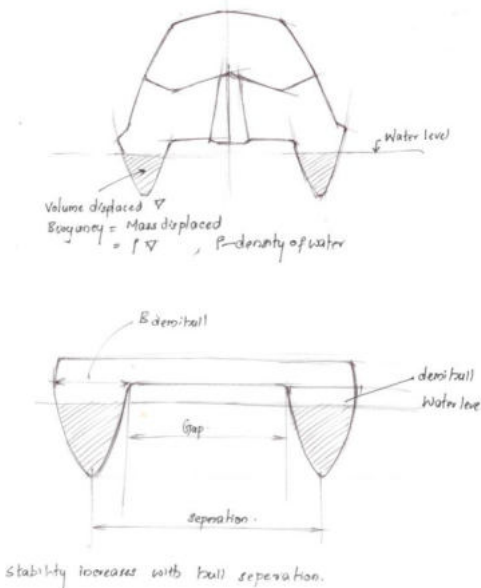
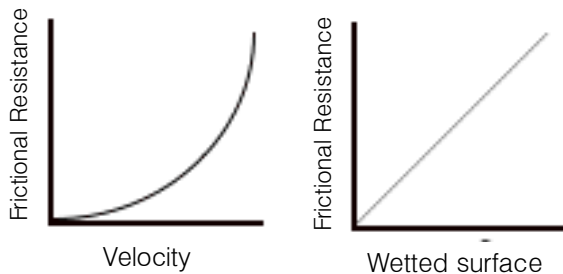
C_f = Coefficient of friction

S_w = Wetted surface

V = Velocity in ft./sec

Wave making resistance does not become important until the Speed/Length ratio begins to exceed 0.7

From above equation frictional resistance is proportional to surface area of wetted part of float and proportional to square of velocity.



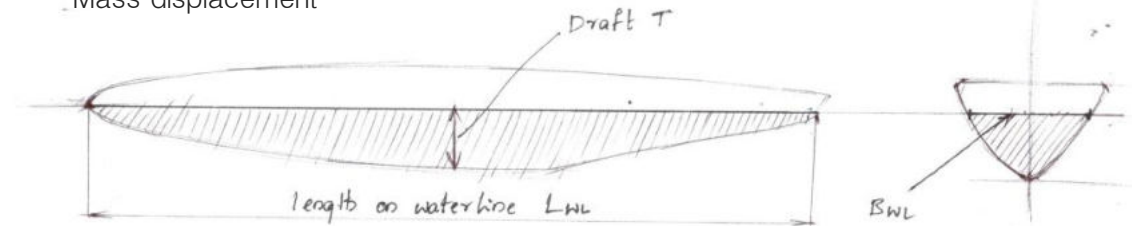
17.5.1 Why weight is so critical

While road vehicle has to overcome rolling resistance and air drag, boat required energy mostly for

- getting forward thrust from water,
- also to generate waves

Wave generation is an undesirable character of boat movement. Wave strength increases with ratio of length and breadth of immersed portion of boat. Normally in Catamaran design this ratio is small due to two narrow floats.

Mass displacement



$$\nabla \text{ Volume displaced} = L_{WL} \times B_{WL} \times T \times C_B$$

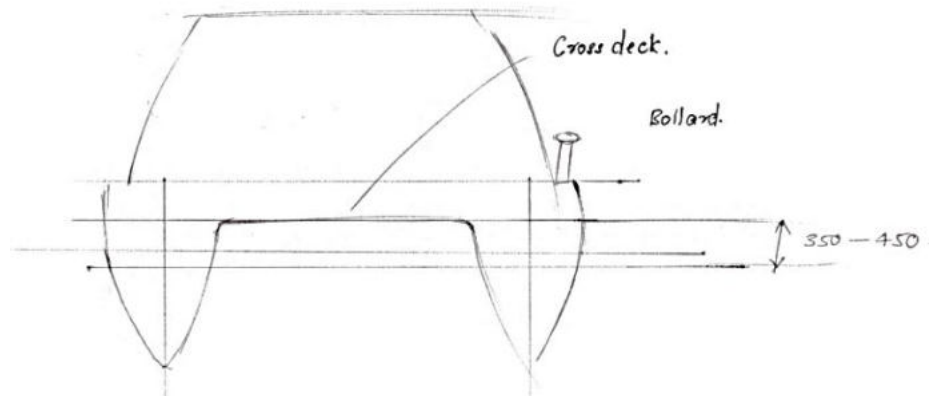
$$C_B = \text{Block coefficient} \approx 0.6 \text{ to } 0.7$$

$$\text{Mass displacement} = \rho \nabla = \text{Total weight of Catamaran.}$$

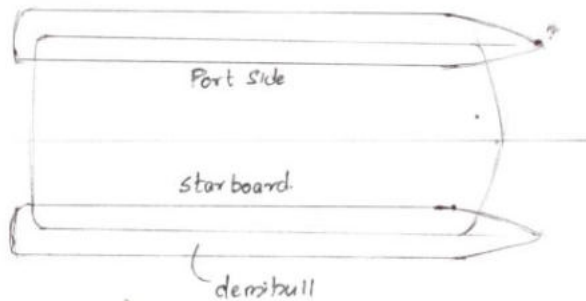
17.6 Other inputs

Bollard

A bollard is a short vertical post. Originally it meant a post used on a ship or a boat, principally for mooring.



TOP VIEW



Lights

- | | |
|----------------------------|-----------------------|
| 1. Forward mast head light | -White |
| 2. Side lights | |
| | Starboard side -Green |
| | Port side -Red |
| 3. Stern light | -White |

Space requirements

Air conditioning-

Space for compressor and support systems

Fuel storage-

Space for fuel storage preferably for round trip. Rectangular shaped fuel tanks below platform helps to save space. Space inside floats can also be utilized for fuel storage.

Water storage-

Enough water storage for use in toilet.

Safety-

Space for life buoys and fire extinguisher.

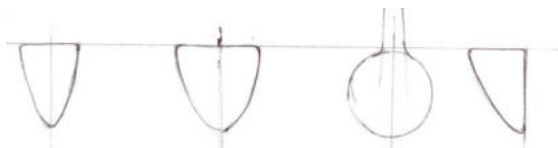
Volume and surface area

For the same volume of displacement, different surface area can be provided for the float.

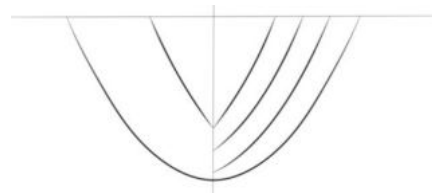


Narrow and deeper float design provides better stability. Though surface area is large, less energy is lost for wave making.. Its also offers good performance with speed.

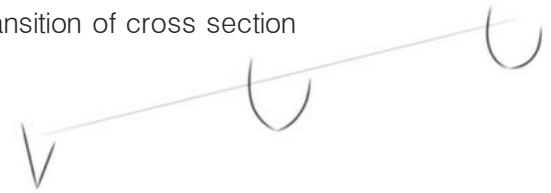
17.6.5 Cross section for float



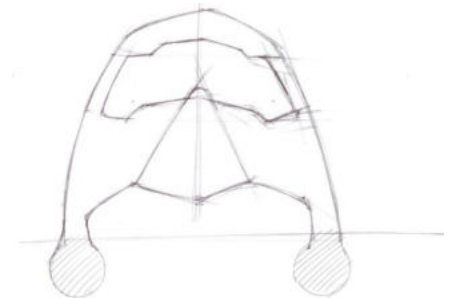
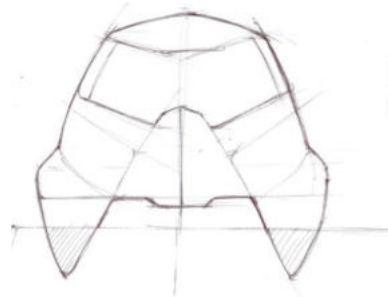
Circular cross section has least surface area for same volume displacement. This opens out an opportunity for fully submersed float for catamaran. The shape of float in this case can be inspired from torpedoes or submarines. For partially immersed floats it is ideal to have a v cross section in front which change to a semicircular cross section near central section and then continues to the rear end of float. This transition of surface helps in better water piercing form and better buoyance from minimum wetted surface area



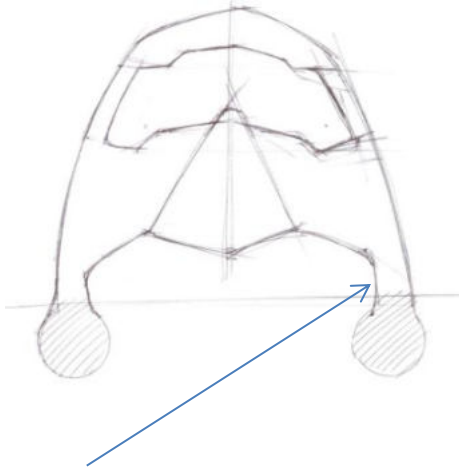
Transition of cross section



IR-109



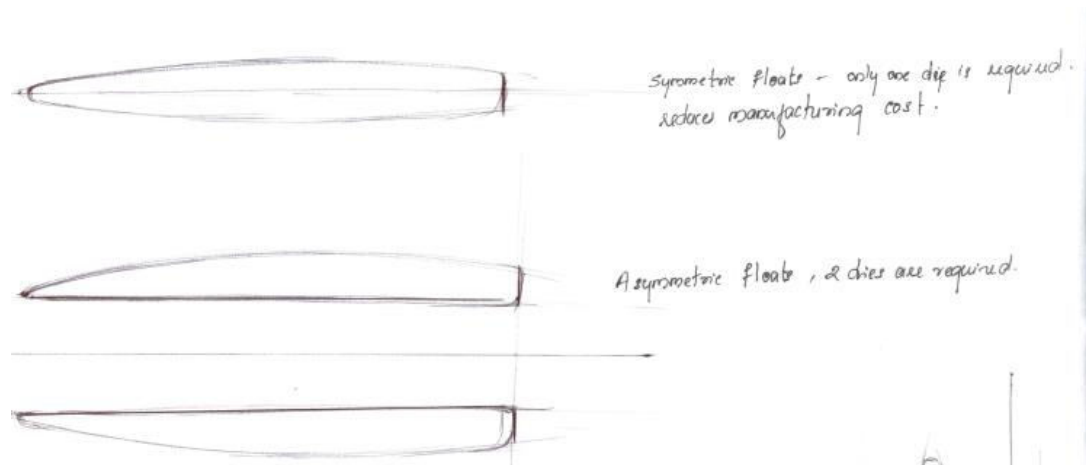
One draw back with fully submersed float is that the stress level at the joints of float increases significantly and also add to cost of design.



High stress

17.6.6 Symmetric and asymmetric float design

From manufacturing point symmetric float design brings down overall cost. Only one mold is required for FRP floats.



Symmetric floats - only one die is required. reduces manufacturing cost.

Asymmetric floats, 2 dies are required.

18 Evaluation

18.1

Electric propulsion

The advantages -

- low maintenance costs,
- limited noise and
- emission-free operation.

The disadvantages

- Limited range due to the weight and size of the batteries. Lead-acid batteries have high weight (38 watt hours / kilogram) and limited capacity when quickly discharged (60% at 1 hour).
- Newer battery technologies like lithium systems (e.g. LiFePO4 or Lithium polymer) offer up to seven times the performance of a lead-acid battery but they are very expensive.

Charging the batteries with a photovoltaic solar system can make the system independent of any external energy source.

For longer trips, the system can have a range-extending gasoline or diesel generator which recharges the batteries.

Costs

Electric outboard motors cost two to three times the cost of a four stroke petrol engine, but operation costs are lower.

Electric motors are usually much more efficient in power to weight ratios. however requires at least twice as much power to compensate for added weight.

Internal combustion engine	Electric propulsion
Polluting in nature	Clean source of power
Output from combined weight of engine and fuel is higher	Output from combined weight of electric motor and batteries is less.
Low initial investment	High initial investment
High running and maintenance costs.	Low running and maintenance costs.
Refill is possible almost every where enabling a long range	Limited range
Low end torque is less	Better low end performance

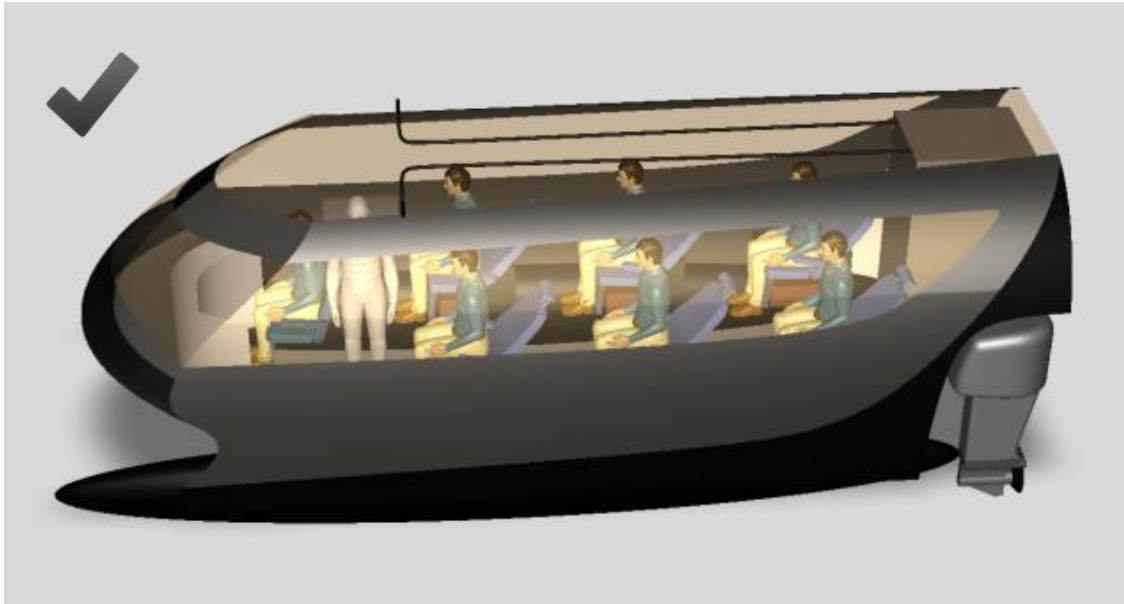
Though electric propulsion has been successful in many examples around the world, IC outboard makes more sense as the source of propulsion in long distance water taxi.

Catamaran design with twin propeller behind each floats enable it to do a 360 turn in its own length. This advantage with the architecture does not demand for further experiments on float design.

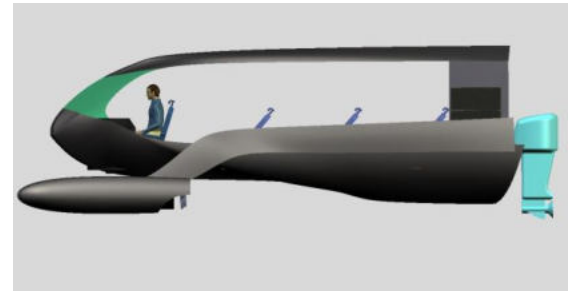
For this project rigid float design is selected for design explorations, though flexible designs on float seems to have practical potential.

18.2 Concept selection

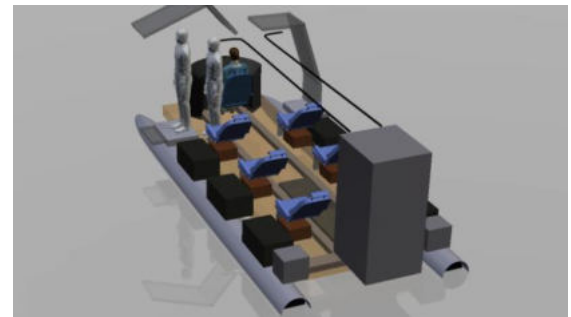
IC out board



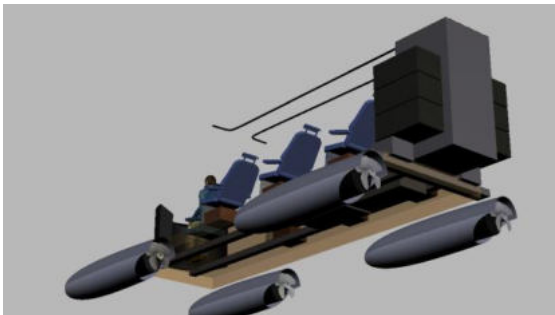
Hybrid Single IC and two electric motors on floats



Pure electric with rigid floats



Electric with split floats



Electric outboard with flexible floats



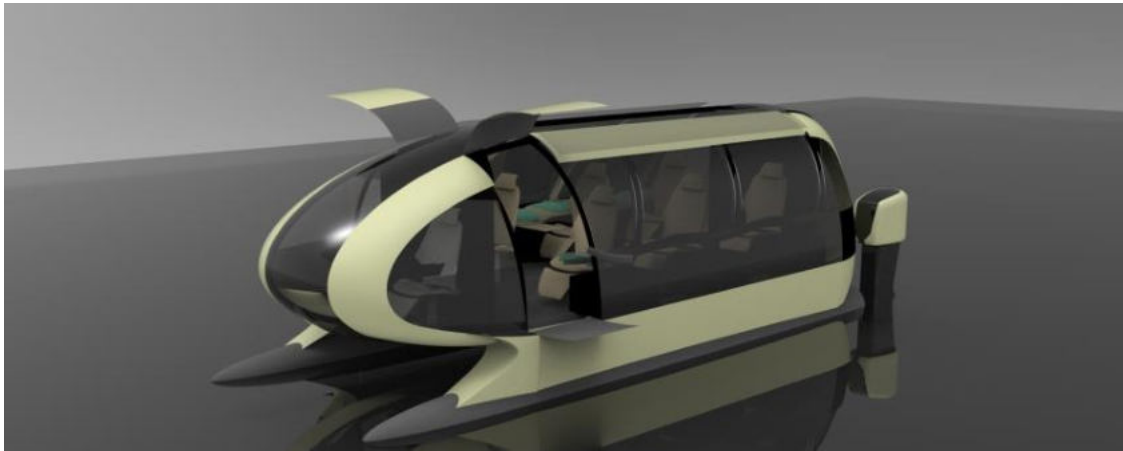
19 Concept detailing

19.1 Float designs selection

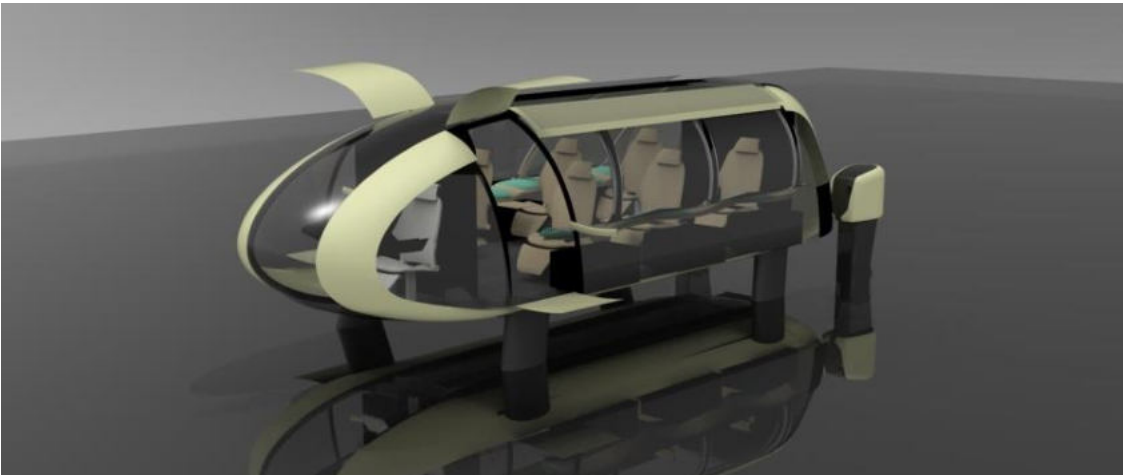
(Inputs from peer review)

Catamaran with two outboard IC engines

Semi submersed floats



Fully submersed floats



Evaluation-Peer review

Semi submersed floats

- Stable feel
- Looks complete and aggressive.
- Feels like floating.
- Safe and balanced with larger surface area on side.

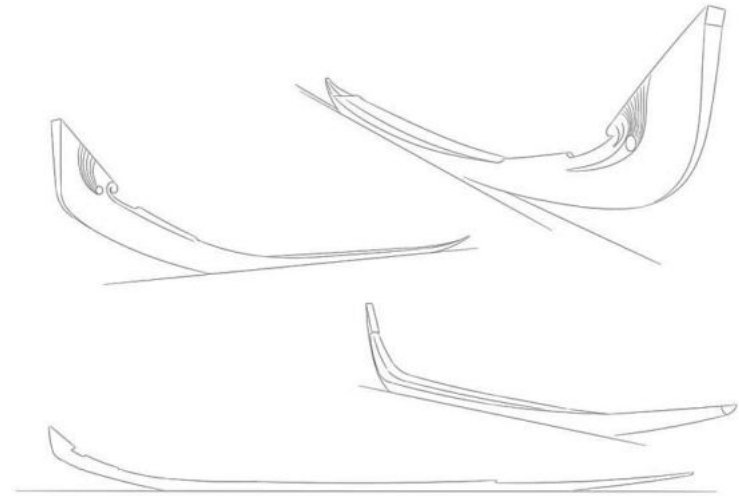
Fully submersed floats

- About to topple down.
- Lacks stability.
- Feels static.
- No floating feel.

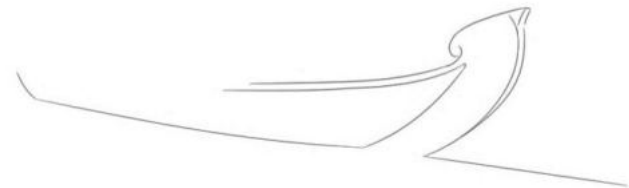
On the basis of above review ,semi submersed float design is taken up for further explorations.

Native Inspirations

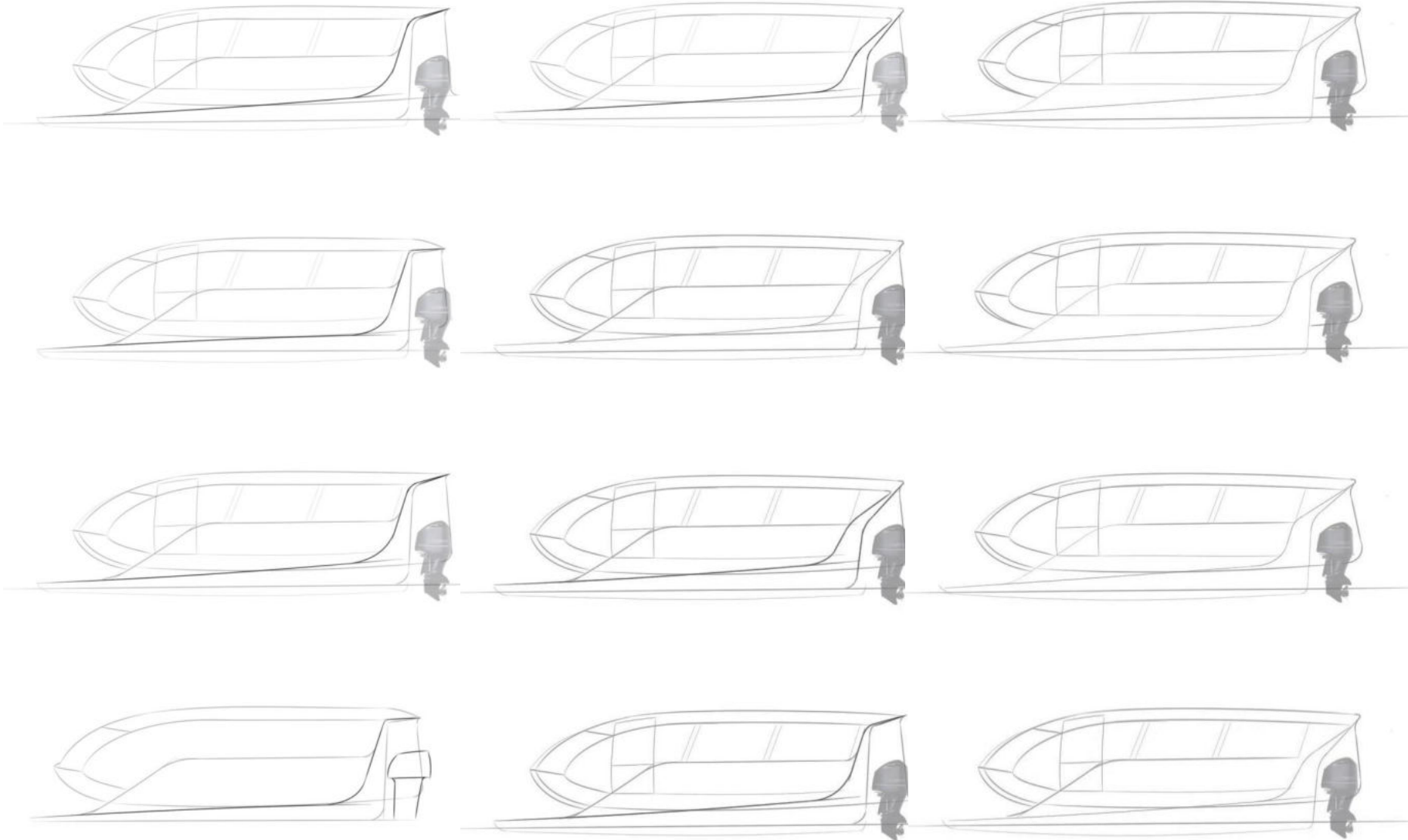
Chundan vallam



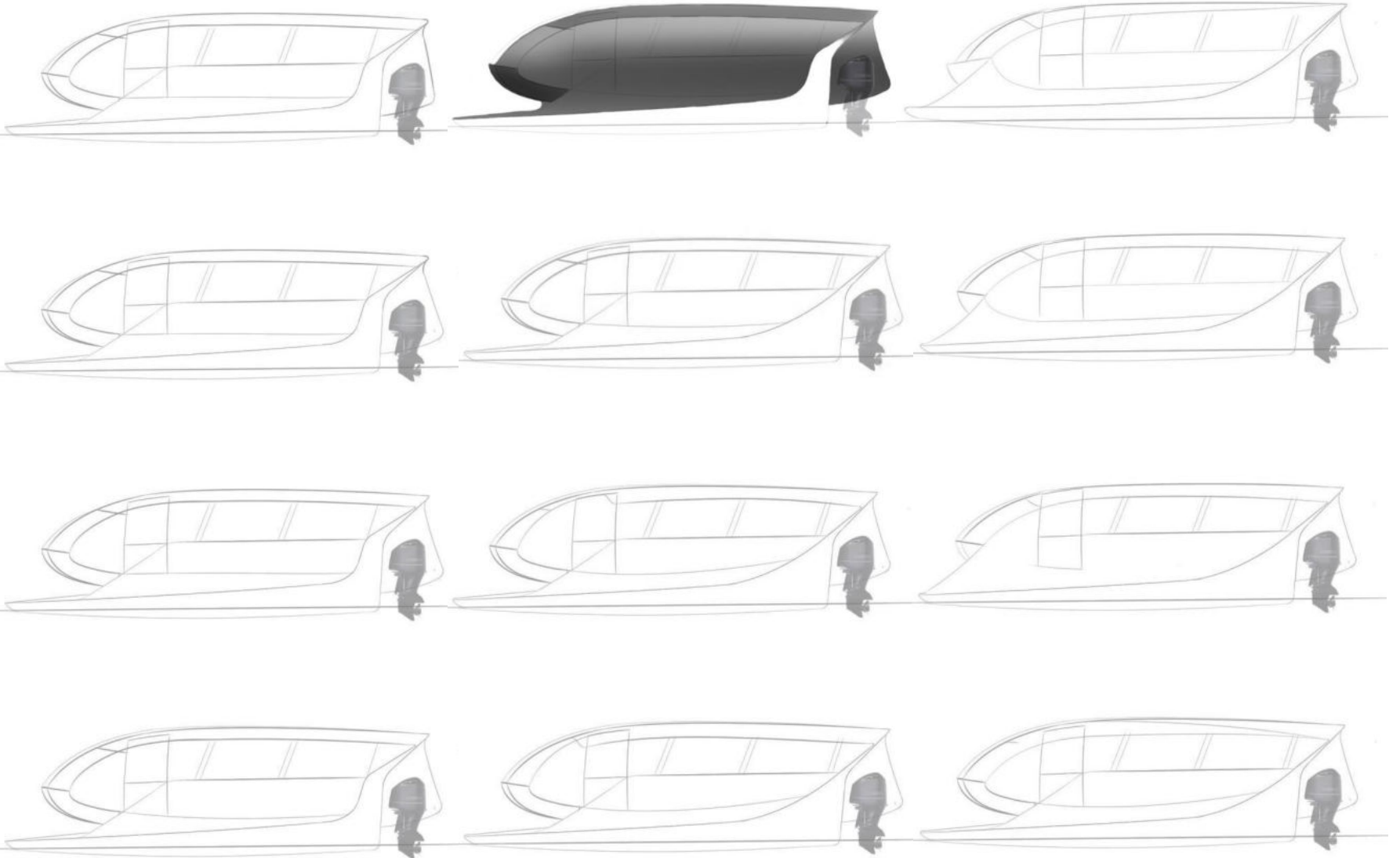
Kettuvallam



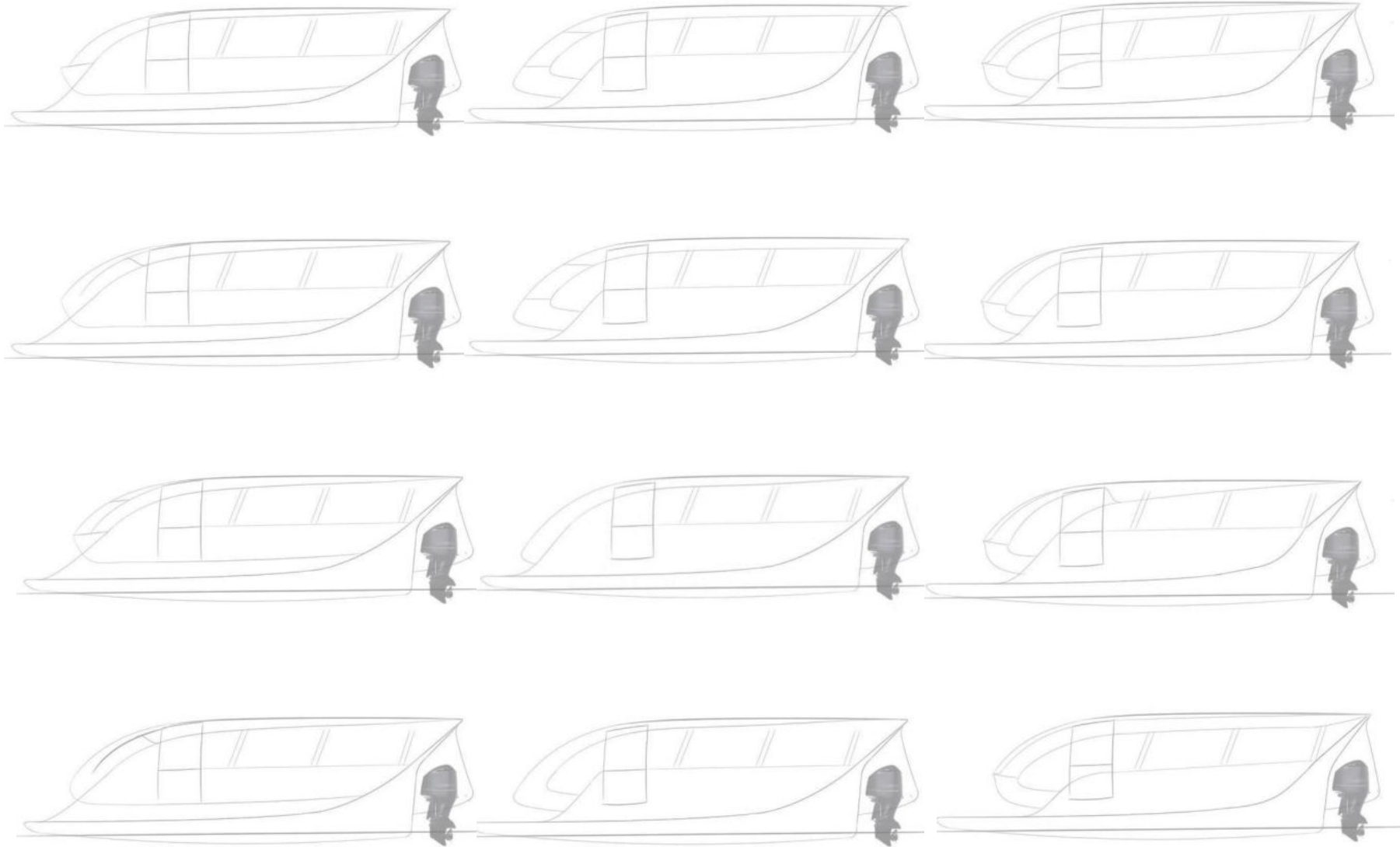
Silhouette explorations



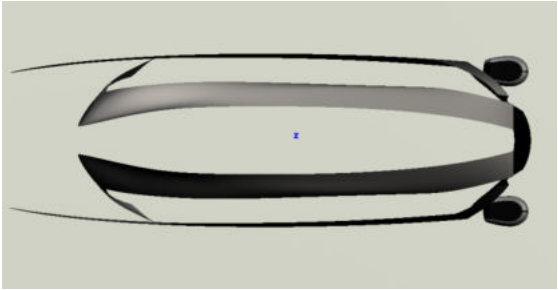
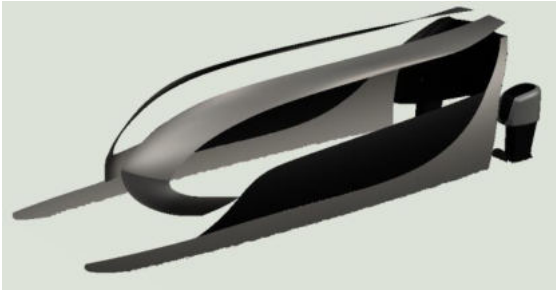
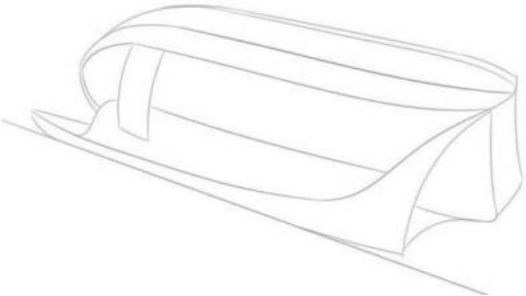
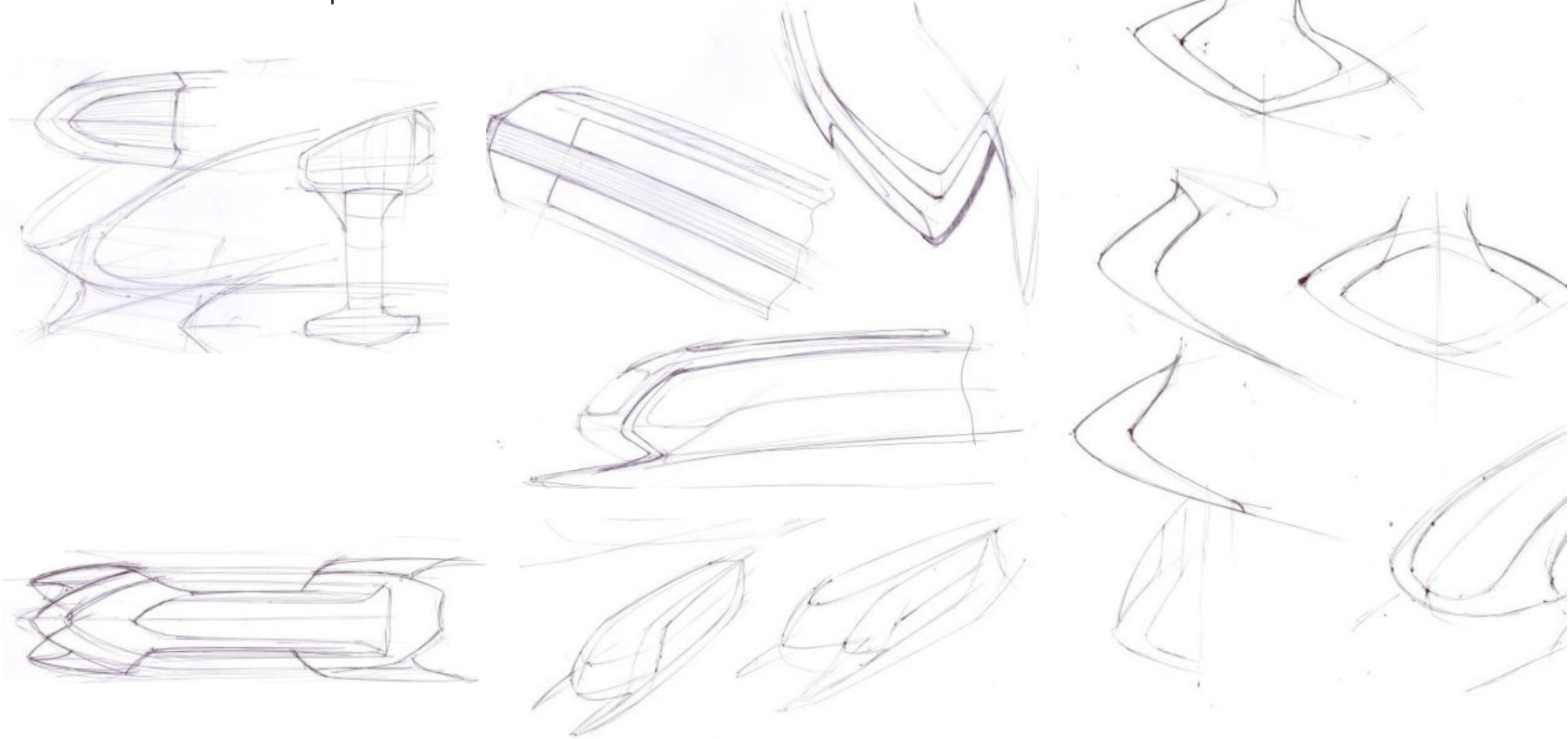
Silhouette explorations



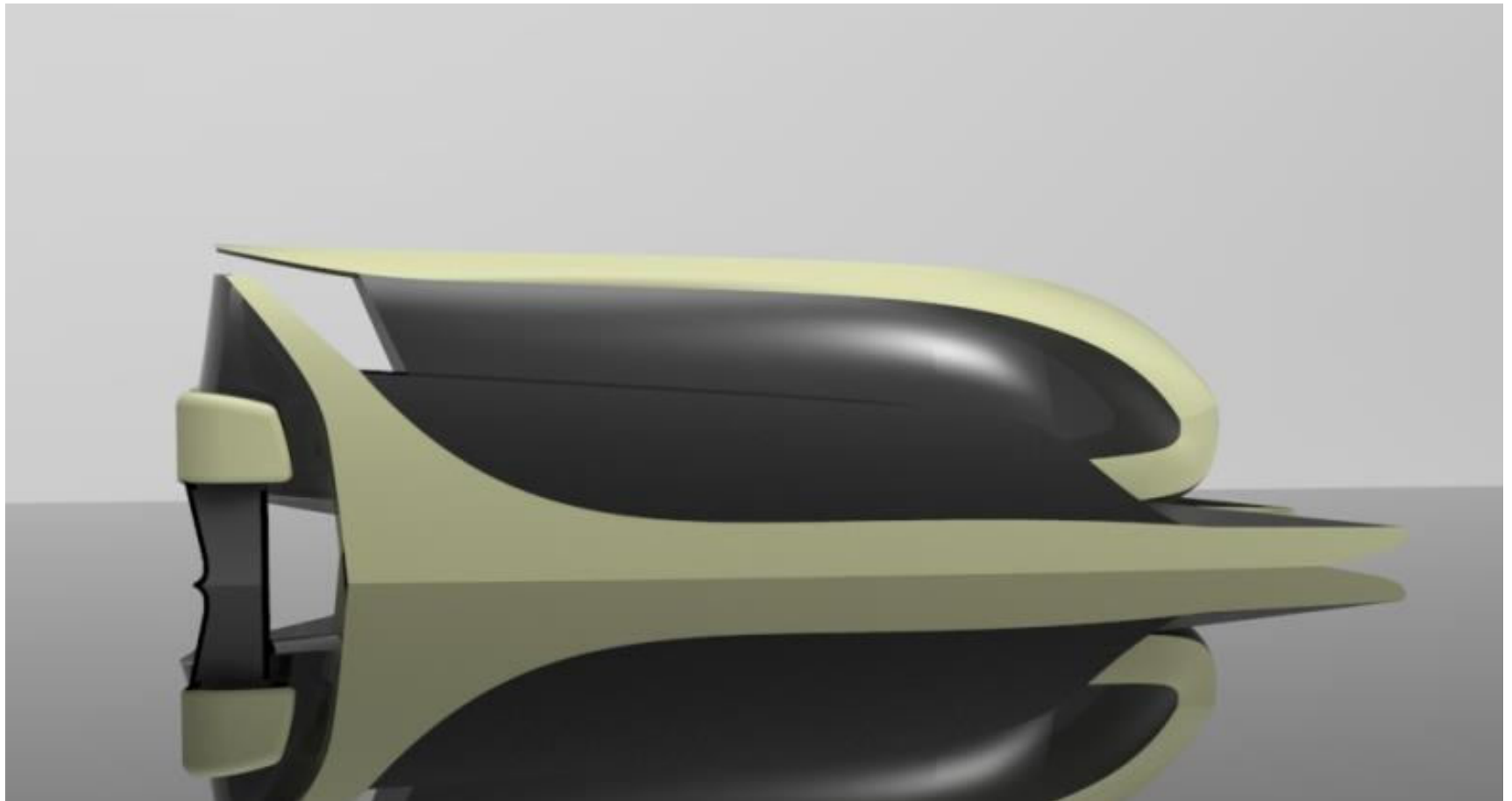
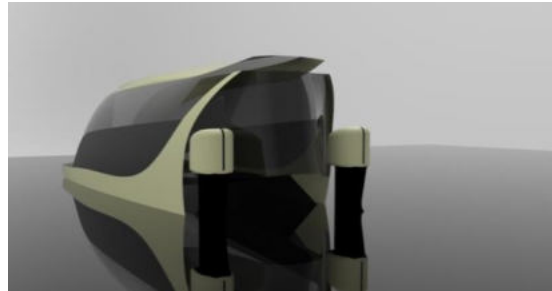
Silhouette explorations



Sketch development



Design-1





IR-118



IR-119

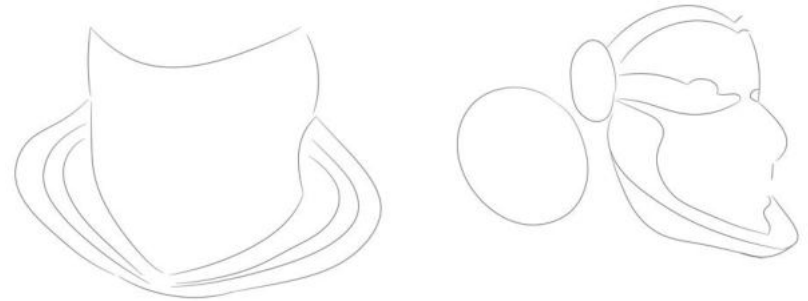


IR-120



IR-121

Images for inspiration



Images board



Inviting



IR-122

Swiftness

Expressive

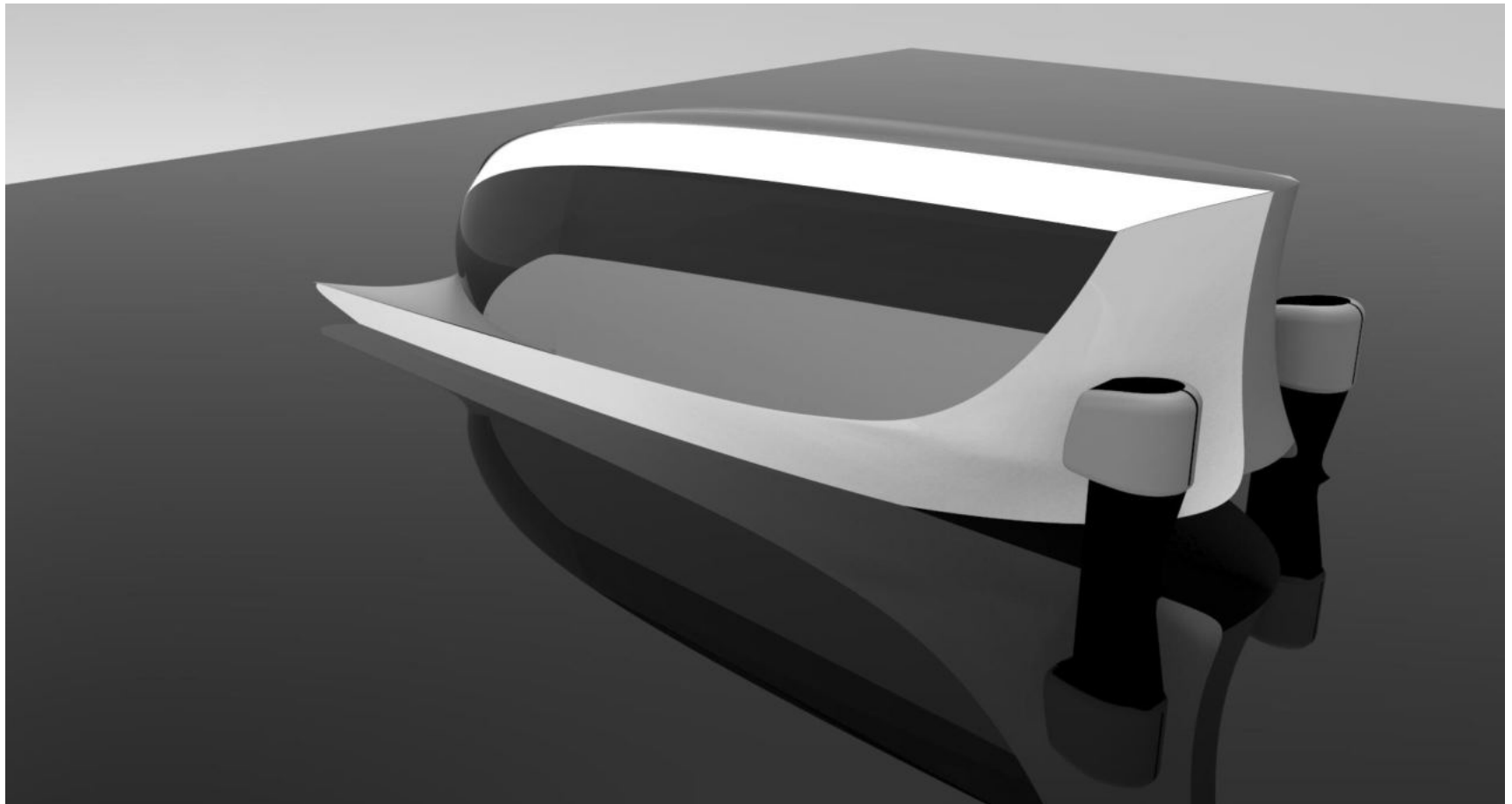
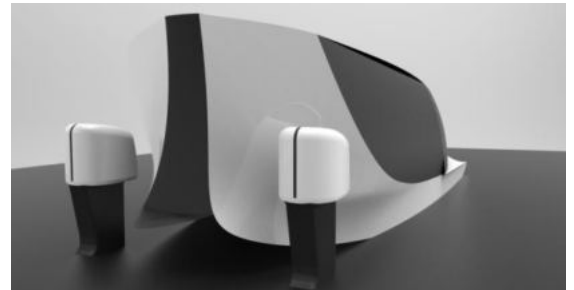
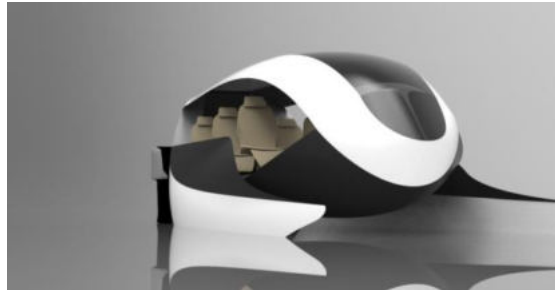


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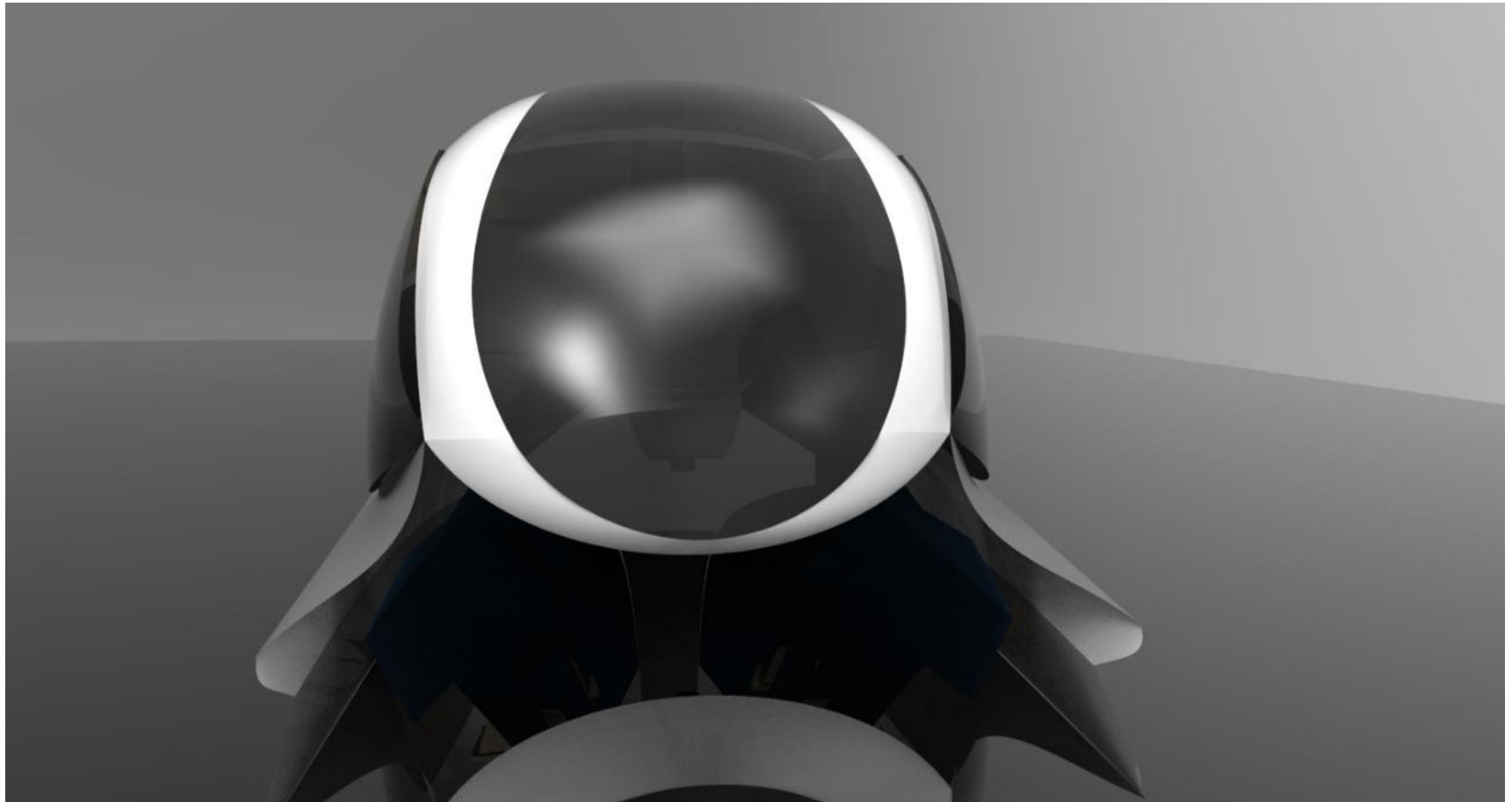
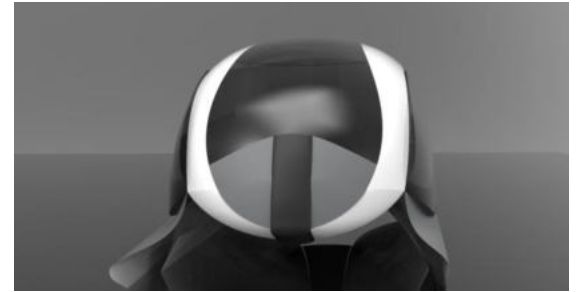
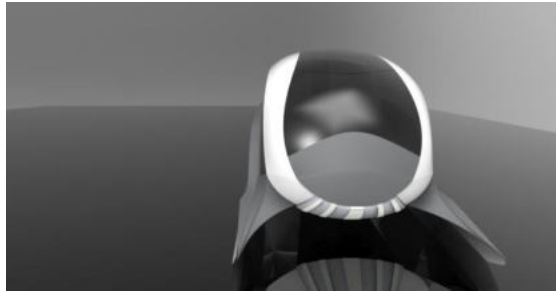


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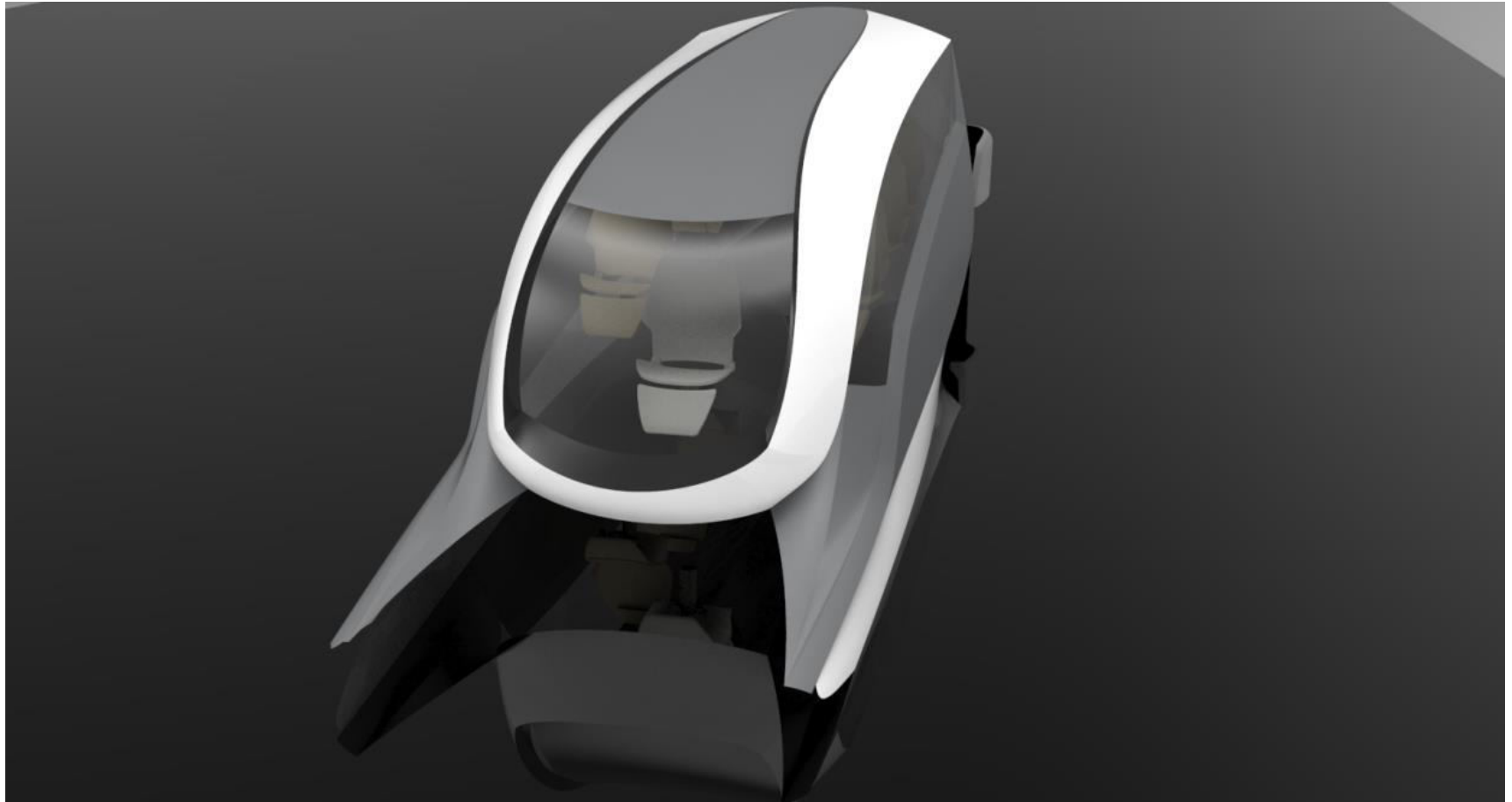
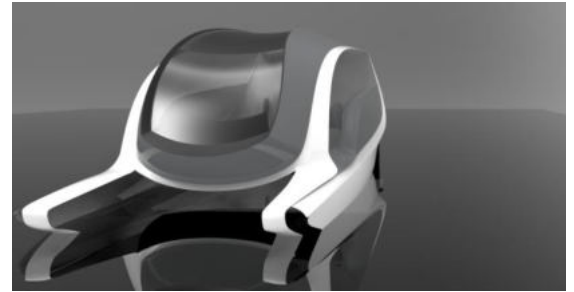
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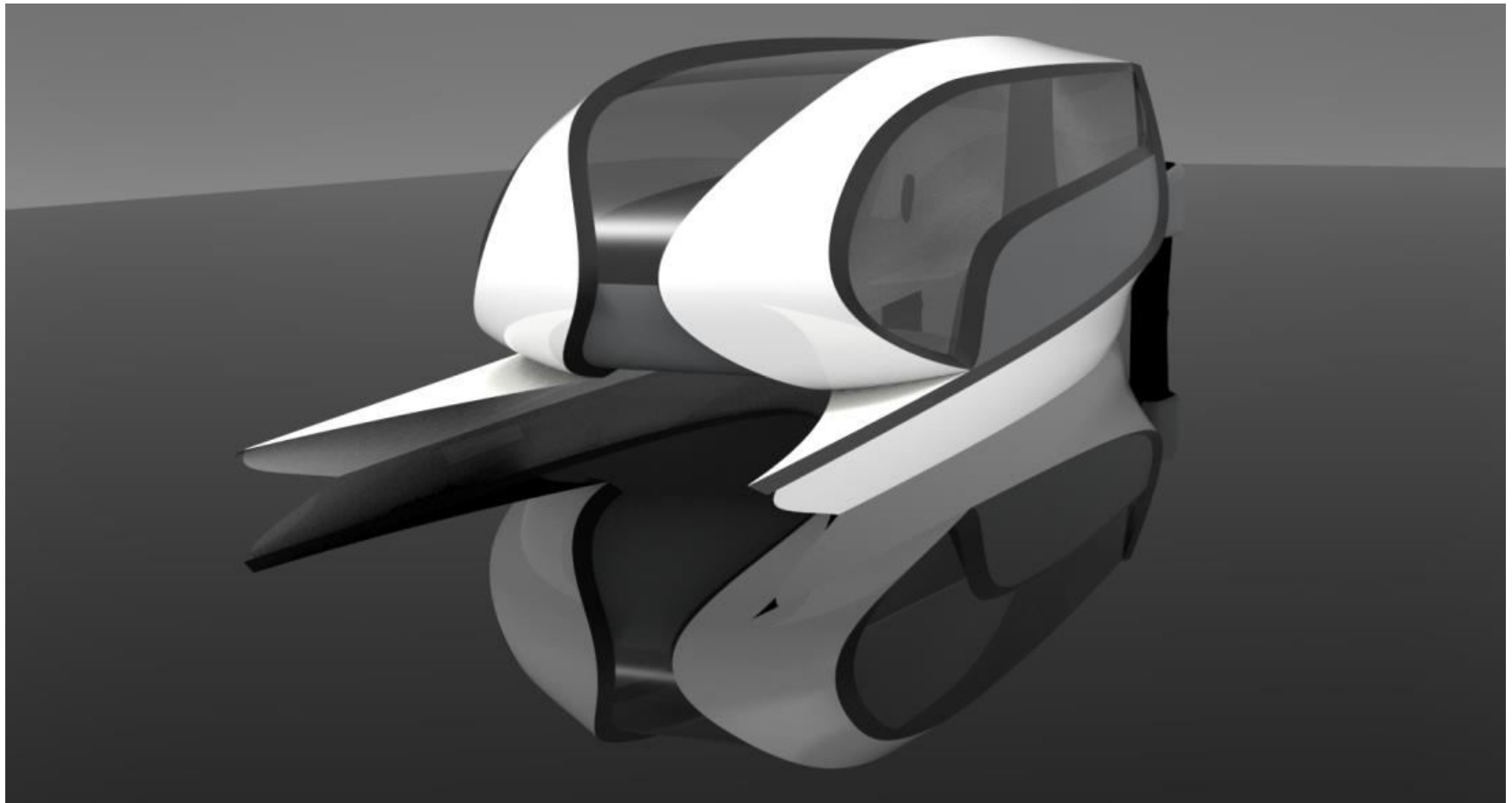
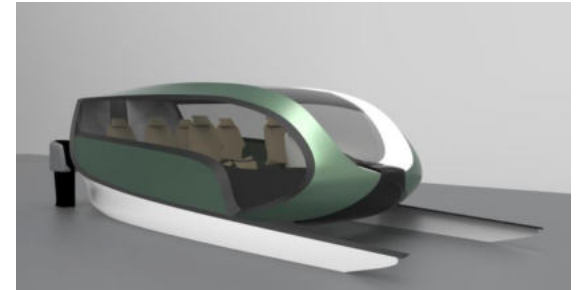
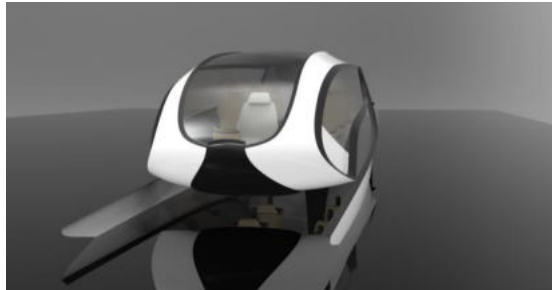
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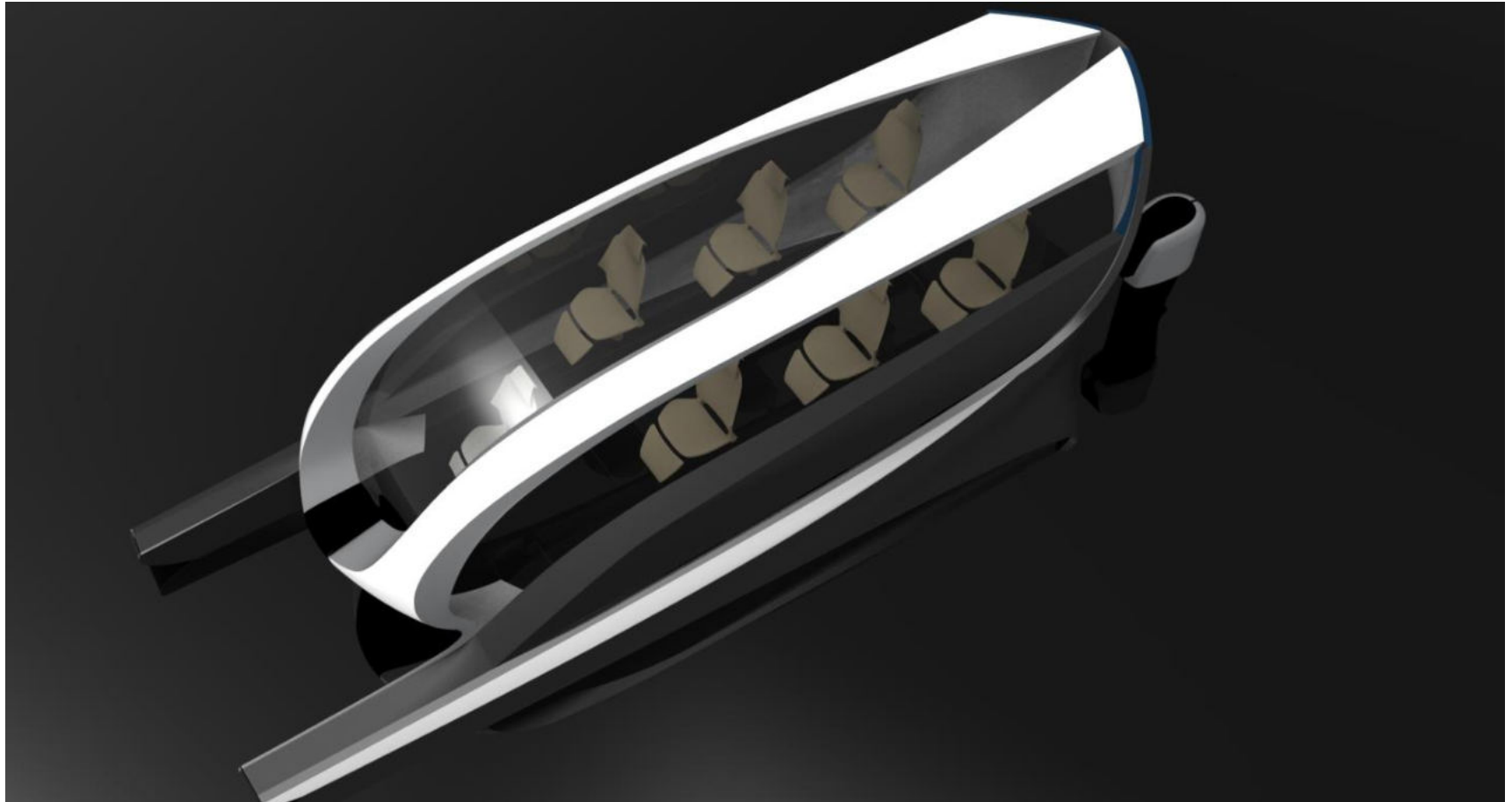
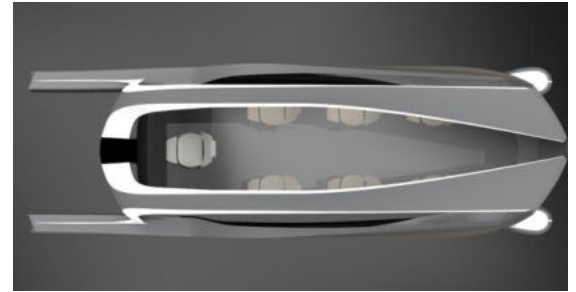
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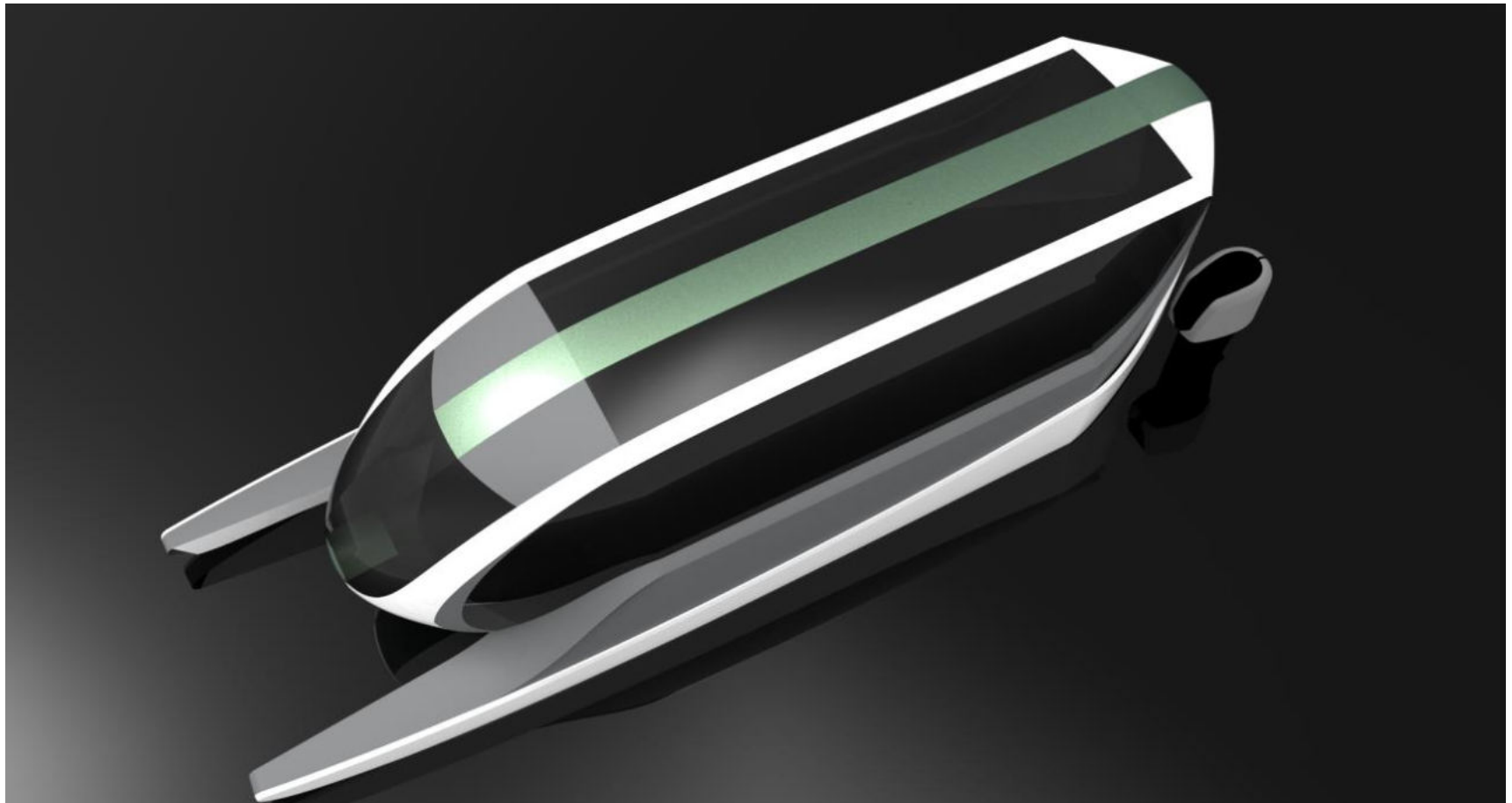
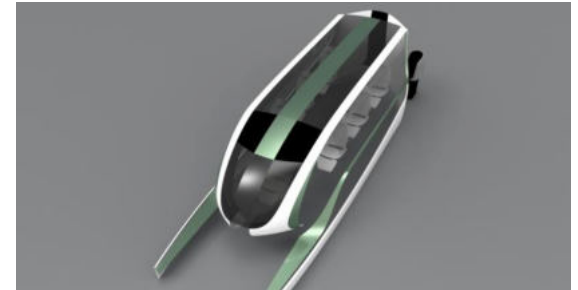
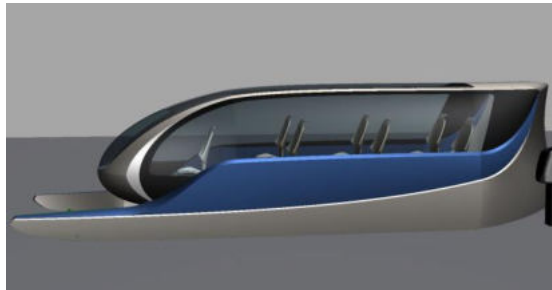
Design-5



Design-5



Design-6

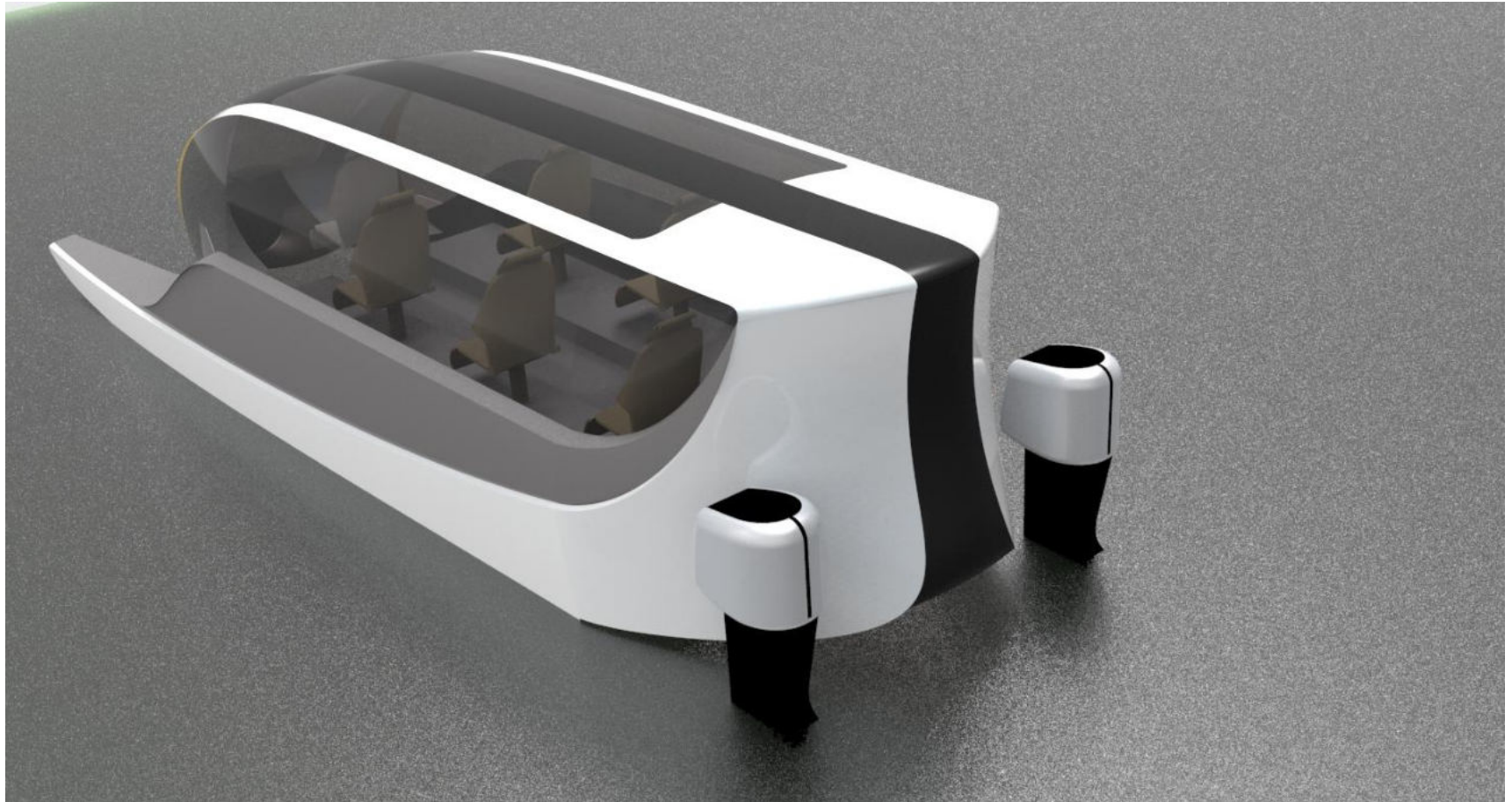


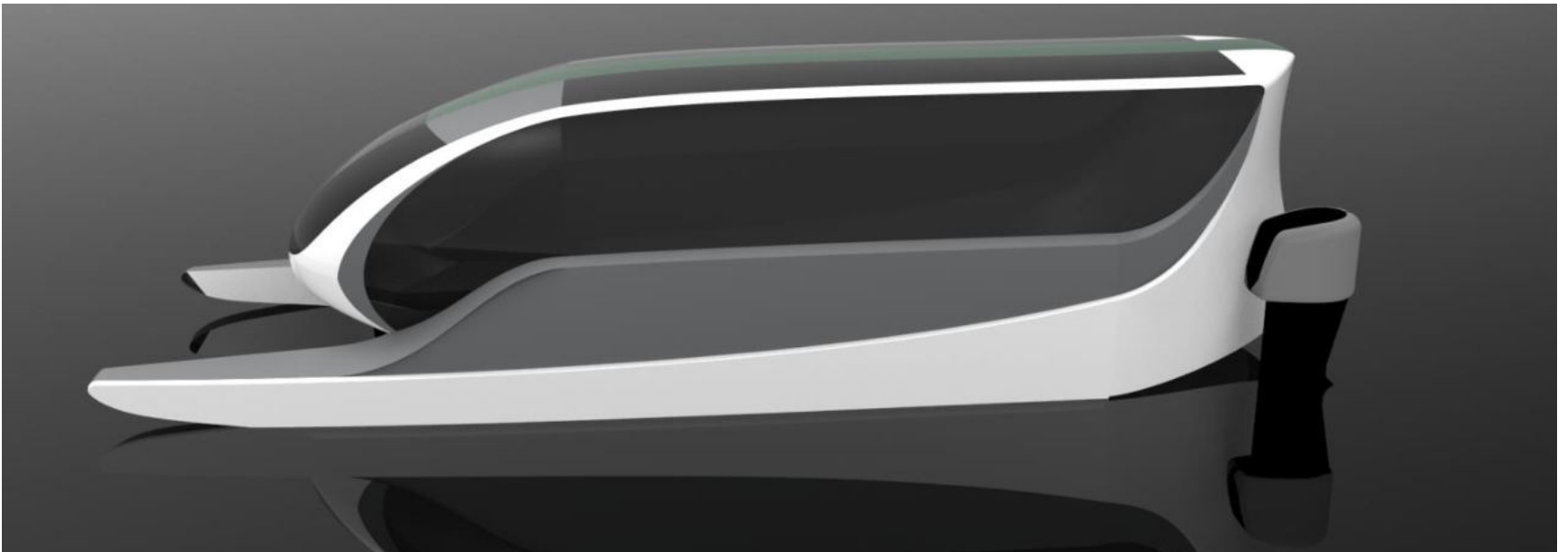
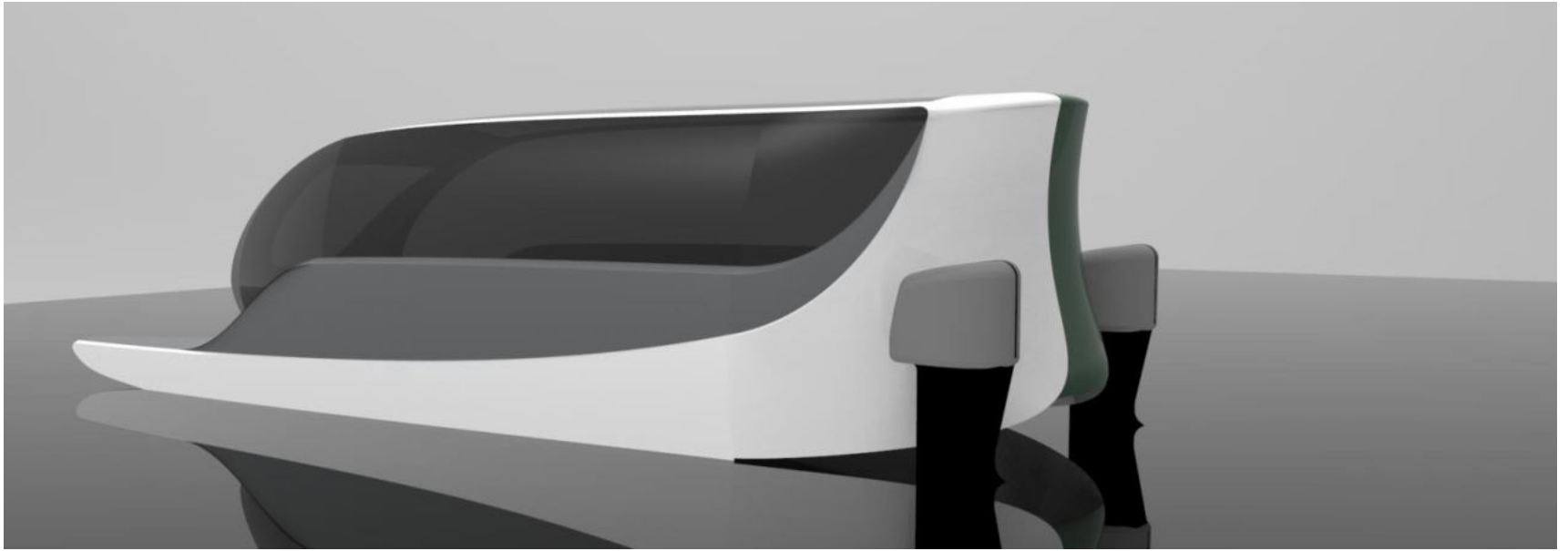
20 Final concept

Design-6

Exterior

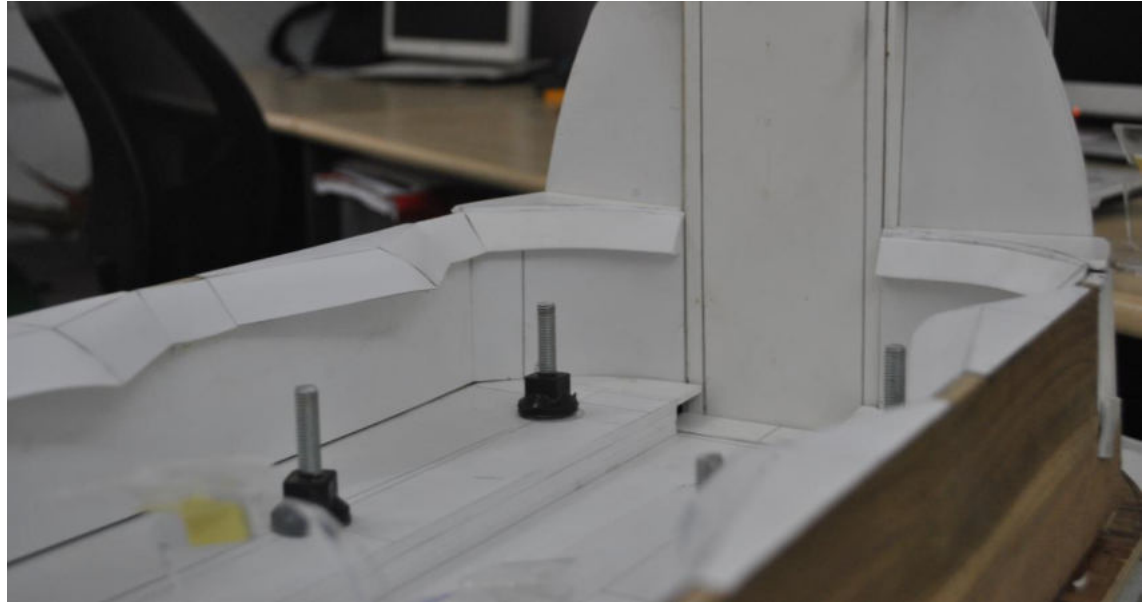
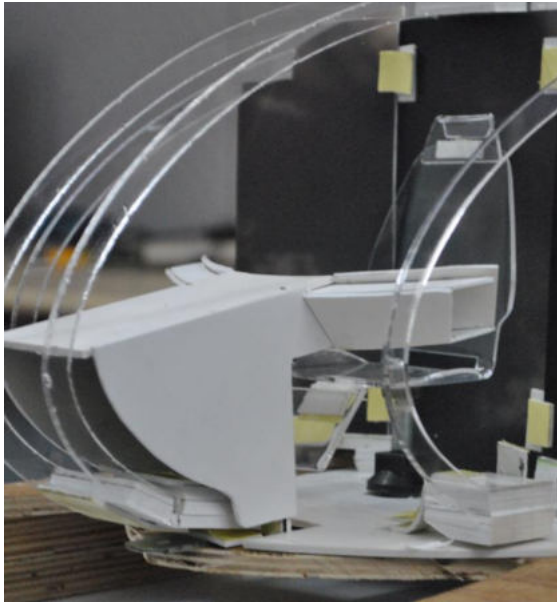
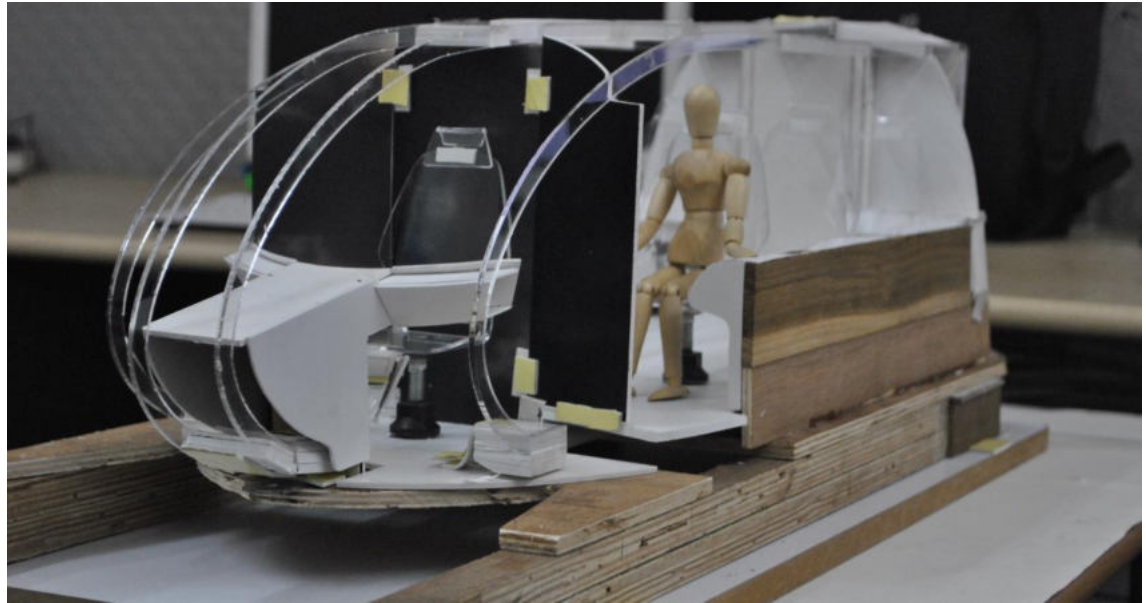
*Design 6 being the most evolved and refined,
is taken up as the final concept*





21 Scaled model

*Base of prototype is made from plywood.
Sun board and hard papers are used for
defining interior space and panels.
Laser cut acrylic provides reference to the
exterior volume.*

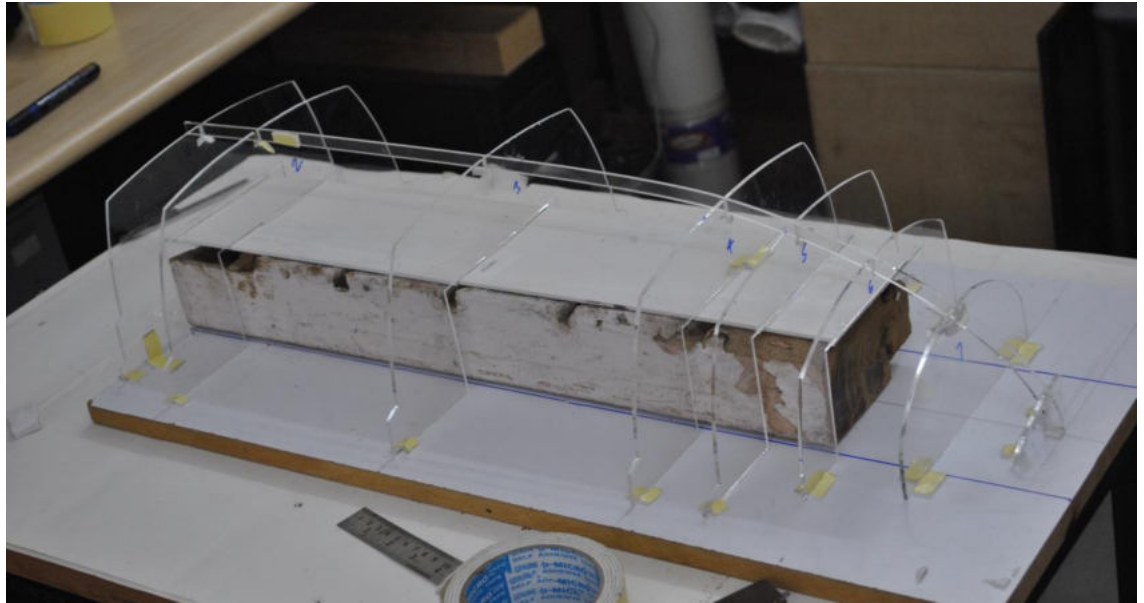


21 Scaled model

Top part of super structure is made with cross sectional reference from CAD model. Laser cut acrylic are used for model reference.

Industrial clay is used as skin and is finished to define surfaces.

POP mould for vacuum forming is made from this model.



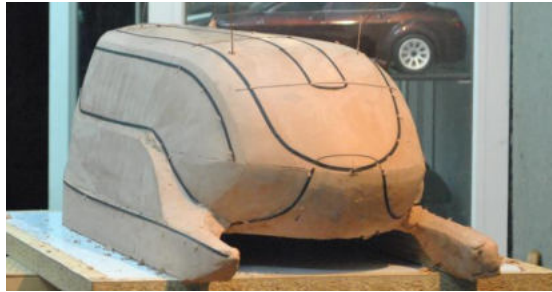
21 Scaled model

*Base is also covered with clay.
The top part is placed to this base for
corrections and refinement.*

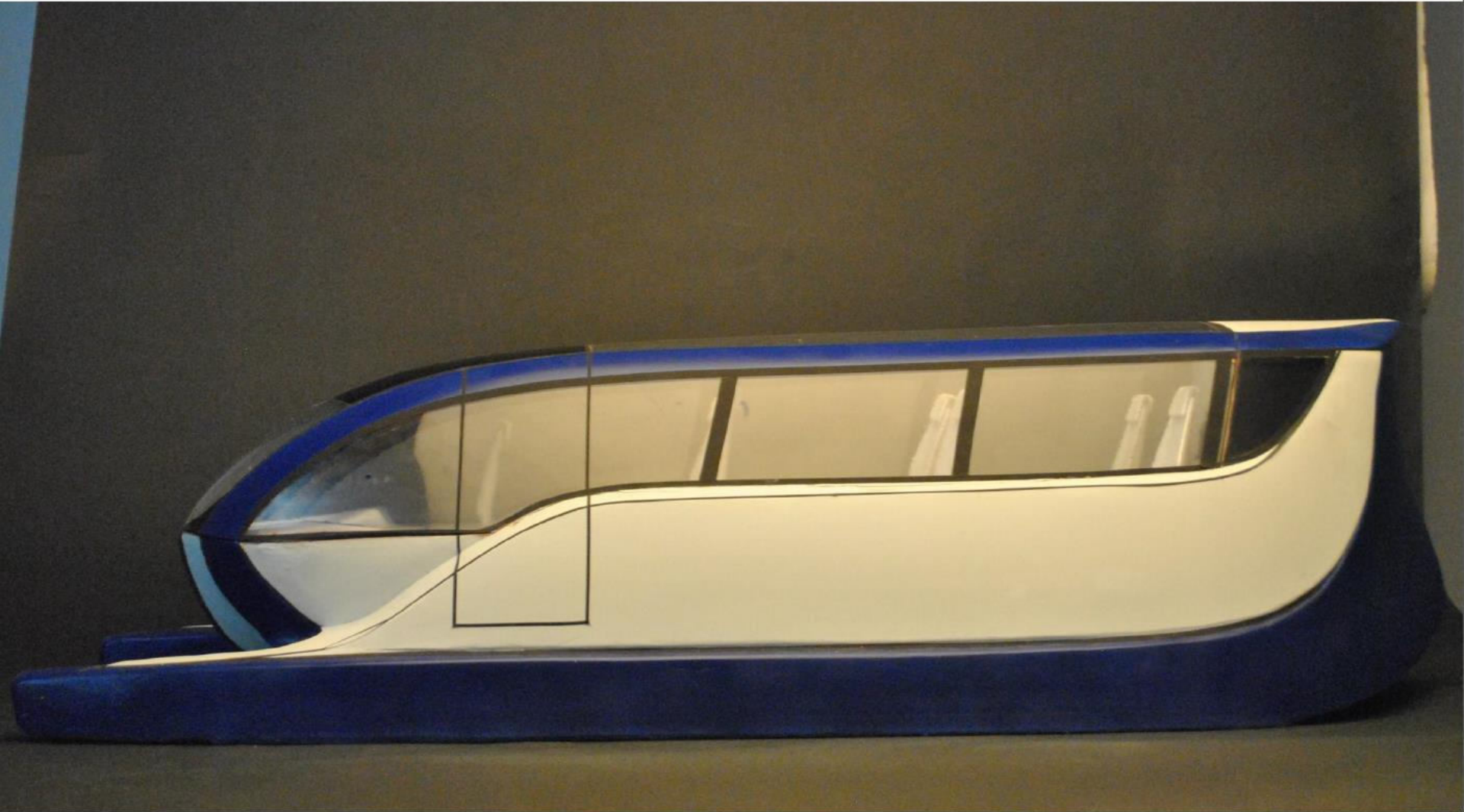


21 Scaled model

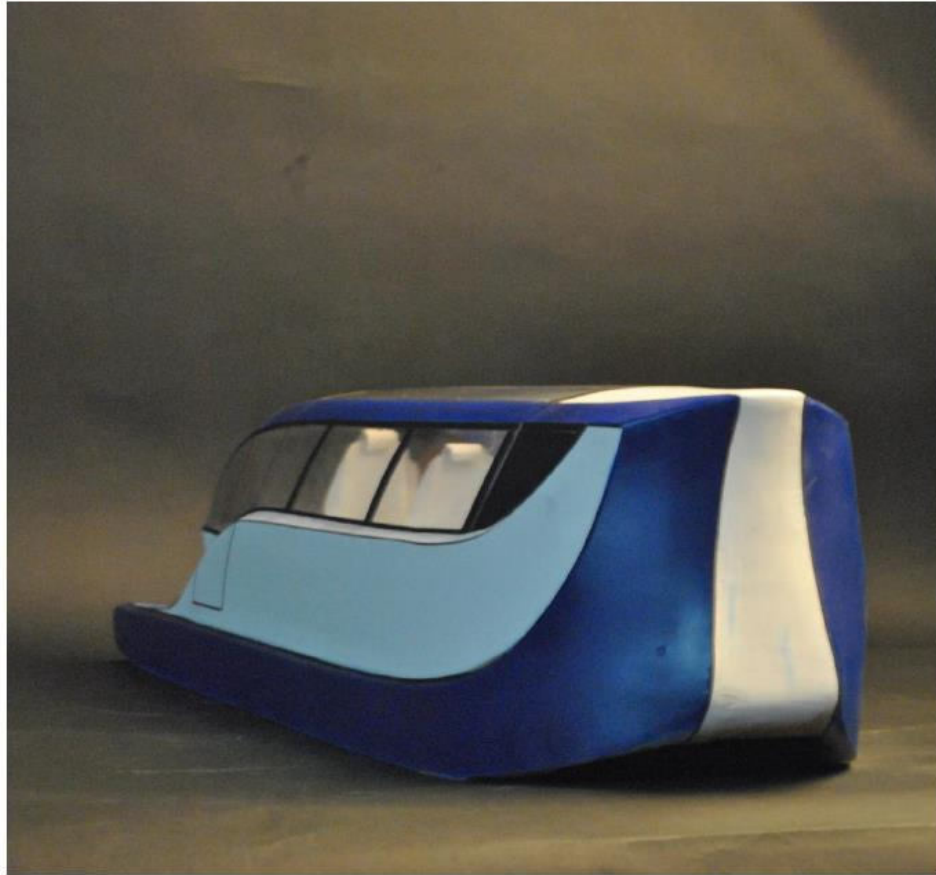
Clay model with roof and window lines.



21 Scaled model



21 Scaled model



22 Reference

Image references

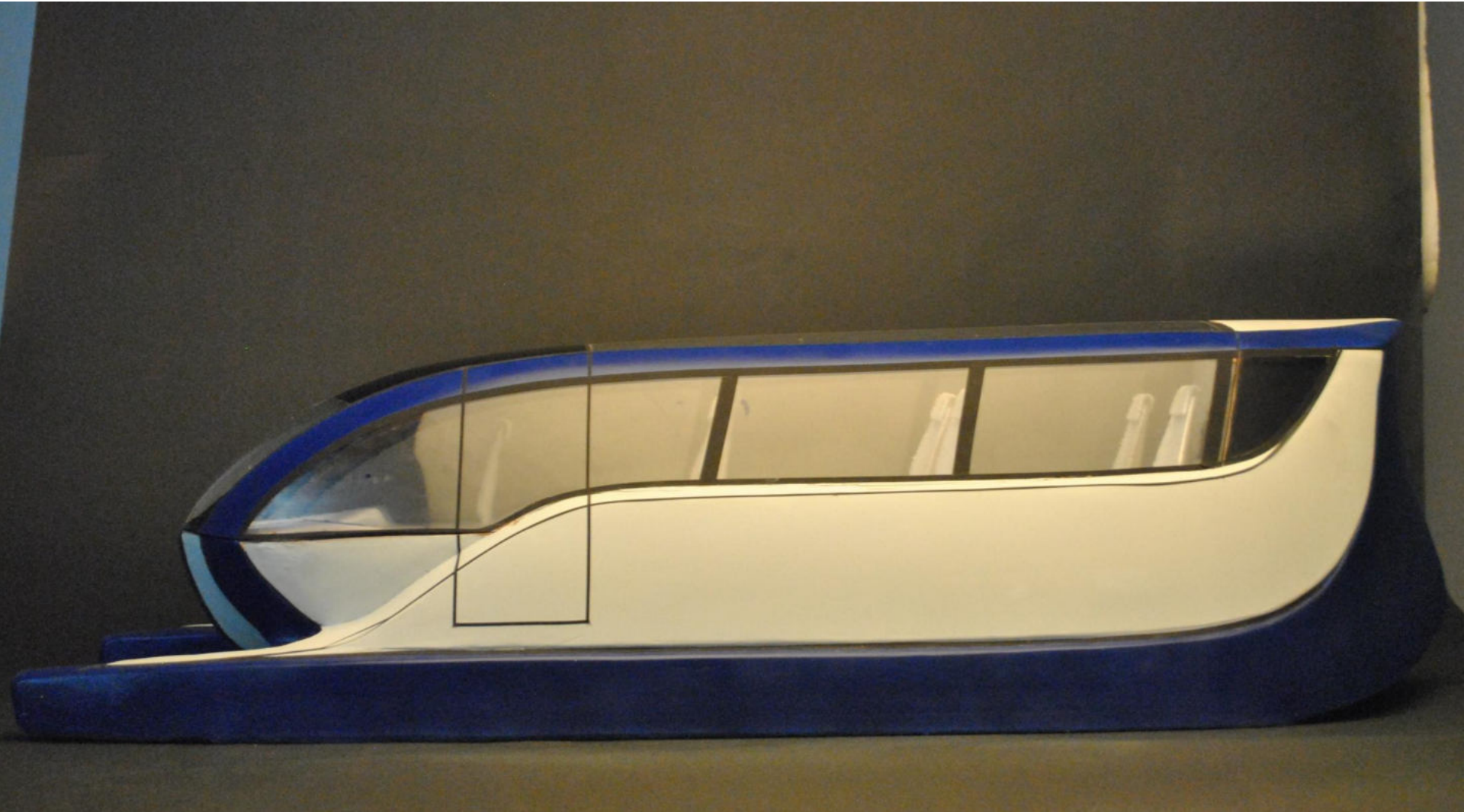
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- IR-2 <http://www.mapsofindia.com/maps/kerala/kerala-city-map.jpg>
- IR-3 <http://www.team-bhp.com/forum/attachments/vintage-cars-classics-india/997423d1349638231-images-traffic-scenes-IR-4>
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21 Scaled model



21 Scaled model

