Design Project 1

DESIGN of a CATAMARAN BASED SOLAR TOURIST BOAT for CENTRAL INSTITUTE of FISHERIES TECHNOLOGY (CIFT)

A multifunctional boat for aqua tourism by Samudra Shipyard Pvt. Ltd

Submitted by:

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Mobility and Vehicle Design

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DECLARATION

I declare that this written report represents my own idea in my own words, and where others' ideas or words have been included, I have mentioned the original source.
I also declare that I have adhered to all principles of academic honesty and integrity and have not falsified, misinterpreted or fabricated any idea, data, facts or source in my submission.
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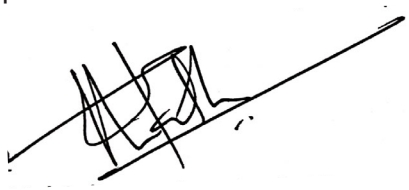

Niketh SJ
176390002
Mobility & Vehicle Design 2017-19

CERTIFICATE

Ref: SSPL/GN / 2018/187
Date: 05th July 2018

Samudra®

TO WHOMSOEVER IT MAY CONCERN

This is to certify that Mr. **Niketh.S.J** (176390002), student from Industrial Design centre (IIT Bombay) has completed his internship with us from 7th May 2018 to 22h June 2018 on design of **Solar Catamaran Boat for CIFT.**

For **Samudra Shipyard Pvt.Ltd.**

Dr.S.Jeevan
Chairman & Managing Director

the art & science of BOATBUILDING

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ACKNOWLEDGEMENT

I would like to sincerely thank Mr. Unni Mohan, designer at Samudra Shipyard Ltd. for his valuable guidance and creative input throughout the project.
I would also like to thank Dr. S Jeevan, CEO of Samudra Shipyard Ltd for giving me this opportunity to work for his firm and gain a better understanding about water transportation.

Thanks to all the employees at Samudra for their endless support and hospitality during the month I spent there.

CONTENTS

1. PROJECT BACKGROUND

1.1 Samudra Shipyard Pvt. Ltd

Located in Aroor on the banks of the Kollam-Kottappuram waterways, **Samudra Shipyard specializes on applying Fibreglass Reinforced Plastic (FRP) technologies to build a wide variety of boats** and related equipment for different purposes. Having an experience of more than three decades in this field, Samudra has also taken part in a number of collaborative projects with other organizations and the state government. This project was done as part of a summer internship held at Samudra

1.2 Central Institute of Fisheries Technology

The Central Institute of Fisheries Technology (CIFT) set up in 1957 is the only national center in the country where research in all disciplines relating to fishing and fish processing is undertaken. The institute started functioning at Cochin in 1957. **CIFT is the client for which this project has been developed.** (About us, *cift.res.in*)

FISH FARM TOURISM

CIFT has several fish farms where tourism has become a prime source of income. In these fish farms, certain varieties of fish are cultured and grown for fishing. The major farm is at Njarakkal, in Vyppin a part of Ernakulam district (Kerala).

In fish farm tourism, tourists are engaged in activities such as boating and fishing from shore and from boats. They are also taken on boat rides through the farm and dropped off at viewpoints or photopoints. These farms will also have adjoining outlets which sell fishing related equipments and fish products. A sumptuous meal with varities of fish dishes are also a major attraction of these spots.

1.3 Project conception

For the development of Aquatourism, **CIFT came up with a proposal to deploy Solar powered boats at the Njarakkal fish farm**. Solar power was chosen as part of a clean energy initiative and also, the electric motor produces considerably lower noise pollution. This noise reduction will provide an undisturbed environment for the fish to thrive in.

Samudra shipyard was consulted for development of the solar boat for this tourism venture. Team Sustain, an expert in solar energy technology, was appointed as the provider for the energy and propulsion technology required for the boat

2. RESEARCH

2.1 Preliminary research

As part of getting familiarised and sensitized towards inland water transport, a couple of days were spent in Alappuzha, travelling in several types of boats. A trip to the Njarakkal fish farm was also made to understand the context in which the design is to be delivered. These trips were highly beneficial as lot of observations were made and inferences were drawn which could help in the design process.

KERALA BACKWATER TOURISM

Due to the presence of an extensive network of backwaters spanning the Kollam, Alappuzha and Ernakulam districts of Kerala, healthy tourism acitivities thrive in these areas. Focussing mainly on leisure rides using different types of boats ranging from small Shikhara boats to 40m house boats, the backwaters provide serene and calm waters for relaxation and enjoyment. Since the tidal variation is less, the jetty and boats are manufactured for lower water levels.

These waterways are not only used for leisure but also as transportation routes for goods and cargo. Government run ferries and boats are also prevalant here which are used for public transport.

SHIKHARA BOAT RIDE

The Shikara is a concept borrowed from the famous day-cruising boats used in Dal Lake, Kashmir. **These are typically small boats which can seat up to 10 people**. The superstructure is open from sides to allow maximum visibility around while the roof provides shade and basic rain protection. **The driver sits up front which gives him good command of manoeuvring. The passengers have plush chairs, divans and cushions lined along the sides of the hull for seating**. The superstructure uses a combination of materials for construction. GI pipes and bamboo are used for framework, along with wooden pillars and covered with woven bamboo sheets. Coir, a traditional rope made using coconut fibres, is used to tie the structure together as well as wrapping some rods or beams. **The open structure and the sedate pace make the Shikara a relaxing day cruiser**. (Ashwin R Krishnan, *Design of single bedroom houseboat for Samudra*)

KOPRA VALLAM by SAMUDRA

The Kopra vallam is a day cruiser designed and introduced by Samudra. It is inspired from traditional kerala boat designs and uses materials such as coir, cane and bamboo to give an ethnic feel.

It can comfortably seat 10 passengers and the driver occupies a cabin above the deck level. This boat also features a toilet and pantry space which was missing in the Shikara boats.

Unlike the shikara, the chairs are not fixed, therefore it allows for multiple seating layouts as per requirement of the passengers.

KERALA STATE WATER TRANSPORT DEPARTMENT BOAT

Aleppey has fragmented sets of small islands which are connected via backwater channels. Instead of connecting these islands via bridges, the Kerala government has arranged for public transport boats under the Kerala State Water Transport Department. These boats ply on fixed routes at fixed time intervals and are capable of carrying from 50 to 100 passengers. This service is very widely used and almost all the trips are house-full.

Earlier these boats used to be made of wood, but now they have moved to iron hulls and frp hulls. The cabin is made either in frp or in wood. It features a diesel engine mounted at the rear or at the centre (depending on boat size). The driver sits at the front or top and has clear view of the waterways.

ADITYA - Solar Ferry

Aditya is India's first solar ferry. It was launched in 2017 and ferries people between Vaikom and Thavanakkadavu in Aleppey, Kerala. **This is India's largest solar powered boat,** and was designed and built by NavAlt - a joint venture between Navgati (Kochi), Alternative Energies (France) and EVE systems (France).

The 20-metre-long and 7-metre-wide boat is covered by 140 square metres (1,500 sq ft) of solar panels rated at 20 kW, which in turn connect to two electric motors of 20 kW, one in each hull. There are 700 kg of lithium-ion batteries in the ship's two hulls with a total capacity of 50 kWh. The catamaran hull and its shape allow it to reach speeds of up to 7.5 knots. The normal operating speed is 5.5 knots (10 km/h) to achieve a 15-minute travel time for a a distance of 2.5 km on water.

It takes 2 trips transporting around 1650 people daily. (Aditya,*wikipedia.org*)

2.2 Primary research

NJARAKKAL FISH FARM

The major fish farm of CIFT is at Njarakkal, in Vyppin a part of Ernakulam district (Kerala).

Njarakkal Farm is located in the heart of Vypin Island and located at Arattuvazhi beach adjacent to Krishi Vigyan Kendra of Central Marine Fisheries Research Institute. This brackish water fish farm is famous for culture of grey mullets (Mugil cephalus). The farm has a 44 acre water body with 3 blocks of fish culture ponds. Pearl spots (Karimeen) are common in this farm which is declared as the State Fish of Kerala. **Tourists are allowed to catch pearl spots by angling. Hooks and line with bait are provided to tourists for angling. Several gazebo like structures have been erected in the water where the tourists are dropped off in boats. They spend some time there either fishing or clicking pictures and are taken back to land**.

The ticket fare of aquatourism is Rs.200/-per head and Rs.100/-per children up to 12 years, which include entry fee, welcome drink, pedal boating, row boating, lunch,etc. The food supply to tourists is managed by the seafood restaurant run by a women self help group selected under Tsunami Emergency Assistance Project of Department of Fisheries, Govt.of Kerala.

Tourists can take rest in hammocks under shade of coconut leaves and can use huts and benches constructed on bunds of fish ponds. Tourists can enjoy sunset at Aarattuvazhi beach which is just a walkable distance of 200 meters away. (Aqua tourism at Njarakkal, *aquatourism.matsyafed.in*)

TOURIST BOATS at NJARAKKAL

The major purpose of boats at Njarakkal fish farm is to carry tourists from the starting point to the gazebo spaces, and then take a trip around the farm and reach back. For this purpose, presently, multiple types of boats are being used.

1. Fibreglass rowboats fitted with outboard diesel engine
2. Canoe
3. Watercycle

Pros

- Smaller capacity - capable of carrying single family rather than having huge number on board, hence better quality time spent as a family

Cons

- No rain protection
- Petrol and diesel engines cause water pollution and sound pollution
- Not specifically designed for fishing purpose

Fibreglass row boats which have been retrofitted with an outboard diesel engine is what is being used mainly here. This provides seating for 5 people and a driver. This single hull boat features a bench seating layout.

The watercycle was launched in Njarakkal as an active boating method to encourage tourism. This was developed and introduced by Samudra Shipyard.

Fibreglass surf module with 1 person and 2person capacities are used here. They are human powered.

Navgati SOLAR FISHING BOAT at CIFT

CIFT had earlier sourced one solar fishing boat from Navgati. This is capable of carrying 4 fishermen and was exclusively used for fishing purposes. The boat has a catamaran style fibre hull with solar panels mounted on the roof.

The boat can be used in reservoirs, small rivers, and aquaculture ponds. This boat also can be used for recreational fishing activities.

The boat is capable of running for 2.5 to 3.0 hours after complete charging and attains a speed of nearly 4.0 knots in calm water. Considering the 240 days of fishing in a year the fuel saved compared to an equivalent diesel powered boat is Rs. 48,000.

Pros

- Cleaner energy used - no noise or water pollution
- Panels act as roofing, hence does 2 jobs
- Small and cozy for travel as a family

Cons

- Low headspace, hence people cant stand comfortably while fishing
- Vertical supports of roof cause a barrier and fishermen cannot freely throw nets
- Low on storage space for nets and fish

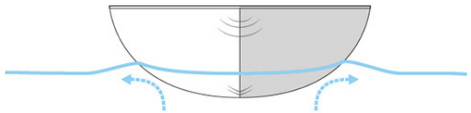
HULL SYSTEM

Types based on function

a) Displacement hulls

Boats with displacement hulls move through the water by pushing the water aside and are designed to cut through the water with very little propulsion.

If you lower a boat into the water, some of the water moves out of the way to adjust for the boat. If you could weigh that displaced water, you would find it equals the weight of the boat. That weight is the boat's displacement. Boats with displacement hulls are limited to slower speeds. A round-bottomed hull shape acts as a displacement hull. Most large cruisers and most sailboats have displacement hulls, allowing them to travel more smoothly through the water.

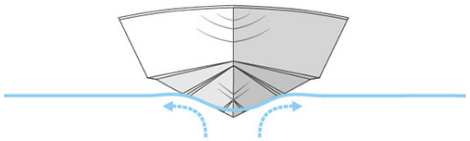


DISPLACEMENT HULL

b) Planing hulls

Boats with planing hulls are designed to rise up and glide on top of the water when enough power is supplied. These boats may operate like displacement hulls when at rest or at slow speeds but climb towards the surface of the water as they move faster. Boats with planing hulls can skim along at high speed, riding almost on top of the water rather than pushing it aside.

Flat-bottomed and vee-bottomed hull shapes act as planing hulls. Most small power-driven vessels, including personal watercraft (PWCs), and some small sailboats have planing hulls, allowing them to travel more rapidly across the water. (Hull types and how they operate, *boat-ed.com*)



PLANING HULL

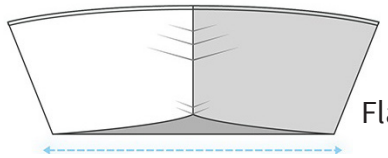
HULL SYSTEM

Types based on shape

a) Flat bottom hulls

Pros - This planing hull has a shallow draft, which is good for fishing in smalllakes and rivers.

Cons - Rides roughly in choppy waters.

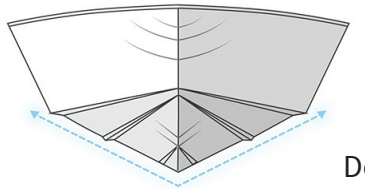


Flat bottom hull

b) Deep V-hulls

Pros - This planing hull gives a smoother ride than a flat bottom hull in rough water.

Cons - Takes more power to move at the same speed as flat bottom hulls. May roll or bank in sharp turns.

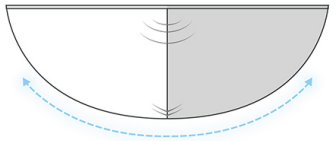


Deep V-hull

c) Round bottom hulls

Pros - This typical displacement hull moves easily through the water even at slow speeds.

Cons - Has a tendency to roll unless it has a deep keel or stabilizers.



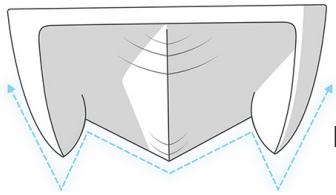
Round bottom hull

d) Multi-hull or Multi-chine hull(Catamarans, trimarans, etc)

Pros - Another example of a displacement hull, the multi-hull has greater stability because of its wide beam.

Cons - Needs a large area when turning.

(Hull types and how they operate, *boat-ed.com*)



Multi hull

PROPULSION SYSTEM

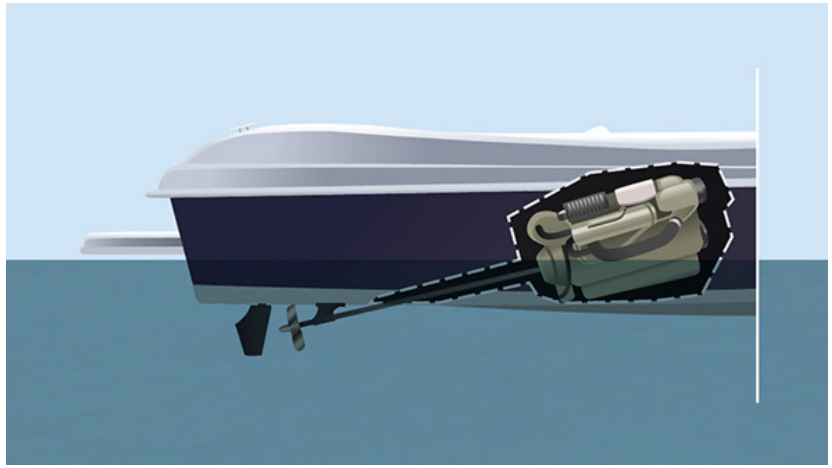
Types based on drive

a) Inboard motor

The term drive is interchangeable with motor and engine, so **an inboard drive is simply a marine engine enclosed inside the boat**. With an inboard drive, the shaft, rudder, and props are beneath the boat, leaving the transom clear.

Inboard drives can be powered either by gasoline or diesel fuel, and single or twin engines are available. A marine V-drive engine is a modified conventional inboard drive that is placed closer to the stern of the boat than a conventional inboard drive. Inboard motors can range from 1-cylinder to 12-cylinder models, but because many are derived from automobile engines, 4-cyclinder or 6-cylinder engines are most common.

Some inboard motors are air-cooled, while others use a water-cooling system -either with a fresh-water radiator similar to that in an automobile, or a water pump system that brings in lake or sea water to cool the engine.



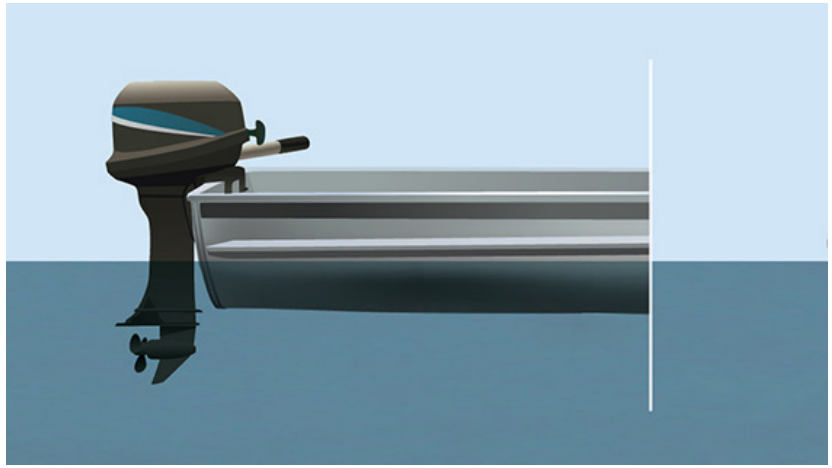
b) Outboard motor

Outboard motors are self-contained engine units mounted to the rear wall (transom) of the boat. Each unit has an engine, propeller, and steering control. In most units, cables attached to the steering wheel actually pivot the entire motor unit to provide steering. **To make it easier to move the boat in and out of the water, the entire motor unit can be pivoted up and out of the water.**

2-cylinder and 3-cylinder models are most common, but very large outboard motors are also available, including V-6 and V-8 engines that rival the power available in inboard drive systems. Most motor types drive a rotating propeller, but some are jet-propulsion systems that move the craft by shooting water through the system.

Outboard motors are the most common type of boat propulsion, found on most freshwater fishing boats and many pleasure craft.

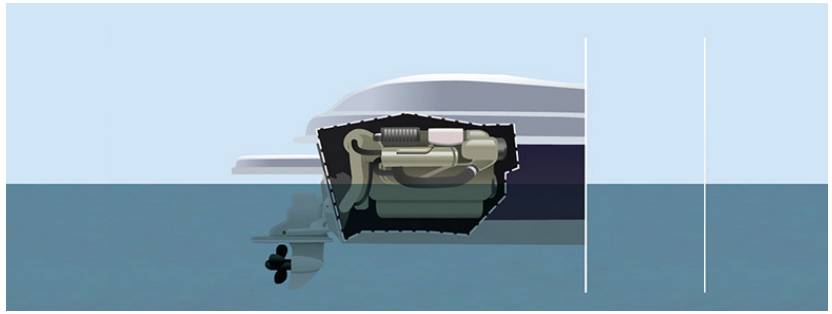
(Boat engine systems, *thoughtco.com*)



c) Stern-drive motors

Otherwise known as the inboard/outboard marine motor, stern drives are thought by some to be the best of both worlds. **The engine is mounted inboard forward of the transom with a shaft that goes through the transom to the drive unit located outside the boat below the water.**

Similar to the outboard lower unit, this portion of the engine has a propeller and acts as a rudder to steer the boat. Like an outboard, the lower drive unit on a stern-drive can be pivoted up to facilitate moving the boat in and out of the water.

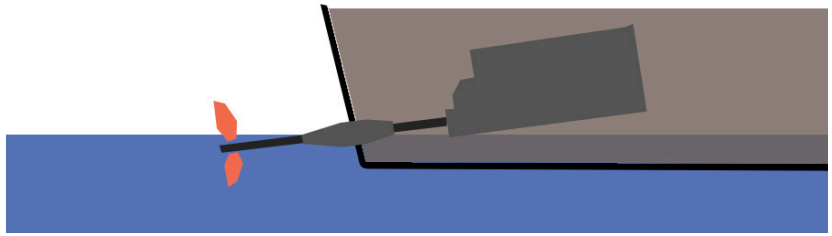


d) Surface drive motor

Surface drives are specialized drives, mostly used by high-performance boats, with an inboard engine that drives a propeller that "pierces" the surface of the water to provide increased thrust.

They operate 'half in and half out' of the water in the planing wake of the boat, with a propeller shaft that exits almost horizontally through the transom.

These drives are used where high speed is goal. Racing boats, such as the familar cigarette boats, use surface drive systems.

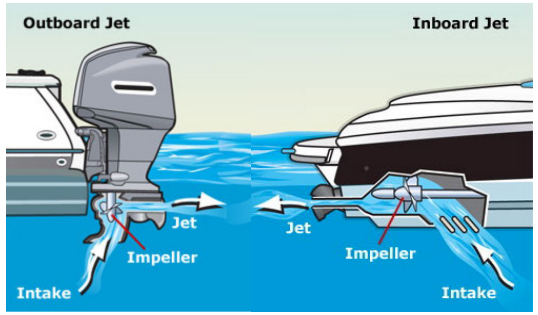


e) Jet drive motors

Most often used in personal watercraft or very large boats, **jet drives replace propellers to push a boat through the water using high- pressure air forced out of the stern of a vessel.** The water jet draws water from beneath the hull and passes it through impellers and out a moveable nozzle that steers the boat.

In smaller boats, jet drives have the advantage of very fast acceleration, but are quite loud and not very efficient when it comes to fuel economy.

(Boat engine systems, *thoughtco.com*)



PROPULSION SYSTEM

Types based on energy source

a) Diesel engine

Both 2-stroke as well as 4-stroke diesel engines are used in the marine industry. The engines used for the main propulsion or turning the propeller/s of the normal ships are usually slow speed 2-stroke engines while those used for providing auxiliary power are usually 4-stroke high speed diesel engines.

Usually diesel engines are provided as inboard motors for boats. This is due to the larger size and cooling system required for such motors (normally water cooled).

Diesel engines are preferred on larger boats which require more power but less speed, and capable of carrying more load. Hence, it is preferred in houseboats and public transport boats.

These **produce heavy noise pollution and vibration**, therefore placement of such engines are a key factor to the travelling comfort of the boat.

(Diesel marine engines, *brighthubengineering.com*)

Yanmar inboard diesel engine with sound damping cabin

b) Petrol engine

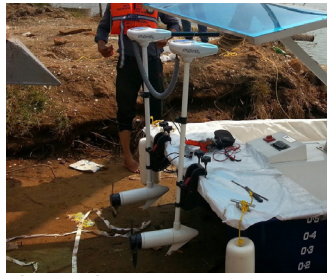
Marine petrol engines are mainly used in speed boats. They are much compact than their diesel counterparts, and more expensive both in capital cost and running cost. They also produce harmful carbon monoxide which maybe dissipated by ventilation if the boat is running. It is because if this, **normally petrol engines are outboard or stern drive engines**. **They produce higher power and help achieve higher speeds also.** They're used in smaller boats and produce lesser noise pollution.

Yamaha outboard petrol engine on fishing boat

c) Electric motor

Electric motors are an upcoming trend in the boat industry. They produce l**esser noise pollution and also doesnt pollute water nor air** while running. But the initial cost is on the higher side due to additional requirements like batteries and solar panels. The **power output of electric motors are very less compared to diesel and petrol engines**. They offer low speeds and are less effective in choppy waters. The range of these motors will depend on the battery capacity.

They are mainly placed as outboard motors for better heat dissipation



Flover Electric motor on CIFT boat

Typical outboard Electric motor

2.3 User research

During the visit to Njarakkal Fish farm, few tourists, fishermen and boat drivers were interviewed to know about what the user expectations were about such a boating facility. Several observations were also made about the working system of the farm and how the tourists behave and interact there. **The tourist demography include all age groups - families touring with infants, school & college kids, elderly, etc.**

Tourist preferences:

- Small groups are better for spending quality time
- Boat should look safe for them to feel safe
- Comfortable seating and maximum openness to give better view angles of the area
- Engine noise seemed to be a bother for lot of tourists - would prefer less noise
- Roof could be included so that sun is not a problem
- Fishing from the boat was seen as an interesting idea

Families prefer boarding in small boats with seats enough for 4-5 people. This improves interaction and helps them quality time with each other. They not only engage in conversations with each other, but the driver is also involved in this. The boat driver is wearing a hat, whereas the tourists dont have any protection from the sun

Boat drivers:

Emerson, 48
Boat driver

- Prefers petrol engines as they are more silent and vibration free
- Says families enjoy the whole experience and often come more than once

Gireesh, 35
Boat driver

- Says many people actually want to experience driving the boat more than fishing
- Wants a boat with a shade from the sun

Vineesh, 38
Boat driver

- Claims that existing boats are not very safe for recreational activities like fishing

Fishermen:

Sabu, 37
Fisherman

- Fishing presently happens on the banks only, and that too pole fishing. If net fishing is to be promoted, then the boat should have more area

Jishnu, 20
Fisherman

- We need something more modern and specifically designed for handling cast-net fishing
- We need more space to keep our equipment and also safely entertain tourists

Dillu, 22
Fisherman

- The fish flee due to the noise produced by the engines, it was easier to do fishing in row boats. We need some engine which is more silent, like electric motors

3. PROJECT REQUIREMENTS

The objective was to design and manufacture a solar tourist boat which was capable of **carrying 4 passengers (including driver)**. This boat should also be **capable of being used for fishing activities** in the fish farm. The price quoted for the boat was only **15lakhs**, hence the major constraint for this project would be delivering the boat under such a tight budget.

Several factors were taken into consideration while developing the final project brief - **What type of hull which will be used? How powerful should the electric motor be? How much should the range be and how many batteries should be accomodated? How many solar panels would be needed and how much power they can generate? How can the fishing activity space and tourist space co-exist within limited space? etc.** were the basic questions which needed answers.

Since CIFT was the client, it had to be something which is designed better than the last solar boat they had acquired from Navgati. For this project, **Samudra consulted Team Sustain - a startup dealing with clean energy solutions, to supply the necessary panels and motor** within the required budget based on the load and speed requirements of the boat. After few consultation sessions and trials of electric motor and battery packs, the final numbers were arrived at.

4. PROJECT BRIEF

Design for a Solar powered tourist boat capable of carrying 4 passengers including driver, which could also be used for fishing purposes in CIFT fish farms.

Propulsion system

ELCO EP-20 Outboard electric motor with comparable gas/petrol rating of 20Hp with push throttle and a cable driven steering system

Input Power	- 7920 Watts
Voltage	- 48 Volts
Maximum current	- 165 Amp DC
Motor type	- Brushless PMAC
Weight	- 65 pounds (29.5Kgs)

Solar panel

SunPower SPR - P18 - 385 - COM panels 2m x 1m (4nos.)

Nominal power	- 385W
Rated voltage	- 43V
Rated current	- 9.03A
Maximum system voltage	- 1500V

Battery system

Trojan T105RE Lead Acid battery

Voltage	- 6V
Connection	- 8 batteries in series to get 48V
Nominal capacity	- 222 Ah for 20hours

Hull system

Catamaran hull based on pre-existing mould

Length	- 8m
Breadth of Demi-hull	- 88cm
Breadth extreme	- 2.4m
Depth	- 75cm
Draught	- 30cm

5. LAYOUT AND PACKAGING

LAYOUT 1

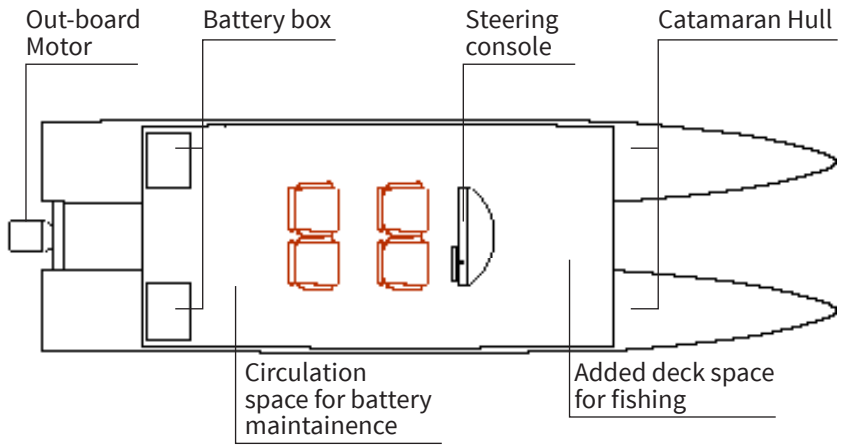
- Features side by side seating in 2 rows
- Seats and driver console concentrated on the centre of the deck and surrounding space freed up for circulation space and fishing
- Deck space has been increased in the front to give a larger space for fishing activity
- Battery boxes split in two - housing 4 batteries each and placed nearer to the motor to reduce power loss
- Solar panels arranged transversely to the longer side of the boat

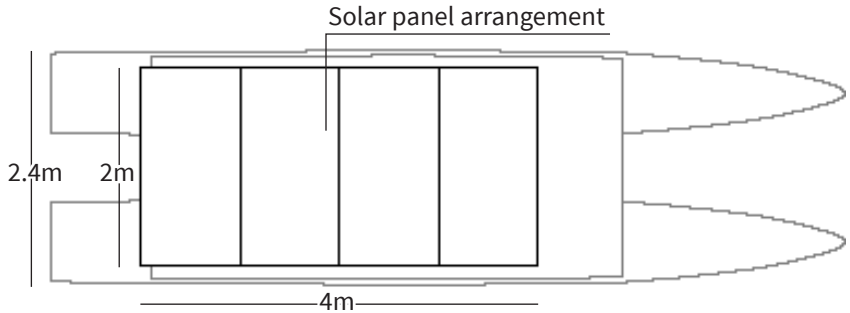
Pros

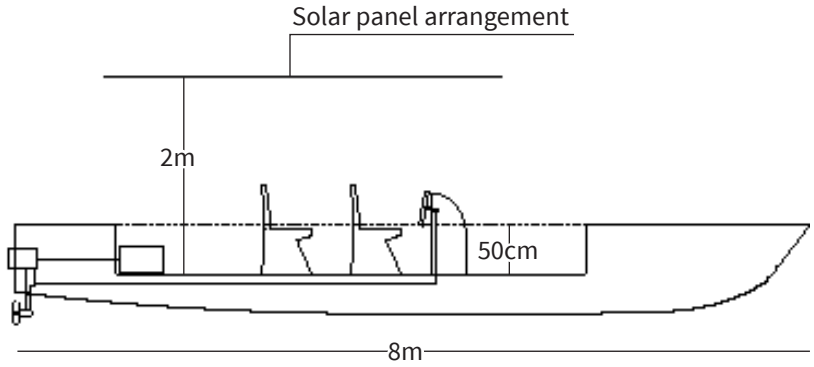
- Ample space for fishing activity
- Close proximity of passengers for interaction

Cons

- Longer length of drive cable - may cause functional issues
- Since seating of driver is away from edge of boat, its harder for him to judge position while docking







LAYOUT 2

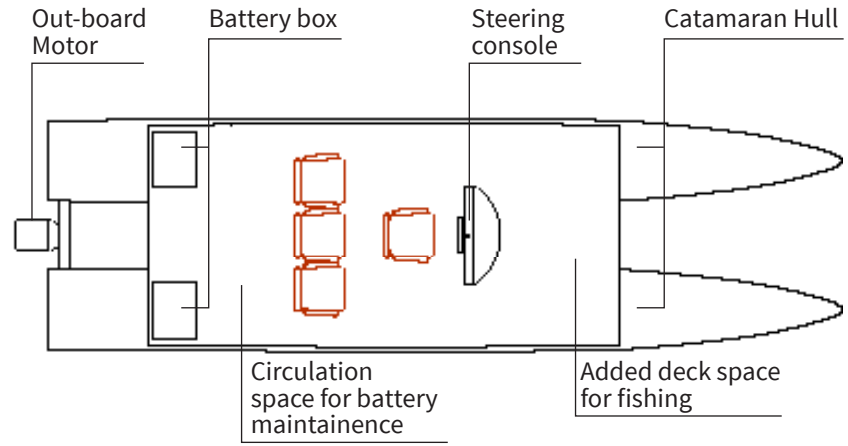
- Features tourist seating in single row with driver further ahead
- Seats and driver console concentrated on the centre of the deck and surrounding space freed up for circulation space and fishing
- Deck space has been increased in the front to give a larger space for fishing activity
- Battery boxes split in two - housing 4 batteries each and placed nearer to the motor to reduce power loss
- Solar panels arranged longitudinally in pairs to the longer side of the boat

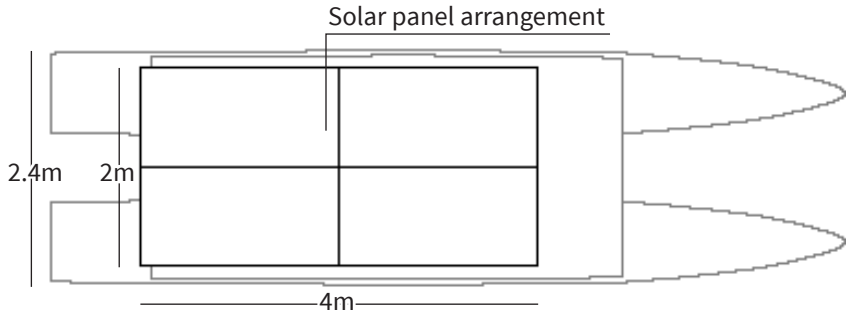
Pros

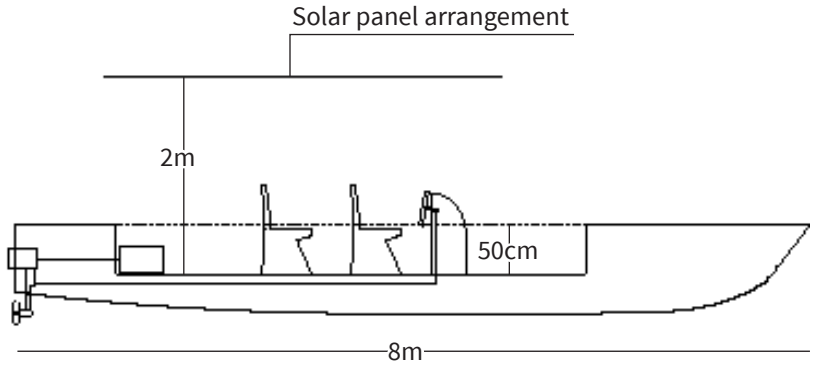
- Ample space for fishing activity
- Close proximity of passengers for interaction

Cons

- Longer length of drive cable - may cause functional issues
- Since seating of driver is away from edge of boat, its harder for him to judge position while docking







LAYOUT 3

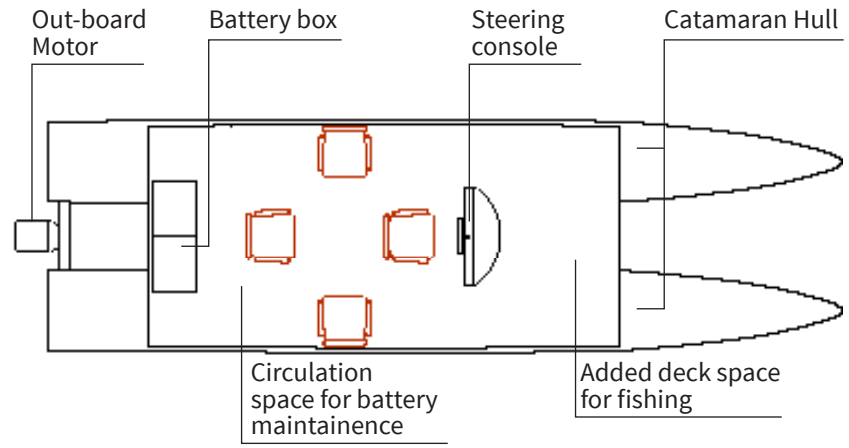
- Features split seating with driver further ahead
- Seats distributed on the sides and driver console in the centre of the deck
- Deck space has been increased in the front to give a larger space for fishing activity
- Single battery box housing 8 batteries in series and placed nearer to the motor to reduce power loss
- Solar panels arranged transversely to the longer side of the boat

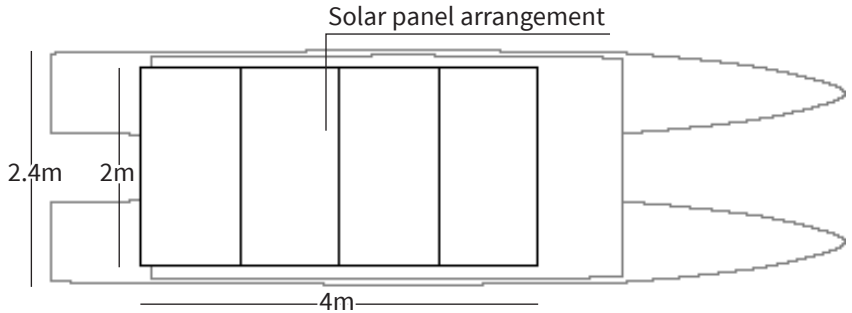
Pros

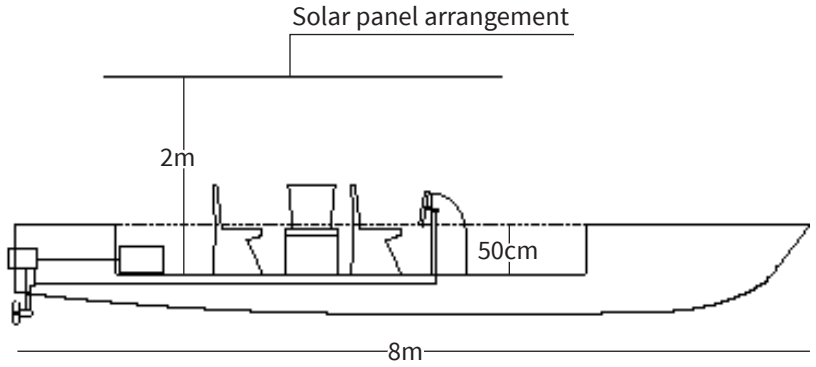
- Battery box unit more compact freeing up more space
- Passengers face each other for better interaction

Cons

- Longer length of drive cable - may cause functional issues
- Since seating of driver is away from edge of boat, its harder for him to judge position while docking







LAYOUT 4

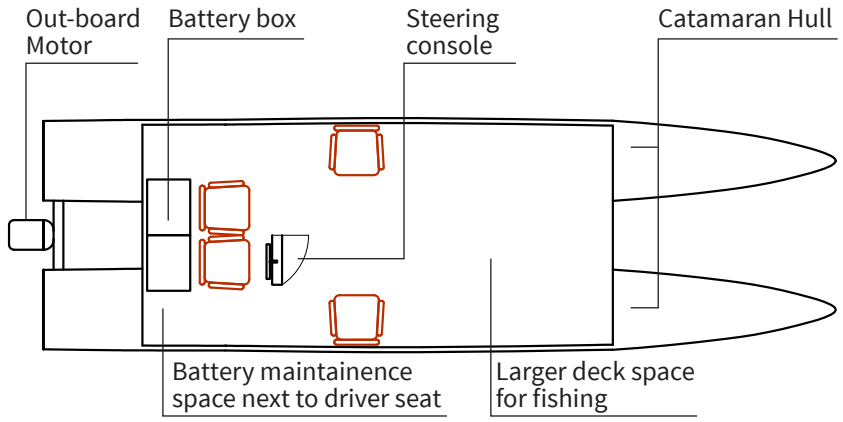
- Features split seating with driver seat nearer to the rear of the boat
- Seats distributed on the sides and driver console moved to the rear
- Deck space further increased in the front to give a larger space for fishing activity
- Single battery box housing 8 batteries in series and placed nearer to the motor to reduce power loss
- Solar panels arranged transversely to the longer side of the boat

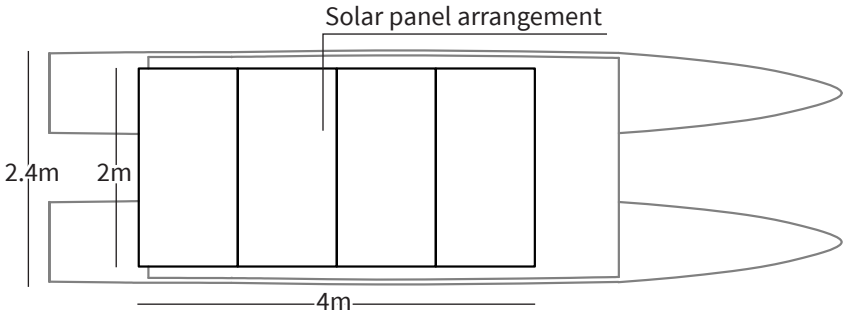
Pros

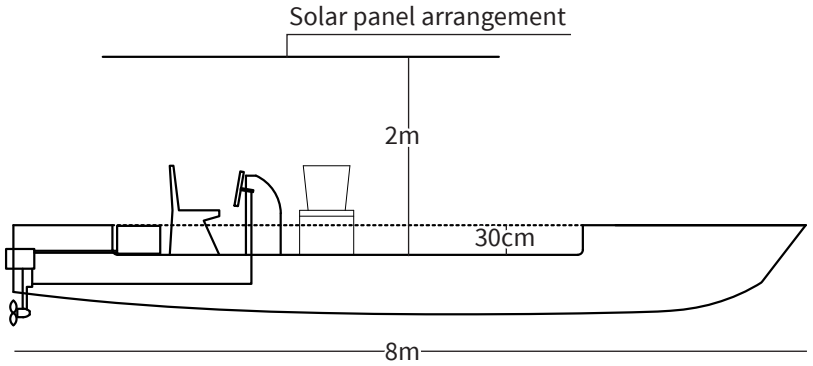
- Battery box unit more compact freeing up more space and nearer to driver for quick checks
- Passengers face each other for better interaction
- Driver console shifted to back and steering cable length reduced - lesser cost
- Platform raised to give better view angle and lesser material wastage

Cons

- Since seating of driver is away from edge of boat, its harder for him to judge position while docking

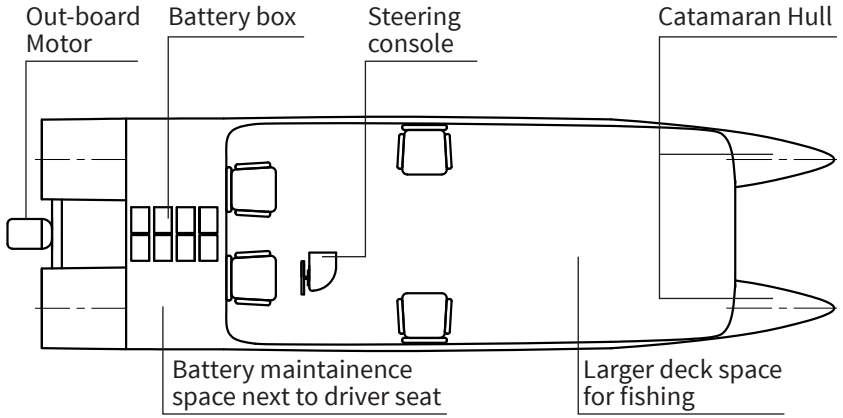




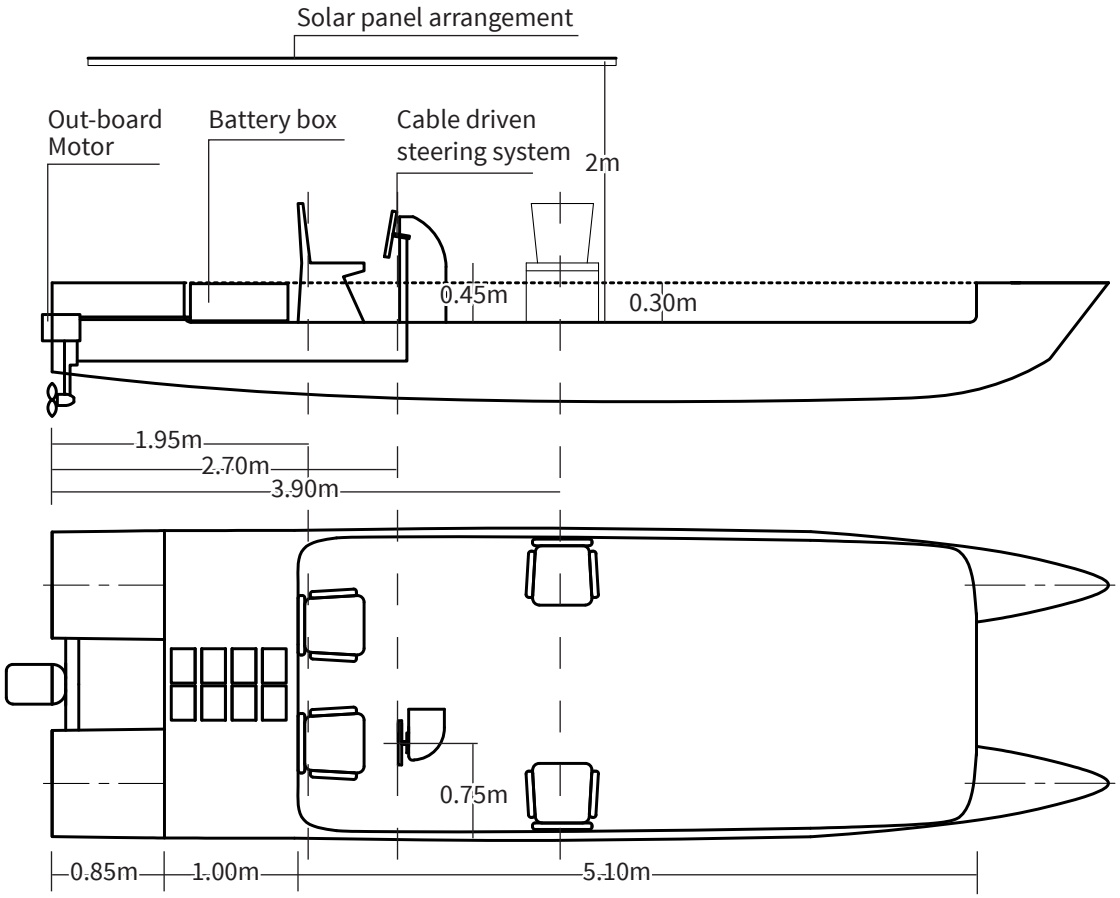


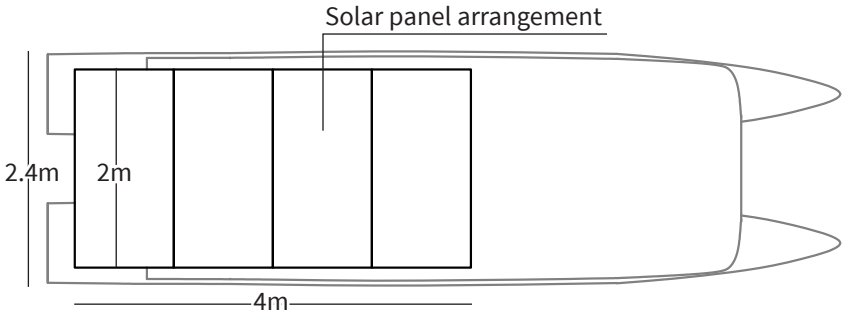
FINAL LAYOUT

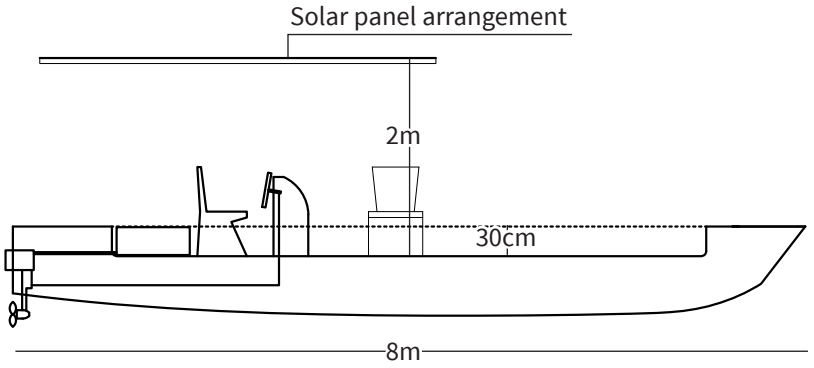
- Layout finalised taking into consideration pros and cons of all possible layouts
- Battery box unit more compact freeing up more space and nearer to driver for quick checks
- Passengers face each other for better interaction
- Driver console shifted to back and steering cable length reduced - lesser cost
- Platform raised to give better view angle and lesser material wastage
- Driver seating moved towards the side so that he gets clearer view while docking



PACKAGING







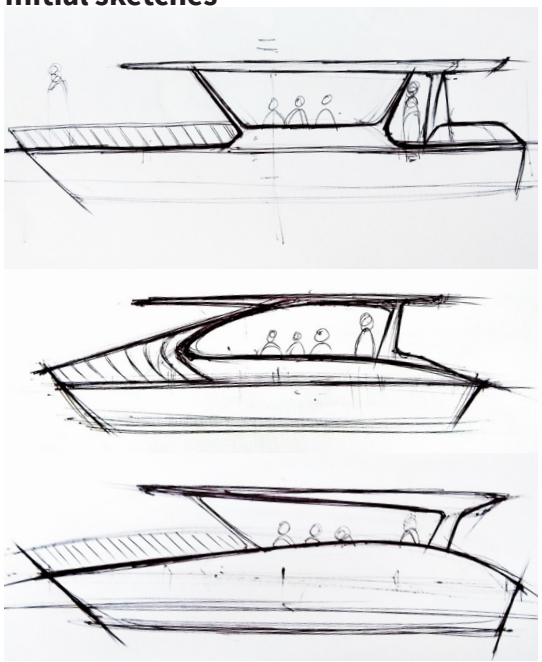
6. IDEATION

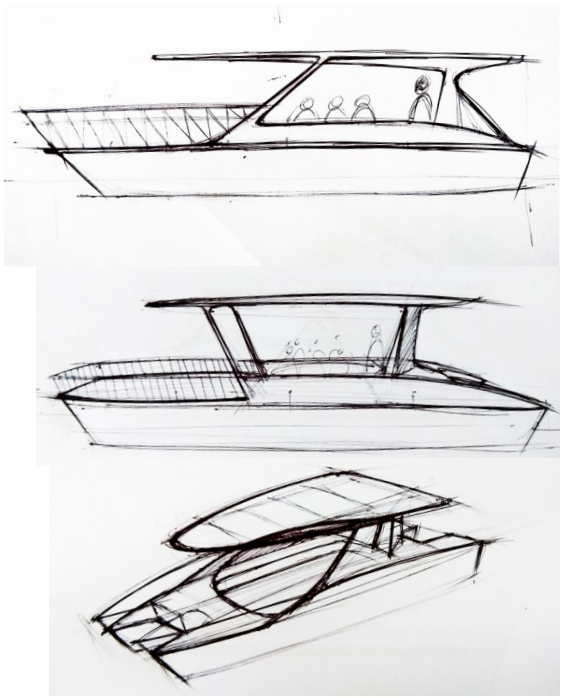
The driving thought behind form development was to **move away from the traditional kerala boat design. The client was looking for something modern and new.**

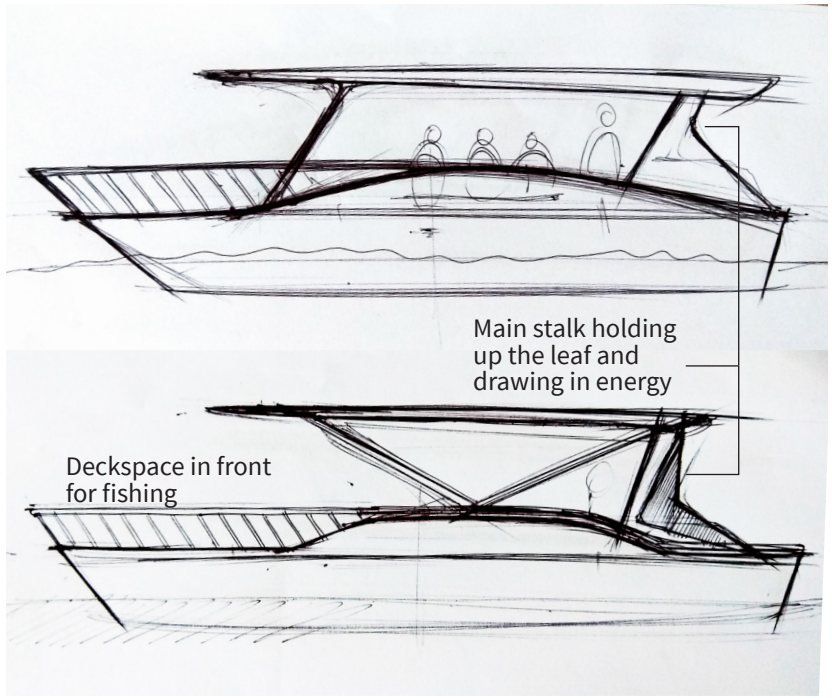
BIOMIMICRY

The design was developed based on the **concept of a water hyacinth** - one of the widely populous water plant species growing in the kerala backwaters. This biomimitic process was found suitable for the design as the processes in both the broad leaved hyacinth and functioning of the solar energy unit would be similar - drawing energy from the sun using a large surface and then transferring it down to be processed. This along with the functional requirement meant that the number of support pillars for the solar panel roof would be drastically reduced or held by using the thinnest of members

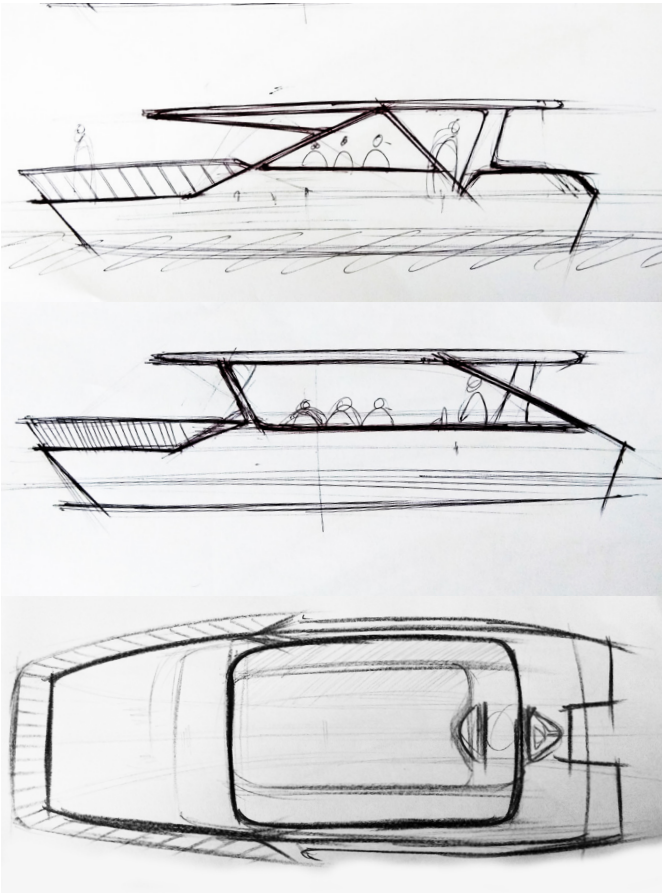
Initial sketches





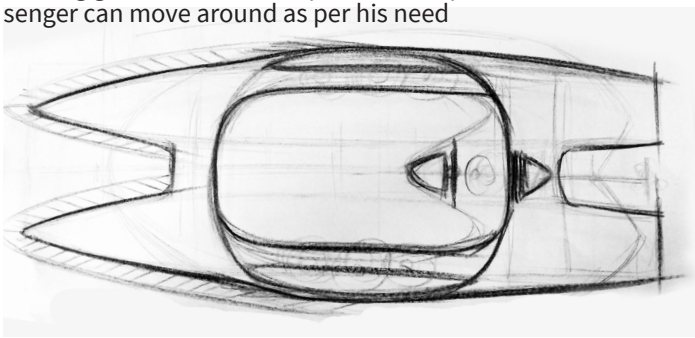


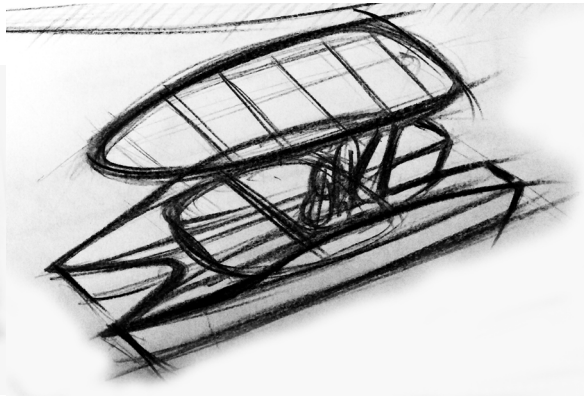
INITIAL SKETCHES

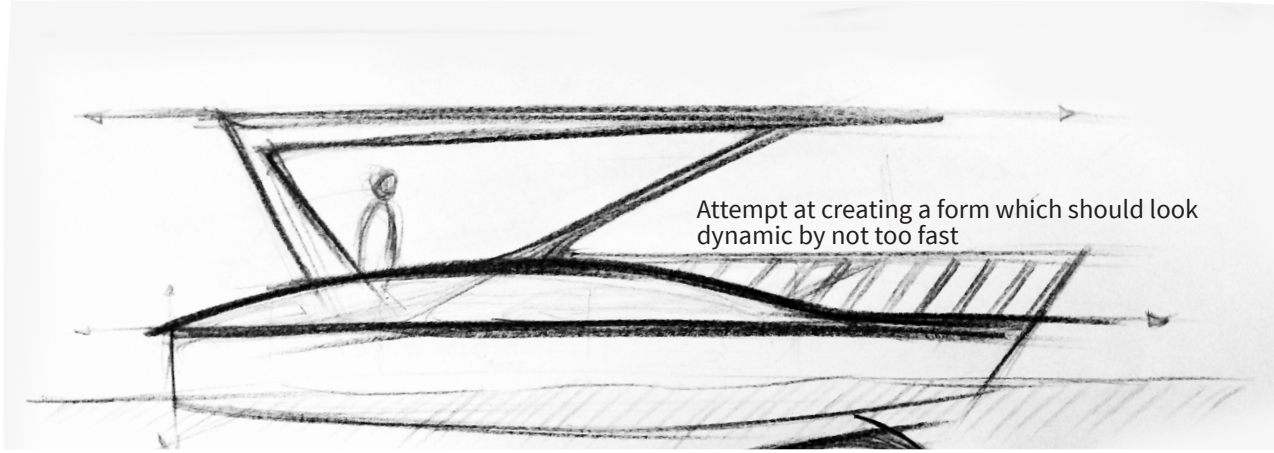


KEY SKETCH

Seating given like a bench space so that passenger can move around as per his need



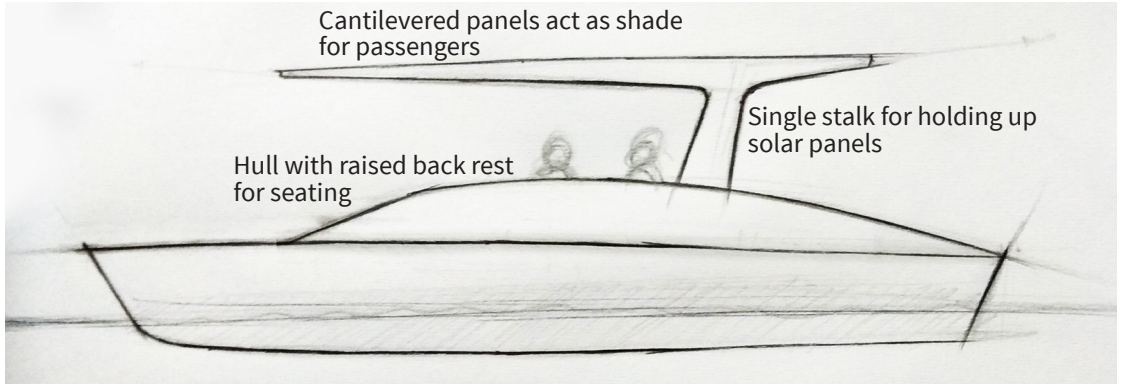


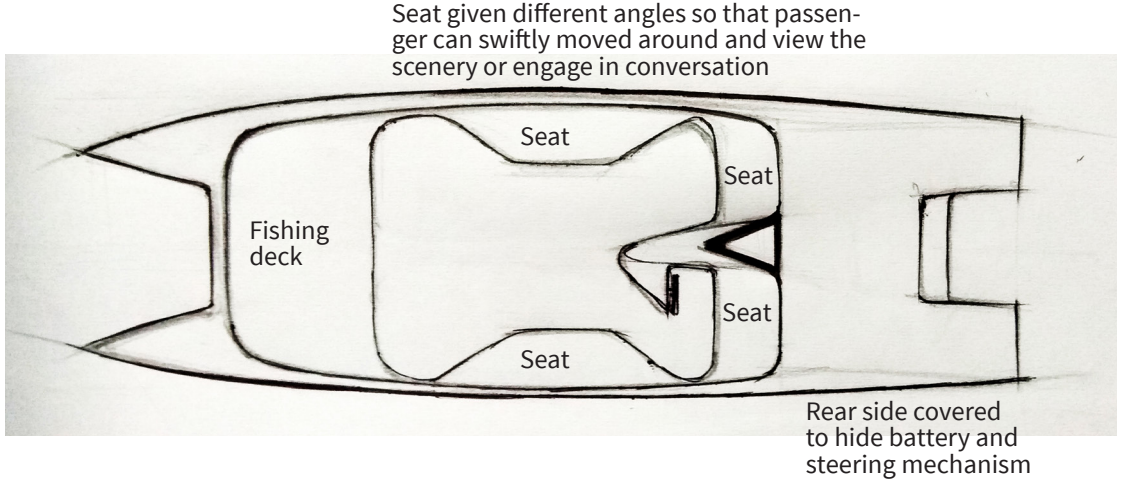


Attempt at creating a form which should look dynamic by not too fast

6. FINAL CONCEPT

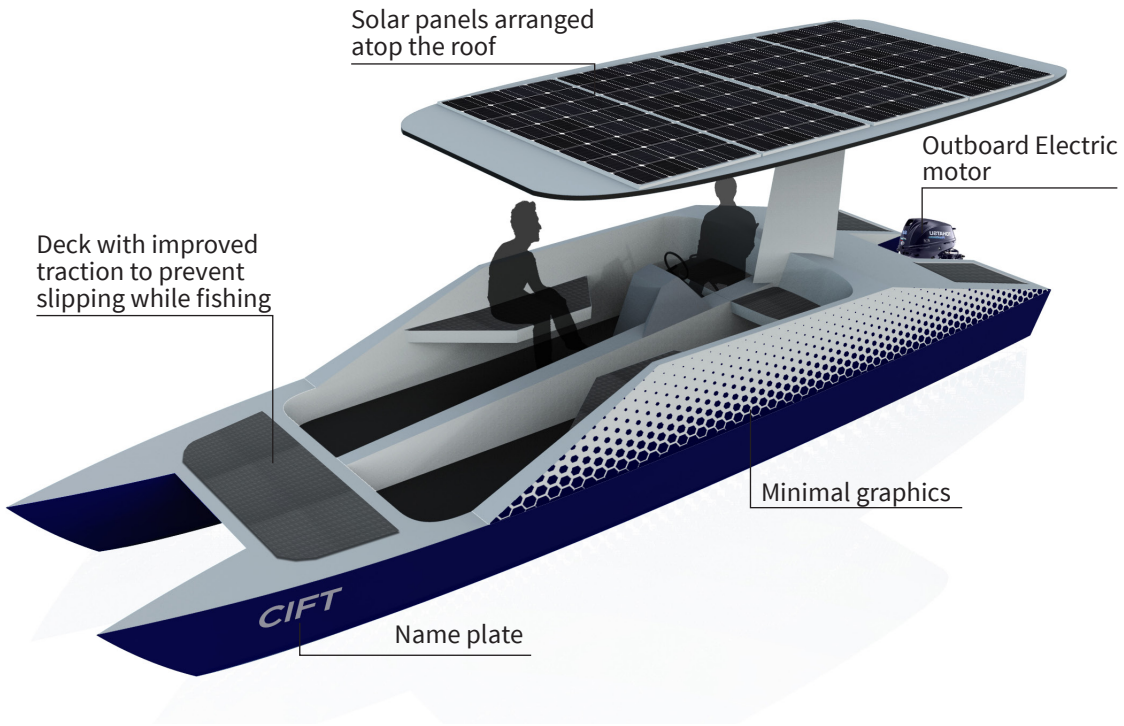
FINAL SKETCH

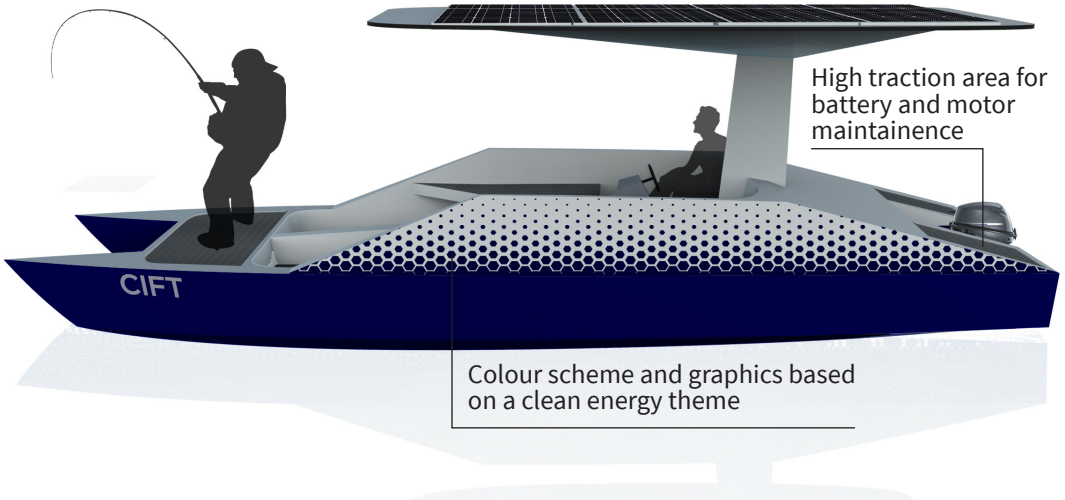




RENDERS

RENDERS


Solar panels arranged atop the roof
Outboard Electric motor
Deck with improved traction to prevent slipping while fishing
Minimal graphics
CIFT
Name plate


High traction area for battery and motor maintainence
CIFT
Colour scheme and graphics based on a clean energy theme

8. MANUFACTURE

8.1 Making the Hull

The manufacture process started with making the hulls for the boat. A pre-existing mould was used for this purpose. The process involved:

PRIMING THE MOULD

- The mould is cleaned thoroughly and made sure it doesnt have any defects and is not damaged.
- A releasing agent is applied on the inside of the mould so that the piece can be easily removed after moulding.
- A gel coat is applied once the releasing agent has dried. This gel coat will contain the colour in which the fibre piece is to moulded. Colouring using gel coat is advantageous than painting the piece later because it gets thoroughly soaked into the fibre when it is laid with resin. The colour doesnt fade and also offers a protective layer to the fibre hull.
- The gel coat is left to dry for 2 hours before fibre and resin can be introduced.

PREPARING THE RESIN AND FIBRE MAT

- Polyester resin is mixed with the required amount of hardener (normally Methyl Ethyl Ketone Peroxide). They are mixed in small batches as the resin hardens fast.
- The glass fibre mats are cut into required size and arranged to be laid.
- Mainly 2 types of fibre glass mats are used - Woven mats & Chopped strand mats.
- Woven mats are used in the first & last layers to get a clean uniform surface finish.
- Chopped strand mats are used in the middle layers to give thickness and strength

A cleaned mould with the releasing agent applied inside

Blue gel coat being applied in the mould for colouring the hull

A roll of chopped strand mat being prepped for laying

Woven mats cut up and kept ready for laying

FIBRE LAYING

- Once the gel coat is dry, the resin and mat are prepped up, the laying process begins.
- The mats are placed in the mould and resin is applied using roller brushes to cover maximum area and get an even spread.
- Care is taken that no airbubbles are formed in this process.
- Once one layer of mat is complete, the next layer is applied without much delay.
- This process continues till about 5 to 6 layers are laid.
- The setup takes upto 2 days to dry up.

Fibre mats being laid into the mould

Resin applied onto the fibre using rollers

RIBBING THE HULL

- While still in the mould, the hulls are ribbed using fibre ribs filled with PU-foam blocks. These ribs give structural strength to the hull and prevent it from shearing under load.
- The ribs are firstly made seperately using plywood moulds. Once stiff, they are released and placed in the hull with PU-foam blocks packed inside to take compressive load.
- Without these ribs, the hull can fail easily when under duress.
- Once the whole setup dries up, it can be removed from the mould

Ribs laid into the hull

Ribs are packed with PU-foam blocks for strength

RELEASING THE HULL

- Once the piece dries up, it can be released from the mould
- The piece can either be lifted off by holding the hull flanges, or it can be removed by filling water in between the mould and piece. This water will slowly lift up the piece and releases it.
- Care is taken not to damage the hull while removing and placing it.

Water being filled to release the hull piece

TRIMMING THE HULL TO DESIGN

- After releasing, the dimensions are marked out as per design and the hull pieces are trimmed to be set up as a catamaran boat.
- This involves cutting away a portion of one side of each hull where the central platform would come (which links both the hulls).

Hull piece trimmed

Both hulls trimmed and ready for assembly

8.3 Making the Solar panel support structure

- The solar panel was to be supported by a single stalk as per design, with cantilevers truss system taking the weight of the panels.
- Here, the innate structural strength of the solar panel frames were used to our advantage. The aluminium frames of the solar panels would help in preventing twist and shear of the panels. These panels would be place transverse to the length of the cantilever to get maximum stability.
- Panel outlines were marked on the floor and the truss was built upside down. It was then erected on its legs and solar panels were mounted to check stability.
- MS box members of 4x8cm and 4x4cm were used for the main trusswork.

MS box members laid out during initial stage

Finishing touches being made to the truss before inverting it

Solar panels being mounted on the erected truss system

Sample seating layout checked after mounting all panels

8.4 Combining the hulls

- The hull pieces are kept side by side at the correct length and height is levelled out. Once they are placed correctly, a preformed platform piece is attached in between the hulls. This piece is connected by adding additional fibre strips on the joints and glueing with resin
- After the platform piece is set, MS box sections are placed transversely in such a way that the steel touches the edge of the hull ribs. This will help in further strengthening the boat and prevents the 2 demi-hulls from twisting.
- These steel members are fused to the hull and platform by using fibre strips and resin. This ensures that both demihulls, the platform and steel beams act as a single unit when taking load

Hull pieces connected and steel beams are introduced

8.5 Making the backrest

- The final design features a raised backrest for the seating provided. This was made using fibreglass, and the hull piece itself was made as the mould.
- The backrest design was sketched out on the side of the hull, the surface was prepared in the same manner as the hull was made.
- The one thing to remember here is that since the piece is made by keeping the hull as the mould, the piece moulded from the left hull would be mounted on the right hull and vice versa.
- The removed pieces are mounted on their respective sides, bolted and strengthened by applying fibre and resin.

Hull being used as the mould for the backrest

Backrest being bolted onto the hull

8.6 Mounting the Solar panel unit

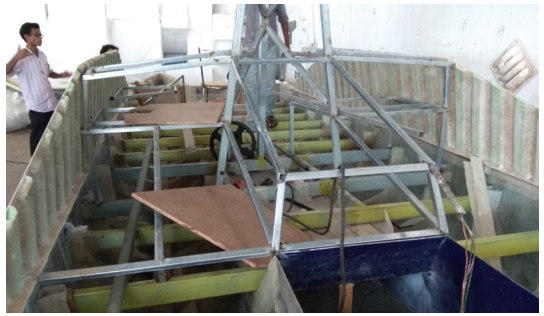
- The trusswork is mounted onto the hull and the legs are welded onto the MS beams laid earlier.
- Once the welding work is done, the solar panels are mounted atop the truss. These panels are connected to the truss using L-brackets and bolted.

The truss legs are welded to the MS beams for support

Panels are mounted and bolted

8.7 Setting up the seats, driver console and battery box

- The base framework of seats, driver console and battery box were made in MS 4x4 box sections.
- MS beams connecting the hulls and the truss legs was used as supports for setting up the basic framework.
- The steering system was installed after the framework was finished.



Battery box and seating framework being setup

Steering unit being setup

8.8 Panelling

- Once the framework was finished, the entire setup was covered using Aluminium composite panels - this was done to bring in the cost within budget, also ACP has a readily finished surface and easy to work with.

Battery box panelling using ACP

Panelling on the truss work

8.9 Mounting the electric motor

- The electric motor is mounted and rear, between the 2 demi hulls

The motor mounted at the rear

9. FINAL PRODUCT

The boat was tested succesfully in the backwaters near Aroor (Aleppey district, in the state of Kerala) with 6 passengers onboard. It will be handed over to the CIFT in mid-July.

The boat being tested in Aroor-Edakochi backwaters

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