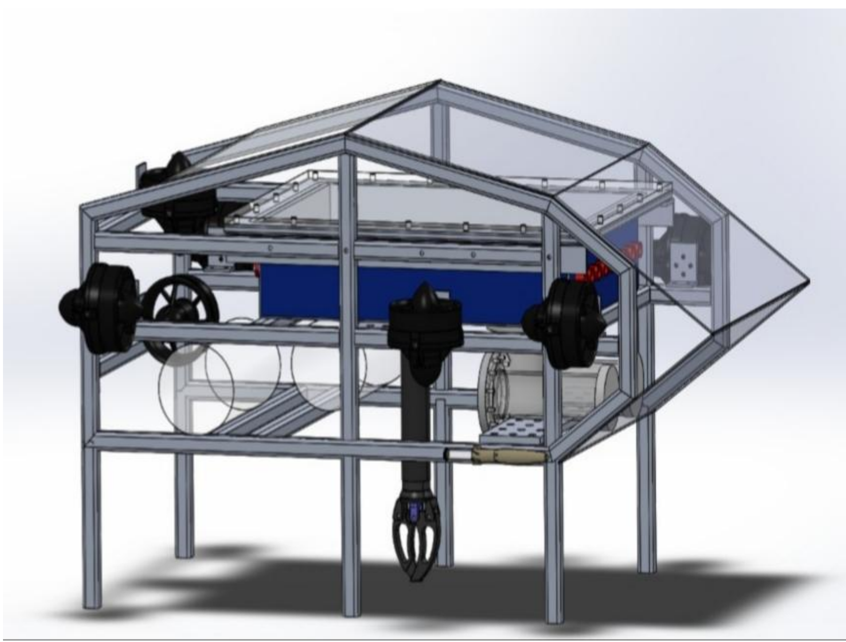
VEHICLE DESIGN

A. Mechanical

Basic vehicle frame design and material selection criteria

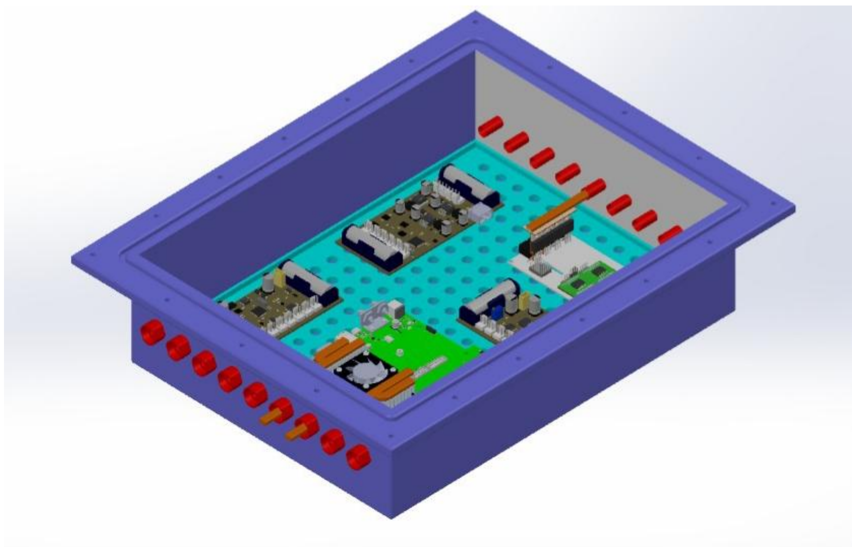
The frame is designed to be compact and modular to reduce drag force down to a minimum and provide efficient hydrodynamics. The frame design borrows some inspiration from Tesla's Cybertruck model. Aluminium is used as the material of the frame due to its lightweight and easy machining ability. The frame is trapezoidal (from the side view). The design of the frame is such that each elementary structure (hollow box and aluminium rods) can be separated from each other. It allows us a never before level of flexibility in adjusting dimensions depending upon the requirements.



Hull Design

The hull design is aimed to provide high strength and rigidity while keeping the weight to a minimum, so we went for an S Glass box-shaped enclosure.

The hull is divided into two layers – one for electronics and circuitry and the other for battery enclosure. The material of the hull is chosen in such a way that it does not crack at a depth of about 10m. This is thoroughly tested by simulation in ANSYS Static Structural by applying hydrostatic pressure equivalent to a depth of 10m underwater.
Both its ends can be easily opened to access the electronics inside. The design also provides watertight sealing to the bot. In case of an accidental failure, the electronic components are placed on a perforated and tapered base plate. This ensures the safety of the circuit in case of leakage as the water first collects at the bottom of the base plate.



Camera Hull Design

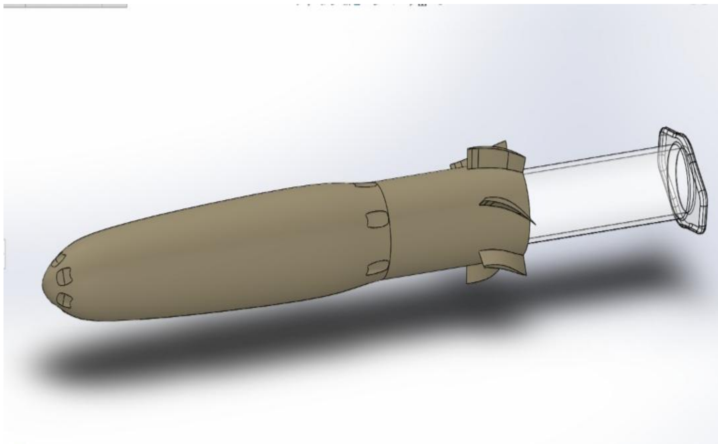
The camera hull is made of acrylic. So similar simulations were performed on the camera hull in ANSYS as done in the main hull to ensure structural integrity.

Object Dropper and Grabber

A very simple mechanism has been employed to drop the required objects from the vehicle. In our mechanism, a BO motor is mounted to a PVC pipe. When the motor rotates, the obstruction causing the object to stay is removed, and hence the object falls. Newton Subsea Gripper, developed by BlueRobotics, is used.

Torpedo

The torpedoes are in the shape of a hollow cylinder of 10mm diameter and are 3D printed for high accuracy. A pressure-based system is used to launch the torpedoes by a tank with pre-filled pressure of 30Pa. The torpedo is connected to the tank through PU fitting pipe passing through a coil actuating solenoid, which on receiving the command opens for about 10 milliseconds, thus allowing the air to pass from the tank to the torpedo through the PU fitting pipe.



Cooling System

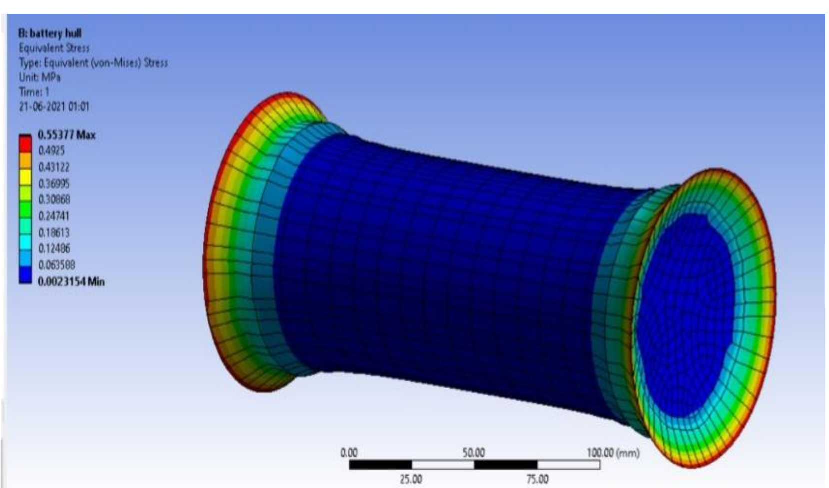
The thermal system consists of a quasi active cooling system.
It helps us provide better cooling without having a heavy toll on our batteries. The primary method of heat transfer is conduction. There are other minor sources of heat, which are cooled by convection due to the circulating air.
The cooling system primarily consists of heat pipes paired with internal cooling mechanisms present in some of the components. The heat pipes help in easy and continuous flow of heat out from the hull via the heat sinks present in the ICs and Jetson.
Jetson has an inbuilt cooling fan which benefits a lot from this cooling system by providing it with a viable heat sink in the otherwise closed environment.
In the earlier models, we did not emphasise a dedicated cooling system as heat released by electronic components of our previous renditions was manageable. In our new vehicle, we have used better and more powerful ICs and a Jetson, which are primary heat sources. Each is connected to heat sinks and further connected to heat pipes. Furthermore, the heat pipes are in contact with the water outside directly for further heat transfer. There is a cooling fan within Jetson that helps us circulate the air in the hull, which is in contact with heat sinks, and heat pipes help in faster cooling and allow circulation of cool air.

Component	**Vendor**	**Model/Type**	**Specs**	**Cost (in INR)**	**Status**

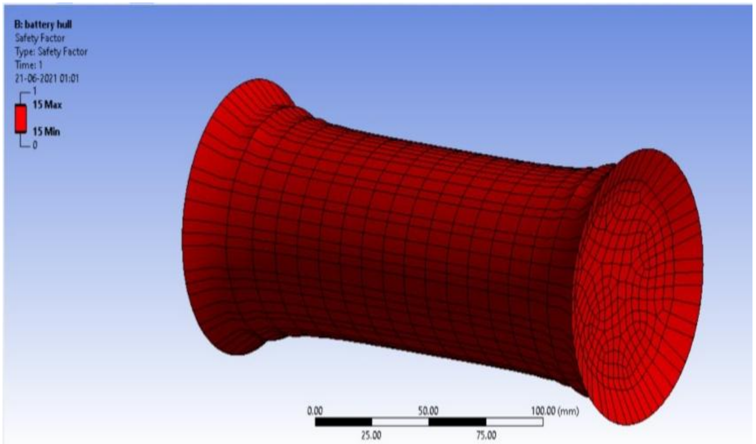
Buoyancy Control					
Frame	Custom made from 20mm Aluminium channels	Aluminium Channels	$(20x20x2)mm^3$	1000	Waiting for acquisition
Waterproof Housing					
Waterproof connectors					
Thrusters	Blue Robotics	T-200	Link to specs	$206 x 8	
Gripper	Blue Robotics	Newton SubSea gripper	Link to specs	$439	

EXPERIMENTAL RESULTS

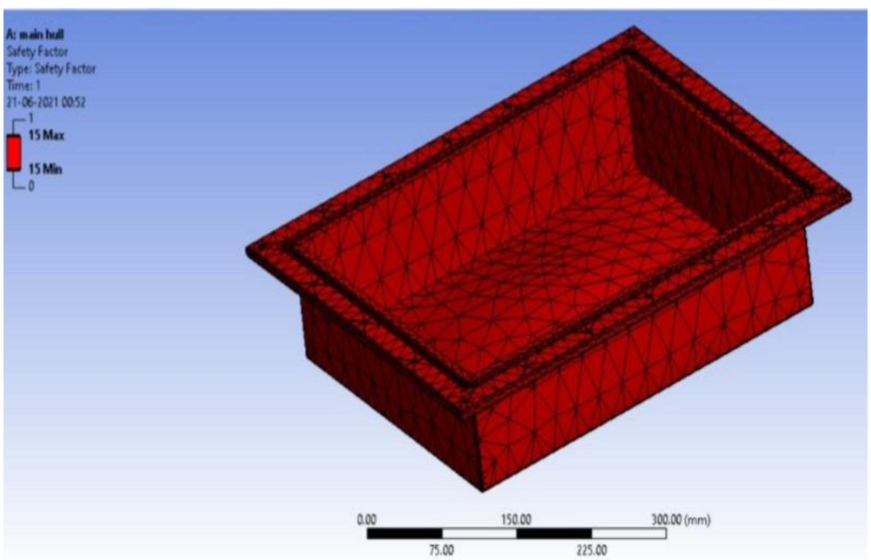
Analysis of the battery hull and main hull using ANSYS Static structural was done considering pressures at a depth of 10m for all possible materials taken into consideration initially.Then appropriate materials were chosen thereby giving results of factor of safety of given structures well above 3(S-Glass was chosen for main hull and battery hull) . Thermal analysis of heat pipes used in the cooling mechanism was done using ANSYS - Steady state Thermal. The cooling system proved efficient to dissipate the heat generated by the electronic components.



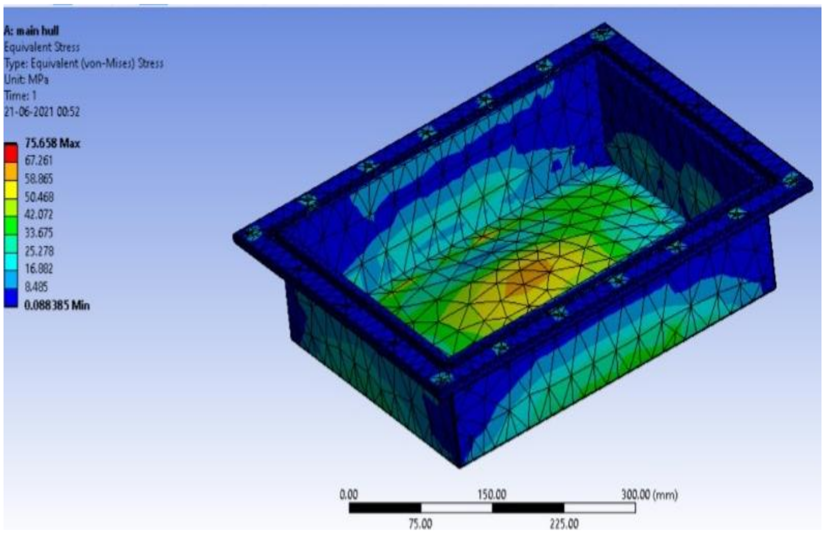
Equivalent stress analysis of Battery hull



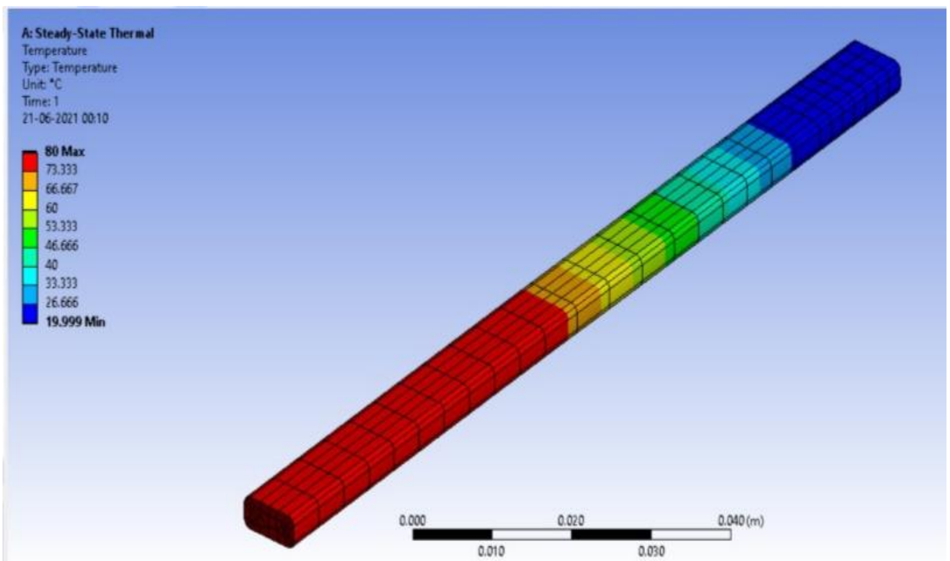
Factor of safety results for battery hull



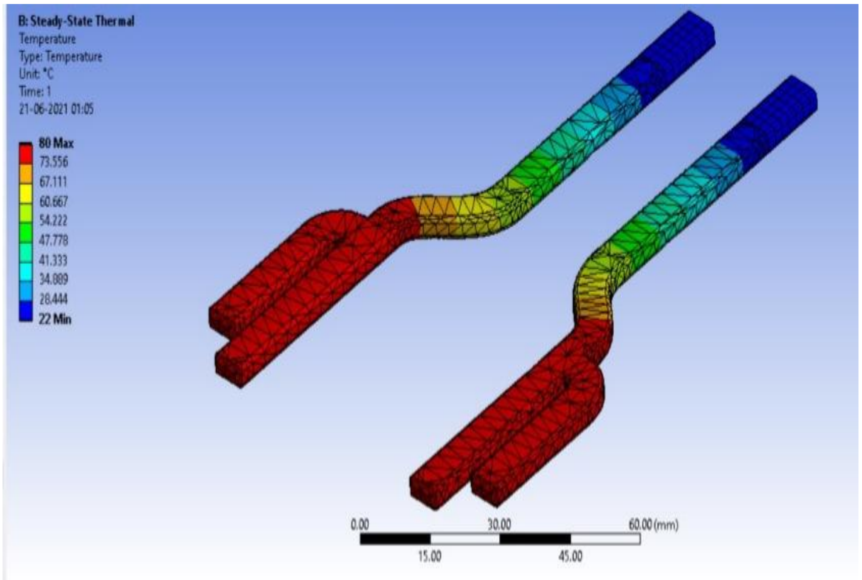
Factor of safety results for analysis of Main Hull



Equivalent Stress results for analysis of Main Hull



Temperature Gradient results for Heat pipe cooling ICs



Temperature gradient results for heat pipe cooling JETSON

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