BE-Mechatronics, SZABIST
FYP Final Year Evaluation (August 2017)

Coastal Shallow-Water Data Buoy

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Project Supervisor :
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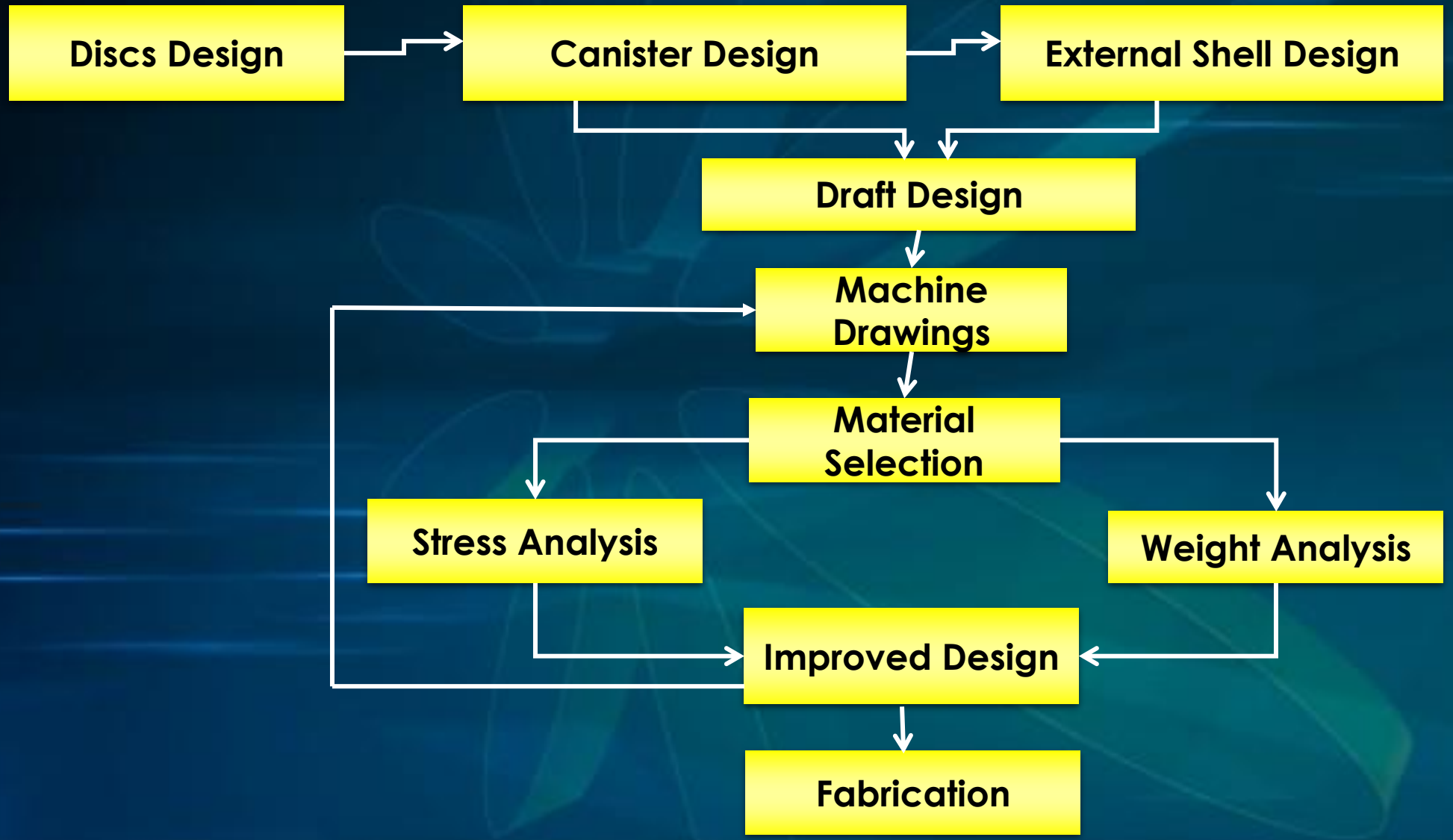
Introduction/Objective

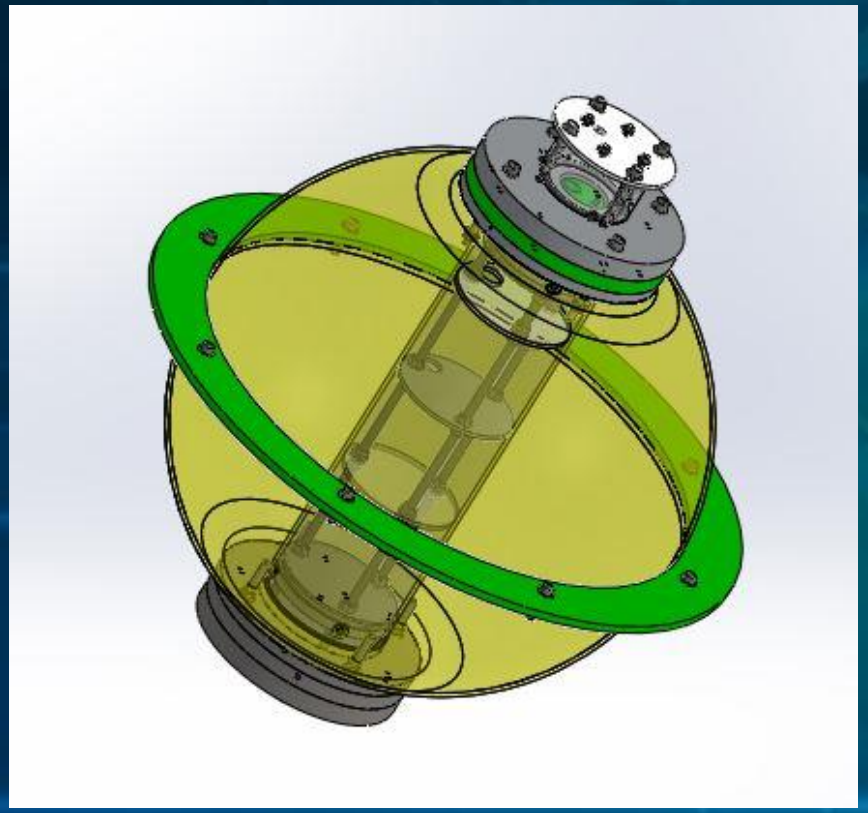
- A Data Buoy Is used to log wave heights at the coast.
- The wave data can be used to assess wave action on the coasts and their effects on fauna and flora.
- Long term wave data studies can be made to develop local wave trends.

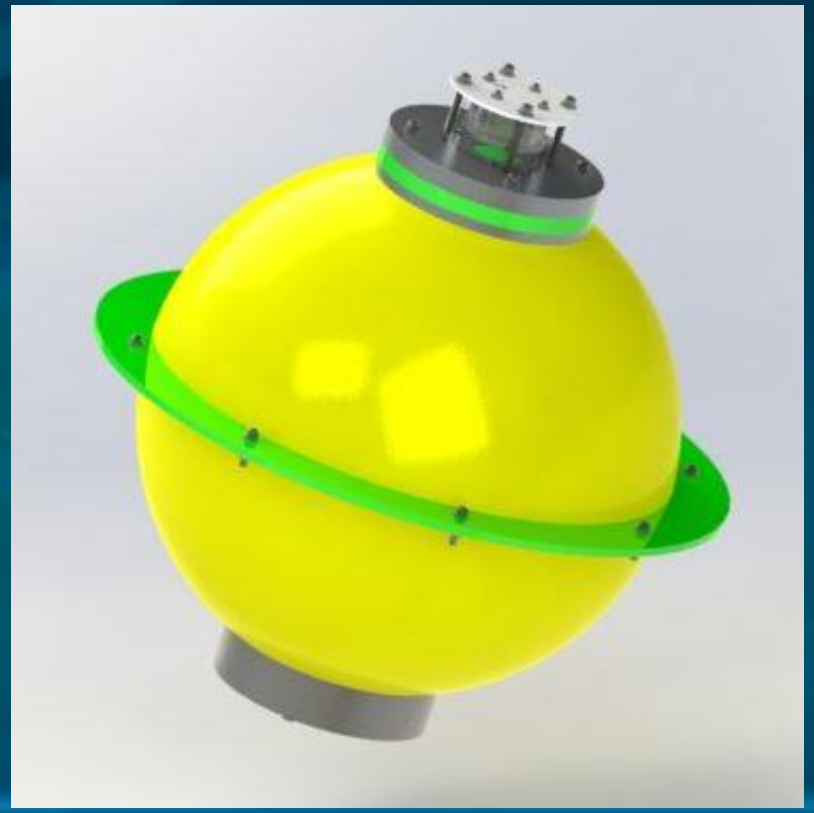
Design Flow Diagram

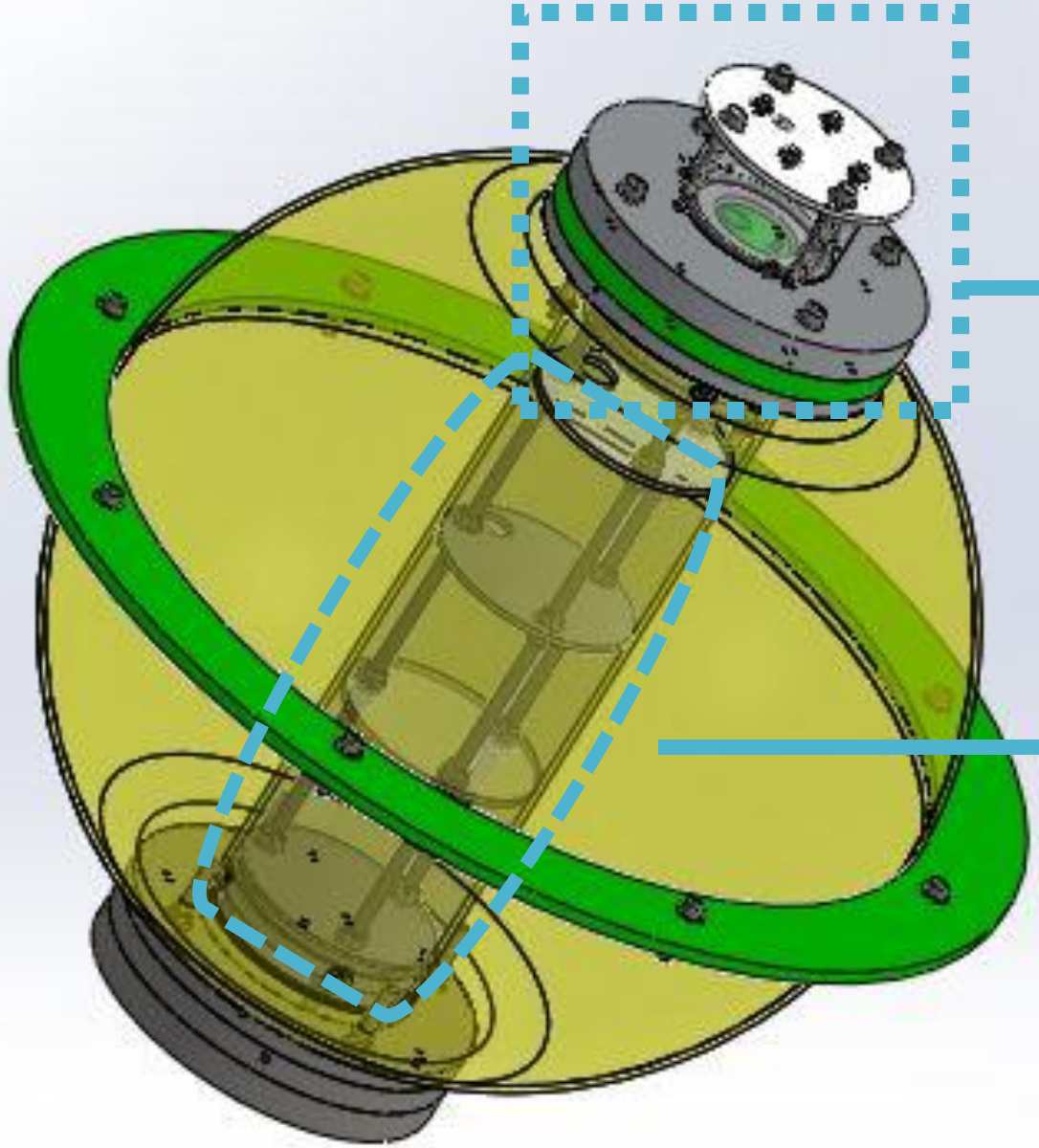


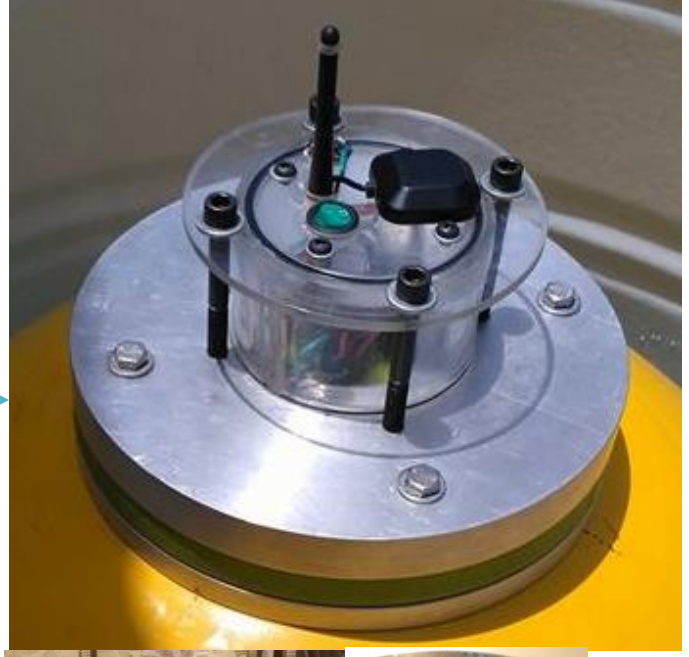
Design

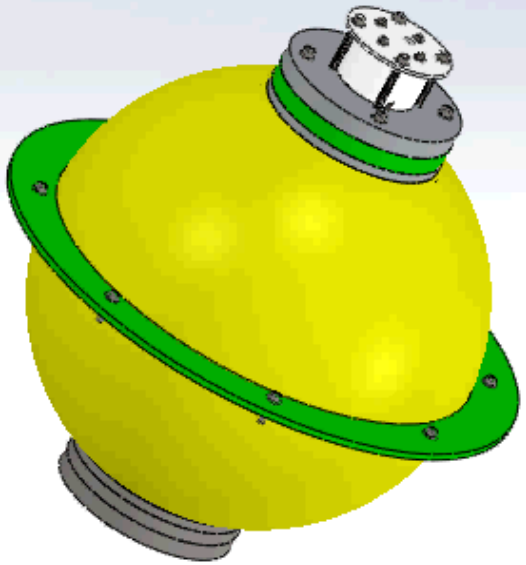
- The structure is mainly divided into an inner structure and outer structure.
- Both sections have been designed taking into account various points of concern such as leakage, corrosion, weight, acting stresses and factor of safety.





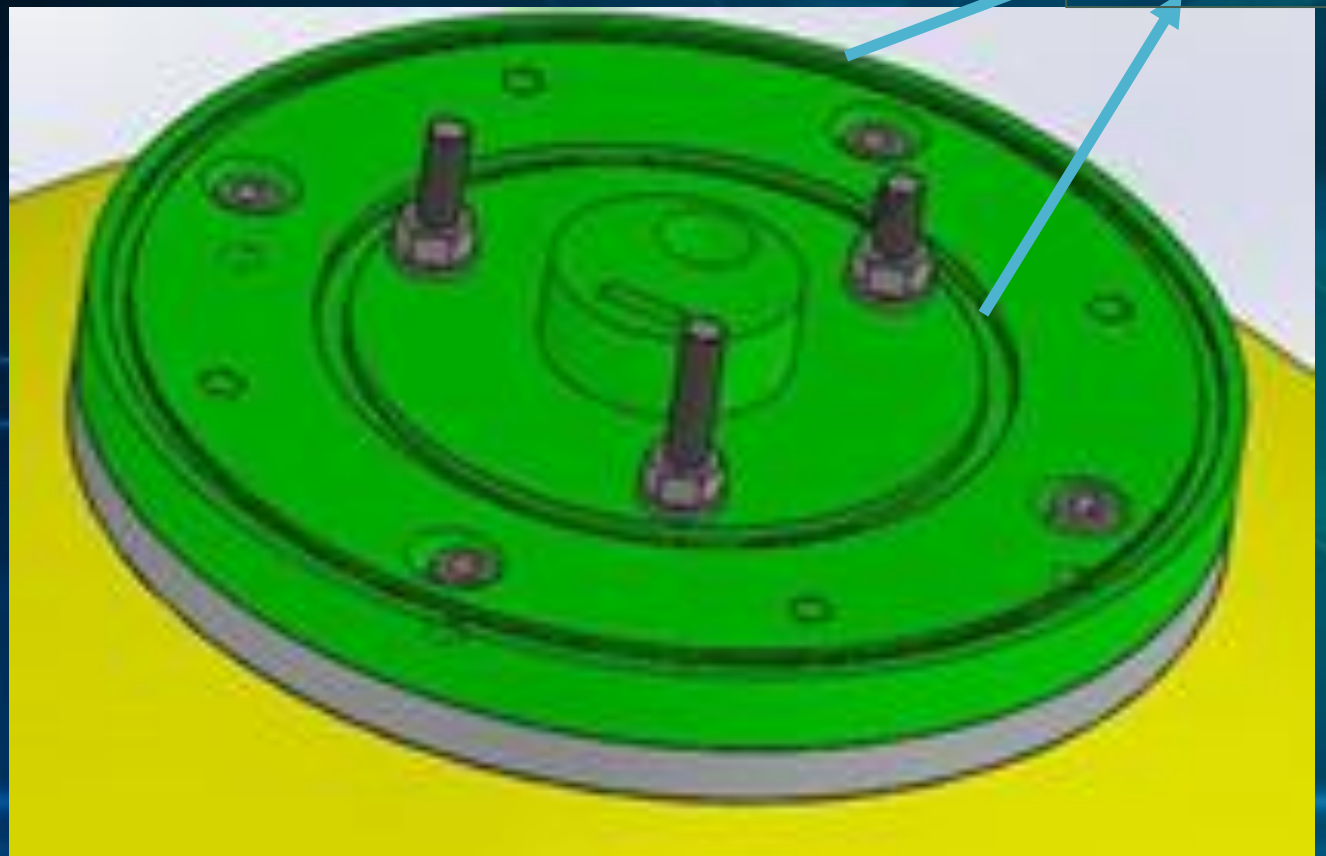






Sealing

- Sealing was done to make the buoy water tight. O-rings were used to provide sealing.
- O-rings are placed at each level where ever there is a leak path.



Corrosion

- The buoy must be corrosion resistant as it sits directly in salt water.
- The shell is made of fiberglass because it is less vulnerable to corrosion than steel and aluminum.
- The plates at the bottom are made of stainless steel 316L.
- Molykote anti-seize compound was used to coat the fasteners in order to facilitate disassembly and resist corrosion.

Stress Analysis

- To determine the maximum stress and its location on each part.
- To determine the required thickness of each part.
- As the fiber glass exhibits somehow between ductile and brittle behavior, hence, the factor of safety is calculated using the following criterion:

Criterion	Max. Stress (MPa)	F.O.S
Distortion Energy Theory	61.7	3.35
Max. Normal Stress Theory	77.2	2.7
Max. Shear Stress Theory	34.8	2.97

Sensitivity Analysis

- A sensitivity analysis was performed in SolidWorks to study the variation in Center of Mass when the distance between the bottom and middle disc changes.
- The Center of mass obtained proves to be almost insensitive to movement of the middle disc.

Distance Between Bottom and Middle Disc (mm)	Center of Mass (X) (mm)	Center of Mass (Y)
77	330.64	- 0.07
100	330.08	- 0.07
150	328.87	- 0.07
175	328.26	- 0.07
200	327.65	- 0.07

Machining

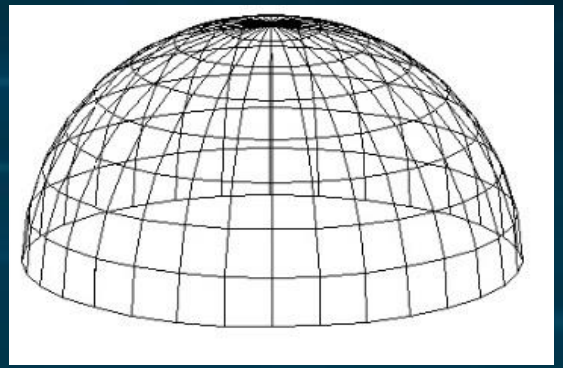
- Machining was carried out by technicians at PNSC Kiamari Workshop (Picture Shown Below).
- All the metal and plastic components were machined free of cost by PNSC after we approached them and introduced our project.

Weight and Buoyancy Analysis

- Weight and Buoyancy analysis was performed to find the radius of buoy for it to float considering the weight of the components that it will carry.
- At present, the buoy sits below the centerline (hoop) and has capacity to carry extra 10 kg.

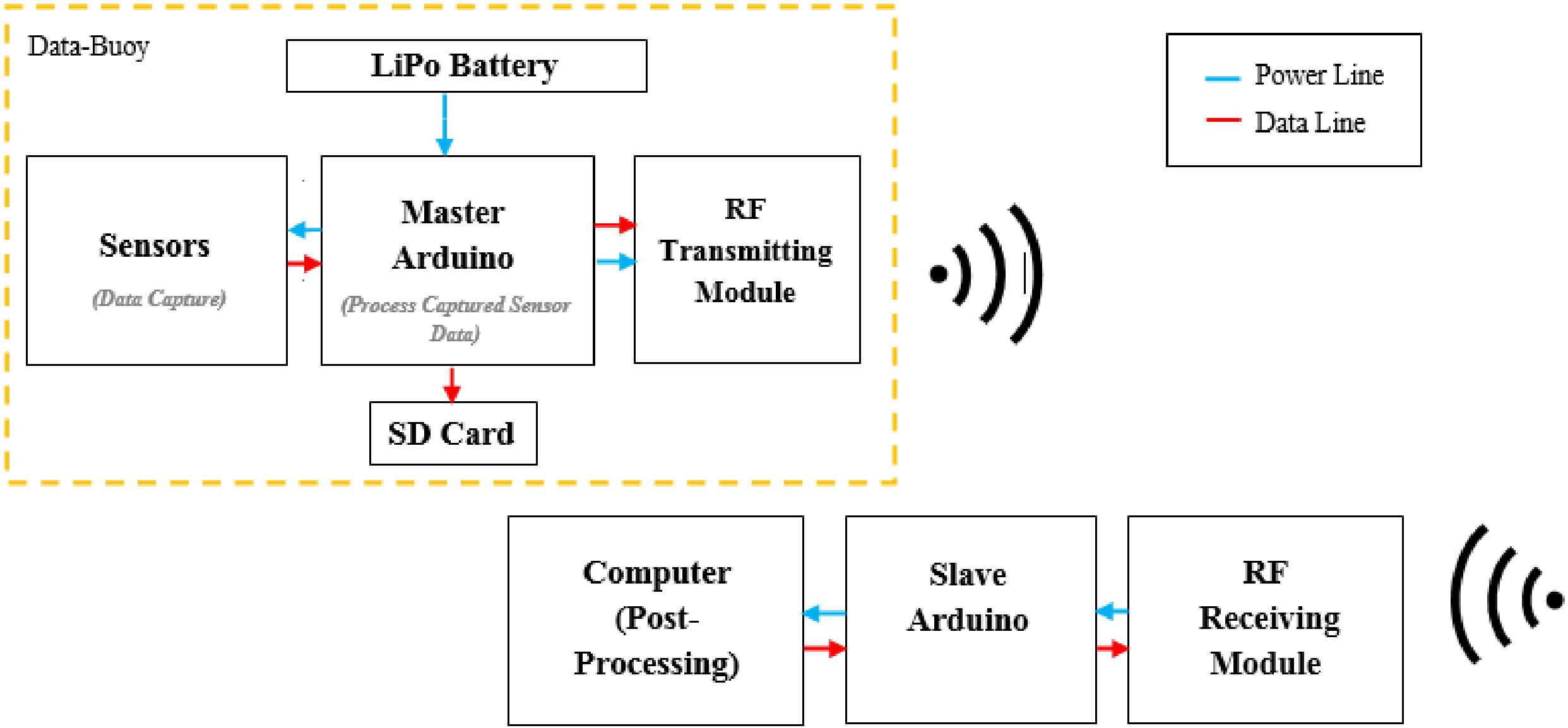
Radius of Buoy 'R'	Chop Length 'L'	Shell Thickness 'Th'	Shell Volume 'V'	TotalWeight Mass 'Wm'	Total Buoyancy Force 'Fb'	Total Buoyancy Mass 'Bm'
0.32 m	0.291 m	0.005 m	0.135 m^3	62.7 kg	1393.2 N	142 kg

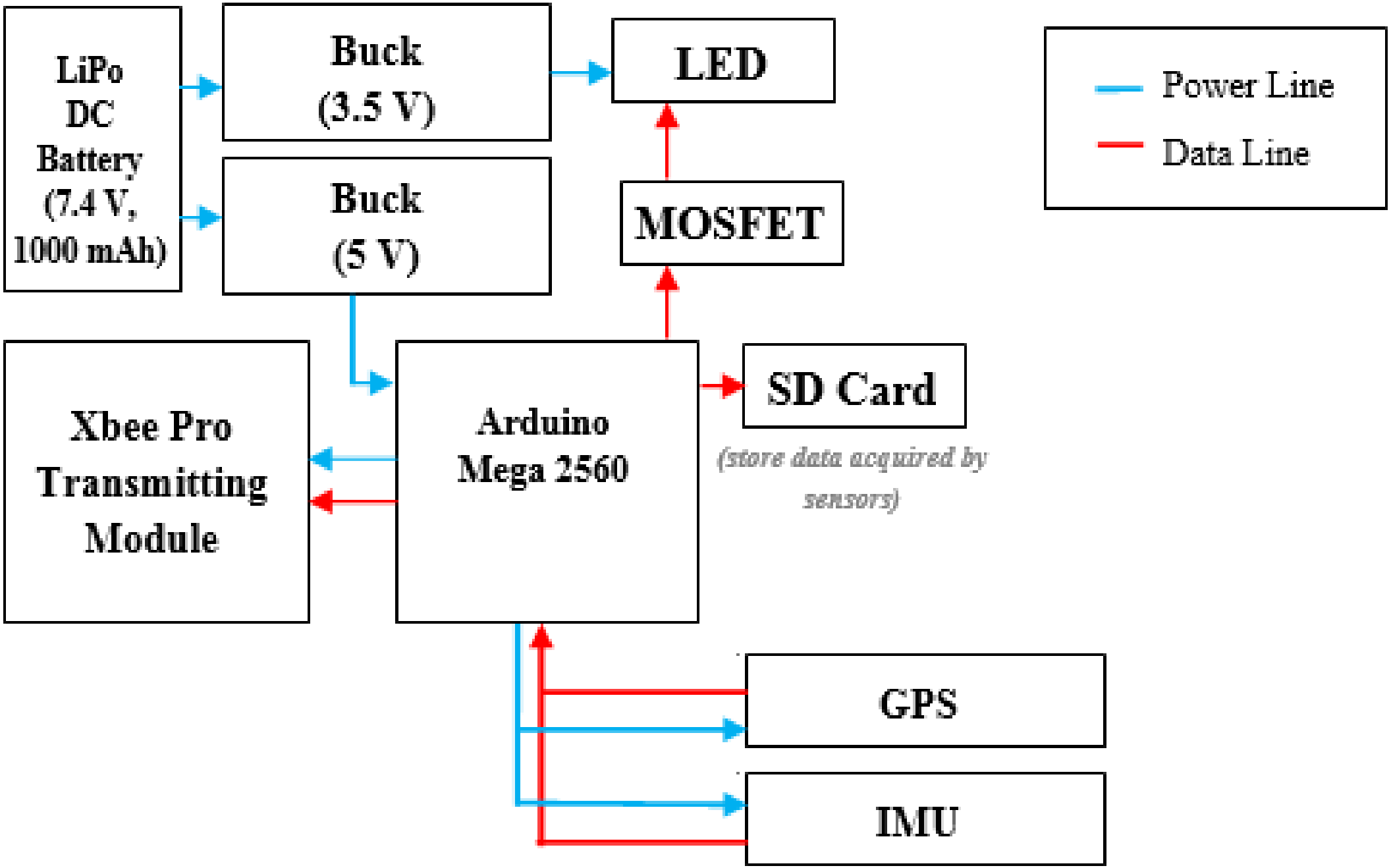
Fiberglass Shell Manufacturing

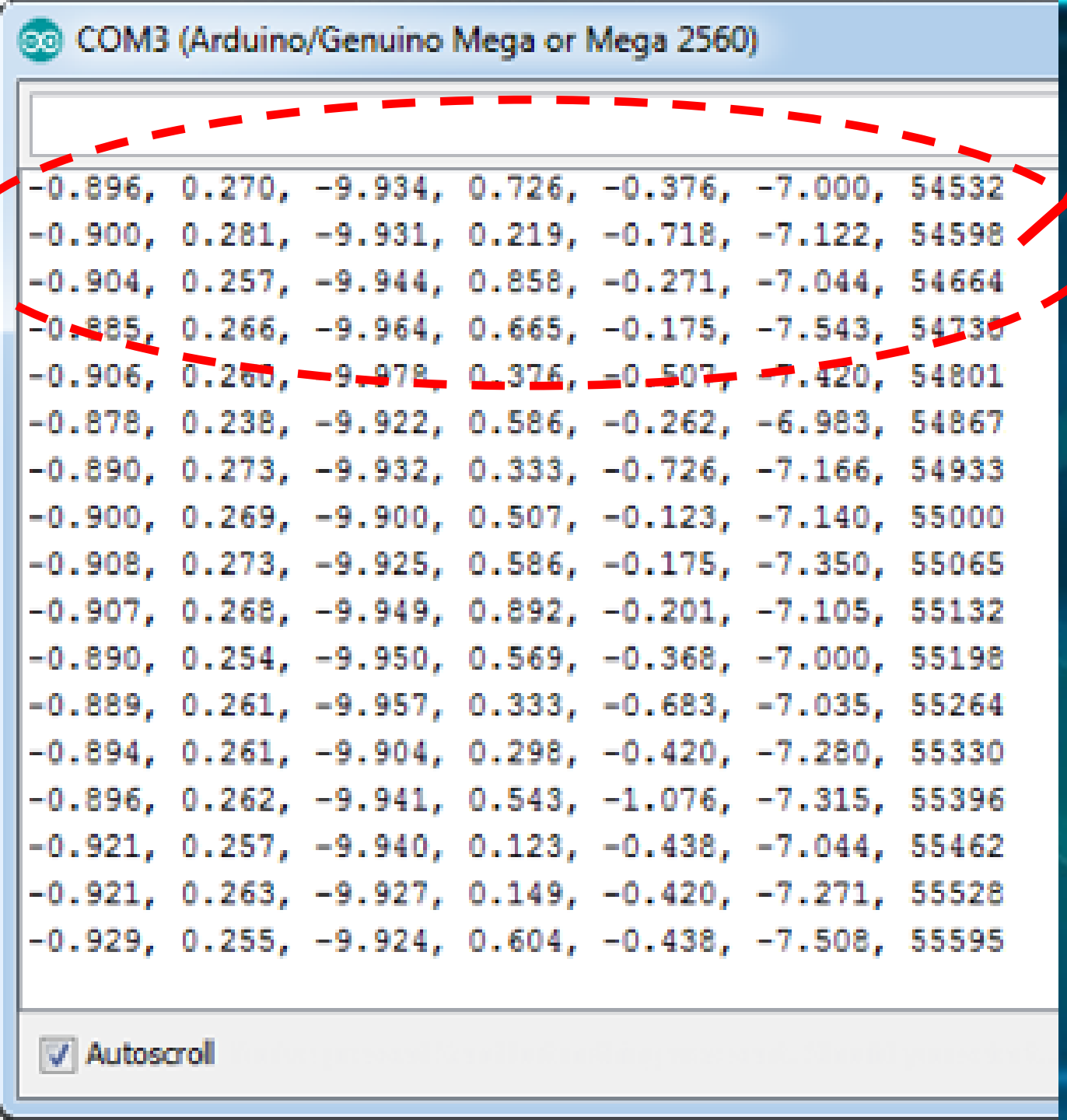


- Fiberglass was manufactured at a local, Malir based company.
- Manufacturing process is as follows:
  - A hemispherical wire pattern of the buoy shape is made which is further used to make a fiberglass mold.
  - Layers of fiberglass (joined together by epoxy resin) are applied inside the mold to cast the final product.

Data Acquisition




LiPo DC Battery (7.4 V, 1000 mAh)
Buck (3.5 V)
Buck (5 V)
LED
MOSFET
Power Line
Data Line
Xbee Pro Transmitting Module
Arduino Mega 2560
SD Card
(store data acquired by sensors)
GPS
IMU



- Accelerometer data coming every ~66ms (15 Hz) in the format

  Ax, Ay, Az, Gx, Gy, Gz

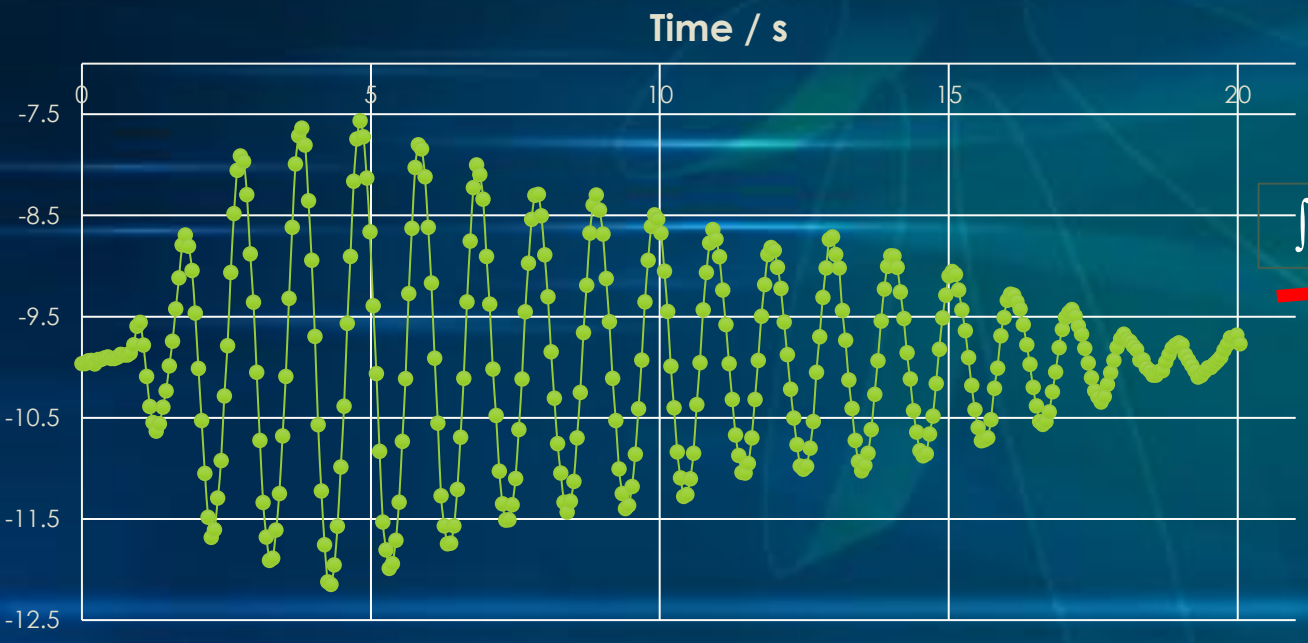
- By double integrating the acceleration we can obtain the wave displacement
- As we are only interested in the wave parallel to the coast we have neglected Ax/Ay and only considered Az, the vertical linear acceleration.

Results

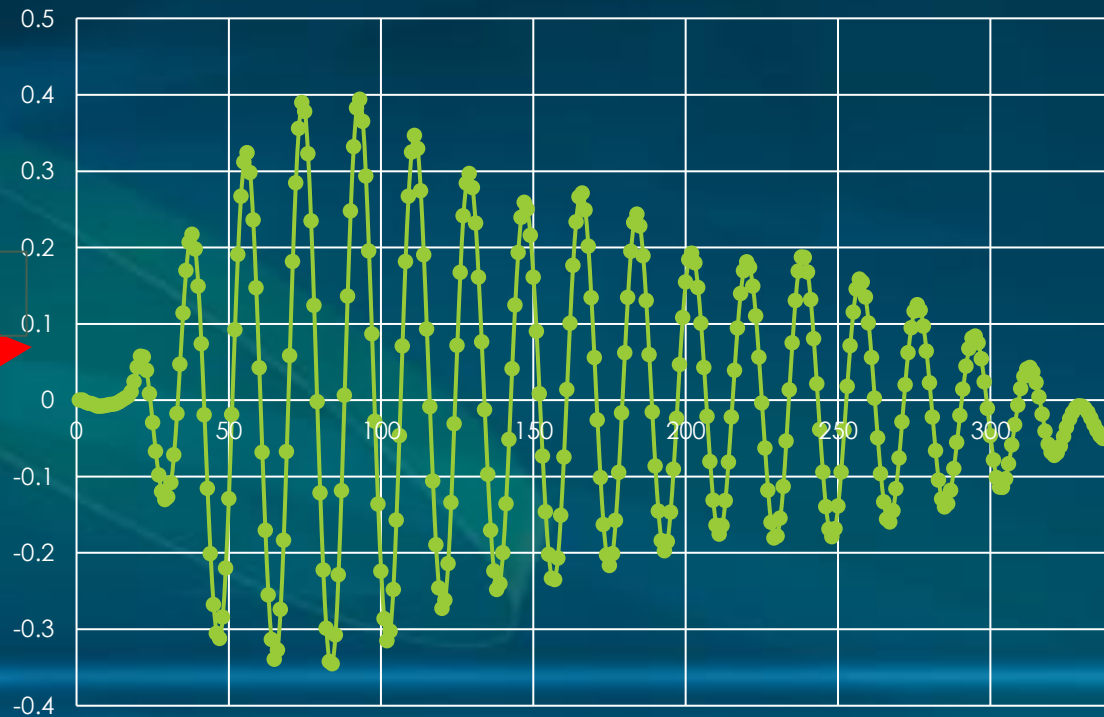
Ax	Ay	Az	Az	Gx	Gy	Gz	T	T(0)	Vz	Sz
-1.12	0.257	-9.962	-0.04209	-0.236	-0.892	-1.339	255700	0	0	0
-1.132	0.266	-9.963	-0.04309	-1.558	-2.109	-0.892	255757	0.057	=J3+0.5*(I4-I3)*(D3+D4)	

- We apply the trapezoidal rule to perform a numerical integration using the formula:

$$Vnew = Vold + \frac{1}{2}\Delta T(A_{i-1} + A_i)$$



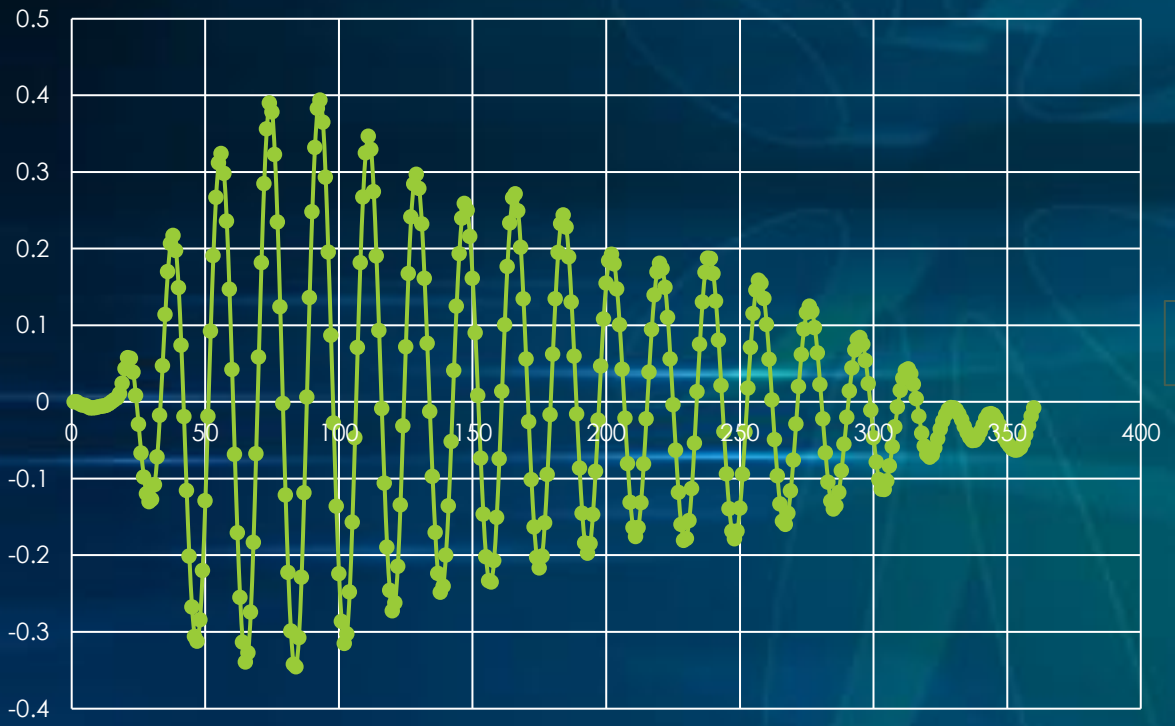
$\int A.\,dt$



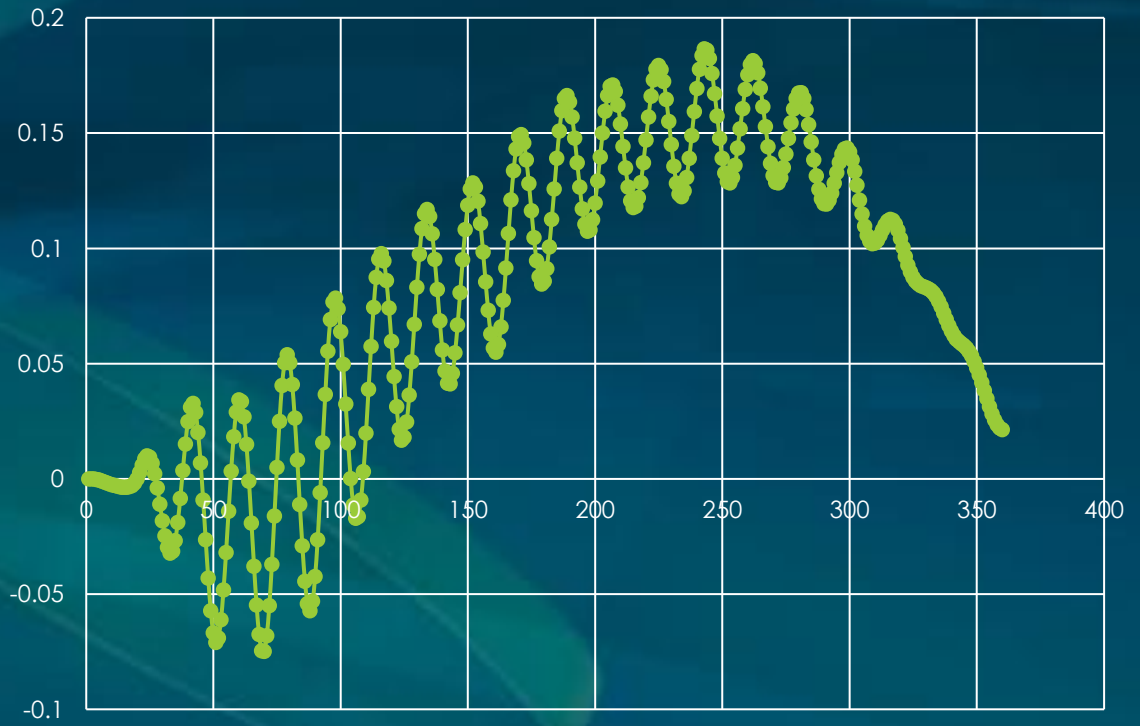
Results

- Integrating the velocity readings we obtain the displacement of the coastal wave.

$$S_{new} = S_{old} + \frac{1}{2}\Delta T(V_{i-1} + V_i)$$



$\int V.\, dt$



Results

- To cross-check the data, we recorded a video of the buoy motion and analyzed the video in Tracker software:

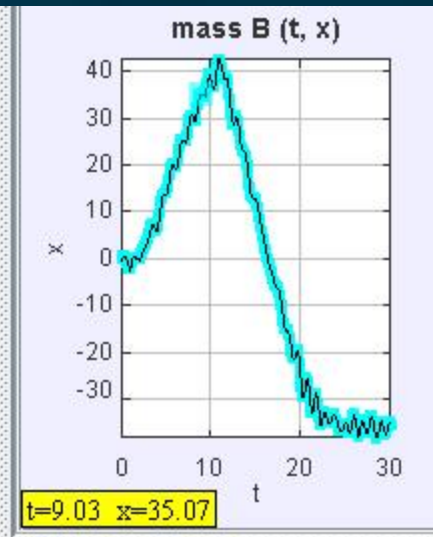


Table | mass B

t	x	y	v_x	v_y	a_x	a_y
8....	34...	0....	4....	12...	-3...	37...
8....	34...	1....	6....	12...	18...	11...
8....	34...	1....	6....	19...	18...	92...
8....	34...	2....	6....	21...	-1...	11...
8....	35...	3....	6....	23...	-5...	55...
8....	35...	4....	2....	28...	-9...	-1...
8....	35...	5....	0....	21...	-3...	-1...	
8....	35...	5....	0....	19...	0....	-1...
8....	35...	6....	0....	15...	0....	-1...
8....	35...	6....	0....	15...	0....	-1...
8....	35...	7....	0....	17...	-7...	-3...

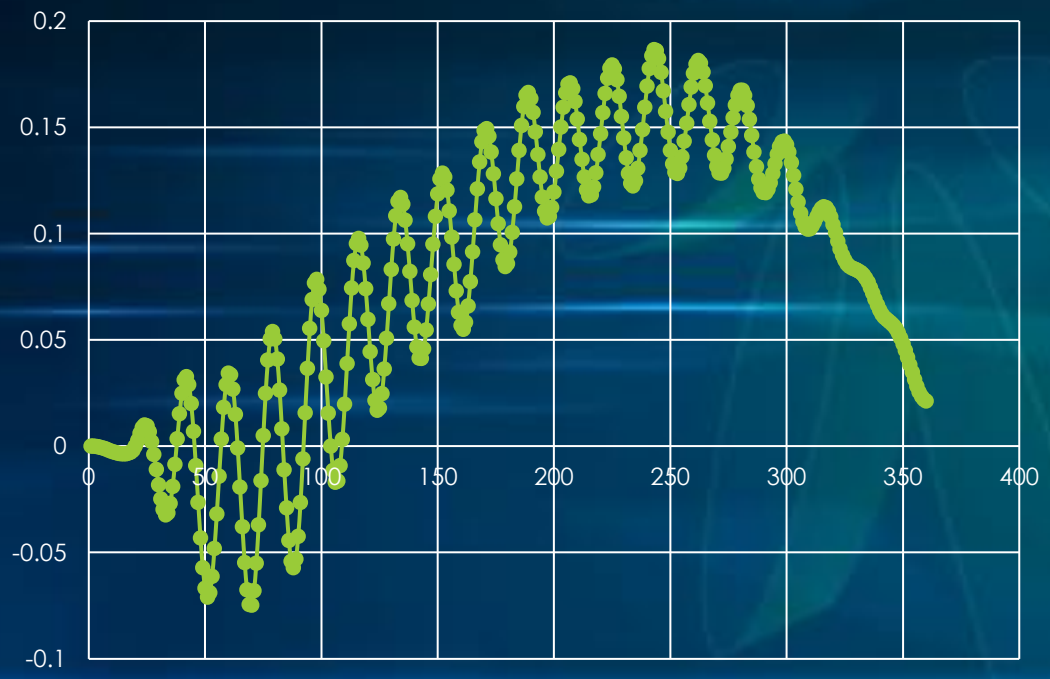
=-9.03

mass B selected (set mass on toolbar, shift-click to re-mark highlighted position)

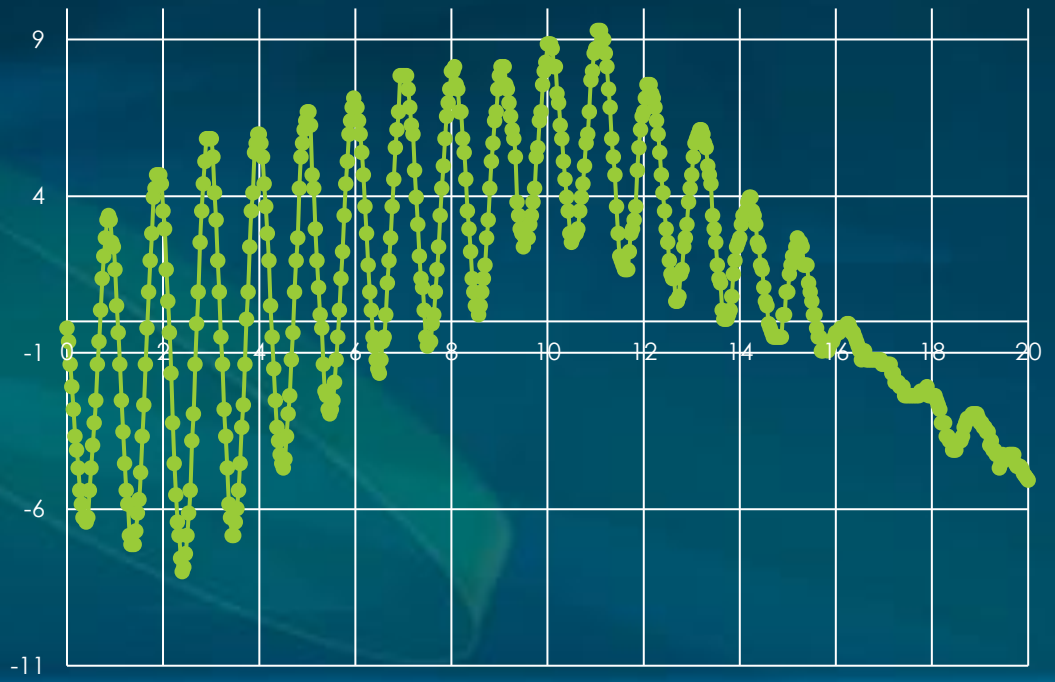
Results

- The displacement data can be obtained directly from Tracker after marking the same reference point in each frame of the video.
- The results are compared to the accelerometer data and look very similar.

ACCELEROMETER DATA



VIDEO ANALYSIS



Results & Future Uses

- In the event the buoy is deployed in a drifting mode, a GPS module onboard can transmit its location.
- The location is broadcast via Xbee every 90 seconds and is accurate to 10 ~meters. The Xbee has a range of 500 meters approximately in a no-obstacle zone.
- The buoy is also dual-purpose which means the container can be taken out and replaced with a WEC mechanism.

Thank You!