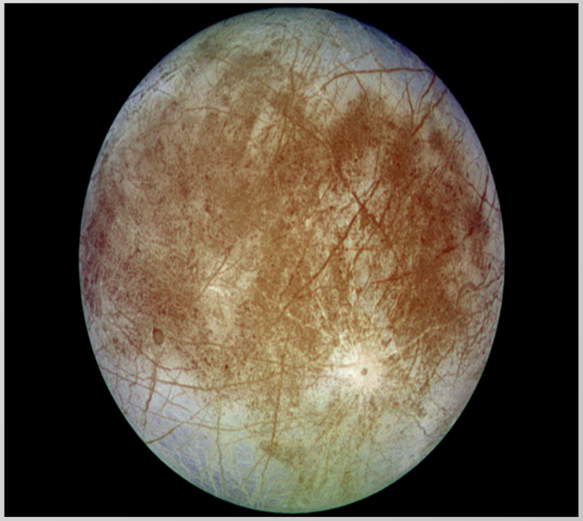
What is Europa?

Europa is :

- Sixth closest moon of planet Jupiter .
- Sixth largest moon in the Solar System .
- A water ocean hypothetically exists beneath a thick shell of ice surfacing Europa.



Project Description

- Explore a multi-node radio communications capability, such that multiple submersibles exchange information underwater with a lander and each other for the purpose of exploring Jupiter's icy moon Europa.

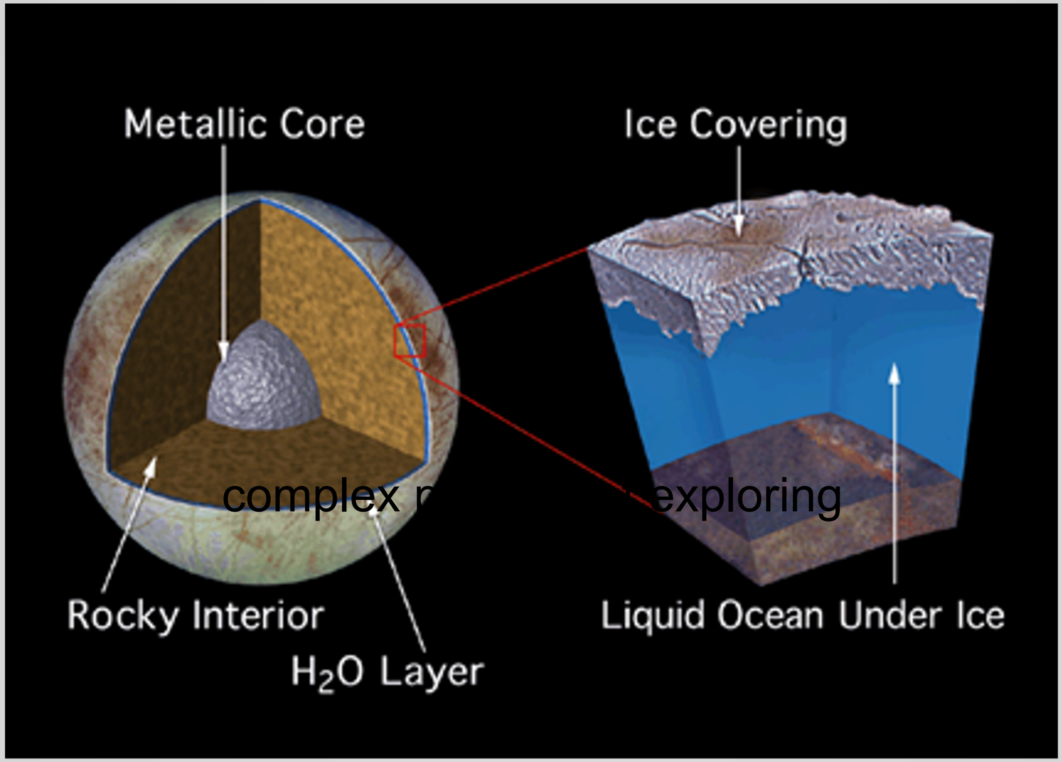
- The exploration region of highest interest lies in the hypothesized sub glacial ocean.

- Europa is a promising life harboring moon.

Project Description

- Develop a concept of operations describing the exploration process as it is pictured to take place after the payload has been deployed underwater.

- Prototype development to test the feasibility of the proposed concept of operations and the viability of RF communication underwater.


Metallic Core
Ice Covering
complex
exploring
Rocky Interior
H_2O Layer
Liquid Ocean Under Ice

What are we looking for ?

- Sign of life on Europa .

- Water Properties and Measurements :

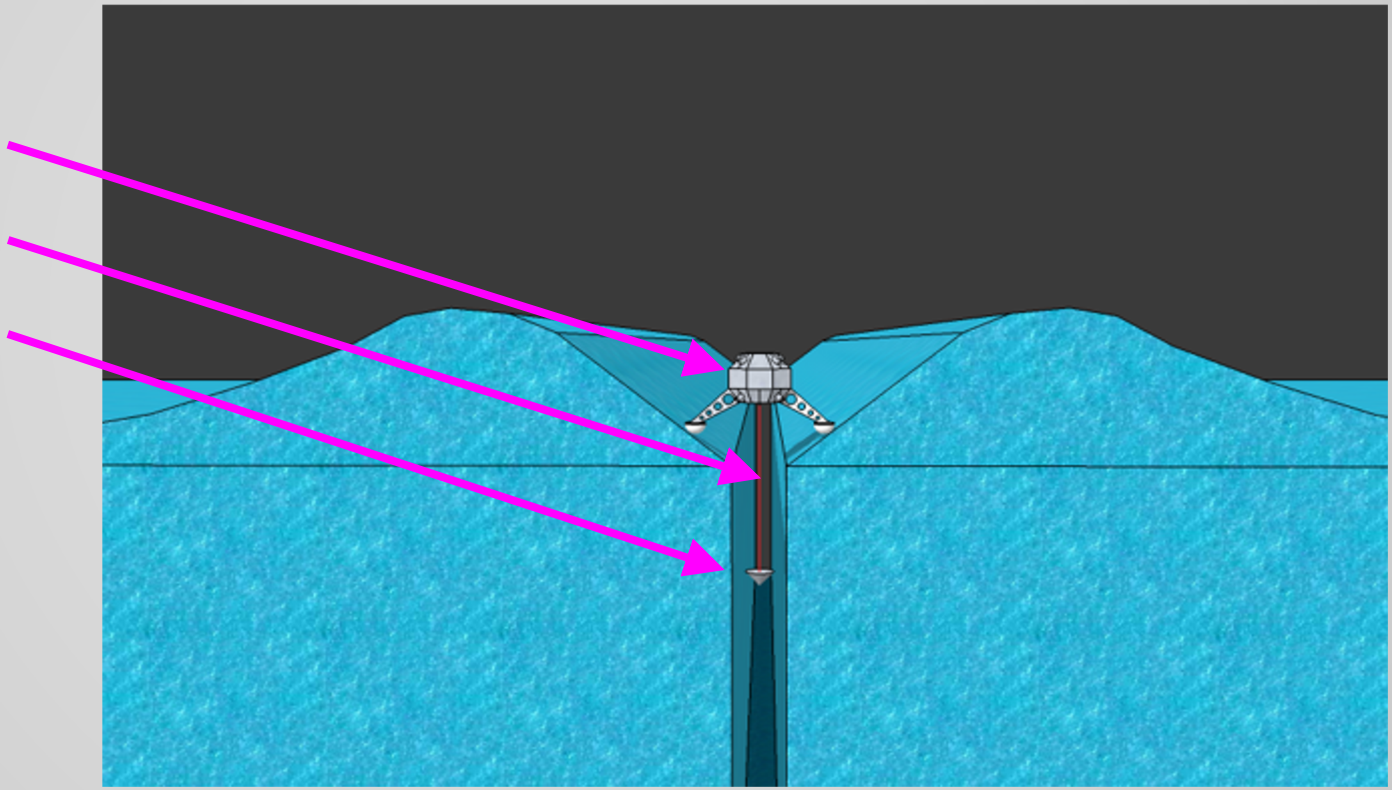
1. pH
2. Pressure
3. Salinity
4. Hardness
5. Dissolved oxygen
6. Specific conductance
7. Water temperature

- Videos and images

Mission concept of operations

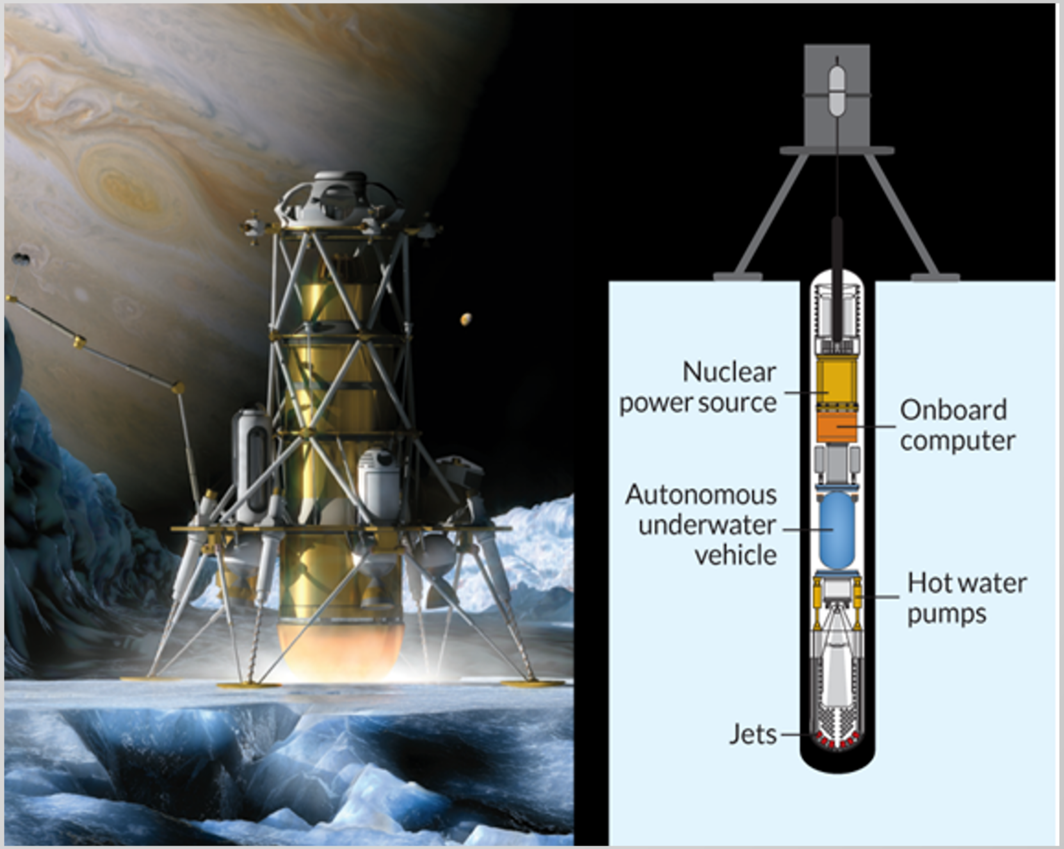
The scenario consists of :

- A lander
- A tether
- A casing



Mission concept of operation

- The **lander** sends information back to earth.
- The **tether** connects the casing with the lander.
- The **casing** holds:



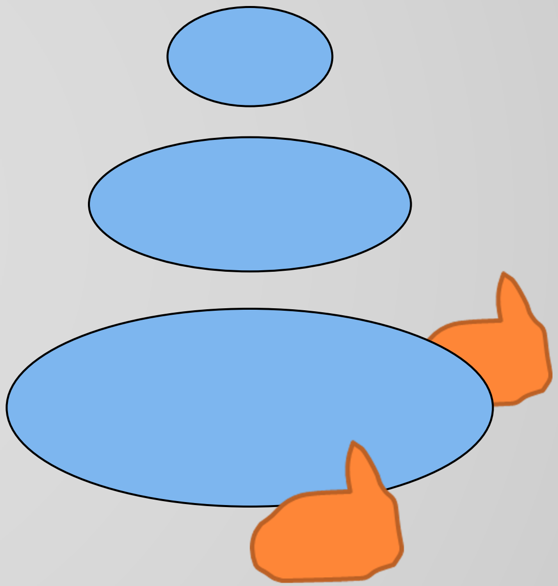
- Two small autonomous underwater vehicles.
- Onboard computer.
- Charging stations.
- Main communication node.

How will AUVs know where to explore?

•AUVs are preprogrammed to explore ocean water and equipped with Artificial Intelligence (AI) to maneuver around obstacles.

•AUVs measure data along circular paths increasing in diameter with depth.

• Miniaturized side-scan sonar is used for mapping and navigating the environment.



Positioning and tracking system

- AUVs' functions require the presence of positioning system to identify a specific location and map the surroundings. The following positioning systems were chosen:

1)Inertial Navigation system

Positioning and tracking system

2)Acoustic system (Ultra short Baseline):

•To mitigate the drifting problem of the Inertial navigation system.

•It identifies the position in two dimensions only.

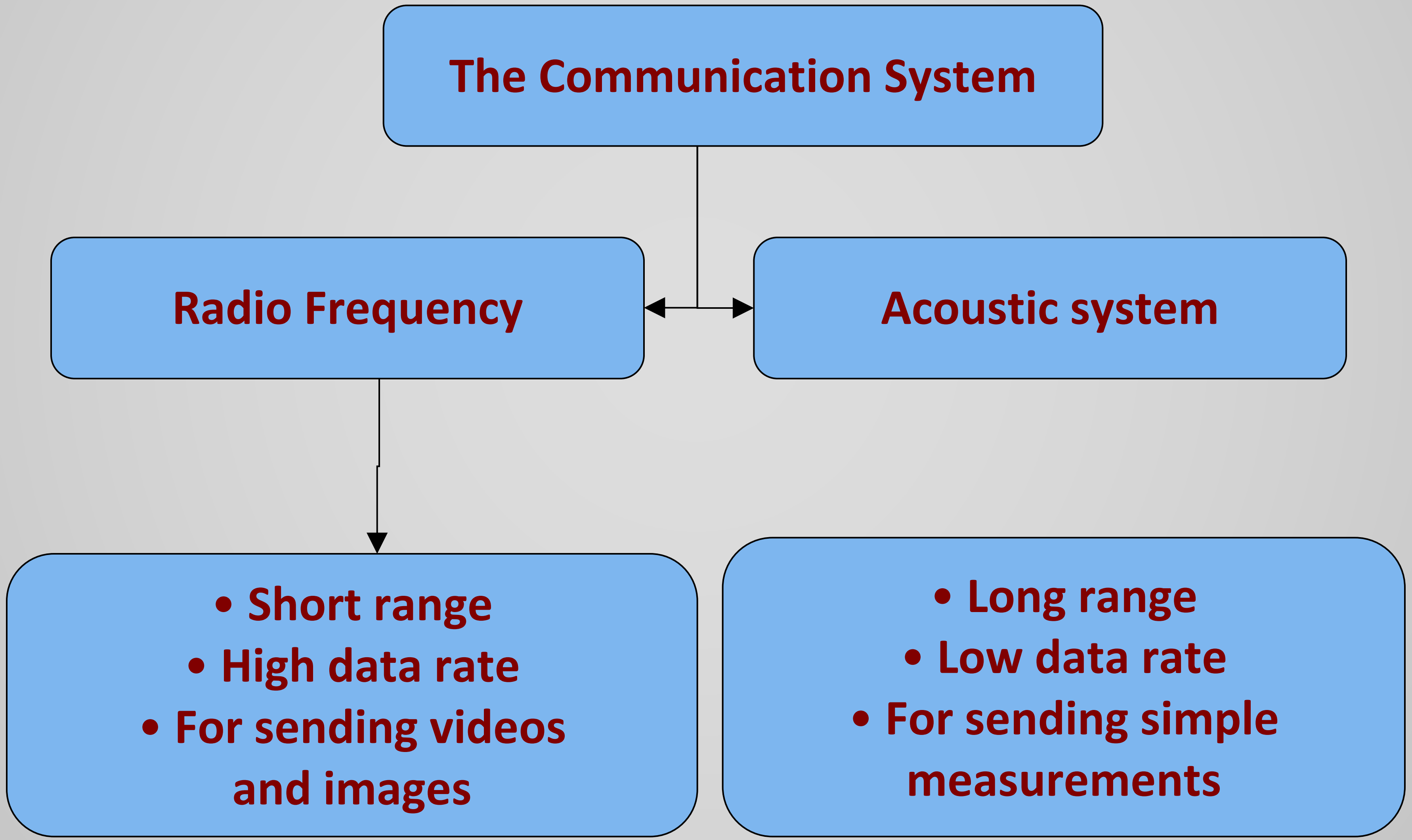
•Main communication node holds an array of transducers.

•Each AUV has a transponder mounted on it.

Positioning and tracking system

- Pressure sensor is used to calculate the third dimension.
- The AUVs are equipped with Artificial Intelligence (AI) to maneuver around obstacles.
- The AUVs have obstacle avoidance capabilities.
- Miniaturized side-scan sonar is used for mapping and navigating the environment.

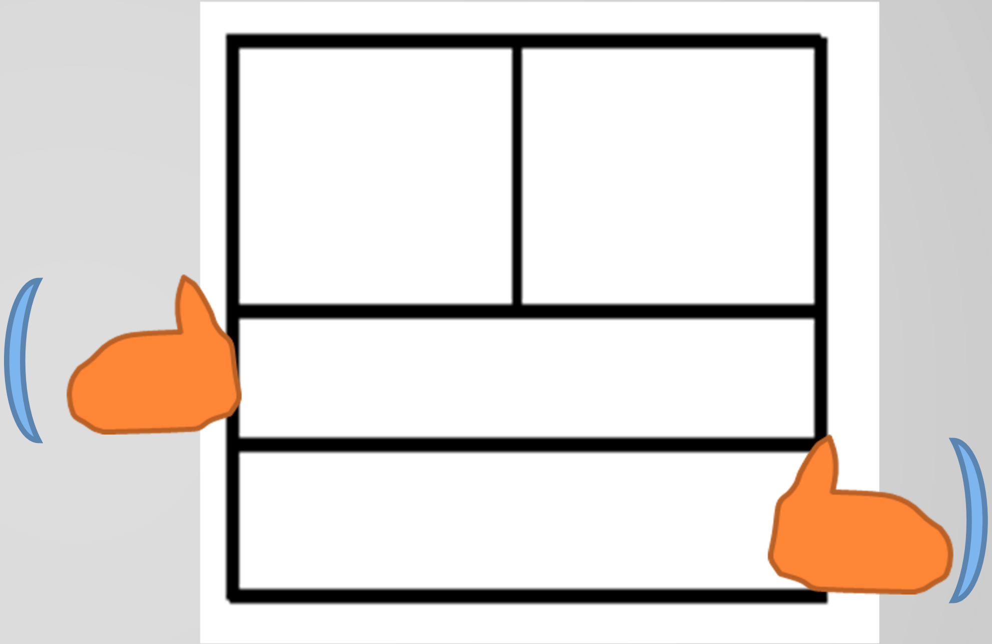
The Communication System



Steps of Exploration

Step1: Arrival and Release

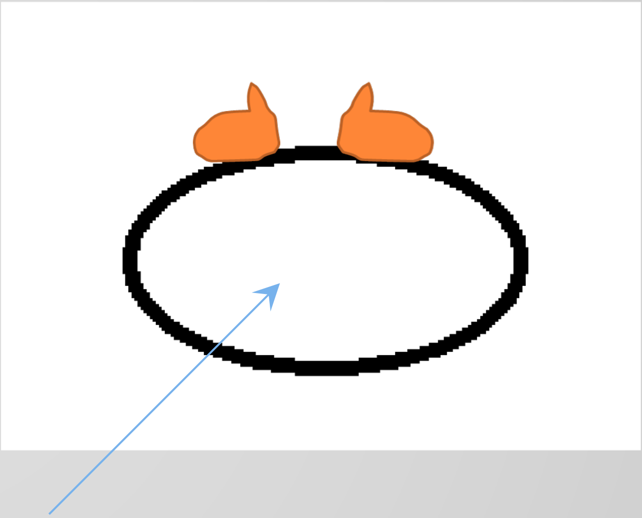
- Lander boots up the main communication node.
- Main communication node turns on the 2 AUVs.
- Chamber exits are open
- AUVs release themselves in water.



Steps of Exploration

Step 2: Initial Readings

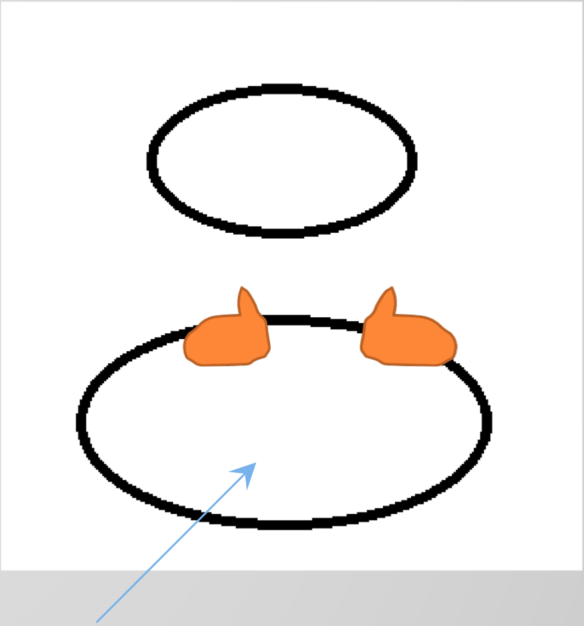
- Each AUV covers the perimeter of half a circle of radius 10 cm and takes measurements instantly after exiting the chambers.



Steps of Exploration

Step 3:

- The two AUVs dive to reach the same level.
- They explore along a circle of 20 cm (numbers are generally subject to change but are representative of the pattern.)



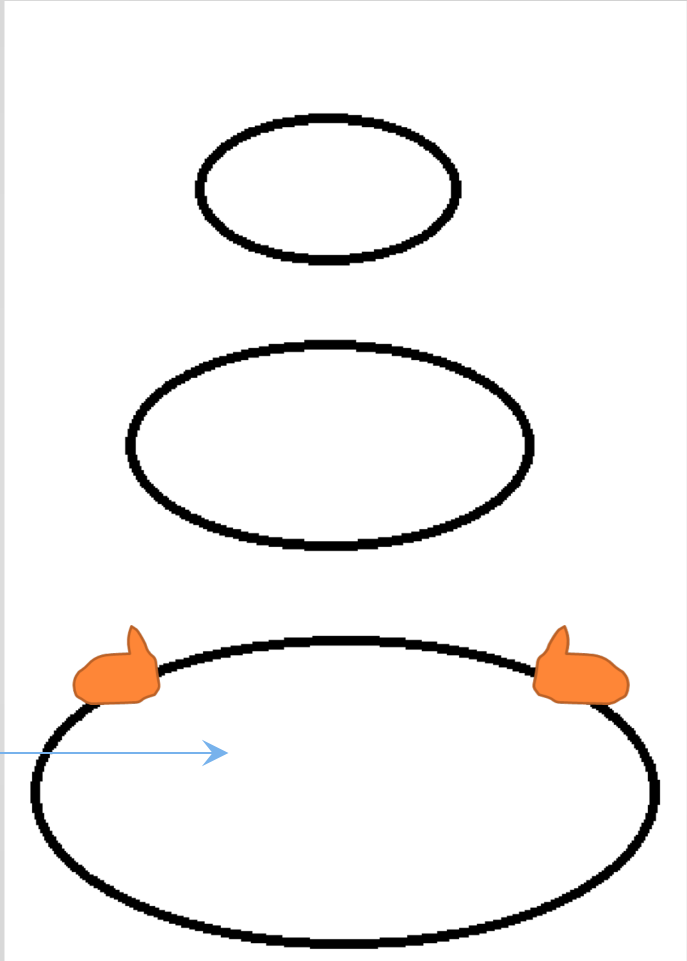
20 cm

Steps of Exploration

4) Step 4:

- AUVs dive an extra 50 cm.
- AUVs cover a circle of radius 50 cm

50 cm



- AUV 1 continues taking small steps.

- AUV 2 starts taking larger steps both deeper and wider.

Steps of Exploration

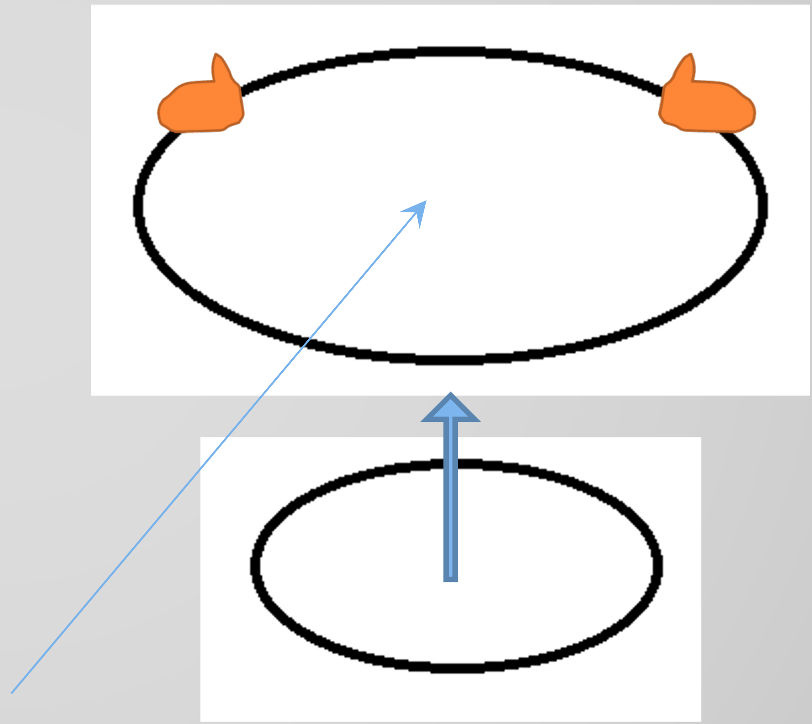
5) Step 5:

- AUV 2 increases its depth and circle radius exponentially: 10m,20m,50m,100m…

Steps of Exploration

6) Step 6:Heading Back

- Same pattern will be followed in the reverse direction.
- AUVs head back to the starting point, with radii of circles increasing with decreased depth.

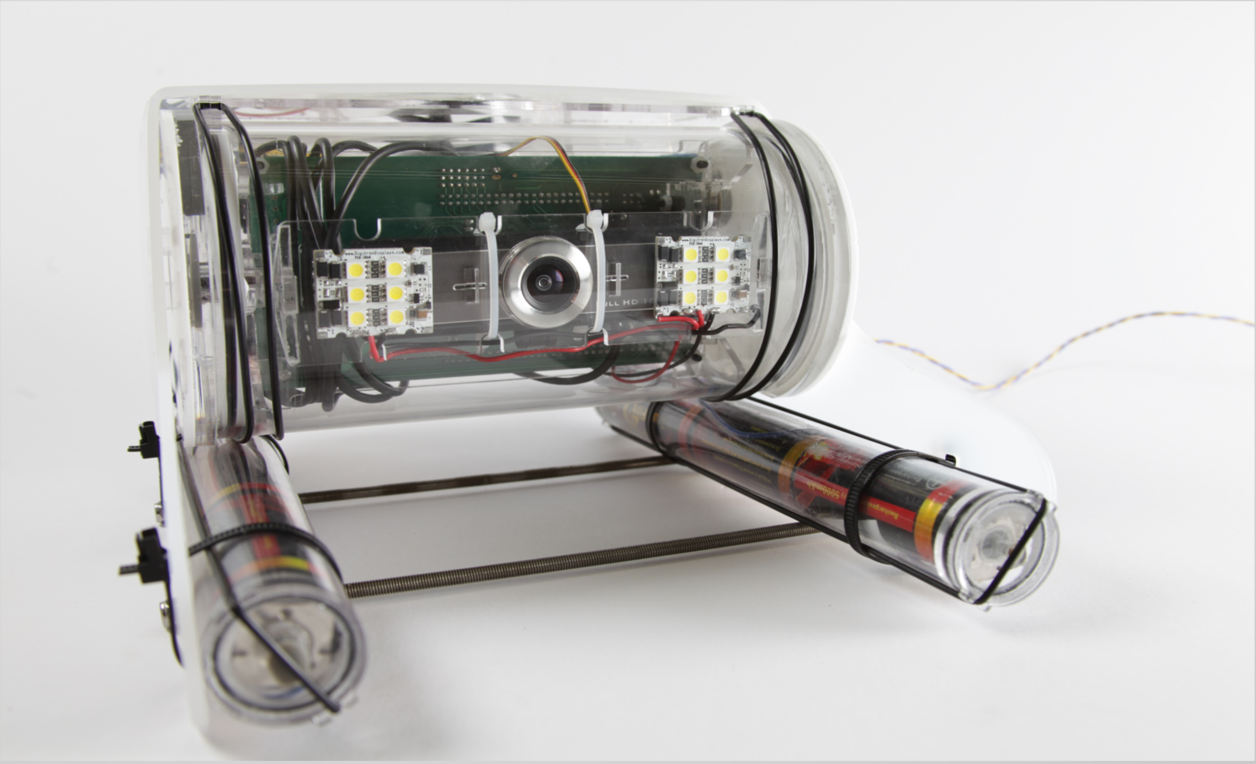


Increased radius

- AUVs charge their batteries periodically from a charging station contained inside the casing connected to solar panel mounted on the surface of the moon.
- Small obstacles are avoided (AI).
- AUVs inspect the path
- AUVs decide on totally new path in case of huge obstacles.

Prototyping : Open ROV

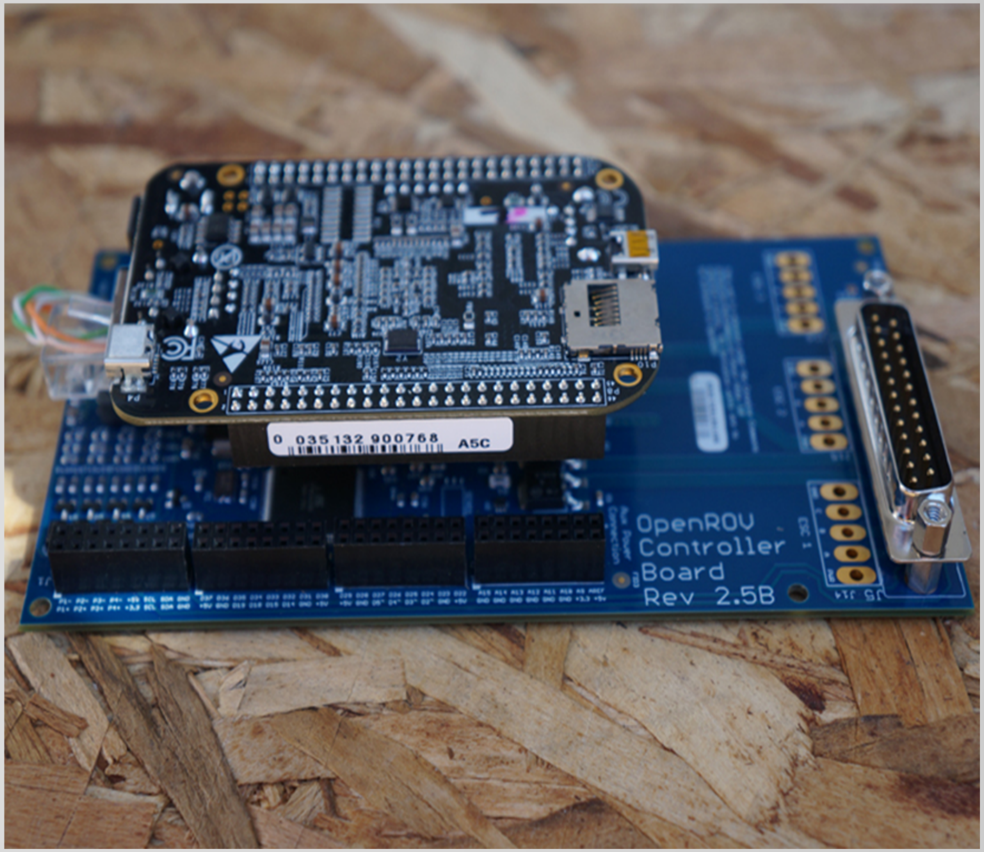
- An ROV was assembled by our team to perform as a main communication node .
- It simulates the motion capability of the AUVs in the CONOPs.



Open ROV Features

Control System

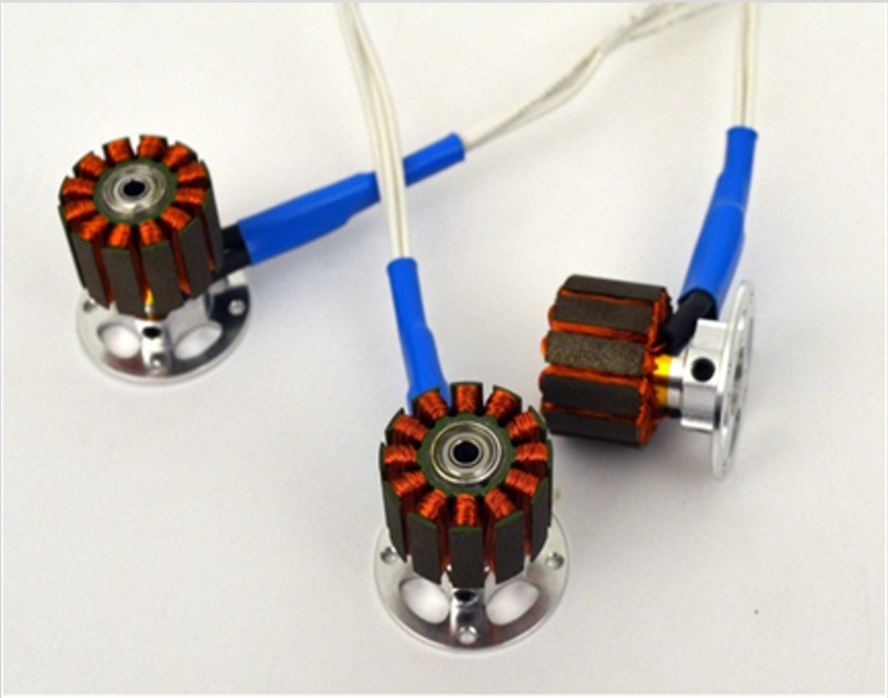
- Beagle bone embedded computer.
- Controller board with an Arduino microcontroller.



Open ROV Features

Motion and Maneuvering System:

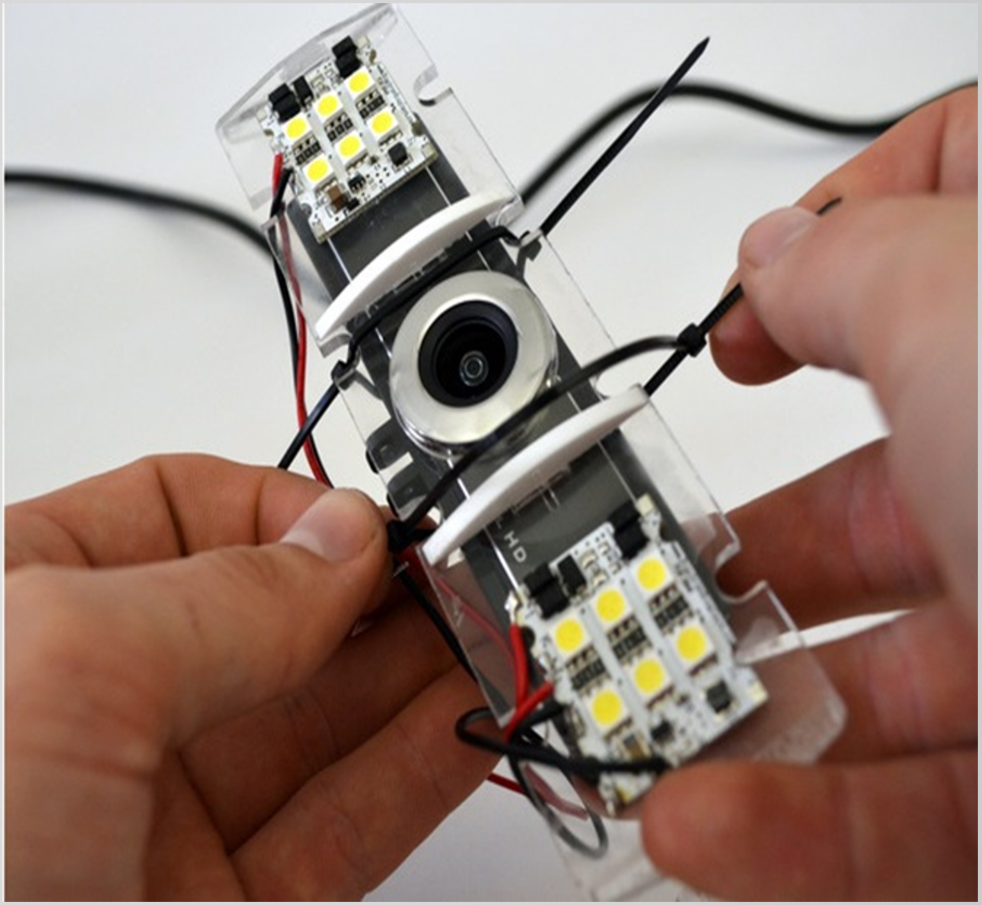
- Three Brushless DC motors with Propellers.
- Electronic Speed Controllers.



Open ROV Features

Imaging System:

- HD Camera with Live streaming video
- LED lights
- Laser for measuring distance.



The Submersibles Design

Three submersibles were designed and built by our team:

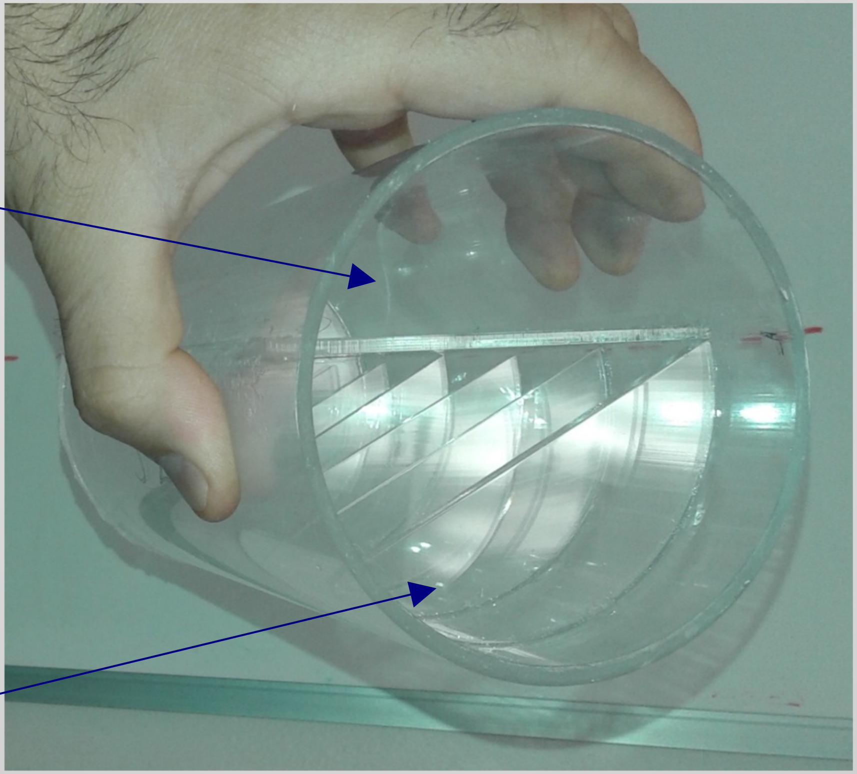
One mounted on the OpenROV (Main communication node), while the other two are equipped with sensors and remain buoyant underwater collecting information and sending it back to the main communication node.

The Submersibles Design

The design is simple and very low cost:

- The main body of the submersibles is a cylindrical Acrylic tube.

Upper plate for the electronics

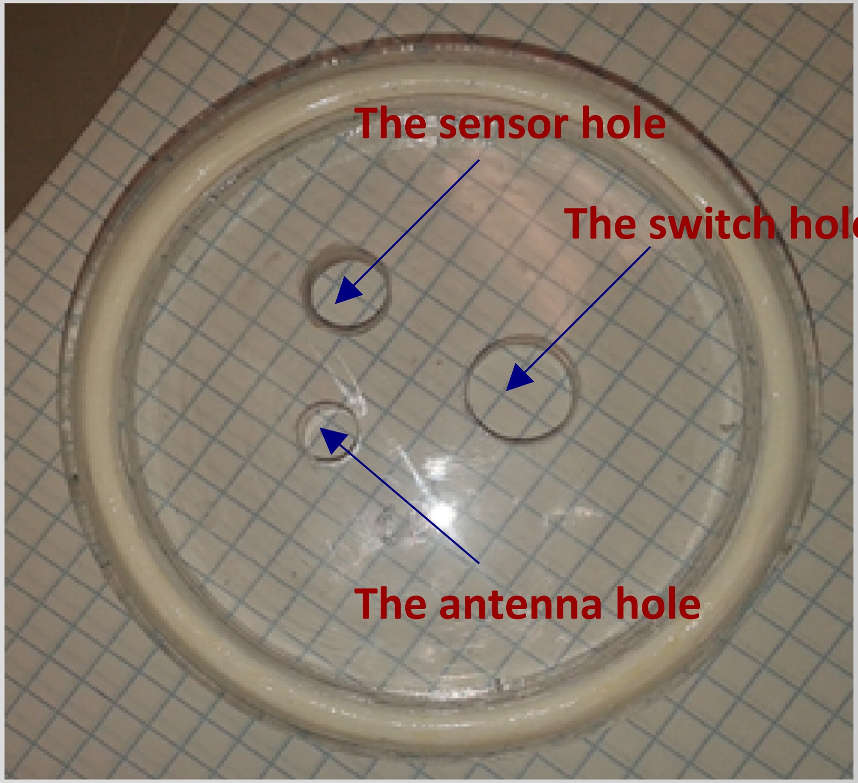


Chambers for placing weights(to achieve buoancy

The Submersibles Design

Easy to build, and can do the job

Laser cutting was used to design the covers and the holes for sensors .



The Submersibles Design

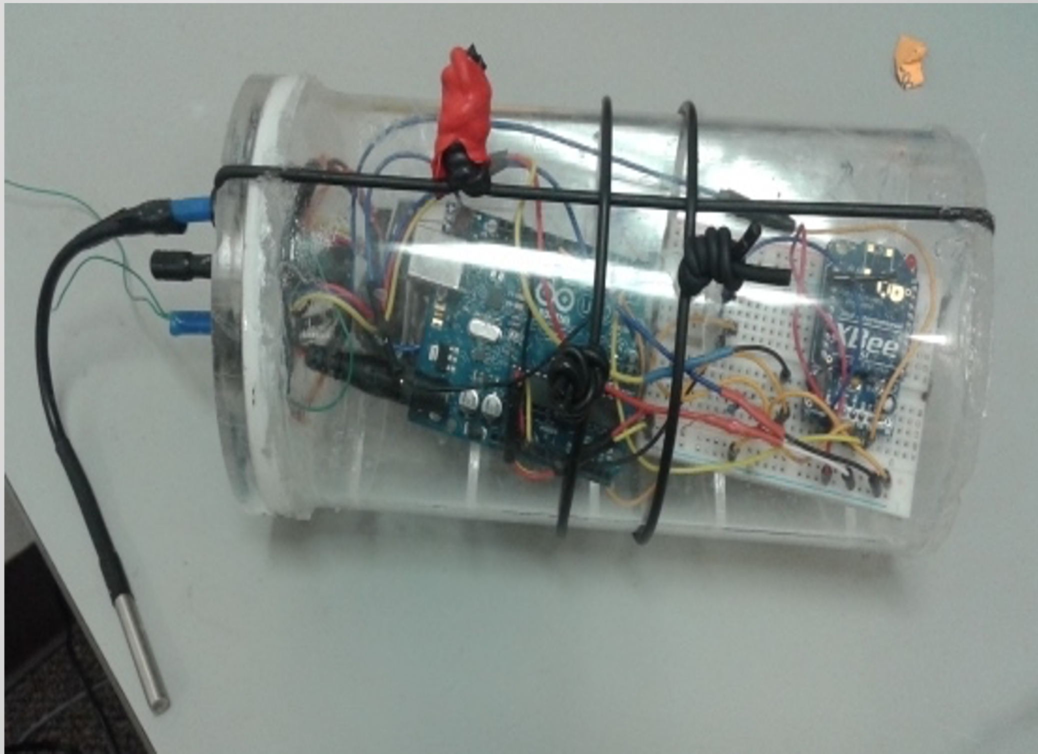
Submersibles hold:

- The communication system components in the inside, as well as the external parts (sensors, antennas and switches) .

Clear Acrylic material was chosen for the following reasons:

1) The ability to see the electronic circuit inside the submersibles.

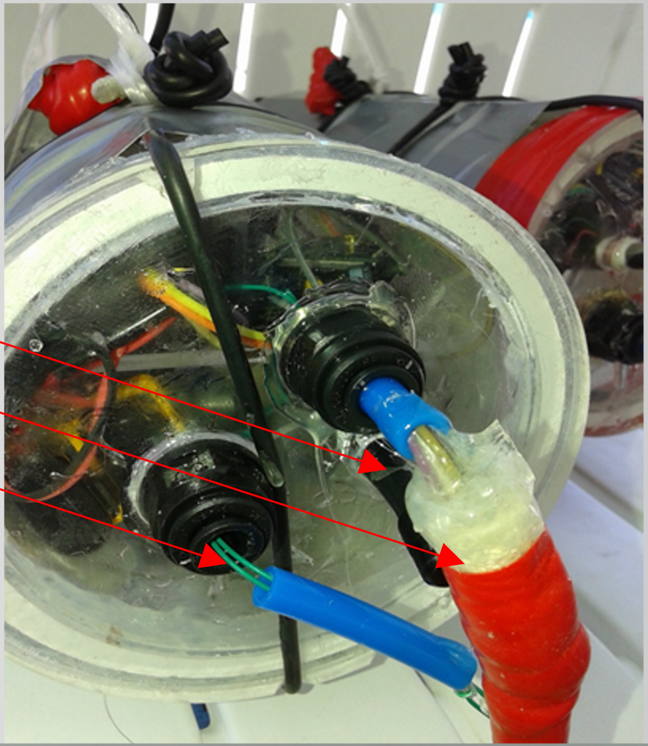
2) The possibility of checking for any leakage.



The Submersibles Design

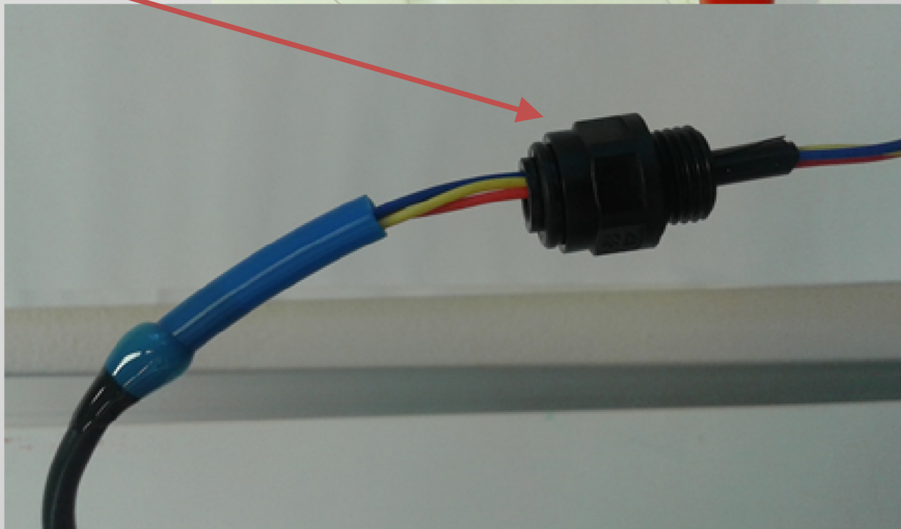
External Parts

- Antenna
- Sensor
- Switch



Pneumatic Fittings

- Threaded to avoid leakage.
- They form a sealed path for the sensors wires.
- Used for pressure relief.



The Submersibles Design

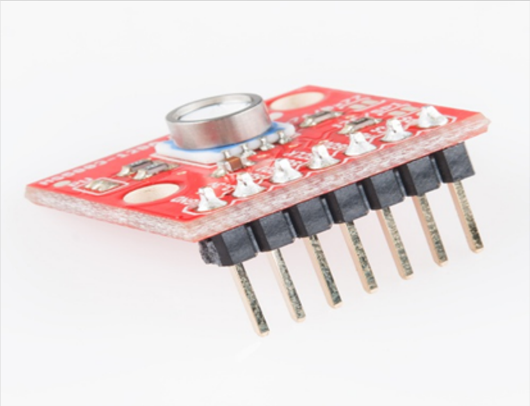
Submersibles

- Weight=1.96 Kg
- Stones inside

Sensor mounted on Submersibles.

- Waterproof temperature sensor

- Pressure sensor



Underwater RF Communication

- Detailed and thorough research was conducted to explore the viability of RF communication underwater utilizing **1mw, 2.4 GHz Xbee modules**.
- **Attenuation problems** of RF led to minimal attention from scientists and engineers for usage in underwater applications.
- Testing of RF communication showed promising results if it is to be used back to back with another communication system that allows for a longer range.

Why Xbee

- Low cost
- Low Power
- Easy to configure
- Reliable
- Supports large number of nodes

Testing the communication system

First Test:

Objectives:

- Find a correlation between the vertical/horizontal distance and the signal strength.
- Study the effect of the antenna orientation on the signal strength.

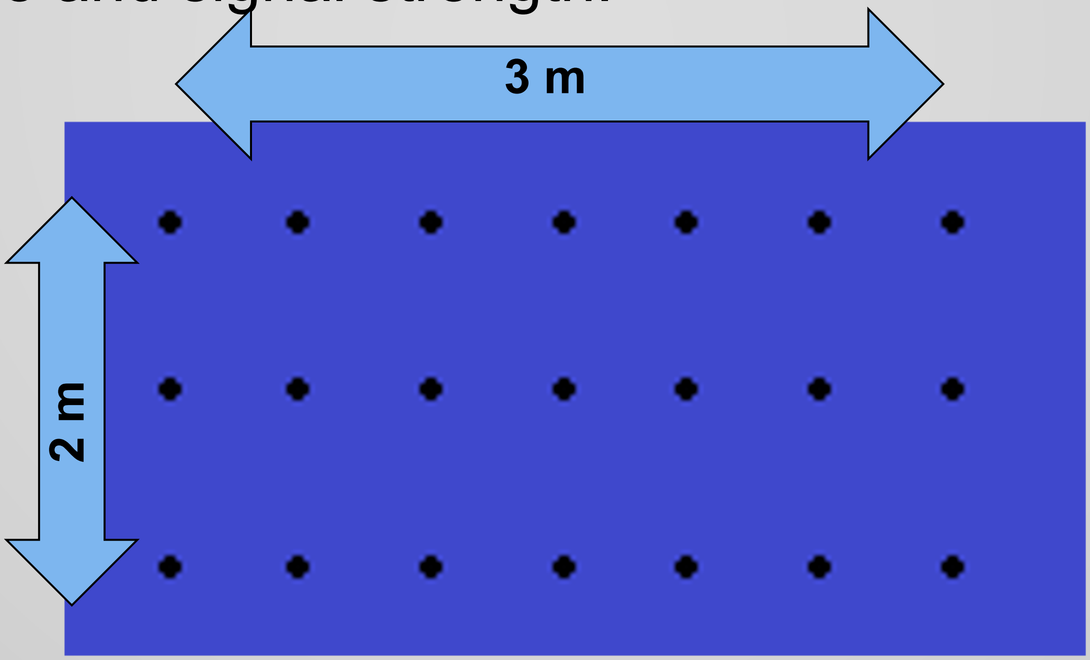
Testing the communication system

- The following test involved three submersibles, two of which were stationary and the third was mounted on the OpenROV.

- Main communication node sends specific commands to the two stationary submersibles to get the sensors readings.

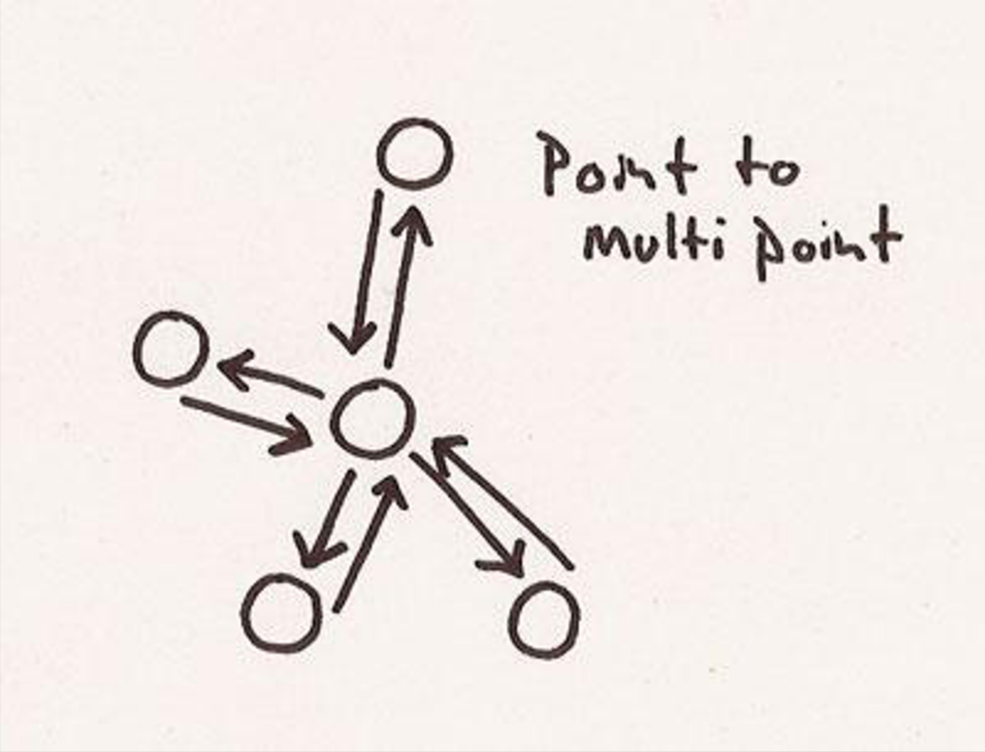
Testing the communication system

- The tests involved having multiple testing points underwater.
- Xbee modules were tested in different arrangements across the points to get a relationship between depth, distance and signal strength.



Point to multi point Network

- One Master Xbee module.
- Two slave Xbee modules.
- Inside each submersible there is a Xbee module connected to an Arduino.



Pool test results

- 1mW Xbees were able to send data between each other when they are 35 cm apart underwater .

- Using 100mW Xbee module will give a better communication range underwater.

Conclusion

- ✓ The viability of radio frequency for Europa mission
- ✓ RF technology applied in underwater communications is an excellent candidate for providing higher data rates than those achieved by acoustic systems.

Thank you