ROV

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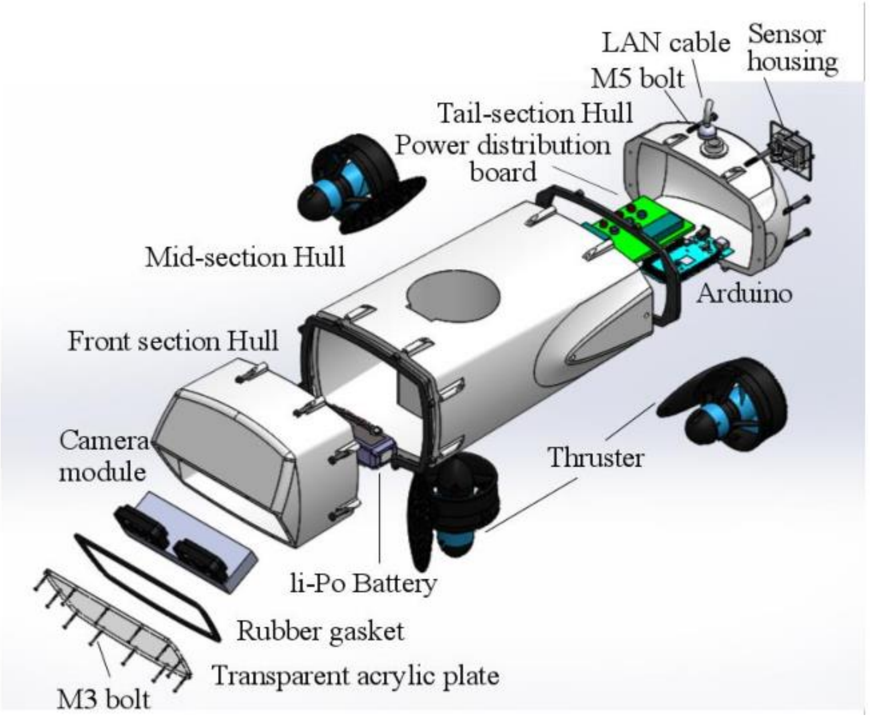
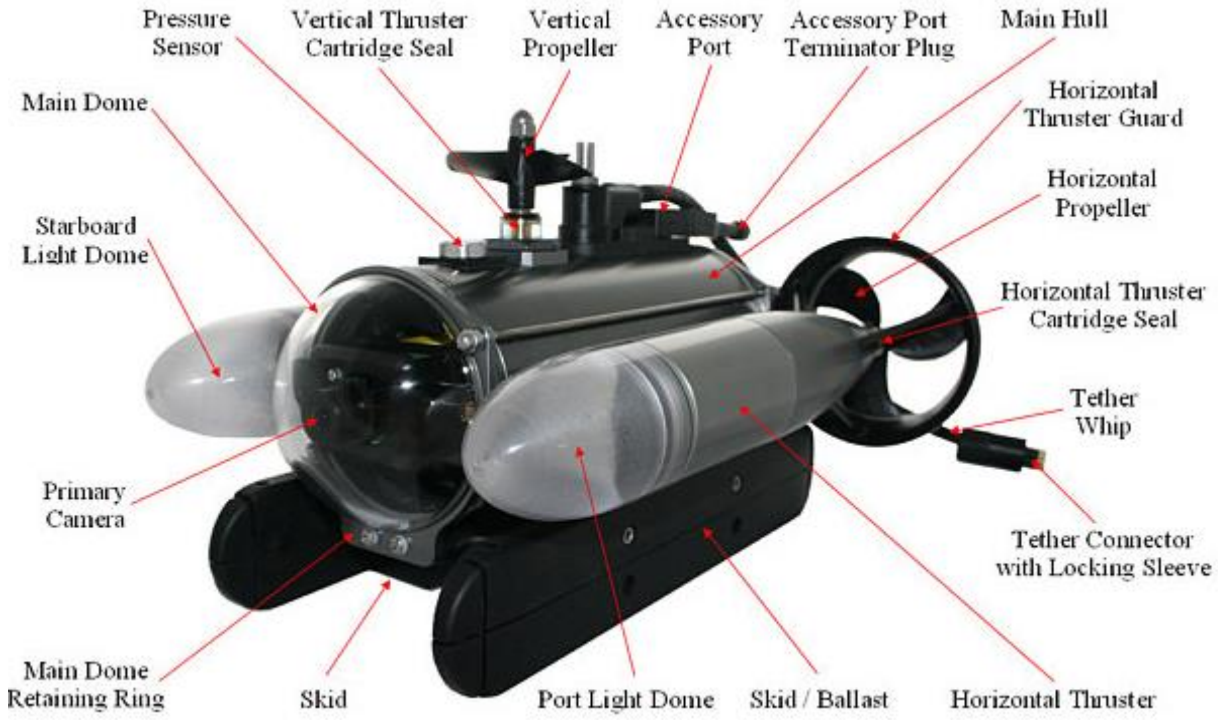
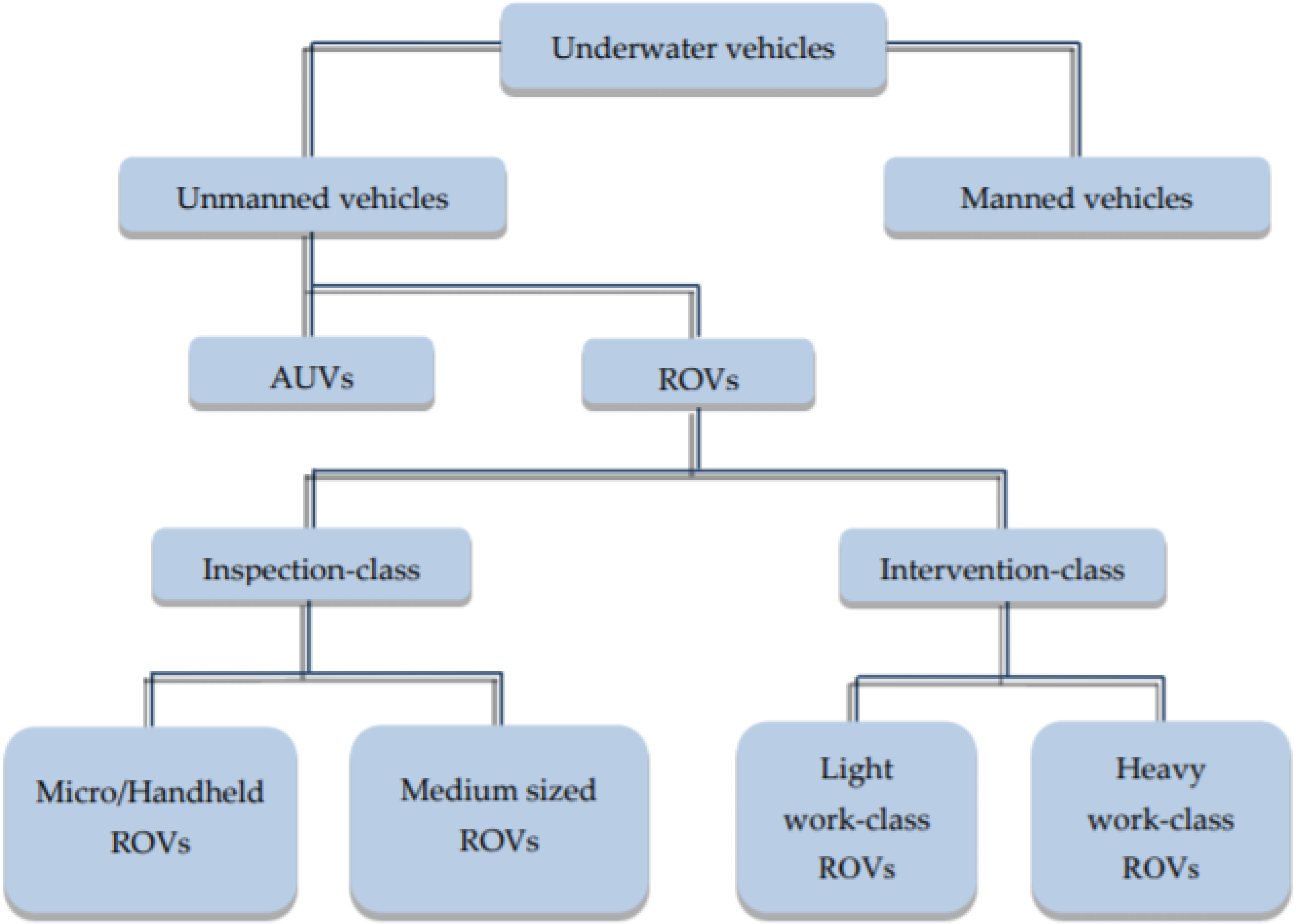
PHYICAL DESIGN

Sample design with components



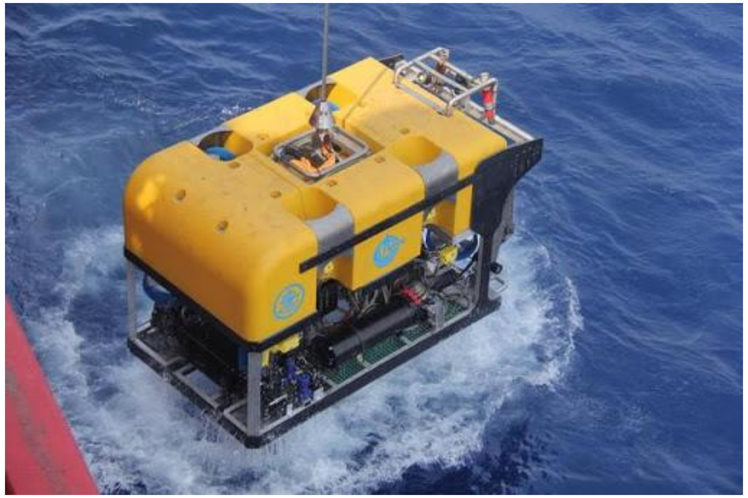



Underwater vehicles
Unmanned vehicles
Manned vehicles
AUVs
ROVs
Inspection-class
Intervention-class
Micro/Handheld ROVs
Medium sized ROVs
Light work-class ROVs
Heavy work-class ROVs

Intervention-Class or work-class ROV

Heavy work-class

- More robust type of machine, weigh up to 5000kg
- Propulsion are usually hydraulically actuated system
- The system can operated at deep area up to 6km depth in sea.
- Capable to do heavy workload



Intervention-Class or work-class ROV

Light work-class

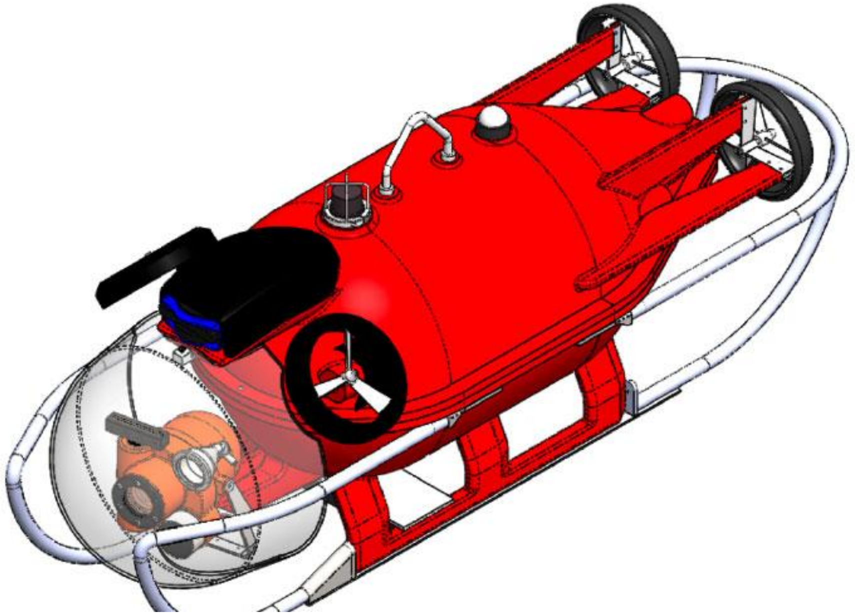
- Weight between 100kg and 1500kg
- Generally all-electric vehicle, and some with hydraulic subsystem
- Can be operated at depth up to 3km
- Work for cleaning, drilling and hot stabbing

INSPECTION CLASS
MICRO OR HANDHELD

- Weight is between 3kg and 20kg, and can be deployed and recovered using manpower alone
- The aim is to reduce operational cost & system complexity.
- Types: cube shapes & streamline design
- Stability is less than open frame medium inspection ROV

INSPECTION CLASS
Medium sized

- Weight between 90kg and 120kg
- Open frame models, allowing for extra sensors and small tools to be added.
- The tools operates such as cleaning, latching or recovering of items.

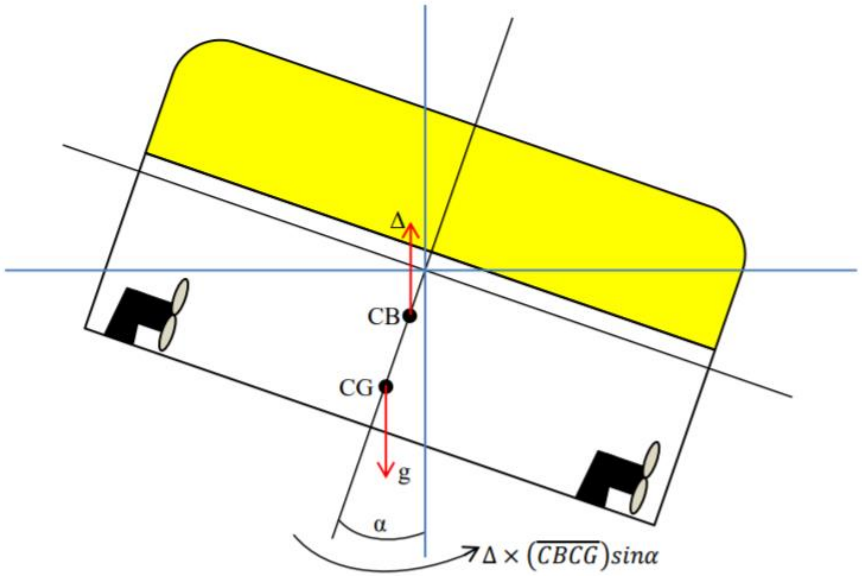


ROV applications

Application	Examples
Environmental	Coastal monitoring, habitat monitoring, pollution assessments
Security	Hull inspections, unexploded (UXO) ordnance surveys, contraband detection
Hydro power	Dam wall inspections, blockage detection at penstock intake
Aquaculture	Net inspection, removal of dead fish
Military	Mine hunting and disposal
Sciences	Seabed investigation, marine life studies, water and sediment sampling
Offshore oil and gas	Pipe and structure inspection, visual leak detection, diver buddy operations
Marine renewable energy	Structure inspection
Nuclear energy	Inspection and operation in areas causing danger to humans
Search and rescue	Search and recovery operations
Archaeology	Area mapping, diving buddy
Civils	Bridge and pier structure monitoring, foundation inspection

ROV (Inspection-class) shape and design

- Commonly open frame type (aids the stability of the robot) related to centre of gravity (CG) and centre of buoyancy (CB)
- If the displaced water from the object could keep its shape, then the CG of this displaced water is equal to the CB of the object. The location and values of the CG and CB is related to the shape, weight and volume of the object.



ROV Buoyancy

- ROV are constructed of material that have density lower than water
- Buoyancy material able to withstand the pressure applied when operating at depth
- Material that often used:
  - Polyurethane foam
  - PUR
  - PIR
  - PVC
  - Co-polymer foam

ROV Frame

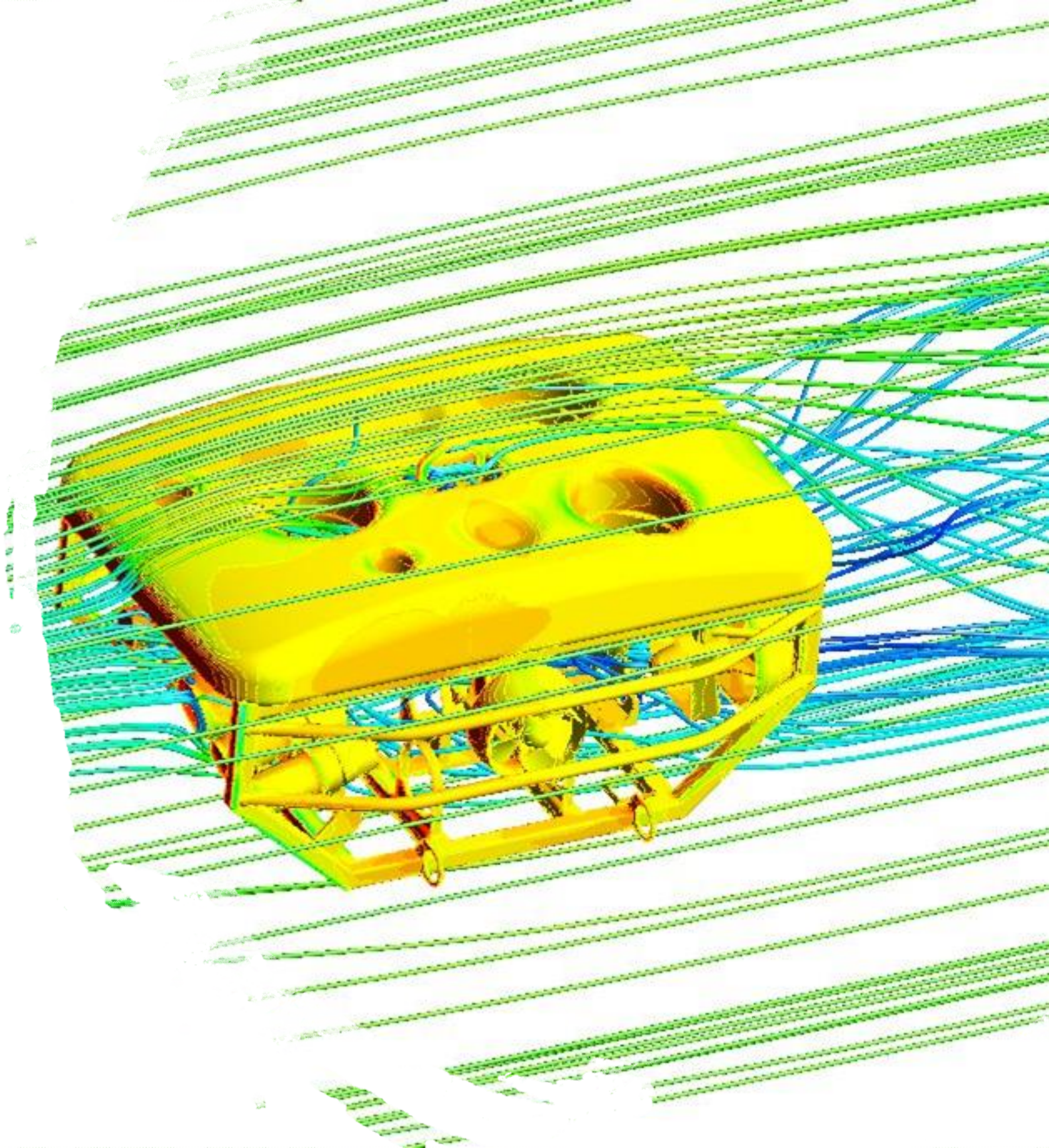
- Frame is used to mount equipment and provide support and protection during operation
- Stainless steel and aluminium is not ideal due to increased weight. So mostly use polymer as frame, such as Acrylonitrile butadiene styrene (ABS), high density polyethylene (HDPE) and polypropylene (PP).

Table 2. Inspection-class ROV polymer frame varieties.

Manufacturer	Model	Polymer Frame
Deep Ocean Engineering	Phantom T5	Polypropylene
ECA Hytec	H300 MII	Polypropylene
Lighthouse	Sirio	H.D. Polyethylene
SeaBotix	L200-4	H.D. Polyethylene
Saab Seaeye	Falcon	Polypropylene
Teledyne Benthos	MiniROVER	H.D. Polyethylene

Hydrodynamics

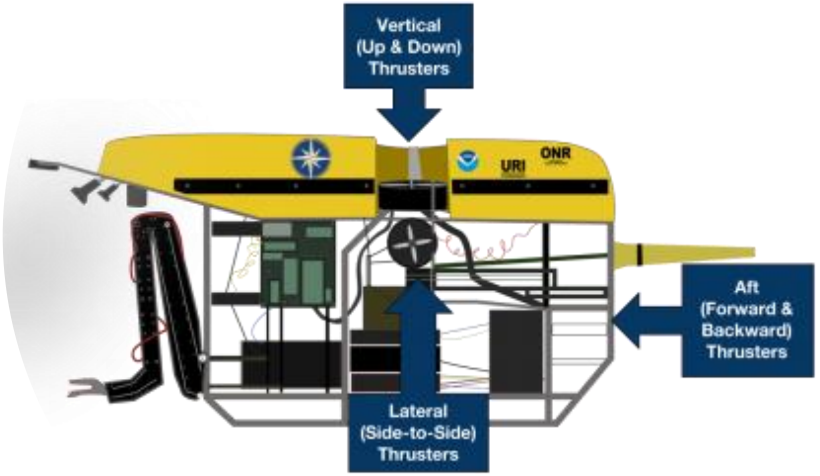
- Mostly used on work-class ROV
- Not design for speed through water but it is designed to use their high power to carry out heavy duty work.



Propulsion / Driving system & actuators

Thrusters

- DC thrusters that Dc motors used are:
  - Brushless DC motors
  - Brushed DC motors
  - Magnetically coupled motors
  - Rim Driven motors



Thruster Configurations/Architectures

- Factors influencing the type of configuration include size, available power, required thrust, degrees of freedom (DOF) required, payload, etc
- ROVs can have varying DOFs, depending on the orientation and number of thrusters on board.
- Orientation:
    - Heave—movement along the vertical plane
    - Surge—longitudinal travel along horizontal plane
    - Sway—lateral movement along horizontal plane
    - Heading—rotation about the vertical axis (z)
    - Pitch—rotation about the lateral axis (y)
    - Roll—rotation about the longitudinal axis (x)
- ROV has at least 3 thruster, 1 vertical, 2 horizontal

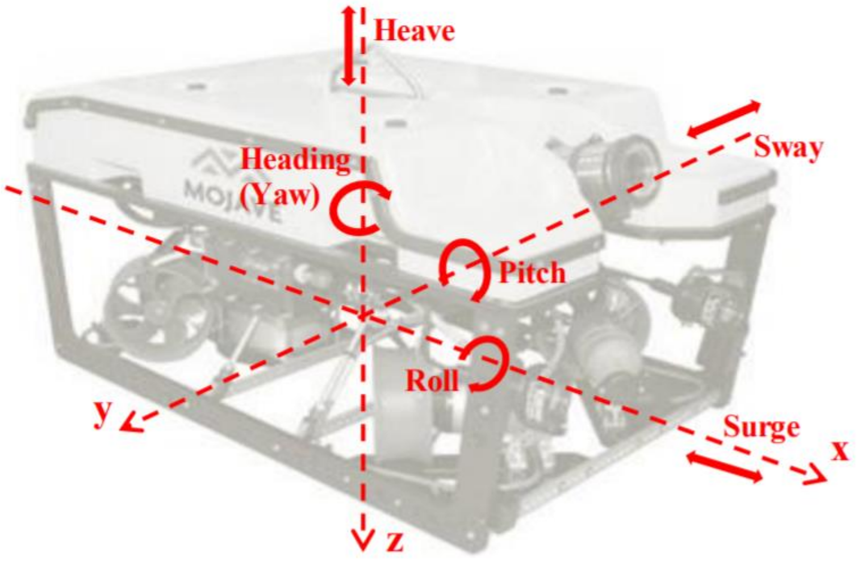
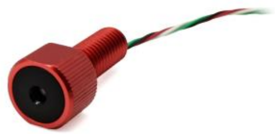


Figure 3. ROV with six degrees of freedom [127].

Navigation System & control

Pressure sensor



- Pressure sensing element made from a strain gauge or piezoelectric material, upon being subjected to pressure, will generate an electric charge, vary resistance or alter the frequency of oscillation from sensor output.

Auto-depth function

- Utilized the feedback from pressure sensor in a low cost system

Fibre optic sensor

- used for pressure and temperature underwater.
- mounted on an ROV for testing and accuracy of between 1 and 3 cm was achieved.

Altimeter

- Aka single beam echo sounder
- Used for detecting an ROV’s distance from seafloor using acoustic pulses
- Optical altimeter:
    - using laser triangulation mapping, have been used for a number of vision-based navigation, motion control and real-time mosaicking applications

Inertial navigation system (INS)

- Operating sensor in INS is inertial measurement unit (IMU), made up of 3 accelerometers and 3 gyros.
- The sensors measures acceleration and rotational velocity

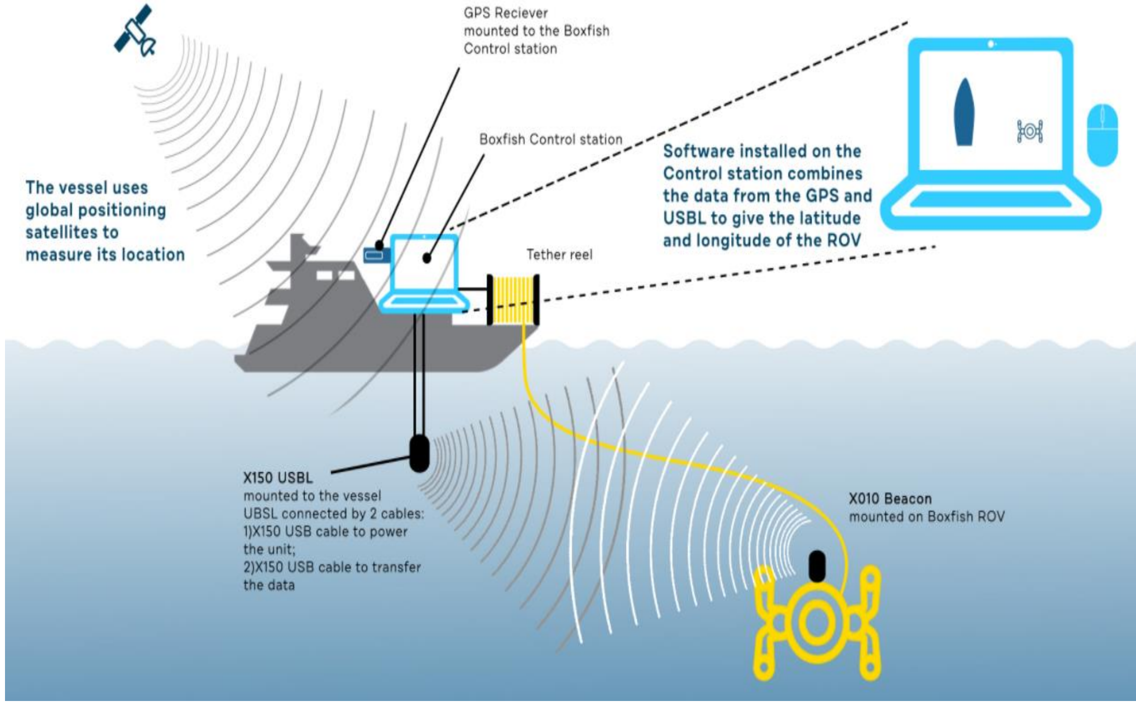
Positional accuracy

- Using advanced ring laser (RLG) or fibre optic gyro (FOG)
- Extremely accurate and not affected by distortion of Earth’s magnetic field and man-made structures and ferromagnetic

USBL System

- The USBL system consists of two main parts: a USBL transponder and a beacon. The USBL transponder is mounted or suspended from your vessel and communicates with the beacon on the Boxfish ROV wirelessly using high-frequency sound waves.

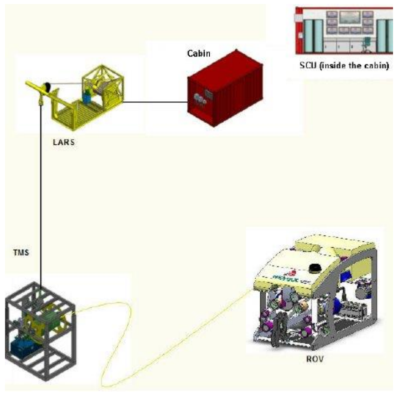
- The USBL transponder periodically transmits commands to the beacon, which the beacon will immediately reply to upon receiving. The USBL transponder can then measure the response time and returning signal direction to calculate the ROV’s 3D position relative to the boat

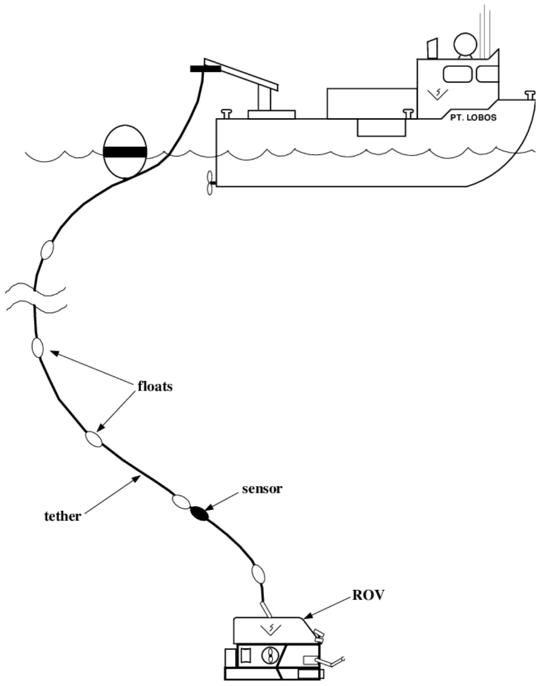


Data Collection and Transmission

Power management

Tethered power system





- the wet end equipment on ROVs utilises DC power at low to medium voltages. However, , low voltage DC transmission from the top to bottom side would require large conductor cross section choice in the tether to minimise ohmic power losses.
- AC power transmission system STEP UP at sending end (top side), STEP DOWN at receiving end (wet side).

Battery power system

- Primary batteries:
  - this type of battery, once discharged, cannot be recharged
  - Alkaline, Inexpensive and safe, however, they have a tendency to outgas hydrogen when stored for long periods
  - Lithium cells, o have a longer shelf life and endurance. . Costs are higher and they should be used with special caution.
- Secondary batteries:
  - this type of battery can be recharged many times, increasing the usable life.
  - Different chemical reactions include lead acid cells, silver-zinc cells, nickel-cadmium (ni-cad) cells, and lithium-ion polymer cells