Robotic Hardware Systems (MCTE 4362)

Remotely Operated Vehicles (ROV)

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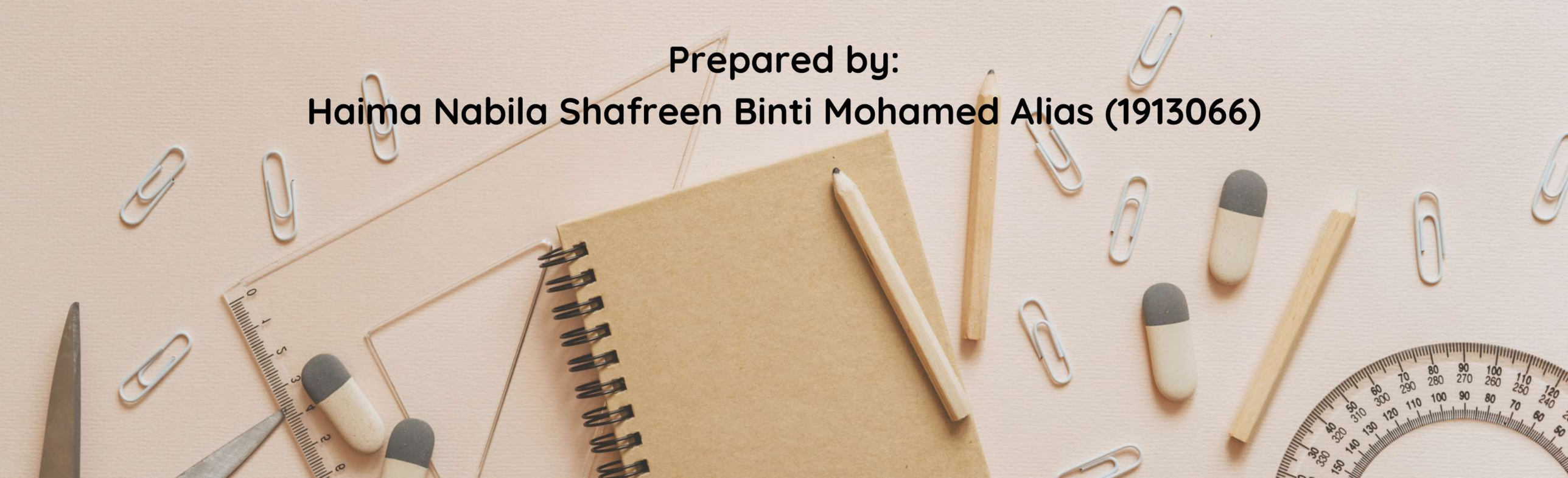


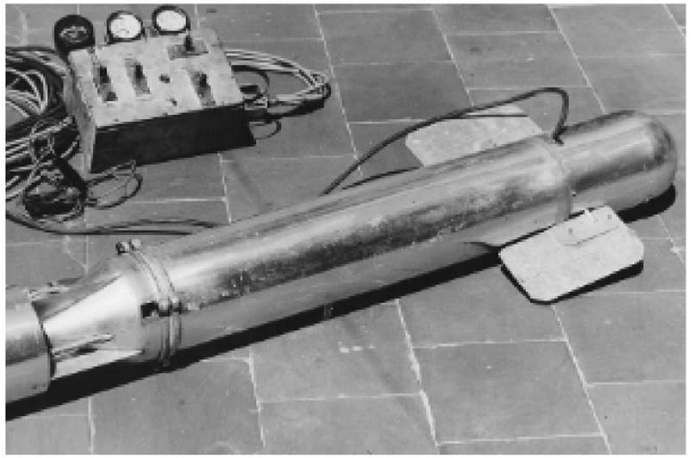
Introduction

- ROV is a type of underwater robot used for various applications such as exploration, research, inspection and maintenance.
- It is typically operated by a human operator using a control panel or joystick from a surface vessel or platform.
- ROVs can be used in a variety of environments, including deep ocean, shallow water, and freshwater systems.
- They can be used for tasks such as pipeline inspection, maintenance and repair, salvage operations, and scientific research.
- ROVs are often used in situations where human divers cannot safely or efficiently operate.

- ROVs can be categorized into two types: work-class ROVs and observation-class ROVs.
- Work-class ROVs are larger and more powerful, and are designed for heavy-duty tasks such as offshore oil and gas drilling, pipeline installation, and subsea construction.
- Observation-class ROVs are smaller and lighter, and are used for tasks such as seabed mapping, marine life observation, and environmental monitoring.

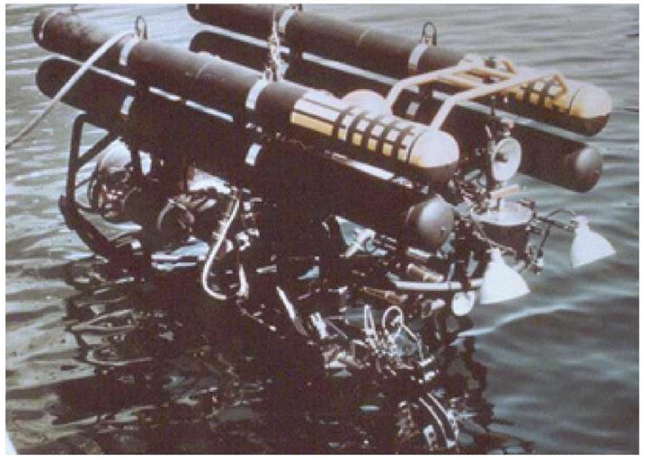
History & Applications

- The first ROV, named POODLE was developed by Dimitri Rebikoff in 1953.
- Most of the early ROVs were developed in the 1960s by the US Navy for military purposes such as mine detection and reconnaissance.



POODLE, developed by Dimitri Rebikoff.

Royal Navy ROV.



CURV I, developed by US Navy.

- The United States Navy developed the ROV technology in the 1960s.
- Commercial firms recognized the potential of ROVs for offshore oil operations.
- Work-class ROVs were created to assist in the development of offshore oil fields.
- Work-class ROVs are larger and more capable than inspection-class ROVs.
- ROVs became essential in the 1980s for offshore development that exceeded the reach of human divers.
- Since then, the offshore oil & gas industry has heavily relied on ROVs for subsea exploration, construction, repair, and maintenance.

- ROVs are now used for a wide range of applications, including underwater exploration, scientific research, search and rescue operations, and even filmmaking.

Saipem: Hydrone-R, used to monitor and inspect underwater.

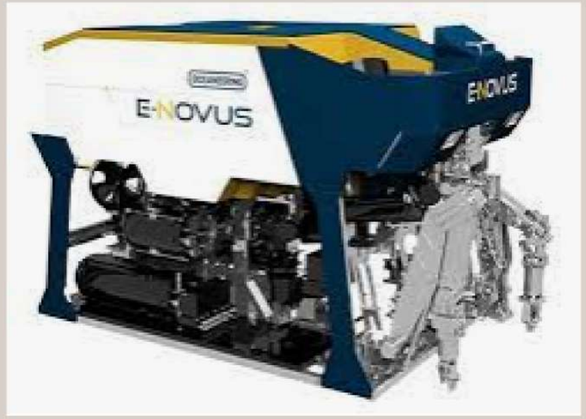
Deep Trekker Revolution, used to search and rescue, inspection and aquaculture.

REMUS 600, used for mine countermeasures, reconnaissance, and underwater survey operations.

Main Components of the Vehicle

1. Hull Design

- The hull is the outer shell of the ROV, which protects the internal components from the underwater environment.
- ROVs have hulls designed to withstand high pressure and corrosive seawater environments. The design varies depending on the intended task, and materials can include aluminum, composite materials, and syntactic foam.
- The hull is typically made of materials such as aluminum, titanium, or composite materials.



Enovus ROV, with open frame hull design.

Double Eagle, with closed hull design.

	Open Frame Hull Design	Closed Hull Design
Definition	ROV with a frame-like structure and exposed internal components	ROV with a fully enclosed outer shell
Advantages	• Lightweight and easy to transport • Allows for easy access to internal components for maintenance and upgrades • Offers greater flexibility in component placement	• Provides more protection for internal components • Offers greater buoyancy control • Provides better resistance to external pressure
Disadvantages	• Vulnerable to damage from collisions and impact • Less protection for internal components from the environment • Limited buoyancy control	• Heavier and more difficult to transport • Limited access to internal components for maintenance and upgrades • Less flexibility in component placement

Main Components of the Vehicle

2. Propulsion System

- ROVs are powered by electric motors and propelled by thrusters that allow for movement in any direction. The propulsion system allows the ROV to move through the water.
- Thrusters can be mounted in different configurations and can be electric or hydraulic.
- ROVs typically use thrusters to control their movement, with some models using a combination of propellers and jets.

BlueROV2

Deep Trekker DTG3

Saab Seaeye Falcon

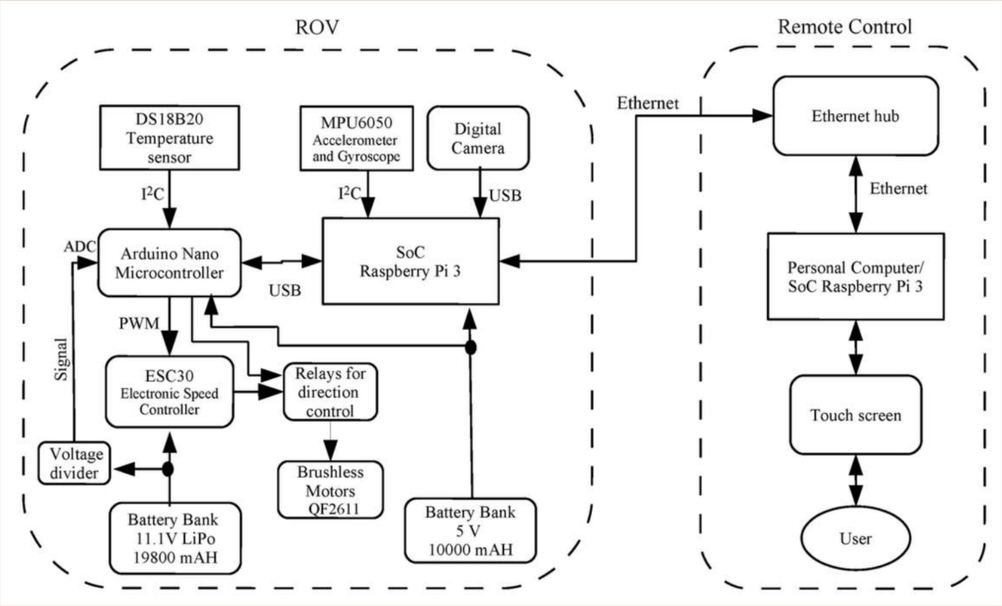
VideoRay Defender

ROV Model	Thruster Type	Number of Thrusters	Propulsion Control
BlueROV2	Electric	6	Four horizontal thrusters for forward, backward, sideways, and rotational movement, and two vertical thrusters for depth control.
Deep Trekker DTG3	Electric	4	Four vectored thrusters providing movement in any direction, controlled independently.
Saab Seaeye Falcon	Hydraulic	5	Five thrusters providing forward, backward, sideways, and rotational movement, with a unique "skid" design.
VideoRay Defender	Propeller blades	2	Two propeller blades housed in ducts, with a unique "bi-directional" design.

Main Components of the Vehicle

3. Navigation System & Control

- ROVs are navigated using sensors like sonar, depth sensors, and cameras.
- The navigation system includes sensors such as depth sensors, compasses, and sonar to help the operator navigate the ROV.
- The control system allows the operator to control the movement and other functions of the ROV.
- The control system includes joysticks and other input devices.



ROV block diagram.

Component	Function	Examples
Navigation System	Helps operator navigate ROV	Depth sensors, compasses, sonar, cameras
Control System	Allows operator to control ROV movement and functions	Joysticks, keyboards, control panels
Input Devices	Allows operator to send commands to ROV	Joysticks, trackballs, gamepads, touchscreens
Output Devices	Displays information about ROV and its environment	Monitor, video screens, digital displays, virtual reality headsets
Software	Runs ROV operations and displays data	Control software, mapping software, diagnostic software

Main Components of the Vehicle

4. Data Collection

- ROVs use sensors and cameras to collect data such as temperature, pressure, and water quality, which is transmitted to the surface for analysis.
- The navigation system includes sensors such as depth sensors, compasses, and sonar to help the operator navigate the ROV.
- The control system allows the operator to control the movement and other functions of the ROV.

Benthos PSA-916, a digital pressure sensor.

Aanderaa, a temperature sensor.

Sea-Bird Scientific CTD, a conductivity and depth sensor.

GoPro HERO Series Camera.

Kongsberg Mesotech MS 1000, a scanning sonar.

Sensor Type	Function	Examples
Pressure sensors	Measure water pressure	Strain gauge sensors, piezoelectric sensors
Temperature sensors	Measure water temperature	Thermocouples, RTDs (resistance temperature detectors), thermistors
Water quality sensors	Measure water parameters	pH sensors, conductivity sensors, dissolved oxygen sensors, turbidity sensors
Cameras	Capture visual data	Digital cameras, high-definition cameras, thermal imaging cameras
Chemical sensors	Measure the concentration of specific chemicals in the water	Fluorescence sensors, amperometric sensors, spectrophotometers

Main Components of the Vehicle

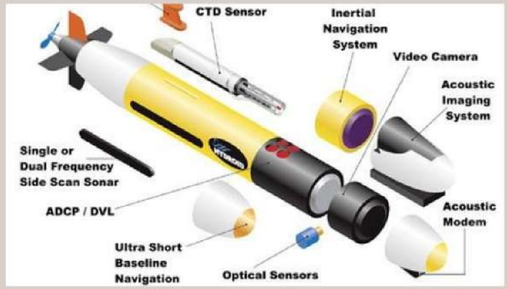
5. Data Transmission

- ROVs use cable, fiber optic cables, acoustic modems, and wireless networks to transmit data collected to the surface.
- Data collected by the ROV is transmitted to the operator on the surface using a tether cable.
- Some ROVs are also equipped with wireless communication systems for transmitting data to a support vessel or other remote location.

The BlueROV2 uses a 300-meter long **tether cable** for transmitting data and power between the ROV and the operator on the surface.

The Saab Seaeye Falcon, are equipped with fiber optic cables for transmitting high-quality video and other data to the surface in real-time.

VideoRay Pro 4 has wireless networking capabilities for cable-free data transmission to the surface.



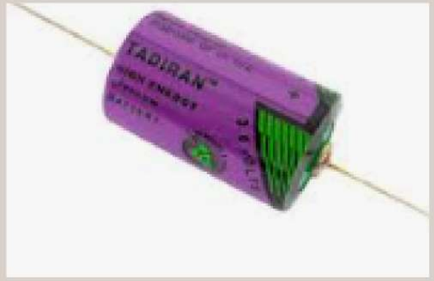
The REMUS 600, uses an acoustic modem for two-way communication with the surface.

Transmission Medium	Function	Examples	Advantages	Disadvantages
Tether Cable	Transmits data from ROV to surface operator	Insulated copper wire or fiber optic cable	Fast and reliable	Limits range and mobility of ROV
Fiber Optic Cable	Transmits data from ROV to surface operator or support vessel	Single-mode or multi-mode glass or plastic fibers	High speed and bandwidth	Expensive and fragile
Acoustic Modems	Transmits data from ROV to underwater receivers or support vessel	Underwater acoustic signals	Can transmit through water	Susceptible to interference and attenuation
Wireless Networks	Transmits data from ROV to surface operator or remote location	Wi-Fi, cellular, satellite, or other wireless technologies	Flexible and mobile	Can be slower and less reliable than wired transmission

Main Components of the Vehicle

6. Power Management

- ROVs require a power source to operate, which can come from batteries, fuel cells, or a tethered power supply.
- Power management systems ensure the vehicle has enough power to complete its mission.
- Power management software is also used to regulate the power supply and usage.



Power Source: Tadiran TLH-5955/P, a Lithium-Ion Battery.

Power Management System: Vicor BCM4414, a DC-DC Converter.

Battery Management: Texas Instruments BQ29700, a Battery Protection Circuit.

Charging System: Mastervolt ChargeMaster 12/25-3, a Battery Charger.

Component	Function	Examples	Advantages	Disadvantages
Power Source	Provides power to the ROV	Batteries, fuel cells, tethered power supply	Portable, easy to replace, flexible	Can be complex, may require specialized expertise to maintain
Power Management System	Regulates and distributes power to the ROV components	Power management software, power distribution board	Optimizes power usage, improves efficiency and reliability	Can be complex, may require specialized expertise to maintain
Battery Management	Manages and monitors the battery charge and discharge cycles	Battery management software	Prolongs battery life, prevents damage	Requires additional hardware and software
Charging System	Recharges the ROV's power source	Charger, power supply	Restores power source, allows for longer missions	May require additional equipment or downtime

Conclusion

- ROVs have become essential in various underwater activities such as research, exploration, and industrial operations.
- The components of ROVs, including the navigation system, control system, data collection, data transmission, and power management system, work together to enable operators to control the ROV and gather data from the underwater environment.
- Sensors and cameras are used to collect data such as temperature, pressure, and water quality, which is then transmitted to the surface using different media such as cables, fiber optic cables, acoustic modems, and wireless networks.
- The power management system powers the ROV's components, using components like lithium-ion batteries, DC-DC converters, battery protection circuits, and battery chargers.
- Despite the limitations of ROVs, such as short battery life and the need for a tether, their benefits in underwater activities far outweigh their drawbacks.

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