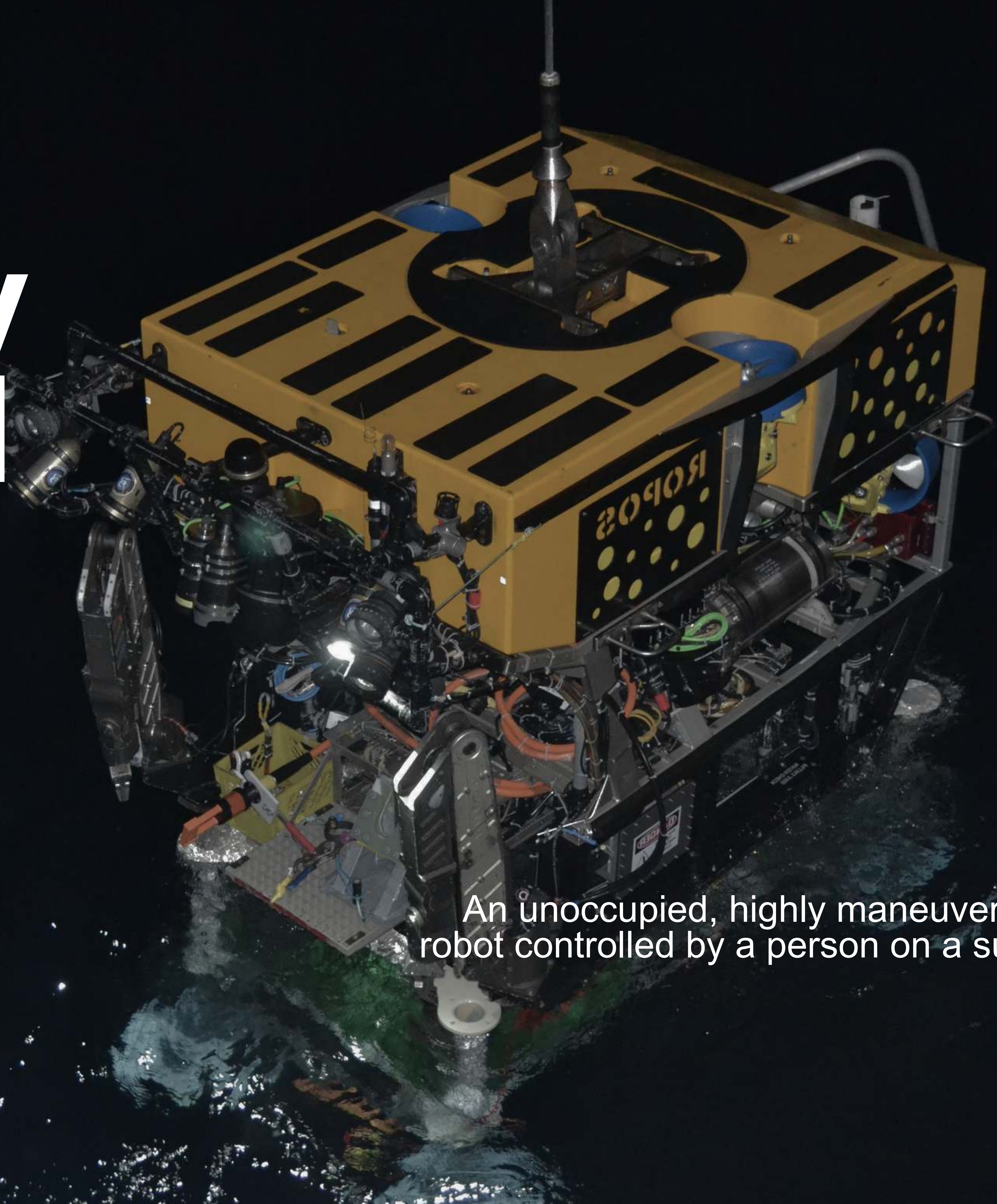
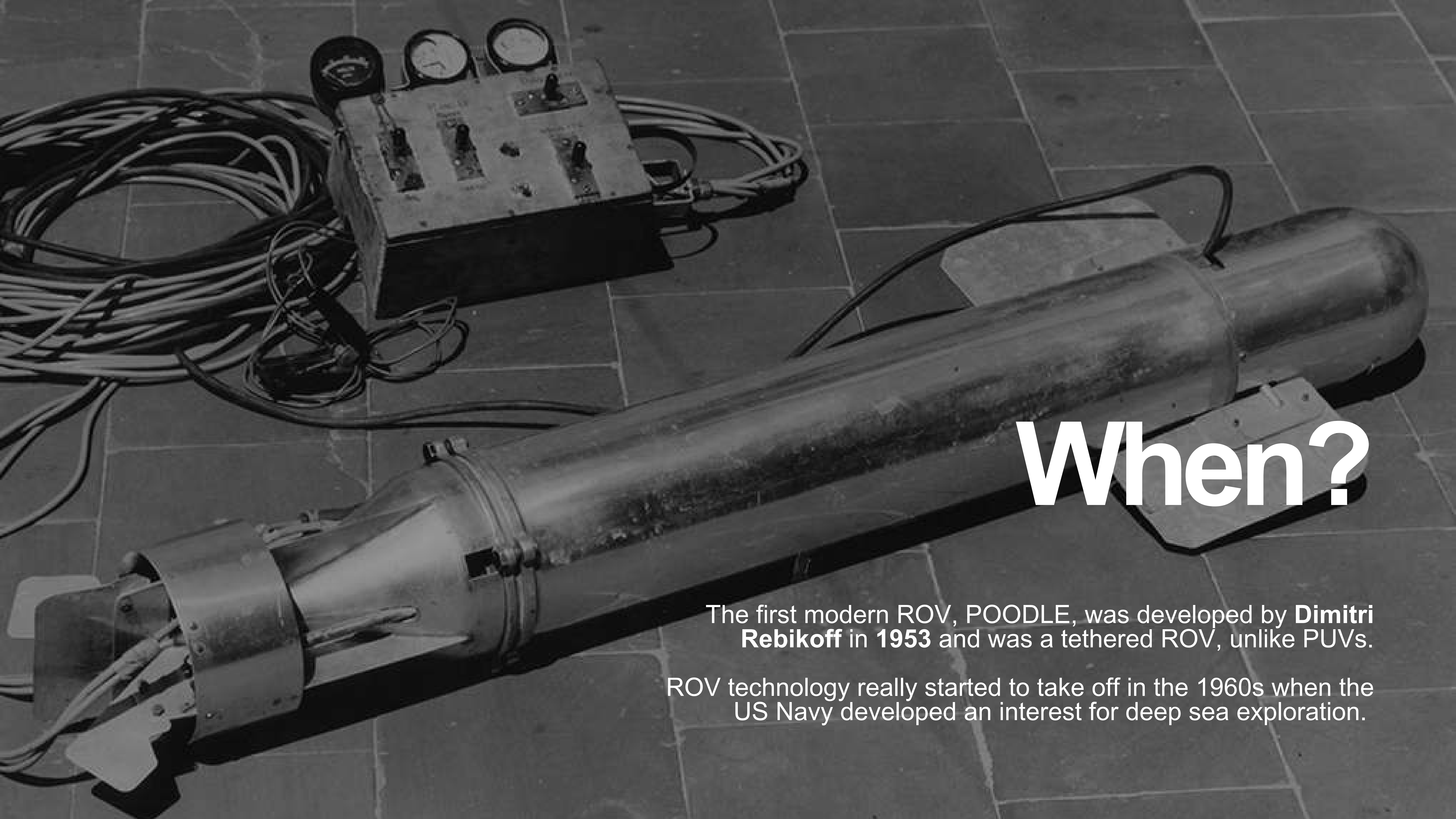
ROV

Remotely Operated Vehicle



An unoccupied, highly maneuverable underwater robot controlled by a person on a surface vessel via cables



When?

The first modern ROV, POODLE, was developed by **Dimitri Rebikoff** in **1953** and was a tethered ROV, unlike PUVs.

ROV technology really started to take off in the 1960s when the US Navy developed an interest for deep sea exploration.

What?

- **Remote Operation**

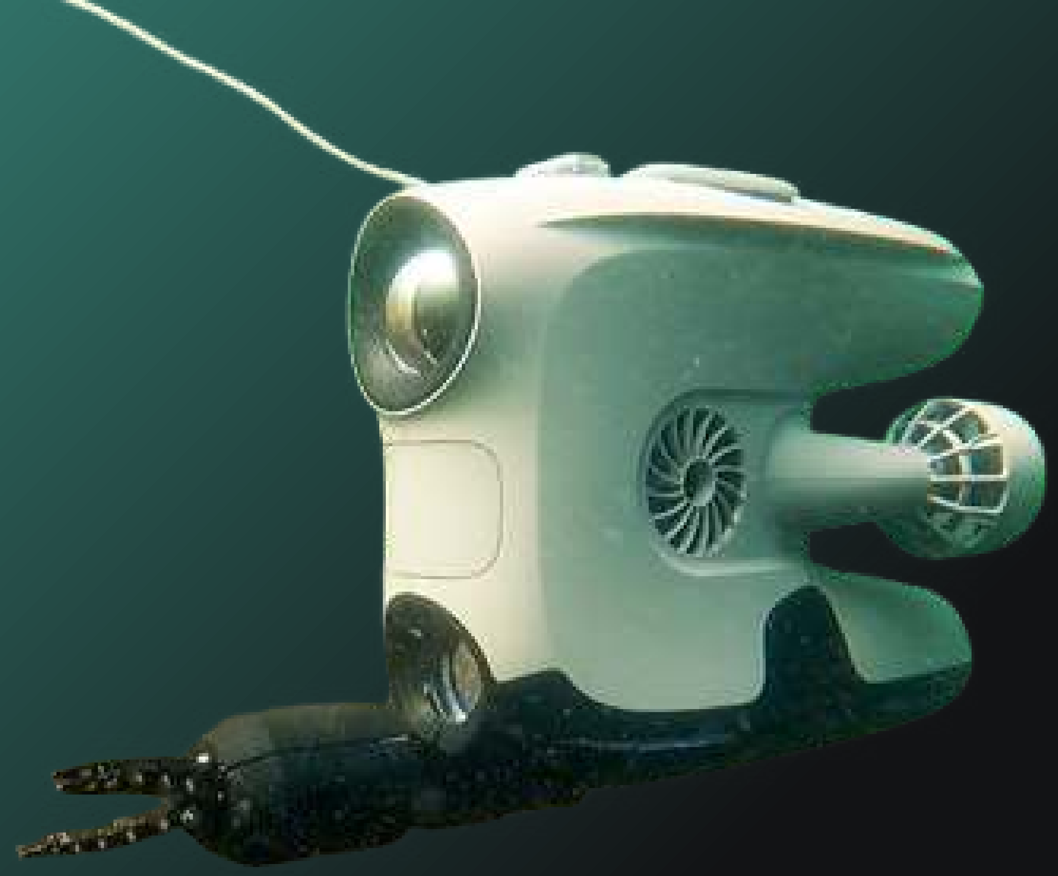
ROVs are controlled by pilots on a surface vessel or shore, allowing for exploration and work in areas inaccessible to humans

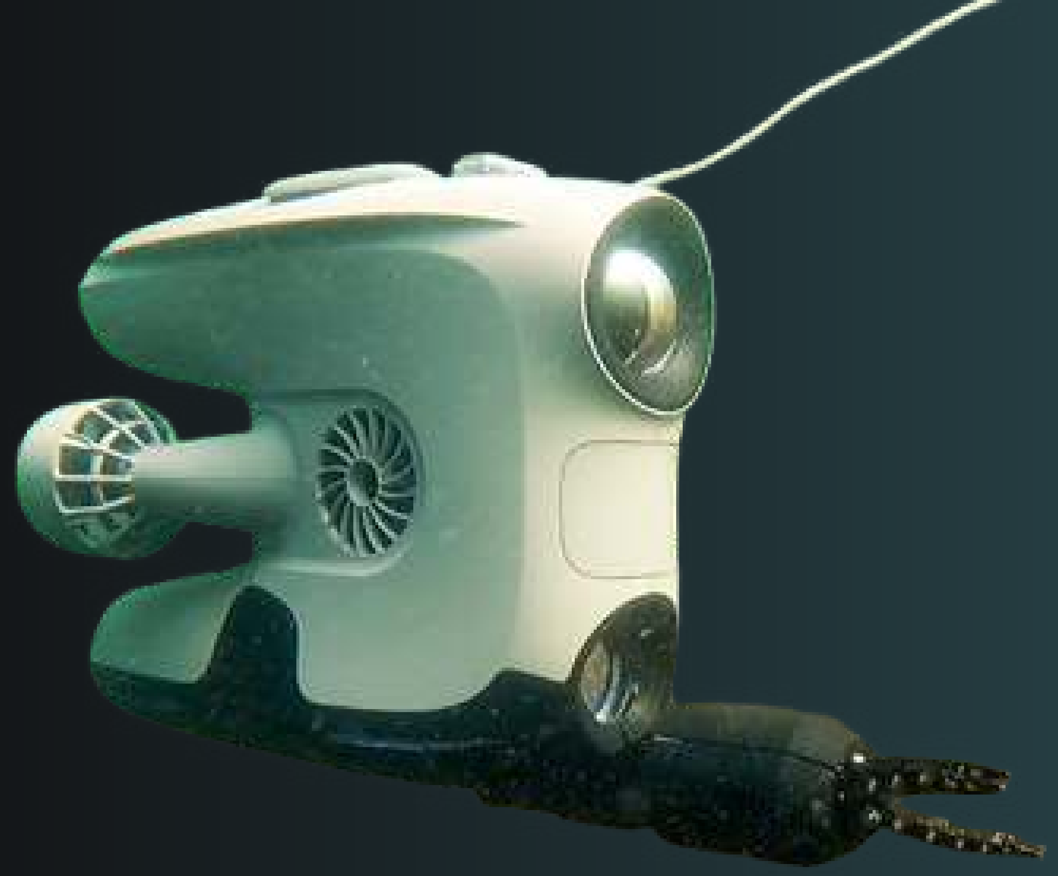
- **Tethered or Untethered:**

ROVs can be tethered to a vessel for power and data transfer or operate independently with onboard batteries

- **Mobility and Maneuverability:**

They are equipped with thrusters that allow for movement in all directions, including forward, backward, up, down, and sideways, as well as the ability to rotate (yaw, pitch, and roll).





Design Issues

- **Pressure and Temperature**

ROVs must withstand immense pressure at depth and extreme temperature variations, requiring robust materials and structural designs.

- **Data Transmission:**

Reliable data transmission from the ROV to the surface vessel is crucial for real-time monitoring and control

- **Umbilical Cable:**

The umbilical cable connecting the ROV to the surface vessel can be a source of problems, including entanglement and drag, requiring careful design and management

Human Machine Interface

Key Features

- Control Mechanism
- Visual Displays

- Communication
- Haptic Feedback
- Data Displays

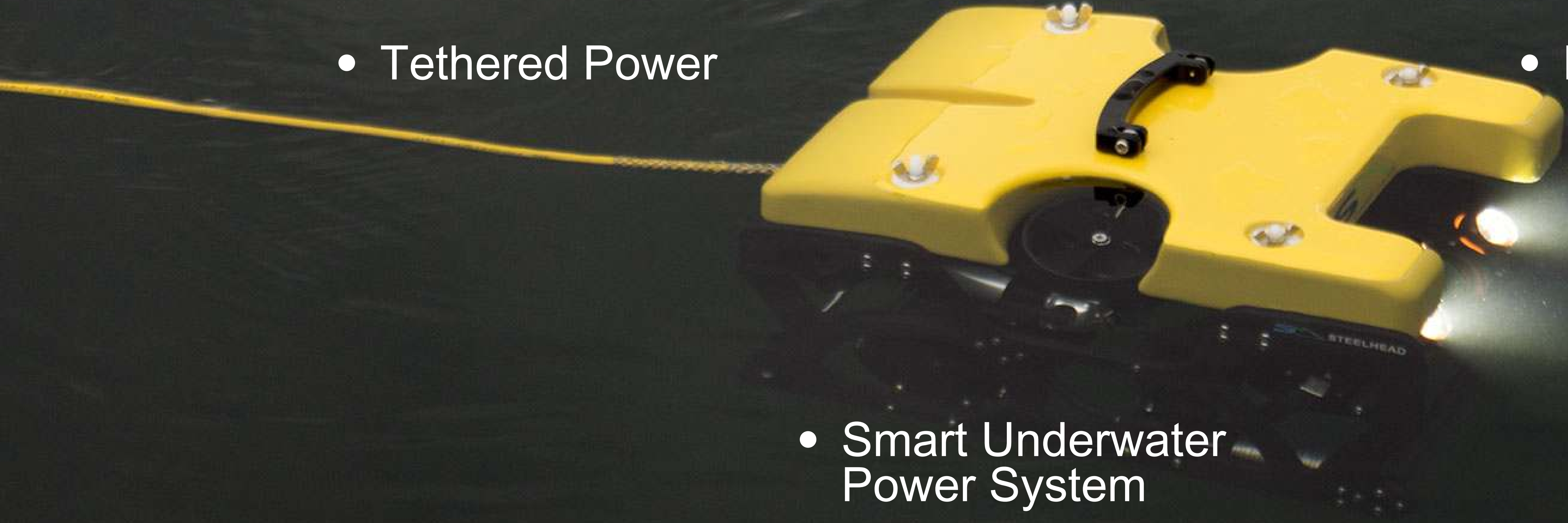
Sensors

- Doppler Velocity Log (DVL)
- Sonar

- Inertial Measurement Unit
- Conductivity, Temperature, Depth
- Gyro compass

Power

- Solar Power
- Tethered Power
- Lithium-Ion Batteries
- Smart Underwater Power System



System Architecture

Key Elements

Subsea System

- Propulsion
- Sensors
- Onboard CPU
- Communication

Topside System

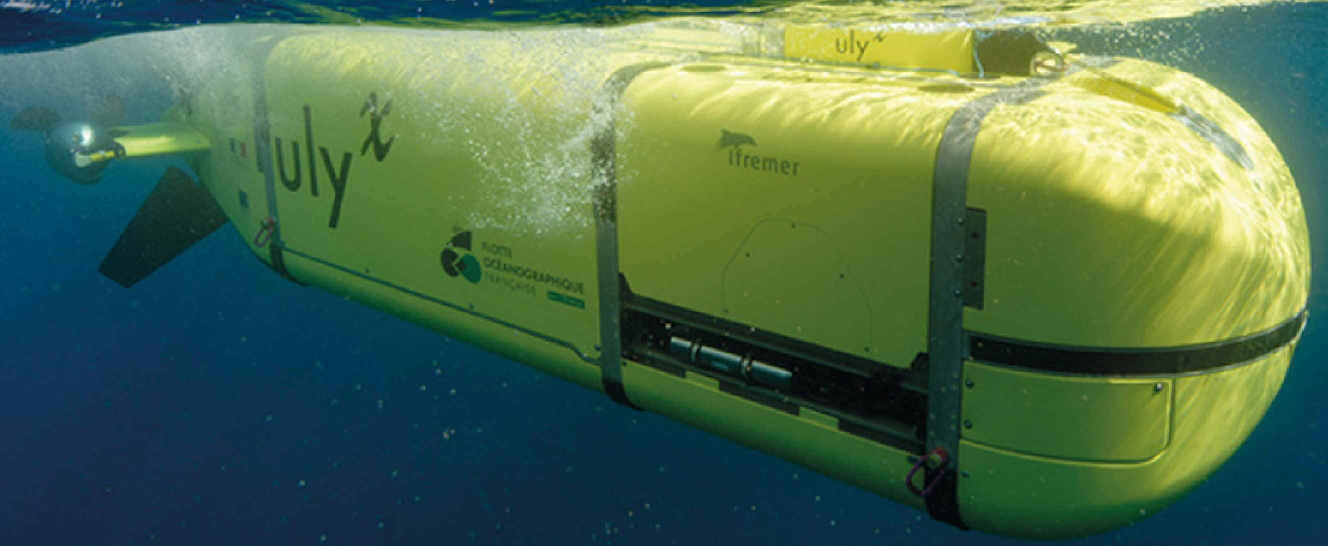
- Controller
- Processing Unit
- Communication

Umbilical

- Power Transmission
- Data Transmission
- Communication

AUV

Autonomous Underwater Vehicle



An unmanned, robotic submarines pre-programmed to explore and collect data underwater without a tether or immediate operator control

When?

These robots were first developed in 1957 at the University of Washington. It was used to study the behavior of submarines and the ocean (specifically diffusion, acoustic transmission, and submarine wakes) in order to aid the navy.

What?

- **Unmanned and Self-Propelled**

AUVs are robotic vehicles that operate underwater without human control or tether.

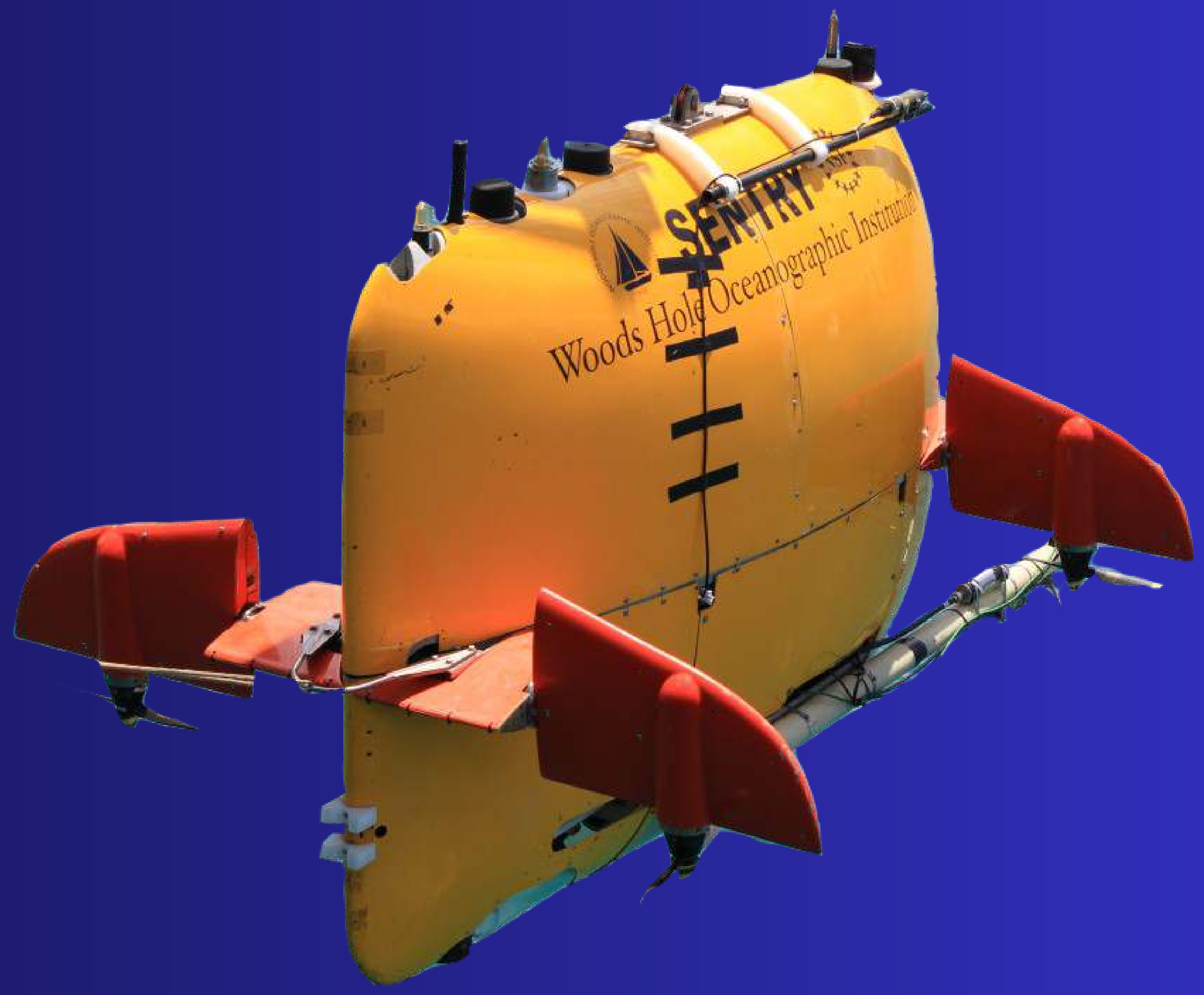
- **Pre-programmed Navigation and Autonomous Operation:**

AUVs are typically programmed with a specific mission profile, including their route, depth, and tasks.

They can navigate autonomously using a combination of sensors and navigation systems

- **Applications in Research and Exploration**

They can explore and map the seabed, study ocean currents and water circulation, and investigate marine ecosystems.



Design Issues

- **Limited Power**

AUVs are typically battery-powered, and the limited energy capacity restricts mission duration and range.

- **Communication Challenges**

Underwater communication is limited and unreliable, requiring efficient and robust technologies.

- **Autonomous Navigation and Control**

Developing robust autonomous navigation and control algorithms is a key challenge.

Human Machine Interface

Data Acquisition & Monitoring

Mission Planning & Control

Communication & Connectivity

Sensors

Sonars

Depth Sensors

pH Sensors

Conductivity, Temperature, Depth (CTD) sensors

Power

Wave Energy

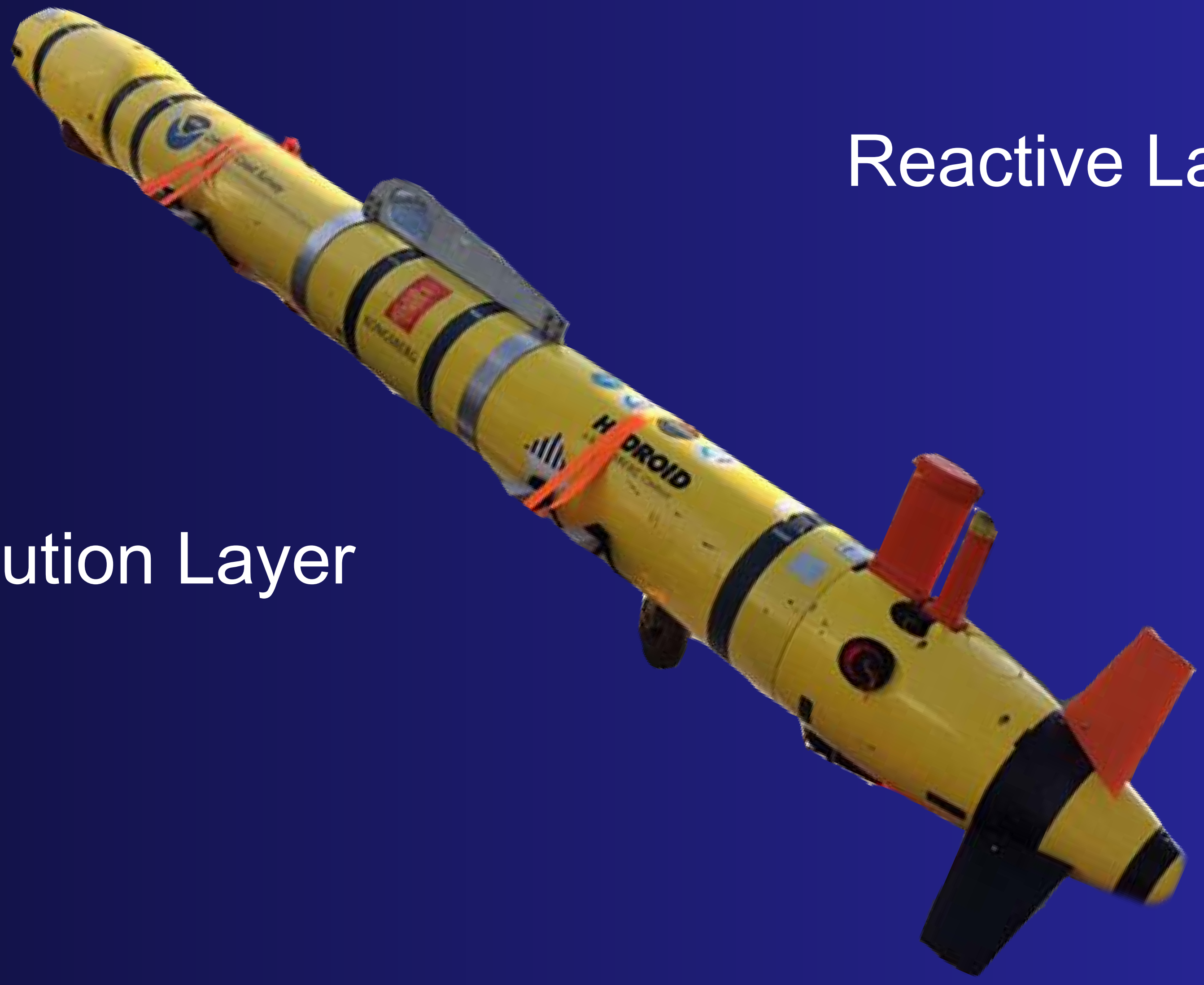
Fuel cells (hydrogen-oxygen)

Solar Power

System Architecture

Key Elements

Perception Layer



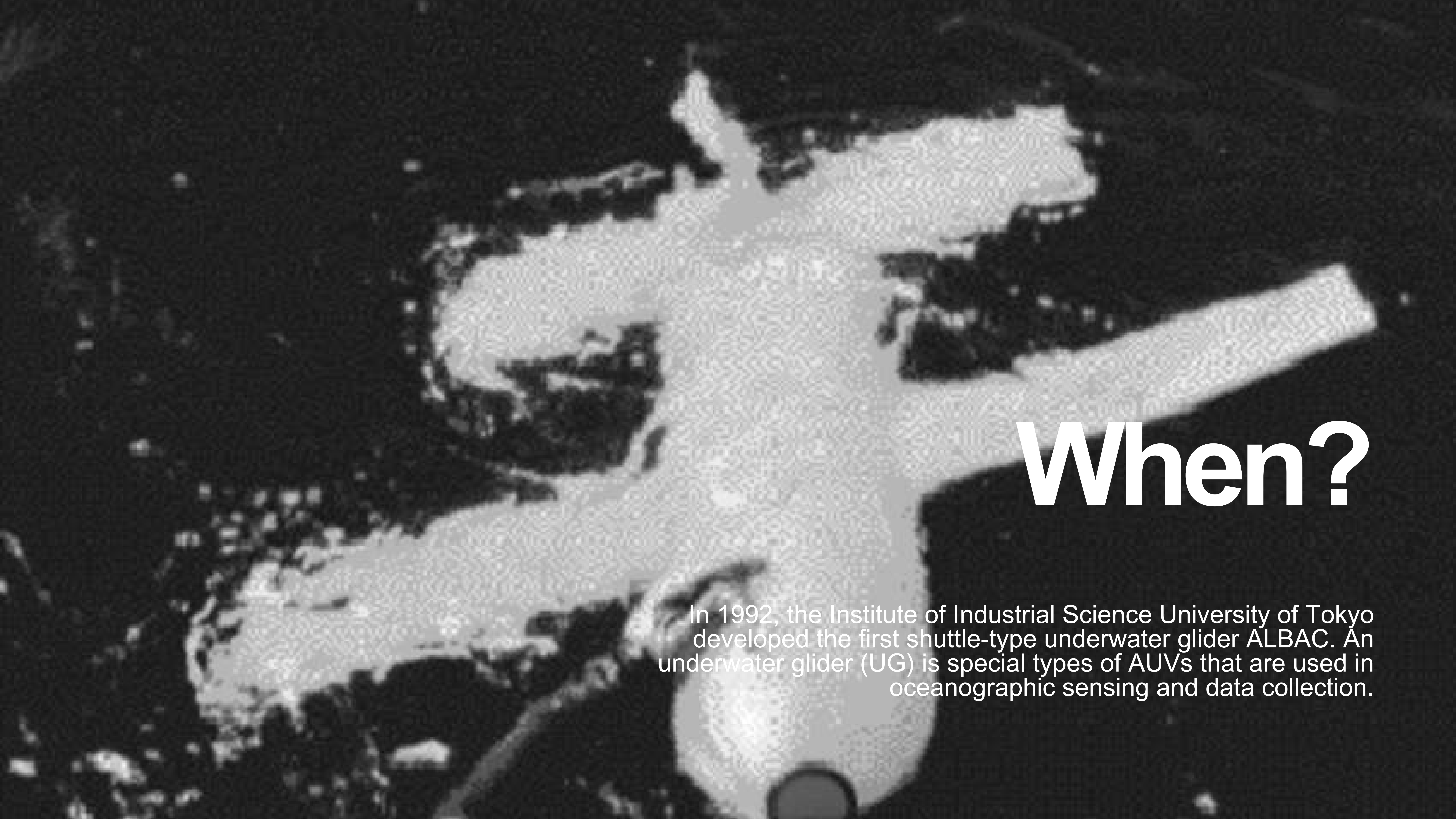
Reactive Layer

Execution Layer

Decision-Making Layer

Underwater Glider

Robotic vehicles that use variable buoyancy and hydrofoils (underwater wings) to move through the water



When?

In 1992, the Institute of Industrial Science University of Tokyo developed the first shuttle-type underwater glider ALBAC. An underwater glider (UG) is special types of AUVs that are used in oceanographic sensing and data collection.

What?

- **Buoyancy Engine:**

Gliders use a "buoyancy engine" to adjust their buoyancy by pumping fluid (oil or water) between internal and external tanks.

- **Hydrofoils:**

They are equipped with hydrofoils (underwater wings) that allow them to glide forward while descending through the water.

- **Unmanned:**

Gliders are designed to operate independently, requiring minimal human intervention.

Design Issues

- **Buoyancy Control at Depth**

The pressure increases significantly with depth, making it difficult for existing buoyancy control mechanisms (e.g., pumps or bladders) to function effectively at greater depths.

- **Hydrodynamic Efficiency and Maneuverability**

The hydrodynamic shapes of the glider hull are not optimized for carrying higher payloads at deeper depths.

- **Payload Capacity**

To maintain agility, speed, and the ability to reach high depths, the internal volume of the glider needs to be reduced, limiting the space available for sensors and other payloads.

Human Machine Interface

Data Visualization of Monitoring

Mission Planning and Control

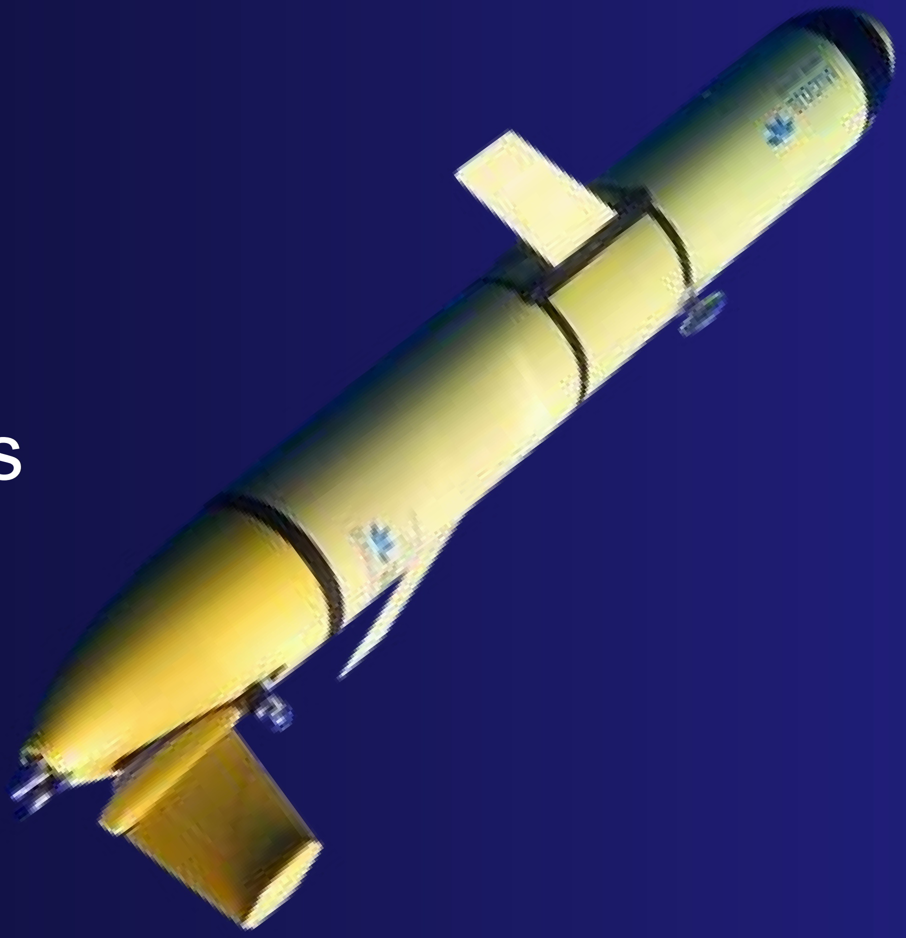
Data Analysis & Interpretation

Sensors

Oxygen Optodes

Conductivity, Temperature, Depth (CTD) sensors

Chlorophyll Fluorometers



Photosynthetically Active Radiation (PAR) sensors

Power

Wave Energy

Ocean Thermal
Energy

Thermal Bouyancy
Engine

System Architecture

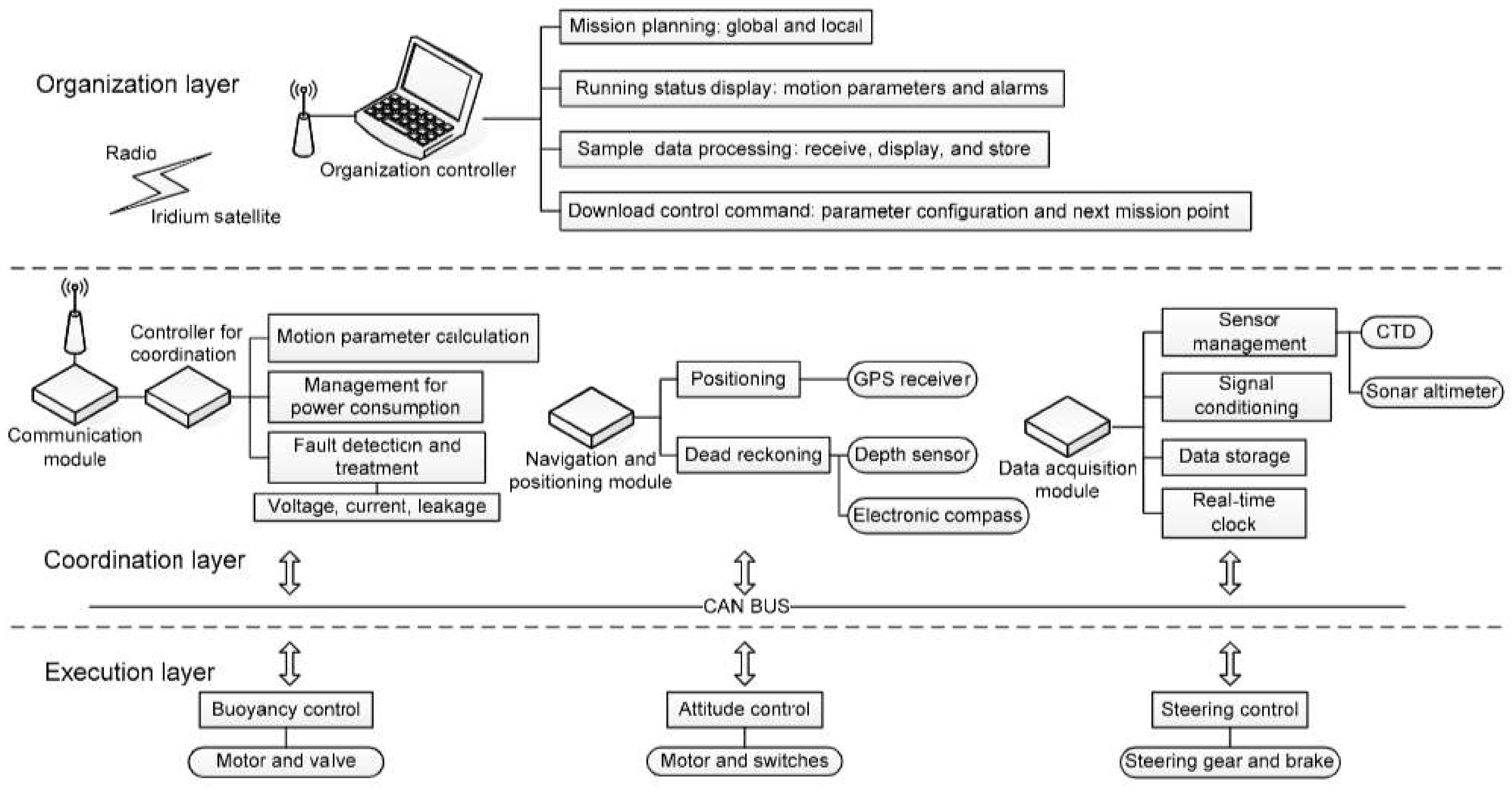


Fig. 5 Flowchart of the glider system

Organization

Coordination

Execution

Crawler

Specialized robotic vehicles designed to traverse along the seabed

When?

The concept of underwater legged or crawling robots emerged in the late 1990s with prototypes like Aquarobot and Ariel/Ursula, followed by more recent developments like Bayonet Ocean Vehicles and the sea star-inspired robot.

What?

- **Legs/Wheels:**

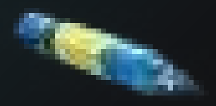
Crawler robots utilize legs or wheels to move across the seabed, allowing them to navigate uneven terrain and perform tasks like inspection and maintenance.

- **Data Acquisition Systems:**

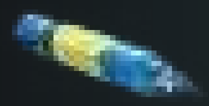
Robust systems are needed to handle the large volumes of data generated by the sensors.

- **Communication System:**

Facilitates communication between the robot and the operator, allowing for remote control and data transmission.



Design Issues



- **Uneven Terrain**

The seafloor is rarely flat, posing a challenge for robots to move smoothly and efficiently.

- **Power Sources**

Choosing an appropriate power source depends on the robot's mission duration and autonomy requirements.

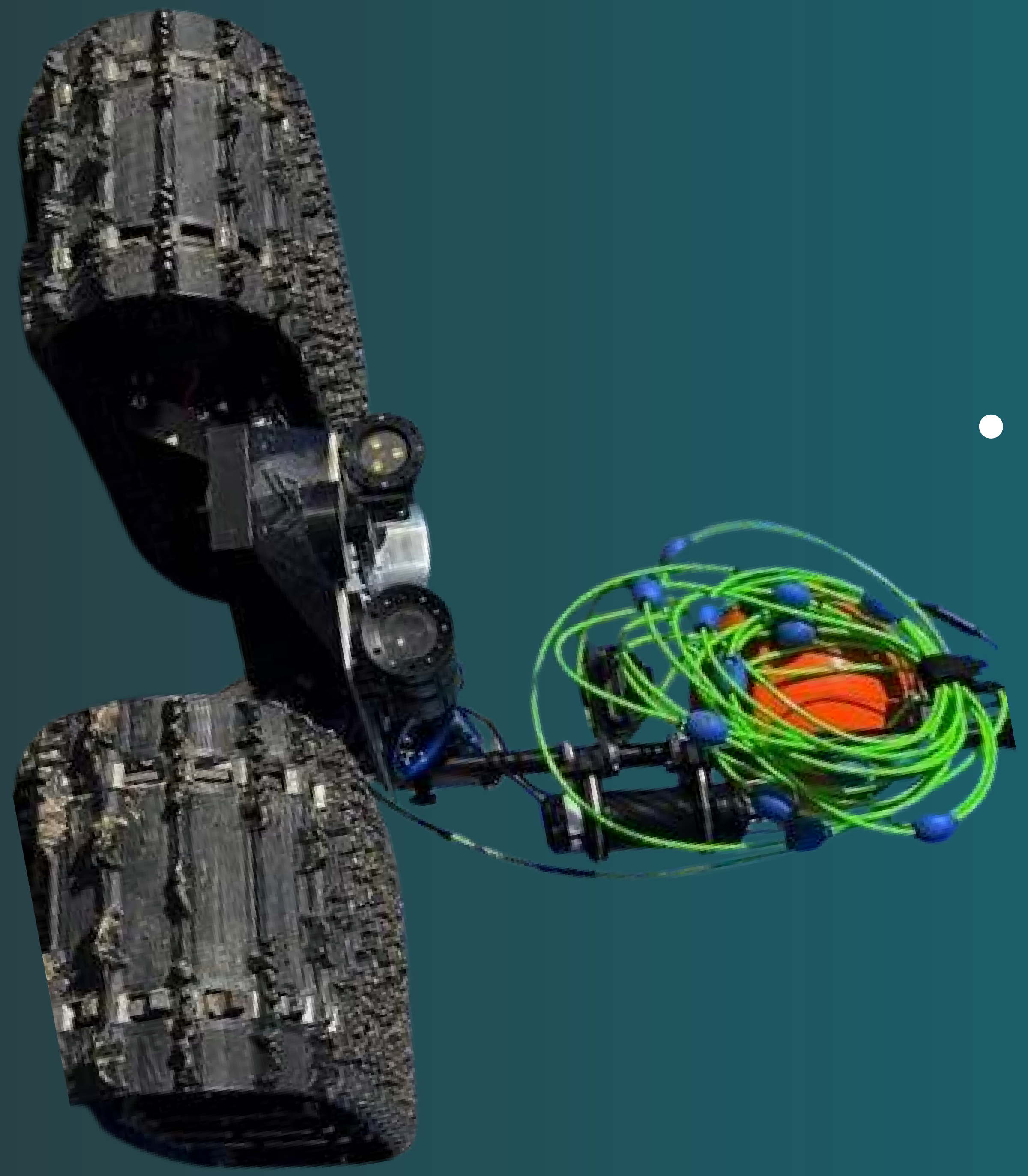
- **Durability**

The robot must withstand the rigors of underwater operation, including impacts and vibrations.

Human Machine Interface

Key Features

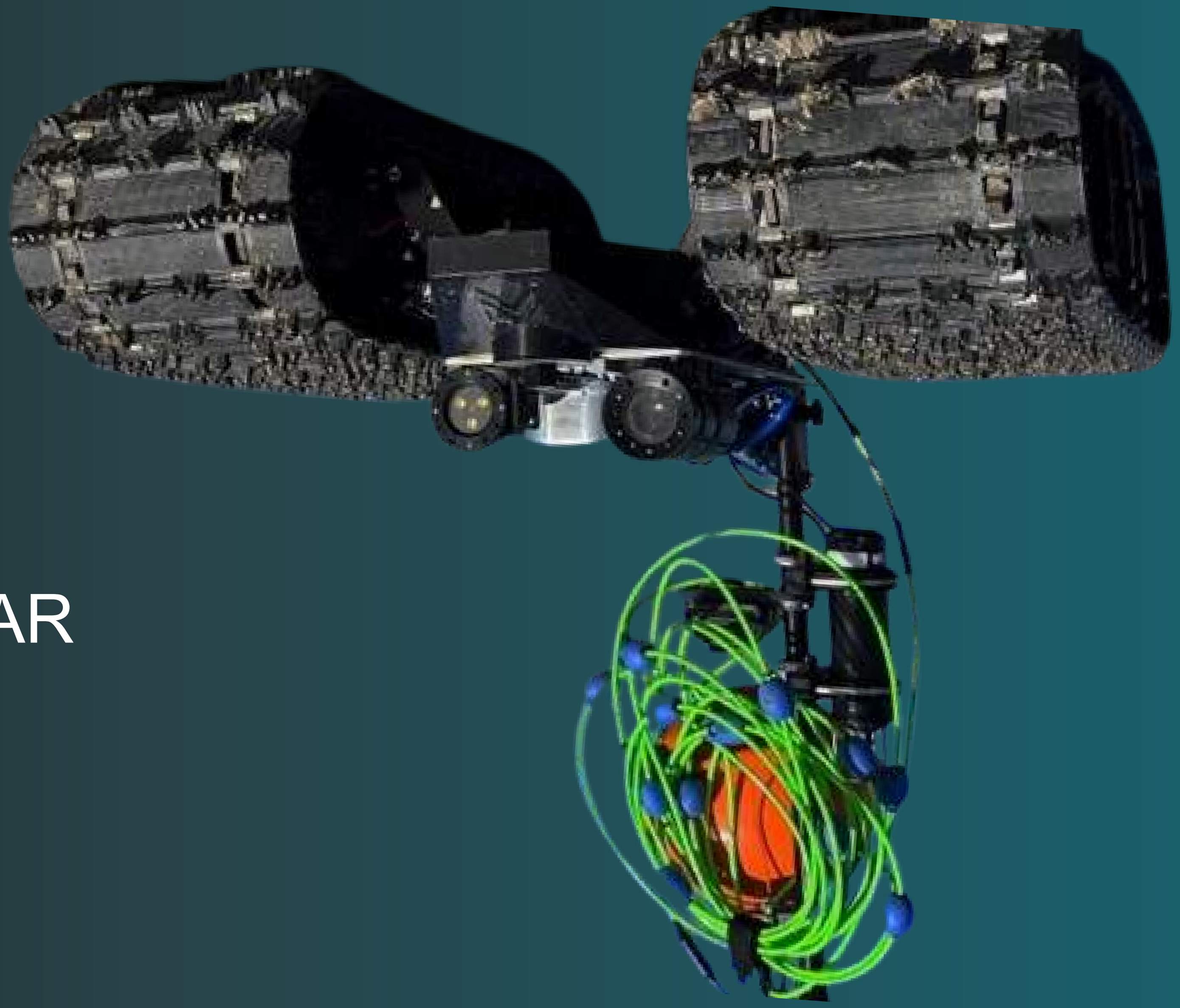
- Control Systems
- User Interfaces



- Sensor & Data Feedback
- Communication Systems
- Mission Planning

Sensors

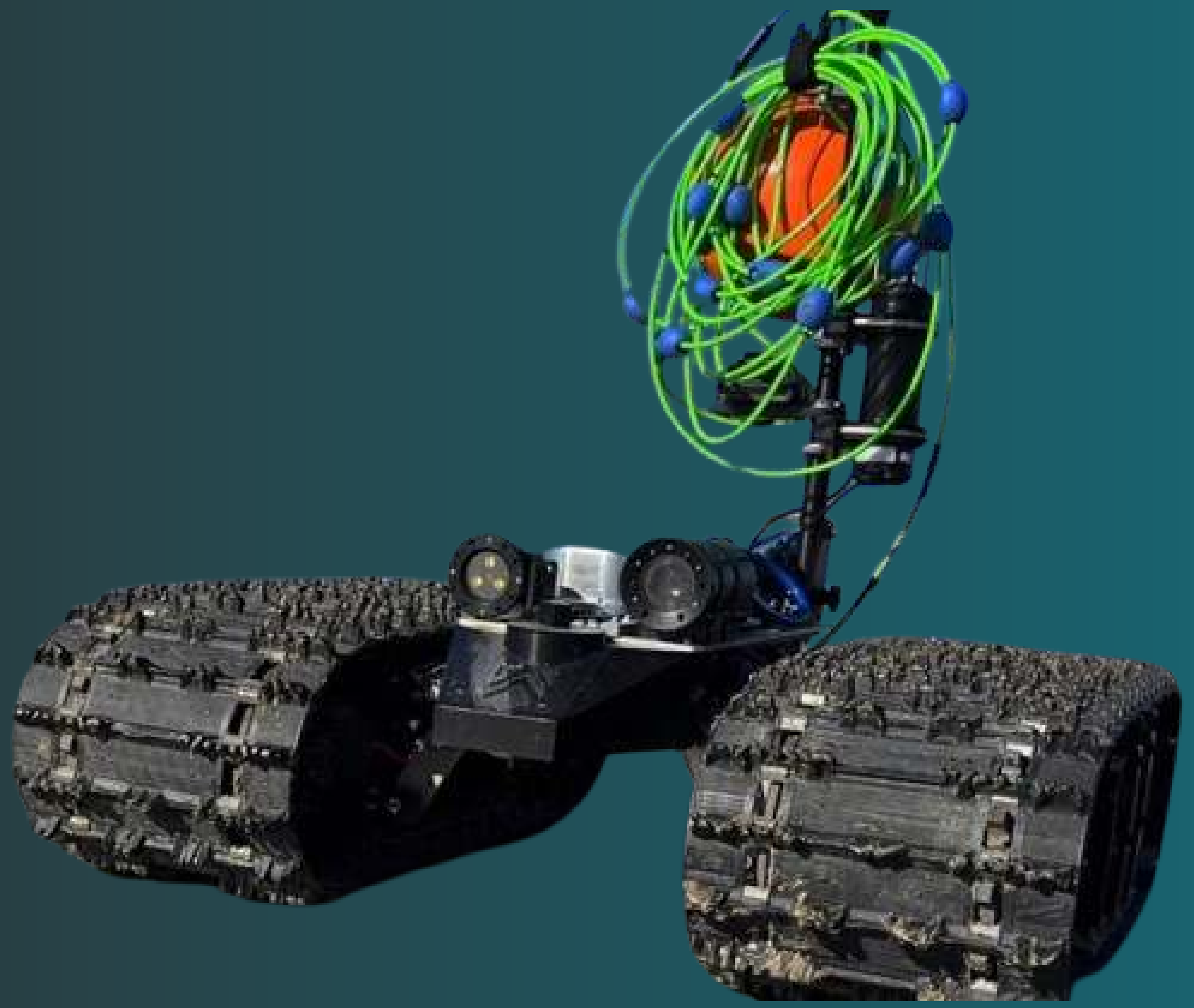
- Sonar
- LiDAR



- Temperature Sensors
- CTD Sensors

Power

- Fuel Cells



- Tetherd

- Battery

System Architecture

Power System

Control System

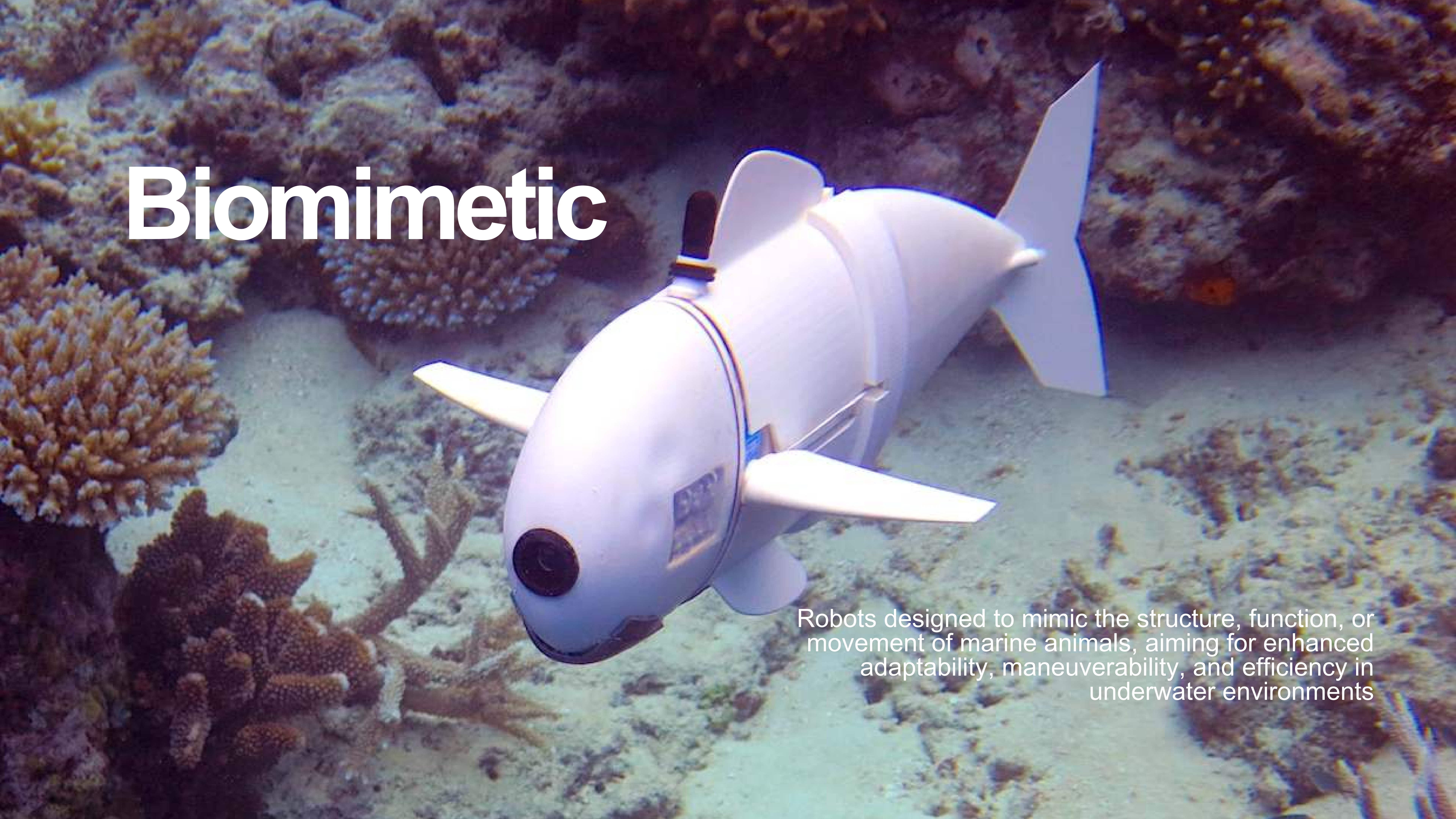
Locomotion System

Sensor Suite

Communication System

Human-Machine Interface

Navigation System



Biomimetic

Robots designed to mimic the structure, function, or movement of marine animals, aiming for enhanced adaptability, maneuverability, and efficiency in underwater environments

When?

Robotic technology relies on advanced information systems that work with mechanical systems. This combination first happened in the 1960s when digital computers were connected to mechanical manipulators used for handling nuclear materials, prosthetics, and other purposes.

What?

- **Inspiration from Nature:**

Biomimetics focuses on studying and understanding natural systems and processes to identify solutions for human challenges.

- **Interdisciplinary Approach:**

Biomimicry necessitates collaboration between biologists, engineers, architects, and other specialists to translate natural principles into practical applications.

- **Simplicity**

Nature often employs elegant and simple solutions to complex problems, which can be a source of inspiration for innovative designs.

Design Issues

- **Natural Systems Are Complex**

Nature's solutions are often intricate and multi-functional, making it difficult to isolate and replicate specific mechanisms in a design.

- **Bridging Disciplines**

Biomimicry requires collaboration between biologists, engineers, and designers, which can be challenging due to different perspectives and terminologies.

- **Manufacturing and Technology**

Some biomimetic designs may require novel materials or manufacturing techniques that are not yet available or practical.

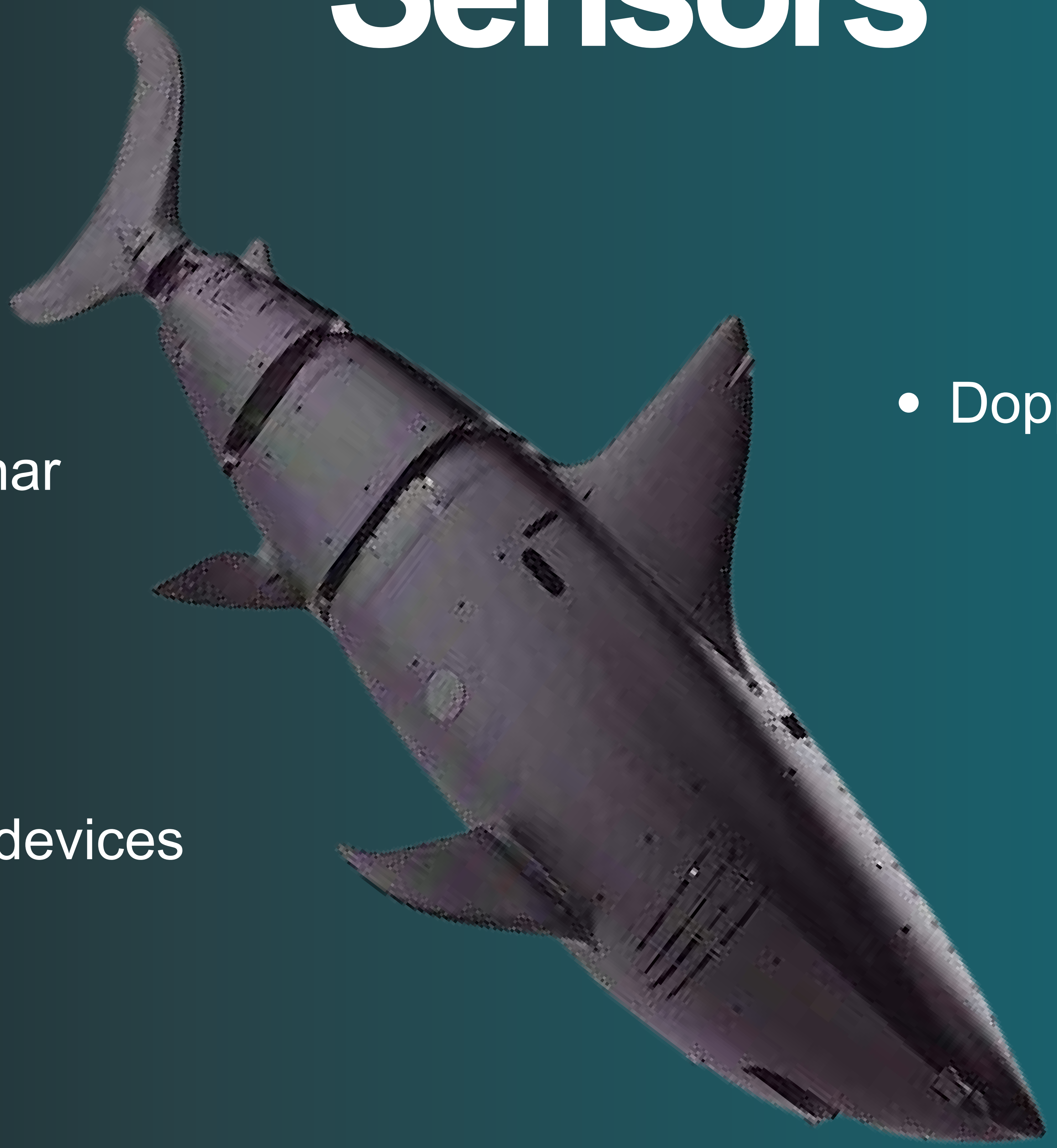
Human Machine Interface

Key Features

- Wearable sensors (Gloves)

- Virtual Reality (VR)

Sensors



- Sonar
- Inertial devices
- Doppler Velocimeters
- Ultrasonic sensors

Power

- Gas Propulsion

- battery fluid
- Battery

System Architecture

Key Elements

Sensing layer

Processing Unit

Navigation & Control

Actuation layer

Communication unit

User Interface