Autonomous Underwater Vessels summary

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Artificial Intelligence &
Information Analysis Lab

Autonomous Underwater Vessels

- Autonomous Underwater Vessels
- AUV technologies
- AUV sensors
- AUV communications
- AUV applications

Autonomous Underwater Vessels

- Autonomous Underwater Vessels (AUVs) operate autonomously, ideally without any human intervention.
- Alternatively, they may be teleoperated.
- Their operator, who may be on shore or aboard a ship.
- AUVs can operate at various depths:
  - From intertidal waters (between the limits of high and low tide) up to 6,000-meter depth.

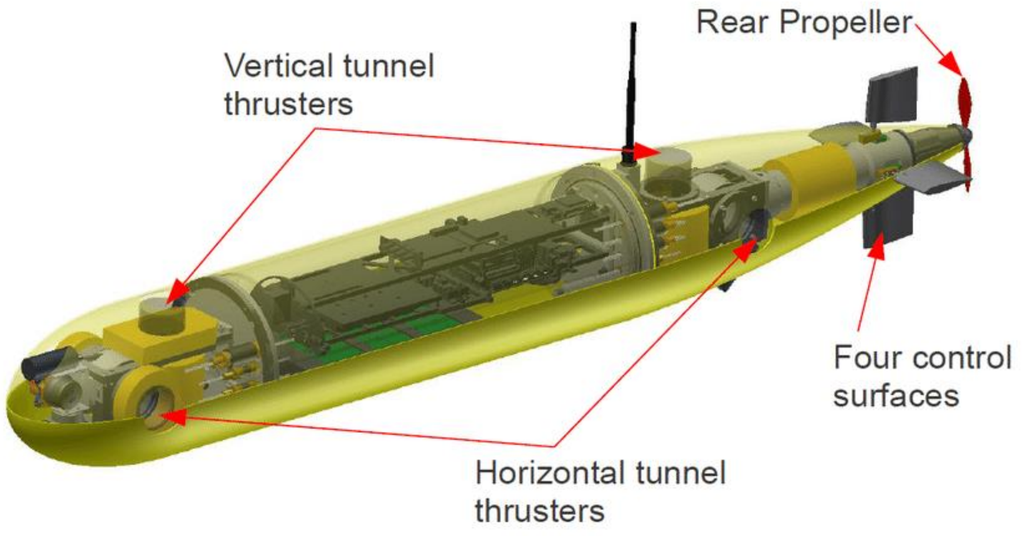
Autonomous Underwater Vessels

- Autonomous Marine Systems produce data that can change ocean exploration and studies.
- A low-cost, fully autonomous vessel can deliver real-time ocean intelligence from anywhere around the world.
- No risk to human life.

Autonomous Underwater Vessels

AUV cons:

- they are expensive to purchase,
- highly expensive to operate.
- They requiring dedicated technical support, and maintenance.

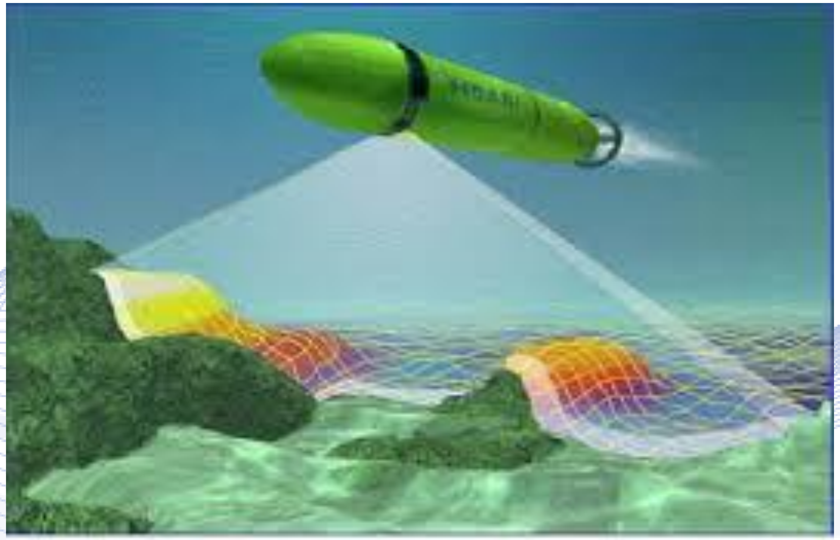


Autonomous Underwater Vessels

- Fully autonomous vessels carry power source on-board to enable propellers or thrusters for AUV motion.
- Most AUVs use specialized batteries, although some AUVs have used fuel cells or rechargeable solar power.
- Certain AUVs, such as gliders, minimize energy demands by allowing gravity and buoyancy to propel them.
- AUVs can run for as short as minutes/hours or as long as days or even months before the battery needs recharging.

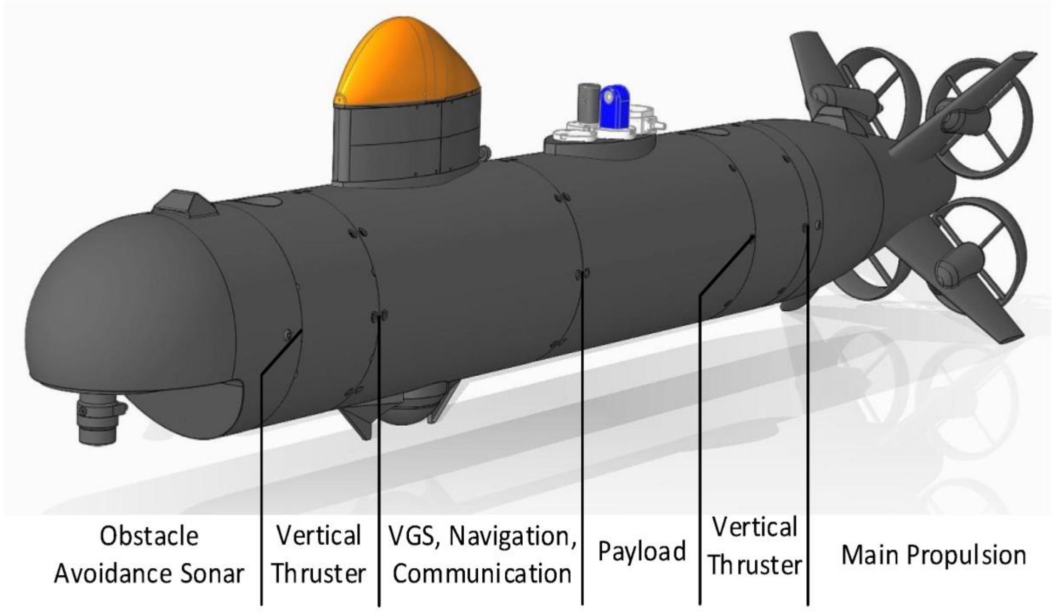
Autonomous Underwater Vessels

- AUVs are often used as survey platforms to map the seafloor or characterize physical or chemical properties of the seabed.



Autonomous Underwater Vessels

- AUVs can be equipped with:
  - Sonar and underwater sensors.
  - Video cameras,
  - Robotic tools, such as drills.
  - Conductivity, temperature, and depth (CTD) sensors.
  - Water sample carousels.



Autonomous Underwater vessels

- Data are recorded and are then either transmitted via satellite when the AUV comes to the surface, or downloaded when the vehicle is recovered.

- AUVs have a wide range of sizes and shapes to meet the required depth range, payload, power needs, and scientific objectives.

Autonomous Underwater vessels

- A submarine glider is an AUV that employs variable-buoyancy propulsion, instead of traditional propellers or thrusters.
- Gliders use small changes in buoyancy in conjunction with wings, to convert vertical fall to forward motion, allowing the instrument to move horizontally at speeds of around 0.5 m/s with low power consumption.

Autonomous Underwater vessels

- They require reduced or no human assistance while traveling, they are suited for collecting data in remote locations, safely and at relatively low cost.
- They serve as a convenient platform for a variety of ocean sensors, such as temperature, conductivity, dissolved oxygen and various bio-optical measurements.

Autonomous Underwater vessels

Five levels of AUS autonomy:

- **No autonomy**: All aspects of operational tasks perform by human operator, even when enhanced with warning or intervention system.
- **Partial Autonomy**: The targeted operational tasks are performed by a human operator that can transfer control of specific sub-tasks to the system. The human operator has overall control of the system and safely operates the system at all time.

Autonomous Underwater vessels

- **Conditional autonomy**: The targeted operational tasks are performed by AVS, without human interaction, while a human operator performs the remaining tasks. Human operator is responsible for its safe operation.
- **High Autonomy**: The targeted operational tasks are performed by AVS, without human interaction, while a human operator performs the remaining tasks. AVS system is responsible for its safe operation.
- **Full Autonomy**: All operational tasks perform by AVS, under any conditions.

Autonomous Underwater vessels

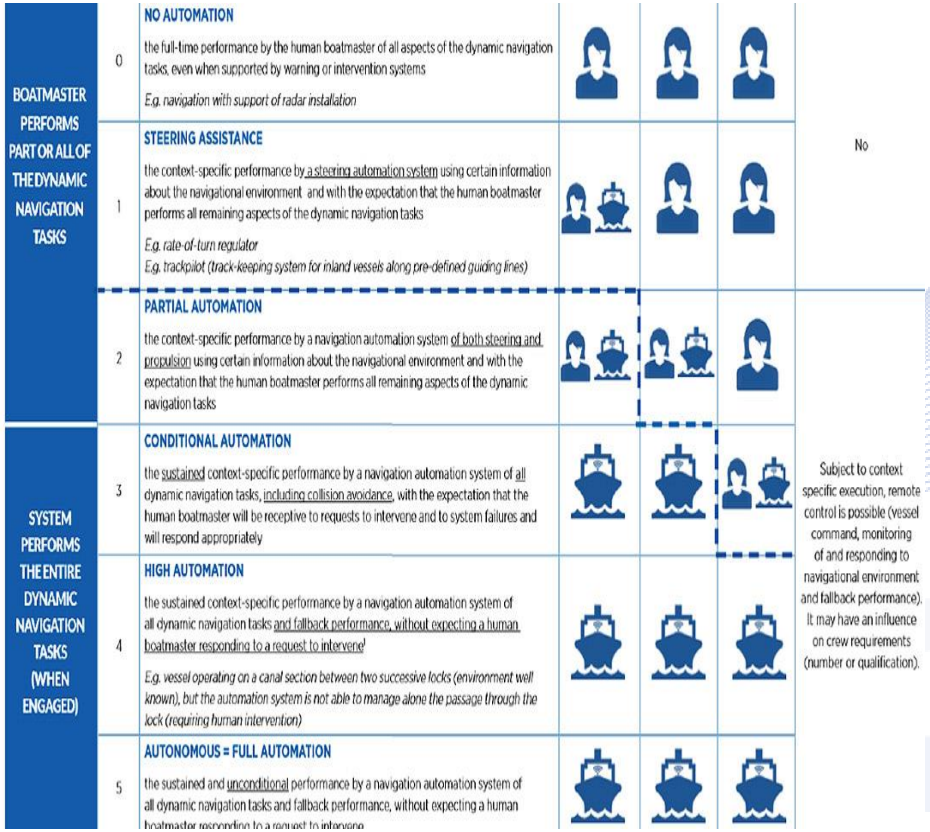
AUS system autonomy depends on its communication capabilities:

- Low communication requirements and less crew is needed for high level of autonomy.
- For low level of autonomy, needs more crew and bigger communication capabilities.

Autonomous Underwater vessels

Level of autonomy:

- Data collected by AUVs are stored in their internal memory and they are not available to the operator until retrieval of the vehicle.
- Underwater data transmission requires a large bandwidth that is not currenly available.



Autonomous Underwater vessels

- The lack of data transmission places strong AUV autonomy requirements.
- Autonomous underwater systems should be able to interpret sensor data and to take decisions accordingly, eventually having a human as a supervisor.

AUV technologies

- AUV Sensing and Imaging
  - Sonar Imaging
  - Multibeam Echo Sounders
  - Sub-bottom Profilers
  - Optical imaging
- AUV Communication
  - Acoustic Communication
  - Electromagnetic Communication

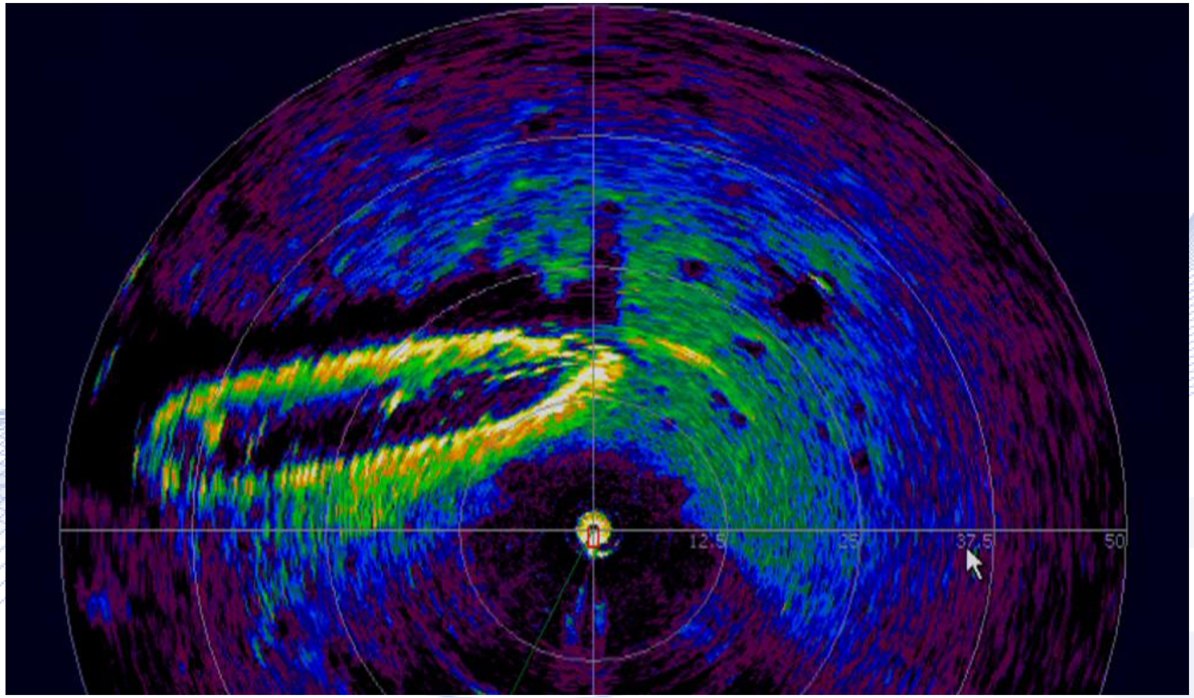
AUV technologies

- AUV Navigation
  - Compass-based Navigation Solutions
  - Inertial Navigation Systems
- Collision Avoidance
  - Sonars
- AUV Propulsion
  - Fin Control Actuators
  - Propulsion Motors
  - Pump Motors

AUV sensors

Hydroacoustics:

- Acoustic Beacons and Modems
- Acoustic Doppler Current Profiler (ADCP)
  - Doppler Velocity Log (DVL)
- Sonar
  - Imaging
  - Ranging / Bathymetric
  - Synthetic Aperture Sonars
- Echo Sounders
- Acoustic Doppler Current Profilers



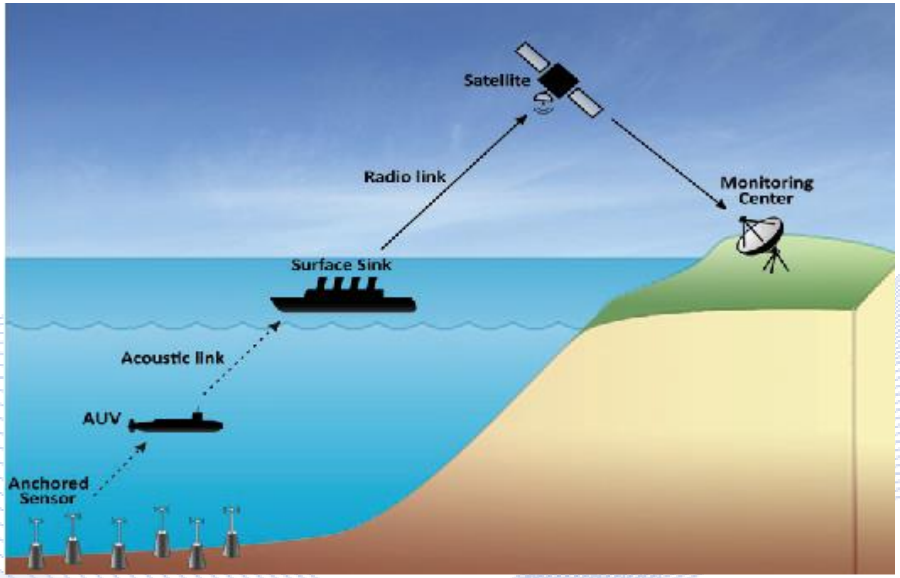
Shipwreck images by ROV Little Hercules' scanning sonar (2012), NOAA Okeanos Explorer Program [NOA].

AUV sensors

- Optical Sensors
  - High resolution still/video Cameras
  - Dual-eye cameras
  - Led Beacons
  - Gated viewing
- Sensors
  - Conductivity, Temperature, and Depth (CTD) Sensors
  - Biochemical Sensors
  - Turbulence sensors
  - Oxygen, Nitrate, Chlorophyll sensors.

AUV communications

- Above water surface, WLAN and radio communications ensure efficient data communication between vessels and the shore, with small delays and losses.
- Underwater communications work very differently:
  - Water, especially sea water, which has much higher electrical conductivity than air and causes strong electromagnetic wave attenuation.



AUV communications

- Acoustic waves, on the other hand, propagate efficiently underwater. Acoustic modems use this principle to send and receive signals underwater.

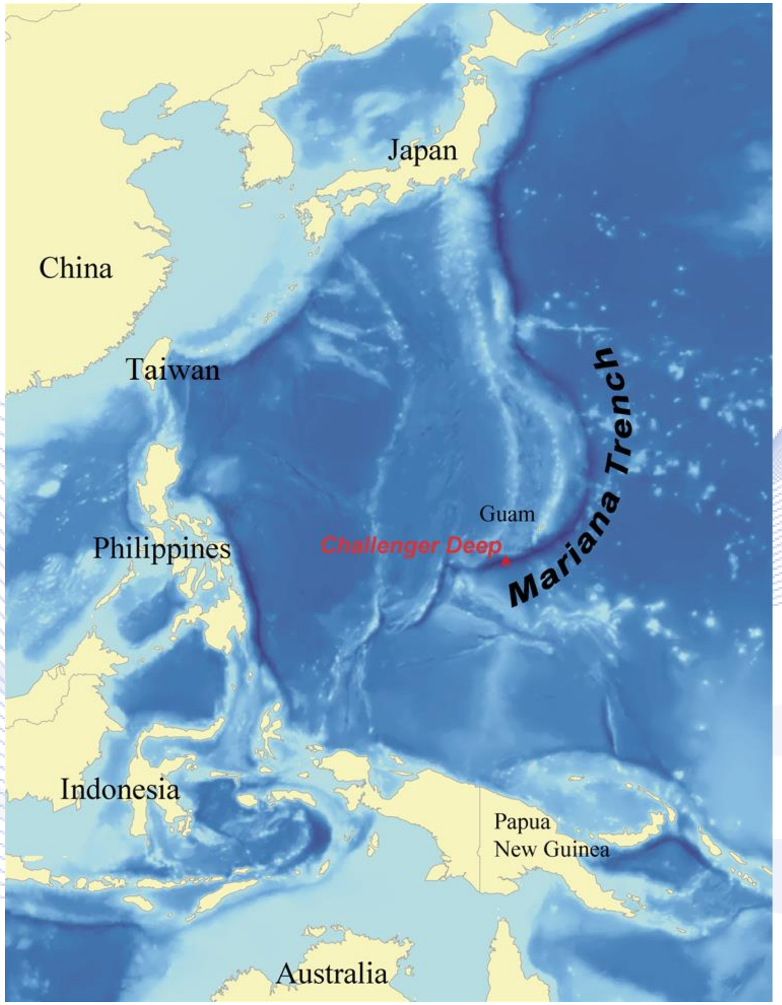
- Underwater modems include electro-acoustic transducers to receive and transmit sound signals in the water by converting electrical energy into acoustic energy (transmitting transducers) and/or acoustic energy into electrical energy (hydrophones).

AUV applications

Ocean Exploration:

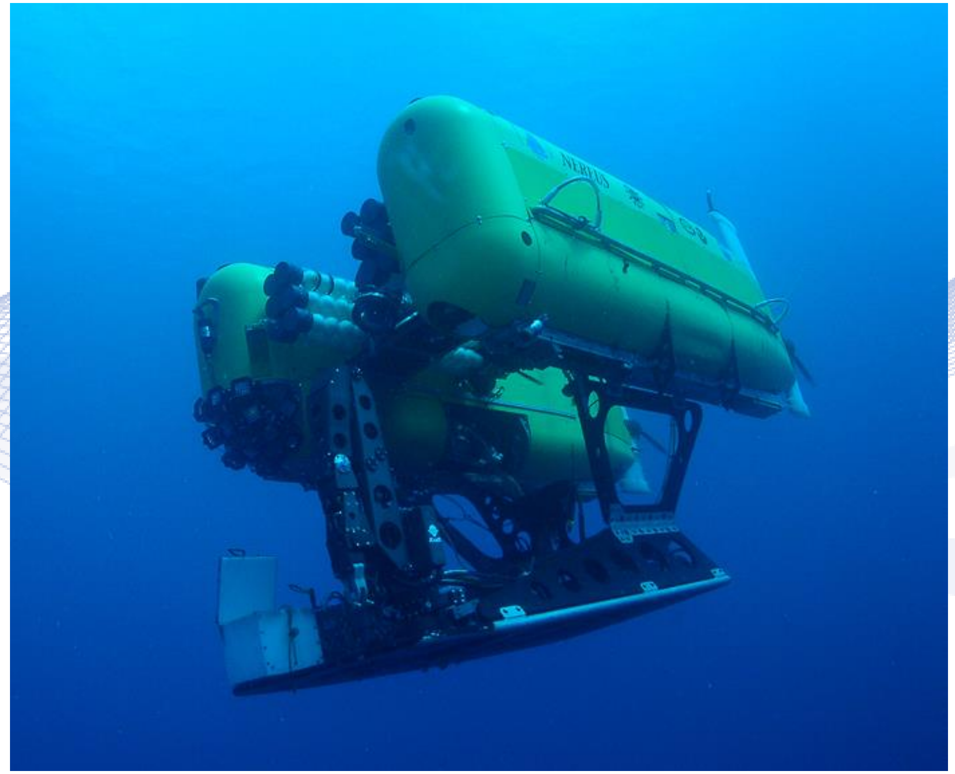
- Ocean floor is mapped at a much lower resolution (5 Km) than the Moon (7m), or other planets.
- Ocean floor mapping requires measuring gravity anomalies and using sonar at floor proximity.
- **Marianas Trench** has maximum depth 10,994 m.

[Wikipedia]



AUV applications

- HROV Nereus is the first autonomous vehicle (hybrid remotely operated vehicle, HROV) to reach the bottom of the Marianas Trench (2009).



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AUV applications

Ocean observation:

- Marine life
  - Habitat Research
  - Fishery Study
- Coral reefs
- Deep sea bottom
- Polar ocean observation
- Water Sampling.

[OCE]

AUV applications

- Defense
  - Underwater border Surveillance
  - Antisubmarine Warfare
  - Mine operations, detection and countermeasures
- Underwater oil exploration
  - Pipeline Surveillance
  - Environmental studies

AUV applications

- Environment monitoring
  - Water polution
  - Sea floor pollution
- Underwater Archeology
  - Ship wreck imaging
  - Sunk cities
- Underwater filming.
- Search & Salvage.

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Q & A

Thank you very much for your attention!

More material in
http://icarus.csd.auth.gr/cvml-web-lecture-series/

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