UNDERWATER VEHICLES

Types of underwater vehicles:

1. HOV Alvin
2. ROV Jason/Medea
3. AUV Sentry
4. HROV Nereid Under ice
5. HOV Deepsea Challenger
6. AUVs
7. Towed Vehicles

Working Principle and Operation:

HOV Alvin: (Launch in 1964)

It is a human occupied vehicle
Length-23.1 feet(7m)
Width-8.4feet(2.6m)
Height-12.1feet(3.7m)
Weight-20,400 kilograms
Depth- 2.8miles
Operating speed-2.0knots(Max speed)

It collects and observes under the sea for upto 10 hours.
It has two robotic arms handle equipment to collect rocks,samples under the sea.
Its seven reversible thrusters permit *Alvin* to hover in the water, maneuver over rugged topography, or rest on the seafloor. With an experienced pilot at the controls, it can collect data throughout the water column, produce a variety of maps, and perform photographic surveys. *Alvin* also has two robotic arms that can manipulate instruments and obtain samples ranging from hard-rock geology to delicate biology, and its sampling basket can be reconfigured daily based on the needs of each dive.

A typical manned submersible consists of four major components: a pressure hull, propellers (thrusters), buoyant materials, and observational and sampling instruments. Currently there are four types of different HOVs: manned submersible (MS), deep submergence rescue vehicle (DSRV), atmospheric diving suit (ADS), and rescue bell.

ROV Jason/Medea: (Launch in 1988) First generation,(2002) Second generation

It is a remotely operated vehicle
Length - 3.4m
Weight - 4,082kg
Speed - 1.5knot forward,0.5knot lateral,1.0knot vertical
Depth - 6,500m
Height - 2.4m
Jason can operated in two ways depending on mission requirement

1. Either as a single body [Jason only]
2. Either as a two body [with ROV Medea]

It is connected to the ship using optical cable.(Cable is about 10km)
A 10km(6 mile) fibre optical cable connects the janson to the ship
It delivers electrical power and commands from the ship to the Jason and returns data and live video images throughout the multiday dive
It is equipped with sonars,Video,Imaging systems,for numerous sampling system.
It is controlled by the scientists,pilots,navigators in the control room in a ship.
In the control room they have a live video of sea and what Jason has collecting
It requires 10 people for complete operation and management of vehicle(from the ship)
Jason dive average for 21hours [max 24 hours]
Jason's manipulator arms collect samples of rock, sediment, or marine life and place them in the vehicle's basket or on "elevator" platforms that float heavier loads to the surface. The average *Jason* dive lasts one to two days, though operators have kept the vehicle down for as long as seven days.
Jason was first launched in 1988, and the system has been used for hundreds of dives to hydrothermal vents in the Pacific, Atlantic, and Indian Oceans. ROV *Jason* is now in its second generation, with a sturdier, more advanced vehicle having been launched in 2002.

The development in 1982 of the first academic remotely operated vehicle (RoV) system, MEDEA/JASON, included a dynamically controlled surface ship, shipboard control center, fiber-optic wire and winch system, tile MEDEA relay vehicle, the remotely operated vehicle JASON. a satellite link, and shore-based control and data processing centers. The short-term goal of this development program was to place the human operators in a control center aboard ship connected by a high-bandwidth fiber optic cable to the vehicles below. The long-term objective of the program, however, is to permit a larger network of scientists to have full access to the at-sea operations from shorebased satellite downlink sites, including full control of the vehicles from shore.

(https://sci-hub.do/10.1016/0967-0637(93)90021-T)

- The Medea/JASON remotely operated vehicle system [Robert D.Ballard]

AUV SENTRY: (Autonomous underwater vehicle):

Dept - 6,000m (19,685 feet)

Hydrodynamic shape [For faster ascents and descents]

It is operates independently from the ship and has no connection cables

It performs missions like solar surveys,image collection,water chemistry and measurements,magnetic measurements and sample collection [including Volcanic areas also] (it collects samples in volcanic areas also)

Its design intended to operate very close to the seafloor on rough terrain.The wings of the AUV sentry is to explore seafloor and it involves searching for features that may be handmade (shipwrecks,pollution) or natural(deep-sea corals,hydrothermal events)

And it maps the underwater region [systematic maps of a region to inform long term geological processors]

For mapping of seafloor it uses sonar [sound navigation and ranging].By using sonars it is possible to make maps quickly

It uses Multibeam Echosounder(MBES)[Type of sonar].It is a type of sonar used to map seabed

The MBES emits pulses of sound into water and listens for the Echo from the seafloor. (Echo means sound or sound caused by the reflection of sound waves from a surface back to the listner).

MBES can listen to 512 Echoes at the sametime from different portions of the seafloor.By using these Echoes the shape of the seafloor can be calculated.By collecting millions of Echoes a detailed 3D model of the seafloor can be generated.

It has a high resolution digital camera for taking pictures of a seafloor.It takes pictures for every 3seconds upto 60hours and provides the data to the scientists.

It has a high power strobe lights that fires every time while takes a picture [Because the under ocean is completely dark].

Sentry carries a superior science sensor suite and enjoys an increased science payload enabling it to be used for both mid-water and near-seabed oceanographic investigations. *Sentry* produces bathymetric, sidescan, subbottom, and magnetic maps of the seafloor and is capable of taking digital bottom photographs in a variety of deep-sea terrains such as mid-ocean ridges, deep-sea vents, and cold seeps at ocean margins. *Sentry* is uniquely able to operate in extreme terrain, including volcano caldera and scarps. *Sentry*'s navigation system uses a doppler velocity log and inertial navigation system, aided by acoustic navigation systems (USBL or LBL). The USBL system also provides acoustic communications, which can be used to obtain the vehicle state and sensor status as well as to retask the vehicle while on the bottom. In addition its standard sensors, *Sentry* has carried a variety of science-supplied sensors, including the Nakamura redox potential probe, ACFR 3-D imaging system, and the Tethys in-situ mass spectrometer.

Like ABE before it, *Sentry* can be used to locate and quantify hydrothermal fluxes. *Sentry* is also capable of a much wider range of oceanographic applications due to its superior sensing suite, increased speed and endurance, improved navigation, and acoustic communications. Like ABE, *Sentry* can be used as a stand alone vehicle or in tandem with *Alvin* or an ROV to increase the efficiency of deep-submergence investigations.

(https://sci-hub.do/https://ieeexplore.ieee.org/abstract/document/7401985/)

HROV Nereid Under ice:

Traditional remotely operated vehicles have so far been limited in their ability to explore these regions [ice covered regions like Arctic and glaciers areas] because they rely on heavy, armored tethers that limit the vehicle's ability to move away from ice disturbed by an ice breaker, to maneuver close to the rapidly changing environment at the foot of a glacier, or to maneuver on the sea floor independently of ice moving at the surface. Engineers at WHOI recently applied technology to this challenge that originally permitted the hybrid remotely operated vehicle (HROV) *Nereus* to reach the deepest parts of the ocean. Instead of making a vehicle capable of reaching great depth, however, they aimed at designing something that could travel great distances, while still remaining under real-time human control.

HROV *Nereid Under-Ice* is built to travel up to 40 kilometers (25 miles) laterally underwater, rather than the few hundred feet of a typical ROV, while still receiving control signals and transmitting data, including high-definition video, back to operators located on a ship via a hair-thin fiber optic tether. Instead of receiving power from this tether, as a traditional ROV does, *Nereid Under-Ice* carries its own battery power on board, which makes the tether much lighter and smaller. In addition, it also carries a full suite of acoustic, chemical, and biological sensors for investigating the underwater environment, as well as a seven-function electro-hydraulic manipulator arm. The vehicle is rated to dive 2,000 meters (6,500 feet) beneath the surface to sample or survey the mid-water or sea floor.

The Nereid Under-Ice (NUI) vehicle enables exploration, detailed examination, and sampling of biological and physical ice-margin and under-ice environments through the use of high-definition video and a 7-function electro-hydraulic manipulator arm, in addition to a range of acoustic, chemical, and biological sensors tailored to suit the needs of an individual expedition. The goal of the NUI system is to provide scientific access to under-ice and ice-margin environments that is presently impractical or infeasible.

Capabilities:

- Real-time exploration under direct human control far from influence of host ice breaker
- HD video and real-time visualization of mapping and survey data products
- Respond to features of interest by altering sensing modality and trajectory as desired
- Vertical mobility – access to pressure-ridges, melt-pools, crevasses, general close inspection and mapping.
- Land against underside of ice or on seafloor
- Precision access to under-ice boundary layer
- Access beneath glacial ice tongues and shelves
- Manipulation, sample retrieval, and instrument emplacement capability (Mar. 2016)

HOV Deepsea Challenger:

The human-occupied vehicle (HOV) *DEEPSEA CHALLENGER* is a one-person submersible capable of reaching full-ocean depth.The deepsea challenger incorporates many new technological advances that will likely help advance underwater exploration for years to come. Among these is its unique vertical orientation in the water, innovative materials such as the highly sophisticated syntactic foam, and a high-quality video imaging system capable of producing 3-D movies of the seafloor.

The 24-foot (7.3-meter) vehicle has three main sections. The biggest section, the "beam," is made of a new kind of syntactic foam, the only flotation material capable of withstanding the crushing pressures of the deep ocean. Roughly 70 percent of the vehicle's volume is made up of this foam, which is composed of glass spheres embedded in an epoxy resin and which provides both flotation and structural support for the vehicle. Incorporating stronger foam opens the door to making more effective use of the material as a structural element and will help make vehicle designs more efficient.

A personnel sphere is slung below the beam; below that is an array of cameras, samplers, and other scientific gear that the pilot can deploy to carry out scientific surveys and collection while on the seafloor. Its unique vertical design enables the deepsea challenger to descend and ascend rapidly through the water, maximizing time on the bottom and enabling the sub to be recalled quickly if weather on the surface worsens suddenly.

The steel personnel sphere is 2.5 inches (6.4 centimeters) thick and 43 inches (109 centimeters) in diameter. It was designed to withstand the crushing pressure of the deep and was tested to an equivalent full-ocean-depth pressure of 16,500 pounds per square inch (1,138 bars); strain gauges attached to the sphere during testing indicated that the sphere could withstand up to 140 percent of the test pressure.

The sub has two booms—long metal poles attached to the sides of the vehicle that the pilot can deploy hydraulically from inside the sphere. One holds a powerful spotlight, and the other a pair of HD cameras. More light is provided by a seven-foot (two-meter) panel of LED lights mounted on the front of the sub above the personnel sphere that can illuminate up to 100 feet (30 meters) through clear water. These high-ouput lighting systems and non-traditional cameras will provide new views of the deep ocean and help bring a broader appreciation for some of the least-understood parts of the planet.

The vehicle runs on power provided by a bank of 70 lithium-ion (Li-ion) battery packs, each the size of a loaf of bread. There are three main buses of batteries—the sub can lose two and still function. Each battery is housed within a plastic case immersed in a bath of silicon oil and equalized to the pressure outside the sub through plastic bladders, enabling the electronics to be exposed to high water pressure without coming in direct contact with seawater. This avoids having to build heavy, pressure-resistant housings to keep the batteries dry and resulted the largest fully pressure-tolerant Li-ion batteries available for deep-ocean exploration.

Beneath the pilot sphere is a payload bay that can be equipped to gather samples and capture images on the ocean floor. The pilot has a number of research tools available, including a slurp gun—a suction sampler that operates like an underwater vacuum cleaner to collect small, soft-bodied animals. A hydraulic manipulator arm controlled with a joystick from the personnel sphere allows the pilot to collect larger or more durable samples and deposit them in a collection basket or a biobox—a thick plastic box with a close-fitting lid designed to keep samples cool—mounted on the front of the sub. The manipulator arm can also deploy a push-core sampler, a device used to collect samples of seafloor sediment.

The pilot has available six cameras to record inside and outside the sub during a dive. The largest is a Red Epic, which captures IMAX-quality, "5K-raw" images and is mounted directly in front of the small viewport on the sphere’s hatch. Other, smaller HD cameras were designed specially for *deep sea challenger* from the sensor up and housed in proprietary titanium housings smaller than a soda can. Two of these sit on the end of the 6.6-foot (2 meter) camera boom to capture 3-D footage of the seafloor. Another two are positioned side-by-side on the wrist of the manipulator arm—one with a wide-angle lens and the other a macro lens for imaging small animals up close. Inside the sphere are two smaller HD cameras that together capture 3-D video of the pilot.

AUVs:

AUVs are programmable,robotic vehicles that depending on their design,can drift,drive or glide through the ocean without real-time control by human operators.AUVs operate independently of humans.Unlike remotely operated vehicles(ROVs),which are tethered to a service vessel,AUVs have no physical connection to their operator.
AUVs carry a variety of equipment for sampling and surveying such as cameras, sonar, and depth sensors. Unlike ROVs, which transmit video via their tethers almost instantaneously to a control room on a ship, an AUV stores all data, including images and other sensor data, on onboard computers until it can be retrieved after the AUV is recovered at the end of a dive.

AUVs can range in size from only a few hundred pounds up to several thousand pounds. They may glide from the sea surface to ocean depths and back or they may stop, hover, and move like blimps or helicopters do through the air.

Fully autonomous operations carry power onboard. Power enables propellers or thrusters to move an AUV through the water and is necessary to operate sensors on the AUV. 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 are attractive options for ocean-based research. They can reach shallower water than boats can and deeper water than human divers or many tethered vehicles can. Once deployed and underwater, AUVs are safe from bad weather and can stay underwater for extended periods of time. They are also scalable, or modular, meaning that scientists can choose which sensors to attach to them depending on their research objectives. AUVs are also less expensive than research vessels, but they can complete identical repeat surveys of an area.

Scientists use AUVs to create maps of the ocean floor, record environmental information, sense what humans have left behind, identify hazards to navigation, explore geologic formations, document shipwrecks, and more.(https://sci-hub.se/10.1016/j.margeo.2014.03.012)

(https://sci-hub.do/https://ieeexplore.ieee.org/abstract/document/1282820/)

Towed Vehicles:

Equipped with a variety of sensors,towed vehicles are lowered over the side of research vessel and pulled through the water at different depths.
Underwater towed systems are fundamental tools for many marine applications which include naval defense, seabed mapping and ocean environmental measurements. These systems can be as simple as a single cable with its towed vehicle, or they may be composed of multiple towed cables and multiple towed bodies.
(https://sci-hub.do/10.1016/s0029-8018(99)00006-2)