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Surveyor, Sampler For Deep-Ocean Operations

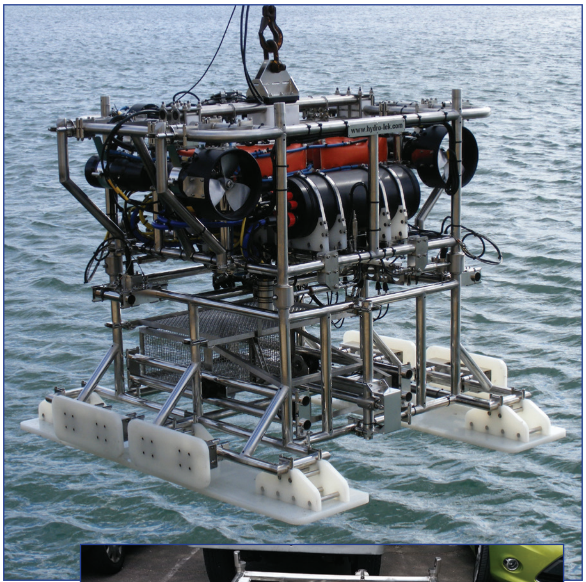
HyBIS Enables Interaction With Seafloor Up to 6,000-Meter Depths

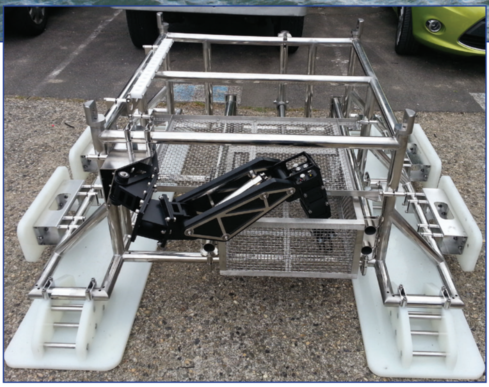
By Dr. Bramley J. Murton • Wendy Glover

Hydro-Lek's (Finchampstead, England) HyBIS (Hydraulic Benthic Interactive Sampler) is a simple, cost-effective, highly versatile and maneuverable underwater platform capable of deployment to 6,000 meters. It is designed to operate in conjunction with existing deck-handling and cable systems carried by most research and survey vessels.

The HyBIS concept was originally developed in collaboration with the National Oceanographic Centre (NOC) in Southampton, England, to survey and interact with the deep-ocean floor without recourse to expensive and complex work-class ROV technology and specialist crew. Unlike a conventional ROV, HyBIS does not have any floatation; rather, it is suspended by its umbilical cable directly from the ship with the advantage that it can recover or deploy a payload up to its own weight of 750 kilograms.

Measuring 2.2 meters high, 1.4 meters wide and 1.5 meters long, HyBIS is a fully modular plug-and-play system comprising the command module, which carries the power management, cameras, lights, hydraulics, thrusters and telemetry; and a variety of lower hydraulic and mechanical tooling modules, which consist of a sampling grab, a manipulator and tool sledge, a winch for instrument recovery, and an ocean bottom seismometer (OBS) and ocean bottom electromagnetic receivers (OBEM) deployment module. All tooling modules are able to be separated on command, allowing the tool module or payload to be accurately deployed or, in the event of an emergency, jettisoned.





(Top) HyBIS, showing Hydro-Lek five-function manipulator in stowed position.

(Bottom) HyBIS manipulator module.

The Command Module

The command module is an open-chassis structure with a footprint of 1,700 by 1,450 millimeters and height of 930 millimeters, and carries all hydraulic and electrical power and distribution. Fabricated from 316-grade tubular stainless steel, the cross-braced open-frame structure ensures an even spread of the load across the chassis that in turn forms the template for the docking system to which the various tool modules are attached. The suspension point is adjustable in two horizontal axes to allow for changes in center of gravity when different tool modules are attached. Attached to the command module are two three-phase thrusters, two hydraulic power packs, two hydraulic valve packs, two dry space pods, an oil-compensated transformer, three cameras, several lights and a hydraulic pan and tilt system.

Electrical Systems

The system is operated from a 7-kilowatt, 380-to-440-volt, single-phase power source at the surface via the umbilical cable. All three-phase power and control supplies for lighting and instrumentation are contained in 6,000-meter-seawater housings. Two reversible thrusters, which are oil-filled and pressure-compensated, produce 40 kilograms of thrust from 1.5-kilowatt motors and are generally able to provide a radius of operation of between 3 and 10 percent of water depth. HyBIS control is via a fiber-optical link that carries all command telemetry for remote operation

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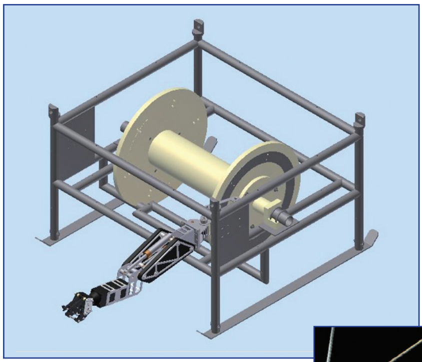
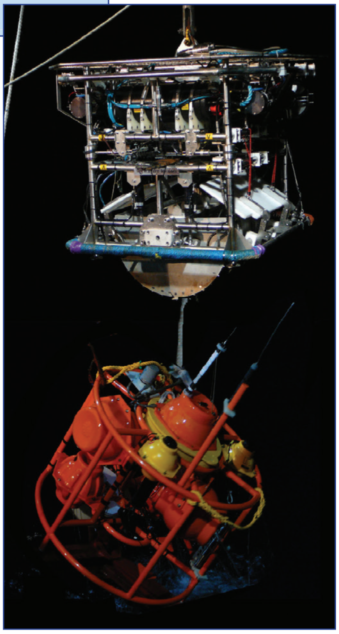




(Top) Isometric view of the lander recovery module, showing the position of the five-function manipulator arm and the passive recovery line drum. The drum carries 600 meters of 20-tonne lifting warp attached to a steel lifting hook and latch.

(Right) The Myrtel lander after being recovered by the HyBIS from a depth of 2,200 meters.

of all hydraulic and electrical functions, including switching for cameras and other ancillary equipment (e.g., television cameras and lighting).

The Tooling Modules

Bulk Sample Module. The basic tool module comprises a clam-shell grab with a 0.3-cubic-meter capacity for collecting samples of small rocks or seafloor sediments with a 30-centimeter penetration depth. Fabricated from aluminium, with stainless steel semicircular braces around the outside of each shell, the grab has a footprint of 0.5 square meters (1,000 by 50 centimeters). It is mounted in an open chassis fabricated from 316 stainless steel tubing and stands 900 centimeters tall. Its upper square frame docks with the lower square frame of the command module via the hydraulic release pins, allowing for it to be jettisoned if required. Four hydraulic rams drive the grab shells with a closure force of 30,000 newtons.

The grab module has been used by NOC to collect geological, biological, gas and other chemical samples from more than 40 separate sites. In 2010, scientists used HyBIS on an expedition in the Cayman Trough to locate and study a new species of shrimp at a depth of 5 kilometers, which they named *Rimicaris Hybisae* after the vehicle they used to discover it.

Hydro-Lek Manipulator Module. Hydro-Lek has developed a tool sledge module in conjunction with the NOC, which comprises a Hydro-Lek five-function manipulator arm and a retractable sample tray that has top and bottom rollers on both sides that are located within tubular rails. Fabricated from stainless steel and surrounded by stainless-steel mesh, the tray retracts into a drawer with a stainless-steel mesh top. This ensures that the samples are fully secure within the retracted tray to prevent their loss or damage in the splash zone when the HyBIS is being recovered.

Attached to the front lower starboard side of the tool sledge is the HLK-RHD5 five-function manipulator arm, with an 80-kilogram lifting capacity (when actuated with 160-bar hydraulic pressure) at its full reach of 943 centimeters. It has a continuous 360-degree rotating jaw, with embedded 12-millimeter-diameter cable cutter. The arm is located on a slew plate, mounted 15 degrees from horizontal such that the arm can reach the seafloor in a 270-degree arc in front of the vehicle, as well as reaching upwards to within 30 degrees from vertical. Because the hydraulic valve packs do not have flow control, the operating hydraulic pressure supplied by one of the two valve packs is reduced to 60 bar. This enables relatively slow, and hence fine, control of the manipulator arm and jaw. The option remains to activate the second hydraulic pump, which is set to 100 bar, to increase the capabilities of the arm's functions, allowing heavier lifting capacity and jaw-closure pressure.

Instrument Recovery Module

HyBIS has also been required to recover relatively heavy instruments from the seafloor. One of these was a 4-tonne benthic observatory deployed in 400 meters of water in the Arctic in August 2011 off Svalbard, Norway. The ship used was the RRS *James Clark Ross*, which is operated by the British Antarctic Survey, a division of the Natural Environment Research Council (NERC). Both the lander and ship from which HyBIS operated belong to NERC.

Limitations set by the vessel operator for this task included a restriction on deployment of more than one umbilical cable to be deployed over the side of the ship at any one time. As a result, a solution was developed that would involve the HyBIS command module deploying a lander recovery module carrying a passively driven drum of 600-meter-long lifting with a 4,000-kilogram safe working load and 200,000-newton breaking strain.

The lander recovery module was fabricated in 316 stainless-steel tubing forming an open chassis structure. It was fitted with a Hydro-Lek HLK-HD5 five-function manipulator arm from the tool sledge module that carried a lifting hook, attached to the jaw of the arm via a T-bar, and spliced onto the lifting warp. This warp was then attached to the 4-tonne lander and the HyBIS instrument recovered to the ship while the lifting warp spooled off from the drum. The drum had both a friction clutch and a restriction on the spooling of the lifting warp to ensure the warp remained tightly wound on the drum. In the event of the lifting warp fouling causing the vessel to become anchored to the lander via the HyBIS vehicle, two options were retained: the capacity to cut the lifting warp with the manipulator arm cable cutter or to jettison the entire lander recovery module.

HyBIS has had prior experience with recovering landers, but not as heavy as the 4-tonne one in the Arctic. In 2008, on its first trials cruise, HyBIS recovered a benthic lander from 2,200 meters of water in a location off the coast of Tenerife, Spain. This lander was a long-term monitoring system with CTD and acoustic Doppler current profilers (ADCP) as part of its scientific payload. It was designed with two independent acoustic releases and glass sphere buoyancy such that it should have jettisoned its anchor weights and returned to the surface on command. Unfortunately, at the end of its trial mission, the lander failed to release its anchors and became stuck on the seafloor. By acoustically ranging to its sonar transponders, its position on the seafloor was triangulated to within a few tens of meters. Deployed from a nondynamic-positioning ship, the HyBIS vehicle managed to sweep a path towards the lander's position and located it after a search across 500 meters of seabed.

Although the HyBIS was only equipped with its grab module, a line and grapple was attached to the lander and the entire assembly recovered to the surface.

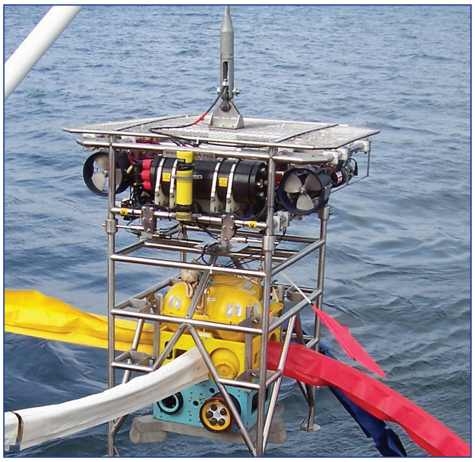
OBS, OBEM Deployment Module

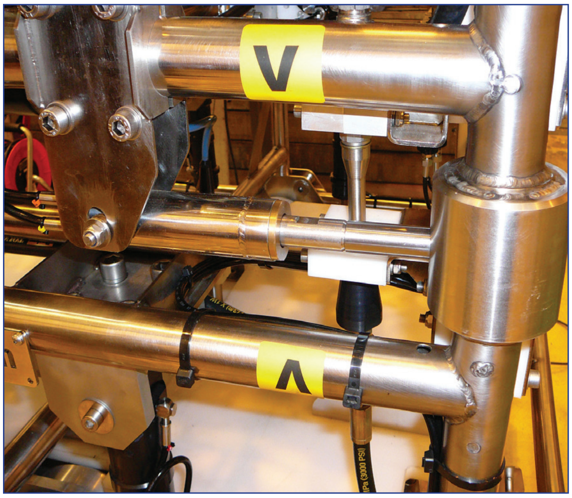
Like the other modules, the OBS deployment module is an open-frame chassis comprising 316 tubular stainless steel and attached to the command module via the four-point docking release system. The module was specifically designed to deploy ocean bottom seismometers and electromagnetic receivers. These instruments have a common footprint size and rely on an anchor weight to hold them to the seafloor, attached to glass floatation via an acoustic and timed release system to return them to the surface.

Traditionally, seismometers have been randomly dropped from the side of a ship into the ocean. However, modern geophysical studies require instruments to be placed on solid parts of the seabed, with a precise position and preferred orientation. The challenge for HyBIS was to deploy a module that would enable the instruments to be positioned on the seafloor, navigated by ultrashort baseline (USBL) transponders and placed on level, well-consolidated parts of the seafloor.

A 100-millimeter stroke cylinder was implemented at the top of the deployment module, forming a retractable rod through which the bottom instruments are held. Once a suitable area of seabed is located and the position is acceptable, the HyBIS rotates via its thrusters until the instruments are oriented in the required way. The hydraulic ram is then activated and the pin withdraws, releasing the instruments onto the seafloor. Post emplacement inspection then confirms the orientation and coupling of the instruments to the seafloor.

Based on the success of HyBIS to target, and accurately position and orientate deep-sea instruments, GEOMAR Helmholtz Centre for Ocean Research Kiel in Germany has commissioned a new HyBIS for further seabed mining exploratory research. The GEOMAR system will be used later this year in the Svalbard archipelago in the European Arctic to sample gas hydrates and map ecosystems related to this environment. Gas hydrate is a crystalline solid consisting of gas molecules, usually methane, having major implications for environmental change and as a potential future energy resource. GEOMAR is also using HyBIS for OBS deployment.





(Top) HyBIS with OBS deployment module for GEOMAR.

(Middle) HyBIS with OBS deployment module for NOC.

(Bottom) Detail showing the hydraulic release mechanism for various tool modules.

Docking Interface System

To meet the requirements to control a variety of tools, HyBIS has a built-in hydraulic latching mechanism controlled via the command module, which allows different tooling options to be deployed. Four hydraulic cylinders are positioned at each corner of the lower module to act as a release mechanism for the various tooling modules.

Surface Control Console. Interaction with the HyBIS is through the surface control console, providing the HyBIS pilot with an open view of the HyBIS environment and the controls to enable accurate maneuvering of the vehicle. Four video streams can be received simultaneously by the console and displayed on an integrated widescreen, showing one video stream full screen or all four streams in a split-screen format. Positional data, including heading, depth and GPS, sit next to critical system information, such as voltage and hydraulic pressure, on a comprehensive on-screen status bar.

All the information received by the console from the subsea module is converted into video format and stored by a digital video recorder allowing more than 300 hours of recording. Recorded data can then be transferred via a USB stick to a PC for easy documentation and reviewing.

For control, an intuitive joystick box plugs into the console to give precise control over the positional thrusters, hydraulics, lights and cameras, and includes safety key switches to ensure safe operation.

A medium-size, ruggedized, splash-proof case protects the surface control console against the elements found on-board, making it thoroughly fit for use in marine deployments.

Conclusion

As a result of its small footprint and relatively simple configuration, HyBIS requires only two operators, making it cost-effective and readily accessible to the scientific community. Unlike a conventional ROV, which involves a team

(Top) The lower module.

(Bottom) Hydro-Lek's portable surface control console for HyBIS.

of specialists, operation of the HyBIS usually requires just a pilot (usually a scientist) and winch driver (usually a ship's crew member).

The versatility of HyBIS has been repeatedly demonstrated by the NOC, which has used HyBIS on more than 100 dives during the last four years. Its most notable achievement was in 2010, when it was used to discover, film and sample the world's deepest hydrothermal vents in the Cayman Trench, which is more than 6,000 meters deep (*Sea Technology*, September 2012). These vents are considered to be the highest-pressure, hottest and most copper-rich seafloor hydrothermal systems known to date.

HyBIS has so far been deployed by the NOC and GEOMAR for missions of bulk sampling, pick and place using a manipulator, OBS/OBEM positioning and orientation, and instrument recovery. ■

Dr. Bramley Murton is a geologist at the National Oceanography Centre, Southampton, England. With more than 20 years' experience researching the deep-ocean floor, he is widely recognized as an expert on the formation of oceanic crust and its hydrothermal mineral resources. Together with Jo Garrard of Hydro-Lek, he developed the HyBIS technology to enable geologists to interact with and work on the deep seafloor in a readily accessible way.

Wendy Glover is head of marketing for Hydro-Lek, based in Wokingham, England, where for the past three years she has been responsible for developing and running public relations and marketing plans. A language and business graduate from Leeds University, Wendy has more than 30 years' experience in sales and marketing across a number of industrial sectors.