Seafloor Networks

atmospheric diving | submarine rescue | subsea tooling | subsea systems engineering | seafloor networks

OceanWorks International

Engineering Your Subsea Solutions

OceanWorks International is an internationally recognized subsea technology company, specializing in the design and manufacture of manned and unmanned subsea systems and specialized equipment for scientific study, oil and gas, military, and other marine markets. We offer a full range of subsea system engineering, design, analysis, fabrication, testing, and project management services. OceanWorks personnel have been at the cutting edge of deep subsea intervention and diving technology, operations, and support for over 30 years.

Starting in 2005 OceanWorks acted as the system designer for the **VENUS** project. OceanWorks' scope of work included the design and manufacture of the shore station, primary nodes, and the Subsea Instrument Interface Modules (SIIM). In 2007 OceanWorks was awarded a contract to design and build 14 SIIMs for the **NEPTUNE** Canada project. The Neptune SIIMs can be configured as either secondary nodes or SIIMs, depending on the application. In December 2008, OceanWorks was awarded a subcontract by Harris CapRock Communications (HCC) and Ocean Specialists, Inc. (OSI) to design and manufacture five seafloor nodes forming the seafloor network portion of the **Offshore Communications Backbone** (OCB) network in Cyprus. The OCB includes the Tsunami Warning and Early Response network for Cyprus (TWERC) system. The OCB system is designed to provide live real time data from five (5) Mediterranean monitoring stations and up to 6kW of power on a re-deployable and expandable grid up to 3000 meters below the sea surface.

OceanWorks' successful track record is based on our extensive understanding of the industry and our ability to develop new, innovative technologies to meet the deep water challenges presented by our customers.

VENUS

VENUS www.venus.uvic.ca is an advanced seafloor network project designed and manufactured by OceanWorks for the University of Victoria. It is designed to operate for 20 years as a permanent infrastructure on the seafloor, providing continuous power and communications to scientific instruments for monitoring the ocean environment.

VENUS is made up of two observatories: a two node coastal seafloor network in the Strait of Georgia and a single node near-shore cabled network at Saanich Inlet. The nodes provide live video and acoustic images and real-time data for scientific research. The Saanich Inlet Observatory has been providing live data to the scientific community since February 2006 and the Strait of Georgia Observatory has been operational since February 2008.

Features of VENUS

- 3 Primary Nodes – Saanich Inlet and Strait of Georgia (2)
- 8 underwater matable SIIM ports per node
- 12 Subsea Instrument Interface Modules (SIIMs)
- Nodes provide power and communications to Subsea Instrument Interface Modules
- Operating depth of 350 meters
- The Strait of Georgia nodes are located at 30 and 40 kms offshore on a common cable providing power from and data back to the shore station
- Integration of a buoyed profiler system

Image courtesy of VENUS

Image courtesy of VENUS

NEPTUNE Canada

NEPTUNE Canada www.neptunecanada.ca is the first regional scale cabled seafloor network. Consisting of an 800 km cable loop and five primary nodes, this ambitious project was completed and installed in the fall of 2009.

The NEPTUNE Canada SIIMs represent the 4th Generation of power management, control and instrument port design based on technology previously developed for VENUS Saanich and Strait of Georgia. The first NEPTUNE Canada SIIMs were delivered in summer 2008, and the most recent in 2011. The SIIM subsystems have been subjected to extensive qualification and accelerated lifetime testing to guarantee the maximum reliability and availability. These subsystems form the core of all OceanWorks cabled seafloor network products.

OceanWorks Contribution to NEPTUNE:

- OceanWorks designed, manufactured and delivered fourteen (14) highly capable 3rd generation SIIMs and two (2) 4th generation SIIMs based on the previous Venus designs
- Each SIIM supports up to 10 individual instrument interfaces with selectable communication protocols (Ethernet or legacy serial communication, software selectable on 4th generation)
- Each SIIM can manage and distribute between 5.25 and 9 kW of power to instruments in a variety of voltages to allow for maximum flexibility
- 2 ports at 375 VDC rated between 5 and 10 Amps
- 8 ports between 12-48 VDC at up to 5 amps (total power of 8 LV ports is 1500W), software selectable on 4th generation
- The SIIM connects to the node via hybrid underwater connectors and allows instruments to be placed up to 10 km away from the node and at depths down to 3000 meters.

OFFSHORE COMMUNICATION BACKBONE (OCB)

Offshore Communications Backbone (OCB). OceanWorks contracted with Harris CapRock Communications (HCC) and Ocean Specialists, Inc. (OSI) to develop a seafloor network for the Mediterranean Sea off the coast of Cyprus. As part of its capability, the system contains the Tsunami Warning and Early Response system for Cyprus (TWERC). The TWERC system is designed with two different types of sensors: an ocean bottom seismometer able to detect earth movement and a bottom pressure recorder, sensitive enough to detect a change in sea surface as slight as a few millimeters on each of the five OCB nodes. The larger OCB system is designed as a fully flexible and re-deployable seafloor network that can supply up to 6 kW of total power for a wide variety of instrumentation for various environmental, oil and gas and scientific investigations ranging up to 3000 meters below the surface and over 250km in total cabled distance. The OCB system brings real time communication, command and control to the seafloor in the open ocean in a self contained and re-deployable configuration.

Features of OCB

- 5 Nodes
- 3000msw rated
- 1800 VDC backbone voltage
- Up to 65km between Nodes
- 1600W per Node
- 6 ports per Node
- Instrument or SIIM connections available at the Node
- Local UPS and data logger at each Node
- Infrastructure for support of the TWERC system for Cyprus
- Skip-a-Node communication infrastructure (single fault tolerant)
- Removal of a Node does not affect other Nodes in the Array

Image courtesy of Harris CapRock Communications

Network Definitions

SHORT HAUL SEAFLOOR NETWORK

A small network located relatively close to the shore station. The network and cable can be configured to be deployed from a small vessel. Telecom or custom light cable options are available. Such a network supports up to 80 instruments located in an area close to the node.

- Distance from Shore: 0 – 10km
- Hardware: Single Secondary Node and optional SIIMs
- Instruments: up to 80
- Data Bandwidth: 1GBit/s
- Power available at Secondary Node: <3kW
- Backbone Voltage: <400VDC

MEDIUM HAUL SEAFLOOR NETWORK

A medium sized network consisting of several nodes spread over an area of interest. Linear, branch or ring topologies can be used to provide efficient coverage of the study area. Instruments can be supported around each node site and at locations up to 10km away with the use of secondary nodes.

- Distance from Shore: 10-200km
- Hardware: Multiple Primary Nodes, Secondary Nodes and SIIMs
- Instruments: up to 80 per primary node location
- Data Bandwidth: 1GBit/s
- Power available at Primary Nodes: 3kW
- Backbone Voltage: <2kVDC

LONG HAUL SEAFLOOR NETWORK

A long haul network consisting of multiple nodes spread over a wide area of interest. Linear, branch or ring topologies can be used to provide efficient coverage of the study area. Instruments can be supported around each node site and at multiple locations up to 10km away with the use of secondary nodes.

- Distance from Shore: >200km
- Hardware: Multiple Primary Nodes, Secondary Nodes and SIIMs
- Instruments: up to 80 per primary node location
- Data Bandwidth: 10GBit/s
- Power available at Primary Nodes: >3kW
- Backbone Voltage: >2kVDC

OPEN OCEAN SEAFLOOR NETWORK

A seafloor network consisting of one or multiple nodes spread over an area of interest. Similar in construction to a short, medium or long-haul seafloor network, but with a connection to an open ocean buoy for power and satellite communications in place of a more traditional shore station. In long haul operations, a single shore station may be replaced with multiple open ocean buoys for power and communication sharing.

- Distance from Shore: as required
- Hardware: Single or Multiple Primary Nodes, Secondary Nodes and SIIMs
- Instruments: up to 80 per primary node location
- Data Bandwidth: 1-10GBit/s subsea and 6MBit/s satellite (full data logging on buoy)
- Power available at Primary Node: dependant on design requirements
- Backbone Voltage: dependent on design requirements

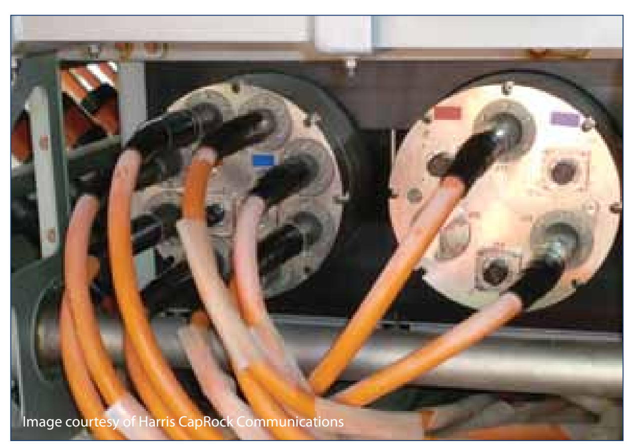


Image courtesy of Harris CapRock Communications

Hardware Definitions

PRIMARY NODE

Primary nodes are connected to the backbone cable and convert the supplied medium voltage (ranging from 1kV to 10kV depending on network distance and power requirements) to an intermediate voltage (375VDC). The intermediate voltage is distributed to a number of ports that can be connected underwater. Similarly, high speed fiber optic communications is distributed to the ports in either copper or fiber communication links. Each port is individually switched and monitored for power draw and ground faults. SIIMs or secondary nodes can be connected to the primary node to form the network. Instruments can be, but are not normally connected directly to the primary node.

- Input: Backbone medium voltage (1kV to 10kV) power and highspeed fiber optic communications
- Output: Intermediate voltage (375VDC) power, fiber or copper communications
- Ports: Typically from 4 to 8 underwater mateable connectors
- Redundancy: Fault tolerant for control, power and communications
- Power return: Seawater
- Structure: Trawl resistant frame with removable electronics pod

SECONDARY NODE

Secondary nodes are connected to the primary node via underwater mateable connectors. The secondary node can be located up to 10km from the primary node and provides further distribution of intermediate voltage power and communications. Instruments can be connected directly to a secondary node or via SIIMs. Each port is individually switched and monitored for power draw and ground faults.

- Input: Intermediate voltage (375VDC) power and fiber optic communications
- Output: Intermediate (375VDC) & Low (15 to 48VDC) voltage power, fiber or copper communications
- Ports: 4 to 8 underwater mateable connectors
- Redundancy: Optional fault tolerance for control, power and communications
- Power return: Cable
- Structure: Optional trawl resistant frame

SUBSEA INSTRUMENT INTERFACE MODULE (SIIM)

The SIIM is connected to primary or secondary nodes via an underwater mateable connector and interfaces up to ten instruments to a single node port. The SIIM provides a range of individually switched and monitored low voltage ports and communication options to support the wide range of oceanographic instruments used on seafloor networks. SIIMs can be daisy chained to allow for additional instrument connection ports.

- Input: Intermediate (375VDC) voltage power and copper communications
- Output: Low (15 to 48VDC) voltage power and copper communications
- Ports: 6 to 10 dry mateable connectors
- Redundancy: Optional fault tolerance for control, power and communications
- Power return: Cable
- Structure: Optional open instrument frame

UNINTERRUPTABLE POWER SUPPLY (UPS)

The UPS system is a modular system that can be scaled based on a standard 150kWh element. The 150kWh module can be used either as a standalone unit or connected together in a daisy-chain or hub configuration providing a capacity from 150kWhr to 1.5MWh. The UPS system allows for load leveling of high power operations on a duty cycle to limit peak current on the greater seafloor network and to provide secure autonomous backup power and control for critical systems and controlled shutdown of sensitive equipment in the event of a network power outage. The UPS system can also be used for centralized power for short deployment subsea systems.

- Battery Lifetime – 5yr deployment
- Subsea monitoring and Data logging – 25yr life
- Expandable to 1.5MWh
- Lead Acid, Li-Ion or other battery types available depending on applications
- Gas production management for Lead Acid battery systems

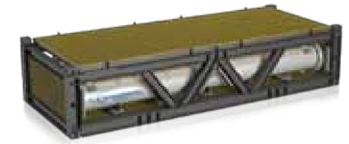
Seafloor Network

SHORE STATION 1

Shore stations have the following:
~ Cable landing area
~ Medium voltage power supply
~ Connection to internet

3 UNINTERRUPTIBLE POWER SUPPLY

Provides load leveling operations to allow high power operations on limited duty cycles or critical equipment power hold up.



2 SIIM INSTRUMENT PLATFORM

Provides power and communications for 10 oceanographic instruments. Connects to a primary or secondary node port.

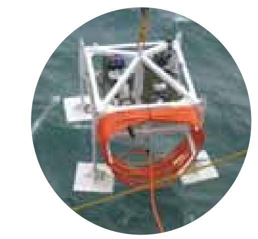


Image courtesy of VENUS

SIIM PACKAGE

4 PRIMARY NODE

Primary nodes are connected to the backbone and convert power to an intermediate voltage. Node ports distribute power, communications, and can be connected underwater.

Image courtesy of Harris CapRock Communications

5 OPEN OCEAN OBSERVATORY

Buoy-based power, communications uplink. Allows for versatile location deployments.

Image courtesy of Harris CapRock Communications

6 STANDARD TELECOMMUNICATIONS CABLE

Single conductor capable of multiple fibres. Cable can be laid or buried depending on requirements.

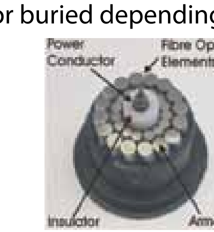


Image courtesy of VENUS

8 HYDROPHONE ARRAY

An example of a science instrument that plugs directly into a node port.

Image courtesy of VENUS

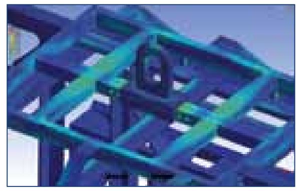
7 SECONDARY NODE

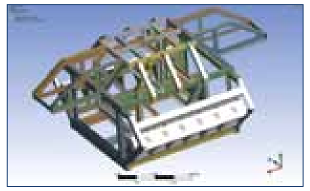
MECHANICAL ANALYSIS

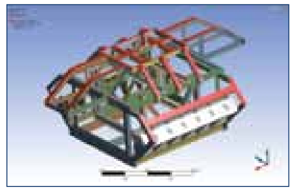
Mechanical structures and pressure vessels are simulated with finite element analysis to confirm the design meets its requirements. Pressure vessels are typically designed and analyzed to withstand a minimum of 1.25 x operating depth pressure. A customer may request a pressure vessel to satisfy other standards such as NAVSEA 9290 for implodeable volumes, certifying the pressure vessel for operation with manned submersibles.

OceanWorks' Capabilities:

- Hydrostatic pressure testing facility
- Vacuum leak tightness testing
- Man rated pressure vessel experience







CORROSION RESISTANCE

Pressure vessels, node pod and trawl resistant frame are engineered with particular attention to ensuring that corrosion is minimized. Design life for the pressure vessels and trawl resistant frame is typically 20 years. Pressure vessel materials are selected based on a number of project constraints including deployment depth, required lifetime, deployment environment (e.g. hydrate fields), cost and schedule. Where required, the pressure vessels are qualified as implodeable volumes in accordance with applicable sections of NAVSEA 9290. Materials are selected to minimize galvanic corrosion and crevice corrosion. Dissimilar materials are separated using galvanic isolators and particular attention is paid to material surface treatments.

Materials used include:

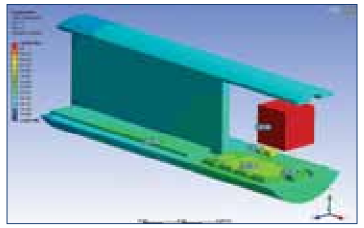
- Titanium, used for long term (25 yr immersion) pressure vessel, rated to 3000 msw (9842 fsw)
- Superduplex stainless steel 2507, used for the moderate term (5-10 yr immersion) pressure vessel rated to 350 msw (1148 fsw)
- Epoxy coated steel used for node trawl-resistant frames
- High Density Polyethylene (HDPE) used in node pods
- Others based on system requirements and customer preference

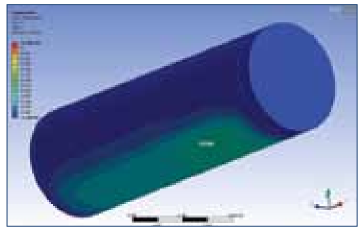
THERMAL DESIGN

A thermal analysis of all pressure vessel enclosed electronics is performed to ensure that ambient operating temperatures remain under 40 ºC. The design of the pressure vessel and electronics chassis is first simulated using ANSYS™ and then validated in a thermal test chamber. Heat dissipation is primarily by conduction, eliminating the need for failure prone fans.

Features of the thermal design include:

- All electronics mounted on aluminum chassis
- Chassis thermally bonded to the pressure vessel via expansion mechanism
- Electronic components are all capable of operating at 70 ºC (158 ºF)
- Operating temperature of the chassis is typically 30 ºC (86 ºF) when the pressure vessel is in water cooler than 10 ºC (50 ºF)
- Temperature of the chassis is monitored by telemetry





Technical Capabilities

RECOVERABLE NODE POD

All power conversion, intermediate voltage distribution and communication electronics are housed in pressure vessels that can be detached easily from the subsea cable and recovered to the surface for service and upgrades. This functionality is achieved by mounting the pressure vessels in a removable pod that is secured to the node base. Underwater mating connecters (fiber optic and electrical) from the node base connect to the node pod to allow easy connection and disconnection from the backbone cable.

Features include:

- A trawl resistant design incorporating low profile ROV grab handles
- An ROV actuated positive lock mechanism that secures the node pod to the base
- ROV connectable single lift point
- Dropped object protection

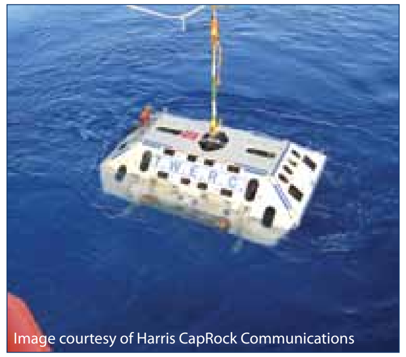


Image courtesy of Harris CapRock Communications

MEDIUM VOLTAGE CONVERTER

The Medium Voltage Converter (MVC) consists of two or more power modules running in parallel. In normal operation, the load is distributed evenly between the two modules. With a design life in excess of 10 years,the two-module design allows for graceful degradation of the power supply in the event of a failure in one power supply module.

The MVC specifications are:

- From 1 kV to 10 kV nominal input voltage depending on model
- Input voltage tolerance of +20% and -50 %
- Over voltage protection against line transients
- Maximum power 3 kW to 10 kW
- Isolated telemetry

UNDERWATER ROV CONNECTORS

Wet mate connectors for power and communications allow the node to be deployed and recovered for maintenance. Wet mate connectors are also used to allow secondary nodes or SIIMs to be plugged into a primary node. The connectors may be plugged or un-plugged using an ROV.

The wet mate connectors have the following features:

- 20 yr life
- 1000 connection cycles before maintenance
- Copper conductors for power and 100 BaseT Ethernet
- Fiber optic for GBit Ethernet communications
- Common interface for intermediate power and communications distribution to SIIMs

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DATA MANAGEMENT AND ARCHIVAL SYSTEMS (DMAS) AND SYSTEMS OPERATIONS

Through our partners we can offer:

- Data Management
- Archival Systems
- Network Operations Center
- Operational Support

SURFACE SUPPORT SOFTWARE

A comprehensive suite of software tools is provided for surface control, monitoring and maintenance of the nodes and SIIMs. The surface software provides the user with an easy to use, graphical HMI, running on a personal computer. Functions supported by the surface software include:

- Monitoring & Control of circuit breakers
- Logging functions to record telemetry, commands, and alarms
- Ability to send e-mail alerts on specified alarm conditions
- User interface to set alarm limits in the subsea processors
- Maintenance functions providing calibration and communication tests
- Scripting functions to provide automated control of frequently executed control sequences

CABLE MODELLING AND TRANSIENT PROTECTION

Underwater infrastructure is often located many kilometers from its power source. Modelling using PSPICE or EMTP of all long power distribution cables is completed early in the design cycle to determine the magnitude of voltage spikes induced by the cable during load changes. Voltage spikes can be in excess of twice the nominal voltage and can damage equipment unless properly suppressed.

Hardware is built to simulate cable sections for system integration testing, eliminating the logistical complexity of utilizing hundreds of kilometers of physical cable for pre-deployment testing. Hardware cable simulators are designed with the following features:

- Modular - allowing various cable lengths to be simulated
- Multiple pi-elements per cable section
- Rack mountable
- Cooling to dissipate line losses

SUBSEA MONITORING AND CONTROL SOFTWARE

Circuit breaker control and telemetry monitoring functions are provided by either a single or dual-redundant, "Commercial off the Shelf (COTS)" single-board computer. Hotel power and the pressure vessel internal environment are also monitored. The subsea firmware provides for normal and maintenance functions. Features of the subsea software include:

- TCP/IP Telnet interface for commands
- UDP transmission of telemetry at variable rates
- User defined circuit breaker limits for current, voltage and ground-fault
- User software defined communication protocols
- User software defined low voltage (12-48 VDC) output
- PTP & NTP timing protocol support
- Circuit breakers automatically shut down when limits are exceeded
- Remote programming and debug capability via TCP/IP

Seafloor networks are utilized for a wide range of applications ranging from:

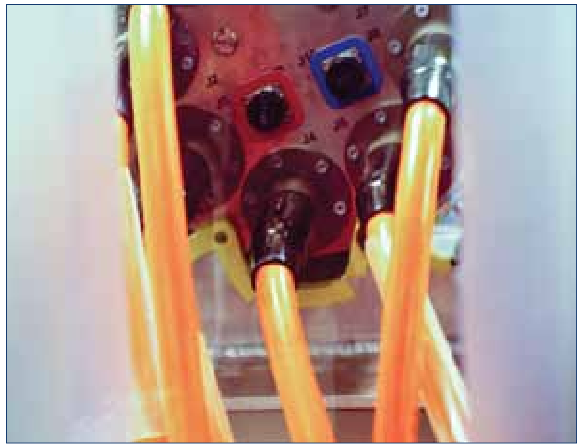
- Oil and Gas subsea infrastructure monitoring
- Scientific real time Internet based research stations
- Coastal security and littoral security infrastructure
- Resident ROV/ AUV/ Crawler interface infrastructure for remote inspection and intervention
- Environmental baseline of currents, sedimentation, chemical and biological activity
- Tsunami and offshore earthquake monitoring for advanced warning to allow for controlled shutdown of transit and nuclear resources
- Oil and Gas subsidence detection
- Life of field geophysical seismic instrumentation arrays
- Seafloor observation stations (acoustic, visual, or other)

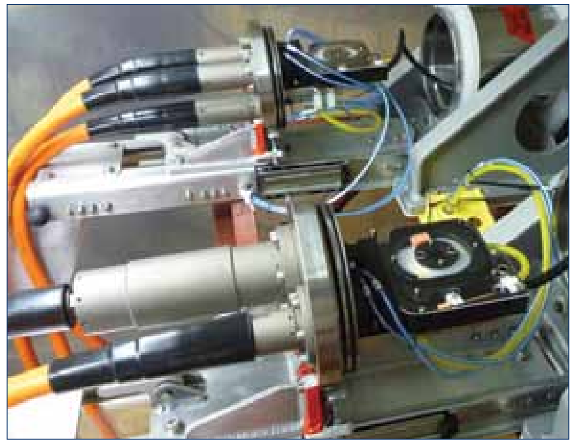
Seafloor networks are designed to be deployed as part of a permanent infrastructure for up to 25 years. As a result they are purposely designed to provide maximum flexibility and modularity in the instrumentation that they can support.

Seafloor networks support a wide range of instruments used for seafloor, sub-seafloor and water column observation. Any instrument with EIA-232/485/422 serial or 10/100 BaseT Ethernet can plug directly into a SIIM or secondary node and can be brought live to the remote desktop of any operator with command access.

Some of the instruments supported and used in seafloor networks include:

- ADCP (Acoustic Doppler Current Profiler)
- Hydrophones
- Temperature & Conductivity meters
- Pressure sensors (including Tsunami monitoring)
- Ocean bottom broad band seismometers
- Cameras (still and video) and associated lights
- Nutrient monitors
- Sample storage containers
- AUV (Autonomous Underwater Vehicle) docks
- Tethered crawlers or ROVs
- Tilt sensors
- Chemical and Biological sensor suites





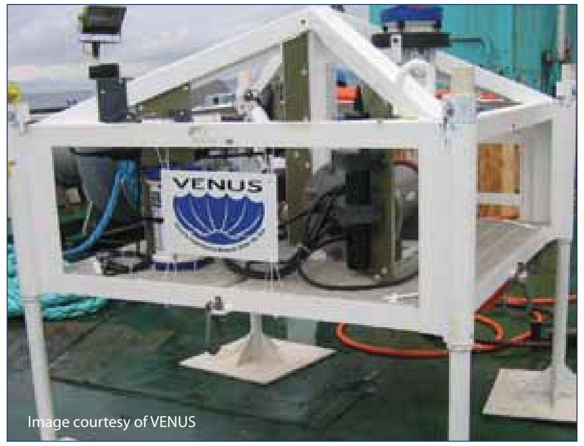


Image courtesy of VENUS

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