NOAA SHIP OKEANOS EXPLORER

Mission Equipment

The **OKEANOS EXPLORER** is dedicated solely to ocean exploration and discovery, supporting the NOAA Office of Ocean Exploration and Research. What separates this ship from most is the real-time data transfer capabilities of the ship via telepresence, there is a higher level of security of the vessel's systems. As such, all visitors and crew are required to be running up-to-date antivirus software with up-to-date scans on their computers prior to arriving on the ship in order to gain access to the internet or the ship's network.

Nearly all of the ship's scientific sensors are integrated into the Scientific Computing System (SCS), which allows for centralized data acquisition and logging from numerous sensors with different sampling rates. One central data set of all sensors is logged continuously, and user-specified subsets of sensor data and independent sampling rates may also be logged simultaneously. All data are time stamped from the ship's high-precision UTC clock and GPS. SCS data can be accessed with feature-rich software from several workstations in the dry lab and control room. Details for individual shipboard sensors and systems are provided below.

More information about specific ship equipment can be found on the Electronics Equipment and Deck Equipment pages.

Computer System and Network

The shipboard network of computers, switches and routers are state of the art to meet the scientific requirements of an information driven world. This network forms the backbone of the Okeanos Explorer's mission structure. It is a combination of fiber optic and Cat 6 connections. The ears and mouth of the Okeanos is the massive 16 foot V-Sat antenna housed in the large ball on the mid mast. This antenna is gyroscopic controlled to keep the ship in contact with the outside world—no matter the weather or distance from shore. The VSAT the primary component of the on board studio called Telepresence.

The network is divided into smaller subnets. The Mission subnet is the administrative and day to day operations including e-mail and internet access. The Scientific subnet is the data acquisition, which allows scientist to collect data and retrieve stored data. The telepresence subnet allows the world a window into the mission itself onboard the EX. It connects cameras, intercoms and scientific computer monitors to the shore-based Exploration Command Centers. It is how scientist on shore can interact in real-time with the crew. The secured Wireless subnet is for mobility—you can go from the ROV hanger to the ROV control room without dragging a cat6 cable and requiring a port to physically plug into. Last is the Visitor subnet which allows visitors

personal internet access without interfering with the other subnets. All government owned network computers using any part of the network still operate under the same security rules as the rest of the fleet.

Computers

The network is controlled by two Dell servers—one primary and one secondary, which is capable of taking over in case of a failure within the primary. Both servers are clones of each other. There are 8 other Dell servers with other roles. Two servers are dedicated to SCS. Two servers are dedicated for ships e-mail. One server is for data manipulation. There is a server for the inventory, maintenance and repair database. A Telepresence server handles the interfacing of the Telepresence network with the V-Sat. The last server is for security to monitor the other servers.
In addition to the servers there are 42 computers onboard. Half of them are directly involved with scientific data acquisition. They serve in roles of SCS clients, remote work stations, and data acquisition and processing stations. This group also includes a wet environment remote computer monitor and keyboard in the wet lab for working with all the water, chemical and biological sampling that may take place in that space. The other half is involved with administrative and ship functional duties. Functional duties include backup communication to the V-sat via Fleet 77 (advance INMARSAT B) and Iridium. To supplement the desktop computer inventory, the ship also carries two Panasonic tough-book laptops.

Network

The entire network is managed by a Smart Cisco router and Cisco switches connected via fiber optic cable with a copper backup in place in case of loss or damage to the fiber. There is a LAN network connection available in every space throughout the ship. These connections can be turned on and off by any of the ship's ETs. To help with mobility, a secured wireless network is available. Again access is only gained with permission of the ET department.

Commercial Software Packages

ArcMap.
Microsoft Office 2007
Hypack
CARIS HIPS and SIPS 6.1
MapInfoProfessional 9.5
Fledermaus 6 and 7
Sonar Whiz

VSAT System (Very Small Aperture Terminal)

3.7 m C-Band SeaTel Tracking Satellite Dish atop main mast in radome for real-time communications with shore. 20 Mbps (megabits per second) upload and 5 Mbps download capable. Non-ROV operations will generally use 5Mbps upload/download. 20 Mbps is primarily for live ROV ops when sending high-definition video, audio, and data streams to shore. Allows real-time voice intercom with ship at ECCs (shore-based control rooms). Real-time data distribution and archiving. Increases breadth of exposure and expertise brought to discoveries very quickly.

Exploration Command Centers

There are currently five Exploration Command Centers (ECCs) located around the country that provide scientists and explorers the ability to participate in missions directly from shore. The ECCs are located at:

- NOAA PMEL, Sand Point, Seattle, WA
- NOAA HQ, Silver Spring, MD
- University of New Hampshire, New Durham, NH
- University of Rhode Island, Kingstown, RI
- Mystic Aquarium, Mystic, CT

The ECCs are equipped with 3 large flat-screen LCD monitors for viewing live imagery from the ship; 3 computer workstations for receiving and viewing data feeds from the ship; and an IP telephony RTS system for real-time two-way audio communications with the ship control room. ECC technology evolves as industry changes standards and new technologies become affordable. The primary role of the ECCs is to provide a broader base of intellectual capital to exploration, and allow explorers to explore from shore.

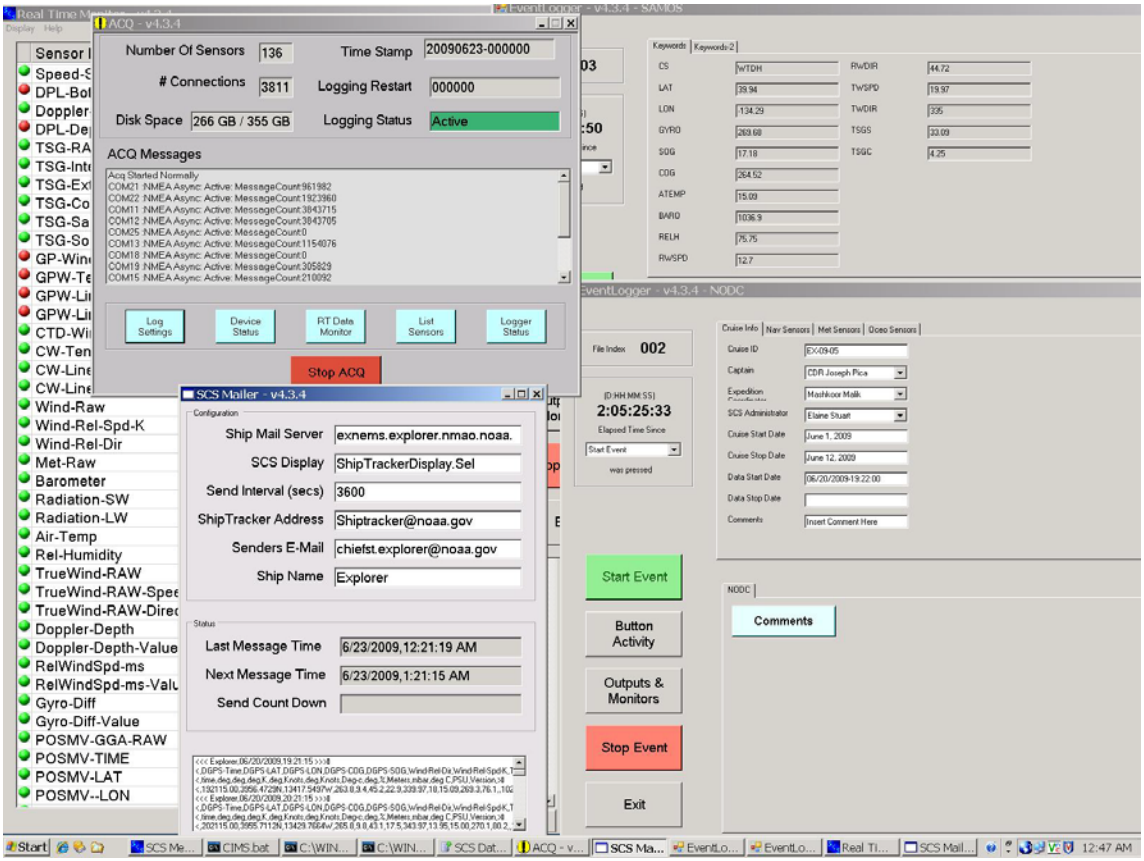
Data Acquisition System

The Scientific Computer System (SCS) software was developed at NOAA Headquarters specifically for the NOAA fleet. SCS is a data acquisition system designed for oceanographic and fisheries applications. The C^{++} based software package is run through point and click menu bars. The SCS package utilizes Graphical User Interface (GUI) technology in the form of time series graphs and directly calls ArcView graphing capabilities.

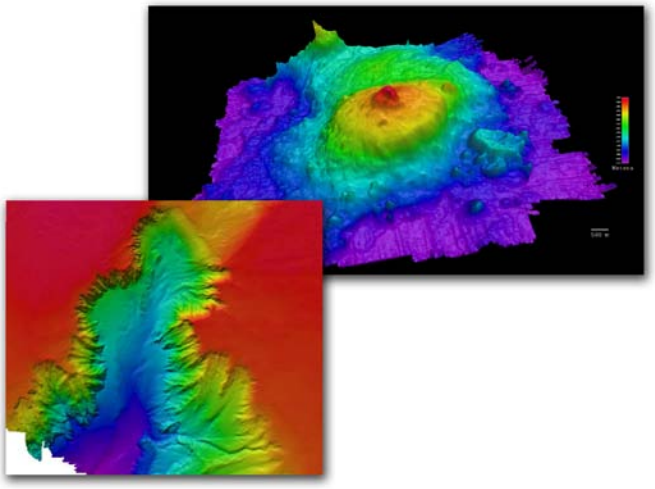
SCS is capable of sending data displays to remote stations (SCS Client) throughout the labs. In addition, ASCII data strings can be sent via RS-232 cable or over the Ethernet. The SCS workstations can provide time series graphs of all acquired data to monitor any changes. Several variables can be plotted against each other in real time X-Y plots. Data can be output in a wide variety of formats. Data output formats include:

- raw data files in binary form
- ASCII data for easy transfer to PC environment

The Okeanos Explorer is currently operating with the first full database logging version of SCS, v4.3.4. The database is supported by Microsoft SQL Server. The theory is to be able to provide data to a wider range of professionals who can select specific data sets for specific time periods. This system is still under construction and testing.



BATHYMETRIC DATA ACQUISITION



Multibeam Echosounder:
Kongsberg Maritime EM302, 30 kHz

The state of the art 30 kHz EM 302 deep water multibeam sonar is manufactured by Kongsberg, Inc of Norway. The system is installed in a custom-designed hull transducer faring. The EM-302 provides the ship with high resolution deep-water mapping for reconnaissance and detailed site mapping to support ocean exploration and discovery.

The EM 302 transducers are modular linear arrays in a Mills cross configuration with separate units for transmit and receive. This sonar offers significantly larger swath width, increased data density and resolution. Beam focusing is applied both during reception and transmission. The system has up to 288 beams / 432 soundings per swath with pointing angles automatically adjusted according to achievable coverage or operator defined limits. In multi-ping mode, 2 swaths are generated per ping cycle, with up to 864 soundings. With multi-ping the transmit fan is duplicated and transmitted with a small difference in along track tilt.

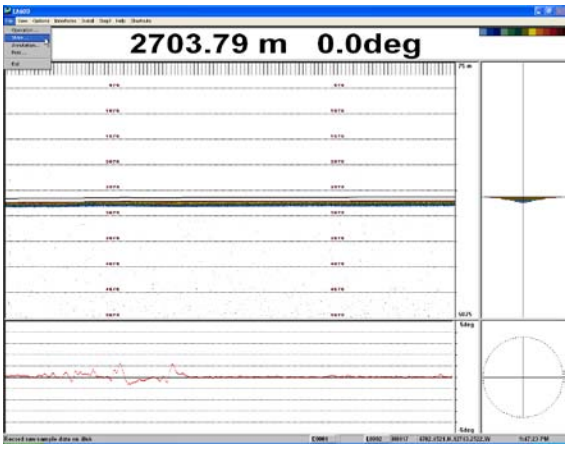
The applied tilt takes into account depth, coverage and vessel speed to give a constant sounding separation along track. The beam spacing can be adjusted as equi-distant or equi-angular. EM 302 uses both CW pulses and FM sweep pulses with pulse compression on reception, in order to increase the maximum useful swath width. The transmit fan is split in several individual sectors with independent active steering according to accomplish compensation for the vessel movements: yaw, pitch and roll. The high density, high resolution, large coverage and water column capability makes EM 302 an ideal system to explore the sea bed and the water column for detection and characterization of a broad spectrum of features.

EM302 Performance Data

Operating frequency	30 kHz
Depth range	10-7000 m
Swath width	5.5xDepth, to approx 8 km
Pulse forms	CW and FM chirp
Swath profiles per ping	1 or 2
Motion compensation:	Yaw ± 10 degrees
	Pitch ± 10 degrees
	Roll ± 15 degrees
Sounding pattern	Equi-distant /equiangular
Depth resolution	1 cm
Side lobe suppression	> 25 dB
Beam focusing	On transmit (per sector) and on reception (dynamic)
Beam forming method	Time delay
Gain control	Automatic
Swath width control	Manual or automatic
Water column logging	Yes
Mammal protection	Yes (Not implemented yes)
Transmit array deg	150(Across track) x 0.5 (Along track)
Receive array deg	1 (Across track) x 30 (Along track)
No. of beams/swath	288
Max no. of soundings/swath	432
Max no. of swaths/pings	2
Max no. of soundings/ping	864
Approx. file sizes:	
Without water column	250 MB/hr (200m) - 80 MB/hr (3000m)
With water column ~ 5 times file sizes @ 2000 m water depth	
Approx. beam foot print:	@ 500 m (~ 4.5m x 9m) @ 3000 (~27m x 52m)
Data format	*.all for bottom bathymetry and backscatter
	*.wcd for water column backscatter
Data processing	Caris HIPS/SIPS, Fledermaus

Single Beam Echosounder:

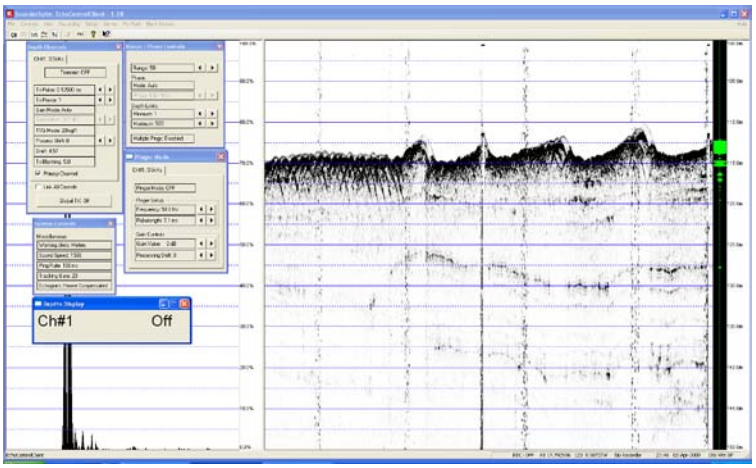
Kongsberg Maritime EA600, 12 kHz, depth rated to 12 km



The EA600 single beam is typically used while conducting a CTD cast to monitor the depth as the ship holds position, or as the CTD is being towed (Tow-yo). Since the Okeanos Explorer primarily maps with the multibeam sonar, the single beam data is only recorded when an interesting feature is observed, or during an operation where the bottom is beyond the EM 302 range (~ 7000 m).

Subbottom Profiler:

Knudsen 3260 Chirp, 3.5 kHz



The Subbottom Profiler is still being tested to determine its usefulness in exploration. The data from the Chirp can be processed with Sonar Whiz and overlaid with bathymetry data from the multibeam to visualize the bottom topography as well as the seafloor layer structure.

METEOROLOGICAL

The Remote Measurement & Research Company, LLC (RMRCo) ZMET Meteorological Sensor package is located on the flying bridge catwalk. The sensors are placed on the centerline (or as close to) of the ship. This package contains the following sensors, and each is recorded by SCS:

Barometer

Digital barometer outputs in millibars.

Air Temperature/Relative Humidity

Combination Vaisala air temperature and relative humidity sensor with radiation shield.

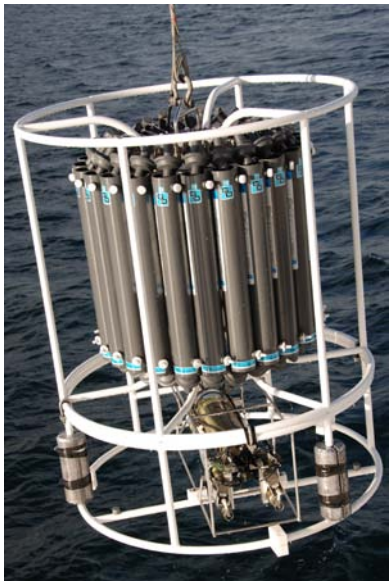
Wind Direction and Speed

RM Young wind bird measures vessel relative direction and speed. SCS then calculates true wind direction and speed as a derived sensor, using the vessel's Course Over Ground (COG), Speed Over Ground (SOG), Heading (GYRO) .

Radiometers

There are two sensors in the RAD system. The Precision Spectral Pyrometer (PSP), on the starboard side, measures the solar spectral region (shortwave). The Precision Infrared Radiometer (PIR), on the port side, measures terrestrial spectral region (longwave).

OCEANOGRAPHIC



PROFILING

CTD

Seabird Electronics Model 9/11+ CTD system in a 24-position rosette frame with a seabird SBE-32 submersible array firing assembly. The SBE 9+ underwater unit has a depth capability of 6800 meters and a dual conductivity/temperature sensor pair. The acquisition computer is running Seasave v 7 data collection software.

The **OKEANOS EXPLORER** has a spare SBE 9+ underwater unit with a dual conductivity/temperature pair.

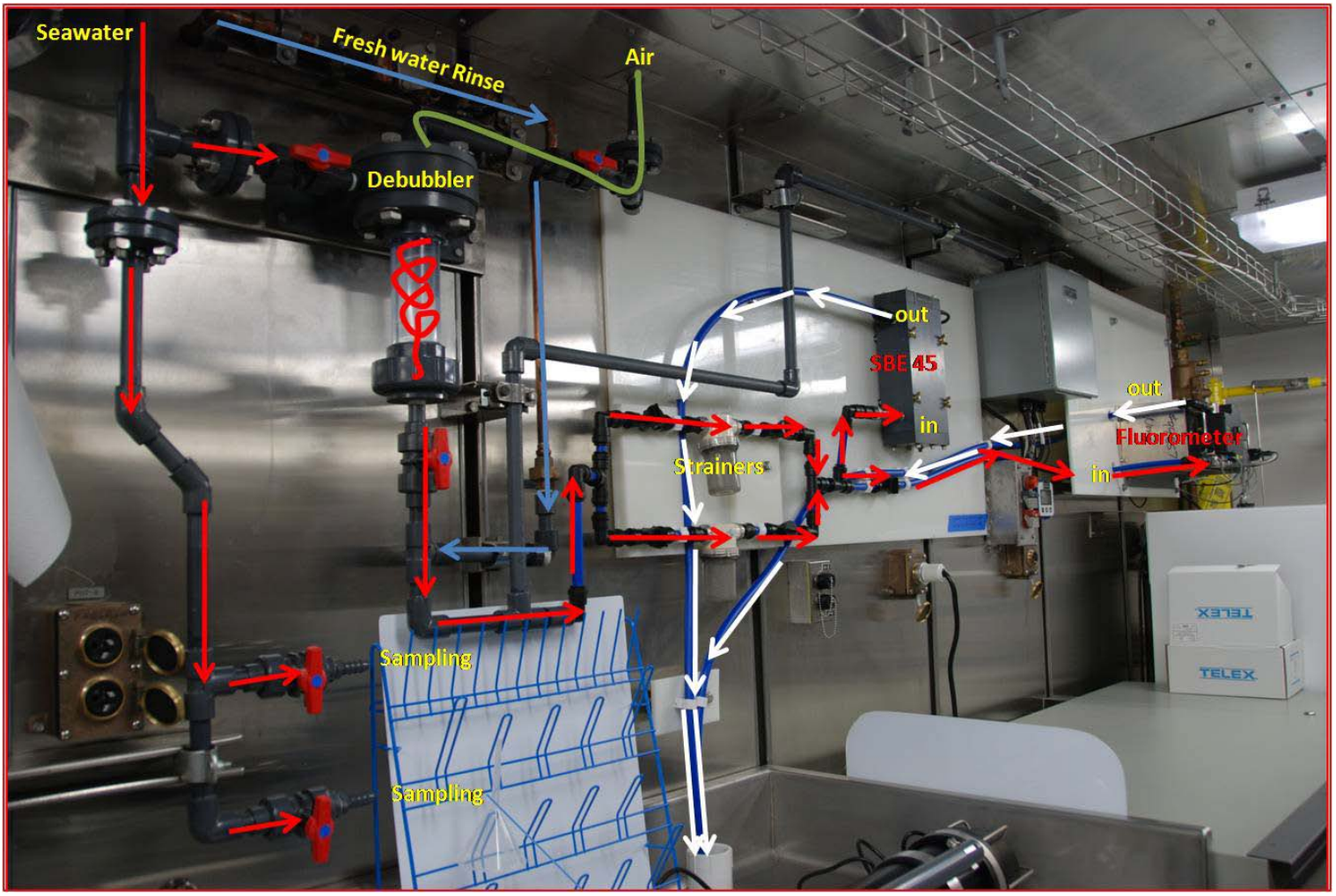
Expendable Bathythermograph (XBT)

Lockheed Martin Sippican Mk-21 XBT system with a portable hand-held launcher is used for obtaining sound velocity profiles while underway. These sound velocity profiles are processed with the NOAA developed Velociwin software and entered into the multibeam echosounder data acquisition software for accurate bathymetry data collection.

SCIENTIFIC SEAWATER SYSTEM

Thermosalinograph (TSG)

Seabird Electronics SBE-45 thermosalinograph, located in wet lab, is capable of measuring the sea surface conductivity and temperature. This data is recorded on SCS and is available for scientific use. There is also an SBE-38 remote temperature sensor located in the bow thruster room which measures the temperature of the water as it enters the ship from the intake on the bow. This temperature value is then used to calculate sound velocity. That calculated sound velocity is then sent to the multibeam echosounder to monitor sea surface sound velocity.



Fluorometer

Installed inline Turner 10-Au Fluorometer with data output to SCS and is available for scientific use.