MSV OCEAN INTERVENTION II

DP-2 MSV

The *Ocean Intervention II* is one of Oceaneering's dynamically positioned (ABS DP Class 2) multi-service vessels (MSVs). The vessel delivers value and flexible capabilities by combining an efficient size, excellent stability, modular components, and a moonpool launched ROV system. Christened in 2000, the *Ocean Intervention II*'s track record is filled with innovative deepwater projects developed from Oceaneering's years of operational experience and engineering expertise in the Gulf of Mexico.

Features

- 1,200 T deck capacity
- 6,500 ft² clear deck
- Two large moonpools
- Onboard ROV tool suite
- 60 T stern A-frame
- 80 T deck crane
- Hydra® Maxximum ROV
- Accommodations for 50
- ABS DP Class 2 Rated
- 50 T Stern Roller

Modular Equipment Options

Optional equipment packages are available for umbilical installations, flowline installations, deepwater pipeline repairs, and subsea tieback work.

- 60 T four-track tensioner
- 500 T carousel
- 28 ft reels/under-rollers
- WASP ADS
- Deck winches
- 80 T coiled tubing reel
- J-lay System
- S-lay System
- Power reel drive system

Typical Projects

- ROV & Diving Support
- Flowline Installation
- Umbilical Installation, Connection
- Pre-lay & Post-lay Mats
- Well Abandonment/Wireline Services
- Hydrate Remediation
- Subsea Pumping
- IMR (Inspection, Maintenance & Repair)

04/06

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MSV OCEAN INTERVENTION II SPECIFICATIONS

Dimensions

Length:	254 ft
Beam:	53.5 ft
Molded Depth:	18.8 ft
Draft:	15 ft
Open Deck Area:	6,500 ft²

Weights

Cargo Deck Load Capacity:	1,430 LT
Main Deck, Load Strength:	1,500 lbs / ft²

Horsepower

Total Available:	6,400
Azimuth Stern Thrusters:	2 x 2,000
Bow Tunnel Thrusters:	2 x 1,000

Capacities

Fuel Oil:	220,000 gal
Lube Oil:	2,400 gal
Fresh Water/Ballast:	93,000 gal

Accommodations

Persons:	50

Lifting Capacity

80 T Nautilus Crane:	20 T lift at boom ∠83°
Stern A-Frame:	60 T
Moonpool A-Frame:	Modular 30 T or 60 T
Stern Roller:	100 T

Performance

Speed, Maximum:	12 knots
Speed, Cruising:	10 knots

Classification

- ABS for unrestricted service
- Maltese Cross A1
- Maltese Cross A.M.S.

Certifications

- USCG
- ABS-DP2
- SOLAS

Dynamic Positioning

Simrad SDP-21:	DP-2

Moonpools

ROV Launch & Recovery:	16 ft x 16 ft
Working Tooling Moonpool:	16 ft x 16 ft

ROV

Hydra® Maxximum:	300 hp system
Complete ROV Tooling Suite	

Built-In Survey System

Fugro Chance:	Redundant inputs to DP-2 system

Call Sign

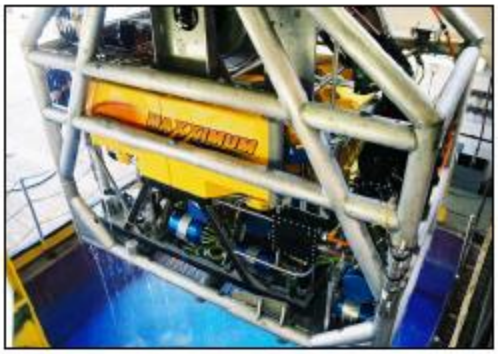
- WCZ7505

Communications System

- CapRock KU Band

Ocean Intervention II plug and abandonment deck layout, with 60 T subsea intervention A-frame

Flexible flowline and umbilical installation spread
Photo by RCMG, LLC



Hydra® Maxximum ROV system is guided through the forward moonpool by a cursor launch system

OCEANEERING

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C-Surveyor III™ AUTONOMOUS UNDERWATER VEHICLE (AUV)

The *C-Surveyor III*™ Autonomous Underwater Vehicle (AUV) was designed to collect deepwater, high-resolution geophysical data for site and route surveys in water depths of up to 3,000 meters. Kongsberg produces the base platform and Oceaneering International, Inc. (OII) made upgrades from their more than 12 years of AUV operating experience. The system is designed for portability and survey work from vessels of opportunity (Figure 1).

Figure 1 – AUV being loaded into a van for an overseas survey.

Primary survey sensors found in the system payload include a Kongsberg EM 2040 Swath Multibeam Sonar (200, 300, and 400 kHz), an EdgeTech 2200-M Side Scan Sonar (410 and 120 kHz) and a custom EdgeTech DW106 Subbottom Profiler (Chirp 1.5 to 10.0 kHz) with 4 projectors and 6 receive hydrophones. A digital still camera and 2Grobotics 3-D Laser Profiler System is available for detailed seabed investigations. This AUV is also equipped with a MicroTesla Marine Magnetometer for detecting ferrous material. An acoustically aided inertial navigation system coupled with an acoustic Doppler velocity speed log and USBL (Ultra Short BaseLine) positioning from the survey vessel is used for primary positioning of the AUV. Ancillary sensors include survey precision depth sensors, altimeter, and Seabird CTD (Conductivity, Temperature, and Depth) probes. A Kongsberg HiPAP 350P or 500 System is typically implemented for tracking the AUV acoustically. A Linkquest Acoustic Modem provides data communications and data through the Acoustic Command Link (ACL) and the Acoustic Data Link (ADL). The shipboard operator communicates and controls the AUV through the ACL and the ADL provides bandwidth for obtaining subsets of the geophysical data. Rechargeable lithium batteries power the AUV for 36 hours on a single charge. Emergency ascent systems include drop weights and an air bag. An emergency acoustic transponder, GPS system, wireless Ethernet, flashing strobe light and Iridium phone system output visual and remote sensing aids for locating the AUV in the event communications are lost with the survey ship.

Three computers control the system functions onboard *C-Surveyor III*™. These computing centers are referred to as the HUGIN (High Precision Untethered Geosurvey and Inspection), payload and navigation processors (Figure 2). These processors use artificial intelligence algorithms based on feedback returned from more than 75 sensors to monitor system health and make real-time decisions regarding performance, maneuverability and data collection. The computers, data storage, and sensor electronics are housed in two titanium spheres designated as the payload and control.

Three topside workstations are dedicated to continuous communications with the vehicle while on missions. The HUGIN Operator Station monitors all AUV sensors related to the

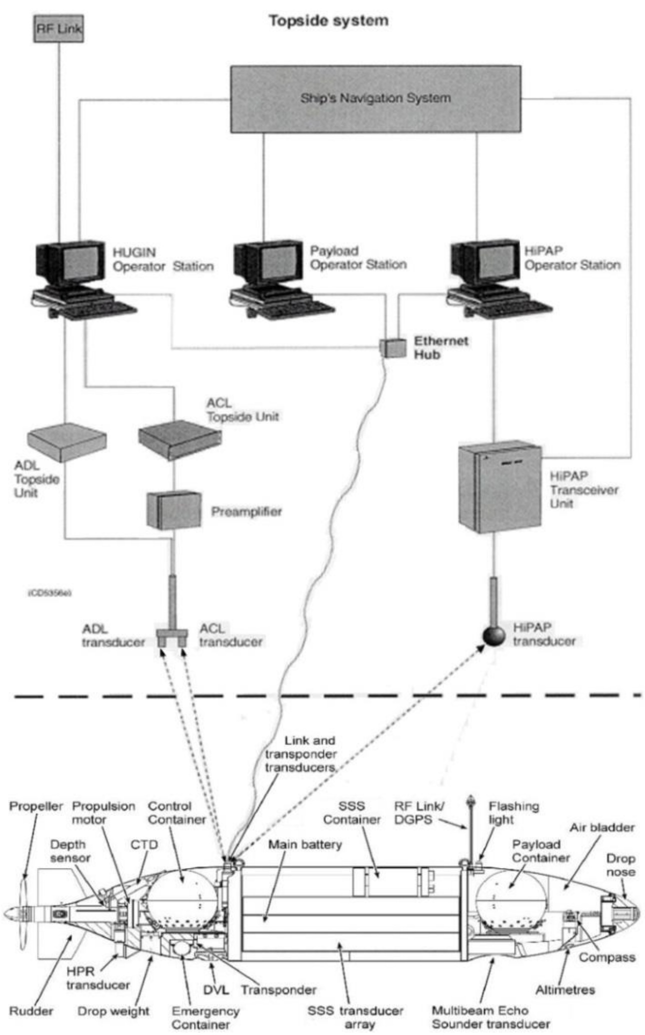

Figure 2 – Basic Internal Arraignment of *C-Surveyor* AUV.

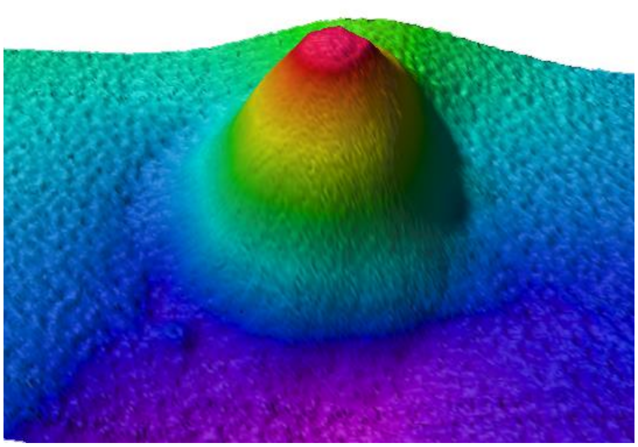

Figure 3 – Multibeam bathymetry imagery of 12-m high mud volcano in Gulf of Mexico

vehicle health and maneuverability. The monitoring software warns operators when values are outside of optimal range. The Payload Operator Station computer provides graphical views of reduced data subsets of subbottom, bathymetry and side scan sonar. The user can turn the geophysical systems on or off, adjust instrument settings and control the data bandwidth as needed. The HiPAP Operator Station provides real-time graphic displays of the *C-Surveyor III*™ vehicle position and the survey ship, which normally follows the AUV on the surface while collecting data.

OII's C-NAV® DGPS signals provide the survey ship position during AUV missions. The trackline running sequence is downloaded to the onboard computer system prior to deployment. The AUV vehicle positions are calculated with a complex Kalman filter algorithm using statistically weighted inputs from the DGPS, Ultra-Short BaseLine (USBL) acoustics, inertial navigation and Doppler velocity speed log. The inertial system consists of a precision gyro and accelerometers to maintain the AUV track for the mission plan.

A Kongsberg EM 2040 Swath Bathymetry System collects soundings in a 220-meter swath underneath the AUV vehicle. The EM 2040 is capable of three frequency ranges – 200, 300 and 400 kHz. The beam pattern at 400 kHz will be 0.7° x 0.7° over a 140° swath yielding up to 400 beams. The AUV normally maintains an altitude of 40 meters above the seabed. An onboard velocimeter records water column velocity corrections and provides real-time data at the transducer face to maintain proper beamforming of the acoustic transmissions.

The data are normally processed and filtered with OII's proprietary HydroMap software. A survey precision depth sensor provides the vehicle depth that is added to the raw multibeam soundings. Atmospheric pressure is recorded aboard the survey vessel and applied as a depth sensor corrector in post processing. Tidal corrections are applied using the Goddard deepwater ocean tide model (Ray, 1999). The final bathymetric dataset is normally delivered at a 3-meter bin size (Figure 3).

The *C-Surveyor III*™ is equipped with a dual frequency EdgeTech 2200-M Side Scan Sonar that employs a calibrated wideband, digital frequency modulated (FM) signal to provide high resolution, low-noise images. This sonar is capable of simultaneously transmitting linearly swept frequency modulated pulses centered at two discrete frequencies: 120 and 410 kHz. The raw data files are post-processed and converted to XTF (eXtended Triton Format) for digital interpretation and hardcopy generation.

Seismic profiles onboard *C-Surveyor III*™ are collected with a custom high-power EdgeTech Chirp Subbottom Profiler (DW106). The four subbottom transducers are capable of transmitting a frequency modulated, high power pulses in the bandwidth between 1 and 6 kHz. The source pulse used on this surveys is between 1.5 and 10.0 kHz and 2 to 10.0kHz. The source pulse is convolved with the recorded trace to prevent source ringing and to remove the source signature from the response of near-seabed strata. The four-transducer system provides significantly more penetration and resolution than a single transducer system (Figure 4). The raw seismic data can be post-processed to create SEG-Y or XTF datasets. The SEG-Y data can be written with static or variable length traces.

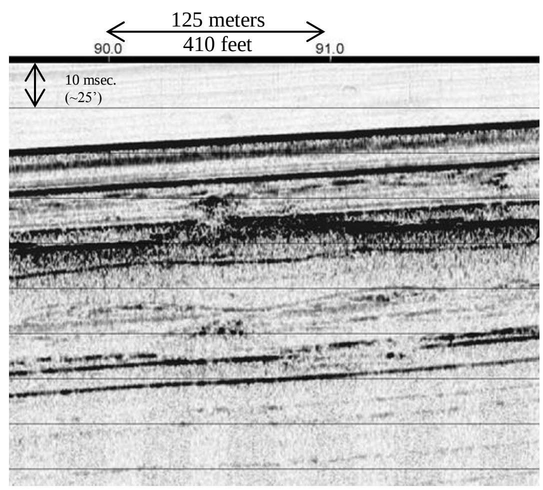

Figure 4 - Subbottom profiler image of buried deepwater channel systems.

OII has developed a digital underwater photography system for their fleet of AUVs (Figure 5). This photography system provides black and white still frame photographs of the seafloor. Practical applications for the acquisition of deepwater photographic seafloor images include investigations of man-made or natural features. Man-made feature investigations may include pipeline infrastructure, sub-sea installations, debris identification or UXO determination. Images can enhance and aid archeological assessments by providing data for possible shipwreck analysis and cultural resource potential (Figure 6). Additionally, this tool can be used for pre-lay and post-lay deepwater pipeline surveys, investigations of broken or displaced pipelines and seafloor assemblies. Natural feature investigations may include verification of potential deepwater benthic communities, gas/fluid seeps, seafloor conditions, and deepwater flora and fauna studies (Figure 7).

Camera image quality and resolution are directly dependent on the clarity of the water and the AUV altitude. Under turbid water conditions, the AUV must be closer to the object of investigation in order to provide a clear image. The length of the camera footprint is equal to 0.75 times the AUV altitude and the aspect ratio is 4:3 (Figure 8). Thus, with an altitude of 10 meters, the image covers an area measuring 7.5 meters in the across track direction and 5.6 meters in the along track direction. Optimally, an AUV altitude of 6 to 8 meters produces the best quality image. The resolution of the image is on the order of 5 millimeters at an AUV altitude of 9 meters.

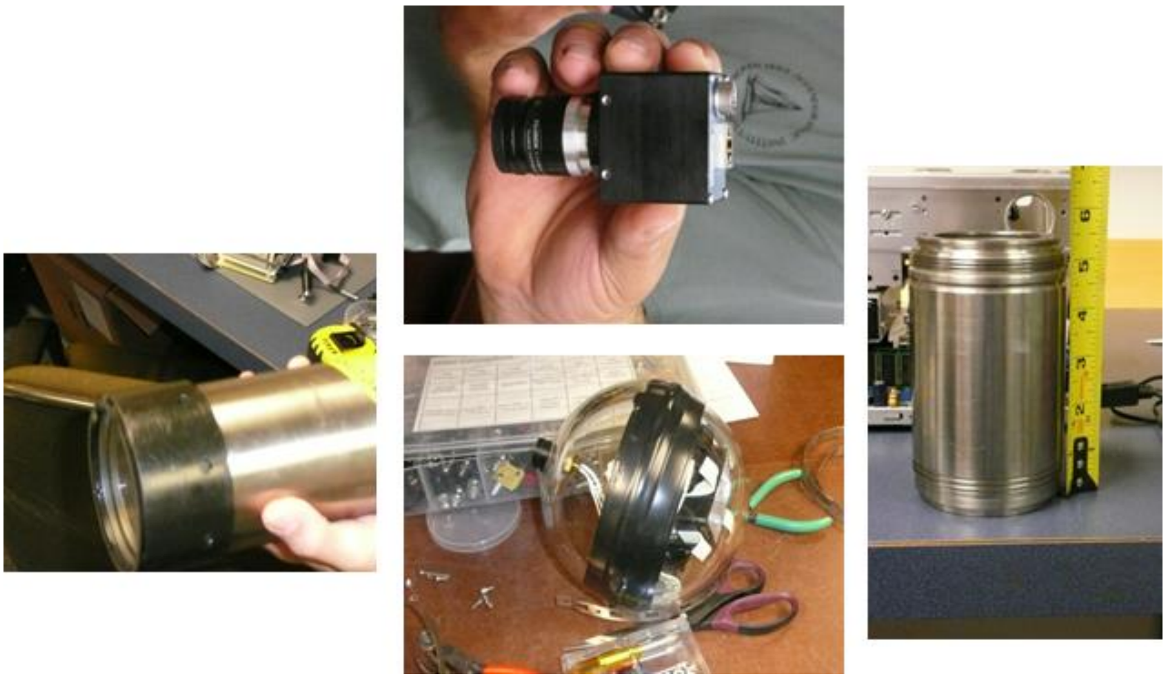

Figure 5 – AUV digital microscopic camera hardware.

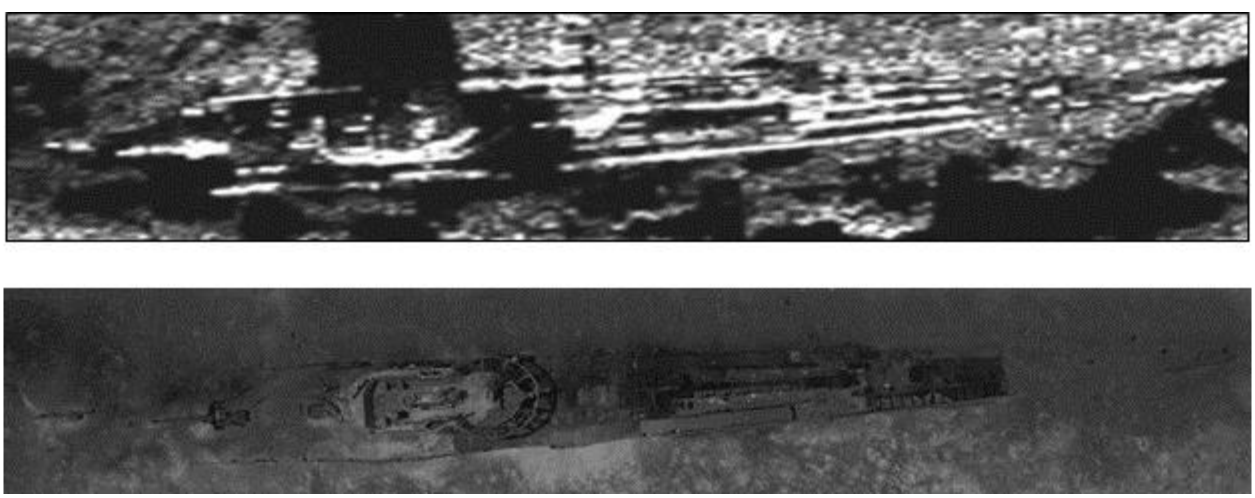

Figure 6 – Conventional side scan sonar image of the German U-boat U-166 (upper), and AUV camera photography of the same U-boat (lower). Camera allows groundtruthing of sonar targets on single mobilization.

The image acquisition rate is currently hard set into the mission planning software. Future software updates will allow the AUV Operator to change the rate prior to and during data collection. Typically, an image is taken approximately every 1.75 seconds which equates to one photo every 3.2 meters of travel at normal survey speeds and provides overlap between successive photos. Line spacing for adjacent tracks of the AUV over an area would typically be set at a 4-to-5-meter interval, providing image overlap of approximately 60% for image mosaicking. All images are referenced with navigation data.

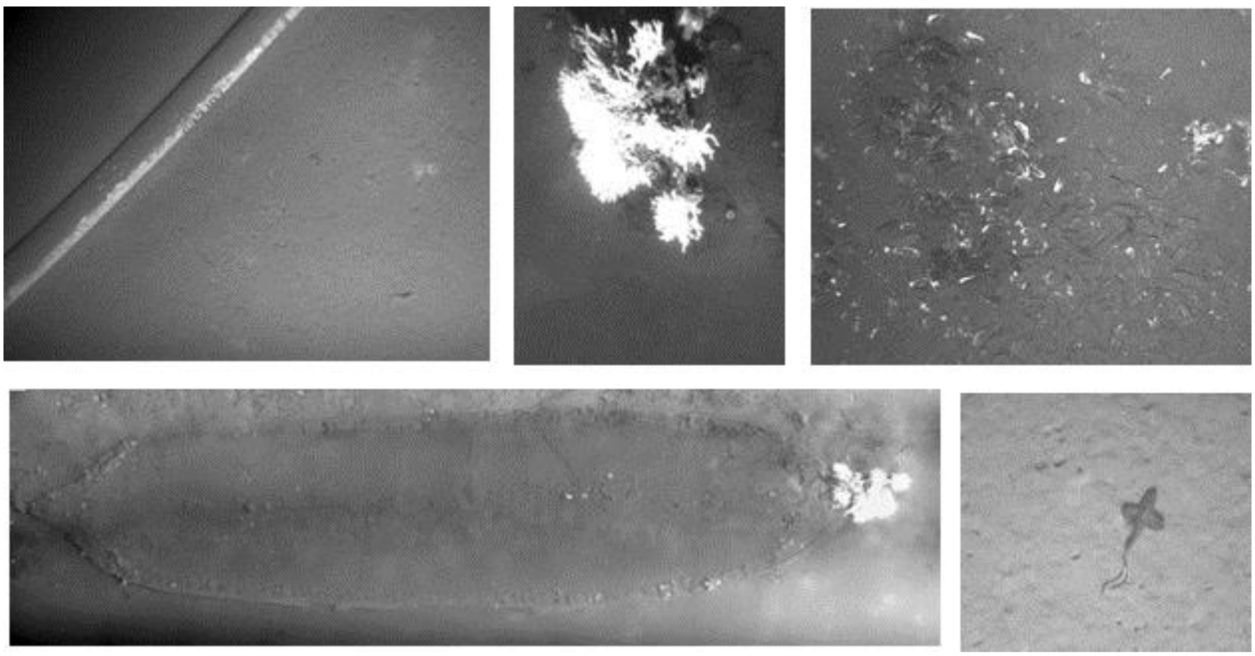

Figure 7 – AUV camera photographs (clockwise from upper left) of a 16-inch pipeline, lophelia coral colony, chemosynthetic community mussels and/or clams, historic shipwreck, and a fish.

Due to the very low altitudes and resulting small image areas, camera investigations are performed independently of other AUV systems during data collection. Additionally, it is required to first perform an area survey utilizing sonar data to identify camera investigation sites and to obtain terrain and obstacle information before lowering AUV altitudes.

A 2G Robotics 3-D Laser Profiler System is installed on the *C-Surveyor* AUV. The laser profiler provides high-resolution bathymetry profiles using laser illumination. It operates at a nominal altitude of 8 meters and has an altitude range of about 5 to 12 meters above the seafloor. The laser produces 1400 vertical measurements across each swath (ping) and can “ping” at up to about 29 Hz. At 8 meters altitude, the system has about 5-millimeter horizontal resolution and about 5-millimeter vertical resolution. The profiles are produced at about 10-centimeter intervals along track. The data is processed with OII’s HydroMap processing system in the same manner as multibeam sonar (Figure 9).

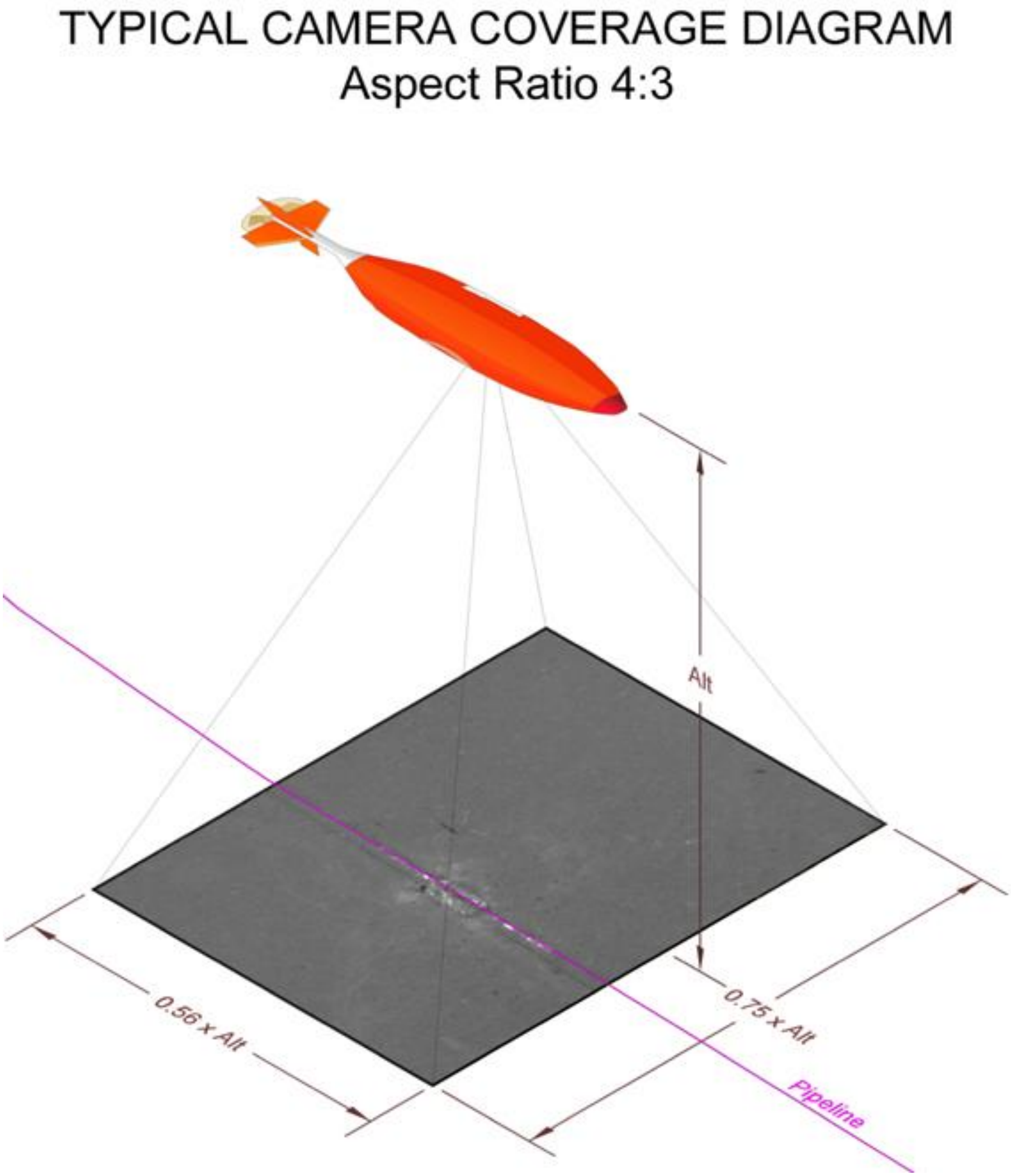

Figure 8 – AUV camera coverage.

Processing of collected photographic data includes navigation synchronization and text imprinting on each still frame. Processing time is approximately 4 hours per statute mile of photo images. The photo processing starts after the navigation processing has been completed and initially quality controlled. Additional time is required for reporting and mapping of data results. Deliverable products include a progressive image slide show, individual photographs, or mosaics of multiple photographs of objects or small areas.

The photographic camera and the laser bathymetry system are optical sensors and are affected by the clarity of the water column in which they are operating. A turbidity sensor has been installed in the *C-Surveyor* AUV to measure the clarity of the water and to provide information about the performance of the optical sensors. The turbidity is measured in units of Nephelometric Turbidity Units (NTU). Another measure used in lakes and ponds is the Secchi depth. The Secchi depth is an extinction range, the range at which a highly contrasted target becomes obscured. There is no standard conversion from NTU to Secchi depth, but a few researchers have developed some empirical formulas to estimate the correlation.

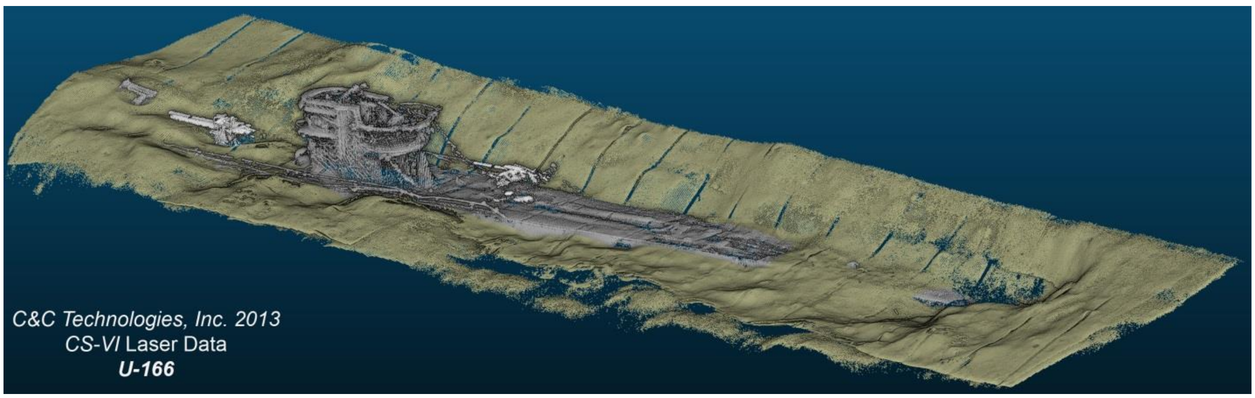

Figure 9 – 3D laser bathymetry showing the German U-boat U-166.

A Geochemical Sensor Suite is also available on the *C-Surveyor* AUV. This suite includes:

- CH_4 Methane sensor
- CO_2 Carbon Dioxide sensor
- PAH (Polycyclic Aromatic Hydrocarbons) sensor

The geochemical sensors on the *C-Surveyor* AUV are design to detect hydrocarbons (PAH), methane and CO_2 in the water column in support of leak and seep detection. These sensor data streams are logged and time-stamped for merging with post-prepossessed navigation to support the generation of wide area contour maps of geochemical concentrations and detections.

The *C-surveyor* AUV has a MicroTesla Marine Magnetometer installed. This sensor supports the detection of ferrous objects. The three-axis magnetometer data is processed with the HydroMap processing system. The processed data can be plotted with any CAD system and the raw data can be exported into any GIS or geophysical software package (Figure 10).

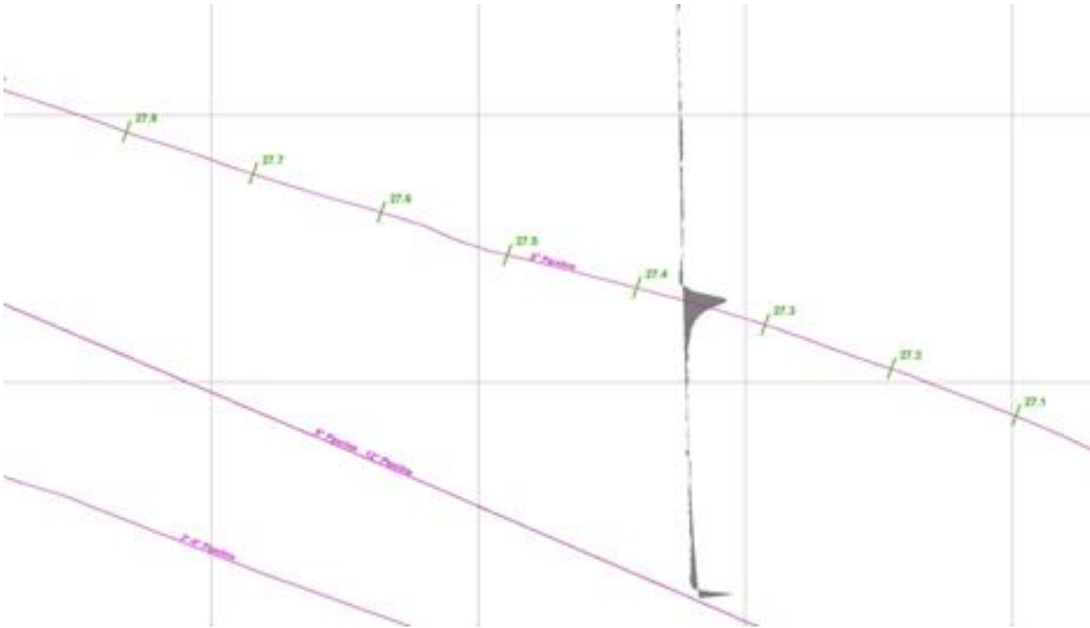

Figure 10 – AUV magnetometer data showing amplitude hits across pipelines.

***C-Surveyor III*™ Survey Sensors:**
Kongsberg EM 2040 Bathymetry and Imagery (200kHz)
EdgeTech 2200-M Side Scan Sonar (120 and/or 410 kHz)
EdgeTech DW106 Subbottom Profiler (Chirp 2–10 kHz, normal 1.5–10 kHz)
Digital Camera
3-D Laser Scanner
Marine Magnetometer
Geochemical Sensor

Ancillary Sensors:
Inertial Navigation
Kongsberg HiPAP USBL
Doppler Velocity Log
Kalman Filter
Fiber Optic Gyro
Motion Reference Unit
Digiquartz Depth Unit
Single-Beam Altimeter
DGPS
Acoustic Communications
    Command and Control (Low Speed Acoustic Modem)
    Data Uplink (High Speed Acoustic Modem)

Vessel Specifications:

Depth Rating:	4,500 meters
Diameter:	1.0 meters

Length:	4.57 meters
Normal Speed:	4 knots
Underwater Endurance @ 4 knots:	24 to 30 hours
Power:	Lithium Rechargeable Batteries

Kongsberg EM 2040 Multibeam Echosounder Specifications:

Frequency	200, kHz
Maximum Ping Rate	50 Hz
Number of Beams per Ping	256
Beamwidth	0.7° × 0.7° @ 400 kHz 1.5° × 1.5° @ 200 and 300 kHz
Beam Spacing	Equiangle or equidistant
Coverage Sector	140°
Range Resolution	0.5% of AUV altitude
Sonar Head Depth Rating	6,000 meters

EdgeTech 2200-M Side Scan Sonar Specifications:

Modulation	Full spectrum chirp frequency modulated pulse with amplitude and phase weighting
Dual Frequency Combinations	120/410 kHz
Common	
Vertical Beam Width	50º
Depression Angle	20º from horizontal
Dynamic Range	20 Bits Effective
Sample Rate	~2,000 samples per channel

Frequency Specific		
Center Frequency	**120 kHz**	**410 kHz**
Pulse Length	4 msec.	2.4 msec.
Range Scale Selection (per side)	100-250 meters	75–125 meters
Maximum Ping Rate	30 pps	41 pps
Range Resolution	3.8 cm	2 cm
Horizontal 3 dB Beam Width	0.75º	0.75º
Transmit Power	2 Joules	2 Joules
Peak Source Level (ref = 1µPa @ 1 m)	210 dB	210 dB
Receiver Sensitivity (ref = 1 V/µPa @ center frequency)	-190 dB	-196 dB

EdgeTech DW106 Chirp Subbottom Profiler Specifications:

Modulation	Frequency modulated pulse with amplitude and phase weighting
Ping Rate	3 Hz average

Calibration	Each system is acoustic tank tested to calibrate for reflection coefficient measurements
Frequency Band	1–6 kHz (normal operation is 1.5 to 10.0 kHz)
Number of Hydrophone Arrays	6
Resolution	6–10 cm
Beam Width	15º–25º
Peak Source level	216 db ref 1µPa @ 1 m

C-NAV® DIFFERENTIAL GPS

C-NAV® is a globally corrected differential GPS system owned and operated by Oceaneering International, Inc. The C-NAV® GPS Receiver combines a dual-frequency, geodetic grade, GPS Receiver with an integrated L-BAND communication RF detector and decoder all linked by an internal microprocessor. C-NAV® uses monitoring stations strategically located around the globe to provide worldwide accuracies on the order of 0.10 meters (4 inches).

Infrastructure:
The system utilizes the GPS satellite system, L-band communication satellites, and a worldwide network of referencing stations to deliver real-time high precision positioning. To provide this unique service, C-Nav has built a global network of dual-frequency reference stations, which constantly receive signals from the GPS satellites as they orbit the earth. Data from these reference stations is fed to the USA processing centers in Torrance, California, and Moline, Illinois where they are processed to generate the differential corrections. From the two processing centers, the correction data is fed via redundant and independent communication links to satellite uplink stations at Laurentides, Quebec, Canada; Perth, Australia; Burum, the Netherlands; Santa Paula, California; Auckland, New Zealand; and Southbury, Connecticut for rebroadcast via the geostationary satellites.

The key to the accuracy and convenience of the C-Nav system is the source of SBAS corrections. GPS satellites transmit navigation data on two L-band frequencies. The C-