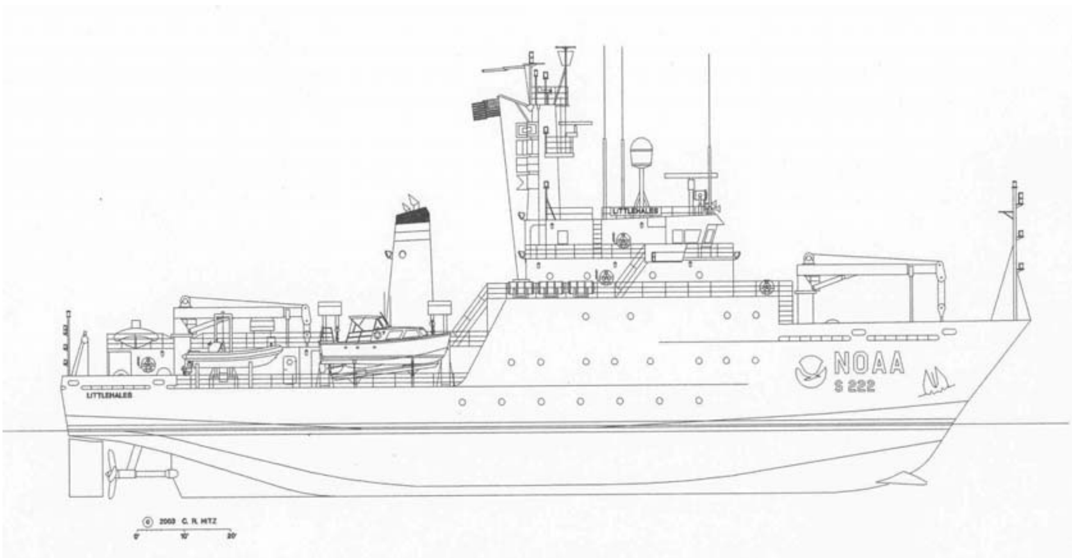
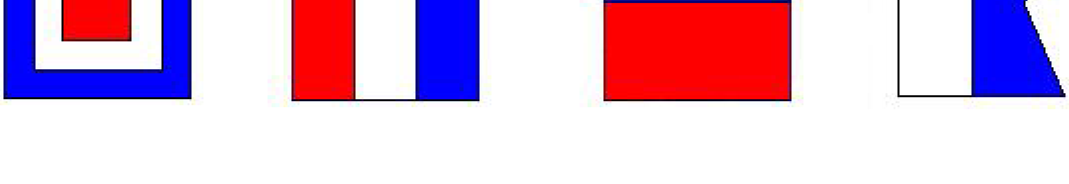
2005 SPRING DAPR

***D**ata*
***A**cquisition and*
***P**rocessing*
***R**eport*



NOAA SHIP THOMAS JEFFERSON



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DATA ACQUISITION AND PROCESSING REPORT

to accompany

PROJECTS OPR-B370-TJ-05, OPR-D304-TJ-05

NOAA Ship THOMAS JEFFERSON
CAPT Emily B. Christman, Commanding Officer

A. EQUIPMENT

All survey data for March-June 2005 were acquired by NOAA Ship THOMAS JEFFERSON and Survey Launches 1005 and 1014. THOMAS JEFFERSON acquired side scan sonar (SSS) data, multibeam echosounder (MBES) data, vertical beam echosounder (VBES) data, and sound velocity profile (SVP) data. Survey Launch 1005 acquired SSS data, MBES data, VBES data, and SVP data. Survey Launch 1014 acquired SSS data, MBES data, VBES data, and SVP data.

The methods and systems described in this report are used to meet full-coverage requirements are in accordance with the National Ocean Service Standing Instructions for Hydrographic Surveys (3/2004), the Hydrographic Surveys Specifications and Deliverables Manual (3/2003), Hydrographic Survey Directives, and the Field Procedures Manual for Hydrographic Surveying (1/2005, v 1.0).

A.1. Echosounding Equipment

ODOM Echotrac DF3200 MK II vertical-beam echosounder

The Odom Echotrac DF3200 MKII is a dual-frequency digital recording echosounder system with an analog paper recorder. The high frequency setting may range from 100 kHz to 1 MHz. The low frequency setting may range from 12 kHz to 50 kHz.

The high frequency transducer on Survey Launch 1005 and Survey Launch 1014 operate at 100 kHz. The high frequency transducer on THOMAS JEFFERSON operates at 200 kHz. The high frequency pulse forms a circular beam with a main-lobe beam footprint of 7.5° at the -6dB point. The low-frequency transducer on all platforms operates at 24 kHz with a rectangular main-lobe beam footprint of 27° (along-track direction) by 47° (across-track direction) at the -6 dB point. Soundings are acquired in meters on both frequencies, with the high frequency selected for all sounding data.

On all three hydrographic survey vessels, the ODOM transducer is rigidly affixed to the hull. On Survey Launches 1005 and 1014, the transducer is through-hull mounted on the starboard side with a curved aluminum fairing surrounding the transducer on all sides. The transducer/fairing assembly is mounted such that the transducer depth of the ODOM is roughly equivalent to the transducer depth of the multibeam echosounder. On THOMAS JEFFERSON, the transducer is installed in an acoustically transparent fiberglass blister on the port side, adjacent to the SIMRAD EM1002 multibeam transducer.

For the purposes of calculating total propagated error (TPE), the ODOM Echotrac MK II is assumed to be a single-frequency multibeam transducer with one beam. The maximum across-track and along-track beam angles are assumed to be identical at a value of 7.5°. The sonar is assumed to have a pulse length of 0.1 ms at 100 kHz and a ping rate of 20 Hz. The values above are the values for Survey Launches 1005 and 1014. As the primary bathymetry source for THOMAS JEFFERSON is almost exclusively the SIMRAD EM1002, the vertical-beam echosounder data for THOMAS JEFFERSON is archived in raw format

The ODOM Echotrac is inappropriate for sole use in situations requiring full bottom bathymetry coverage. The ODOM Echotrac does not meet NOAA object detection specifications. Combined ODOM Echotrac bathymetric acquisition and KLEIN 5500 side-scan sonar acquisition meets NOAA specifications for full bottom coverage and object detection.

Owing to its wide beamwidth, vessel pitch and roll calculations are not applied to ODOM Echotrac data. During typical acquisition conditions, the high-frequency beamwidth is sufficiently wide to receive a primary-lobe hit at nadir regardless of vessel attitude. This breaks down, however, when the vessel pitches more than 3° or rolls more than 5°. Care was taken to avoid using the ODOM as the primary source of bathymetry in situations where the pitch or roll will cause attitude artifacts or side-lobe hits.

KONGSBERG SIMRAD EM 1002 MULTIBEAM ECHOSOUNDER

The Kongsberg SIMRAD EM1002 system is a single-frequency, digital recording multibeam echosounder with an operating frequency of about 95 kHz. The SIMRAD EM1002 aboard THOMAS JEFFERSON was installed in August 2001 in Jacksonville, FL, while the ship was still under the purview of the U.S. Navy.

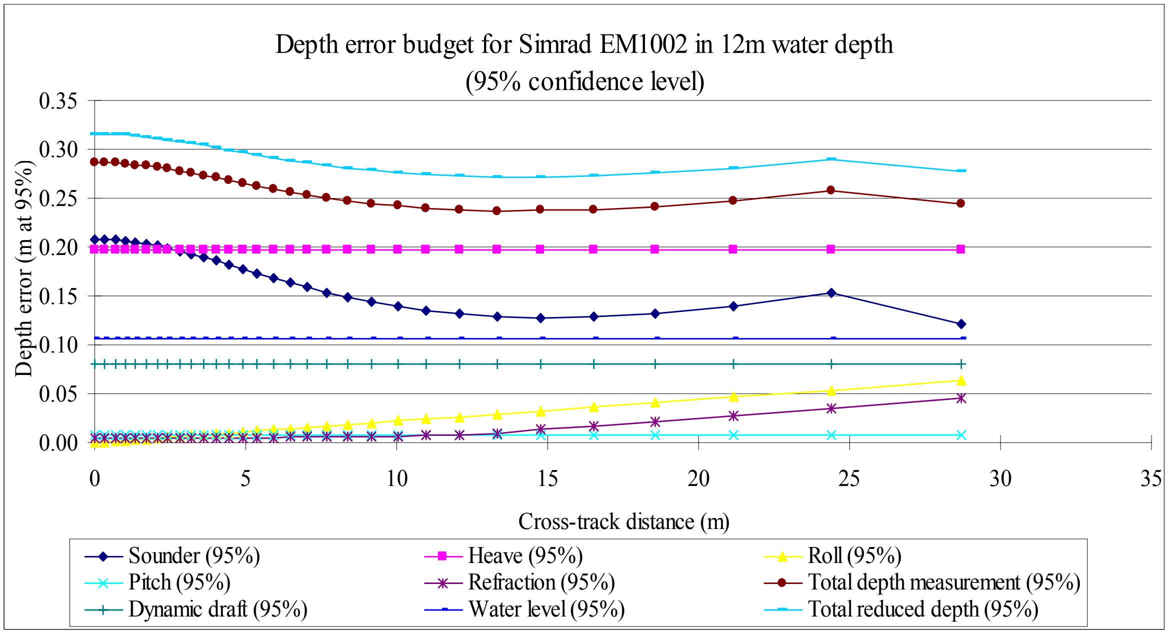
The SIMRAD EM1002 transducer consists of a curved transmitter array and flat receiver array encased in an acoustically transparent fiberglass blister that is rigidly fixed to the hull of THOMAS JEFFERSON at the keel near frame 20. The SIMRAD EM1002 forms 111 beams each of which has a 2° across-track beam footprint for a maximum total swath width of 150°. Each beam has an along-track beam resolution of 1.5°. The ping rate is nominally 10 Hz, but may vary depending on water depth, swath width, or user specification. The SIMRAD EM1002 is capable of bottom detection in depths from 5-1000m. Aboard the THOMAS JEFFERSON the SIMRAD EM1002 is used in depths from 10m-1000m.

Active beam steering is performed to correct for sound velocity at the transducer head using an Applied Microsystems Smart SV&T sea surface sound velocity sensor. This sensor will be discussed in more detail in the Sound Velocity Equipment section. In addition, the curved face of the transducer array is designed to mechanically steer acoustic energy.

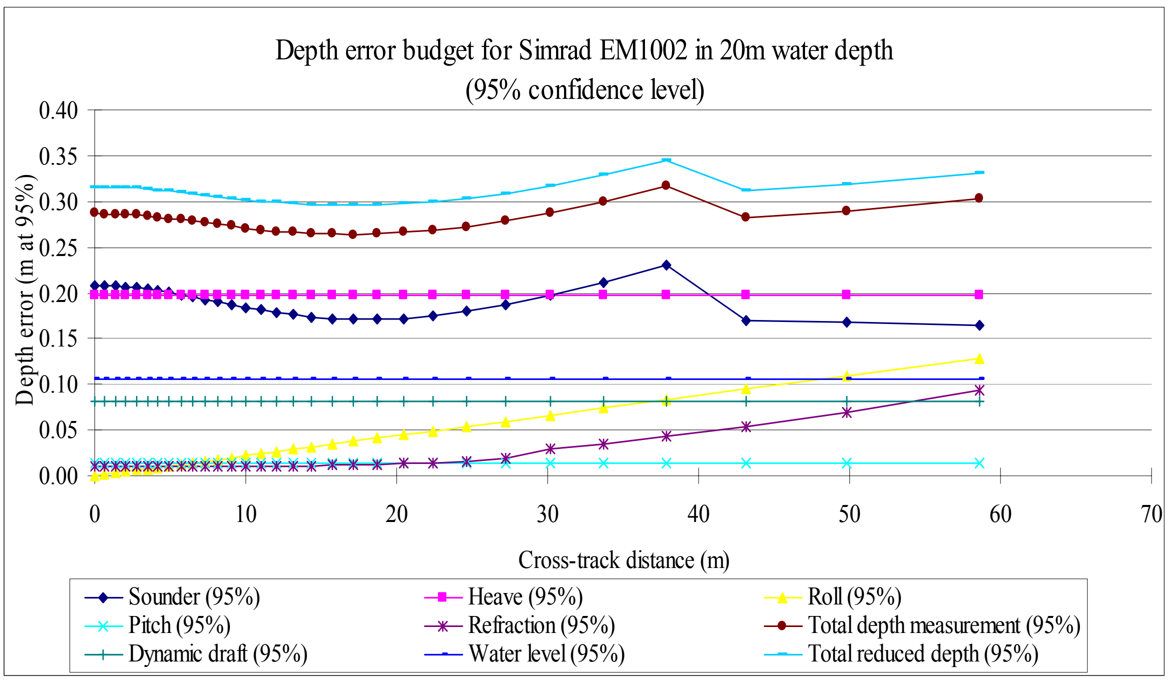
Acoustic backscatter data is acquired concurrently with bathymetry information. The SIMRAD acoustic backscatter data is automatically slant-range corrected by the SIMRAD operating system. Acoustic backscatter data is not used for generating hydrographic products; it is usually archived or used to generate third party and scientific data products.

The SIMRAD EM1002 does not meet NOAA specifications for object detection in shallow water (<20m). EM1002 data must be acquired with either side-scan sonar or high-resolution multibeam echosounder data (e.g. RESON 8125) to meet NOAA object detection specifications in shallow water.

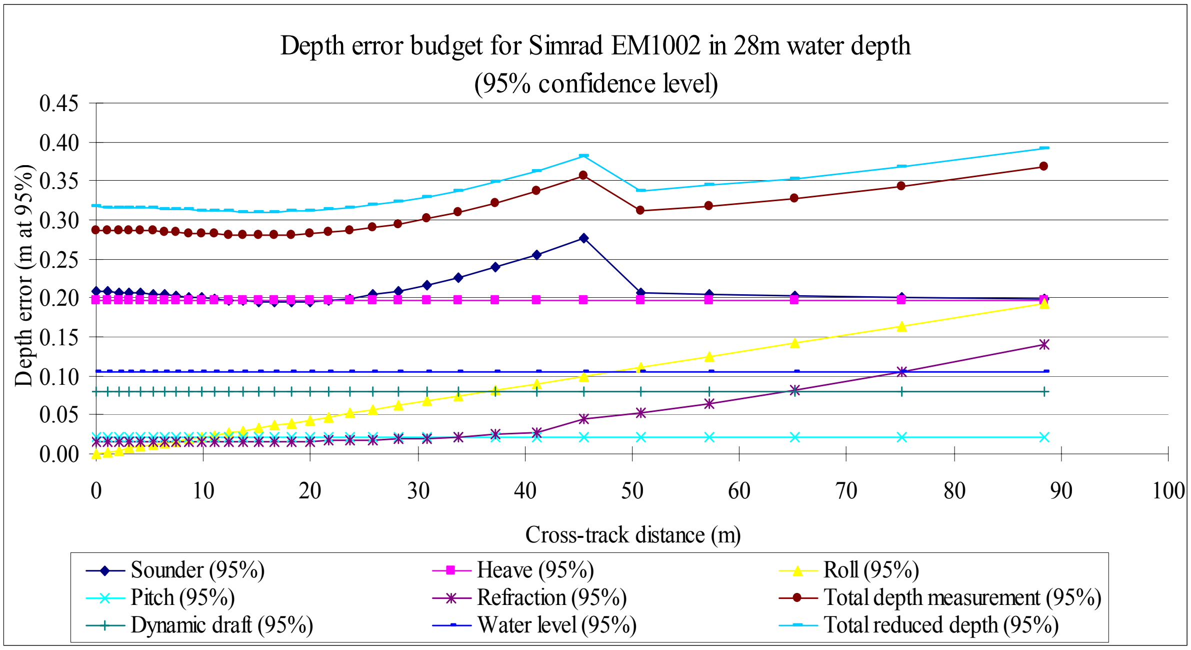
For the purposes of calculating total propagated error, the SIMRAD EM1002 is assumed to have an operational frequency of 95 kHz, pulse length of 0.2ms and a typical ping rate of 10Hz.



Depth error budget for Simrad EM1002 in 12m water depth
(95% confidence level)
Depth error (m at 95%)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0
5
10
15
20
25
30
35
Cross-track distance (m)
Sounder (95%)
Heave (95%)
Roll (95%)
Pitch (95%)
Refraction (95%)
Total depth measurement (95%)
Dynamic draft (95%)
Water level (95%)
Total reduced depth (95%)



Depth error budget for Simrad EM1002 in 20m water depth
(95% confidence level)
Depth error (m at 95%)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0
10
20
30
40
50
60
70
Cross-track distance (m)
Sounder (95%)
Heave (95%)
Roll (95%)
Pitch (95%)
Refraction (95%)
Total depth measurement (95%)
Dynamic draft (95%)
Water level (95%)
Total reduced depth (95%)



The SIMRAD error model has been released to the public. The above charts display the known error budget for the SIMRAD EM1002 in the following conditions:

Water Depth	12m / 20m / 28m
Sound Speed	1500 m s^{-1}
Roll Angle	1°
Pitch Angle	1°
Seafloor Slope Angle	2°

These values are typical for surveying in the North Atlantic Ocean, particularly in spring or autumn when the water column is well mixed.

With these parameters in mind, the best expected performance of the SIMRAD EM1002, as installed on THOMAS JEFFERSON in 15m of water with an isopycnal water column and sound velocity of 1500 ms^{-1}, is to the IHO Order 1 standard. Actual performance will vary according to sea state, swell, tide zoning error, and sound velocity spatial and temporal distribution.

RESON SeaBat 8101 Multibeam Echosounder

The RESON SeaBat 8101 multibeam echosounder system is a single-frequency, digital-recording multibeam echosounder with an operating frequency of 240 kHz. The RESON 8101 transducer consists of a curved transmitter array and solid cylindrical receiver array rigidly affixed to the keel of Survey Launch 1005.

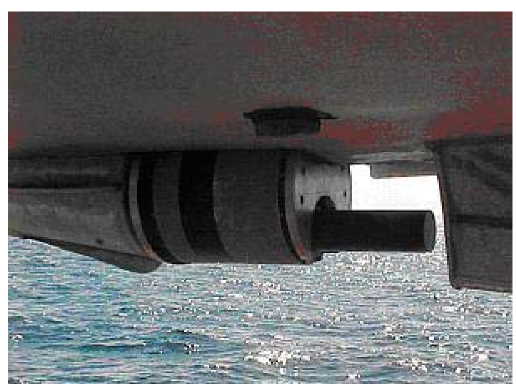
The RESON 8101 forms 101 beams each of which has a 1.5° across-track beam footprint for a maximum total swath width of 150°. Each beam has an along-track resolution of 1.5°. The ping rate is nominally 20-30 Hz, but may vary according to user specification. The RESON 8101 sonar is capable of bottom detection in depths from 3-300m. Aboard Survey Launch 1005 the RESON 8101 is used in depths from 3-60m.

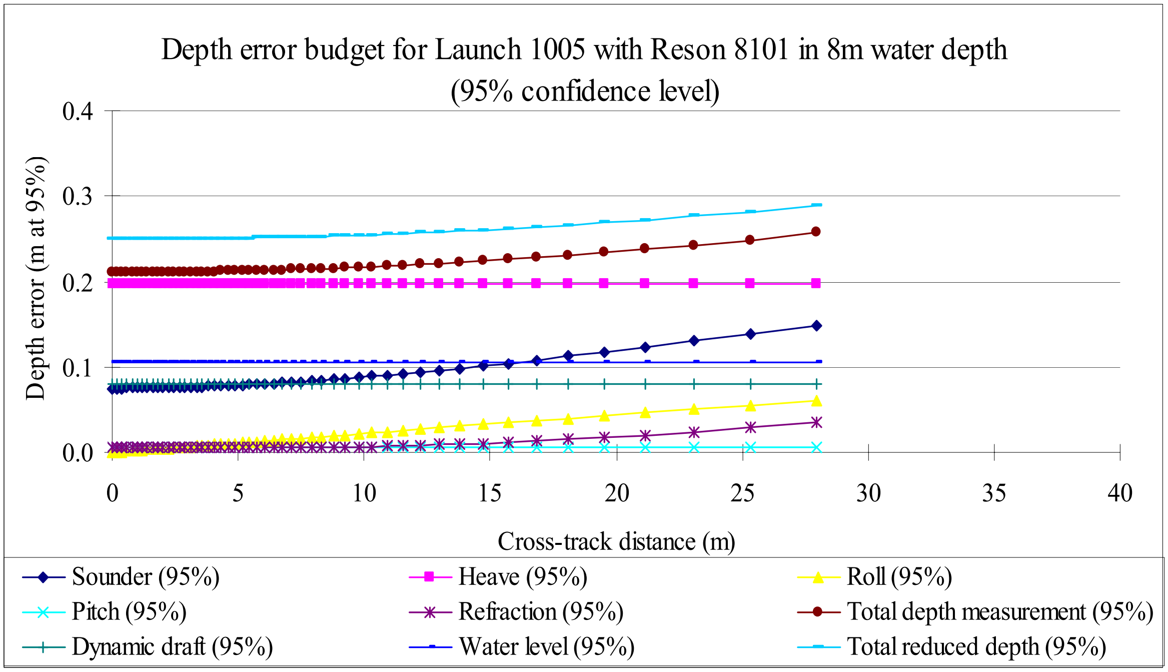
The RESON 8101 does not perform active beam steering. The curved faces of the transmit and receive arrays are designed to mechanically steer acoustic energy.

While the primary use of the RESON 8101 is determining bathymetry, acoustic backscatter data from this sonar is recorded and archived. This data is recorded in "snippet" format, where the acoustic backscatter strength for each ping/beam is measured over time (on the order of hundreds of microseconds). Snippets backscatter data is not used to generate hydrographic products; it is usually archived or used to generate end-user scientific products.

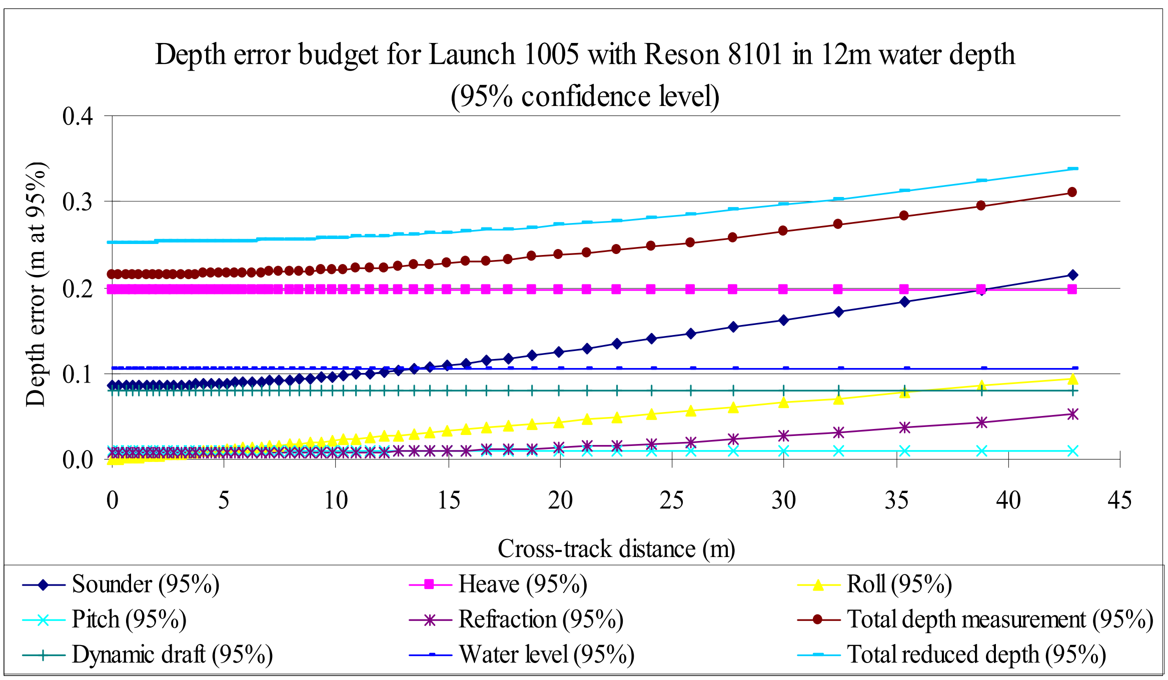
The error model of the RESON 8101 has not been released to the public. For the purposes of calculating total propagated error, the RESON 8101 is assumed to have an operational frequency of 240 kHz, pulse length of 0.15ms, and a typical ping rate of 30Hz.

The outer beams of the RESON 8101 (45°-75° off nadir) do not meet NOAA specifications for object detection in water deeper than 10m. 200% bottom coverage data from the RESON 8101, under most conditions, will meet NOAA object detection specifications. RESON 8101 data acquired concurrently with side-scan sonar data meets NOAA object detection specifications.

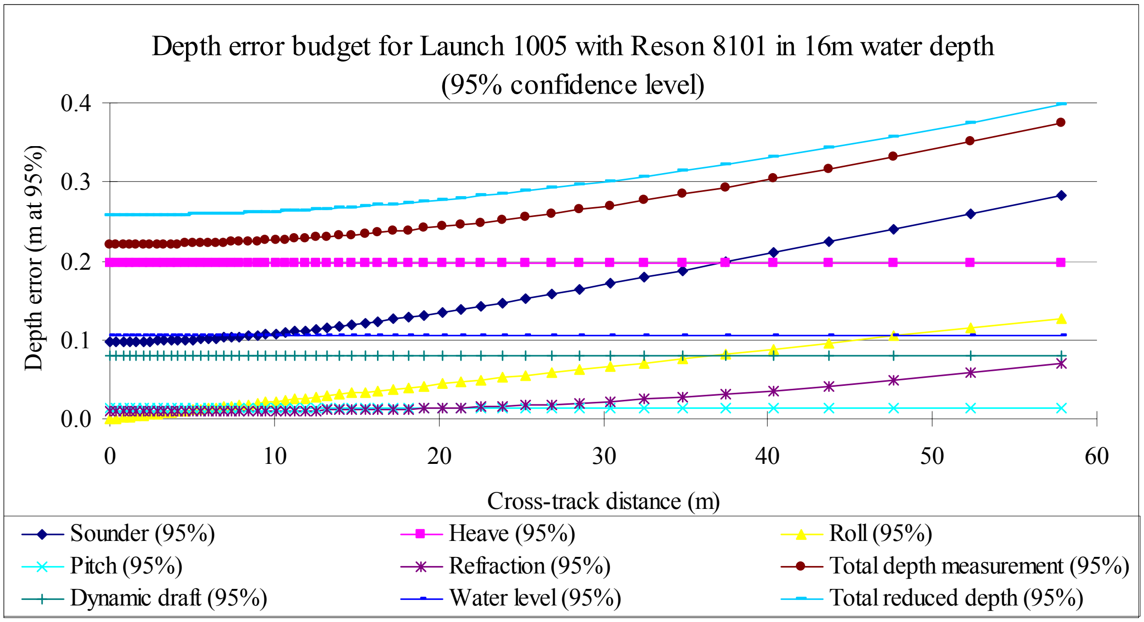




Depth error budget for Launch 1005 with Reson 8101 in 8m water depth
(95% confidence level)
Depth error (m at 95%)
0.4
0.3
0.2
0.1
0.0
0
5
10
15
20
25
30
35
40
Cross-track distance (m)
Sounder (95%)
Heave (95%)
Roll (95%)
Pitch (95%)
Refraction (95%)
Total depth measurement (95%)
Dynamic draft (95%)
Water level (95%)
Total reduced depth (95%)



Depth error budget for Launch 1005 with Reson 8101 in 12m water depth
(95% confidence level)
Depth error (m at 95%)
0.4
0.3
0.2
0.1
0.0
0
5
10
15
20
25
30
35
40
45
Cross-track distance (m)
Sounder (95%)
Heave (95%)
Roll (95%)
Pitch (95%)
Refraction (95%)
Total depth measurement (95%)
Dynamic draft (95%)
Water level (95%)
Total reduced depth (95%)



The RESON error model was released to the public, but has not been incorporated into this model. The above charts display an empirically derived error budget for the RESON Seabat 8101 in the following conditions:

Water Depth	8m / 12m / 16m
Sound Speed	1500 m s^{-1}
Roll Angle	1°
Pitch Angle	1°
Seafloor Slope Angle	2°

These values are typical for surveying in the North Atlantic, particularly in spring or autumn when the water column is well mixed.

With these parameters in mind, the best expected performance of the RESON 8101, as installed on Survey Launch 1005, is to the IHO Special Order from 0-8m water depth for all beams, to IHO Special Order from 0-45° off nadir in depths from 8-20m, and to IHO Order I for the full swath in depths greater than 8m. Actual performance will vary according to sea state, swell, tide zoning error, and sound velocity spatial and temporal distribution.

RESON SEABAT 8125 MULTIBEAM ECHOSOUNDER

The RESON SeaBat 8125 multibeam echosounder is a single-frequency, digital-recording multibeam echosounder with an operating frequency of 455 kHz. The RESON 8125 transducer consists of a flat transmitter array and solid cylindrical receiver array. The transducer unit is bolted to a flat aluminum plate, which is in turn bolted to an aluminum sled that is mounted on the hull of Survey Launch 1014.

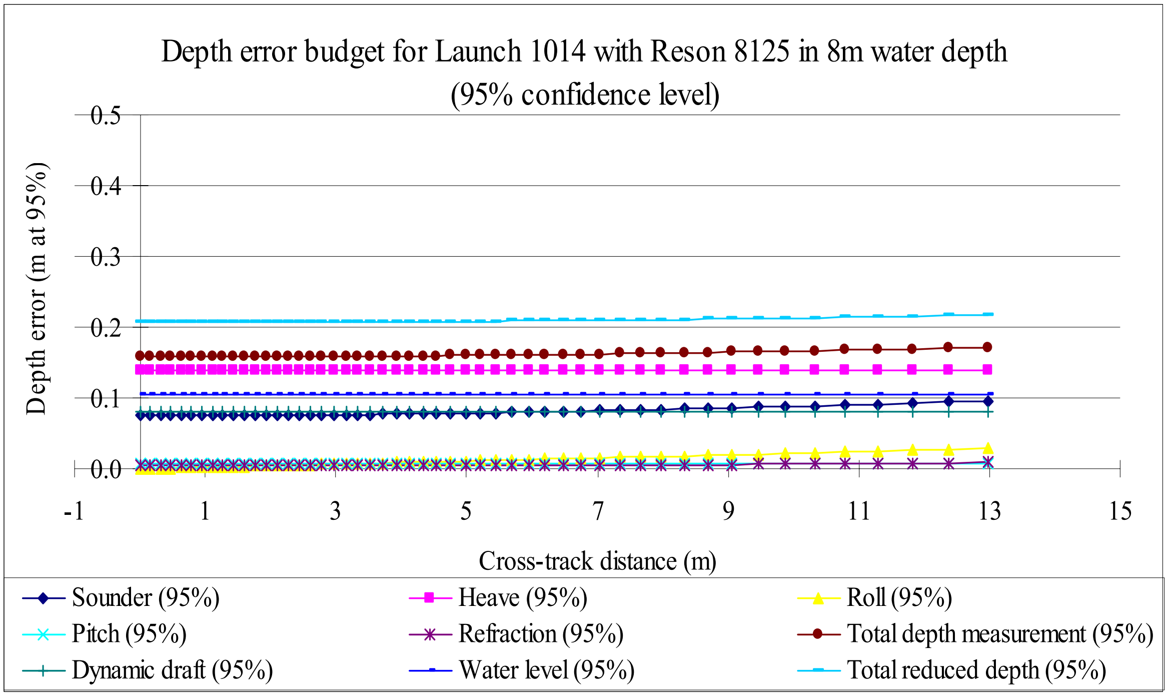
The RESON 8125 forms 240 beams each of which has a 0.5° across-track beam footprint for a maximum total swath width of 120°. Each beam has an along-track resolution of 1°. The ping rate is nominally 20-40 Hz, but may vary according to user specification. The RESON 8125 sonar is capable of bottom detection in depths from 3-120m. Aboard Survey Launch 1014 the RESON 8125 is used in depths from 4-40m.

The RESON 8125 performs active beam steering to correct for sound velocity at the transducer head using an ODOM Hydrographic Systems Digibar Pro sea surface sound velocity sensor. This sensor will be discussed in more detail in the Sound Velocity Equipment section.

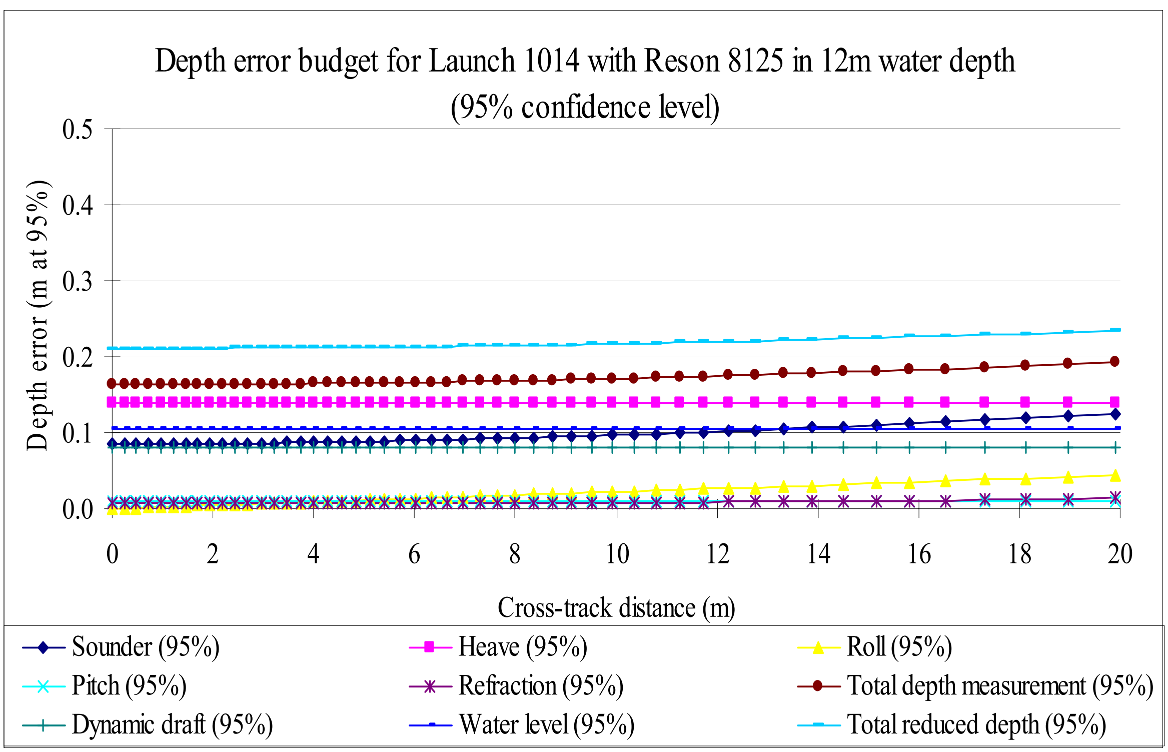
While the primary use of the RESON 8125 is determining bathymetry, acoustic backscatter data from this sonar is recorded and archived. This data is recorded in "snippet" format, where the acoustic backscatter strength for each ping/beam is measured over time (on the order of hundreds of microseconds). Backscatter snippet data is not used to generate hydrographic products; it is usually archived or used to generate end-user scientific products.

The error model of the RESON 8125 has not been released to the public. For the purposes of calculating total propagated error, the RESON 8125 is assumed to have an operational frequency of 455 kHz, a pulse length of 0.15ms, and a typical ping rate of 40Hz.

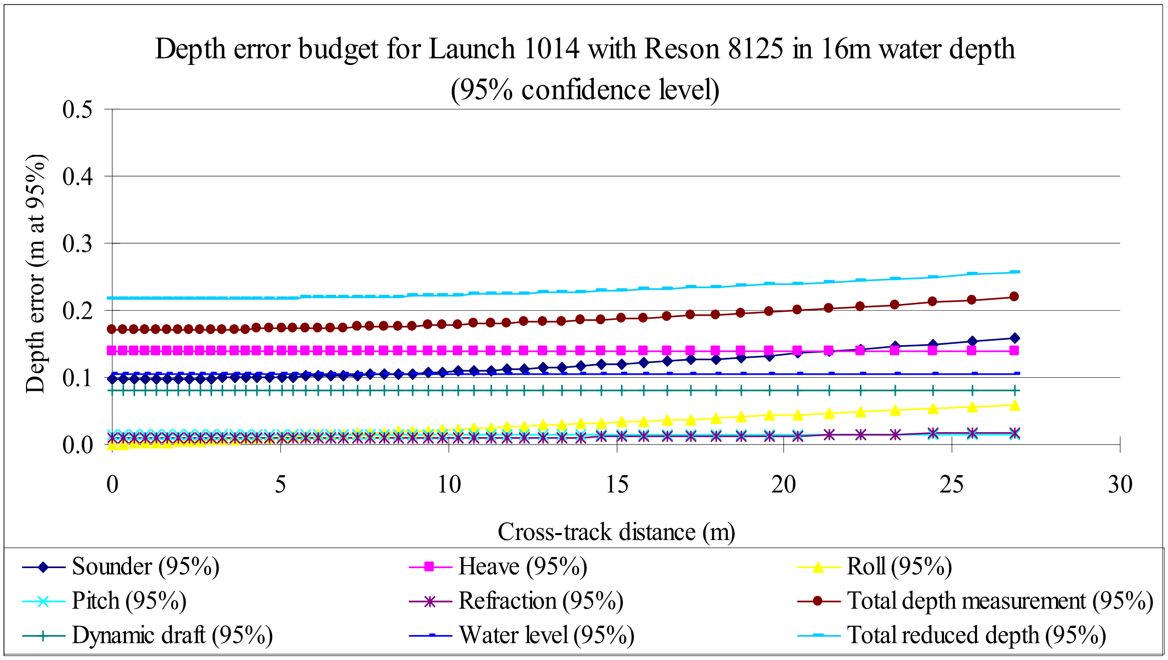
The RESON 8125 meets NOAA specifications for object detection in shallow water.



Depth error budget for Launch 1014 with Reson 8125 in 8m water depth
(95% confidence level)
Depth error (m at 95%)
0.5
0.4
0.3
0.2
0.1
0.0
-1
1
3
5
7
9
11
13
15
Cross-track distance (m)
Sounder (95%)
Heave (95%)
Roll (95%)
Pitch (95%)
Refraction (95%)
Total depth measurement (95%)
Dynamic draft (95%)
Water level (95%)
Total reduced depth (95%)



Depth error budget for Launch 1014 with Reson 8125 in 12m water depth
(95% confidence level)
Depth error (m at 95%)
0.5
0.4
0.3
0.2
0.1
0.0
0
2
4
6
8
10
12
14
16
18
20
Cross-track distance (m)
Sounder (95%)
Heave (95%)
Roll (95%)
Pitch (95%)
Refraction (95%)
Total depth measurement (95%)
Dynamic draft (95%)
Water level (95%)
Total reduced depth (95%)



The RESON error model has been released to the public, but is not incorporated into the above error budget. The above charts display an empirically derived error budget for the RESON Seabat 8125 in the following conditions:

Water Depth	8m / 12m / 16m
Sound Speed	1500 m s^{-1}
Roll Angle	1°
Pitch Angle	1°
Seafloor Slope Angle	2°

These values are typical for surveying in the North Atlantic, particularly in spring or autumn when the water column is well mixed.

With these parameters in mind, the best expected performance of the RESON 8125, as installed on Survey Launch 1014, is to the IHO Special Order standard. Actual performance will vary according to sea state, swell, tide zoning error, and sound velocity spatial and temporal distribution

A.2. Acoustic Imaging Equipment

KLEIN 5500 High-speed Side Scan Sonar

The KLEIN 5500 high-resolution side-scan sonar system is a digital-recording, beam-forming acoustic imagery device with an operating frequency of 455 kHz and vertical beam angle of 40°. The KLEIN 5500 system consists of a KLEIN towfish, model T5100 Transceiver/Processing Unit (TPU), and a computer for user interface. Stern-towed units also include a tow cable telemetry assembly. There are two configurations for data acquisition using the KLEIN 5500 system: stern-towed and hull-mounted.

The KLEIN 5500 system is distinct from other commercially-available side scan sonars in that it forms 5 simultaneous, dynamically-focused receiver beams per transducer face to improve along-track resolution. This improves along-track resolution to approximately 30cm at the 100m range scale, even when acquiring data at up to 10 knots. Across-track resolution is typically 7.5cm at the 100m range scale. The achievable 0.3m resolution meets the NOAA Hydrographic Surveys Specifications and Deliverables Manual (HSSDM) for object detection.

Stern-Towed Configuration

Aboard THOMAS JEFFERSON, side-scan sonar acquisition is performed with a stern tow. The towfish is deployed from DT Marine electric-hydraulic winch spooled with approximately 300m of armored steel coaxial cable encased in a green haired fairing. The cable is run through a block attached to a C-frame on the starboard side of the fantail. A yellow metal depressor wing is mounted to the body of the towfish at the cable connection point. Vertical and lateral stabilizing fins are attached to the tail end of the towfish.

Hull-Mounted Configuration

Aboard Survey Launch 1005 and Survey Launch 1014, the towfish is mounted to an aluminum sled using omega brackets. The sled is then hard-mounted to the port side of the hull. This sled-mount system is identical to that used for the RESON 8125 system aboard Survey Launch 1014.

Figure 12: Hull-Mount Configuration

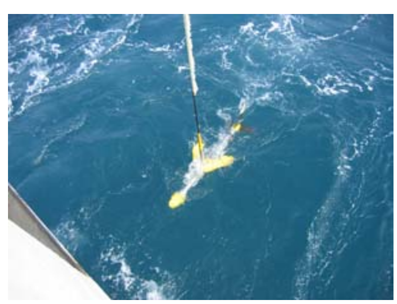


Figure 13: Towed Configuration

A.3. Manual Sounding Equipment

Divers Least Depth Gauge

The divers least depth gauge is a hand-held device that uses pressure to determine depth of water over a discrete point (e.g. mast of a shipwreck). A raw sounding obtained during a dive is corrected with verified tides and a sound velocity profile acquired in the vicinity of the object. The sound velocity profile is acquired from THOMAS JEFFERSON or one of the launches.

Lead Lines

Lead lines are composed of brass or bronze wire that is encased in dark red cotton tiller rope and marked at predetermined intervals. Lead lines are used for acquiring soundings in very shallow or restricted waters, areas where an echosounder will have extreme difficulty in resolving the water bottom (e.g. kelp or eelgrass), and to perform confidence checks against acoustic echosounders and/or divers least depth gauges. Leadlines aboard THOMAS JEFFERSON and Survey Launches 1005 and 1014 are marked in whole meters and decimeters. An alternative method of determining manual depths is to use a steel engineering tape with a lead attached. Lead lines were calibrated in January 2005. Calibration documents are located in Appendix II of the 2005 Hydrographic Systems Certification Report, 17 May 2005.

A.4. Positioning and Orientation Equipment

A basic requirement of multibeam hydrography is accurate ships position and attitude data during data acquisition. THOMAS JEFFERSON uses inertial positioning/orientation sensors and U.S. Coast Guard Differential GPS (DGPS) for a highly accurate blended position and orientation solution.

THOMAS JEFFERSON, Survey Launch 1005, and Survey Launch 1014 are each equipped with Trimble DSM212L DGPS receivers. The DSM212L includes a 12-channel GPS receiver capable of receiving external RTCM correctors from a shore-based reference station. The system outputs position information one time per second. Best expected position accuracy with the DSM212L system is less than one meter with 5 or more space vehicle vectors in the solution. This system is very accurate in the long term (>5 min) but subject to short period noise.

Inertial position calculations on THOMAS JEFFERSON, Survey Launch 1005, and Survey Launch 1014 are provided by an Applanix POS/MV Model 320 v. 3. The

POS/MV 320 system includes dual GPS antennas, an inertial measurement unit (IMU), and data processor (PCS). The IMU measures linear and angular accelerations corresponding to the major motions of the vessel (heave, pitch, roll, yaw) and inputs this data to the PCS, where it is combined with a GPS position determined by carrier-phase differential measurements to give the final position solution. The POS/MV position solution is not sensitive to short period noise, but its accuracy decays rapidly over time.

The blended DGPS and inertial position/orientation solution has typical values of 0.02° true roll and pitch accuracy, 0.02° heading accuracy, 2m position accuracy, and 0.03 ms^{-1} velocity accuracy. These parameters are monitored in real time during acquisition using the POS/MV user interface software.

Survey Launches 1005 and 1014 are equipped with Precise Timing, a multibeam sonar acquisition configuration which applies a time stamp *at the point of acquisition* to all incoming sonar, attitude, and positioning data. The timing message is generated by the POS/MV and synchronizes the launch RESON system time with the POS/MV UTC time. Although Precise Time reduces the effect of time latency on multibeam data, corrections for residual time latency biases must still be made via a patch test.

Two of the PCS units failed May 15 and 24 respectively and were subsequently returned to the vendor for repair. During the time when PCS systems were out for repair PCS units were swapped from platform to platform to continue operations. Every time a unit was installed on a platform, the original configuration file was loaded and GAMS calibration re-run. See Appendix I for details.

The Heave Bandwidth Settings were changed frequently depending on the long-period motion expected from Survey Launch 1005 and 1014.

Further documentation on Precise Timing may be found in Appendix V of the 2005 Hydrographic Systems Certification Report, 17 May 2005.

A.5. Sound Velocity Profilers

Sea-Bird SBE19/19+ CTD Profilers

Sound velocity correction is essential for multibeam hydrography. THOMAS JEFFERSON and SURVEY LAUNCH 1005 and 1014 acquire water column sound velocity data using Sea-Bird Electronics SeaCat SBE19 and SBE19+ Conductivity-Temperature-Depth (CTD) profilers. Temperature is measured directly. Salinity is calculated from measured electrical conductivity. Depth is calculated from strain gauge pressure.

THOMAS JEFFERSON is equipped with a SeaCat SBE19 DeepCat CTD profiler with strain gauge pressure sensor. The DeepCat is capable of CTD profiling at depths from 0-3400m. Post-calibration initial accuracy specifications were not available. Post calibration drift is expected to be 0.02 °C yr^{-1}, 0.012S m^{-1} yr^{-1}, and 4.5 psia yr^{-1} for temperature, conductivity, and pressure, respectively. The DeepCat is deployed using an electric-hydraulic winch with approximately 500m steel cable.

Survey Launch 1005 and Survey Launch 1014 are each equipped with a SeaCat SBE19+ CTD profiler with strain gauge pressure sensor. The SBE19+ has a specified post-calibration temperature accuracy of 0.005 °C, conductivity accuracy of 0.0005S m^{-1}, and strain-gauge pressure accuracy of 0.35 psia. Post calibration drift is expected to be 0.002 °C yr^{-1}, 0.004S m^{-1} yr^{-1}, and 0.168 psia yr^{-1} for temperature, conductivity, and pressure, respectively. The SBE19+ is capable of CTD profiling at depths from 0-350m. The SBE19+ is deployed by hand from Survey Launch 1005 and 1014.

All CTD instruments were returned to the manufacturer for calibration during the 2004-2005 winter in-port period. Calibration documents are contained in Appendix II of the 2005 Hydrographic Systems Certification Report (HSCR), 17 May 2005.

Sea Surface Sound Velocimeters

Unlike CTD profilers, sea surface sound velocimeters (SSVS) calculate sound velocity in water using two-way travel time. The typical SSVS consists of a transducer and a reflector at a known distance from the transducer. A pulse of known frequency is emitted, reflects at the reflector surface, and returns to the transducer. The two-way travel time is measured, and sound velocity derived from the two-way travel time. SSVS are required for multibeam systems that perform active beam steering at the transducer head. The Kongsberg SIMRAD EM1002 and RESON 8125 systems both require SSVS data.

Applied Microsystems Smart SV & T Probe

The AML Smart SV&T Probe is a real-time time-of-flight sound velocimeter and thermistor sensor. The manufacturer specified sound velocity accuracy is 0.05 ms^{-1} and temperature accuracy is 0.05 °C. Empirical observations of drift show a sound velocity drift of approximately 0.5 ms^{-1} $yr^{-1}$and temperature drift of approximately 0.05 °C yr^{-1}. Aboard THOMAS JEFFERSON, the AML Smart SV&T probe is mounted in an insulated sea chest in the sonar void. Sea surface temperature and sound velocity values are output to the SIMRAD EM1002 system at a rate of 10 Hz.

The AML Smart SV&T Probe was returned to the manufacturer for calibration during the 2004-2005 winter in-port period. Estimated error of the Calibration documents are contained in Appendix II of the 2005 HSCR, 17 May 2005.

ODOM HYDROGRAPHIC SYSTEMS DIGIBAR PRO

The Digibar Pro is a real-time time-of-flight sea surface sound velocimeter. The manufacturer specified sound velocity accuracy is 0.3 ms^{-1}. Aboard Survey Launch 1014, the Digibar Pro is mounted to an aluminum sled, aft of the RESON 8125 transducer. Sea surface temperature and sound velocity values are output to the RESON 8125 system at a rate of 10 Hz.

The Digibar Pro was returned to the manufacturer for calibration during the 2004-2005 winter in-port period. Calibration documents are contained in Appendix II of the 2005 HSCR, 17 May 2005.

B. Software Systems

B.1 Acquisition Software

Coastal Oceanographics *Hypack Max*

Coastal Oceanographics *Hypack Max* is a multi-function marine survey software package. *Hypack Max* is used for vessel navigation during sidescan and multibeam acquisition, and acquisition of vertical-beam echosounder data. Survey lines, vessel position with respect to lines, and various navigation parameters are displayed on a screen both at the acquisition station and on a repeater screen for the helmsman or coxswain.

Kongsberg Simrad *Merlin*

Kongsberg Simrad *Merlin* is a Sun Microsystems-based real-time multibeam acquisition and quality control designed for the SIMRAD EM1002 multibeam echosounder. This system is used for multibeam acquisition aboard THOMAS JEFFERSON.

Triton Elics International Imaging *ISIS*

TI *Isis* is an acquisition software package providing imagery displays, area coverage displays, and real-time ping strength displays. *Isis* is used for acquisition of side-scan sonar imagery on THOMAS JEFFERSON and for multibeam echosounder and side-scan sonar acquisition aboard Survey Launches 1005 and 1014.

B.2. Processing Software

CARIS *HIPS v5.4*

CARIS *HIPS* (Hydrographic Information Processing System) is used for all initial processing of multibeam and vertical beam echosounder bathymetry data, including tide, sound velocity, and vessel offset correction and data cleaning. CARIS *HIPS* 5.4 uses statistical modeling to create uncertainty-weighted Bathymetry with Associated Statistical Error (BASE) surfaces to assist the hydrographer in data cleaning and hydrographic product generation.

CARIS SIPS (Side-scan Information Processing System) is used for all processing of side-scan sonar imagery, including cable layback correction, slant range correction, contact selection, and mosaic generation.

CARIS *HIPS* AND *SIPS v6.0 BETA*

CARIS HIPS and SIPS v6.0 BETA is used for CUBE (Combined Uncertainty Bathymetry Estimator) surface generation and surface direction user editing. User Hypothesis selection was not done for the time period covered by the DAPR.

As functionality of CARIS HIPS and SIPS 6.0 BETA is tested, some basic processing steps are done using the software including: tide, sound velocity, vessel offset correction, data cleaning, and data conversion.

CUBE surfaces and finalized CUBE surfaces are the bathymetry product provided.

ERROR MODELING IN CARIS HIPS

A table describing values used to compute TPE of soundings acquired by THOMAS JEFFERSON and her launches is contained in Appendix I of the 2005 Hydrographic Systems Certification Report, 17 May 2005.

HSTP PYDRO

HSTP *PYDRO* is a proprietary program for the classification of side-scan sonar and multibeam bathymetry contacts and for the creation of preliminary smooth sheets. Multibeam contacts (Designated soundings), side-scan sonar contacts, and detached position contacts are analyzed, grouped, and granted S-57 classifications. High resolution BASE surface data is entered into the program and excessed to survey scale. The final product is a Preliminary Smooth Sheet (PSS), which is delivered to the Atlantic Hydrographic Branch as part of the final submission package.

HSTP *VELOCWIN*

HSTP *Velocwin* is a proprietary program for the processing of sound velocity casts. This program uses Sea-Bird Electronics *SeaSoft* software to convert hexadecimal SeaCat data into ASCII conductivity-temperature-depth data, and then converts the ASCII data into a depth-binned sound velocity file. These sound velocity files are applied to the data in CARIS *HIPS*. *Velocwin* is also used to check the accuracy of sound velocity casts, to calculate least depth from a Divers Least Depth Gauge, and to archive sound velocity information for the National Oceanographic Data Center.

MapInfo Professional

MapInfo Professional is the Geographic Information System (GIS) software package used aboard THOMAS JEFFERSON. *MapInfo* is used for final data analysis and creating end-user plots.

B.3. Visualization Software

Interactive Visualization Systems *Fledermaus*

IVS *Fledermaus* is an interactive digital terrain model visualization software package. Digital terrain models, side-scan mosaics, and ancillary data are imported into *Fledermaus* for the creation of scenes (user-specified zooming interface) and fly-through (movies). *Fledermaus* is not used for hydrographic product generation, but is frequently used for scientific end user product generation.

University of New Hampshire *GeoZui 3D*

UNH *GeoZui 3D* is an interactive, zooming visualization software package. Data is imported and converted to gridded universal terrain models (GUTMs), which the user may then zoom through, rotate, and view the data in various ways. *GeoZui 3D* is not used for hydrographic product generation, but is frequently used for detailed inspection of BASE surface data, presentation, and scientific end user product generation.

C. Acquisition Methods

THOMAS JEFFERSON and her launches acquire hydrographic data according to the Letter Instructions for each survey. The Letter Instructions for a given survey typically call for 200% bottom coverage of the survey area, and generally gives the field party discretion as to how that 200% bottom coverage is achieved. Under certain conditions, e.g. a desired IHO Special Order survey, the Letter Instructions will specify acquisition method.

The two most commonly-used methods to achieve 200% bottom coverage are 200% side-scan sonar with vertical beam bathymetry, and 100% side scan sonar + 100% multibeam bathymetry coverage.

200% Side Scan Sonar + VBES

Two line plans (100% coverage and 200% coverage) are developed for the desired range scale. Line spacing for the first 100% coverage is 120m at the 75 meter range scale and 160m at the 100 meter range scale. The line spacing for the second 100% coverage is identical to the spacing for the first 100%, and the first line of the second 100% coverage is offset by half the line spacing.

As VBES is the primary source of bathymetry for this type of survey, lines are run perpendicular or near perpendicular to the expected bathymetry contour. VBES data is logged both digitally and in analog paper record format. Least depths of features located by the side scan sonar must be developed by MBES, closely-spaced VBES, or Divers Least Depth Gauge.

In very shallow water (<10m), flat sandy bottoms, and areas with a low probability of anthropogenic artifacts, 200% SSS is often more efficient than attempting 100% MBES + 100% SSS coverage.

100% Side Scan Sonar + 100% MBES

Two line plans are developed: one 100% SSS line plan and one 100% MBES line plan. Line spacing for the SSS line plan is identical to the spacing discussed above. Line spacing for the MBES line plan varies from three to five times water depth. Data acquired at wide line spacings are examined frequently in CARIS HIPS to determine if outer beam data is acceptable. If necessary, outer beam data is rejected and data is acquired at a more conservative line spacing.

As MBES is the primary source of bathymetry for this type of survey, lines are run parallel or near parallel to the expected bathymetry contour. Running perpendicular to the contour causes rapid changes in the swath width, and is inefficient compared to running parallel to the depth contour. Least depths of features located by side scan sonar or multibeam echosounder may be developed by RESON 8125 MBES or Divers Least Depth Gauge should the basic bathymetry coverage be insufficient or undesirable for that purpose.

100% MBES + 100% SSS surveys are most desirable in areas of rapidly changing bottom type, rapidly changing bathymetry, areas of prior glaciations, ports and harbors, and areas with a high probability of anthropogenic artifacts.

100% MBES

While uncommon for near-shore or shallow-water navigable area surveys, this type of survey is typically used for offshore/deep-water navigable area surveys and for special-purpose surveys. Examples of special-purpose surveys include surveys of marine protected areas or surveys of geologically important areas. Lines are run parallel to depth contours where feasible. For these surveys, the NOAA multibeam bathymetry coverage specification of 3.3 pings per 3 meters of water bottom may be waived. Backscatter data (both SIMRAD backscatter and RESON Snippets) are recorded.

Crosslines

Crosslines are acquired as an additional confidence check to the performance of echosounder data. According to the 2005 Field Procedures Manual, a VBES survey requires crossline mileage equal in length to 8% of the total linear nautical mileage of mainscheme data, and an MBES survey requires crossline mileage equal in length to 5% of the total linear nautical mileage of mainscheme data. Crosslines are used to check sonar confidence and to provide a meaningful comparison between nadir beams and outer beams of a multibeam mainscheme acquisition line.

D. Corrections to Echo Sounding

D.1. SOUND VELOCITY

SBE19 Conductivity, Temperature and Depth (CTD) Profilers

Sound velocity profiles for the THOMAS JEFFERSON are acquired with a Sea-Bird Electronics SeaCat SBE19 CTD profiler. Sound velocity profiles for Launch 1005 and 1014 are acquired with Sea-Bird Electronics SeaCat SBE19+ CTD profilers. Raw conductivity, temperature and pressure data are processed using the program **Velocwin** which generates sound velocity profiles for CARIS **HIPS and SIPS 5.4**. Sound velocity correctors are applied to MBES and VBES soundings in CARIS **HIPS and SIPS 5.4** during post processing only. Calibration reports for the SBE19/19+ CTD profilers are included in Appendix II of this report.

The speed of sound through water is determined by a minimum of one cast every three to four hours of MBES acquisition, in accordance with the Standing Letter Instructions and NOS Specifications and Deliverables for Hydrographic Surveys. Casts were conducted more frequently when changing survey areas, or when it was felt that conditions, such as change in weather, tide, or current would warrant additional sound velocity profiles.

The sound velocity casts are extended in **Velocwin** and applied to the Simrad MBES and RESON MBES data in CARIS **HIPS and SIPS 5.4** during post processing.

Kongsberg SIMRAD Surface Sound Velocity System

THOMAS JEFFERSON is equipped with a Kongsberg Simrad Surface Sound Velocity System (SSVS). The SSVS uses an Applied Microsystems Limited Sound Velocity and Temperature Smart Sensor to measure sound velocity and temperature at the depth of the Simrad EM 1002 transducer. Mounted in THOMAS JEFFERSON's transducer void, the smart sensor samples water pumped through insulated stainless steel pipes passing through the void. This unit calculates and outputs temperature and sound velocity ten times per second to the EM1002 Sun operator workstation for real-time beam-steering at the transducer head. These values are averaged by Simrad before application every three seconds. This averaging mitigates the effects of false measurements.

RESON 8125 Surface Sound Velocity System

Survey Launch 1014 is equipped with an Odom Hydrographic Systems Digibar Pro sea surface sound velocity sensor. The sensor is used to measure sound velocity at the depth of the RESON 8125 transducer. This data is used for real-time beam-steering at the transducer head. The sensor is mounted just aft of the transducer on the hull mounted equipment sled.

D.2. WATER LEVEL CORRECTORS

Soundings are initially reduced to Mean Lower-Low Water (MLLW) using predicted tides or preliminary water level data from the local, primary tide gauge obtained from the Center for Operational Oceanographic Products and Services (CO-OPS) web site. For all projects, a simple predicted tide table is applied to MBES data in CARIS HIPS and SIPS during the Merge process. A zone-corrected verified water level or approved water level tide file is supplied by CO-OPS, which is then reapplied to all CARIS **HIPS and SIPS 5.4**.

D.3. HEAVE, PITCH, ROLL AND HEADING, INCLUDING BIASES AND NAVIGATION TIMING ERRORS

Heave, pitch, roll, and navigation latency bias for each vessel are corrected during a multibeam bias calibration test (patch test). MBES vessel offsets, dynamic draft correctors, and system bias values are contained in HIPS Vessel Configuration Files (VCFs and HVFs). These offsets and biases are applied to the sounding data during processing in CARIS HIPS and SIPS 5.4. The VCFs, HVFs and Patch Test data are included with the digital data. A Patch Test or verification of certain biases is also performed at the start of each project before acquiring MBES data in the new survey area. The preliminary Patch Test Report for each vessel can be found in Appendix I of the 2005 Hydrographic System Certification Report. Reports for subsequent patch tests may be found in the appropriate Vessel Offsets folder and in Appendix II of this report.

D.4. VESSEL OFFSETS AND DYNAMIC DRAFT CORRECTORS

THOMAS JEFFERSON OFFSETS AND DYNAMIC DRAFT

A partial re-survey of THOMAS JEFFERSON vessel offsets was conducted on March 10, 2005 by NGS personnel. This resurvey was in response to a change in POS/MV antenna configuration following mast work during the 2004-2005 winter inport period. The procedure and results are in the Offset Confirmation Report contained in Appendix III of the 2005 Hydrographic System Certification Report.

Preliminary static draft measurements are made at the beginning of each leg. Static draft for THOMAS JEFFERSON is measured using a bubble tube located in lower survey stores. Additional static draft measurements will be made as needed with changing conditions, such as engineers switching ballast, or if on a particularly long leg where a large amount of fuel consumption occurs.

Dynamic draft measurements were made on THOMAS JEFFERSON on March 24-25, 2005. Refer to Appendix I of the 2005 Hydrographic System Certification Report for detailed results.

LAUNCH 1005 OFFSETS AND DYNAMIC DRAFT

Vessel offset measurements were made on Launch 1005 on March 26, 2004. Static draft measurements for Launch 1005 were made on March 22, 2005 and dynamic draft measurements were made on March 25, 2005. Refer to Appendix I of the 2005 Hydrographic System Certification Report for detailed results.

LAUNCH 1014 OFFSETS AND DYNAMIC DRAFT

Vessel offset measurements were made on Launch 1014 on March 31, 2004. Static draft measurements for Launch 1014 were made on November 10, 2004 and dynamic draft measurements were made on March 25, 2005. Refer to Appendix I of the 2005 Hydrographic System Certification Report for detailed results

E. Data Processing and Quality Control

E.1. Bathymetry

Raw bathymetry data (XTF, SIMRAD, and HYPACK VBES) are converted into CARIS HDCS data format upon completion of daily acquisition. Conversion parameters vary for each data format, and are stored in the LogFile of each HDCS processed line folder. After data conversion, water level, sound velocity, attitude, and navigation data are applied as described in sections D.1. – D.4. Bathymetry lines are then merged. Following merge, Total Propagated Error (TPE) is calculated for each sounding. For a more detailed explanation of TPE calculation of multibeam and vertical beam echosounder data, refer to NOAA Ship THOMAS JEFFERSON BASE Surface SOP v 1.3 (26 October 2004).

Vertical Beam Bathymetry

When vertical beam echosounder is the sole source of bathymetry (e.g. 200% SSS + VBES survey), vertical beam echosounder data is loaded into CARIS HIPS as described above. The data is then examined and cleaned in CARIS Singlebeam Editor. Analog paper records are used to provide extra information to the hydrographers during data cleaning.

If the survey includes both VBES and MBES as the primary source of bathymetry (e.g. launches acquire VBES and ship acquires MBES), then VBES data will be included into a BASE Surface with the MBES bathymetry. Total propagated error for the VBES system assumes that a vertical-beam echosounder is equivalent to a multibeam echosounder with one beam. Resolution of the VBES BASE Surface will be equal to the resolution of the adjacent MBES BASE Surface.

If the primary source of bathymetry for a survey is MBES, VBES data is acquired but not processed, and is immediately archived in raw format. This data should not be used for creation of any hydrographic or scientific product.

Multibeam Bathymetry

After computation of TPE, multibeam lines are either used to create a new CUBE Surface or are added to an existing CUBE Surface. The resulting layers are analyzed by the data processor to identify blunders, systematic errors, where the CUBE surface failed, and to identify significant waterbottom features. Blunders are rejected by the data processor in CARIS Subset Editor (multi-line spatial view). Systematic errors are identified and documented by the data processor. If the systematic error can be corrected it is done at this time.

To obtain optimal resolution of bathymetry data, several different CUBE Surfaces of various resolutions are created. Guidelines for surface resolutions specified in either the Letter Instructions of Field Procedures Manual are followed except where either higher resolution is desired or where a particular system doesn't support the specified resolution.

Traditional CARIS crossline certifications are no longer performed. The error modeling inherent in the CUBE Surface concept allows the hydrographer to examine the surface and determine whether the data of which the surface is created is acceptable or not.

GEOZUI and Fledermaus are used to assist the data processor in identifying data outliers and systematic errors harder to detect with other methods.

Hypothesis selection available in CARIS 6.0 are not currently used for CUBE surfaces.

E.2. Imagery

Side scan sonar data are converted from *.xtf (TEI ISIS raw format) to HDCS. Side scan data are processed using CARIS SIPS 5.4.

Processing side scan data includes examining and editing fish height, vessel heading (gyro), and vessel navigation records. Fish navigation is recalculated using CARIS SIPS 5.4. Tow point offsets (C-frame and cable out), fish depth, fish attitude, and water depth are used to calculate horizontal layback.

After fish navigation is recalculated, side scan imagery data are slant-range corrected to 0.1m with beam pattern correction. The slant-range corrected side scan imagery data are closely examined for any targets. Targets-of-interest are evaluated as potential contacts based upon apparent shadow length and appearance, particularly targets which do not appear to be natural in origin. Contacts are selected and saved to a contact file for each line of SSS data. Contact selection includes measuring apparent height, selecting contact position, and creating a contact snapshot (*.tif) image.

Side scan sonar coverage is determined by using mosaics generated in CARIS SIPS 5.4 and imported into MapInfo. If any deficiencies in the side scan sonar data are found, a holiday line file is created from the mosaics, and additional lines of SSS are acquired, in order to meet the requirements set forth in the Hydrographic Surveys Letter Instructions.

E.3. Bathymetry Analysis and Feature Classification

Following data cleaning in CARIS HIPS and SIPS, uncertainty-weighted bathymetry grids and CARIS contacts are inserted into a PYDRO Preliminary Smooth Sheet (PSS). Side Scan Sonar (SSS), Multi Beam Echo Sounding (MBES) and Vertical Beam Echo Sounding (VBES) data are imported into PYDRO using the "Insert CARIS Line

Features" tool. Images of contacts exported from CARIS are displayed in the Image Notebook Editor in PYDRO. Contacts are arranged by day and line and can be selected in the data "Tree" window. Information concerning a specific contact is reviewed in the Editor Notebook Window in PYDRO. This information includes contact position, AWOIS item positions, surrounding depths, contact cross references, and charting recommendations. Each contact is reviewed, and information flags are set accordingly. The available flags are "Resolved", "Rejected", "Primary Hit", "Significant", "Chart", and "DTON" (see Figure 14).

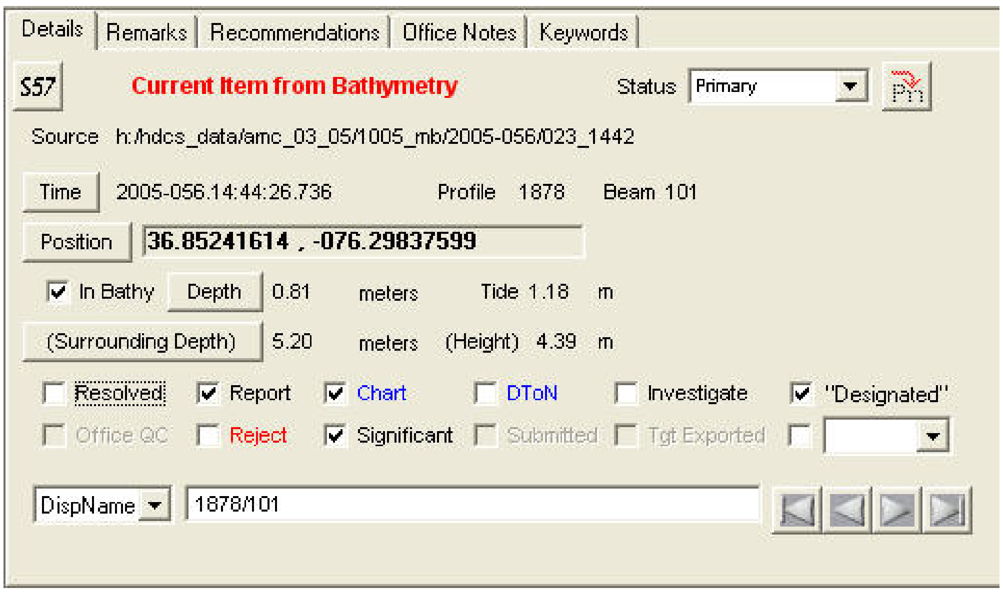


Figure 14

Contacts are classified according to type of contact (e.g. MBES, SSS, DP, etc), confidence, and proximity to other contacts. Although this will vary from survey to survey, the following general rules apply for classification of contacts:

- MBES contacts will be classified as primary contacts over SSS, DP, and GP contacts;
- If there are two or more MBES contacts for the same feature, the MBES contact of least depth is classified as the primary contact;
- If there is no bathymetry contact for a feature, then the SSS position will be classified as primary contact over DP and GP contacts;
- If there are two or more SSS contacts for the same feature, then the SSS contact that best represents the feature is classified as the primary contact;
- If there are no bathymetry or imagery contacts, then the DP contact that best represents the feature is classified as the primary contact.

Multiple representations of one distinct feature (e.g. contacts from two or more SSS lines on a known wreck) may be grouped. For a group of features, one representation is selected as the primary contact, and all others are selected as secondary contacts with respect to the primary contact.

Significant features are defined by the Hydrographic Survey Specifications and Deliverables as an object rising more than 1m above the seafloor in water depth of 0-20m, and an object rising 10% of depth above the seafloor in water depths greater than 20m. Either echosounder least depth or side-scan sonar acoustic shadow height may be used to determine height of an object off the water bottom. The following types of features are always significant contacts: wrecks, obstructions, pipelines, and piers and wharves.

Contacts appearing significant are further investigated by multibeam. If there is no known least depth of good confidence on a significant feature, then the feature will be flagged as “Investigate.” Features with such a tag must be further developed, in order of preference, with multibeam echosounder, divers least depth gauge, or vertical beam echosounder.

Any items that are to be addressed in the Item Investigation section of the Descriptive Report are flagged as “Chart”. Examples of Chart items include position of new or repositioned Aids to Navigation, permanent man-made features which do not pose a danger to surface navigation, or dynamic sedimentary bedforms which have not been previously noted on the chart. Items which have the “Chart” flag set could also be further designated for inclusion in the Danger to Navigation Report by choosing the “DTON” flag. Dangers to Navigation are submitted to the Commanding Officer for review prior to submission to the Marine Charting Division (MCD).

After a feature is fully classified, primary features are flagged as “Resolved.” If a primary feature is flagged “Resolved,” then the secondary features correlated to that primary feature are automatically flagged “Resolved” and are given the same full classification as the primary feature.

E.4. Product Generation

The ship’s bathymetry product is a collection of finalized CUBE surfaces, which maintains the optimal resolution for a given depth range and allows for more efficient and objective cartographic representations. Although OCS is still the primary “ship’s customer”, there are a number of other users who have a great interest in bathymetric models produced by NOAA’s Hydrographic survey platforms.

Side scan sonar data is used to create high-resolution mosaics of the seafloor. These mosaics are used to identify contacts on the sea floor, as well as general bottom type. When permitted by Letter Instructions these mosaics are used to determine where to acquire full multibeam coverage and developments. In areas without full multibeam coverage, side scan sonar data are analyzed for significant individual contacts and subsequent development.

The Pydro Preliminary Smooth Sheet (PSS) is the ship's record of the survey, from which the final survey is created at the Atlantic Hydrographic Branch. The PSS consists of the final CUBE surface collection and S-57 classified features.

Data visualization products, including Gridded Universal Terrain Models (GUTMs) and IVF Fledermaus Scene and Movie files, are generated as end user scientific products and as media relations products. These products are not submitted for cartographic purposes, and should not be used for navigation.

RESON Snippets data and SIMRAD acoustic backscatter data are collected during multibeam data acquisition, but are not used for bathymetric processing. Backscatter mosaics are generated for end user scientific products.

The ship will occasionally produce high-resolution digital terrain models, multibeam echosounder backscatter mosaics and XYZ bathymetry grids for third party scientific users. These are special request products.

APPROVAL

As Chief of Party, I have ensured that standard field surveying and processing procedures were adhered to during these projects in accordance with the National Ocean Service Standing Instructions for Hydrographic Surveys (3/2004), the Hydrographic Surveys Specifications and Deliverables Manual (3/2003), Hydrographic Survey Directives, and the Field Procedures Manual for Hydrographic Surveying (1/2005, v 1.0).

I acknowledge that all of the information contained in this report is complete and accurate to the best of my knowledge.

Submitted:

ENS Stephen Kuzirian
Hydrographer

Approved and Forwarded:

LT Marc Moser, NOAA
Field Operations Officer

CAPT Emily B. Christman, NOAA
Commanding Officer

Special thanks to PS Helen Stewart who contributed a significant amount of work in creating this document before detaching from the THOMAS JEFFERSON in early 2005.

APPENDIX I – EQUIPMENT

Equipment Serial Numbers

Equipment	Serial Number(s)	Vendor Calibration	Firmware Updated	Remarks	
Odom Echotrac DF3200 MKII Echosounder	Launch 1014 - 9644				
	Launch 1005 - 9708				
	TJ - 9643				
Simrad EM1002 Multibeam Echosounder	Transducer 267				
	Transceiver 222				
Reson 8101 Mutibeam Echosounder	Processor 13976				
	Transducer 089704				
Reson 8125 Multibeam Echosounder	Processor 31381				
	Transducer 1501014				
Klein 5500 HSHR side scan sonar processor	Launch 1005 - 91184				
	Launch 1014 - 91566				
	TJ - 91182				
Klein 5500 HSHR side scan sonar towfish	276	1/11/2005	Hull mounted 1005	Unit sent to RA 5/2005	
	278	1/11/2005	Ship's initial unit	01-Deck	
	292	1/11/2005	Ship's current unit	Main Deck	
Trimble DSM212L	Launch 1005 - 0220168291				
	Launch 1014 - 0220157923				
	TJ - 0020159721				
	TJ - 0220159716				
Trimble GPS Pathfinder Pro XRS Receiver	224025052				
Diver Least Depth Gauges	68334	1/24/2005			
Velocity Profiler	285	1/12/2005	3/22/2005		
Seabird SBE 19 Plus SVP	4281	12/3/2003		LOANER	
Seabird SBE 19 Plus SVP	4486	12/4/2004	3/22/2005		
Seabird SBE 19 Plus SVP	4487	12/4/2004	3/22/2005		
Odom DIGIBAR-Pro Profiling Sound Velocimeter	98130-0124403	12/8/2004	N/A		
Applied Microsystems Smart SV & Tw Probe	4823	11/23/2004			
Applanix TSS Position and Orientation System	PCS Change Date	Start of Season	5/15/2005	5/24/2005	5/31/2005
	Launch 1005 PCS	207	780	none	780
	Launch 1005 IMU	103	103	103	103
	Launch 1014 PCS	402	207	207	402
	Launch 1014 IMU	30	30	30	30
	TJ PCS	780	None	780	none
	TJ IMU	007	007	007	007

Software	Version	Intalled
Acquisition		
Hypack Max	4.3.5.8	03/05
Isis	6.6.136.0	03/05
TEI Suite	v297	03/05
SIS	2.5 Build 60 a1	07/05
Horizantal Control		
TSIP Talker	2.0	
POS/MV Controller (3102)	2.1	01/05
POS/MV Controller (3101)	3.2	08/05
Sound Velocity		
Velocwin	8.7.6	01/05
Processing		
Pydro	v5.33	05/05
MapInfo	6.5	02/04
MapBasic	5.0	
Vertical Mapper	3.0	05/05
Fledermaus	6.2	08/05
GeoZui	3.4	08/05
Grid Manipulator	Shepware	08/05
CARIS GIS	4.4a 3.0	07/05
CARIS HIPS & SIPS	5.4 HF 1-27	07/05
CARIS HIPS & SIPS	6.0	08/05
Utilities		
KapConv	3.4.1	07/05
HydroMI	v5.33	
Tides and Currents	2.6	
Cygwin		10/31/2005
WorldReg	1.0	
NOAA Chart Reprojector	2.0.4	02/05

APPENDIX II – PATCH TEST REPORTS

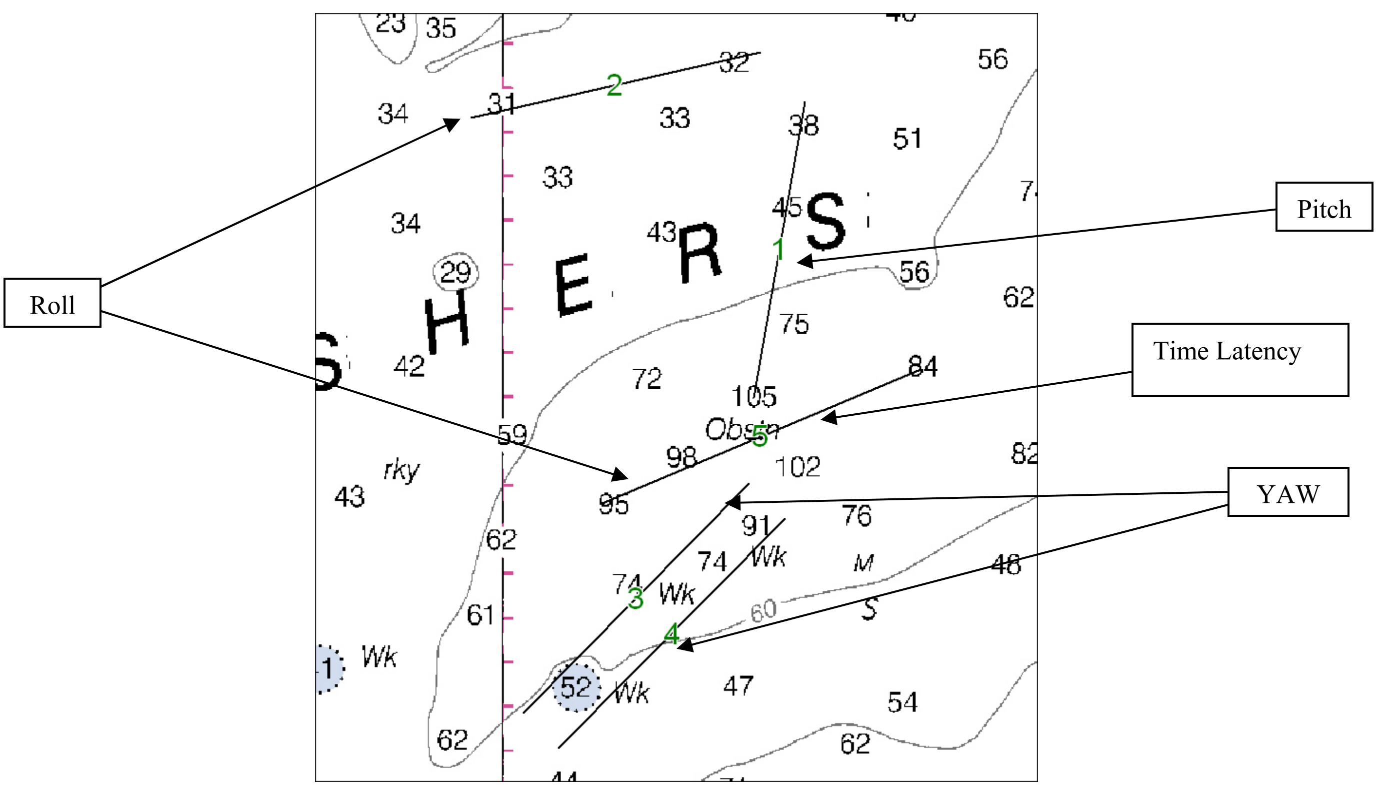
FIELD CALIBRATION REPORT
SURVEY LAUNCH 1005
Multibeam Reson 8101

Background: Launch 1005 is a multi-purpose survey vessel capable of acquiring either Multibeam bathymetry or high-resolution side scan sonar. The Reson 8101 shallow-water Multibeam system is permanently mounted to the hull of the vessel, while a Klein 5000 high-speed high-resolution side scan sonar can be attached to the hull on a metal sled. The launch is currently equipped with the Reson 8101 shallow-water Multibeam echosounder. The Reson 8101 has a nominal frequency of 240 kHz, with a ping rate of 10-40 Hz with 101 beams and maximum range of approximately 50 m.

Objective: A field calibration patch test assesses relative alignment between the vessel's attitude sensor and Multibeam sonar. The purpose of this patch test is to determine the biases associated with sonar IMU time delay, pitch, roll and yaw. Determined values were entered in the CARIS vessel configuration file *1005_mb*.

Location, Date, and Personnel: On April 23, 2005 SS Oberg, ENS Jaskoski, SST Forfinski, and AST Wood conducted a field calibration of the SeaBat 8101 for time delay, pitch, roll, and heading bias. The patch test was performed in Fisher's Island Sound, approximately 1.5 NM North of Silver Eel Cove and 0.3 NM West of North Dumpling. See Chart: 13212 and graphics below.

Patch Test Line Plan JD 113



Equipment:

Reson 8125 Multibeam echosounder
TSS POS/MV 3
Trimble DSM 212L DGPS receiver
Seacat SBE19 sound velocity profiler

PROCEDURES

ACQUISITION: See graphic, “Patch Test Data Acquired JD113”

Time Latency: Historically, timing bias was determined by two pair of coincident lines run at different speeds in the same direction. One pair up slope and one down slope, each line within the pair run at 4 and 9 knots over a well defined slope. However, for “Precise Timing” a new technique was employed. Time latency can be determined by examining the residual uncorrected roll at the edge of a swath. To accentuate the affect of timing latency, these lines should be acquired in fairly deep water over a smooth bottom exhibiting some non-trivial amount of dynamic roll. In other words, data should not be acquired when sea state is calm, “dead flat.”

For this patch test, line 5 was run over one to two foot seas. The line was run with an average course made good of 246 degrees maintaining a speed between 6.0 and 7.5 knots. Fluctuations in vessel course made good from 234 to 262 degrees are an indication of a somewhat rough sea state. Once the vessel settled the average speed was 6.5 knots. The same line was then run maintaining a reciprocal average course made good of 065 degrees maintaining a speed between 5.5 and 7.5 knots. Once again fluctuations in vessel course made good from 056 to 076 degrees are an indication of a somewhat rough sea state. Once the vessel settled the average speed was 6 knots. The basin depth varied from 26 to 36 meters.

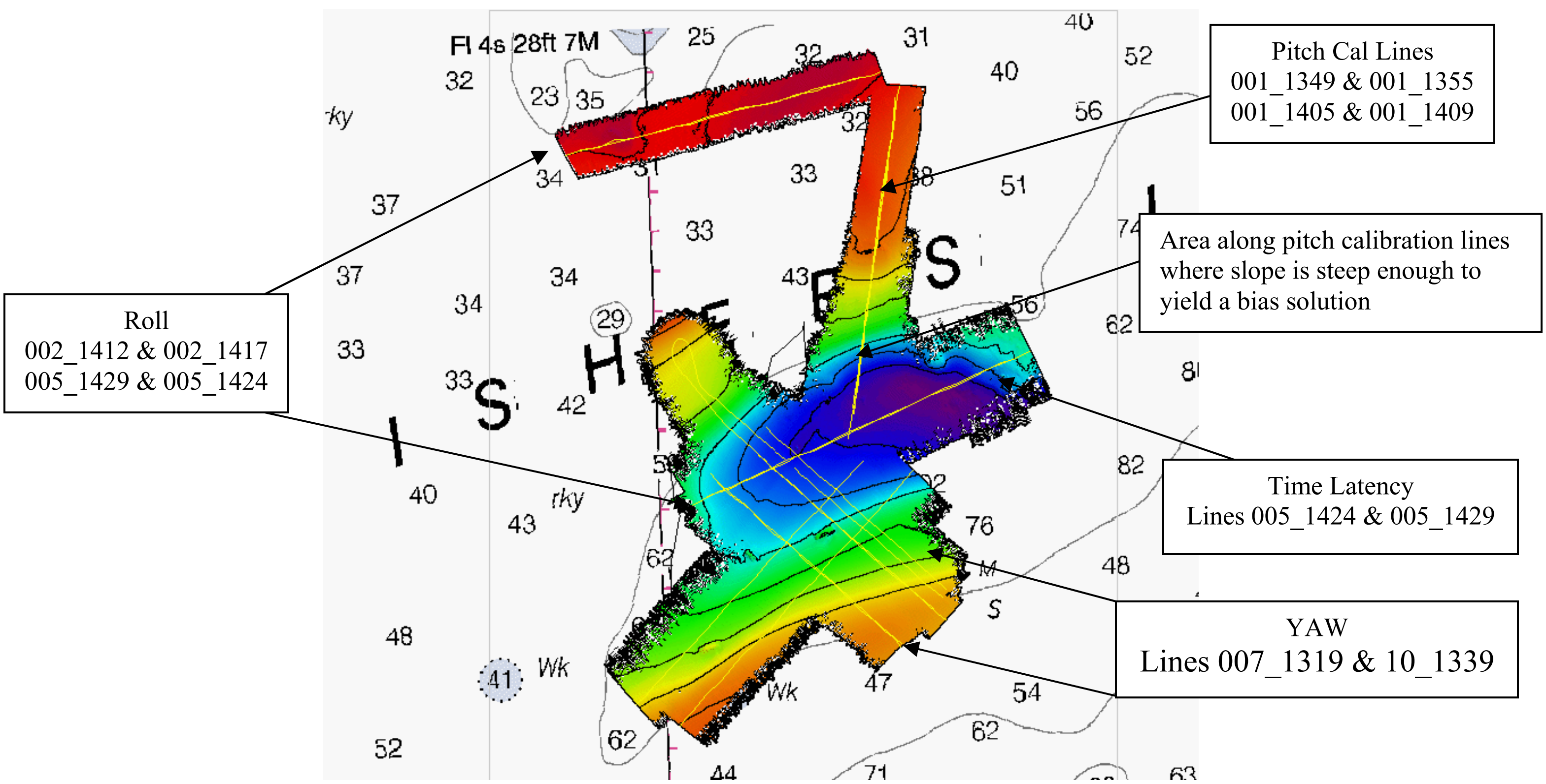
Pitch: To correct for pitch bias, one method is to run a line over a moderate slope of 10 to 20 degrees. The line should be run twice in opposite directions at any speed. The bias is depth dependant not speed dependant.

For this patch test, two pair of coincident lines were run approximately 600 m over a basin that ranged in depth from 13 to 35 meters. Lines 001_1349 and 001_1355 were run with an average headings of 009 and 189 degrees, respectively at 3-4 knots up and down the slope. The second pair, lines 001_1405 and 001_1409 were run at average headings of 188 and 008 degrees, respectively at 10-11.5 knots up and down a the same slope. The fluctuations in course made good for the second pair of pitch calibration lines (001_1409 course made good ranged from 003-015 degrees and 001_1405 ranged from 183-193 degrees) was an indication of worsening sea state.

Roll: To correct for roll bias, it is important that a line be run over a relatively flat basin in opposing directions at the same speed. One pair of coincident lines, heading 065 and 256 degrees respectively, was run at 6-7.0 knots over a relatively flat area; bottom depths varied from 10 to 12 meters. A second set of coincident lines, heading 245 and 076 degrees respectively, was run at 6-6.5 knots in deeper water over a relatively flat basin; bottom depths varied from 26 to 35 meters.

Yaw: To correct for heading bias, it is important, that two parallel lines offset by a swath width be run in the same direction at the same speed over a target. Two lines offset by 80 meters over three charted wrecks were set up for yaw comparison. However, after running the planned lines, 3 & 4 for yaw calibration, the survey crew determined the target could be better imaged by running Lines 007_1319 and 10_1339, heading 312 degrees offset by 127 m at 6-6.5 knots.

Patch Test Data Acquired JD113



PROCESSING

To properly determine all bias, it is imperative that initial values in CARIS vessel configuration file *1005_mb* be set to zero and time latency be evaluated first. The data sets were compared using the Calibration tool in CARIS 5.4. The calibrations were processed in the order specified: time, pitch, roll, and heading. The value for each bias was immediately entered into the vessel configuration file for 1005_mb. All lines were remerged between data sets, in order to ensure that the new biases were applied to the data before making the next adjustment. Time bias is rechecked as the other parameters are determined. See "Results and Recommendations" table below.

Time Latency: Lines 005_1424 and 005_1429 were reviewed independently in CARIS calibration mode along line at the outer beams of the swath to determine a roll time error, latency. The subsets were several beamwidths. The data was reviewed in 12 different areas (6 subsets per line) and highly consistent.

Pitch: Each pair of pitch line sets were compared near nadir, in the along track direction in CARIS calibration mode. The steepest track of the run is a rise over run of 6:53 between the 33 and 27 meter contours at the southern third of the line. Bias determined in this region yield reasonable results. Observed errors in the flatter regions of the line, the northern end yield large suspect bias results. The pair of coincident lines run at 3-4 knots observed errors varied from 0.5 to 1.5 yielding an average of 0.89. The lower observed errors are from the steepest sloping track at the northern end of the lines. The pair of coincident lines run at 10-11.5 knots observed error varied from 1.8 -2.2, 6 subsets all from the southern third of the line, because of its steeper slope, yielding an average of 2.00. The observed error average of the two pair of coincident lines is 1.445

Roll: The data was reviewed in CARIS calibration mode for an average across track displacement of soundings. The average observed error for the coincident lines run in the shallower water and in the deeper water is -0.72.

Yaw: The survey crew's new line plan accurately imaged the wreck. The data was reviewed in CARIS calibration mode for an average across and along track displacement of soundings.

Results and Recommendations:

1005 Patch Test Results	04/23/05 DN 113	04/02/04 DN 091	08/05/04 DN 218	08/19/04 DN 232
Navigation Time Error:	*Procedure Change N/A*	-0.17	-0.29	+ 0.30
Time Latency	0.08	N/A	N/A	N/A
Pitch bias:	1.445	-0.25	1.46	- 1.66
Roll bias:	-0.72	-0.2	-0.22	- 0.22
Yaw bias:	0.05	2.5	-.070	- 0.12

This patch test was necessary due to acquisition in a new locale, New London, CT. The hydrographer recommends using the results of this field calibration set to merge hydrographic data and analyzing recent cross lines to determine confidence. Repeatability of pitch bias needs to be achieved.

FIELD CALIBRATION REPORT
SURVEY LAUNCH 1014
Multibeam Reson 8125

Background:

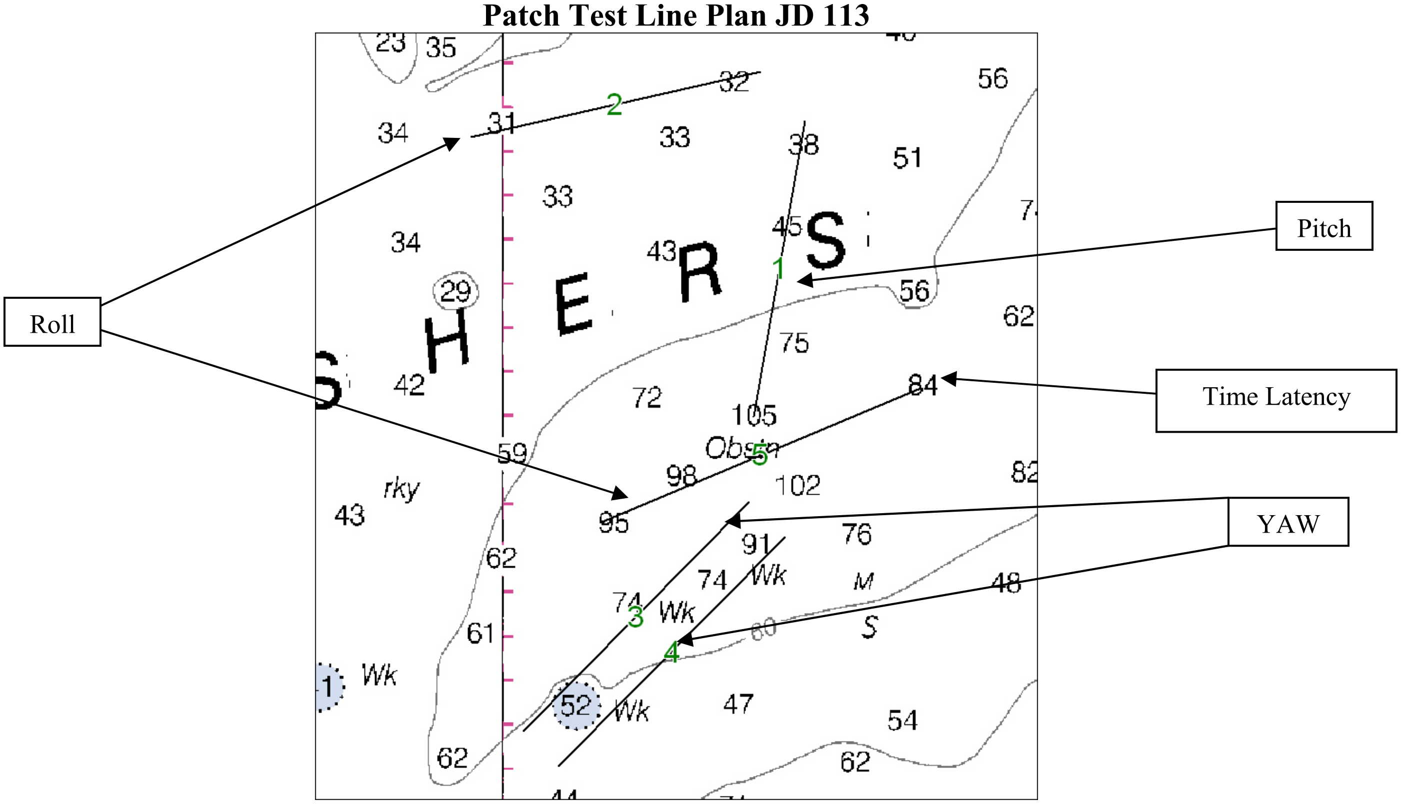
Launch 1014 is a multi-purpose survey platform capable of acquiring Multibeam bathymetry or Klein 5000 high-resolution side scan sonar imagery. Multibeam bathymetry is acquired by using a Reson 8125 Shallow-Water Multibeam (SWMB) echosounder, rigidly mounted to the keel of the platform. The Reson 8125 has a nominal frequency of 455 kHz, with a ping rate of 10-40 Hz with 240 beams and a maximum range of approximately 30m. Residual biases due to the misalignment of the sonar were assessed in CARIS HIPS and entered in the CARIS vessel configuration file 1014_MB.

Location, Date, and Personnel:

On April 23, 2005 ENS Kuzirian, LTJG Ringel, Cartographer- Norris Wike, and AST Erin Campbell conducted a field calibration of the SeaBat 8125 for time delay, pitch, roll, and heading bias. The patch test was performed in Fisher's Island Sound, approximately 1.5 NM North of Silver Eel Cove and 0.3 NM West of North Dumpling. See Chart: 13212 and graphics below.

Due to weather and inconclusive results for pitch and yaw bias, ENS Kuzirian, LTJG Ringel, and AST Wood conducted additional data acquisition for field calibration of the SeaBat 8125 on April 25, 2005. The additional lines were run in Twotree Island channel SE of Jordan Cove and North of Bartlett reef.

Patch Test Line Plan JD 113



Equipment:

Reson 8125 Multibeam echosounder
TSS POS/MV 3
Trimble DSM 212L DGPS receiver
Seacat SBE19 sound velocity profiler

Procedure:

Time Latency:
Historically, timing bias was determined by two pair of coincident lines run at different speeds in the same direction. One pair up slope and one down slope, each line within the pair run at 4 and 9 knots over a well defined slope. However, for "Precise Timing" a new technique was employed. Time latency can be determined by examining the residual uncorrected roll at the edge of a swath. To accentuate the affect of timing latency, these lines should be acquired in fairly deep water over a smooth bottom exhibiting some non-trivial amount of dynamic roll. In other words, data should not be acquired when sea state is calm, "dead flat."

For this patch test a line was run at 6 to 6.5 knots over one to two foot seas, first heading 65 degrees and then heading 245 degrees. The basin depth varied from 26 to 35 meters.

Pitch: To correct for pitch bias, it is important that a line be run over a moderate incline with a slope of 10-20 degrees perpendicular to contours or a feature at different speeds (relatively slow and fast) and in opposite directions.

For this patch test, two pair of coincident lines were run 565 m over a basin that ranged in depth from 12 to 33 meters. The first pair, lines 001_1249 and 001_1255 were run at 4-4.5 knots up and down a well defined slope. The second pair, lines 001_1300 and 001_1304 were run at 8-8.5 knots up and down a well defined slope. On JD115, a third set of lines, 428_1341 and 1344 were run at 7.5-8.0 knots, heading 195 degrees and 22 degrees, respectively, to ensure the confidence of bias calibration.

Roll: To correct for roll bias, it is important that a line be run over a relatively flat basin in opposing directions at the same speed. One pair of coincident lines, heading 255 and 75 degrees respectively, was run at 6-6.5 knots over a relatively flat area; bottom depths varied from 10 to 12 meters. A second set of coincident lines, heading 245 and 65 degrees respectively, was also run at 6-6.5 knots in deeper water over a relatively flat basin; bottom depths varied from 26 to 35 meters.

Yaw: To correct for heading bias, it is important, that two parallel lines offset by a swath width be run in the same direction at the same speed over a target. Two lines offset by 80 meters over three charted wrecks were set up for yaw comparison. However, the survey was cancelled due to fog rain and rough seas. On Julian day 115 another pair of parallel lines, 645_1351 and 646_1357 at 7.5 knots heading 115 degrees were run adjacent to charted rocks. The data was acceptable.

PROCESSING

To properly determine all bias, it is imperative that initial values in CARIS vessel configuration file *1014_mb* be set to zero and time latency be evaluated first. The data sets were compared using the Calibration tool in CARIS 5.4. The calibrations were processed in the order specified: time, pitch, roll, and heading. The value for each bias was immediately entered into the vessel configuration file for 1014_mb. All lines were remerged between data sets, in order to ensure that the new biases were applied to the data before making the next adjustment. Time bias is rechecked as the other parameters are determined. See "Results and Recommendations" table below.

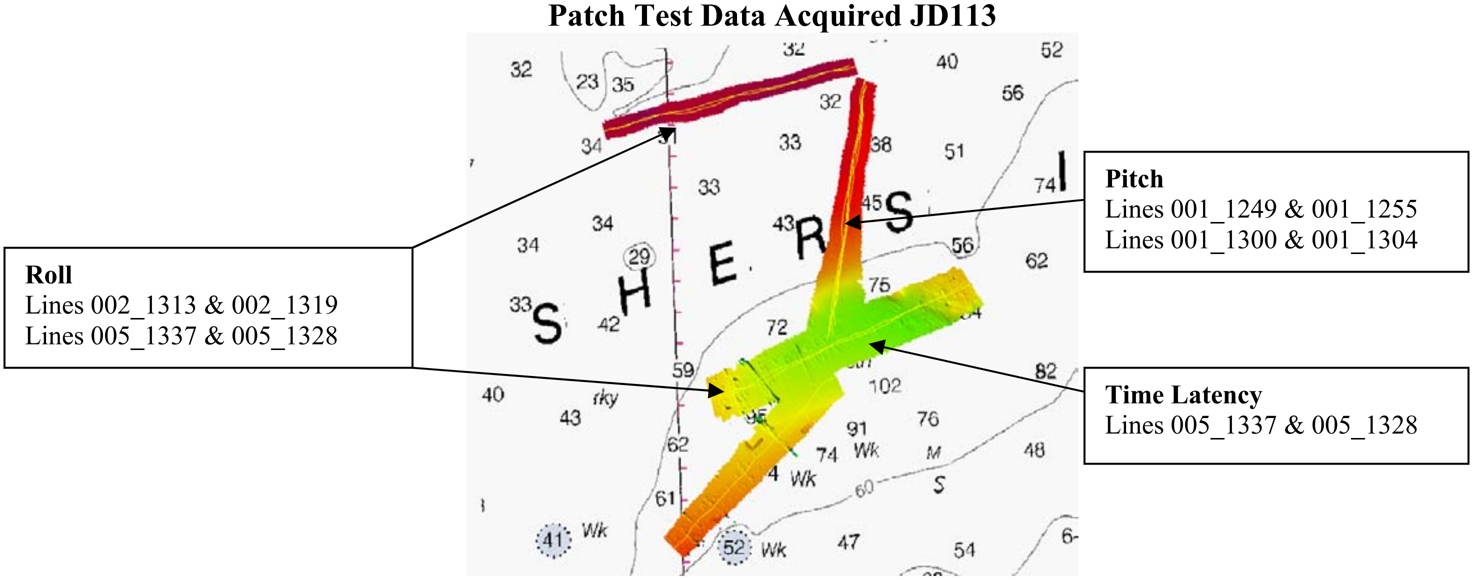
Time Latency: The lines were reviewed in CARIS calibration mode at the outer beams of the swath to determine a roll time error, latency. The data was reviewed in 12 different areas and highly consistent. An average latency of 0.08 sec was obvious.

Pitch: Each pair was reviewed in CARIS calibration mode at the steepest track of the run; 16% slope with a rise over run of 6:53 for an average along track nadir displacement of soundings.

Roll: The data was reviewed in CARIS calibration mode for an average across track displacement of soundings. The average observed error for the coincident lines run in the shallower water is -0.0475. The average observed error for the coincident lines run in the deeper water is -0.08. The overall observed error average is -0.064.

Yaw: Data from JD115 was evaluated along line using the calibration tool in CARIS 5.4 and a bias of 0.40 was observed.

Patch Test Data Acquired JD113



Results and Recommendations:

1014 Patch Test Results	04/23/05 DN 113	04/02/04 DN 091	08/05/04 DN 218	08/19/04 DN 232
Navigation Time Error:	Procedure Change N/A	-0.17	-0.29	+ 0.30
Time Latency	0.08	N/A	N/A	N/A
Pitch bias:	-0.825	-0.25	1.46	- 1.66
Roll bias:	-0.064	-0.2	-0.22	- 0.22
Yaw bias:	0.400	2.5	-.070	- 0.12

This patch test was necessary due to beginning acquisition in a new locale, New London CT and to the re-mounting of the multi-beam transducer after conducting a survey with a hull mounted Klein 5000.

SURVEY LAUNCH 1014
MBES CALIBRATION 2005

Background:

During data processing for project OPR-D304-TJ-05 it was noted that the roll value for survey Launch 1014 appeared to be incorrect.

Location:

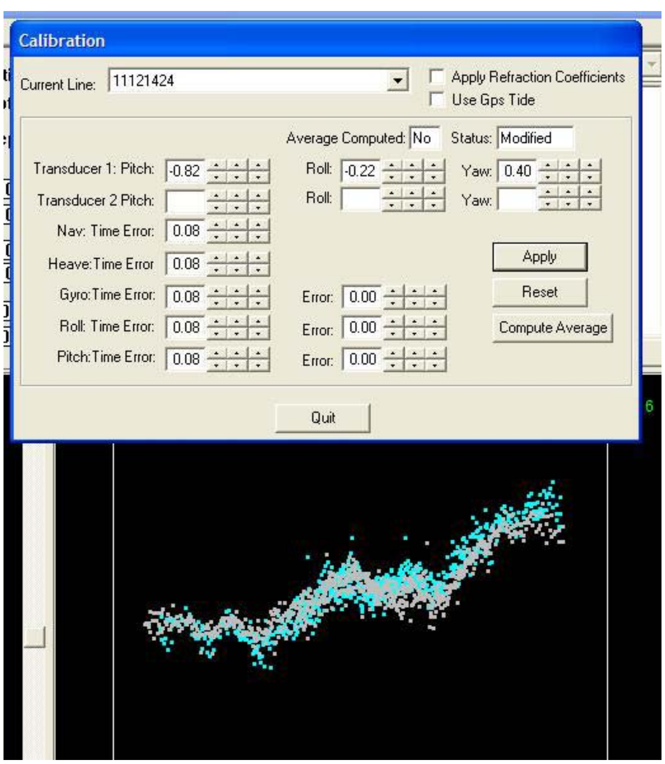
Two reciprocal survey lines were acquired in approximately 15 meters of water within the survey limits of H11301 on June 4, 2005 (155) by SST Lewit. A value of −0.22 was determined for these data and has been backdated to Dn151.

Equipment:

RESON SeaBat 8125 multibeam echo-sounder
TSS POS/MV 320
Trimble DSM 212L DGPS receiver
Seacat SBE19 (+) sound velocity profiler

Results and Recommendations:

Roll bias -0.22



NOAA ship THOMAS JEFFERSON
Launch 1014 patch test
Measurements made on 22 June 2005,
Thimble Shoal Channel, Chesapeake Bay.
By ENS Kuzirian

The final patch test was run to check the calibration of the RESON 8125 Multi-Beam Echo-Sounder (MBES) System installed on the soon to retire NOAA launch 1014. The data from this test was used to adjust correctors used to process survey data or to verify that the current correctors are adequate. These values were applied to the HVF with a time stamp of DN 173 (22 June 2005). The RESON SeaBat 8125 MBES consists of 240 individual transducer receivers each of which has a beamwidth of 0.5^o for a total across track sweep of 120^o. The SeaBat 8125 operates at an acoustic frequency of 455 Khz. This patch test consisted of different lines driven in various directions and speeds around the Thimble Shoal Channel north of Little Creek, Virginia, (see figure 1).

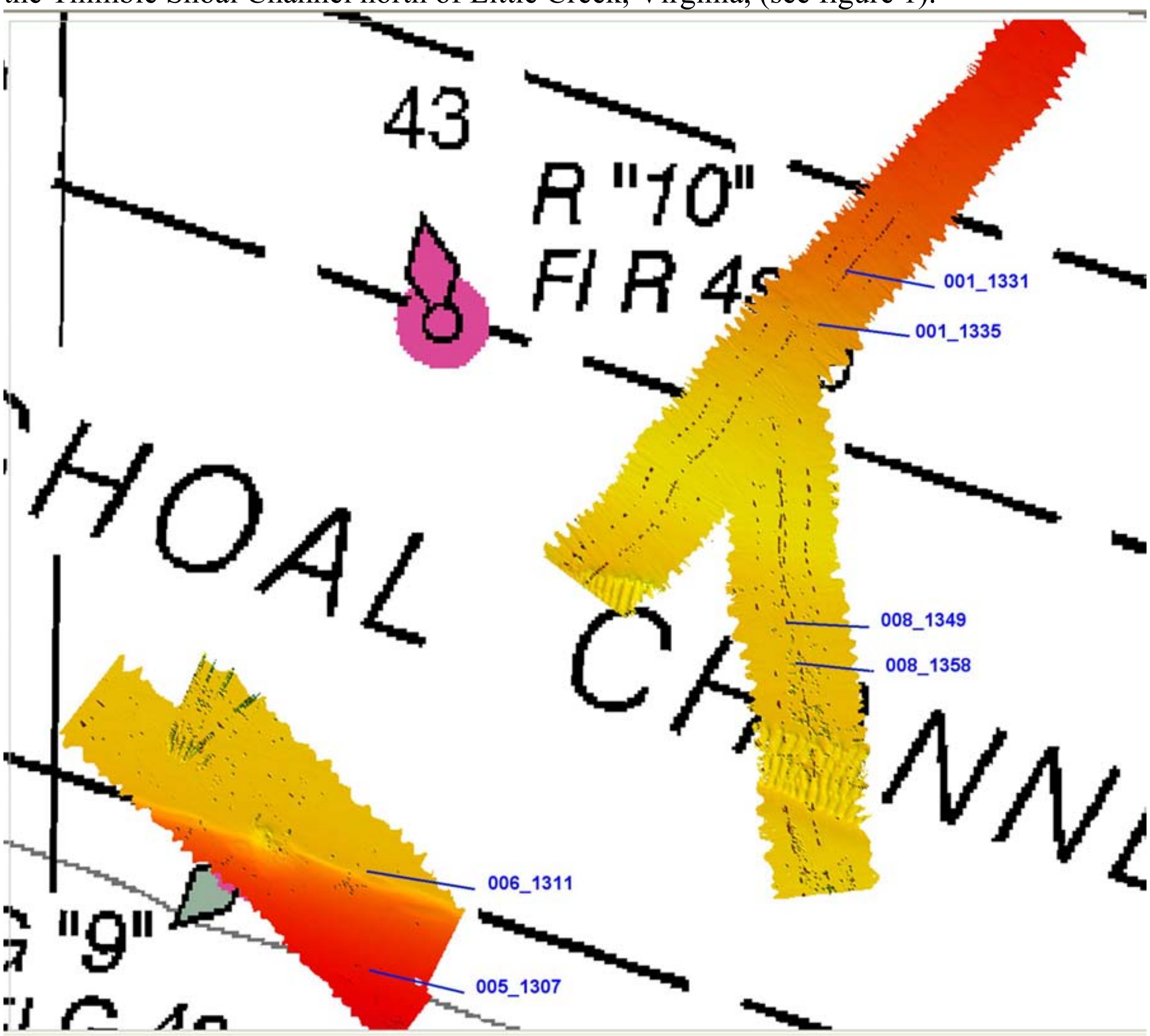


Figure 1: Patch test location along Thimble Shoal Channel west of the Chesapeake Bay Bridge Tunnel showing transversed lines. NOAA Survey Launch 1014, 22 June 2005.

The crew who collected the patch test data consisted of AB Perry; cox'n, AST Wood; HIC, and AST Glomb; crew. The lines driven were designed for different purposes. Line 008_1349 (run southeasterly at 7.5 kts) and 008_1358 (run northwesterly at 7.0 kts), in a relatively flat and level location, were used to solve for Time Latency and Roll Bias. Line 001_1331 was run in a northerly direction and 001_1335 run in a southerly direction, both at 4.5 kts to solve for Pitch Bias. Lines 001_1331 and 001_1335 were run perpendicular to a dredged slope. Lines 005_1307 and 006_1311 (on either side of the mooring block for channel buoy '9') were both run in a southeasterly direction at 5.5 kts to solve for Heading Bias. Figure 2 is highlights from the data acquisition log describing how the lines were collected.

CARIS 6.0 was used for the calibration of the results.

THOMAS JEFFERSON Hydrographic Survey Data Acquisition Log

Project: OPR- D304-RU/TJ-05 Registry:H11323 Date:06/22/05 DN 173

Wind <5KTS Sheet: G Location: LITTLE CREEK

Personnel: PERRY
WOOD
GLOMB

Sound Velocity Casts

File name:	Latitude	Longitude	Depth	ext depth
05173135.9ex	36/58/45	076/07/52	16.5	21.5
05173135.9ex	26/58/44	076/07/47	16.7	21.7

Method 8125MB

Line #	SSS File Name	REMARKS
008	008_1349	SE DIRECTION AT 7.5 KTS FOR TIME LATENCY
008	008_1349	SE DIRECTION AT 7.5 KTS FOR ROLL BIAS
008	008_1358	NW DIRECTION AT 7.0 KTS FOR ROLL BIAS
001	001_1331	N DIRECTION AT 4.5 KTS FOR PITCH BIAS
001	001_1335	S DIRECTION AT 4.5 KTS FOR PITCH BIAS
005	005_1307	SE DIRECTION AT 5.5 KTS FOR HEADING BIAS
006	006_1311	SE DIRECTION AT 5.5 KTS FOR HEADING BIAS

Figure 2: Data acquisition log from Survey Launch 1014 on 22 June 2005.

Results and Recommendations:

1014 Patch Test Results	06/22/05 DN 173	04/02/04 DN 091	08/05/04 DN 218	08/19/04 DN 232
Navigation Time Error:	N/A	-0.17	-0.29	+ 0.30
Time Latency	0.08sec	N/A	N/A	N/A
Pitch bias:	-0.90°	-0.25	1.46	-1.66
Roll bias:	-0.17^{o}	-0.2	-0.22	-0.22
Yaw bias:	0.72°	2.5	-0.070	-0.12

NOAA ship THOMAS JEFFERSON
Launch 1005 patch test
Measurements made on June 22, 2005,
Thimble Shoal Channel,
Chesapeake Bay.
By AST Wood

A final patch test was run to check the calibration of the RESON 8101 Multi-Beam Echo-Sounder (MBES) System installed on the soon to retire NOAA launch 1005. The data from this test may be used to adjust correctors used to process survey data or to verify that the current correctors are adequate. The RESON SeaBat 8101 MBES consists of 101 individual transducer receivers each of which has a beamwidth of 1.5° for a total across track sweep of 150°. The SeaBat 8101 operates at an acoustic frequency of 240 Khz.[1] This patch test consisted of different lines driven in various directions and speeds around the Thimble Shoal Channel north of Little Creek, Virginia, (see figure 1).

1: SeaBat 8101 Multibeam Echosounder System OPERATORS MANUAL, RESON, Inc., Goleta, CA, August 2002-version 3.02.

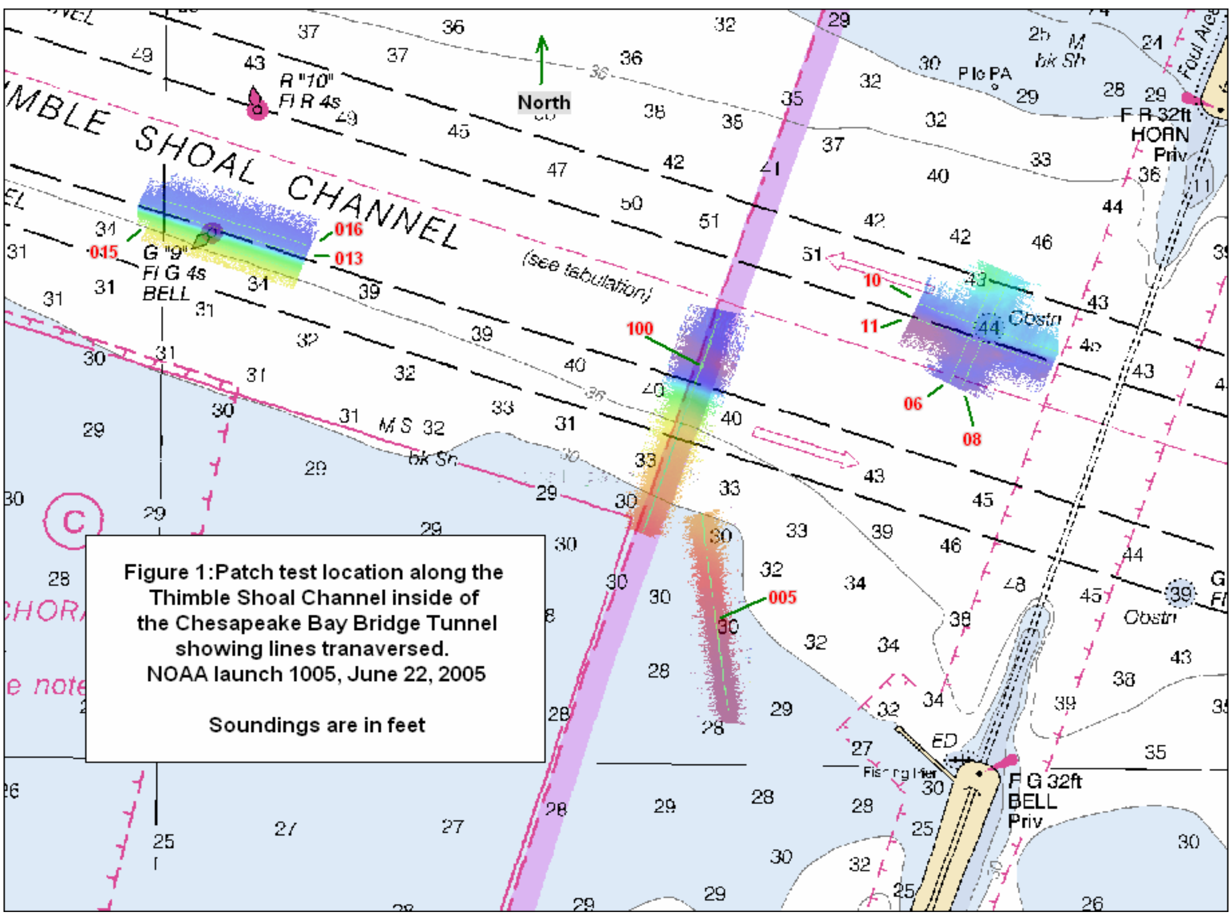


figure 1:patch test working grounds.

The crew who collected the patch test data consisted of SS Oberg; cox'n, ENS Davidson; HIC, and ENS Adler; crew. The lines driven were designed for different purposes. Line 005 (in a relatively flat and level location) was run in both directions at about 5 ½ kts in order to adjust the roll timing and roll bias. Line 100 (perpendicular to a dredged slope) was run four times in opposite directions at different speeds (about 8 kts and 4 kts). This line was used to test the calibration of the MBES head pitch. Lines 016 and 015 (on either side of the mooring block for channel buoy '9') and lines 110 and 111 (on either side of a rock) were driven in the same direction at about 5½ kts; the resulting data were used to verify the heading adjustment (side to side) of the MBES head. Figure 2 is highlights from the data acquisition log describing how the lines were collected.

CARIS 6.0 was used for the calibration of the results.

THOMAS JEFFERSON Hydrographic Survey Data Acquisition Log

Project: OPR- D304-RU/TJ-05 Registry:H11323 Date:06/22/05 DN 173

Wind <5KTS Sheet: G Location: LITTLE CREEK

Personnel: DAVIDSON
OBERG
ADLER

Sound Velocity Casts

File name:	Latitude	Longitude	Depth	ext depth
05173122.5ex	36/58/28	076/08/11	9.5	12.4
05173141.4ex	36/58/39	076/07/37	16.8	21.8

Method 8101MB

Line #	SSS File Name	REMARKS
100	1250	NORTH 8 KTS – PITCH/TIME LAT.
100	1257	SOUTH 8KTS – PITCH/TIME LAT.
100	1307	NORTH 3.8KTS – PITCH /TIME LAT.
100	1314	SOUTH 3.8 KTS – PITCH/TIME LAT.
5	1322	NORTH 5.6 – ROLL / TIME LAT.
5	1328	SOUTH 5.6 – ROLL / TIME LAT.
6	1341	NORTH 5.6 KTS – YAW
8	1346	NORTH 5.6KTS - YAW
10	1353	WEST 5.6KTS – YAW ATLERNATE
11	1357	WEST5.6 KTS – YAW ALTERNATE
13	1406	WEST 5.6 KTS – YAW ALT. 2
15	1411	WEST 5.6 KTS – YAW ALT 2
16	1428	WEST YAW ALT 2

figure 2: data from acquisition log from launch 1005 on June 22, 2005.

Results and Recommendations:

1005 Patch Test Results	06/22/05 DN 173	04/23/05 DN 113	04/02/04 DN 091	08/05/04 DN 218
Navigation Time Error:		*Procedure Change N/A*	-0.17	-0.29
Time Latency	0.08sec	0.08	N/A	N/A
Pitch bias:	0.95°	1.445	-0.25	1.46
Roll bias:	-0.70°	-0.72	-0.2	-0.22
Yaw bias:	-0.14°	0.05	2.5	-.070

These values are similar to those from the patch test of April 23, 2005. The variation seen is probably within the error of the test.

APPENDIX III – Thomas Jefferson BASE Surface SOP v 1.3 (26 October 2004)