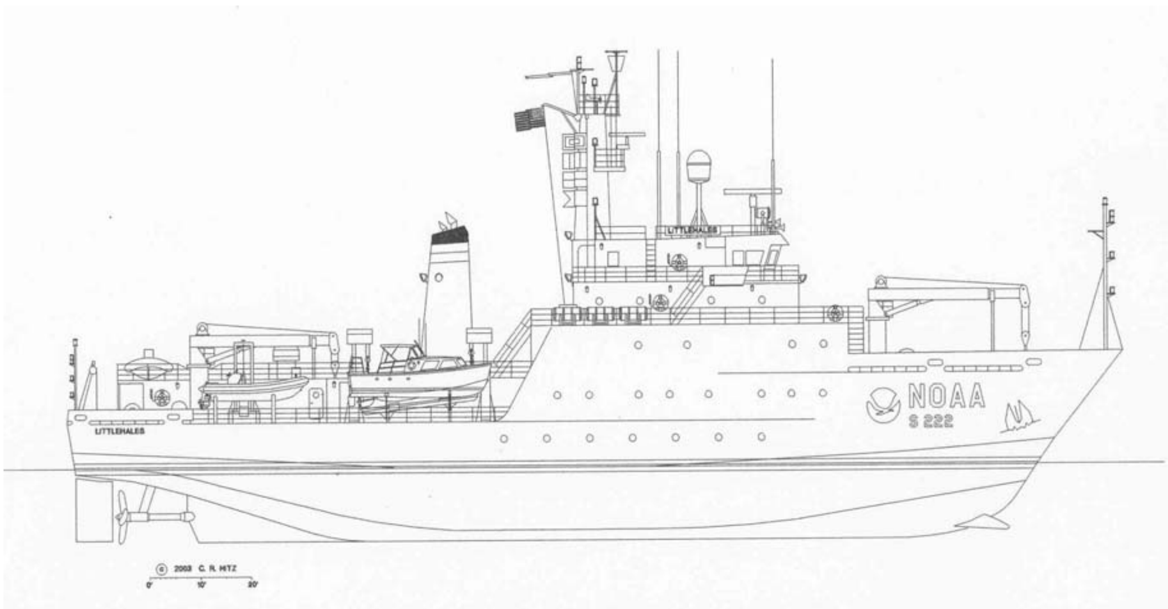
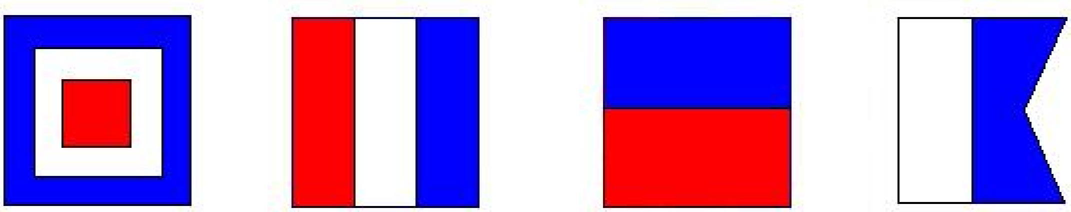
2006 DAPR

***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-D304-TJ-06, S-F910-TJ-06, OPR-G374-TJ-06, OPR-B310-TJ-06

NOAA Ship THOMAS JEFFERSON
CDR Raymond C. Slagle, Commanding

A. EQUIPMENT

All survey data for March-July 2006 were acquired by NOAA Ship THOMAS JEFFERSON and Survey Launches 3101 and 3102. 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 3101 acquired MBES data and SVP data. Survey Launch 3102 acquired SSS data, MBES 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 (7/2006), Hydrographic Survey Directives, and the Field Procedures Manual for Hydrographic Surveying (2/2006, v 2.1).

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 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 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. 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.

The ODOM Echotrac MKII was used for bathymetry data acquisition for project
S-F910-TJ-06. It is also used to provide a depth input to the Brooke Ocean MVP System. Hypack was used as the acquisition software package.

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&P 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. An outerbeam roll calibration coefficient is determined before starting acquisition for a project. This value is entered into the acquisition software and cannot be post processed.

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 between one and eight Hz.

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.

For any given survey area optimal line spacing is determined for the system. A maximum width is set in the acquisition software (using the equidistant setting). The resulting swath is usually less than the maximum of 75 degrees. This compressed swath increases the ping frequency and therefore the data density. The windows based Kongsberg Seafloor Information System (SIS) software package is used to acquire EM1002 data.

RESON SEABAT 7125 MULTIBEAM ECHOSOUNDER

The RESON SeaBat 7125 system is a single-frequency, digital recording multibeam echosounder with a central frequency of 400 kHz. The RESON 7125 aboard THOMAS JEFFERSON was installed in February 2006 in Charleston, SC. The RESON 7125 system aboard THOMAS JEFFERSON consists of two transducer arrays, one on each side of the vessel, in a steel assembly with a curved fairing. The RESON 7125 forms 256 beams per receive array each of which has a 0.5° across-track resolution and 1° along-track resolution. The RESON 7125 has a maximum ping rate of 48 Hz and is capable of bottom detection in depths from 1-200 m.

The RESON 7125 is capable of acquiring data in either dual or single head mode. In dual head mode, the RESON 7125 uses an “alternating ping” method of bathymetry acquisition to prevent interference between the two echosounders. As of the writing of this document, data acquired in dual head mode has proven to be unreliable for Complete or OD coverage, so single head data only was acquired with the RESON 7125 system.

While the primary use of the RESON 7125 is determining bathymetry, acoustic backscatter data from this sonar may be recorded and archived. This data is recorded in RESON “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 are not used to generate hydrographic products; they are usually archived or used to generate end-user scientific products. Due to file size and data storage issues, snippets are usually acquired only upon request and not for routine hydrographic survey operations. For these reasons, snippets were not acquired with the RESON 7125.

As this is a new system, evaluation of its performance regarding IHO order is ongoing but inconclusive thus far.

The RESON 7125 performs active beam steering to correct for sound velocity at the transducer head using an Applied Microsystems LTD Sound Velocity and Pressure Smart Sensor. This sensor will be discussed in more detail in the Sound Velocity Equipment Section.

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 deployed on a retractable arm from the hull of Survey Launch 3102. 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 3102 the RESON 8101 is used in depths from 3-60m.

The RESON 8101 does not perform active beam steering. The curved faces of the transducer 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 may be recorded and archived. This data is recorded in RESON "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 are not used to generate hydrographic products; they are usually archived or used to generate end-user scientific products. Due to file size and data storage issues, snippets are usually acquired only upon request and not for routine hydrographic survey operations. For these reasons, snippets were not acquired with the Reson 8101.

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.

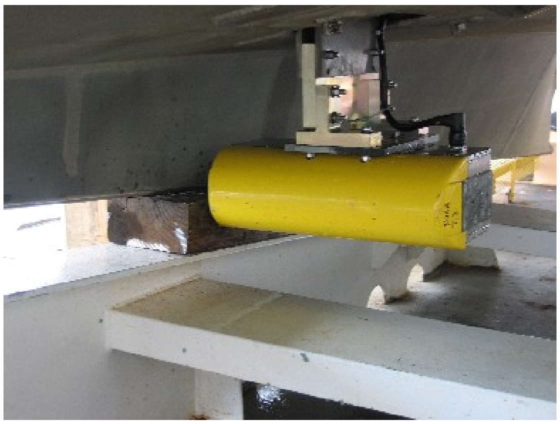
The outer beams of the RESON 8101 (45°-75° off nadir) do not meet NOAA specifications for object detection in water deeper than 10m. 200% bottom coverage data from the RESON 8101, under most conditions, will meet NOAA object detection specifications. RESON 8101 data acquired concurrently with side-scan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

The best expected performance of the RESON 8101, as installed on Survey Launch 3102, 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.

The software acquisition package TEI ISIS is used to acquire data with the RESON 8101.

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 deployed on a retractable arm from the hull of Survey Launch 3101.



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 3101 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 may be 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 are not used to generate hydrographic products; they are usually archived or used to generate end-user scientific products. Due to file size and data storage issues, snippets are usually acquired only upon request and not for routine hydrographic survey operations. For these reasons, snippets were not acquired with the Reson 8125.

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.

The best expected performance of the RESON 8125, as installed on Survey Launch 3101, 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 systematic data artifact was observed in RESON 8125 data throughout the first half of the field season. This artifact appeared at first glance to be a bad roll bias offset, but subsequent testing showed that it was caused by loose mounting bolts in the swing arm itself, rather than the horizontal mounting plate. The bolts were tightened on August 16^{th}, 2006, and a series of four test lines run on August 17th, 2006, showed that this corrected the problem. An additional issue in RESON 8125 data regarding precise dynamic timing latency was also observed and was corrected by modifying the HIPS Vessel File for affected lines. Further discussion of both of these issues is found in section D.3.

A.2. Acoustic Imaging Equipment

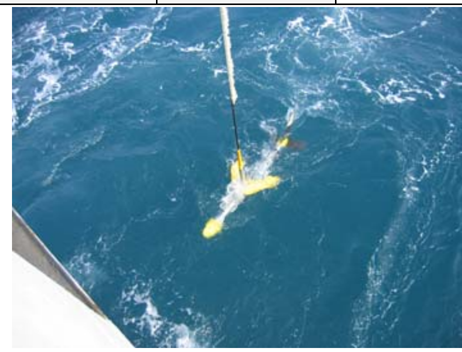
KLEIN 5500 High-speed Side Scan Sonar

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, a 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. TEI ISIS is used to acquire data with the KLEIN 5000 side scan sonar.

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 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. A Todco cable counter monitors the amount of cable out, which is logged in the acquisition software.

Hull-Mounted Configuration
Aboard Survey Launch 3102, the towfish is mounted to an aluminum sled using omega brackets. The hull-mounted configuration is used in depths of twenty meters or less.



Hull-Mount Configuration **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. Calibration was accomplished on the divers least depth gauge during the 2005-2006 winter inport period.

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 3101 and 3102 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 and orientation sensors and U.S. Coast Guard Differential GPS (DGPS) for a highly accurate blended position and orientation solution.

THOMAS JEFFERSON, Survey Launch 3101, and Survey Launch 3102 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 and Survey Launch 3101 are provided by an Applanix POS/MV Model 320 v.4. Inertial position calculations on Survey Launch 3102 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 3101 and 3102 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. Appendix 3 of the Field Procedures Manual may be referenced for a more in-depth discussion of Precise Timing.

The Heave Bandwidth Settings were changed frequently depending on the long-period motion expected from Survey Launch 3101 and 3102. Both launch POS/MV systems utilized True Heave (a long-period recording of vessel heave used to detect longer period sea swells that may not be detected during short-period heave calculations) for a post processed heave solution.

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 3101 and 3102 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. The DeepCat was not used during hydrographic survey operation through August, 2006 as it was on loan to R/V Nancy Foster.

Survey Launch 3101 and Survey Launch 3102 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 3101 and 3102.

All CTD instruments were returned to the manufacturer for calibration during the 2005-2006 winter in-port period. Calibration documents are contained in Appendix II of the 2006 Hydrographic Systems Readiness Report (HSRR), 12 May 2006.

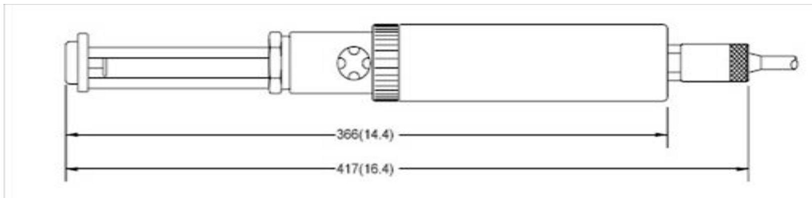
BROOKE OCEAN TECHNOLOGY MOVING VESSEL PROFILER 100

The Moving Vessel Profiler (MVP) is a self-contained profiling system capable of sampling water column profiles to 100m depth. The MVP consists of a computer-controlled high speed hydraulic winch, a cable metering, over-boarding and docking system, a conductor cable and a streamlined free fall fish (FFF) housing an Applied Microsystems “time of flight” SV&P Smart Sensor (see SV&P below) . The system as configured aboard the THOMAS JEFFERSON, collects vertical profiles of sound velocity data while the ship is underway at survey speed. The unit is located on the fantail and controlled remotely by the hydrographer in charge (HIC) from the ship’s acquisition room. The MVP is capable of importing its data directly into the

Kongsberg SIMRAD EM 1002 multi-beam echosounder (MBES) at the time of acquisition. When using MVP casts in conjunction with the RESON 7125 MBES, sound velocity data is processed using Velocwin software, then applied in CARIS HIPS during post processing.

The MVP towfish was lost at sea on August 2, 2006, but recovered August 5, 2006, and returned to Electrical Engineering Division at MOC-A. It will be sent to Brooke Ocean for inspection and possible repair during the next fiscal year (October, 2007).

Applied Microsystems LTD – Sound Velocity & Pressure Smart Sensor (SV&P)



The SV&P Smart Sensor is the main instrument housed on the MVP free fall fish; it is designed to directly measure sound velocity and pressure in water. Its small size, extremely fast response time and high sampling rate make the sensor ideal for fast profiles or tow speeds. The sensor has internal calibration coefficients and outputs real-time data to allow a “plug and play” environment. The stainless steel, right-angle end cap instrument operates as a stand alone unit with a fixed 19200 baud rate, RS-485 communications interface. Maximum depth is 1000 meters.

SV&P Smart Sensor specifications:
Sound Velocity -
1400 to 1550 m/s standard measuring range.
±0.050 meters per second accuracy.
0.015 meters per second resolution.
145 µs response time.
Temperature compensated.
Pressure –
±0.05% full scale accuracy.
dbar resolution.
10 ms response time.

The Applied Microsystems Smart SV&P Sensor was calibrated by the manufacturer on 12-08-2004.

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.

The AML Smart SV&P 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&P 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. Data are sent in real time to the Kongsberg EM1002 transducer.

The AML Smart SV&P Probe was returned to the manufacturer and calibrated during the 2005-2006 winter in-port period.

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 3101, 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. Data are sent in real time to the RESON 8125 processor unit.

The Digibar Pro was returned to the manufacturer and calibrated during the 2005-2006 winter in-port period. Calibration documents and information may be found in the 2006 Hydrographic System Readiness Report and attachments, dated 9 May 2006.

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. Hypack Max is also used to acquire ODOM vertical beam data on THOMAS JEFFERSON as well as detached positions from all three platforms

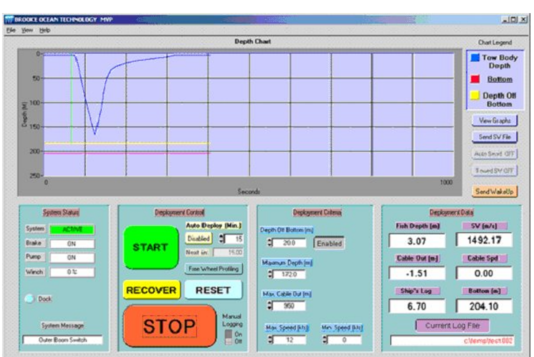
Kongsberg Simrad *SIS*

Kongsberg Seafloor Information System (SIS) is a windows based acquisition software package providing real time coverage, sensor control and monitoring for the EM 1002 multibeam echosounder. SIS was installed July 2005.

Triton Imaging *ISIS*

TI *Isis* is a Windows-based 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 and RESON 7125 bathymetry on THOMAS JEFFERSON and for RESON 8125 and 8101 multibeam and side-scan sonar acquisition aboard Survey Launches 3101 and 3102.

Brooke Ocean Technology MVP Controller



The MVP controller software allows the MVP system to operate automatically using a variety of deployment parameters which are set via easy-to-use, user interface screens. Data can be viewed in real-time and can be sent directly to a compatable multibeam echosounder's processor. The MVP software provides graphical display (strip charts) of sensor data in real time as well as saving alpertinent data to files on a cast by cast basis.

MVP Main Controller Screen

B.2. PROCESSING SOFTWARE

CARIS *HIPS v 6.0*

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* 6.0 uses statistical modeling to create Bathymetry with Associated Statistical Error (BASE) surfaces in one of three ways: swath-angle weighted grids, uncertainty-weighted grids, and Combined Uncertainty and Bathymetry Estimator (CUBE) algorithm grids. Refer to Section 4.2.1 of the 2006 Field Procedures Manual for a detailed description of navigation surface processing.

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. The towpoint entry for the hull mounted side scan sonar HVF was eliminated from the launch HVF's due to problems with processing software CARIS. The reference point was changed from the IMU to towfish for this change.

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. *Velocwin* software is also used to process Moving Vessel Profiler (MVP) sound velocity data into a CARIS compatible format. *Velocwin* allows for batch processing of the numerous .calc files generated by the MVP during multi-beam echosounder (MBES) acquisition. The resulting .svp files are applied in CARIS HIPS post-processing to correct for sound velocity variation within the water column. 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 8.0/8.5

MapInfo Professional is the Geographic Information System (GIS) software package used aboard THOMAS JEFFERSON. *MapInfo* is used for sheet management, line planning, 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 + Complete 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 Complete MBES + 100% SSS coverage.

A variation of this acquisition method is to acquire incomplete multibeam coverage (Skunk Stripe). The multibeam echosounder is used as the primary source of bathymetry, but as complete bottom coverage is obtained with 200% side scan sonar, complete multibeam coverage is not attempted.

100% Side Scan Sonar + Complete 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.

The concept of “Complete” multibeam coverage arose in an attempt to better define full bottom coverage for sounding data destined to create a bathymetric grid. Complete MBES coverage is defined as resolution of 10 to 20% of water depth, to a minimum resolution of 1 meter. A Complete MBES survey must meet the following criteria:

- Maximum propagation distance of soundings to a grid node is 20% of the water depth or one grid node, whichever is greater.
- At least 95% of all nodes on the surface must be populated.
- Maximum surface uncertainty is IHO Order I for depths less than 100m and IHO Order II for depths greater than 100m.
- No holidays in the grid larger than 3 nodes in the largest dimension.

Complete MBES surveys on THOMAS JEFFERSON in shallow water have a typical resolution of 2m. Depending on the operating system, complete MBES may not necessarily meet the NOAA object detection specification. As complete MBES is typically acquired concurrently with 100% SSS, the object detection requirement is met by side scan sonar.

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, RESON 7125 MBES, or Divers Least Depth Gauge should the basic bathymetry coverage be insufficient or undesirable for that purpose.

100% SSS + Complete MBES 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.

Object Detection MBES

Object Detection MBES (OD MBES) is acquired when side scan sonar acquisition is impractical or unsafe. Two echosounder systems aboard THOMAS JEFFERSON may be used for OD MBES: RESON 7125 and RESON 8125. To meet NOAA Object Detection specification, OD MBES must meet the following criteria:

- Grid resolution of 2% to 4% of the water depth, with a minimum resolution of 0.5 meters.
- Maximum propagation distance of soundings to node of 4% of water depth or one grid resolution, whichever is greater.
- At least 99% of all nodes must be populated.
- Maximum surface uncertainty is IHO Order I for depths less than 100m and IHO Order II for depths greater than 100m.
- No holiday larger than 3 nodes in the largest dimension.
- Any holiday at the top of a rock, wreck, shoal, or other significant feature must be filled, even if the gap is less than 3 nodes across, unless acquiring data over the top of that feature presented excessive danger to the vessel.

Crosslines

Crosslines are acquired as an additional confidence check to the performance of echosounder data. According to the 2006 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. Crosslines are compared to the product navigation surface in CARIS HIPS 6.0. The results of the Crossline QC test are submitted in Separate II of the Descriptive Report of each project.

D. Corrections to Echo Sounding

D.1. Sound Velocity

SBE19 Conductivity, Temperature and Depth (CTD) Profilers

Sound velocity profiles for the THOMAS JEFFERSON and for Launches 3101 and 3102 are acquired with a Sea-Bird Electronics SeaCat SBE19+ CTD profiler. Raw conductivity, temperature and pressure data are processed using the program *HSTP Velocwin* which generates sound velocity profiles for CARIS HIPS 6.0. Sound velocity correctors are applied to MBES and VBES soundings in CARIS HIPS 6.0 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 daily for VBES acquisition and 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 *HSTP Velocwin* and applied to ODOM VBES, Simrad MBES and RESON MBES data in CARIS HIPS 6.0 during post processing.

Brooke Ocean MVP

In addition to using a CTD for acquisition of sound velocity (SV) data, THOMAS JEFFERSON also uses a Brooke Ocean MVP. After deploying the MVP at the local control station and transferring control to the Acquisition Room, the HIC may initiate MVP casts at any time without impeding ship operations. While the periodicity of casts ultimately varies with environmental factors and the dynamic nature of a given area, casts are typically taken at least once every hour (usually one every 30 minutes) and are evenly spaced over the geographic survey area.

The HIC initiates the cast by pressing the “Start” button on the MVP software controller window. The MVP system is then fully automated and allows the MVP towfish to freefall toward the bottom until it reaches an operator-input safety depth, at which point the system stops the freefall and recovers the fish back to its original docking position. The SV data acquired by the MVP is transmitted to a raw SV file folder, where the HIC conducts a basic check of the data for correct day number, sound velocity data, and file format/integrity. The SV cast may also be graphically viewed and compared with other casts using the associated feature in the MVP controller software.

Like CTD casts, MVP casts are processed and/or extended for use in CARIS HIPS 6.0 using *HSTP Velocwin*.

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 SIS 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 3101 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. Water level correctors with tide zoning supplied by CO-OPS are applied to all sounding data in CARIS HIPS 6.0 with the Tide Correction module.

After daily acquisition is complete, preliminary unverified (observed) water levels are downloaded from the CO-OPS website or from CO-OPS TideBot automated water level observations delivery program. Observed water level files are converted to CARIS tide files and applied to all sounding data using preliminary zoning. Most surveys submitted by THOMAS JEFFERSON personnel have been corrected to MLLW using observed water levels with preliminary tide zoning.

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 Patch Test Report for each vessel can be found in the Hydrographic Systems Readiness Report dated 09 May 2006.

As mentioned in A.1, the RESON 8125 MBES displayed two similar yet unrelated roll errors. The first issue identified was "pole wobble," or a roll-related issue best seen in the MBES outer beams. Loose bolts on the 8125 mounting plate allowed the echosounder to move slightly left or right, depending on the hydrodynamic forces acting on it. This error was discovered in August and subsequently corrected by tightening the mounting plate bolts. However, even after tightening the bolts, a periodic roll error appeared in the MBES data from the RESON 8125, forcing further investigation. Searching revealed a dynamic precise time latency error. The discussion that follows shows the ship's findings in detail:

D.3.1. DYNAMIC PRECISE TIMING LATENCY ON LAUNCH 3101

Background

Launch 3101 employs a hull-mounted Reson 8125 shallow-water multibeam echosounder with a POS/MV Model 320 v.4. The POS/MV measures vessel attitude to accurately determine the directionality of each ping. The Triton ISIS software program is used on Launch 3101 to collect position, attitude, and bathymetry data for entry into a raw data .xtf file for post-acquisition processing. These three systems (ISIS, POS/MV, and Reson 8125), enable the hydrographer to use precise timing.

Precise Timing

Prior to employment of precise timing capability, ISIS applied time stamps to acquired data as they entered the ISIS processor. Since ISIS received data from multiple sources (i.e. from the POS/MV or from the Reson), variations existed in the time delays between acquisition and time stamping, resulting in potential mismatch of position/attitude data and bathymetry data. The use of precise timing reduces the effect of this latency.

Precise timing works by applying a time stamp when the data is collected at the instrument (POS/MV or Reson), rather than when it reaches the acquisition computer (ISIS). Obviously, all three major components must be synchronized to make precise timing work. The POS/MV sends out a timing message (GPS time) that the Reson 8125 and ISIS use to update their system clocks, creating a more accurate time stamp in all data. The use of precise timing requires that only one variable be solved: latency between POS/MV and Reson times.

Solving for Precise Timing

The standard method used to solve for precise timing involves examining the outer beams of a line acquired over a flat seafloor area. Any latency between the Reson and POS/MV creates "waviness" in the outer beams (Figure 1). By altering roll timing error, attitude data can be synchronized with corresponding bathymetry and "flatten" the outer beams (Figure 2). This latency is assumed to be a static offset; its manifestation is specific and unlike any other, making it a simple error for which to solve. However, when taken out of context, the latency could be mistaken for a “jitter” in the sonar mount (also known as “pole wobble”).

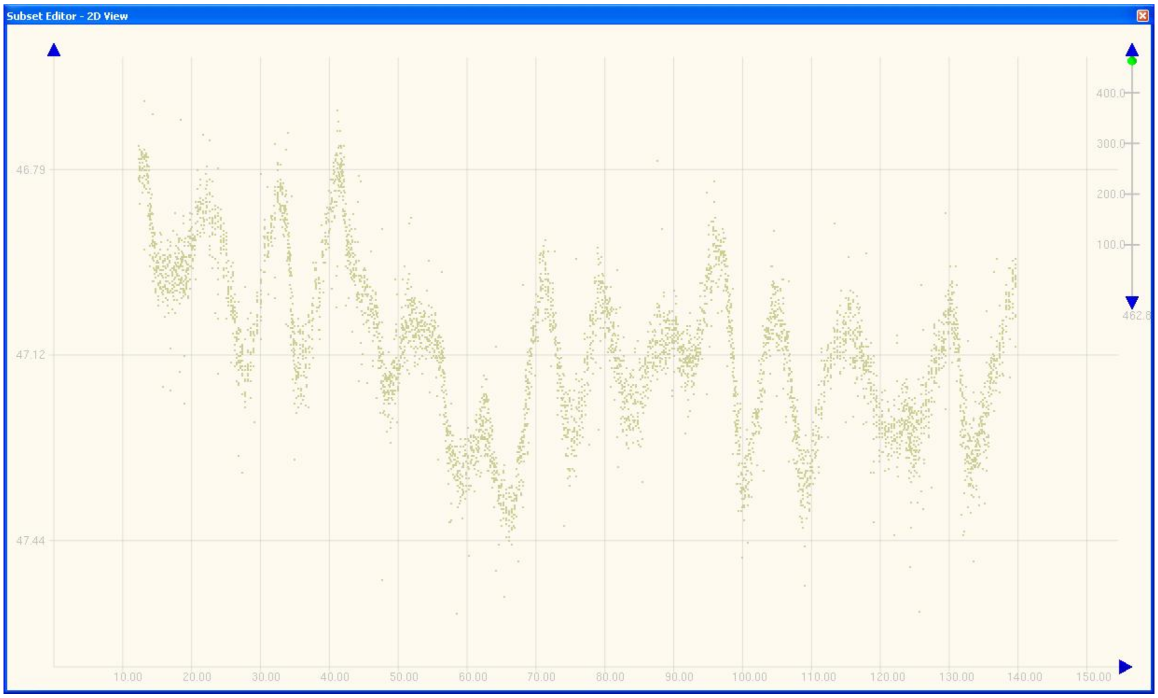


Figure 1- Precise Timing Error

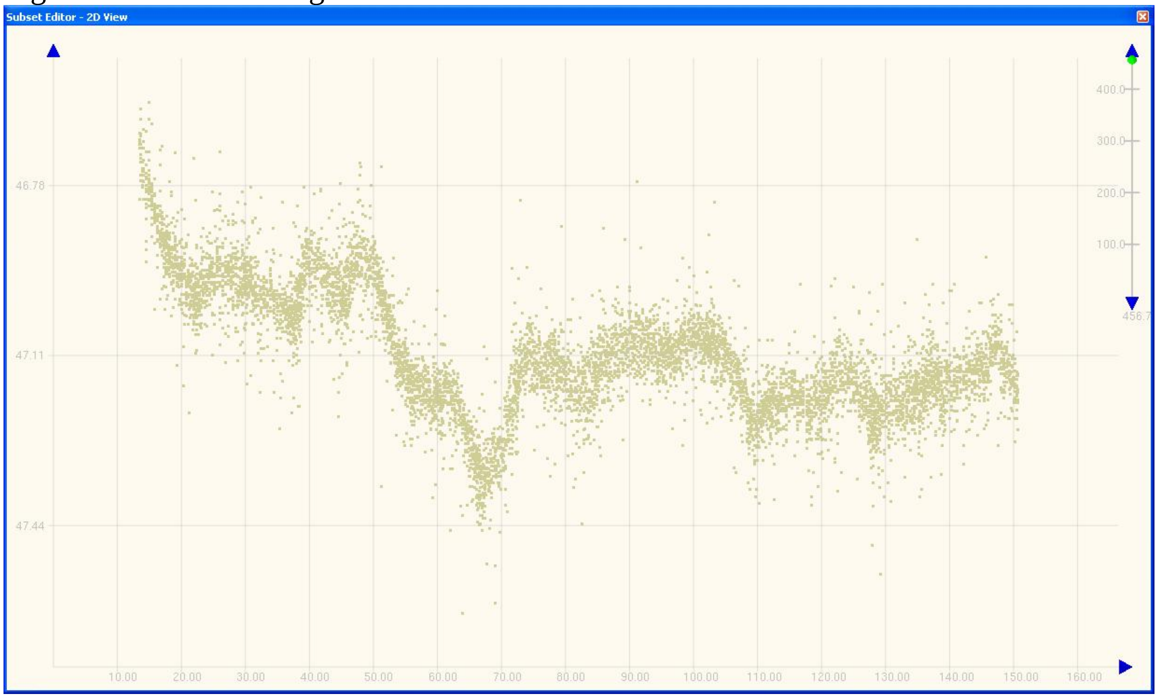


Figure 2- Precise Timing Corrected

Identifying a Precise Timing Error in the Data

Of the numerous potential mechanical causes of pole wobble on Launch 3101, it most likely results from having loose bolts on the sonar mounting plates. As such, it would exhibit a unique data artifact at relatively random intervals and be seen throughout all periods of acquisition until mechanically repaired. Accounting for pole wobble in the Caris HIPS Vessel File (HVF) would require numerous entries specific to exact soundings, and finding the appropriate entry values would be difficult at best. The HVF entry that would correct for this physical roll error from pole wobble is Swath→Roll. Because of the specificity of the entry and the fact that it could result in several hundred entries over a single day, changing the HVF for pole wobble would be unjustified, unrealistic, and (worst case) hydrographically unethical.

In contrast, precise timing error has a specific context and is in no way "random". Although it may apparently occur at random times, it does not occur throughout the day, nor does it occur every day. Also, when it is seen, it is consistent over a specific time frame. This particular error was first observed in Reson 8125 MBES data from day number 164 of 2006 and lasted for approximately 1 hour. The error began at the start of a line and slowly increased until it disappeared completely between lines of acquisition. The error has been observed several times since then in the same general context. A visually "wavy" BASE surface presents the first clue in identification of this error (Figure 3).

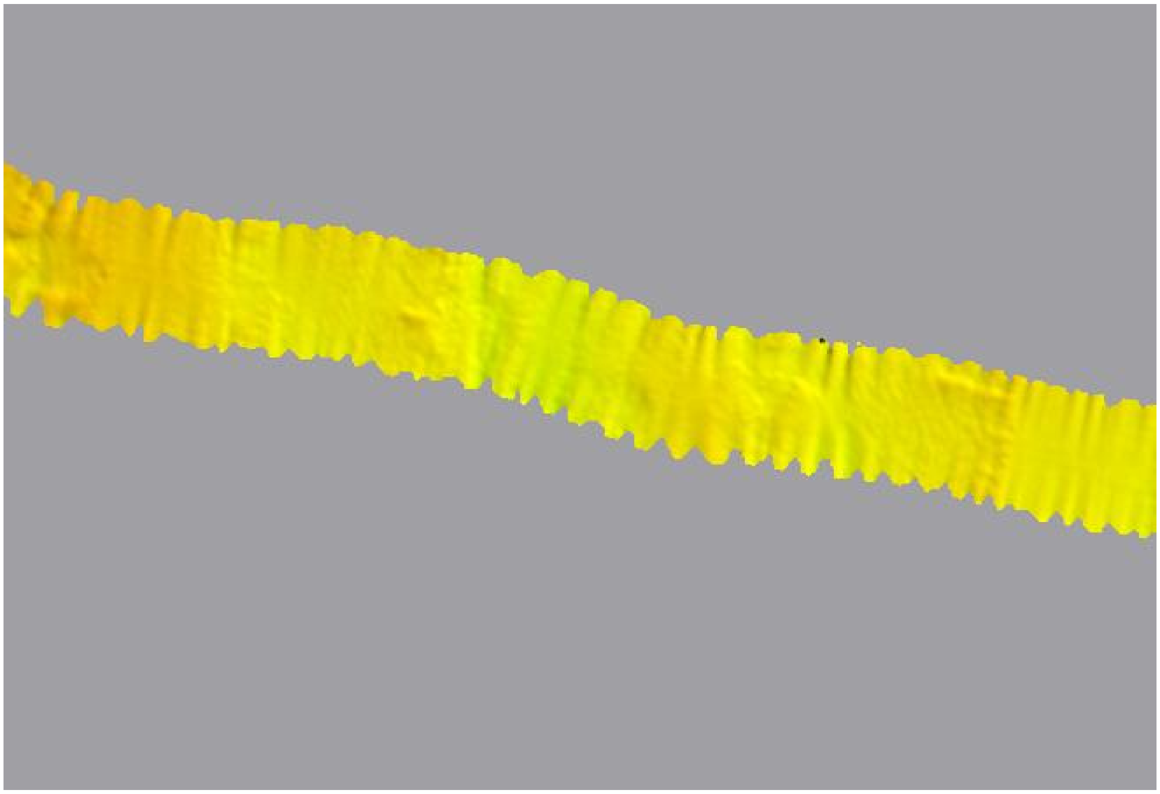


Figure 3-"Wavy" BASE surface generated from lines with a precise timing error.

After identifying the potential precise timing error, one must determine its periodicity. Questions should be asked in the following order:

1. Is the "waviness" seen consistently throughout an entire line?
2. If so, does it reoccur in other lines?
3. Is the "waviness" seen throughout the entire day or is it confined to a specific time frame?
4. If it is confined to a specific time frame, can the "waviness" be consistently "flattened" without causing "waviness" elsewhere using the roll timing error entry in the HVF?
5. Does the latency increase throughout the time frame?

If the "waviness" is caused by pole wobble, changing the roll timing error would not "flatten" the data uniformly. While this dynamic latency in 8125 data has occurred this field season, it is rare and at most requires four HVF entries to account for an increasing latency throughout the time frame. To determine how many entries are required, lines throughout the time frame are analyzed and latencies averaged. The total number of entries depends on the extent to which the latency increases. Generally, an increase of 0.02-0.03 seconds requires a new entry, but the hydrographer must determine an applicable threshold based upon survey specifications.

<u>Source of the Latency</u>

After much contemplation it is believed that the latency originates in the Reson 8125 processing unit (PU). The observed error always applies as a negative time to the bathymetry, implying that the time stamp recorded by the PU is later than the corresponding positioning and attitude data. For example, the PU may record a sounding at 12:34:06.25 when, in actuality, it was recorded at 12:34:06.20.

The PU clock updates to GPS time using the POS/MV $UTC string, the basis of precise timing, and both the Reson 8125 PU and ISIS computer update with this time stamp. As discussed previously, this allows for POS/MV and MBES data to reach the ISIS computer at different times but still be recorded at the same time. However, at times the Reson 8125 PU may introduce a delay in data time stamping. Due to interrupts sent from the ISIS computer, or from attitude data sent from the POS/MV, it is possible that the bathymetry data from the receiver is not time stamped immediately as designed; the interrupts, in essence, jumble up the instruction set and cause the time stamp delay. Then, at some point in the future, the instruction set will be able to "catch up" (maybe during a break between acquisition lines) and the data will be time stamped at the appropriate time. To determine the cause of the delay, the issued instructions would need to be monitored or recorded, a troubleshooting process not currently realistically plausible onboard THOMAS JEFFERSON.

A problem within the ISIS computer (also used for the POS/MV controller on Launch 3101) presents another possible cause of the latency. Interrupts (e.g. return values from true heave logging, satellite geometry observations) sent from the ISIS computer may cause a delay in the transmission of the $UTC string from the POS/MV. However, because the dynamic latency is seen so infrequently, and the result only appears during post-acquisition processing, it is difficult to determine its ultimate source with any certainty. Between the two possibilities, an issue with the Reson 8125 PU seems most likely.

It has been suggested that the "wavy" roll error observed in some 8125 data results from pole wobble, but deeper investigation reveals a different issue. A recent "jitter" in Reson 8125 data resulted from having loose mounting plate bolts. After tightening the bolts, the "jitter" no longer appeared in the data. However, the precise timing roll error is still seen periodically, despite the tightening of the mounting plate. It appears at different times of day and endures for anywhere from 30 minutes to 1.5 hours. In the near future, the ISIS computer onboard Launch 3101 will be replaced. If the issue is then corrected, the old ISIS computer obviously would have originated the latency problem. Again, this command believes the Reson 8125 PU to be the more likely culprit. Only time will tell…

Discussion

Some may suggest that using multiple HVFs during a survey translates into changing data to make it "look right". However, if this were the case, it would be a breach in scientific protocol and ethics. THOMAS JEFFERSON is in no way trying to hide flaws in the data but rather trying to accurately reflect the dynamic aspect of the system on Launch 3101. The latency can be accurately and consistently determined, and therefore the HVF should reflect this. The source of the dynamic latency may become clear in the future, but until then dynamic changes will be recorded as they appear.

D.4. VESSEL OFFSETS AND DYNAMIC DRAFT CORRECTORS

THOMAS JEFFERSON OFFSETS AND DYNAMIC DRAFT

While a partial re-survey of THOMAS JEFFERSON vessel offsets was conducted on March 10, 2005 by NGS personnel, no changes in offsets have occurred during the 2006 Field Season. The procedure and results of the 2005 re-survey may be found in 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 13 June and 8 July 2006. Refer to the 2006 Hydrographic Systems Readiness Report dated 09 May 2006for detailed results.

Launch 3101 Offsets and Dynamic Draft

Vessel offset measurements were made on Launch 3101 on August 19, 2005 by NGS personnel. Static draft measurements for Launch 3101 were determined using a sight tube. Site tube measurements were made from a reference point with respect to the IMU. These measurements were made at the beginning and end of each working day while the vessel is dead in the water. Dynamic draft measurements were made on 30 March 2006. Refer the Hydrographic Systems Readiness Report dated 09 May 2006 for detailed results.

Launch 3102 Offsets and Dynamic Draft

Vessel offset measurements were made on Launch 3102 on August 25, 2005 by NGS personnel. Static draft measurements for Launch 3102 are determined using a sight tube. Site tube measurements were made from a reference point with respect to the IMU. These measurements were made at the beginning and end of each working day while the vessel is dead in the water. Dynamic draft measurements were made on 29 March 2006. Refer to the Hydrographic Systems Readiness Report dated 09 May 2006 for detailed results.

E. DATA PROCESSING AND QUALITY CONTROL

E.1. BATHYMETRY

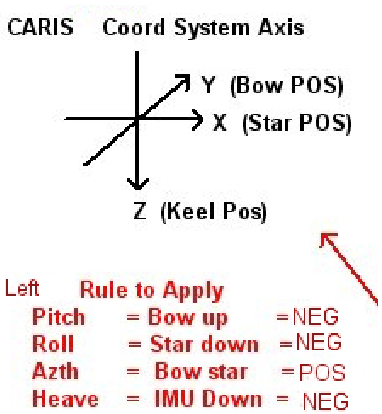
Raw bathymetry data (XTF, SIMRAD, and HYPACK VBES) are converted into CARIS HDCS data format upon completion of daily acquisition. Conversion parameters vary for each data format, and are stored in the LogFile of each HDCS processed line folder. After data conversion, water level, sound velocity, attitude, 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 Section 4.2.1.1 of the 2006 NOAA Field Procedures Manual (v. 2.1, February 2006).

ERROR MODELING IN CARIS HIPS

A table describing values used to compute TPE of soundings acquired by THOMAS JEFFERSON and her launches is entered below.

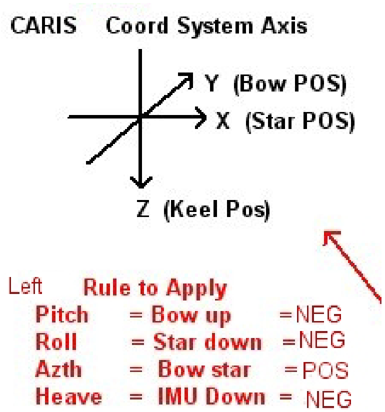
Caris Coordinates for THOMAS JEFFERSON

DESCRIPTION	X_AXIS	Y_AXIS	Z_AXIS
Optical Reference Unit	0.000	-0.844	-0.116
POS/MV IMU	0.000	0.000	0.000
Port POS/MV Aero Antenna 1 Phase Center	1.356	-10.282	-22.320
Stbd POS/MV Aero Antenna 2 Phase Center	3.563	-10.166	-22.336
EM1002 Transducer	2.384	-0.560	5.153
200 kHz Transducer	0.494	-1.902	4.980
24 kHz Transducer	2.213	-2.429	4.663
SSS Block NGS plus Aug extension	6.374	-42.553	-4.797
Waterline	N/A	N/A	0.260
7125 Port Transducer	-3.655	-2.369	5.070
7125 Stbd Transducer	8.499	-2.364	5.071



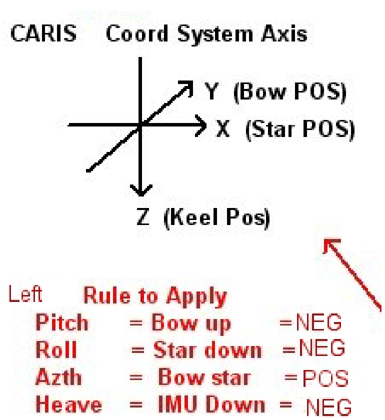
3101 Caris Offsets

ITEM	DESCRIPTION	X_AXIS	Y_AXIS	Z_AXIS
1	POS/MV IMU	0.000	0.000	0.000
2	Port POS/MV Aero Antenna 1 Phase Center	-0.711	-0.866	-3.789
3	Stbd POS/MV Aero Antenna 2 Phase Center	-0.717	0.631	-3.800
4	Reson 8125	-0.379	-0.116	0.600
5	Klein 5000	-0.500	-0.040	-0.660
6	Waterline	N/A	N/A	-0.220



3102 Caris Offsets

ITEM	DESCRIPTION	X_AXIS	Y_AXIS	Z_AXIS
1	POS/MV IMU	0.000	0.000	0.000
2	Port POS/MV Aero Antenna 1 Phase Center	-0.794	-0.962	-3.743
3	Stbd POS/MV Aero Antenna 2 Phase Center	0.691	-0.955	-3.761
4	Reson 8101	-0.362	-0.064	0.529
5	Klein 5000	-0.485	-0.008	-0.602
6	Waterline	N/A	N/A	-0.220



NOAA Ship THOMAS JEFFERSON	Prepared by: ENS Winner	Approved By: LT Moser, FOO
Document: TPE Paramaters		Effective Date: May 25th,

Project	Vessel	Tide Values		Sound Speed Values	
		Measured	Zoning	Measured	Surface
H11303	3101	0	0.18	0.05	0.3
	3102	0	0.18	0.05	0
	S222	0	0.18	0.05	0.06
H11323	1005	0	0.18	0.05	0
	1014	0	0.18	0.05	0.3
	3101	0	0.18	0.05	0.3
	3102	0	0.18	0.05	0
H11585	S222	0	0.13	0.05	0.06
H11568	3101	0	0.18	0.05	0.3
	3102	0	0.18	0.05	0
	S222	0	0.18	0.05	0.06
H11411	3101	0	0.21	0.05	0.3
	3102	0	0.21	0.05	0
	S222	0	0.21	0.05	0.06
H11413	3101	0	0.21	0.05	0.3
	3102	0	0.21	0.05	0
	S222	0	0.21	0.05	0.06
H11414		0	0.21	0.05	
H11600	3101	0	0.18	0.05	0.3
	3102	0	0.18	0.05	0
	S222	0	0.18	0.05	0.06
H11601	3101	0	0.18	0.05	0.3
	3102	0	0.18	0.05	0
	S222	0	0.18	0.05	0.06

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. Total propagated error for the VBES system assumes that a vertical-beam echosounder is equivalent to a multibeam echosounder with one beam. An uncertainty-weighted BASE Surface is computed for the survey area and submitted with analog paper records as a deliverable.

When bathymetry data for a survey is a combination of primary VBES and primary MBES, a collection of finalized uncertainty-weighted mean bathymetric surfaces is generated as the product of the survey. Resolution of the VBES BASE Surface will be standard resolution for Complete MBES (typically 2m in shallow water), even though coverage in the area of VBES acquisition will be sparse.

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

MULTIBEAM BATHYMETRY

Depending on acquisition type, MBES bathymetry may be processed using either an uncertainty-weighted navigation surface or a CUBE surface.

When the primary source of bathymetry for a survey area is VBES, a combination of VBES and MBES, or skunk-striped MBES, a collection of finalized uncertainty-weighted mean bathymetric surfaces is generated as the product of the survey. The data is examined and cleaned as necessary. Blunders are rejected, and lines with major systematic errors are removed from the grid. Systematic errors are identified and documented by the office processor. The product surface is generated at standard resolution for Complete MBES (typically 2m in shallow water) even though bathymetry data may be sparse.

When Complete or OD MBES is the primary source of bathymetry, a collection of finalized CUBE surfaces is generated as the product of the survey. 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 bottom 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. The final resolution of the product surfaces depends on whether Complete or OD MBES is specified in the letter instructions.

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 6.0.

Processing side scan data includes examining and editing fish height, vessel heading (gyro), and vessel navigation records. When side scan sonar is towed, fish navigation is recalculated using CARIS SIPS 6.0. 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 6.0 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 Survey 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. DP and GP features are inserted using the “Generic Data Parser” 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).

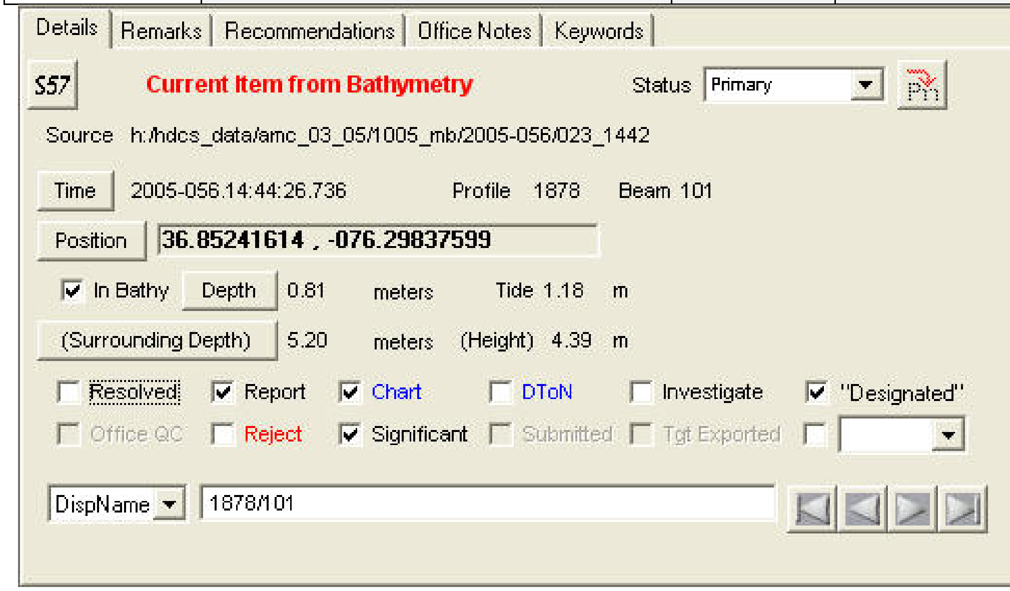


Figure 14

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 with a MBES system capable of meeting NOAA object detection specifications. 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 final bathymetric deliverable to the Atlantic Hydrographic Branch is a collection of finalized BASE surfaces. The resolution of these surfaces varies according to acquisition type specified in the Letter Instructions.

Side scan sonar data are 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.

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. A Microsoft Access database file (.mdb) containing all S-57 features is exported from Pydro.

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 may be recorded during multibeam data acquisition, but are not used for bathymetric processing. Backscatter mosaics are generated for end user scientific products and should not be used for navigation.

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 (7/2006), Hydrographic Survey Directives, and the Field Procedures Manual for Hydrographic Surveying (212006, v 2.1).

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

Submitted:

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Approved and Forwarded:

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APPENDIX I – EQUIPMENT and SOFTWARE

APPENDIX II – Patch Tests