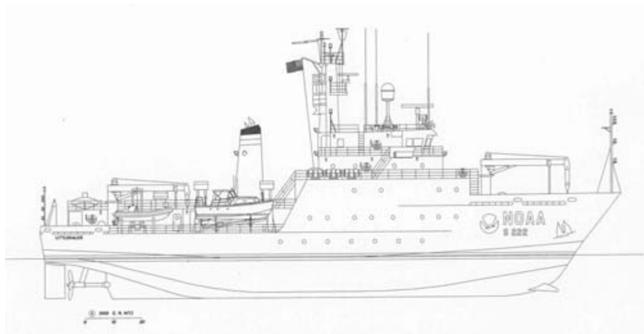
U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE

NOAA Ship THOMAS JEFFERSON
Data Acquisition and Processing Report



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Type of Survey Navigable Area *Project No.* OPR-B310-TJ-07 *Time Frame* June- September 2007	*Type of Survey* Navigable Area *Project No.* M-A902-TJ/GM-07 *Time Frame* September- November 2007
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Chief of Party

CDR P. Tod Schattgen, NOAA

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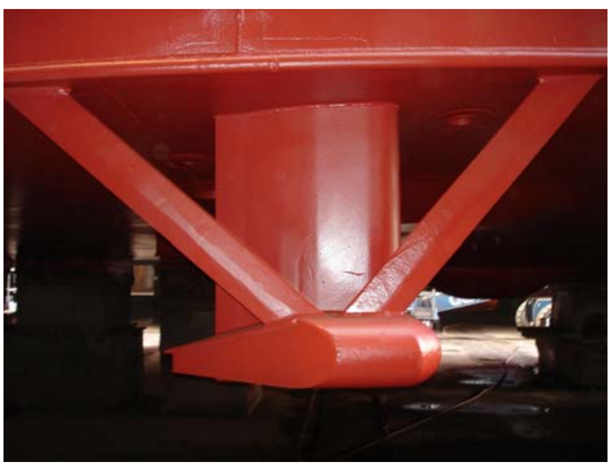
A. Equipment

All survey data for 2007 were acquired by NOAA Ship THOMAS JEFFERSON and Survey Launches 3101 and 3102. THOMAS JEFFERSON acquired multibeam echosounder (MBES) data, vertical beam echosounder (VBES) data, and sound velocity profile (SVP) data. Survey Launches 3101 and 3102 acquired side-scan sonar (SSS) data, MBES data, and SVP data.

The methods and systems described in this report are used to meet full-coverage requirements and are in accordance with the National Ocean Service Standing Instructions for Hydrographic Surveys (3/2004), the Hydrographic Surveys Specifications and Deliverables Manual (4/2007), Hydrographic Survey Directives, and the Field Procedures Manual for Hydrographic Surveying (3/2007, v 2.1).

A.1. Echosounding Equipment

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. Dual-head acquisition is performed using a master and slave setup, where the port side transducer settings are automatically applied to the starboard side transducer.

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.

The best expected performance of the RESON 7125, as installed on THOMAS JEFFERSON, 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, and is typically to the IHO Order 1 standard.

The RESON 7125 performs active beam steering to correct for sound velocity at the transducer head using an Applied Microsystems LTD Sound Velocity and Temperature 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. 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 limitations, snippets are acquired only upon request and not for routine hydrographic survey operations.

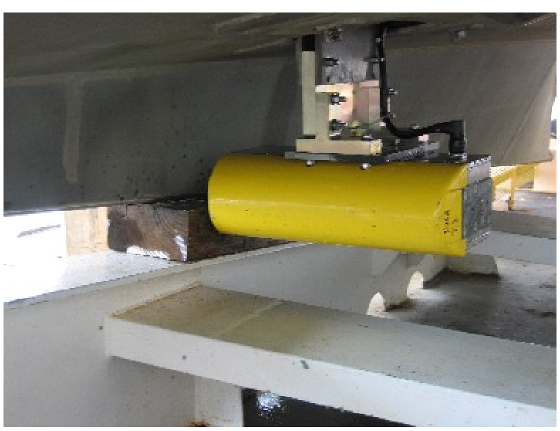
For the purposes of calculating total propagated error, the RESON 8101 is assumed to have an operational frequency of 240 kHz, pulse length of 0.15ms, and a typical ping rate of 30Hz.

Outer beams of the RESON 8101 (45°-75° off nadir) do not meet NOAA specifications for object detection in water deeper than 10m. The RESON 8101 echosounder may be used for complete multibeam and set line spacing multibeam acquisition. If used for development of significant features, care is taken in line spacing to ensure that only the center of the swath (from nadir to 45°) is used to acquire least depths. RESON 8101 data acquired concurrently with side-scan sonar data meets NOAA object detection specifications. The RESON 8101 is used to acquire multibeam and sidescan data concurrently. Information regarding this configuration is discussed in section D.

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, and is typically to the IHO Order 1 standard.

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 RESON "Snippet" format. 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 limitations, snippets are acquired only upon request and not for routine hydrographic survey operations.

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, and is typically to the IHO Order 1 standard.

A systematic data artifact was found last year regarding the precise timing with this system. This issue is corrected by modifying the HIPS Vessel File for affected lines. Further discussion of this issue is found in section D.

A.2. Acoustic Imaging Equipment

KLEIN 5000 High-speed Side Scan Sonar

The KLEIN 5000 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 5000 system consists of a KLEIN 5250 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 5000 system: stern-towed and hull-mounted.

The KLEIN 5000 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. TI ISIS is used to acquire data with the KLEIN 5000 side scan sonar.

Hull-Mounted Configuration
Aboard both survey launches, the towfish is mounted to an aluminum sled using omega brackets. The hull-mounted configuration is used in depths of twenty meters or less. Aboard Launches 3101 and 3102 a layback error of -0.8 seconds was found during the Hydrographic Systems Readiness Review. Aboard Launch 3102, sidescan was collected concurrently with Reson 8101 MBES data using a combined ISIS and Hypack computer.

A.3. Manual Sounding Equipment

Diver Least Depth Gauge

The diver 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 diver least depth gauge during the 2006-2007 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 to perform confidence checks against acoustic echosounders. 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.

A.4. Positioning and Orientation Equipment

Applanix POS/MV

A basic requirement of multibeam hydrography is accurate ship's 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, Survey Launch 3101, and Survey Launch 3102 are provided by an Applanix POS/MV Model 320 v.4. The system onboard Launch 3102 was installed during the 2006-2007 winter in port period, replacing the previous v.3 unit. 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. These values meet the position accuracy standard for an IHO Order 1 survey.

Survey Launches 3101 and 3102 are equipped with Precise Timing, a multibeam sonar acquisition configuration which attempts to synchronize all data to the same time. The timing message is generated by the POS/MV which is received by both ISIS and the Reson TPU. At the time of acquisition of data, the POS/MV-generated time stamp is applied to the data instead of the system clock. Precise Timing reduces the variable effects of time latency and creates a single, measurable latency. This is determined via a patch test. Appendix 3 of the Field Procedures Manual contains a more in-depth description of Precise Timing.

THOMAS JEFFERSON uses a modified version of Precise Time; only Reson 81xx systems are capable of true Precise Time. The 7125 TPU is not capable of altering its time stamp based on an exterior message. While attitude data are time-stamped based on the POS/MV time, the navigation and the echosounder are based on their system clocks. As a result, a solution for both Navigation Timing and Precise Timing are required.

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.

A table showing standard IHO S-44 positional accuracy limits is shown on the following page.

TABLE 1

Summary of Minimum Standards for Hydrographic Surveys

ORDER	Special	1	2	3
Examples of Typical Areas	Harbours, berthing areas, and associated critical channels with minimum underkeel clearances	Harbours, harbour approach channels, recommended tracks and some coastal areas with depths up to 100 m	Areas not described in Special Order and Order 1, or areas up to 200 m water depth	Offshore areas not described in Special Order, and Orders 1 and 2
Horizontal Accuracy (95% Confidence Level)	2 m	5 m + 5% of depth	20 m + 5% of depth	150 m + 5% of depth
Depth Accuracy for Reduced Depths (95% Confidence Level) (1)	a = 0.25 m b = 0.0075	a = 0.5 m b = 0.013	a = 1.0 m b = 0.023	Same as Order 2
100% Bottom Search	Compulsory (2)	Required in selected areas (2)	May be required in selected areas	Not applicable
System Detection Capability	Cubic features > 1 m	Cubic features > 2 m in depths up to 40 m; 10% of depth beyond 40 m (3)	Same as Order 1	Not applicable
Maximum Line Spacing (4)	Not applicable, as 100% search compulsory	3 x average depth or 25 m, whichever is greater	3-4 x average depth or 200 m, whichever is greater	4 x average depth

(1) To calculate the error limits for depth accuracy the corresponding values of a and b listed in Table 1 have to be introduced into the formula

$$\pm\sqrt{[a^2 + (b*d)^2]}$$

with
- a constant depth error, i.e. the sum of all constant errors
- b*d depth dependent error, i.e. the sum of all depth dependent errors
- b factor of depth dependent error
- d depth

(2) For safety of navigation purposes, the use of an accurately specified mechanical sweep to guarantee a minimum safe clearance depth throughout an area may be considered sufficient for Special Order and Order 1 surveys.

(3) The value of 40 m has been chosen considering the maximum expected draught of vessels.

(4) The line spacing can be expanded if procedures for ensuring an adequate sounding density are used (see 3.4.2)

A.5. Sound Velocity Profilers

Sea-Bird SBE19/19+ CTD Profilers

THOMAS JEFFERSON and Survey Launches 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 1500m of galvanized steel cable.

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 2006-2007 winter inport period. Calibration documents are contained in Appendix II of the 2007 Hydrographic Systems Readiness Report (HSRR).

Brooke Ocean Technology Moving Vessel Profiler 100

The Moving Vessel Profiler (MVP) (at left) 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.

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 Reson 7125 and Reson 8125 systems both require SSVS data.

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 in real time to the SIMRAD EM1002 and Reson 7125 systems at a rate of 10 Hz. Data are sent in real time to the Kongsberg EM1002 transducer.

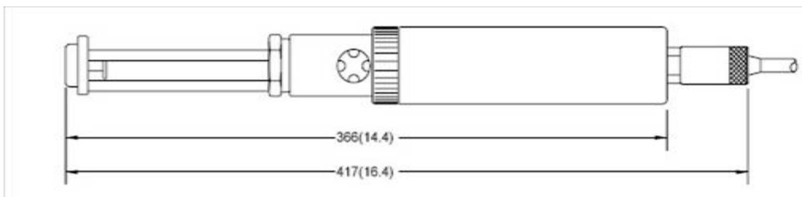
The AML Smart SV&T Probe was returned to the manufacturer and calibrated during the 2006-2007 winter in-port period. Shortly after the 2007 field season began, problems were noticed with the sensor and it was determined that vendor repairs were needed. The sensor was sent to EEB and AML in April 2007 and returned to the ship 10 May 2007.

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 on 9 January 2007. Calibration documents are contained in Appendix II of the 2007 Hydrographic Systems Readiness Report (HSRR). The Digibar Pro failed on 4 August 2007 due to the development of a "blister" on the transducer face. An onboard spare Digibar probe acquired during Spring 2007 from Marine Operations Center Pacific was installed and compared with separate and independent casts from the ship's three Seabird CTDs. Comparison results showed that the spare Digibar Pro would accurately and sufficiently measure surface SV for operation with the Reson 8125 MBES. This probe remained in service for the remainder of the field season and will be sent off for manufacturer calibration during the 2007-2008 winter inport period.

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.

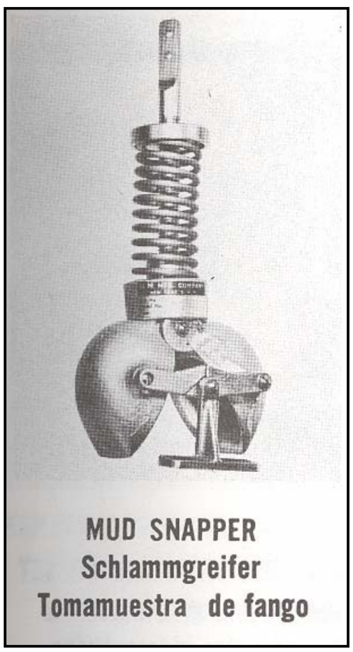
The Applied Microsystems Smart SV&P Sensor was calibrated by the manufacturer on January 16, 2007. Calibration documents are contained in Appendix II of the 2007 Hydrographic Systems Readiness Report (HSRR).

A.6. Bottom Samplers

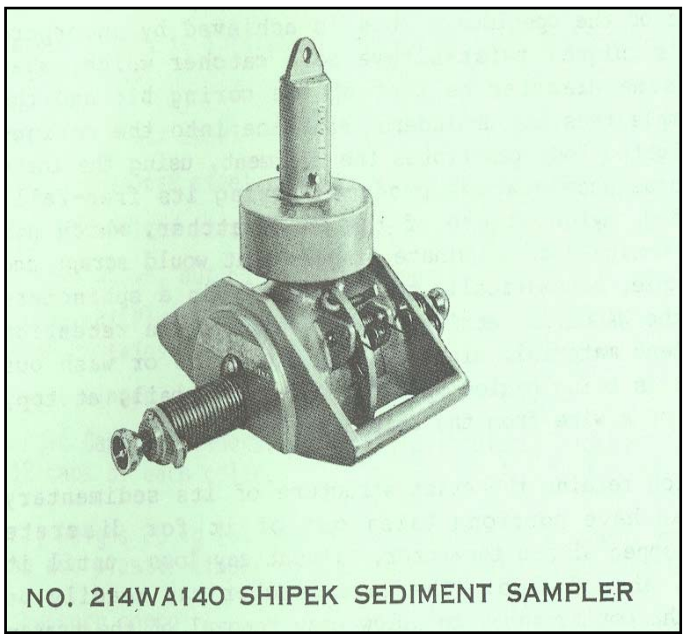
Two types of bottom samplers are used aboard THOMAS JEFFERSON for analyzing bottom sediments.

The Khalsico Mud Snapper model 214WA100 may be deployed by one person by hand. It utilizes a foot trip mechanism with adjustable spring tension and acquires a 4 cm surface penetration in a clamshell grabber. This sampler is best used for shallow water samples acquired on the survey launches.

The Shipek Sediment Sampler model 214WA140 was designed for unconsolidated sediment, from soft ooze to hard packed, coarse sand. The unit is cocked with a special wrench and tripped to sample by depression of a weight when touching the bottom. A rotating bucket provides a maximum surface penetration of 10 cm and preserves the sample from washout. As it is typically used for samples acquired in deeper waters by the ship, it is deployed with 2-3 personnel using the ship's ocean winch.



Khalisco Mud Snapper



Shipek Sediment Sampler

A.7. Software Systems

Acquisition Software

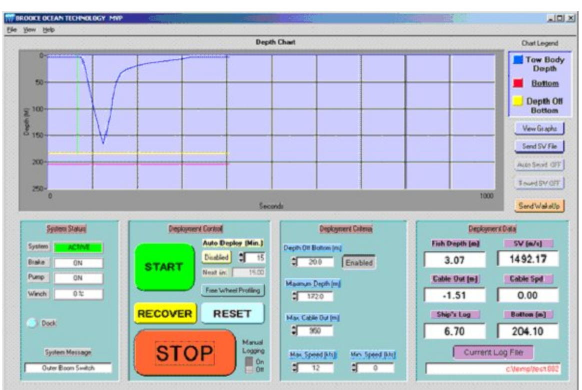
HYPACK MAX

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 and detached positions on all three platforms.

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



MVP Main Controller Screen

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

Processing Software

CARIS *HIPS AND SIPS V 6.1*

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* 6.1 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 2007 Field Procedures Manual for a detailed description of navigation surface processing. Creation of grids as bathymetric products is discussed in section D of this report.

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, towpoint entry, 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 assigned 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 file (PSS), which is delivered to the Atlantic Hydrographic Branch as part of the final submission package.

Pydro Versions 7.3 and later have functionality for TCARI installed. TCARI is described in detail in section D.3. The TCARI file for the area is received from NOS and loaded into Pydro along with the predicted, observed, or verified tide files for the corresponding stations. The use of TCARI is specified in the Project Instructions.

Pydro is also used for chart comparisons, generation of chartlets, generation of Danger to Navigation reports, generation of appendices to the Descriptive Report, compilation of survey statistics, and generation of standard NOAA forms such as the Descriptive Report cover sheet.

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 multibeam echosounder acquisition. The resulting .svp files are applied in CARIS HIPS during 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 and to archive sound velocity information for the National Oceanographic Data Center.

MapInfo Professional 9.0

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.

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). Finalized grids and Bathymetry Attributed Grids (BAGs) generated in CARIS HIPS are loaded into *Fledermaus* for quality verification. *Fledermaus* may also be used to generate end-user scientific and public-release products upon request.

A.8. Acquisition Procedures

Acquisition Types

All platforms acquire hydrographic data according to the Letter Instructions for each survey. The Letter Instructions for a given survey will specify the acquisition method desired. The Letter Instructions will occasionally state the desired coverage and give the field unit discretion as to the best method to achieve that coverage.

The following survey types were used during field operations by THOMAS JEFFERSON in the fall of 2007:

- Set Line Spacing
- Complete MBES Coverage
- 100% SSS + Complete MBES
- Object Detection SSS Coverage
- Object Detection MBES Coverage

These coverage types are described in detail in the 2007 Hydrographic Survey Specifications and Deliverables.

Line plans are designed by the field unit according to the coverage type specified in the Letter Instructions. Occasionally the Letter Instructions will give discretion regarding which coverage type to use to the field unit. Line planning and coverage type will be discussed in detail in the Descriptive Report for each survey.

Vessel Acquisition Configurations

THOMAS JEFFERSON and Survey Launch 3101 use TI Isis for all RESON multibeam acquisition. Side scan sonar is not operated concurrently with the RESON 8125 as the central frequency of this system is the same as that of the KLEIN 5000. THOMAS JEFFERSON may operate SSS concurrently with the ODOM VBES and/or RESON 7125 MBES systems. In this case, SSS and MBES data are recorded with TI ISIS on separate acquisition computers and VBES data are recorded with Hypack. Survey Launch 3101 may operate SSS without recorded bathymetry; data are recorded with TI ISIS.

Survey Launch 3102 uses a single TI ISIS interface to record both SSS and RESON 8101 MBES data concurrently. In the single ISIS window, both systems are visible to the hydrographer, and the hydrographer can control each system via the ISIS interface. Multibeam backscatter is not acquired in this configuration. With this exception, both systems operate as if they were running independent of the other. Physical interference from the side scan sonar transducer and occasional acoustic or electric interference necessitates the use of strong data filters in post-processing of multibeam soundings when this type of data is recorded. Typically the processed swath width of the RESON 8101 is filtered to 20° off nadir during post-processing when soundings are recorded concurrently with SSS. This acquisition configuration is adequate to meet NOAA object detection requirements for Set Line Spacing surveys.

Crosslines

Crosslines are acquired as an additional confidence check to the performance of echosounder 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 6.1. The results of the Crossline QC test are submitted in Separate V of the Descriptive Report of each project.

Along-Track Coverage

All platforms must acquire bathymetry data such that the specification requiring a minimum of 3.2 pings per 3 meters in the along-track direction is met. For Complete MBES surveys, there must be at least one ping for every 1 meter grid node; the standard of 3.2 pings per 3 meters is used for all calculations. For Object Detection MBES, the minimum grid resolution of 0.5 requires a minimum of 2 pings per meter. For the purposes of this calculation, sounding coverage of 2.2 pings per meter is considered adequate to meet Object Detection MBES standards.

Acquisition speeds are monitored and limited so that this specification can be met based on the ping rate and the coverage type.

B. Quality Control

B.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 2007 NOAA Field Procedures Manual (v. 2.2, March 2007).

Depending on acquisition type, MBES bathymetry may be processed using either an uncertainty-weighted navigation surface or a CUBE surface. Uncertainty-weighted BASE surfaces and CUBE surfaces are described in detail in the *2007 NOS Field Procedures Manual* and the *CARIS HIPS/SIPS 6.1 Users Manual*.

When the primary source of bathymetry for a survey area is a combination of VBES and MBES, a collection of finalized uncertainty-weighted mean bathymetric surfaces is generated as the product of the survey. CUBE is not permitted for this type of survey. When the primary source of bathymetry for this type of survey is set line spacing MBES data (also known as “skunk striped”), CUBE shall be used. The use of CUBE in this situation is required to guarantee proper nodal propagation distances as described in section 5.1.1.3 of the 2007 Hydrographic Survey Specifications and Deliverables. 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 even though bathymetry data may be sparse.

When Complete or OD MBES is the primary source of bathymetry, data are processed using CUBE grids. The use of CUBE is mandatory to ensure compliance with the specification described in the paragraph above. After computation of TPE, multibeam lines are either used to create a new BASE Surface or are added to an existing BASE Surface. The resulting layers are analyzed by the data processor to identify blunders, systematic errors, and to identify significant bottom features. Blunders are rejected by the data processor in CARIS Subset Editor (multi-line spatial view) or CARIS Swath Editor (single-line time-series view). Systematic errors are identified and documented by the data processor. Least depths of navigationally significant features are flagged as “designated soundings,” which both identifies the object as a navigationally significant object for import in to Pydro and forces the depth of the grid to match the least depth of the feature. Hypothesis selection (available in CARIS 6.1) is not allowed per specifications and is not used aboard THOMAS JEFFERSON.

After data editing is complete, grids are finalized and combined to create a product grid, which is then exported to the Bathymetry Attributed Grid (.BAG) format. The final resolution of the product surfaces depends on whether Complete or OD MBES is specified in the letter instructions.

Fledermaus is used to assist the data processor in identifying data outliers and systematic errors harder to detect with other methods. They may also be used to determine navigational significance and for chart comparison.

B.2. Error Modeling in CARIS Hips

CARIS computes TPE based on both the static and dynamic measurements of the vessel. These values are based on the offsets tables found in Appendix II. As well, CARIS uses survey-specific information including a tidal zoning error estimate and speed of sound measurement errors. Offset values are entered into the CARIS *.hvf file. During processing, the tidal zoning and speed of sound measurement errors are applied. Tidal zoning values are provided with the Letter Instructions in a separate tidal information document. Instrument-specific values are obtained from either the CARIS TPE resource website or per HSD guidance (eg. Hydrographic Surveys Technical Directive 2007-2). TPE Parameters for each survey are listed in the Descriptive Report.

B.3. Bathymetry Analysis and Feature Classification

Following data cleaning in CARIS HIPS and SIPS, uncertainty-weighted or CUBE 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).

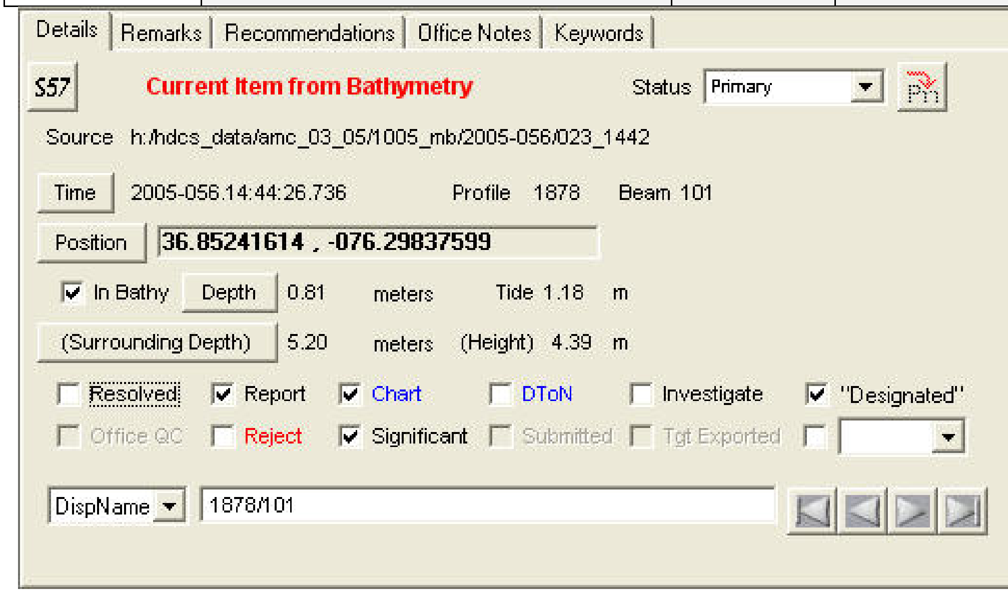


Figure 14

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, diver 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.

B.4. Imagery

Side scan sonar data are converted from *.xtf (TI ISIS raw format) to HDCS. Side scan data are processed using CARIS SIPS 6.1.

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 6.1. 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 6.1 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.

B.5. Survey Deliverables and Ancillary Product Generation

The ship's final bathymetric deliverables to the Atlantic Hydrographic Branch are a collection of Bathymetry Attributed Grids (BAGs), BASE surfaces, the Pydro PSS (including S-57 feature classifications), the Descriptive Report, side scan sonar mosaics (when applicable), and two sun-illuminated digital terrain models of the multibeam bathymetry. 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 and will vary from survey to survey.

C. Corrections to Echo Soundings

C.1. Sound Velocity

Sound speed data acquired by the sea surface sound velocity sensors on THOMAS JEFFERSON and Survey Launch 3101 are neither recorded nor used for post-processing of echosounder data. The sea surface sound velocity sensors will not be discussed further in this section.

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 6.1. Sound velocity correctors are applied to MBES and VBES soundings in CARIS HIPS 6.1 during post processing only. Calibration reports for the SBE19/19+ CTD profilers are included in the HSRR.

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 are conducted more frequently when changing survey areas, or when environmental conditions such as changes in weather, tide, or current would warrant additional sound velocity profiles.

The sound velocity casts are extended in *HSTP Velocwin* and applied to all bathymetric data in CARIS HIPS 6.1 during post processing.

Brooke Ocean MVP

In addition to using a CTD for acquisition of sound velocity (SV) data, THOMAS JEFFERSON also acquires SV data with a Brooke Ocean MVP. After deploying the MVP at the local control station and transferring control to the Acquisition Room, the hydrographer may initiate MVP casts at any time without impeding ship operations. While the frequency 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 hydrographer initiates the cast by pressing the “Start” button on the MVP software controller window. The MVP system 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 hydrographer 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 6.1 using *HSTP Velocwin*.

C.2. Water Level Correctors

Soundings are initially reduced to Mean Lower-Low Water (MLLW) using preliminary (observed) water level data. Data may be obtained from the primary tide gauge through the Center for Operational Oceanographic Products and Services (CO-OPS) web site or TideBot automated water level observation delivery program. Observed water level files are converted to CARIS tide files (.tid) and/or text files and applied to all sounding data using either discrete tide zoning in CARIS HIPS or the TCARI module in Pydro, as provided by CO-OPS. The type of water level correction used in a survey is specified in the Letter Instructions.

When discrete tide zoning is the type of final water level correction specified in the Smooth Tide Note, THOMAS JEFFERSON personnel use verified water levels and tide zoning provided by CO-OPS for hydrographic product generation.

C.3. TCARI

TCARI grid files are submitted to THOMAS JEFFERSON as part of the Project Instruction package. A grid is computed using the shoreline, a limiting boundary, and the positions of two or more water level gauges. Harmonic constants, residual water levels, and gauge weights are interpolated for each grid point, using the data from the water level gauges as control points. Water level corrections are applied in Pydro using the TCARI tools found in Pydro 7.xx and beyond. When using TCARI for datum reduction, water level corrections are not applied to echosounder data in CARIS. Following water level correction, data is merged and processed as described in Section E: Data Processing.

Unlike CARIS .tid files, the water level datum for TCARI surveys will be at Mean Sea Level (MSL). The TCARI algorithm automatically corrects MSL water levels to MLLW datum.

C.4. Multibeam Calibration Procedures

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 Files (HVFs). These offsets and biases are applied to the sounding data during processing in CARIS HIPS 6.1. The 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 2007 Hydrographic Systems Readiness Report.

A systematic precise timing latency has been observed aboard Launch 3101. This error is further documented in the report titled, "Dynamic Precise Timing Latency on Launch 3101" included in Appendix I.

C.5. Vessel Offsets and Dynamic Draft Correctors

Tables for all offsets and dynamic draft measurements can be found in Appendix II.

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 2007 Field Season. The GPS antennae for the POS/MV system aboard were replaced with a newer model. The mounts were not changed and it was determined that there was no change in the offsets between the original antennae and the newer model. The procedure and results of the 2005 re-survey may be found in the 2007 Hydrographic Systems Readiness 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 30, 2007.

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 31 March 2007.

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 was dead in the water. Dynamic draft measurements were made on 3 April 2007. Due to the installation of a POS M/V 320 v.4 onboard 3102, the GPS antenna offsets changed. At the recommendation of HSTP, the X and Y offsets remained the same, but the Z offset was lowered by 5 mm (entered as +0.005 m) in the POS M/V controller setup, as the v.4 antennae are slightly shorter than v.3 antennae.

D. 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 (4/2007), Hydrographic Survey Directives, and the Field Procedures Manual for Hydrographic Surveying (3/2007, 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:

ENS William Winner, NOAA
Junior Officer

Approved and Forwarded:

LT Christiaan van Westendorp, NOAA
Field Operations Officer

CDR P. Tod Schattgen, NOAA
Commanding Officer

Appendix I

DYNAMIC PRECISE TIMING LATENCY ON LAUNCH 3101

NOAA Ship THOMAS JEFFERSON
LT Chris van Westendorp, NOAA
ENS William Winner, NOAA

Background

THOMAS JEFFERSON took delivery of Hydrographic Survey Launch 3101 during the summer of 2005. 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”).

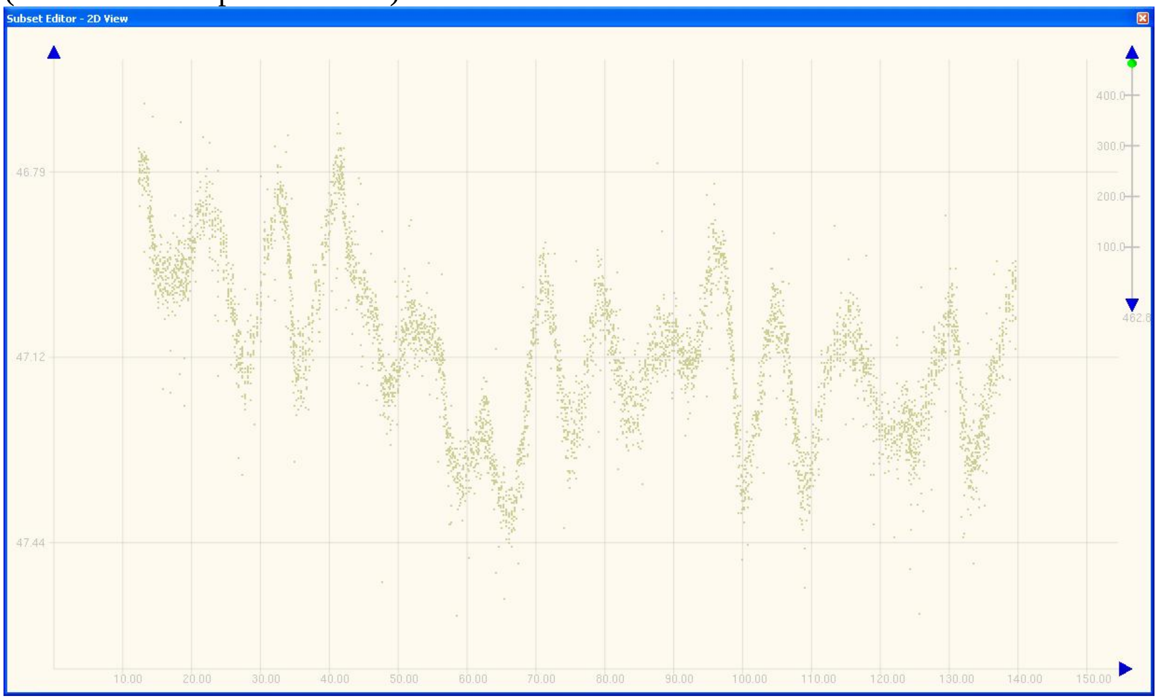


Figure 1- Precise Timing Error

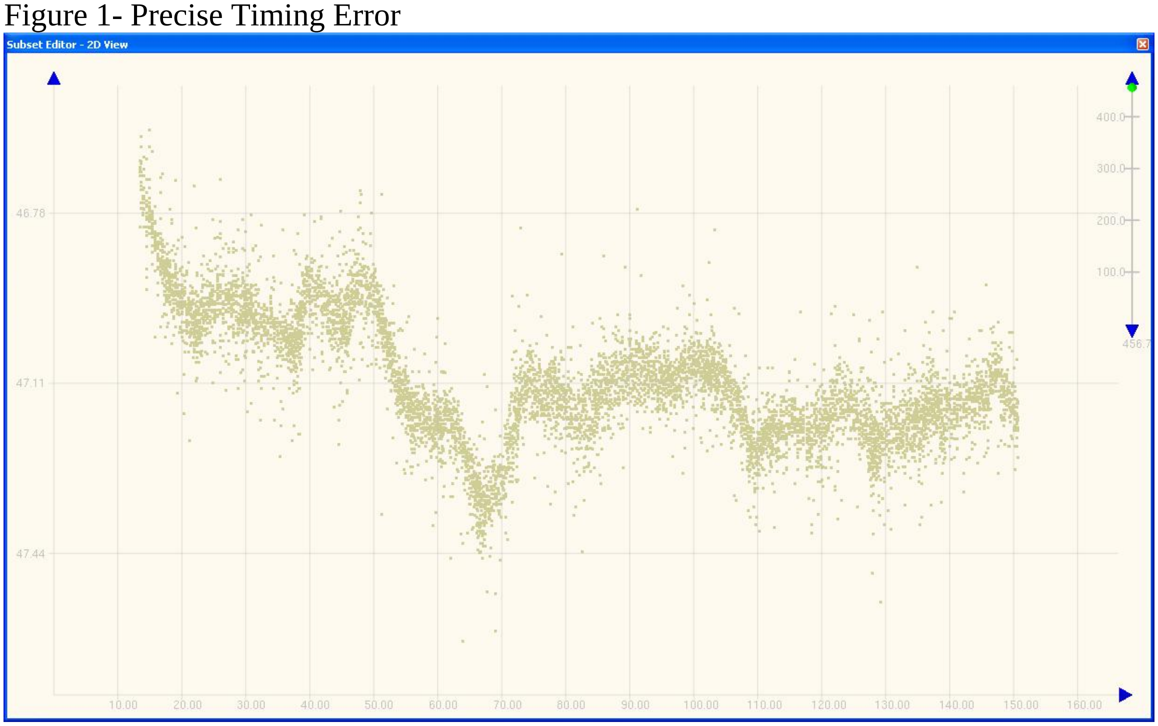


Figure 2- Precise Timing Corrected

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).

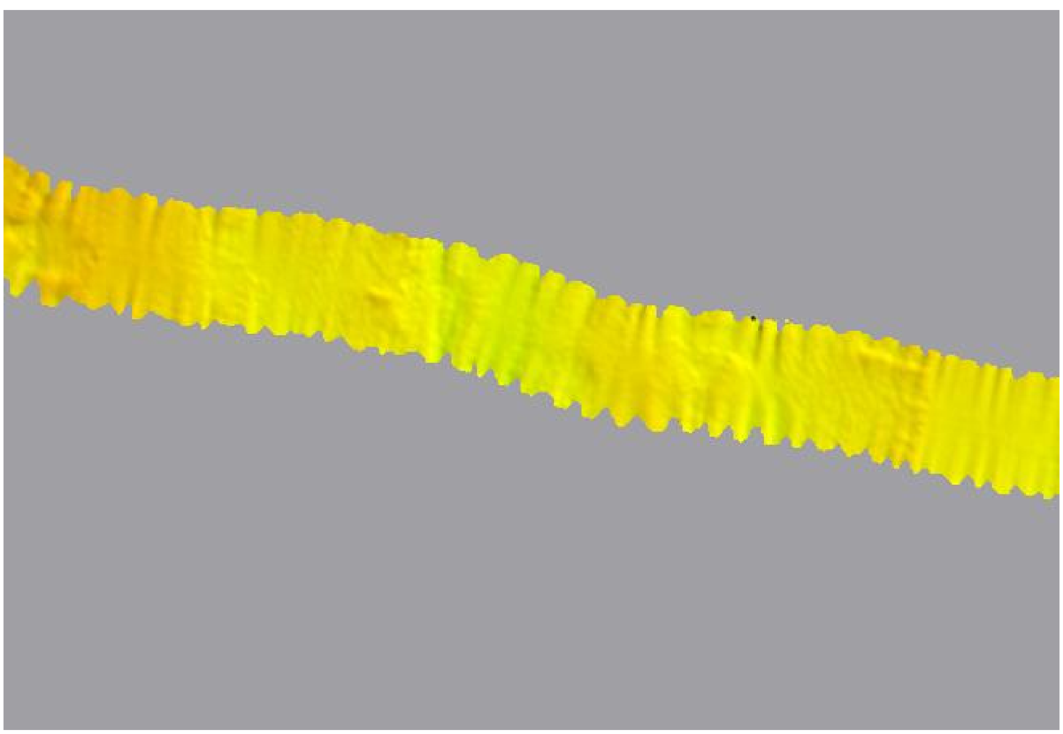


Figure 3-"Wavy" BASE surface generated from lines with a precise timing error.

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.

Questions and comments may be forwarded to:

Chris van Westendorp, LT/NOAA
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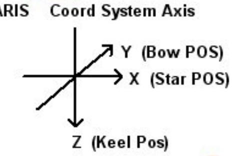
Appendix II

Vessel Static Offsets

NOAA Ship THOMAS JEFFERSON	Prepared by: William Winner	Approved By:
Document: Caris Coordinates		Effective Date:

ITEM	DESCRIPTION	X_AXIS	Y_AXIS	Z_AXIS
1	Optical Reference Unit	0.000	-0.844	-0.116
2	POS/MV IMU	0.000	0.000	0.000
3	Port POS/MV Aero Antenna 1 Phase Center	1.356	-10.282	-22.320
4	Stbd POS/MV Aero Antenna 2 Phase Center	3.563	-10.166	-22.336
5	EM1002 Transducer	2.384	-0.560	5.153
6	200 kHz Transducer	0.494	-1.902	4.980
7	24 kHz Transducer	2.213	-2.429	4.663
8	SSS Block NGS plus Aug extension	6.374	-42.553	-4.797
9	Waterline	N/A	N/A	0.570
10	7125 Port Transducer	-3.655	-2.369	5.070
11	7125 Stbd Transducer	8.499	-2.364	5.071

CARIS Coord System Axis



Left Rule to Apply

Pitch = Bow up =NEG
Roll = Star down =NEG
Azth = Bow star =POS
Heave = IMU Down = NEG

NOAA Ship THOMAS JEFFERSON	Prepared by: William Winner	Approved By:
Document: 3101 Caris Coordinates		Effective Date:

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

NOAA Ship THOMAS JEFFERSON	Prepared by: William Winner	Approved By:
Document: 3102 Caris Coordinates		Effective Date:

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

Vessel Dynamic Offsets

S222- Dynamic Draft

S-222 Change in Draft (meters)	Speed (m/s)	RPM
0	1.72	Pony engine clutch ahead
0.13	2.51	Main engine 350 RPM
0.14	3.00	Pony engine full
0.20	3.49	Main engine 450 RPM
0.21	4.16	Main engine 550 RPM
0.17	4.81	Main engine 650 RPM
0.16	5.17	Main engine 700 RPM

3101- Dynamic Draft

3101 Combined median offset	speed	RPM
0	1.025875	Trolling
-0.030898122	2.835	800
-0.038	3.391	1000
-0.082333333	3.884	1200
-0.0515	4.303	1400
-0.036	4.6435	1600

3102- Dynamic Draft

3102 Combined median offset	speed	RPM
0	1.41125	trolling
0.011833	1.961	600
-0.01967	2.7	800
-0.01983	3.287	1000
-0.04083	3.844	1200
-0.0525	4.26	1400
0.078667	4.622	1600