

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

Data Acquisition & Processing Report

Type of Survey Multibeam and Sidescan Sonar

Project No. OPR-D302-KR-07

Time Frame: 06 July 2007 – 18 November 2007

LOCALITY

State Delaware - Maryland

General Locality Atlantic Ocean

2007

**CHIEF OF PARTY**

Gary R. Davis

Science Applications International Corporation

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**DATE** \_\_\_\_\_

NOAA FORM 77-28 (11-72)	U.S. DEPARTMENT OF COMMERCE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION	REGISTRY NO.  <b>H11647</b> <b>H11648</b> <b>H11649</b> <b>H11650</b>
<b>HYDROGRAPHIC TITLE SHEET</b>		FIELD NO. <b>C, D, E, F</b>
<b>INSTRUCTIONS</b> – When the Hydrographic Sheet is forwarded to the office, it should be accompanied by this form filled in as completely as possible.		
State: <u>Delaware - Maryland</u> General Locality: <u>Atlantic Ocean</u> Locality: <u>East of Cape Henlopen (H11647); East of Indian River Inlet (H11648); East of Fenwick Island (H11649); 7 NM East of Fenwick Island (H11650)</u>  Scale: <u>1:20,000</u> Date of Survey <u>06 July 2007 - 19 November 2007</u>  Instructions Dated: <u>22 February 2007</u> Project No. <u>OPR-D302-KR-07</u>  Vessel: <u>M/V Atlantic Surveyor, D582365</u>  Chief of Party: <u>Gary R. Davis</u>  Surveyed by: <u>Brian Biggert, Alex Bernier, Gary Davis, Paul Donaldson, Chuck Holloway, Jason Infantino, Mike Kelly, Jeff Koch, Colette LeBeau, Rick Nadeau, Chris Pinero, Evan Robertson, Alex Schneider, Jeremy Shambaugh, Deb Smith, and Tom Waddington.</u>  Soundings taken by <u>echo sounder</u> hand lead, pole: <u>MULTIBEAM RESON SEABAT 8101</u>  Graphic record scaled by _____  Graphic record checked by _____ Automated plot _____  Verification by _____  Soundings in fathoms, feet, <u>meters</u> at MLW, <u>MLLW</u>		
REMARKS: <b>Contract:</b> <u>DG133C-05-CQ-1088</u> <b>Contractor:</b> <u>Science Applications International Corp., 221 Third Street, Newport, RI 02840 USA</u> <b>Subcontractors:</b> <u>Williamson &amp; Associates, 1124 NW 53<sup>rd</sup> Street, Seattle WA 98107; Rotator Staffing Services, PO Box 366, 557 Cranbury Rd, E. Brunswick NJ 08816</u> <b>Times:</b> <u>All times are recorded in UTC</u> <b>UTM Zone:</b> <u>Zone 18</u> <b>Purpose:</b> <u>To provide NOAA with modern, accurate hydrographic survey data for the purpose of updating the relevant nautical charts of the assigned areas: Sheet C (H11647), Sheet D (H11648), Sheet E (H11649), Sheet F (H11650) in the Mid-Atlantic Corridor, Coast of Delaware and Maryland.</u>		

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## ACRONYMS

<b><u>Acronym</u></b>	<b><u>Definition</u></b>
ASCII	American Standard Code for Information Interchange
BAG	Bathymetric Attributed Grid
CI	Confidence Interval
CMG	Course Made Good
CTD	Conductivity, Temperature, Depth profiler
CUBE	Combined Uncertainty and Bathymetric Estimator
DGPS	Differential Global Positioning System
DPC	Data Processing Center
DR	Descriptive Report
EPF	Error Parameters File
GPS	Global Positioning System
GSF	Generic Sensor Format
IHO	International Hydrographic Organization
IMU	Inertial Measurement Unit
ISO	International Organization for Standardization
ISS-2000	Integrated Survey Software 2000
ISSC	Integrated Survey System Computer
JD	Julian Day
kW	Kilowatt
LTO	Liner Tape-Open
MVE	Multi-View Editor
MVP	Moving Vessel Profiler
NAS	Network Attached Storage
NMEA	National Marine Electronics Association
NOAA	National Oceanic and Atmospheric Administration
PFM	Pure File Magic
POS/MV	Position Orientation System/Marine Vessels
RPM	Revolutions Per Minute
SABER	Survey Analysis and area Based EditoR
SAIC	Science Applications International Corporation
SAT	Sea Acceptance Tests, or Swath Alignment Tool
SSP	Sound Speed Profile
SV&P	Sound Velocity and Pressure Sensor
TPE	Total Propagated Error
TPU	Total Propagated Uncertainty
UPS	Uninterruptible Power Supply
XTF	eXtended Triton Format

## A. EQUIPMENT

### **DATA ACQUISITION**

Central to Science Applications International Corporation's (SAIC) survey system was the Integrated Survey System Computer (ISSC). The ISSC consisted of a high-end dual processor computer with the Windows XP operating system, which ran SAIC's Integrated Survey Software 2000 (**ISS-2000**) software. This software provided survey planning and real-time survey control in addition to data acquisition and logging for multibeam and navigation data. An Applanix Position Orientation System/Marine Vessels (POS/MV) Inertial Measurement Unit (IMU) with Version 4 firmware (backward compatible) was used to provide positioning, heave, and vessel motion data during these surveys. The POS/MV backward compatibility mode ensured that the positioning and motion data format was compatible with the **ISS-2000**. Klein 3000 sidescan sonar data were acquired using Klein's **SonarPro** software running on a computer with the Windows XP operating system.

### **DATA PROCESSING**

Post-acquisition multibeam processing was performed both on board the survey vessel and in the Newport, RI, office using a high-end dual processor computer with the Linux operating system, which ran SAIC's **SABER** (Survey Analysis and Area Based Editor) software. Sidescan sonar data were reviewed for targets, quality and contact generation in Triton **Isis** software both on the survey vessel and in the Newport, Rhode Island, office. Subsequently, within **SABER**, sidescan mosaics were created and sidescan contacts were correlated with multibeam data.

### **THE SURVEY VESSEL**

The platform used for data collection was the *M/V Atlantic Surveyor* (Figure A-1). The vessel was equipped with an autopilot, echo sounder, Differential Global Positioning System (DGPS), radars, and two 40 kW diesel generators. Accommodations for up to twelve surveyors were available within three cabins. Table A-1 presents the vessel characteristics for the *M/V Atlantic Surveyor*.



**Figure A-1. The *M/V Atlantic Surveyor***

**Table A-1. Survey Vessel Characteristics, *M/V Atlantic Surveyor***

Vessel Name	LOA (Ft)	Beam (Ft)	Draft (Ft)	Max Speed	Gross Tonnage	Power (Hp)	Registration Number
<i>M/V Atlantic Surveyor</i>	110'	26'	9.0'	14 knots	Displacement 68.0 Net Tons Deck Load 65.0 Long Tons	900	D582365

Three 20-foot International Organization for Standardization (ISO) containers and a 55 kW generator were secured on the aft deck. The first ISO van was used as the real-time, survey data collection office, the second van was used for the data processing office, and the third van was used for spares storage, maintenance, and repairs. The generator provided dedicated power to the survey containers and associated survey equipment.

The POS/MV IMU was mounted below the main deck of the vessel, 0.34 meters port of centerline and 0.34 meters forward, 0.12 meters starboard, and 1.64 meters above the RESON 8101 transducer acoustic center. The multibeam sounder transducer was mounted on the hull 0.46 meters port of centerline. A Brook Ocean Technologies Moving Vessel Profiler 30 (MVP-30) was mounted to the starboard stern quarter. Configuration parameters, offsets, and installation diagrams are included in Section C of this report.

### **SINGLEBEAM SYSTEMS AND OPERATIONS**

SAIC did not utilize singlebeam sonar on this survey for verification of the recorded nadir beam depth from the multibeam system. Periodic leadline comparisons were made during port calls (approximately every 5-7 survey days) in lieu of a singlebeam sonar comparison in accordance with Section 5.1.3.1 of the NOS Hydrographic Surveys Specifications and Deliverables, April 2007. Leadline results are included with the survey data in Section I of the Separates of each sheet's Descriptive Report (DR).

### **MULTIBEAM SYSTEMS AND OPERATIONS**

The real-time multibeam acquisition system used for these surveys included each of the following unless further specified:

- Windows XP workstation (ISSC) for data acquisition, system control, survey planning, survey operations, and real-time quality control
- Reson 8101 multibeam transducer
- Reson 81P sonar processor
- POS M/V 320 Position and Orientation System Version 4 with a Trimble ProBeacon Differential Receiver
- Trimble 4000 GPS Receiver with a Trimble ProBeacon Differential Receiver
- MVP 30 Moving Vessel Profiler with interchangeable Applied Microsystems Smart Sound Velocity and Pressure Sensors and a Notebook computer to interface with the ISSC and the deck control unit
- Notebook computer for maintaining daily navigation and operation logs
- Seabird Model SBE 19 Conductivity, Temperature, Depth (CTD) profiler
- Uninterrupted power supplies (UPS) for protection of the entire system

The user selectable range scale on the Reson 8101 was adjusted appropriately depending upon the survey depth.

### **SIDESCAN SONAR SYSTEMS AND OPERATIONS**

The sidescan system used for these surveys included each of the following:

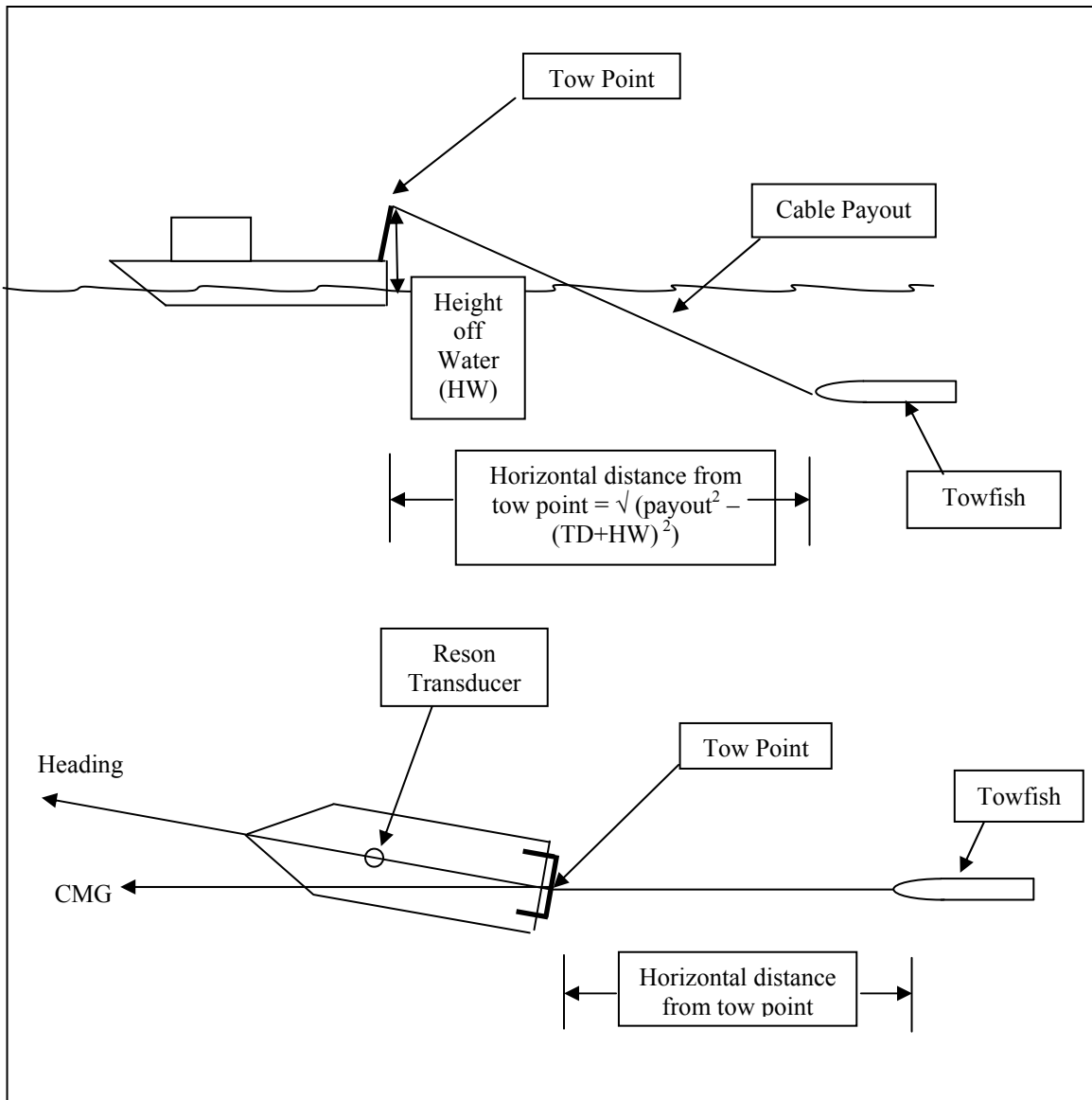
- Klein 3000 digital sidescan sonar towfish with a Klein K1 K-wing depressor
- Klein 3000 Windows XP computer for data collection and logging of sidescan sonar data with Klein **SonarPro** software
- Klein 3000 Transceiver Processing Unit
- McArtney sheave with cable payout indicator
- Sea Mac winch with remote controller
- Uninterrupted power supplies (UPS) for protection of the computer system

The Klein 3000 is a conventional dual frequency sidescan sonar system. The sonar ping rate is automatically set by the transceiver based on the range scale setting selected by the user. At a range scale of 50 meters, the ping rate is 15 pings/second and at a range scale of 75 meters, the ping rate is 10 pings/second. Based on these ping rates, maximum survey speeds were established for each range scale setting to ensure that there were a minimum of three pings per meter in the along-track direction. The maximum survey speeds were 9.7 knots at the 50 meter range and 6.4 knots at the 75 meter range. Sidescan operations were conducted in water depths ranging from 1.79 to 33.56 meters (5 to 110 feet). The 50 meter range scale was used on all four sheets in areas where the water depths were predominantly less than 18 meters (60 feet). The 75 meter range scale was used only on H11648 and H11650 in areas where the water depths were consistently deeper than 18 meters (60 feet).



During survey operations, digital data from the Klein 3000 processor were sent directly to the Klein 3000 computer for display and logging by Klein **SonarPro** software. Raw digital sidescan data from the Klein 3000 were collected in eXtended Triton Format (XTF) and maintained at full resolution, with no conversion or down sampling techniques applied. Sidescan data file names were changed automatically every hour and manually at the completion of a survey line. These files were archived to the data processing computer for initial processing and quality control review at the completion of each survey line. At the end of each survey day (i.e. Julian Day, JD) the raw XTF sidescan data files were backed up on digital tapes which were shipped to the Data Processing Center in Newport, RI, during port calls.

Towfish positioning was provided by **ISS-2000** through a program module called "rtcatnry" that used a Payout and Towfish Depth method (Figure A-2) to compute towfish positions. The position of the tow point (or block) was continually computed based on the known offsets from the Reson 8101 to the tow point and the vessel heading. The towfish position was then calculated from tow point position using the measured cable out (received by **ISS-2000** from the cable payout meter), the towfish pressure depth (sent via a serial interface from the Klein 3000 computer to the **ISS-2000**), and the Course Made Good (CMG) of the vessel. The calculated towfish position was sent to the Klein 3000 data collection computer once per second in the form of a GGA (NMEA-183, National Marine Electronics Association, Global Positioning System Fix Data String) message where it was merged with the sonar data file. Cable adjustments were made using a remote winch controller inside the real time survey van in order to maintain acceptable towfish altitudes and sonar record quality. Changes to the amount of cable out were automatically saved to the **ISS-2000** message file and a payout file.



**Figure A-2. Geometry of Sidescan Towfish Position Calculations Using the Payout and Depth Method.**

Towfish altitude was maintained between 8% and 20% of the range scale (4-10 meters at 50m range; 6-15 meters at 75m range), when conditions permitted. For vessel, equipment, and personnel safety, data were occasionally collected at towfish altitudes outside the 8% to 20% of the range over shoal areas and in the vicinity of charted obstructions or wrecks. In some regions of the survey area, the presence of a significant density layer also required that the altitude of the towfish be maintained outside the 8% to 20% of the range to reduce the effect of refraction that could mask small targets in the outer sonar swath range. When the towfish altitude was outside of the 8% to 20% range, periodic confidence checks on linear features (e.g. trawl scars) or geological features (e.g. sand waves or sediment boundaries) were made to verify the quality of the sonar data across the full sonar record range.

For most of these surveys, a K-wing depressor was attached directly to the towfish and served to keep it below the vessel wake, even in shallower near shore waters at slower survey speeds. The use of the K-wing reduced the amount of cable payout, which in turn reduced the positioning error of the towfish. Another benefit to having less cable out was the increased maneuverability of the ship in shallow water. Less cable out reduced the need to recover cable prior to turning for the next survey line, permitted tighter turns and increased survey efficiency.

### **SOUND SPEED PROFILES**

A Brooke Ocean Technology Moving Vessel Profiler (MVP) with an Applied Microsystems Smart Sound Velocity and Pressure (SV&P) sensor or a Seabird Electronics SBE-19 CTD was used to collect sound speed profile (SSP) data. SSP data were obtained at intervals frequent enough to reduce sound speed errors. The frequency of casts was based on observed sound speed changes from previously collected profiles and time elapsed since the last cast. Periodically during a survey day, multiple casts were taken along a survey line to identify the rate and location of sound speed changes. Based on the observed trend of sound speed changes along a line, the cast frequency and location for subsequent lines were modified accordingly. Confidence checks of the sound speed profile casts were conducted weekly by comparing two consecutive casts taken with different Sound Velocity and Pressure sensors or with a Sound Velocity and Pressure sensor and a Seabird SBE-19 CTD.

Serial numbers and calibration dates are listed below. Sound speed data and calibration records are included with the survey data in Section II of the Separates for each sheet's Descriptive Report.

Applied Microsystems Ltd., SV&P Smart Sensor, Serial Number 4523  
Calibration Dates: 18 May 2007 and 26 February 2008.

Applied Microsystems Ltd., SV&P Smart Sensor, Serial Number 4404  
Calibration Dates: 18 May 2007. Sensor was damaged beyond repair during survey operations. No post survey calibrations available.

Applied Microsystems Ltd., SV&P Smart Sensor, Serial Number 5332  
Calibration Dates: 18 July 2007 and 26 February 2008.

Applied Microsystems Ltd., SV&P Smart Sensor, Serial Number 4880  
Calibration Dates: 8 March 2007 and 26 February 2008.

Seabird Electronics, Inc., CTD, Serial Number 0648  
Calibration Dates: 12 June 2007 and 08 February 2008.

## **DATA ACQUISITION AND PROCESSING SOFTWARE**

Data acquisition was carried out using the SAIC **ISS-2000** Version 3.12.3 software for Windows XP operating systems to control real-time navigation, data time tagging, and data logging.

Survey planning, data processing and analysis were carried out using the SAIC **Survey Planning** and **SABER** Version 4.1.12 software packages for LINUX operating systems. On 05 July 2007, **SABER** version 4.1.12.1 and patches was installed on the survey vessel and used throughout the rest of the survey operations. On 16 July 2007, **SABER** version 4.1.12.1 and patches was installed in the Data Processing Center. On 12 October 2007 **SABER** version 4.1.16 with patches was installed in the Data Processing Center only.

**SonarPro** version 9.6, running on a Windows XP platform was used for sidescan data acquisition.

**Isis** version 6.06, running on a Windows XP platform was used for sidescan data quality review, target identification and contact generation.

## **B. QUALITY CONTROL**

A systematic approach to tracking data has been developed to maintain data quality and integrity. Several forms and checklists have been developed to track the flow of data from acquisition through final processing. These forms are presented in the Separates section included with the data for each survey.

During data collection, survey watch standers continuously monitored the systems, checking for errors and alarms. Thresholds set in the **ISS-2000** system alerted the watch stander by displaying alarm messages when error thresholds or tolerances were exceeded. Alarm conditions that may have compromised survey data quality were corrected and noted in both the navigation log and the message files. Warning messages such as the temporary loss of differential GPS, excessive cross track error, or vessel speed approaching the maximum allowable survey speed were addressed by the watch stander and automatically recorded into a message file. Approximately every 1-2 hours the real-time watch standers completed checklists to verify critical system settings and ensure valid data collection.

Following data collection, initial processing began on the vessel. This included the first level of quality assurance:

- Initial swath editing of multibeam data flagging invalid pings and beams
- Generation of a preliminary PFM CUBE surface
- Second review and editing of multibeam data PFM Cube surface
- Open beam angles where appropriate to identify obstructions outside the cut-off angle
- Identify items for investigation with additional multibeam coverage
- Turning unacceptable data “offline”

- Turning additional data “online”
- Identification and flagging of obstructions and wrecks
- Track plots
- Preliminary minimum sounding grids
- Crossline checks
- Generation of preliminary sidescan coverage mosaics
- Identification of holidays in the sidescan coverage

On a daily basis, the data were binned to minimum depth layers, populating each bin with the shoalest sounding in that bin while maintaining its true position and depth. The following binned grids were created and used for initial crossline analysis, tide zone boundary comparisons, and day to day data comparisons.

- Main scheme, item, and holiday fill survey lines
- Crosslines using only near nadir ( $\pm 5^\circ$  from nadir)

These daily comparisons were used to monitor adequacy and completeness of data and sounding correctors.

During port calls a complete backup of all raw and processed multibeam data and sidescan data was sent to the Newport Data Processing Center (DPC). Analysis of the data at the Newport facility included the following steps:

- Generation of multibeam and sidescan track line plots
- Generation of sidescan contact files
- Application of verified water level correctors to multibeam data
- Application of delayed heave
- Computation of Total Propagated Uncertainty (TPU) for each depth value in the multibeam data
- Generation of a 1 meter CUBE PFM surface for analysis of coverage, areas with high TPU, and features.
- Cross line analysis of multibeam data
- Comparison with prior surveys
- Generation of final CUBE PFM surface(s)
- Generation of S-57 feature file
- Comparison with existing charts
- Quality control reviews of sidescan data and contacts
- Final Coverage mosaic of sidescan sonar data
- Correlation of sidescan contacts with multibeam data
- Generation of final Bathymetric Attributed Grid(s) (BAG) and metadata products
- Final quality control of all delivered data products

Details of the survey system uncertainty model, data processing and quality control procedures for multibeam and sidescan data are described in detail in the following sections.

### **SURVEY SYSTEM UNCERTAINTY MODEL**

The Total Propagated Uncertainty (TPU) model that SAIC has adopted has its genesis at the Naval Oceanographic Office (NAVOCEANO), and is based on work by Rob Hare and others (“Error Budget Analysis for NAVOCEANO Hydrographic Survey Systems, Task 2 FY 01”, 2001, *HSRC FY01 Task 2 Final Report*). Until recently, this concept had been referred to as the Total Propagated Error (TPE) model; however, because true error can not be measured, the term “uncertainty” has now replaced “error” throughout this discussion. This terminology has been adopted by the International Hydrographic Organization in Special Publication No. 44, “*IHO Standards for Hydrographic Surveys, 5<sup>th</sup> Edition, February 2008*”. The fidelity of any uncertainty model is coupled to the applicability of the equations that are used to estimate each of the components that contribute to the overall uncertainty that is inherent in each sounding. SAIC’s approach to quantifying the TPU is to decompose the cumulative uncertainty for each sounding into its individual components and then further decompose those into a horizontal and vertical components. The model then combines the horizontal and vertical uncertainty components to yield an estimate of the system uncertainty as a whole. This cumulative system uncertainty is the Total Propagated Uncertainty. By using this approach, SAIC can more easily incorporate future uncertainty information provided by sensor manufacturers into the model. This also allows SAIC to continuously improve the fidelity of the model as our understanding of the sensors increases or as more sophisticated sensors are added to a system.

The data needed to drive the error model were captured as parameters taken from the Error Parameter File (EPF), which is an ASCII text file typically created during survey system installation and integration. The parameters were also obtained from values recorded in the multibeam Generic Sensor Format (GSF) file(s) during data collection and processing. While the input units vary, all uncertainty values that contributed to the cumulative TPU estimate were eventually converted to meters by **SABER’s Errors** program. The cumulative TPU estimates were recorded as the Horizontal Uncertainty and Vertical Uncertainty at the 95% confidence level in the GSF file. These uncertainty estimates were then used to estimate the accuracy of each individual sounding’s position and depth during both data acquisition and data processing.

Tables B-1 and B-2 show the values entered in the errors parameter file. All parameter uncertainties in this file were entered at the one sigma level of confidence, but the outputs from **SABER’s Errors** program are at the two sigma or 95% confidence level. Sign conventions are: X = positive forward, Y = positive starboard, Z = positive down.

**Table B-1. 2007 M/V Atlantic Surveyor Error Parameter File (EPF)**

<b>Parameter</b>	<b>Value</b>	<b>Units</b>
static draft	2.30*	Meters
draft error (uncertainty)	0.01	Meters
draft variation error	0.02	Meters
squat error (uncertainty)	0.02	Meters
fixed heave error component (uncertainty)	0.05	Meters
perc swellheave_err component (uncertainty)	5.00	Percent

Parameter	Value	Units
roll_measurement_error (uncertainty)	0.02	Degrees
pitch_measurement_error (uncertainty)	0.02	Degrees
heading_measurement_error (uncertainty)	0.02	Degrees
speed_measurement_error (uncertainty)	0.015	meters/second (m/s)
SSSV_measurement_error (uncertainty)	1.00	meters/second (m/s)
predicted_tide_measurement_error (uncertainty)	0.17	Meters
observed_tide_measurement_error (uncertainty)	0.07	Meters
tide_zone_error (uncertainty)	0.10	Meters
positioning_device_x_offset	4.62	Meters
positioning_device_xoffset_err (uncertainty)	0.012	Meters
positioning_device_y_offset	-0.54	Meters
positioning_device_yoffset_err (uncertainty)	0.05	Meters
positioning_device_z_offset	-7.98	Meters
positioning_device_zoffset_err (uncertainty)	0.013	Meters
VRU_device_x_offset	0.34	Meters
VRU_device_x_offset_error (uncertainty)	0.01	Meters
VRU_device_y_offset	0.12	Meters
VRU_device_y_offset_error (uncertainty)	0.01	Meters
VRU_device_z_offset	-1.64	Meters
VRU_device_z_offset_error (uncertainty)	0.01	Meters
gps_latency	0.00	milliseconds (msec)
vr_latency	0.00	milliseconds (msec)
gps_latency_error (uncertainty)	1.00	milliseconds (msec)
vr_latency_error (uncertainty)	1.00	milliseconds (msec)
horizontal_navigation_error (uncertainty)	0.75*	Meters
svp_measurement_error (uncertainty)	1.00	meters/second (m/s)

\*NOTE: These values would only be used if not included in the GSF file

**Table B-2. 2007 Reson 8101 Sonar Parameters**

Parameter	Value	Units
transducer_device_x_offset	0.00*	Meters
transducer_device_xoffset_error (uncertainty)	0.00	Meters
transducer_device_y_offset	0.00*	Meters
transducer_device_yoffset_error (uncertainty)	0.00	Meters
transducer_device_z_offset	0.00*	Meters
transducer_device_zoffset_error (uncertainty)	0.00	Meters
roll_offset_error (uncertainty)	0.005	Degrees
pitch_offset_error (uncertainty)	0.05	Degrees
heading_offset_error (uncertainty)	0.05	Degrees
mechanical_pitch_comp_error (uncertainty)	0.00	Degrees
sounder_latency	0.00*	milliseconds (msec)
sounder_latency_error (uncertainty)	1.00	milliseconds (msec)
model_tuning_factor	6.00	Meters
amplitude_phase_transition	1.00	Meters
range_sampling_res	0.05*	Meters

\*NOTE: These values would only be used if not included in the GSF file

### **MULTIBEAM DATA PROCESSING**

At the end of each survey line, all data files were closed and new files opened for data logging. The closed files were then auto-archived to the on-board processing computers where track lines were generated and the multibeam data file was reviewed to flag erroneous data such as noise, flyers, fish, etc. The multibeam data were reviewed and edited on-board the vessel using SAIC's **Multi-View Editor (MVE)** program. This tool is a geo-referenced editor, which can project each beam in its true geographic position and depth in both plan and profile views. Preliminary Total Propagated Uncertainty attribution was applied to the GSF files and they were loaded into a two-meter PFM CUBE surface. Further review and edits to the data were performed from the PFM grid. Periodically both the raw and processed data were backed up onto digital tapes, and external hard drives. These tapes and hard drives were shipped to the Data Processing Center in Newport, RI at each port call.

Once the data were in Newport and extracted to the Network Attached Storage (NAS) unit for the DPC, the initial processing step was to create track lines from the multibeam data. Once created, the tracks were reviewed to confirm that no navigational errors existed and that the tracks extended to the survey limits. Verified water levels, delayed heave, and if necessary, corrections to the draft were also applied to the data at this time. The final Total Propagated Uncertainty for each depth was then calculated and applied to the multibeam data.

For each survey sheet, all multibeam data were then processed into a one-meter node PFM CUBE Surface for analysis using **SABER** and **MVE**. The one-meter node PFM CUBE Surface was generated to demonstrate coverage for the entire sheet and to provide the best estimate of the depth for depths 15 meters and deeper. A separate half-meter node PFM CUBE Surface was generated to provide a best estimate of depth for depths less than 15 meters. All individual soundings used in development of the final CUBE depth surface had modeled vertical and horizontal uncertainty values at or below the allowable error specified in the April 2007 edition of the "NOS Hydrographic Surveys Specifications and Deliverables."

Two separate uncertainty surfaces are calculated by the **SABER** software, CUBE Standard Deviation and Average Total Propagated Uncertainty (Average TPU). The CUBE Standard Deviation is a measure of the general agreement between all of the soundings that contributed to the best hypothesis for each node. The Average TPU is the average of the vertical uncertainty component for each sounding that contributed to the best hypothesis for the node. A third uncertainty surface is generated from the larger of these two uncertainties at each node and is referred to as the Final Uncertainty.

After creation of the initial one-meter and half-meter PFM CUBE surfaces, the **SABER Check PFM Uncertainty** function was used to highlight all of the cases where computed final node uncertainties exceeded IHO Order 1. An initial review of the areas with final uncertainties exceeding IHO Order 1 revealed that most of these areas were around wrecks, obstructions, and on steep slopes where there tended to be much greater variability in the soundings that contributed to a particular node. In some cases, this



uncertainty review resulted in the creation of additional features or designated soundings on reliable soundings that were shoaler than the CUBE depths by one-half the allowable uncertainty for that depth. In addition, the uncertainty review also highlighted some areas that required additional data cleaning. When all multibeam files and the PFM CUBE Surface's were determined to be satisfactory, the PFM's CUBE Depth Surface and the Final Uncertainty Surface (the greater of the CUBE standard deviation or the Average TPE for each node) were converted to a BAG for delivery.

Crossline analyses were conducted during data processing to assess the agreement between the main scheme and crossline data that were acquired during the survey. Because the crosslines were acquired at varying time periods throughout the survey period, the crossline analyses provided an indication of potential temporal issues (e.g., tides, speed of sound, draft) that may affect the data. For crossline analysis the data were binned to minimum depth layers, populating each bin with the shoalest sounding in that bin at its true position and depth. The following binned grids were created and used for crossline analysis:

- Main scheme, item, and holiday fill survey lines
- Crosslines using only near nadir ( $\pm 5^\circ$  from nadir)

A depth difference surface was then computed between the main scheme and crossline grid, and the **SABER Junction Analyses** routine was used to summarize the results of this depth difference grid. Results of the crossline analysis are presented in the Descriptive Report for each survey.

Multibeam coverage analysis was also conducted during data processing and on the final CUBE surface to identify areas where multibeam holidays exceeded the allowable three contiguous nodes. These survey operations were conducted at set line spacing optimized to achieve 200% sidescan sonar coverage; 100% multibeam coverage was not required. Main scheme lines were run at 40-meter line spacing (while running the sidescan at a 50-meter range scale) and 65-meter line spacing (while running the sidescan at a 75-meter range scale). The **SABER Gapchecker** routine was run on the one-meter CUBE surface to identify multibeam data holidays exceeding the allowable three contiguous nodes. In addition the entire surface was visually scanned for holidays. While field operations were still underway, additional survey lines were run to fill any holidays that were detected. A limited number of small multibeam coverage gaps may have remained after data processing, resulting primarily from additional cleaning of noise in the outer beams caused by cavitation or schools of fish. Results of the multibeam coverage analysis are presented in the Descriptive Report for each survey.

### **SIDECAN SONAR DATA PROCESSING**

During data acquisition, the Klein 3000 digital sidescan data were recorded in XTF format on the hard disk of the Klein 3000 computer. After the file name change at the end of each line, the sidescan data files were auto-archived to the on-board data processing computer. Onboard sidescan data processing included, at a minimum, generating towfish track plots and initial imagery mosaics for coverage verification and

quality control. When possible, initial data review and contact generation was performed on board the vessel as well. All original and processed sidescan data files were backed up on digital tapes and external hard drives for transfer to the Data Processing Center.

Either on the vessel or at the DPC, initial processing also included re-navigating the towfish to apply more accurate towfish positions using the **SABER Navup** routine. This routine replaced the towfish positions recorded in the original sidescan XTF file with the towfish positions recorded in the real-time catenary data file recorded by **ISS-2000**. The **Navup** routine also computed and applied a unique position and heading for each ping record (as opposed to the 1 Hz position data recorded during data acquisition). Each record in the catenary file includes:

- Time
- Fish position
- Cable out
- Layback
- Fish velocity
- Fish heading
- Fish depth
- Tow angle

During examination of sidescan sonar data, a sidescan review log was generated and maintained throughout the process. This review log initially incorporated all of the relevant information about each sidescan data file, including the line begin and line end times, survey line name, corresponding multibeam and sidescan file names, line azimuth, and any operator notations made during data acquisition. During the subsequent sidescan data review stages, the review log was updated to reflect data quality concerns, to highlight data gaps (due to refraction, fish, etc.), to identify significant sidescan contacts, and to address any other pertinent issues regarding interpretation of the with the sidescan data. The sidescan review log is included in Separates I of the Descriptive Report for each sheet.

### Sidescan Quality Review

During the sidescan review, an experienced sonar data analyst conducted a quality review of each sidescan file using Triton **Isis** to replay the data. During this review, the processor assessed the overall quality of the data and defined holidays in the data where the quality was insufficient to clearly detect seafloor contacts across the full range scale. The times of and reasons for these data holidays were entered into the sidescan review log. The times of all noted sidescan data gaps were incorporated into the sidescan data time window files that were then used to depict the data gap within the applicable sidescan coverage mosaic. Data holidays were generally characterized by:

- Surface noise (vessel wakes, sea clutter, and/or waves)
- Towfish motion (yaw and heave)
- Electrical noise
- Acoustic noise
- Large, dense schools of fish
- Density layers (refraction)

### Sidescan Coverage Analysis

A time window file listing the times of all valid online sidescan data was created, along with separate sidescan file lists for the first and second 100% coverage mosaic. The time window file and file lists were then used to create towfish track lines and mosaics in **SABER**. The first and second 100% coverage mosaics were reviewed using tools in **SABER** to verify swath coverage and to plan additional survey lines to fill in any data gaps.

### Sidescan Contact Analysis

During sidescan review, sonar contacts were selected and measured using the **Isis Target** utility. Significant sidescan contacts were chosen based on size and height, or a unique sonar signature. In general, contacts with a computed target height greater than 50 centimeters were selected. Within charted fish havens, contacts were made on objects with a least depth less than the authorized minimum depth, wrecks, or unusually large objects. Contacts with a unique sonar signature (e.g. size, shape, and reflectivity) were typically selected regardless of height. Contacts made within **ISIS** were saved as a “.CON” file, which included a snapshot of the image and the following contact information:

- Year and JD
- Time
- Position
- Fish altitude
- Slant range to contact (Note: port = negative #, starboard = positive #)
- Contact length, width, and height (based on shadow length, fish altitude, and slant range)

During sidescan data review in **ISIS**, the Average Display Downsample Method was used because it provided the best general-purpose review setting. This setting specifies how the data will be sampled for display in the waterfall display. Down sampling is necessary since the number of pixels displayed is constrained by the width of the display window and the screen resolution. The Triton **Isis Target** utility does not down sample the sidescan data to display the sonar image. If the number of samples contained in the sidescan data record exceeds the number of pixels available on the screen, the software will only show a portion of the record at a single time and provides a scroll bar to be able to view the remaining part of the record. When measuring contacts within Triton **Isis Target**, the length is always the along track dimension and the width is always the across track dimension. Therefore you can have a width measurement that is longer than the length measurement.

Wrecks and large objects were positioned at their highest point based on the observed acoustic shadow. Similarly, contacts for debris fields were positioned at the highest object in the debris field. Additional contacts were made on other man-made objects such as exposed cables, pipelines, and sewer outfalls. In addition to contacts, the sidescan review log also includes entries for many non-significant seafloor objects (e.g.,

fishing gear, small objects, etc.) that were identified during the sidescan review. The sidescan review log is included in Separates I of the Descriptive Report for each sheet.

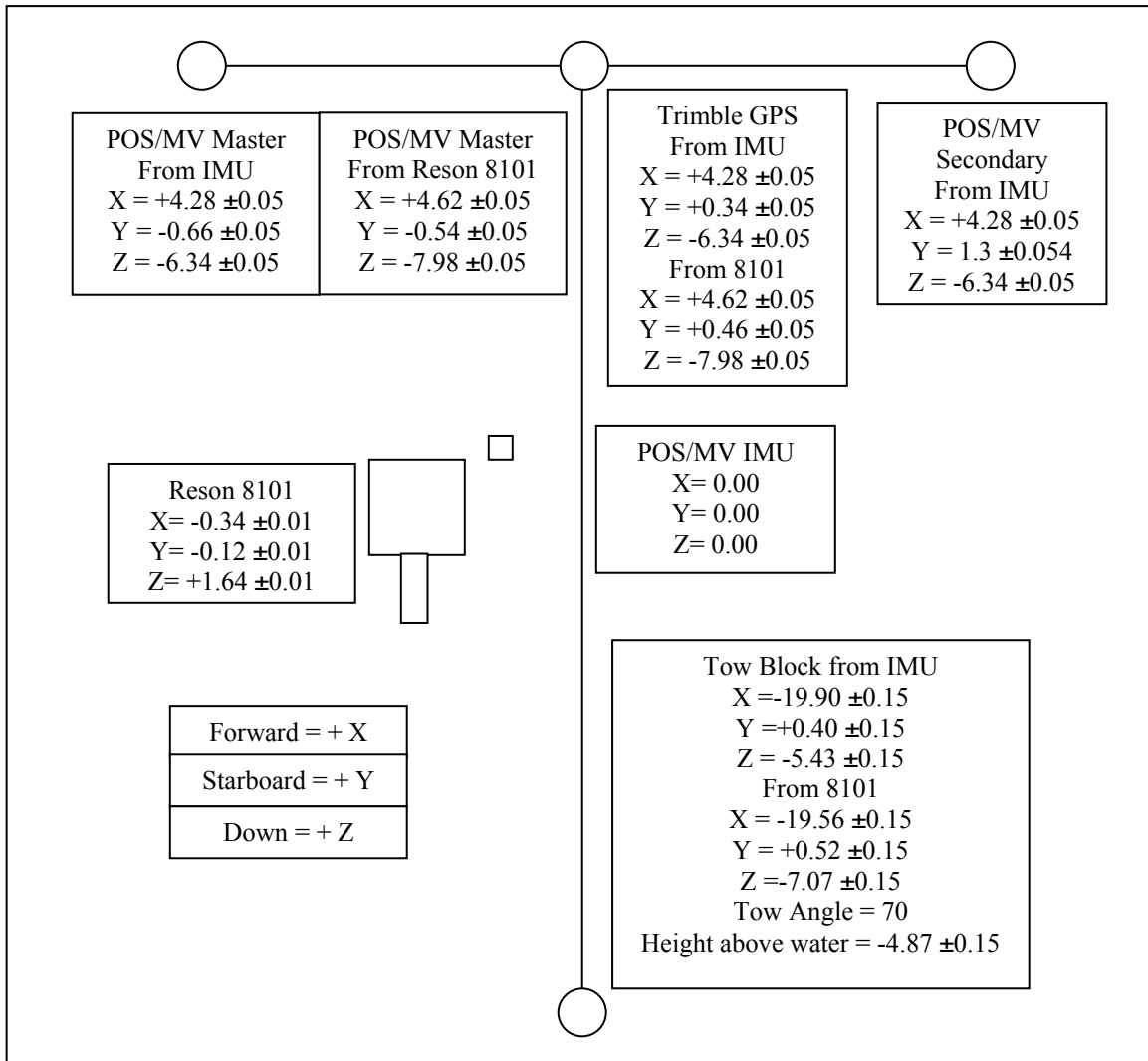
After a second, independent, review of the sidescan files was completed; the contact files were converted into a sidescan contact (CTV) file and tiff images using a **SABER** program called **isis2ctv**. The CTV is a text file that documents all of the contact attributes contained in the individual contact files. In **SABER**, the CTV file was directly loaded and viewed as a separate data layer along with a gridded depth layer. By comparing the multibeam bathymetry with the sidescan contact data, both datasets could be evaluated to determine the significance of a contact and the need to create additional sidescan contacts or multibeam features. Positions and depths of features were determined directly from the multibeam data in SAIC's **MVE** swath editor by flagging the least depth on the object. A multibeam feature file (CNT) was created using the **SABER get\_features** routine which extracted flagged features from the GSF multibeam data. The final correlation process updated the CNT file with the type of feature (obstruction, wreck, etc.) and the CTV file with the feature-to-contact correlation.

### C. CORRECTIONS TO ECHO SOUNDINGS

The data submitted are fully corrected with uncertainties associated with each sounding; therefore, the vessel file will be all zeros.

#### VESSEL CONFIGURATION PARAMETERS

Figure C-1 depicts the *M/V Atlantic Surveyor* sensor configuration and the vessel offsets are tabulated in Table C-1. All measurements are in meters. For the surveys, the Reson 8101 transducer was hull-mounted. Offset measurements were made from the IMU with the final position being computed and reported as the acoustic center of the Reson 8101. The reference point for the entire system was located at the Reson 8101 transducer acoustic center.



**Figure C-1. Configuration and Offsets of M/V Atlantic Surveyor Sensors during the 2007 Survey Operations (measurements in meters with 68% CI measurement errors)**

**Table C-1. *M/V Atlantic Surveyor* Offset Measurements of Antenna and Transducer during the 2007 Survey Operations (measurements in meters with 68% CI measurement errors)**

Sensor	Offset in ISS-2000		Offset in POS/MV	
Multibeam Reson 8101 Transducer Hull Mount (Ref to vessel lever arm)			X	-0.34 ±0.01
			Y	-0.12 ±0.01
			Z	+1.64 ±0.01
Reference to Heave (Ref to IMU lever arm)			X	0.00
			Y	0.00
			Z	0.00
POS/MV GPS Master Antenna (Ref to primary GPS lever arm)			X	4.28 ±0.05
			Y	-0.66 ±0.05
			Z	-6.34 ±0.05
Reference to Vessel			X	-0.34 ±0.01
			Y	-0.12 ±0.01
			Z	+1.64 ±0.01
Trimble GPS Antenna	X	+4.62 ±0.05		
	Y	+0.46 ±0.05		
	Z	-7.98 ±0.05		
A-Frame Tow Block (Z = Height above the Water)	X	-19.5 ±0.15		
	Y	+0.52 ±0.15		
	Z	-4.87 ±0.15		

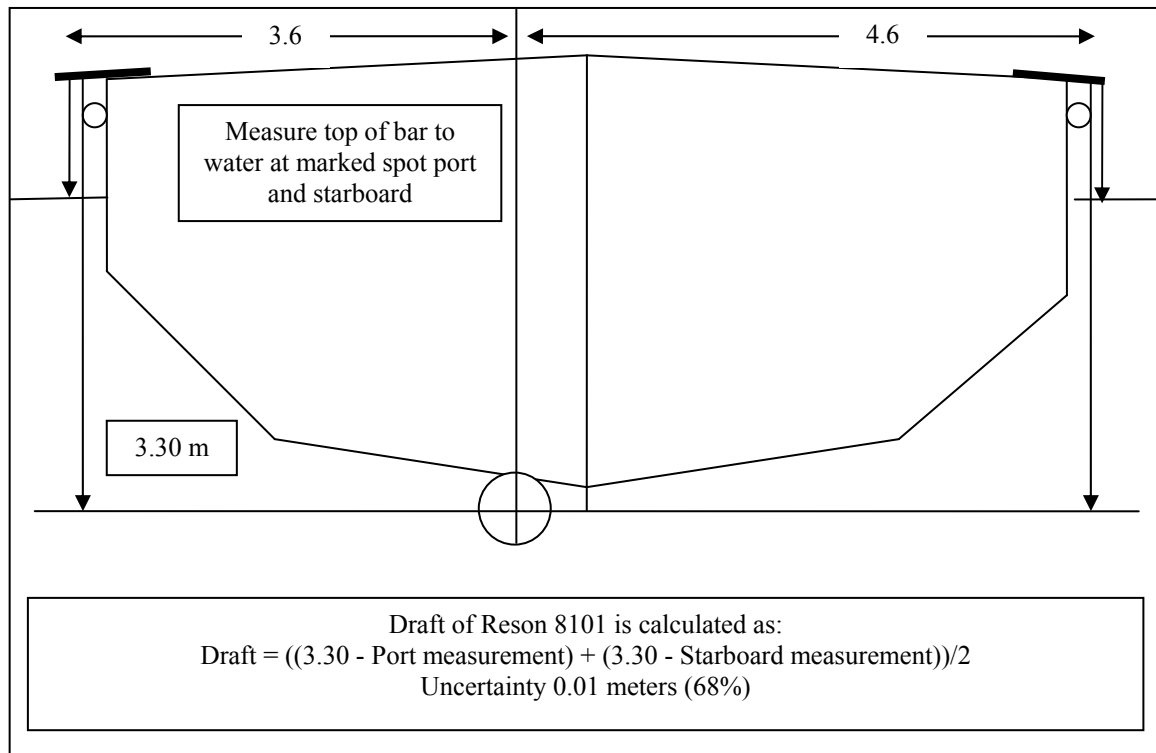
The SAIC Integrated Survey System (**ISS-2000**) and the POS/MV utilize a coordinate system where “z” is considered to be positive down, “x” is considered to be positive forward, and “y” is considered to be positive athwart ships to starboard. Sensor offsets were entered into either the POS/MV or **ISS-2000** and all sensors connected to **ISS-2000** have their coordinate system transformed to match the one used by **ISS-2000**.

### STATIC AND DYNAMIC DRAFT MEASUREMENTS

#### Static Draft

Figure C-2 shows the draft calculations for the *M/V Atlantic Surveyor*. Depth of the transducer’s acoustic center below the deck (3.30 meters) was determined from measurements made while the boat was hauled in May 2004. By subtracting the measured distance from the main deck to the waterline on both sides of the vessel, and averaging the two values, the transducer distance below the water surface (static draft) was determined.

Static draft measurements were taken on each side of the vessel at each port call, both after arrival and before departure, in order to prorate the daily draft for fuel and water consumption. The draft value was then recorded in the real-time Navigation Log. If the static draft value changed from the previously noted value, the new value was entered into the **ISS-2000** system. The observed and prorated static draft for each survey is included with the survey data in Section I of the Separates of each Sheet’s Descriptive Report.



**Figure C-2. M/V Atlantic Surveyor Draft Determination**

### Dynamic Draft

Dynamic draft values were confirmed during the 2007 Sea Acceptance Test (SAT). A multibeam soundings reference was established by bringing the vessel to “all stop” and drifting. Two transects were created, one crossed across the reference swath at a selected spot and the other was aligned along the center line of the drift. Each line was run twice at each of the shaft RPM settings. An initial set of survey lines was run on Julian Day 183 and repeated on Julian Day 184. Lines were run parallel to the drift line as well as perpendicular to the drift line with the settlement and squat values determined during the 2007 SAT entered into **ISS-2000**. This procedure is valid because the IMU and the multibeam transducer were mounted almost directly in line vertically. A PFM of the data was made and the differences in the nadir beam depths at various RPM settings were examined in **SABER’s Multi View Editor**. The reference file and the two files for the desired shaft RPM were displayed simultaneously, and depth differences were measured at several places. Difference grids of the 5 degree nadir beams were also made to compare to the PFM. Table C-2 summarizes the shaft RPM, depth corrector approximate speed and SAT multibeam files used. A shaft RPM counter provides automatic input to the Settlement and Squat look up table in the **ISS-2000** system. Approximate speeds in Table C-2 are for reference only.

**Table C-2. M/V Atlantic Surveyor Settlement and Squat Determination**

Shaft RPM	Depth Corrector	Approximate Speed (Kts)	Files	
			Julian Day 183	Julian Day 184
0	0.00 ±0.02	0	asmba07183.d04	asmba07184.d04
140	0.03 ±0.02	4	asmba07183.d05 asmba07183.d06	asmba07184.d05 asmba07184.d06
180	0.05 ±0.02	5	asmba07183.d07 asmba07183.d08	asmba07184.d07 asmba07184.d08
220	0.06 ±0.02	6	asmba07183.d09 asmba07183.d10	NOT RUN
250	0.07 ±0.02	7	asmba07183.d11 asmba07183.d12	asmba07184.d09 asmba07184.d10
300	0.10 ±0.02	8	asmba07183.d13 asmba07183.d14	asmba07184.d11 asmba07184.d12
340	0.10 ±0.02	9	asmba07183.d15 asmba07183.d16	asmba07184.d13 asmba07184.d14
380	0.13 ±0.02	10	asmba07183.d17 asmba07183.d18	asmba07184.d15 asmba07184.d16

### SPEED OF SOUND

A Moving Vessel Profiler (MVP), constructed by Brooke Ocean Technology Ltd., with an Applied Microsystems Ltd. Smart Sound Velocity and Pressure (SV&P) sensor, was used to determine sound speed profiles for corrections to multibeam sonar soundings. During repairs of the MVP or upon failure of the instrument, a Seabird Electronics SBE-19 CTD was used to obtain sound speed profiles.

Weekly confidence checks were obtained using consecutive casts with two different SV&P sensors or with a Seabird Electronics SBE-19 CTD. After downloading the sound speed profile (SSP) casts, graphs and tabulated lists were used to compare the two casts for discrepancies.

During multibeam acquisition, SSP casts were uploaded to **ISS-2000** immediately after they were taken. In **ISS-2000**, the profiles were reviewed for quality and edited as necessary, compared to the preceding casts, and then “applied” to the system. Once applied, **ISS-2000** used the cast for speed and ray tracing corrections to the multibeam sounding data. If sounding depths exceeded the cast depth, the **ISS-2000** used the deepest sound speed value of the cast to extend the profile to the maximum depth.

Factors considered in determining how often a SSP cast was needed included shape and proximity of the coastline, sources and proximity of freshwater, seasonal changes, wind, sea state, cloud cover, and observed changes from the previous profiles. Casts were taken at the beginning of each survey leg, approximately one-hour intervals thereafter, and upon moving to a different survey area.

Quality control tools in **ISS-2000**, including real-time displays of color-coded coverage and a multibeam swath waterfall display, were used to monitor how the sound speed affected the multibeam data. By using these techniques any severe effects due to sound speed profiling could clearly be seen when viewing multibeam data in an along-track

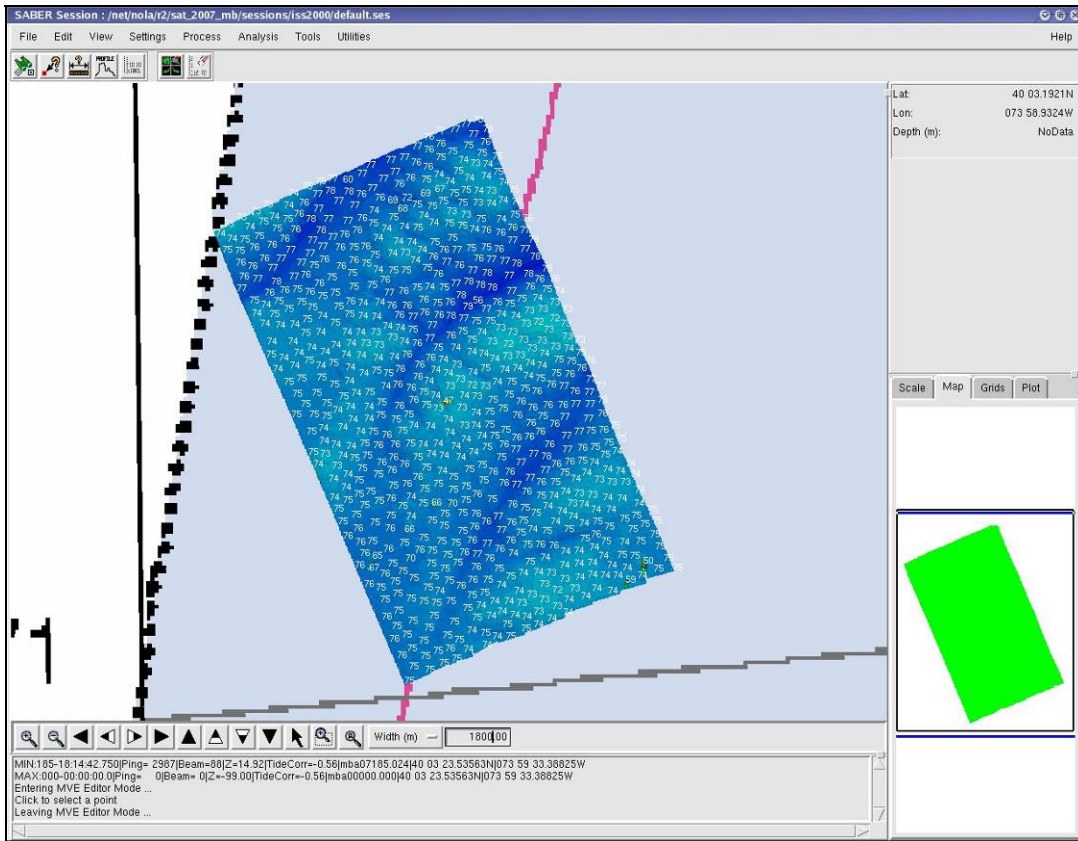


direction. Proper sound speed application and effects were also analyzed throughout the survey by using SAIC’s **Analyze Crossings** software.

A table including all SSP casts, date, location, and maximum depth is located in Section II of the Separates of the sheet’s DR.

**MULTIBEAM ACCURACY**

In the vicinity of the alignment site, a small survey was run with swaths from several main scheme lines and a crossline covering a wreck. This survey, in addition to selected soundings over a color-by-depth grid, is shown in Figure C-3. Cross line comparisons based on predicted tides and preliminary zoning are presented in Table C-3. Comparisons between main scheme and crossline data from this small survey show that 95% of comparisons are within 20 centimeters and 99% are within 30 centimeters.



**Figure C-3. Survey Grid and Selected Soundings**

**Table C-3. Junction Analysis of Cross versus Main Scheme**

Depth Difference Range (cm)	All		Positive		Negative		Zero
	Count	Percent	Count	Percent	Count	Percent	Count
0-5cm	3517	49.45	1822	40.82	1275	57.23	420
5-10cm	2224	80.72	1526	75	698	88.55	
10-15cm	798	91.94	581	88.02	217	98.29	
15-20cm	275	95.81	256	93.75	19	99.15	
20-25cm	192	98.51	190	98.01	2	99.24	
25-30cm	65	99.42	65	99.46	0	99.24	
>30	41	100	24	100	17	100	

**MULTIBEAM CALIBRATIONS**

Navigation positioning, heading, heave, roll and pitch were provided by the Applanix POS/MV 320 Inertial Navigation System. Resolution and accuracy of this system are:

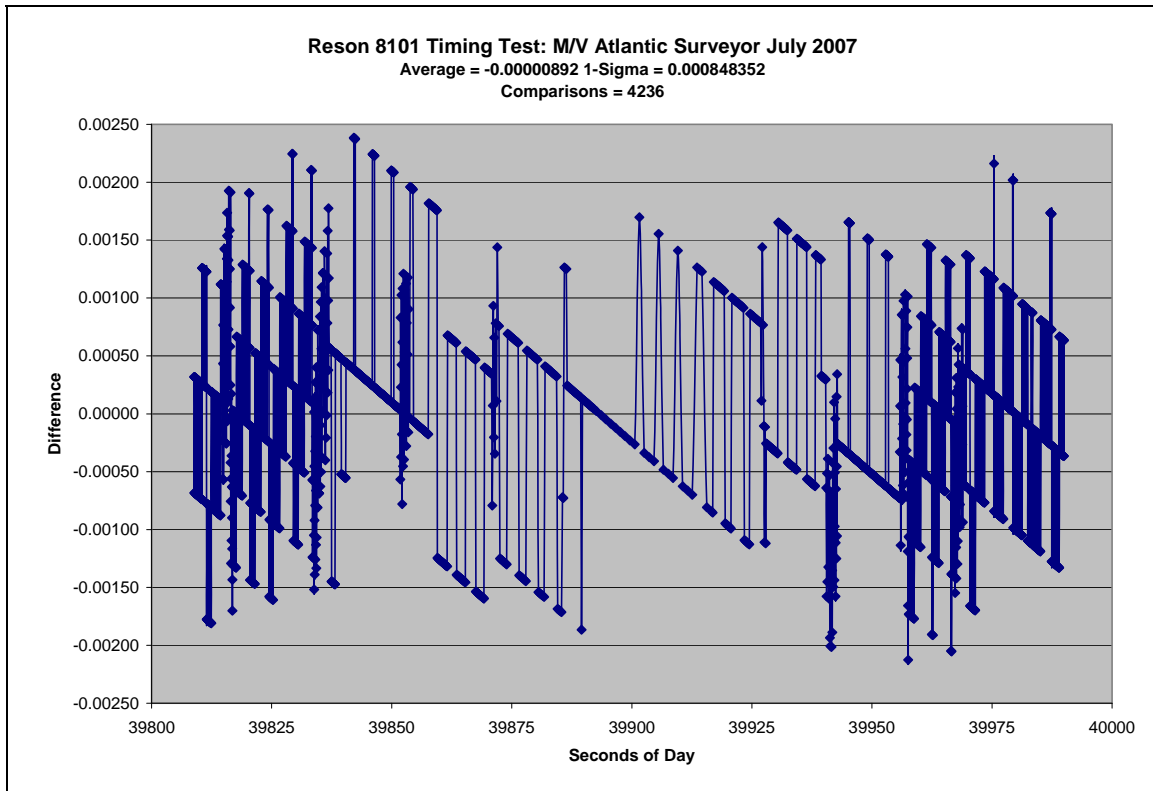
- Heave Resolution 1 cm, Accuracy greater of 5 cm or 5% of heave amplitude
- Roll Resolution 0.01°, Accuracy 0.02°
- Pitch Resolution 0.01°, Accuracy 0.02°

The Applanix True Heave option was used to record delayed heave for application in post processing.

**Timing Test**

A ping timing test was completed on 05 July 2007 to verify that no timing errors existed within the survey system. The fundamental measurement tool is the event marking capability of the Symmetricom BC635PCI IRIG-B card. An event is characterized by a positive-going TTL pulse occurring on the event line of the IRIG-B connector on the back of the ISSC. The pulses of interest are the transmit trigger of the RESON 81-P and the 1PPS timing pulses from the POS/MV. This test demonstrated that all GSF ping times matched the corresponding IRIG-B event times to within 2.5 milliseconds or less. The times in each file were compared and the results are plotted in

Figure C-4. Timing tests of **ISS-2000** were successfully completed prior to any other calibration tests.



**Figure C-4. Timing Test Results**

**Multibeam Bias Calibration**

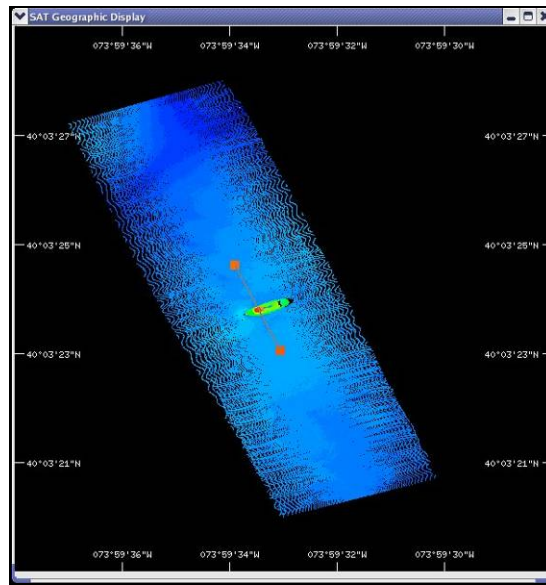
Multibeam alignment calibration was performed on 02 July 2007 (JD183) prior to commencing survey operations. The alignment was performed on a 47-foot wreck in the fish haven approximately 6 kilometers southeast of Manasquan Inlet. The wreck is charted in 40° 03' 23.55"N 073° 59' 33.25"W. The wreck is located in a fish haven approximately 6 kilometers southeast of Manasquan Inlet. The calibration resulted in bias values shown in Table C-4. Before running bias calibration lines, all instrument offsets were entered into **ISS-2000** and all bias values were set to zero. Bias determinations were made using the **SABER Swath Alignment Tool (SAT)** program.

**Table C-4. Alignment Biases Calculated Using Swath Alignment Tool**

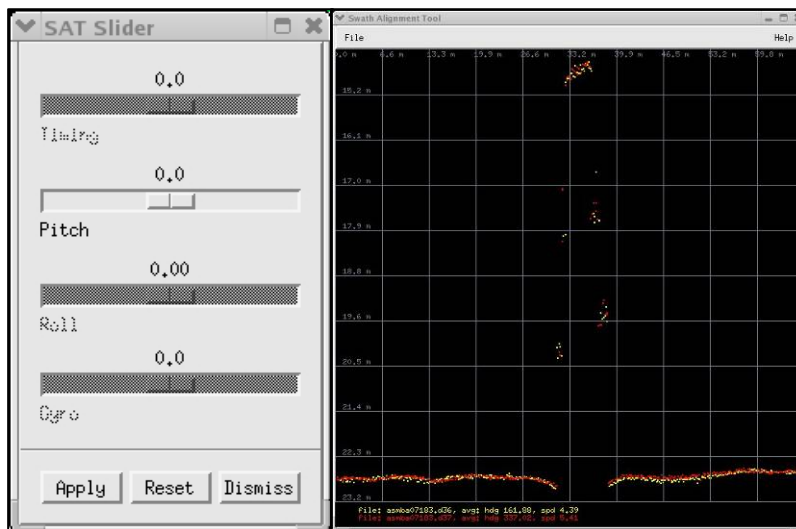
Component	Multibeam files (pairs)		Bias
<b>Pitch</b>	asmba07183.d36	asmba07183.d37	+0.8° ±0.02°
<b>Roll</b>	asmba07183.d36	asmba07183.d37	+0.83° ±0.02°
<b>Gyro</b>	asmba07183.d38	asmba07183.d38	+2.0° ±0.02°

**Pitch Alignment (02 July 2007)**

Two sets of lines were collected for pitch bias calculation. All lines were run along the same survey transect so that separate comparisons could be made. Several samples were viewed for each set of comparison lines in order to determine an accurate measurement of the pitch bias. Figure C-5 and Figure C-6 are images of the SAT tool depicting data collected with the  $+0.8^\circ$  pitch bias entered in the ISS-2000 system; therefore the indicated bias is zero.



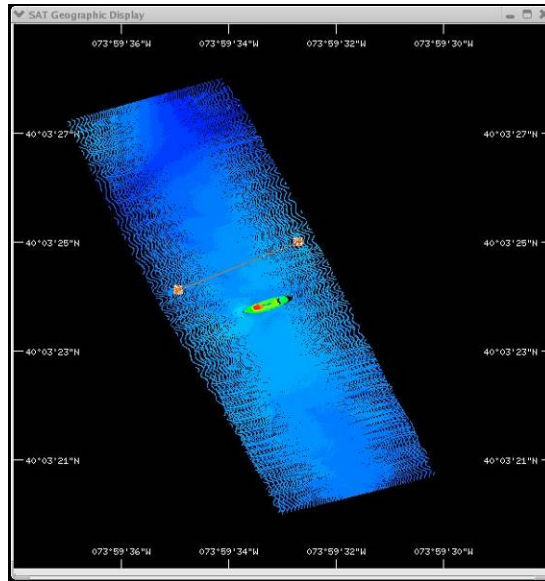
**Figure C-5. SAT Tool, Plan View Depicting  $+0.8^\circ$  Pitch Bias**



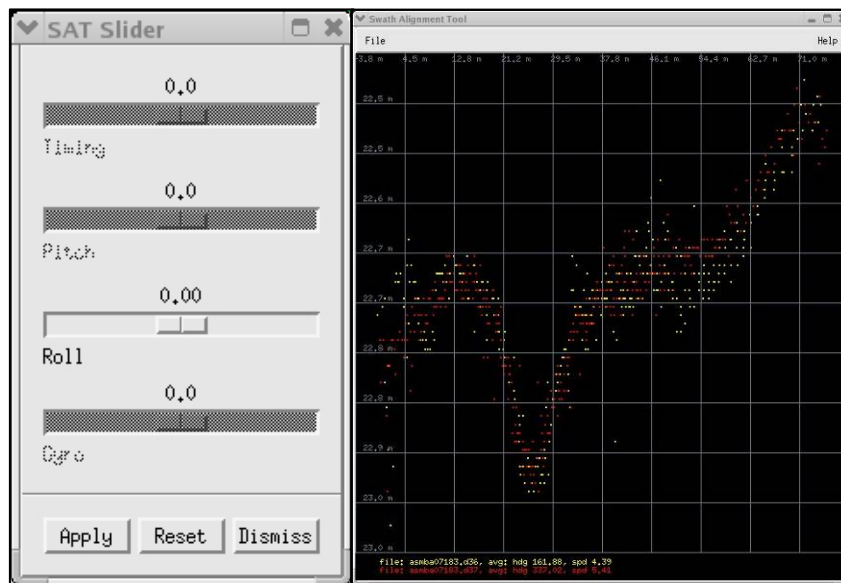
**Figure C-6. SAT Tool, Depth vs. Distance Plot Depicting  $+0.8^\circ$  Pitch Bias Roll Alignment (02 July 2007)**

**Roll Alignment (02 July 2007)**

Two sets of lines were collected for roll bias calculation. All lines were run along the same survey transect in order that separate comparisons could be made. Several samples were viewed for each set of comparison lines in order to determine an accurate measurement of the roll bias. Figure C-7 and Figure C-8 are images of the SAT tool depicting data collected with the +0.83 roll bias entered in the ISS-2000 system; therefore the indicated bias is zero.



**Figure C-7. SAT Tool, Plan View Depicting +0.83 Roll Bias**



**Figure C-8. SAT Tool, Depth vs. Distance Depicting +0.83 Roll Bias Heading Alignment (02 July 2007)**

### Heading Alignment (02 July 2007)

Two sets of lines were collected for heading bias calculation. Lines were run on either side of the charted wreck in opposite directions in order that separate comparisons could be made. Several samples were viewed for each set of comparison lines in order to determine an accurate measurement of the heading bias. Figure C-9 and Figure C-10 are images of the SAT tool depicting data collected with the +2.0° heading bias entered in the ISS-2000 system; therefore the indicated bias is zero.

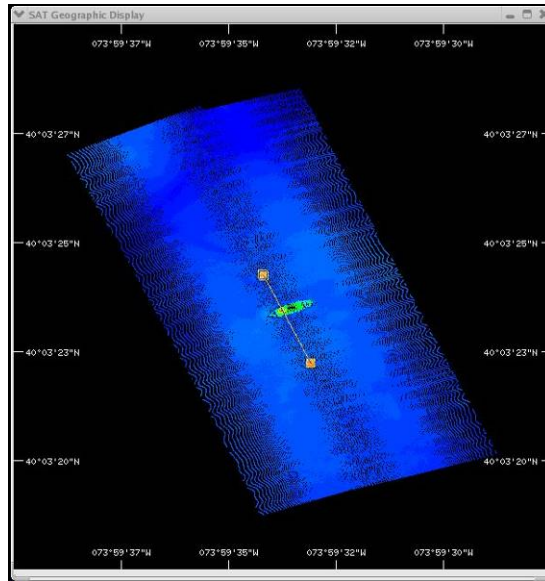


Figure C-9. SAT Tool, Plan View Depicting +2.0 Heading Bias

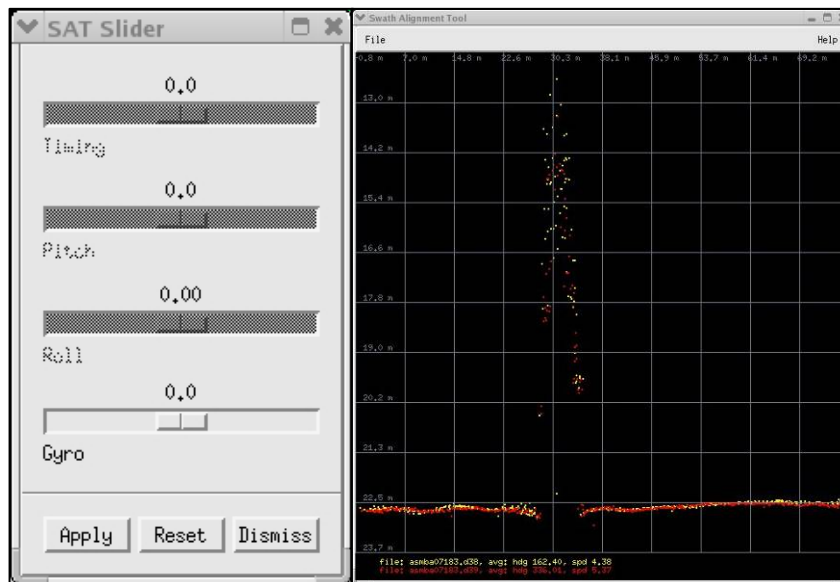


Figure C-10. SAT Tool, Depth vs. Distance Depicting +2.0 Heading Bias

### **TIDES AND WATER LEVELS**

NOAA tide station 8534720 Atlantic City, NJ was the source of final verified water level heights for the Mid-Atlantic Corridor, Coast of Delaware surveys. Preliminary and verified water level data for this station were downloaded from the NOAA Center for Operational Oceanographic Products and Services Tides & Currents web site (<http://tidesandcurrents.noaa.gov/>). All water level data in meters were annotated with Coordinated Universal Time (UTC).

Final water level files for each tide zone were created from downloaded verified tide data using the **SABER Create Water Level Files** tool. Water level files contained water level heights that were algebraically subtracted from depths to correct the sounding for tides and water levels. These water level files were applied to the multibeam data using the **SABER Apply Tides** program within the **SABER** software.

When it was necessary to apply updated water level correctors such as verified tides to the GSF files, the program removed the previous water level corrector and applied the new corrector. Each time a routine was run on the GSF multibeam data file, a history record was appended to the end of the GSF file documenting the date and water level files applied. For quality assurance, the **SABER Check Tides** program was run on all GSF files to confirm that the appropriate water level corrector had been applied to the GSF file.

After confirmation that verified water levels were applied to all multibeam data, grids were created and analyzed using various color change intervals. The color intervals provided a means to check for significant, unnatural changes in depth across zone boundaries due to water level correction errors, unusual currents, storm surges, etc.

The primary means for analyzing the adequacy of zoning was observing zone boundary crossings in **MVE**. In addition, cross line analysis using the **SABER Analyze Crossings** software was used to identify possible depth discrepancies resulting from the applied water level corrector. Discrepancies were further analyzed to determine if they were the result of incorrect zoning parameters or weather (wind) conditions between the tide station and the survey area. The NOAA provided preliminary zone boundaries and zoning parameters are presented in Table C-5.

**Table C-5. Preliminary Tide Zone Parameters**

<b>Zone</b>	<b>Time Corrector (minutes)</b>	<b>Range Ratio</b>	<b>Reference Station</b>
DB1	0	1.00	8557380
DB1A	-12	1.00	8557380
SA26	0	0.92	8534720
SA26A	0	0.87	8534720
SA27	+6	0.88	8534720
SA27A	+6	0.92	8534720
SA28	+6	0.97	8534720
SA35	+18	0.97	8534720
SA36	+18	0.93	8534720

Zone	Time Corrector (minutes)	Range Ratio	Reference Station
SA37	+30	0.98	8534720
SA38	-36	1.00	8557380
SA44	-24	1.00	8557380

### Final Tide Note

H11648, H11649, and H11650 surveys were entirely within preliminary water level zones for Atlantic City, NJ, 8534720 (SA26, SA26A, SA27, SA27A, and SA36). Analysis of the multibeam data from all three surveys in **MVE** and in depth grids revealed minimal depth jumps across the junction of the zones. A spreadsheet analysis of the correctors for each zone (summarized in Table C-6) also confirmed the adequacy of zoning correctors based on Atlantic City, NJ (8534720). For this analysis, observed verified water levels from 06 July 2007 through 18 November 2007, were entered into the spreadsheet. Correctors were computed at 6 minute intervals for each zone. Differences were computed zone-to-zone. As a result, the NOAA preliminary zone boundaries and zoning parameters for Atlantic City (8534720) were accepted as final and applied to all multibeam data for H11648, H11649, and H11650.

**Table C-6. Comparison of Water Level Correctors with Zoning Parameters for Station 8534720**

Zones	SA36 - SA27A	SA26 - SA27A	SA27 - SA27A	SA26A - SA27A	SA26A - SA27
Maximum	0.182	0.118	0.004	0.072	0.097
Minimum	-0.125	-0.097	-0.075	-0.168	-0.104
Average	0.008	0.000	-0.031	-0.039	-0.008
Standard Deviation	0.045	0.025	0.018	0.033	0.024

H11647 survey used preliminary zones from both Lewes, DE; 8557380 (DB1A SA38, and SA44); and Atlantic City, NJ; 8534720 (SA37, SA35, SA28, SA36, and SA27A). Analysis of the H11647 multibeam data in **MVE** and in depth grids revealed significant jumps across the junction of zones based on Atlantic City, NJ (8534720) and the zones based on Lewes, DE (8557380). A spreadsheet was constructed to compare the two sets of NOAA preliminary zoning parameters. The results are summarized in Table C-7. For this analysis, observed verified water levels from 06 July 2007 through 18 November 2007, for both stations were entered in the spreadsheet. Correctors were computed at 6-minute intervals for each zone. Differences (Table C-7) were computed for each zone on Lewes, DE (8557380) with the adjacent zone on Atlantic City, NJ (8534720).



**Table C-7. Comparison of Water Level Correctors with Zoning Parameters for Station 855738 and 8534720**

Zones	SA38 – SA37	SA44 – SA37
Maximum	0.248	0.307
Minimum	-0.235	-0.327
Average	0.000	0.000
Standard Deviation	0.088	0.128

This verified the observed significant difference in multibeam depths caused by differences in verified water level correctors at the zone boundaries depended on the stage of the tide and environmental factors (wind and rain). As a result of this analysis the water level zoning correctors based entirely on Atlantic City, NJ (8534720) were applied to all multibeam data for H11647. Zone DB1 was not used, and zone DB1A was extended slightly on the west to incorporate the one line of multibeam data extending across the Cape Henlopen area. All other zone boundaries were the preliminary boundaries provided by NOAA.

Zoning parameters for zones DB1A, SA28, SA37, SA38, and SA44 were modified to minimize water level corrector jumps across the zone boundaries using verified observed water level data from the Atlantic City, NJ (8534720) station. All final correctors are shown in Table C-8.

**Table C-8. Final Tide Zone Parameters**

Zone	Time Corrector (minutes)	Range Ratio	Reference Station
DB1A	+18.0	0.96	8534720
SA26	0	0.92	8534720
SA26A	0	0.87	8534720
SA27	+6	0.88	8534720
SA27A	+6	0.92	8534720
SA28	+12	0.92	8534720
SA35	+18	0.97	8534720
SA36	+18	0.93	8534720
SA37	+18	0.98	8534720
SA38	+12	0.99	8534720
SA44	+12	0.98	8534720

A spreadsheet was constructed to compare water level correctors across these zone boundaries for H11647 using the final zone parameters and the results are shown in table C-9. In addition the multibeam data crossing these boundaries were compared in MVE and by observing the crossings in the depth grids.

**Table C-9. Comparison of Water Level Correctors with Zoning Parameters for Station 8534720 for H11647**

<b>Zones</b>	<b>DB1A – SA44</b>	<b>SA38 – SA44</b>	<b>SA37 – SA44</b>	<b>SA37 – SA38</b>	<b>SA37 – SA35</b>	<b>SA28 – SA35</b>	<b>SA36 – SA35</b>	<b>SA36 – SA27A</b>
Maximum	0.091	0.019	0.103	0.096	0.019	0.076	0.004	0.182
Minimum	-0.157	-0.001	-0.126	-0.143	-0.001	-0.173	-0.074	-0.125
Average	-0.016	0.008	0.000	-0.008	0.008	-0.039	-0.031	0.008
Standard Deviation	0.028	0.005	0.027	0.027	0.005	0.034	0.018	0.045

**D. APPROVAL SHEET**

02 May 2008

**LETTER OF APPROVAL**

REGISTRY NUMBER: H11647, H11648, H11649, H11650

This Data Acquisition and Processing Report for project OPR-D302-KR-07, Mid-Atlantic Corridor, Coast of Delaware - Maryland Project is respectfully submitted.

Field operations and data processing contributing to the accomplishment of these surveys, H11647, H11648, H11649 and H11650, were conducted under supervision of myself and lead hydrographers Paul L. Donaldson, Jason M. Infantino, Tom Waddington, and Rick Nadeau with frequent personal checks of progress and adequacy. This report has been closely reviewed and is considered complete and adequate as per the Statement of Work.

Reports concurrently submitted to NOAA for this project include:

<u>Report</u>	<u>Submission Date</u>
H11650 Descriptive Report	02 May 2008

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

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