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-G443-KR-09*

Time Frame: *28 October 2009 – Ongoing*

LOCALITY

State *Georgia*

General Locality *Atlantic Ocean*

2009 – 2010

CHIEF OF PARTY

Charles F. Holloway
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.

H12095
H12096
H12097
H12098
H12099

HYDROGRAPHIC TITLE SHEET

INSTRUCTIONS – When the Hydrographic Sheet is forwarded to the office, it should be accompanied by this form filled in as completely as possible.

FIELD NO**. A, B, C, D and E**

State: Georgia
General Locality: Atlantic Ocean
Locality: *Northern Brunswick Safety Fairway (H12095); Southern Brunswick Safety Fairway (H12096); Northern St. Marys Safety Fairway (H12097); St. Marys Safety Fairways (H12098); Southern St. Marys Safety Fairway (H12099)*

Scale: 1:20,000 Date of Survey *28 October 2009 - Ongoing*

Instructions Dated: June 2009 Project No. OPR-G443-KR-09

Vessel: *M/V Atlantic Surveyor*, D582365

Chief of Party: Charles F. Holloway

Surveyed by: *Dan Baker, Alex Bernier, Jediah Bishop, Dan Burgo, Gary Davis, Paul Donaldson, Chuck Holloway, Jason Infantino, Colette LeBeau, Rick Nadeau, Katie Offerman, Evan Robertson, Eva Rosendale, Deb Smith, Jennifer Stone, and Bridget Williams*

Soundings taken by **echo sounder**, hand lead, pole: MULTIBEAM RESON SEABAT 7125

Graphic record scaled by

Graphic record checked by Automated plot

Verification by

Soundings in fathoms, feet**,** **meters** at MLW, **MLLW**

REMARKS: **Contract**: DG133C-08-CQ-0003
Contractor: Science Applications International Corp., 221 Third Street; Newport, RI 02840 USA
Subcontractors: Rotator Staffing Services, PO Box 366, 557 Cranbury Rd, E. Brunswick NJ 08816
Times: All times are recorded in UTC
UTM Zone: Zone 17
Purpose: To provide NOAA with modern, accurate hydrographic survey data for the purpose of updating the relevant nautical charts of the assigned areas: Sheet A (H12095), Sheet B (H12096), Sheet C (H12097), Sheet D (H12098), and Sheet E (H12099) Georgia Safety Fairways, Atlantic Ocean.

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ACRONYMS

Acronym	**Definition**
ASCII	**A**merican **S**tandard **C**ode for **I**nformation **I**nterchange
BAG	**B**athymetric **A**ttributed **G**rid
CI	**C**onfidence **I**nterval
CMG	**C**ourse **M**ade **G**ood
CTD	**C**onductivity, **T**emperature, **D**epth profiler
CUBE	**C**ombined **U**ncertainty and **B**athymetric **E**stimator
DAPR	**D**ata **A**cquisition and **P**rocessing **R**eport
DGPS	**D**ifferential **G**lobal **P**ositioning **S**ystem
DPC	**D**ata **P**rocessing **C**enter
DR	**D**escriptive **R**eport
EPF	**E**rror **P**arameters **F**ile
GPS	**G**lobal **P**ositioning **S**ystem
GSF	**G**eneric **S**ensor **F**ormat
IHO	**I**nternational **H**ydrographic **O**rganization
IMU	**I**nertial **M**easurement **U**nit
ISO	**I**nternational **O**rganization for **S**tandardization
ISS-2000	**I**ntegrated **S**urvey **S**oftware **2000**
ISSC	**I**ntegrated **S**urvey **S**ystem **C**omputer
JD	**J**ulian **D**ay
kW	**K**ilo**w**att
MVE	**M**ulti-**V**iew **E**ditor
MVP	**M**oving **V**essel **P**rofiler
NAVOCEANO	**N**aval **OCEAN**ographic **O**ffice
NAS	**N**etwork **A**ttached **S**torage
NMEA	**N**ational **M**arine **E**lectronics **A**ssociation
NOAA	**N**ational **O**ceanic and **A**tmospheric **A**dministration
NOS	**N**ational **O**cean **S**ervice
PFM	**P**ure **F**ile **M**agic
POS/MV	**P**osition **O**rientation **S**ystem/**M**arine **V**essels
RI	**R**hode **I**sland
RPM	**R**evolutions **P**er **M**inute
SABER	**S**urvey **A**nalysis and area **B**ased **E**dito**R**
SAIC	**S**cience **A**pplications **I**nternational **C**orporation
SAT	**S**ea **A**cceptance **T**ests, or **S**wath **A**lignment **T**ool
SSP	**S**ound **S**peed **P**rofile
SV&P	**S**ound **V**elocity and **P**ressure Sensor
TPE	**T**otal **P**ropagated **E**rror
TPU	**T**otal **P**ropagated **U**ncertainty
UPS	**U**ninterruptible **P**ower **S**upply
XTF	e**X**tended **T**riton **F**ormat

PREFACE

This Data Acquisition and Processing Report (DAPR) applies to sheets H12095, H12096, H12097, H12098, and H12099. Survey data were collected on two sheets (H12098 and H12099) in calendar year 2009; however only sheet H12099 was completed during 2009. Data collection will continue on sheets H12095, H12096, H12097, and H12098 in 2010, but will occur after delivery of this DAPR and the Descriptive Report (DR) for sheet H12099. Therefore this DAPR only refers to the data collection and processing that took place on data collected in 2009. Any variations that may occur subsequent to the delivery of this DAPR will be addressed in the appropriate sections of each sheet's Descriptive Report.

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 dual processor computer with the Windows XP (Service Pack 2) 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 was used to provide positioning, heave, and vessel motion data during these surveys. Klein 3000 sidescan sonar data were acquired using Klein's **SonarPro** software running on a computer with the Windows XP (Service Pack 2) operating system.

DATA PROCESSING

Data were stored on a Network Attached Storage (NAS) system that all computers were able to access. 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, RI, 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
M/V Atlantic Surveyor	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 40 kW generator were secured on the aft deck. The first container was used as the real-time, survey data collection office, the second container was used for the data processing office, and the third container was used for spares storage, maintenance, and repairs. The generator provided dedicated power to the sidescan winch, ISO containers and associated survey equipment.

The POS/MV IMU was mounted port of the keel below the main deck of the vessel and the Reson 7125 transducer mount was hull-mounted port of the vessel’s keel. A Brooke Ocean Technology 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 10-12 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 2009. 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 7125 multibeam transducer
- Reson 7-P sonar processor

2009 Reson System	
Firmware	**Version/SN**
7k Upload Interface	3.7.2.5
7k Center	3.0.7.1
7k I/O	3.3.0.7
SVP-70 S/N	4408372

- POS/MV 320 Position and Orientation System Version 4 with a Trimble ProBeacon Differential Receiver (primary positioning sensor)

2009 POS/MV System	
System	**Version/Model**
MV-320	Ver4
SERIAL NUMBER	S/N2575
HARDWARE	HW2.9-7
SOFTWARE	SW03.42-May28/07
ICD	ICD03.25
OPERATING SYSTEM	OS425B14
IMU TYPE	IMU2
PRIMARY GPS TYPE	PGPS13
SECONDARY GPS TYPE	SGPS13
DMI TYPE	DMI0
GIMBAL TYPE	GIM0
OPTION 1	THV-0

- Trimble 7400 GPS Receivers with a Trimble ProBeacon Differential Receiver (secondary positioning sensor).
- 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

2009 MVP-30 System	
System	**Version/Model/SN**
MVP	30
Software	2.430
SV&P Sensor	5332
SV&P Sensor	5454
SV&P Sensor	4880
SV&P Sensor	5455
SV&P Sensor	4523

- Monarch shaft RPM sensors
- Notebook computer for maintaining daily navigation and operation logs
- Uninterrupted power supplies (UPS) for protection of the entire system

The Reson 7125 was operated as a single frequency system at 400 kHz. The Reson 7125 is capable of 256 Equi-Angular, 512 Equi-Angular, or 512 Equi-Distant beams. In all cases the beams are dynamically focused resulting in a 0.5 degree across-track receive beamwidth and a 1.0 degree along-track transmit beamwidth.

Beam configuration was selected according to the dominant depths expected across each sheet. In deeper waters, 512 beams equi-distant mode was used and in shallower waters, 256 beams equi-angular mode was used. These configurations were chosen due to their resultant data file sizes and achievable bottom coverage. The ping rate was controlled by the user selected range scale on the Reson 7125. When the system was configured for 512 equi-distant beams, the maximum ping rate was manually set to 10 or 11 hertz. For the 256 equi-angular mode, the maximum ping rate was manually set to 15 hertz. By manually setting the ping rates for each beam configuration, the size of the GSF files remained manageable while still ensuring adequate bottom coverage.

The maximum vessel speed was primarily determined according to the range scale setting of the sidescan sonar. Environmental conditions further regulated vessel speeds with slower speeds achieved over shoal areas or during times of inclement weather. For deeper water, the maximum survey speeds were approximately six knots. With a maximum ping rate of approximately 10 – 11 Hz the theoretical along track ping rate was 3.2 – 3.6 pings/meter of travel. In the shallow water configuration, maximum survey speeds were approximately 8.5 knots. With a maximum ping rate set to 15 Hz, the theoretical along track ping rate was approximately 3.4 pings/meter of travel. Item investigations were collected at slower speeds, generally four to six knots, and utilized the 512 equi-distant beam configuration with no maximum ping rate set.

All multibeam data and associated metadata are collected and stored on the real-time survey computer (ISSC) via a dual logging architecture. This method ensures a copy of all data files are logged to separate hard drives during the initial file creation. At the end of each Julian Day data files are additionally backed up to magnetic tape. File names are changed at the end of each line at which time an archiving routine is run. The archiving routine copies all files to an onboard network attached storage system (NAS). The data located on the NAS are then processed. All processed data are backed up to an external hard drive and magnetic tape approximately every one to two days. The external hard drive and copies of the magnetic tape backups are then shipped to SAIC's data processing center in Newport, RI, approximately every 10 to 12 days for further processing and archiving.

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. Data were collected at 100 kHz and 500 kHz concurrently. 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 75 meters, the ping rate is 10Hz. Based on this ping rate, maximum survey speeds were established to ensure that there were a minimum of three pings per meter in the along-track direction. The maximum allowable survey speed was 6.4 knots for the 75-meter range scale setting. Therefore the survey speed was typically less than 6 knots. Sidescan operations were conducted in water depths ranging from approximately 15 to 31 meters (51 to 102 feet). The 75-meter range scale setting was used exclusively on sheets H12098 and H12099 and is also planned for the remaining three sheets of the Georgia Safety Fairways survey.

During survey operations, digital data from the Klein 3000 processor were sent directly to the Klein 3000 computer for display and logging by Klein's **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 approximately every hour and manually at the completion of a survey line. These files were archived to the data NAS 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 and external hard drives 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 7125 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 acquisition 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 and payout files.

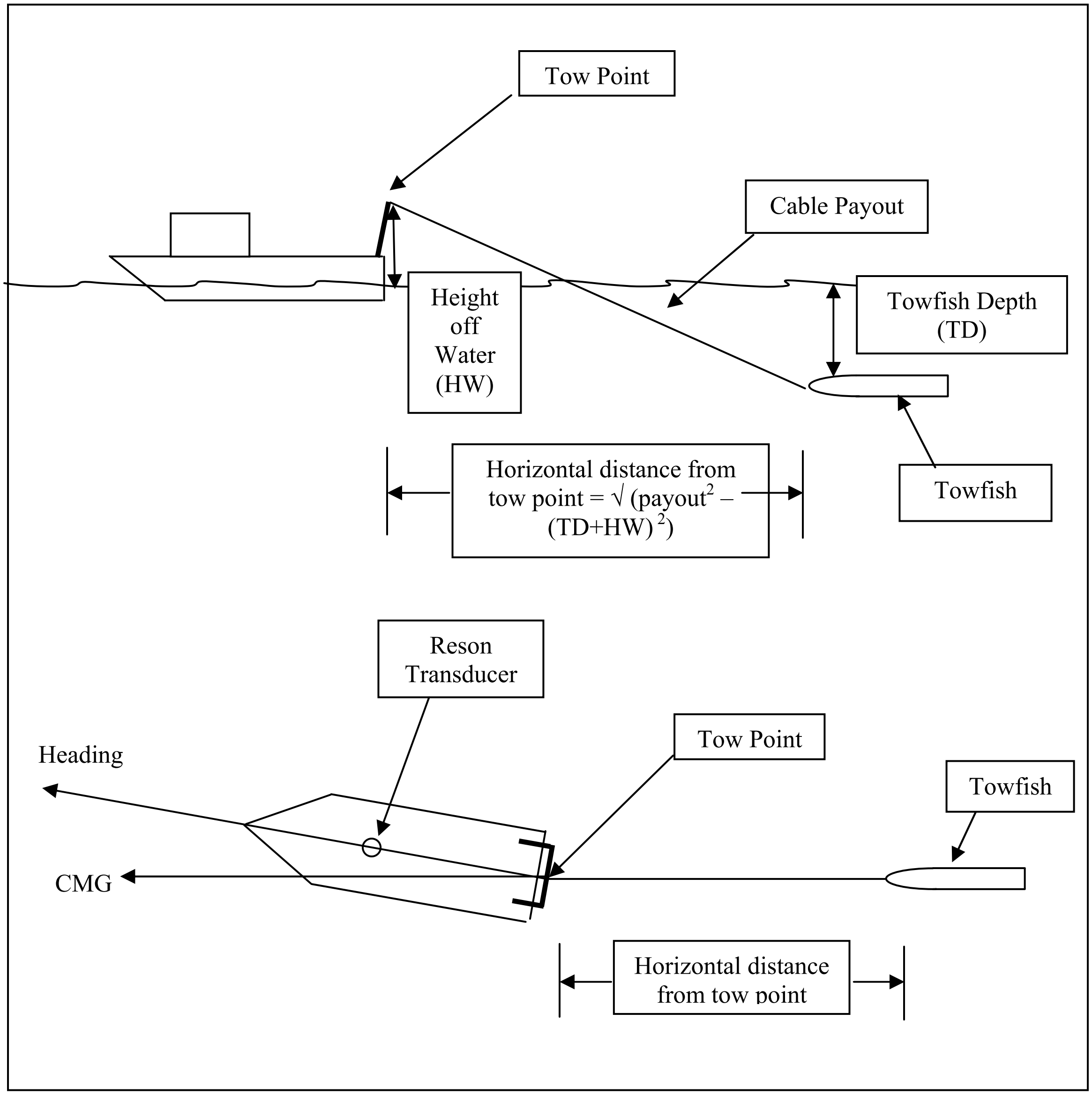

Figure A-2. Geometry of Sidescan Towfish Position Calculations Using the Payout and Depth Method.

Towfish altitude was maintained between 8% and 20% of the range scale (6-15 meters at 75-meter 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 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, which 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 was used to collect sound speed profile (SSP) data. SSP data were obtained at intervals frequent enough to reduce sound speed errors in the multibeam data. 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 data were periodically conducted (6 to 13 days) by comparing two consecutive casts taken with different Sound Velocity and Pressure sensor.

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: 08 July 2009, 07 October 2009 and 15 March 2010.

- Applied Microsystems Ltd., SV&P Smart Sensor, Serial Number 4880
    - Calibration Dates: 08 July 2009 and 15 March 2010.

- Applied Microsystems Ltd., SV&P Smart Sensor, Serial Number 5332
    - Calibration Dates: 27 May 2009, 08 October 2009 and 15 March 2010.

- Applied Microsystems Ltd., SV&P Smart Sensor, Serial Number 5454
    - Calibration Dates: 27 May 2009 and 05 February 2010.

- Applied Microsystems Ltd., SV&P Smart Sensor, Serial Number 5455
    - Calibration Dates: 28 August 2008, 01 September 2009 and 15 March 2010.

DATA ACQUISITION AND PROCESSING SOFTWARE

Data acquisition was carried out using the SAIC **ISS-2000** Version 4.1.0.11.2 software for Windows XP operating systems to control acquisition navigation, data time tagging, and data logging.

Survey planning, data processing and analysis were carried out using the SAIC **Survey Planning** and **SABER** Version 4.3.0.12.1 software packages for LINUX operating systems. On 20 August 2009 SABER version 4.3.0.12.2 was installed in the Data Processing Center. On 28 January 2010 SABER version 4.3.0.13.1 was installed in the Data Processing Center. On 10 February 2010 SABER version 4.3.0.13.2 was installed in the Data Processing Center. On 15 February 2010 SABER version 4.3.0.13.3 was installed in the Data Processing Center. On 30 March 2010 SABER version 4.3.0.16.1 was installed in the Data Processing Center and used until delivery.

SonarPro version 11.3, 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 2-3 hours the acquisition 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
- Application of delayed heave
- Generation of a preliminary PFM CUBE surface
- Second review and editing of multibeam data PFM CUBE surface

- Open beam angles where appropriate to identify significant features outside the cut-off angle
- Identify significant features for investigation with additional multibeam coverage
- Turning unacceptable data “offline”
- Turning additional data “online”
- Identification and flagging of significant features
- Track plots
- Preliminary minimum sounding grids
- Cross line checks
- First review of sidescan data
- Generation of preliminary sidescan coverage mosaics
- Identification of holidays in the sidescan coverage

On a daily basis, the multibeam 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 cross line analysis, tide zone boundary comparisons, and day-to-day data comparisons.

- Main scheme, item, and holiday fill survey lines
- Cross lines using only near nadir (±5° 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
- Second review of sidescan data
- Generation of sidescan contact files
- Application of verified water level correctors to multibeam data
- Computation of Total Propagated Uncertainty (TPU) for each depth value in the multibeam data
- Generation of a one-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*). The Total Propagated Error (TPE) terminology has been replaced by Total Propagated Uncertainty (TPU) in the hydrographic community and was adopted by the International Hydrographic Organization in Special Publication No. 44, "*IHO Standards for Hydrographic Surveys, 5th 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 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 uncertainty model were captured as parameters taken from the **SABER** Error Parameter File (EPF), which is a 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. Individual soundings that had vertical and horizontal uncertainty values above IHO Order 1 were flagged as invalid during uncertainty attribution of the GSF files.

Table B-1 and Table 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. 2009 *M/V Atlantic Surveyor* Error Parameter File (EPF)

Parameter	Value	Units
VRU Offset – X	0.34	Meters
VRU Offset – Y	0.29	Meters
VRU Offset – Z	-1.71	Meters
VRU Offset Error – X (uncertainty)	0.005	Meters
VRU Offset Error – Y (uncertainty)	0.011	Meters
VRU Offset Error – Z (uncertainty)	0.013	Meters
VRU Latency	0.00	milliseconds (msec)
VRU Latency Error (uncertainty)	1.00	milliseconds (msec)
Heading Measurement Error (uncertainty)	0.02	Degrees
Roll Measurement Error (uncertainty)	0.02	Degrees
Pitch Measurement Error (uncertainty)	0.02	Degrees
Heave Fixed Error (uncertainty)	0.05	Meters
Heave Error (% error of height) (uncertainty)	5.00	Percent
Antenna Offset – X	4.60	Meters
Antenna Offset – Y	-0.37	Meters
Antenna Offset – Z	-8.09	Meters
Antenna Offset Error – X (uncertainty)	0.013	Meters
Antenna Offset Error – Y (uncertainty)	0.012	Meters
Antenna Offset Error – Z (uncertainty)	0.025	Meters
Estimated Error in Vessel Speed (uncertainty)	0.0299	Knots
GPS Latency	0.00	milliseconds (msec)
GPS Latency Error (uncertainty)	1.00	milliseconds (msec)
Horizontal Navigation Error (uncertainty)	0.75*	Meters
Vertical Navigation Error (uncertainty)	0.20*	Meters
Static Draft Error (uncertainty)	0.01	Meters
Loading Draft Error (uncertainty)	0.02	Meters
Settlement & Squat Error (uncertainty)	0.02	Meters
Predicted Tide Measurement Error (uncertainty)	0.17	Meters
Observed Tide Measurement Error (uncertainty)	0.07	Meters
Unknown Tide Measurement Error (uncertainty)	0.50	Meters
Tidal Zone Error (uncertainty)	0.10	Meters
Surface Sound Speed Error (uncertainty)	1.00	meters/second (m/s)
SEP Uncertainty	0.15	Meters
SVP Measurement Error (uncertainty)	1.00	meters/second (m/s)
Depth Sensor Bias	0.00	Meters
Depth Measurement Error (% error of depth) (uncertainty)	0.00	Percent
Wave Height Removal Error (uncertainty)	0.05	Meters

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

Table B-2. 2009 Reson 7125 Sonar Parameters

Parameter	Value	Units
Transducer Offset – X	0.00*	Meters
Transducer Offset – Y	0.00*	Meters
Transducer Offset – Z	0.00*	Meters
Transducer Offset Error – X (uncertainty)	0.02	Meters
Transducer Offset Error – Y (uncertainty)	0.02	Meters
Transducer Offset Error – Z (uncertainty)	0.02	Meters

Parameter	Value	Units
Roll Offset Error (uncertainty)	0.005	Degrees
Pitch Offset Error (uncertainty)	0.05	Degrees
Heading Offset Error (uncertainty)	0.05	Degrees
Model Tuning Factor	6.00	N/A
Amplitude Phase Transition	1	Samples
Latency	0.00	milliseconds (msec)
Latency Error (uncertainty)	1.00	milliseconds (msec)
Installation Angle	0.0	Degrees

*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 archived to the onboard processing computers where track lines were generated and the multibeam data files were 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. Delayed heave and 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.

The GSF multibeam files delivered for sheets H12095, H12096, H12097 H12098, and H12099 are in GSF version 3.01 format. This version of GSF is compatible with Caris version 6.1.2.8 using the HotFix delivered to the Atlantic Hydrographic Branch on 18 December 2009. The Caris version 6.1.2.8 HotFix has also been included with the delivery for sheet H12099. In addition, Caris version 7.0 is compatible with this version of GSF using HotFix 5.

CUBE Surfaces

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. 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 2009 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 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 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 were converted to Bathymetric Attributed Grids (BAGs) for delivery.

Repeatability Tests

A junction analysis was conducted during data processing to assess the agreement between the main scheme and cross line data that were acquired during the survey. Because the cross lines were acquired at varying time periods throughout the survey period, the junction analysis provided an indication of potential temporal issues (e.g., tides, speed of sound, draft) that may affect the data. For junction 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 cross line analysis:

- Main scheme, item, and holiday fill survey lines
- Cross lines using only near nadir (±5° from nadir)

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

In addition to the surface comparison, a beam by beam comparison of cross line data to main scheme data was performed for each survey area. This two-step process begins by finding all center ping crossings that occur between the main scheme lines and cross lines within the sheet. This was accomplished by running **SABER's Find Crossings** utility on two file lists, one containing main scheme files and one containing cross line files. The resulting file contains positional data for all crossings between the two file lists and can be displayed in **SABER**. A subset of 25 crossings for each survey was established by selecting crossings that were separated both temporally and spatially and in relatively flat areas within each survey area.

The second step of the process was completed using **SABER's Analyze Crossings** utility. For each crossing, two analysis reports are generated. One report contains the results of the near nadir beams of the main scheme line compared to all beams of the full swath of the cross line and the second contains the results of the near nadir beams of the cross line compared to the beams of the full swath of the main scheme line. The output report from **SABER's Analyze Crossings** utility contains the total number of comparisons, number and percentage of comparisons that meet an operator specified criteria for acceptable depth difference, maximum differences, minimum differences and statistics which include mean, standard deviation, and R95 values for each beam-to-beam comparison. Results are presented in the Descriptive Report.

Coverage

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 a set line spacing optimized to achieve 200% sidescan sonar coverage; 100% multibeam coverage was not required. For 200% sidescan coverage, main scheme lines were run at 65-meter line spacing while running the sidescan at a 75-meter range scale. The **SABER Gapchecker** routine was run on the 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.

SIDESCAN 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 acquisition computer. After the file name change at the end of each line, the sidescan data files were archived to the onboard data processing computer. Onboard sidescan data processing included, at a minimum, generating towfish track lines and initial imagery mosaics for coverage verification and quality control. Some initial data review and contact generation was performed onboard the vessel as time permitted. 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 catenary data file recorded during acquisition 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 included:

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

During collection of the 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 file name(s), line azimuth, and operator notations made during the acquisition. Throughout the subsequent sidescan data review stages, the review log was updated to reflect data quality concerns, highlight data gaps (due to refraction, fish, etc.), identify significant sidescan contacts, and to address any other pertinent issues regarding interpretation of the sidescan data. The final sidescan review log is included in Separates I of the Descriptive Report for each sheet.

Sidescan Quality Review

After initial processing, 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 mosaics. The time window file and file lists were then used to create the 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, saved, and reported in the sidescan review log. 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 ".CON" files, 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

During sidescan data review in **Isis**, the Average Display Down Sample 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.

After a second independent review of the sidescan data was completed, the contact files were converted into a sidescan contact (CTV) file and tiff images using a **SABER** program called **isis2ctv**. The CTV lists all of the contact attributes contained in the individual contact files. In **SABER**, the CTV file was 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_ds_features** routine. The CNT file contains the position, depth, type of feature, and attributes extracted from the flagged features in the GSF multibeam data. The final correlation of the sidescan contacts and multibeam features was done in **SABER** which updated the CNT file with the type of feature (obstruction, wreck, etc.) and the CTV file with the feature-to-contact information.

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

Table C-1 lists the *M/V Atlantic Surveyor* sensor configuration and the vessel offsets are depicted in Figure C-1. All measurements are in meters. Offset measurements were made from the IMU with the final position being computed and reported as the acoustic center of the Reson 7125.

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**.

Table C-1. *M/V Atlantic Surveyor* Antenna and Transducer Offsets Relative to the POS/MV IMU Vessel Reference Point, measurements in meters

Sensor	Offset in ISS-2000		Offset in POS/MV	
Multibeam Reson 7125 Transducer Hull Mount			X	-0.34 ±0.005
			Y	-0.29 ±0.011
			Z	+1.71 ±0.013
Reference to Heave			X	0.00
			Y	0.00
			Z	0.00
Reference to Vessel			X	-0.34 ±0.005
			Y	-0.29 ±0.011
			Z	+1.71 ±0.013
POS/MV GPS Master Antenna			X	+4.26 ±0.012
			Y	-0.66 ±0.005
			Z	-6.38 ±0.015
Trimble GPS Antenna From Transducer	X	+4.60 ±0.013		
	Y	+0.63±0.012		
	Z	-8.06 ±0.020		
A-Frame Tow Block (X and Y from Reson 7125 Transducer. Z is height above water.	X	-19.56 ±0.150		
	Y	+0.69 ±0.150		
	Z	-4.87 ±0.150		

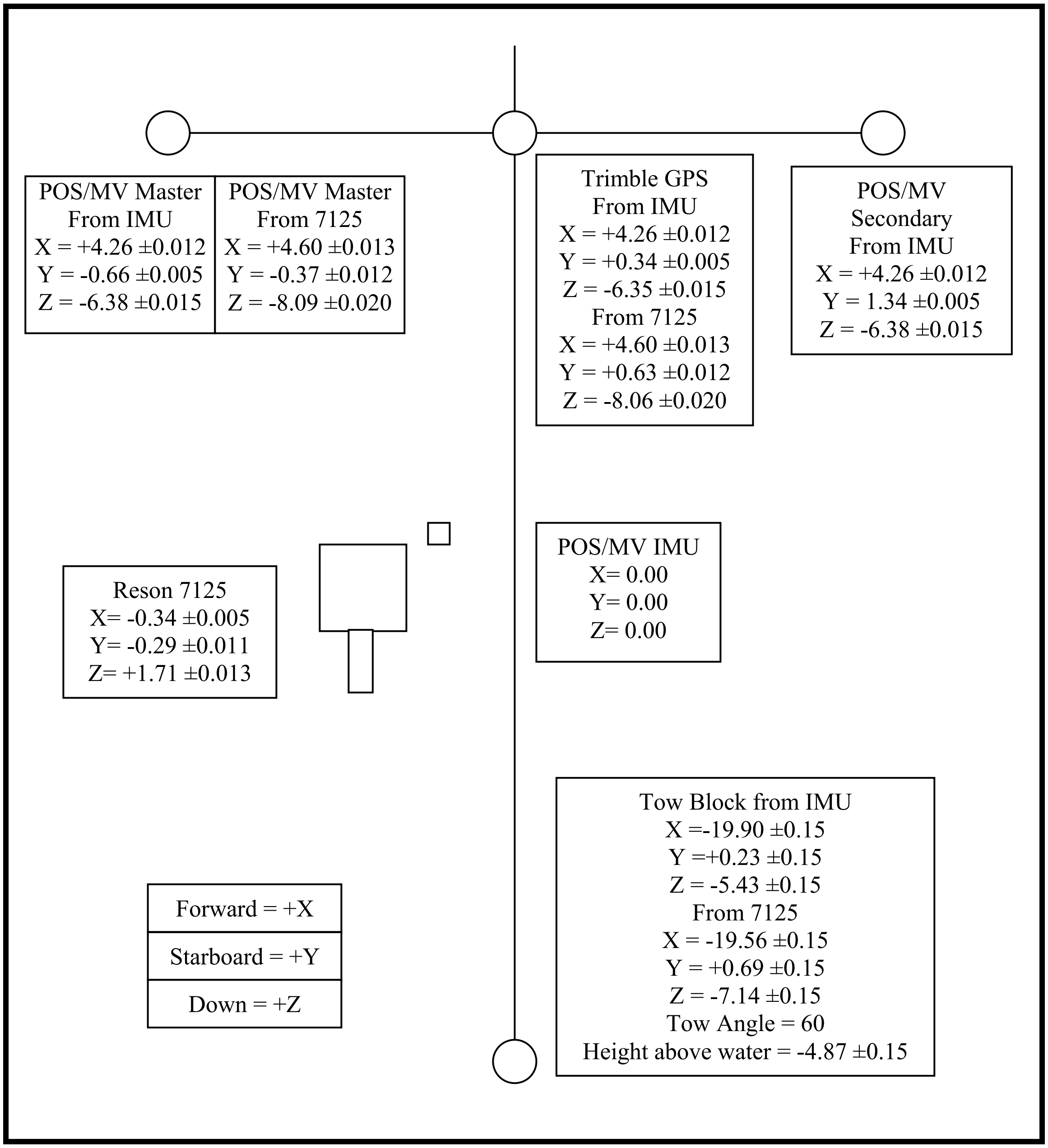

Figure C-1. Configuration and Offsets of *M/V Atlantic Surveyor* Sensors (measurements in meters with 68% CI measurement errors)

STATIC AND DYNAMIC DRAFT MEASUREMENTS

Static Draft

Figure C-2 shows the draft calculations for the *M/V Atlantic Surveyor*. The Reson 7125 transducer is hull-mounted 0.50 meters port of the vessel's center line and 3.42 meters below the vessel's main deck. To determine the draft a 0.02 meter square metal bar is placed on the deck so that it extends out far enough to allow a direct measurement to the water line. The distance from the top of the metal bar to the water surface is measured and subtracted from the transducer hull depth plus the thickness of the bar to determine the draft of the transducer's electronic center.

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 acquisition 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/or prorated static draft for each survey day is included with the survey data in Section I of the Separates of each Sheet's Descriptive Report.

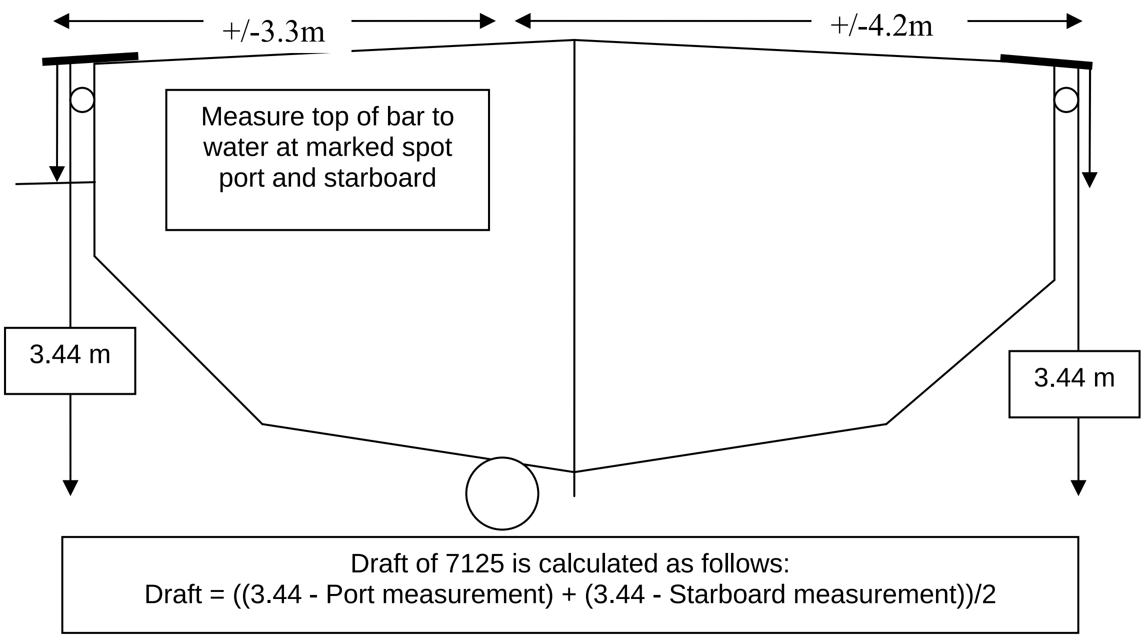

Figure C-2. *M/V Atlantic Surveyor* Draft Determination

Dynamic Draft

Dynamic draft values were confirmed during the 2009 Sea Acceptance Test (SAT). An initial depth reference surface was created by stopping the vessel and acquiring multibeam data as the vessel drifted with the prevailing current. A survey transect was then established perpendicular to the reference surface. This transect was run twice (once in each direction) at each of the six shaft rpm settings. This test was done on JD 189 to determine the settlement and squat correctors and repeated on JD 190 to verify the

settlement and squat correctors entered into the vessel configuration file. A 0.5-meter average grid was created for the drift line and each of the RPM pairs. Difference grids were then created between the average grid from drift reference line and the average grid for each of the RPM pairs. Only the near nadir (5 degree) beams were used to create the average grids. The settlement and squat values were computed by averaging the measured grid differences for each of the RPM settings.
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.

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

Shaft RPM	Depth Corrector	Approximate Speed (Kts)	Files	
			Julian Day 189	Julian Day 190
0	0.00	0	asmba09189.d02	asmba09190.d06
140	0.02	4	asmba09189.d03 asmba09189.d04	asmba09190.d07 asmba09190.d08
180	0.03	5	asmba09189.d15 asmba09189.d16	asmba09190.d09 asmba09190.d10
250	0.04	6	asmba09189.d07 asmba09189.d08	asmba09190.d11 asmba09190.d12
300	0.07	8	asmba09189.d09 asmba09189.d10	asmba09190.d13 asmba09190.d14
340	0.09	9	asmba09189.d11 asmba09189.d12	asmba09190.d15 asmba09190.d16
380	0.10	10	asmba09189.d13 asmba09189.d14	asmba09190.d17 asmba09190.d18

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.

Periodic (every 6-13 survey days) confidence checks were obtained using consecutive casts with two different SV&P sensors. 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, 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 two-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.

A table including all SSP casts, date, location, application times and maximum depth is located in Section II of the Separates of each sheet's Descriptive Report.

The Reson 7125 multibeam sonar uses a collocated SV sensor to aid in the beam forming process. The Reson 7-P processor allows for manual entry of SV values when an SV sensor is not present. On 17 November 2009 (JD 321) the SV senor, collocated with the 7125 transducer, started sending data intermittently. Troubleshooting steps were taken to assess the cause of the dropped data string. It was determined that the sensor or data cable was failing. The survey crew monitored the data flow and compared it with the data acquired with the MVP-30 which was set up in a towed configuration sending a continuous data string displayed within **ISS-2000**'s environmental monitor display. The delta between the two sensors was generally less than 0.5 meters per second. On 19 November 2009, the collocated sensor stopped sending data and values received from the MVP-30 in a towed configuration were used to manually input a value within the Reson 7-P. On 14 December 2009, a spare SV sensor was deployed off the starboard rail, inline with the 7125 transducer and to a depth equal to the 7125 transducer's draft. This continuous data string was sent directly into the Reson 7-P. On 15 December 2009, the pole mount for the SV sensor failed and manual SV entries based on the towed MVP-30 data were resumed until the end of survey.

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 0.01º, Accuracy 0.02º
- Pitch Resolution 0.01º, Accuracy 0.02º

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 07 July 2009, prior to all other calibration tests, to verify that no timing errors exist within the survey system. The fundamental 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 7-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 2.0 milliseconds. These time differences are plotted in Figure C-3.

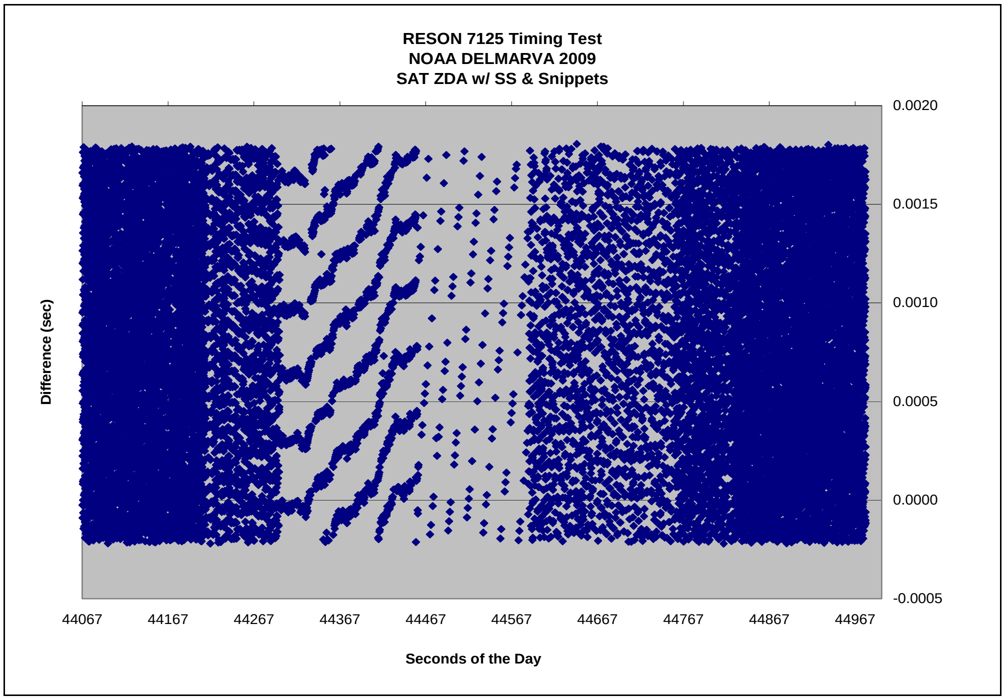

Figure C-3. Timing Test Results (time differences of ping trigger event vs. ping time tag from GSF)

Multibeam Bias Calibration

Roll, pitch, and yaw biases were determined on 08 July 2009 (JD189) over a 47-foot wreck in the fish haven approximately 6 kilometers southeast of Manasquan Inlet in New Jersey (Table C-3). The wreck is charted in 40° 03.3925'N 073° 59.5541'W.

Table C-3. Final Multibeam Files Verifying Alignment Biases Calculated using the SABER Swath Alignment Tool (SAT)

Component	Multibeam files (pairs)		Bias
Pitch	asmba09189.d36	asmba09189.d39	+2.1°
Roll	asmba09189.d36	asmba09189.d39	+0.14°
Gyro	asmba09189.d41	asmba09189.d42	+1.4°

Pitch Alignment

Multibeam data from two lines run in opposite directions were collected for pitch bias calculations. These lines were run along the same survey transect. The process was repeated several times to determine an accurate measurement of the pitch bias. Figure C-4 and Figure C-5 are images of the **SABER SAT** tool depicting data collected with the +2.1° pitch bias entered in the **ISS-2000** system; therefore the indicated bias is zero.

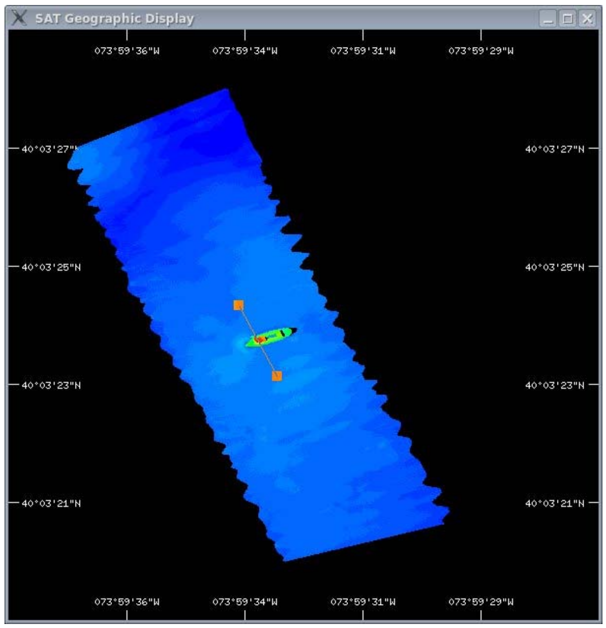

Figure C-4. SAT Tool, Plan View Depicting +2.1° Pitch Bias

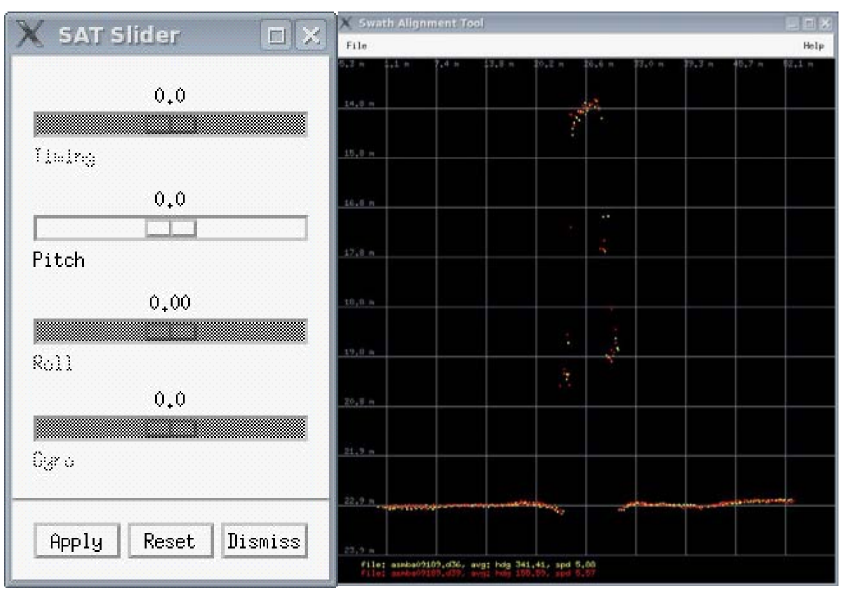

Figure C-5. SAT Tool, Depth vs. Distance Plot Depicting +2.1° Pitch Bias

Roll Alignment

Multibeam data from two lines run in opposite directions were collected for roll bias calculations. These lines were run along the same survey transect. The process was repeated several times to determine an accurate measurement of the roll bias. Figure C-6 and Figure C-7 are images of the **SABER SAT** tool depicting data collected with the +0.14° roll bias entered in the ISS200 system; therefore the indicated bias is zero.

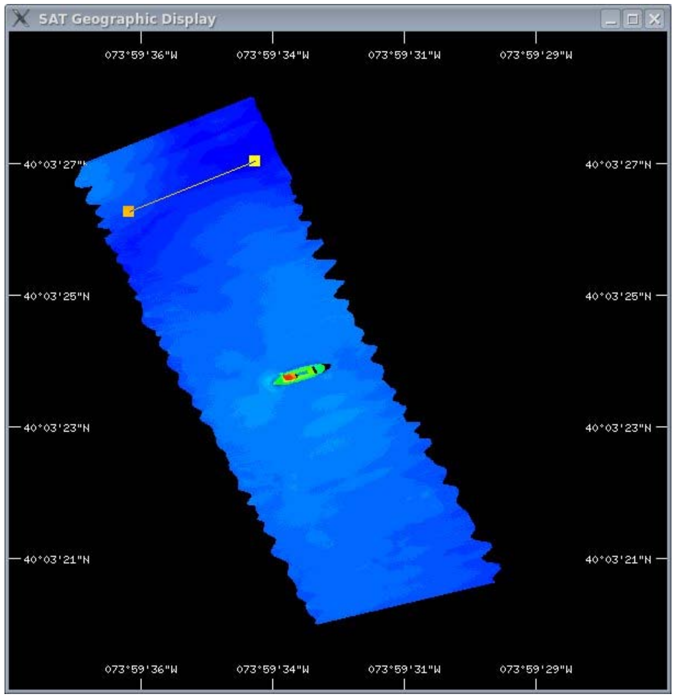

Figure C-6. SAT Tool, Plan View Depicting +0.14° Roll Bias

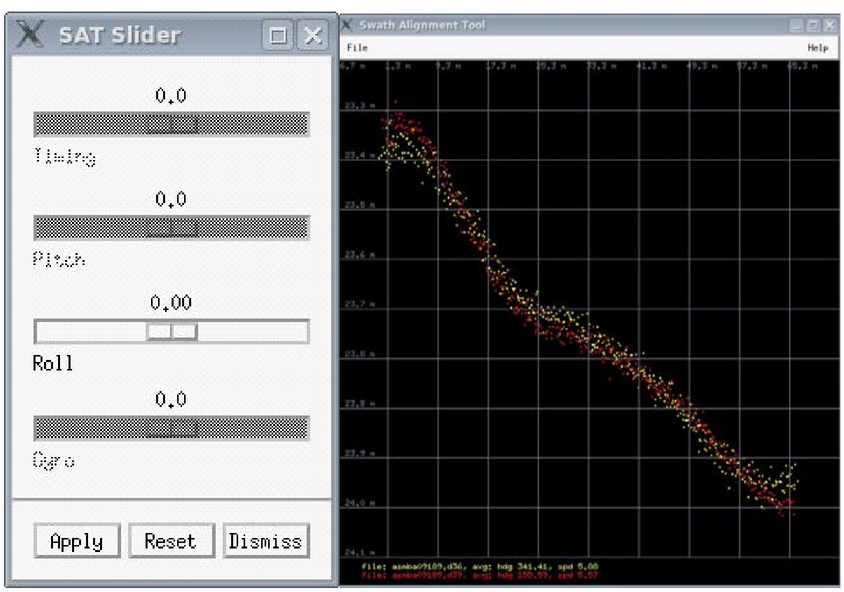

Figure C-7. SAT Tool, Depth vs. Distance Depicting +0.14° Roll Bias

Heading Alignment

Multibeam data from two 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. The process was repeated several times to determine an accurate measurement of the heading bias. Figure C-8 and Figure C-9 are images of the **SABER SAT** tool depicting data collected with the +1.4° heading bias entered in the **ISS-2000** system; therefore the indicated bias is zero.

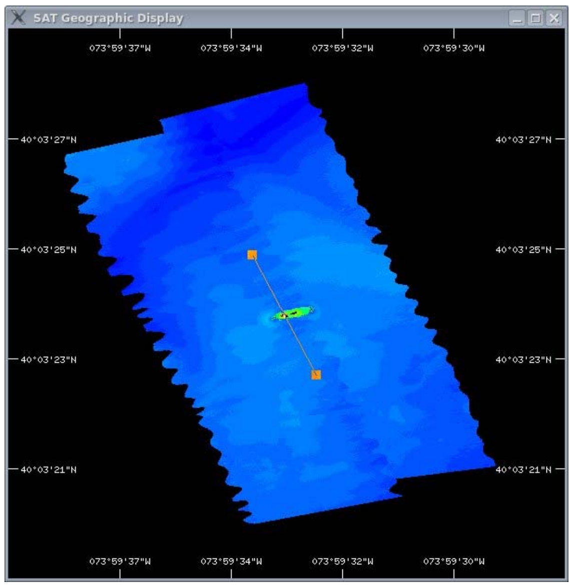

Figure C-8. SAT Tool, Plan View Depicting +1.4° Heading Bias

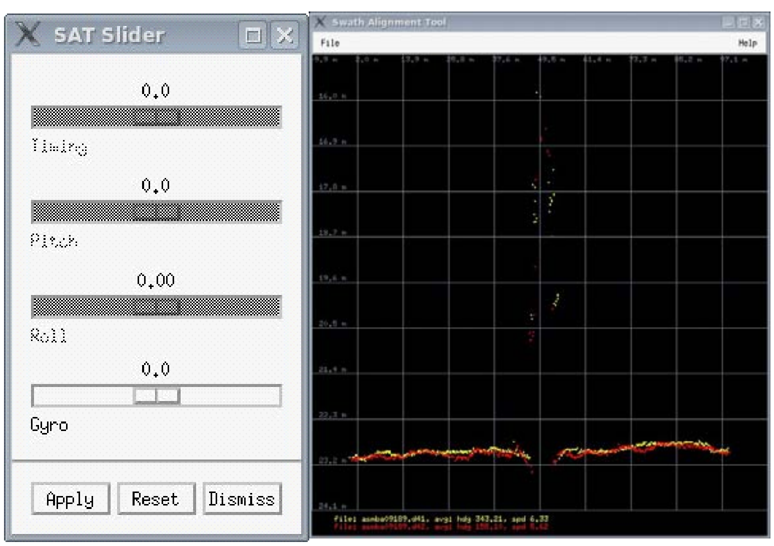

Figure C-9. SAT Tool, Depth vs. Distance Depicting +1.4 Heading Bias

MULTIBEAM ACCURACY

After all calibration tests were complete, a system verification survey was run in the vicinity of the wreck alignment site consisting of 19 main scheme lines and three cross lines centered on the wreck. All depths were corrected for predicted tides using zoning for the Atlantic City tide gauge, 8534720. For the multibeam data, the class one cutoff angle was set to 5° and class two cutoff set to 60°. Standard multibeam data processing procedures were followed to clean the data, apply delayed heave and calculate uncertainty. One-meter minimum grids of the main scheme lines, class one cross lines, and all lines were created. A one-meter PFM of all the data was also generated and processed using the gap checker and check uncertainty routines. The results of the system verification survey provided an overview assessment of the data acquisition and processing procedures outlined for the project. The resulting minimum grid with selected soundings (in feet) is shown in Figure C-10. The PFM with CUBE depths and Uncertainties are shown in Figure C-11 and Figure C-12 respectively. The junction analysis results for the depth differences between the main and cross lines are shown in Table C-4 and report very positive results for the system set-up and procedures.

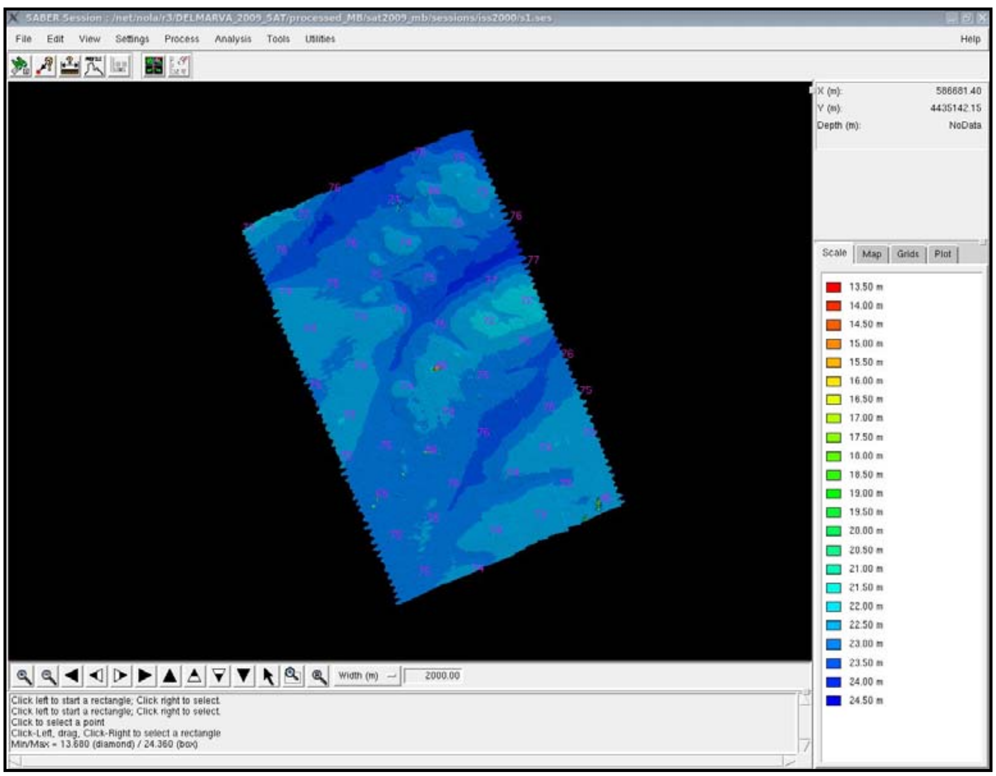

Figure C-10. Verification Survey Minimum Depth Grid and Selected Soundings

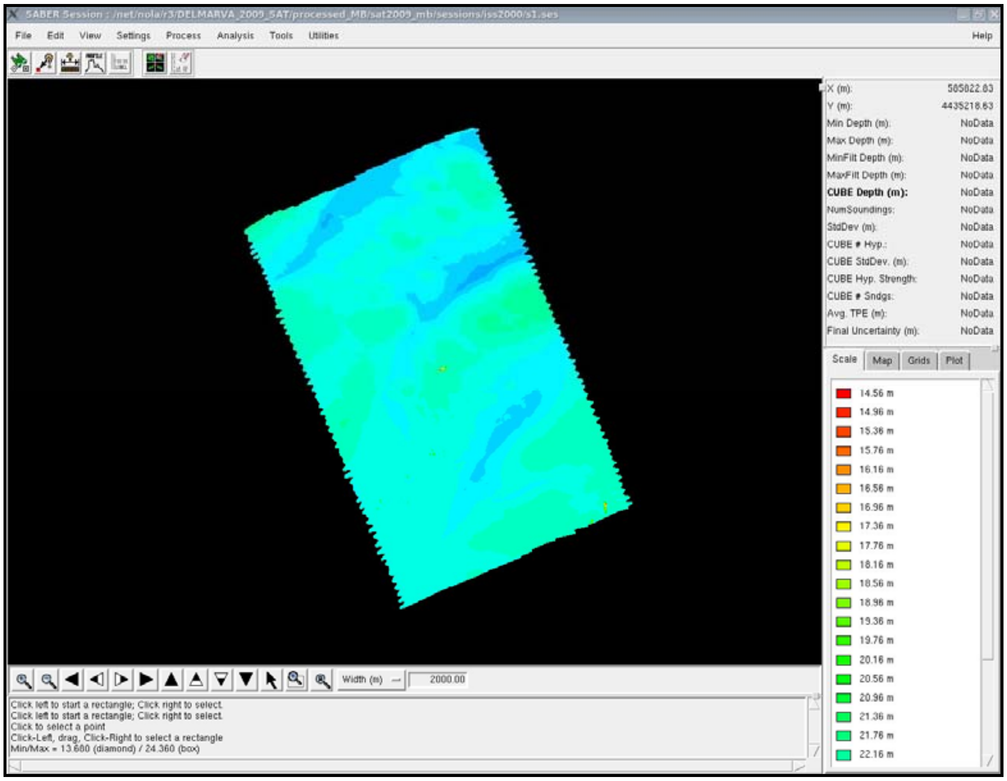

Figure C-11. Verification Survey PFM CUBE Depths

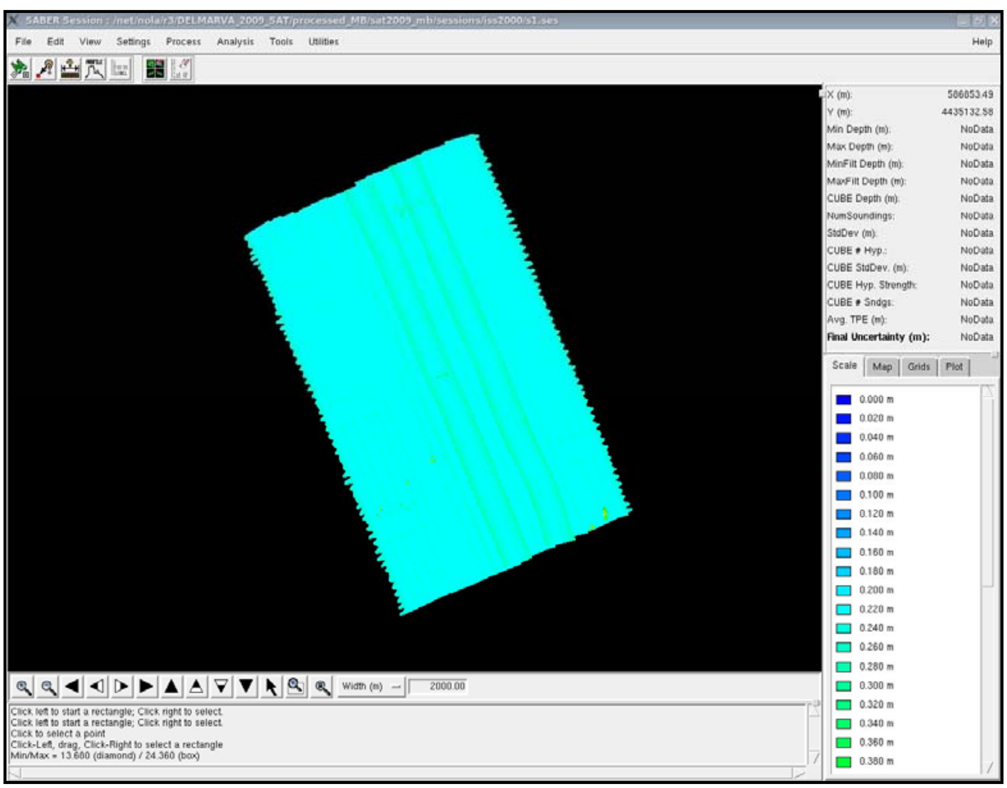

Figure C-12. Verification Survey PFM Uncertainties

Table C-4. Verification Survey Junction Analysis of Cross versus Main Scheme

Depth Difference Range (cm)	All		Positive		Negative		Zero	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
0-5cm	4352	76.06	1930	33.73	1820	31.81	602	10.52
5-10cm	1278	22.33	682	11.90	596	10.42		
10-15cm	88	1.54	52	0.91	36	0.63		
15-20cm	3	0.05	3	0.05	0	0.00		
>20cm	1	0.02	1	0.02	0	0.00		
Total	5722	100.00%	2668	46.63%	2452	42.85%	602	10.52%

Additional Patch Tests

Roll, pitch, and yaw biases were confirmed on 28 October 2009 (JD301) over a 43-foot wreck approximately 17 kilometers east southeast of St. Mary's River Entrance in Georgia. The wreck is charted in 30° 39.3621'N 081° 14.1085'W.

Table C-5. Multibeam Files (JD 301) Verifying Alignment Biases Calculated using the Swath Alignment Tool

Component	Multibeam files (pairs)		Result
Pitch	asmba09301.d12	asmba09301.d13	+2.1°
Roll	asmba09301.d12	asmba09301.d13	+0.14°
Gyro	asmba09301.d14	asmba09301.d15	+1.4°

TIDES AND WATER LEVELS

NOAA tide station 8720030 Fernandina Beach, FL was the source of final verified water level heights for the Georgia Safety Fairways 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. All water level data were in meters and annotated with Coordinated Universal Time (UTC).

Final water level files for each tide zone were created from the 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 each 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 correctors had been applied to the GSF files.

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 correctors. 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 for the Georgia Safety Fairways project are presented in Table C-6.

Table C-6. Preliminary Tide Zone Parameters

Zone	Time Corrector (minutes)	Range Ratio	Reference Station
SA189	-36	0.98	8720030
SA191	-48	0.95	8720030
SA192	-36	0.95	8720030
SA195	-36	0.91	8720030
SA196	-48	0.91	8720030
SA197	-48	0.88	8720030
SA200	-48	0.85	8720030

Final Tide Note

The H12095, H12096, H12097, H12098 and H12099 surveys fell entirely within preliminary water level zones SA189, SA191, SA192, SA195, SA196, SA197 and SA200 for Fernandina Beach, FL, 8720030. Analysis of the multibeam data collected to date, performed using **MVE** and gridded depths, revealed minimal depth jumps across the junction of the zones. Using data collected through the end of survey operations in 2009, a spreadsheet analysis of the water level correctors for each zone and the differences observed at the boundaries of adjacent zones also confirmed the adequacy of zoning correctors based on Fernandina Beach, FL (8720030). For the analysis, observed verified water levels from 28 October 2009 through 16 December 2009 were entered into the spreadsheet. Correctors were computed at six minute intervals for each zone. Differences were computed at the zone boundaries and summarized in Table C-7. As a result, the NOAA preliminary zone boundaries and zoning parameters for Fernandina Beach, FL (8720030) were accepted as final and applied to all multibeam data for H12095, H12096, H12097, H12098 and H12099. The junctions involving zones SA189 and SA191 do not apply for 2009 as no data were collected in these zones. They are reported as a check prior to data to be collected in 2010. The final analysis of the zone-to-zone comparisons for H12095 and H12096 will be submitted with the Horizontal and Vertical Control Report and in each sheet's Descriptive Report.

Table C-7. Differences in Water Level Correctors between Adjacent Zones Using Zoning Parameters for Station 8720030 for 2009

Zone Boundary	SA189 – SA192	SA192 – SA191	SA191 – SA196	SA196 – SA195	SA192 – SA195	SA197 – SA200	SA196 – SA197
Minimum Difference	-0.010	-0.140	-0.014	-0.116	-0.014	-0.011	-0.011
Maximum Difference	0.075	-0.122	0.100	0.134	0.100	0.075	0.075
Average Difference	0.019	0.000	0.025	0.000	0.025	0.019	0.019
Standard Deviation	0.023	0.045	0.031	0.043	0.031	0.023	0.023

D. APPROVAL SHEET

09 April 2010

LETTER OF APPROVAL

REGISTRY NUMBER: H12095, H12096, H12097, H12098, H12099

This Data Acquisition and Processing Report for project OPR-G443-KR-09, Georgia Safety Fairways Project is respectfully submitted.

Field operations and data processing contributing to the accomplishment of these surveys, H12001, H12002, and H12003 were conducted under supervision of myself and lead hydrographers Paul L. Donaldson, Jason M. Infantino, Gary R. Davis, Evan J. Robertson and Deborah M. Smith 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:

Report	**Submission Date**
H12099 Descriptive Report 10-TR-006	09 April 2010

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

Charles F. Holloway

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Charles F. Holloway
Lead Hydrographer
Science Applications International Corporation
09 April 2010