

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

Data Acquisition & Processing Report

Type of Survey Multibeam and Side Scan Sonar

Project No. OPR-D302-KR-06

Time Frame: 01 June 2006 – 09 September 2006

LOCALITY

State Delaware

General Locality Atlantic Ocean

2006

CHIEF OF PARTY

Gary R. Davis

Science Applications International Corporation

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NOAA FORM 77-28 (11-72)	U.S. DEPARTMENT OF COMMERCE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION HYDROGRAPHIC TITLE SHEET	REGISTRY NO. H11554 H11555
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
State: <u>Delaware</u> General Locality: <u>Atlantic Ocean</u> Sublocality: <u>25 NMI ESE of Cape Henlopen, 30 NMI SE of Cape Henlopen</u> Scale: <u>1:20,000</u> Date of Survey <u>01 June 2006 - 09 September 2006</u> Instructions Dated: <u>01 February 2006</u> Project No. <u>OPR-D302-KR-06</u> Vessel: <u>M/V Atlantic Surveyor, D582365</u> Chief of Party: <u>Gary R. Davis, Paul L. Donaldson</u> Surveyed by: <u>Brian Biggert, Curtis Clement, Gary Davis, Paul Donaldson, Sean Halpin, Karen Hart, Chuck Holloway, Erick Huchzermeyer, Jason Infantino, Meme Lobecker, Matt Meyer, Rick Nadeau, Evan Robertson, Jeremy Shambaugh, Deb Smith, and Ryan Thomas</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: Contract: DG133C-05-CQ-1088 Contractor: Science Applications International Corp., 221 Third Street; Newport, RI 02840 USA Subcontractors: Williamson & Associates, 1124 NW 53 rd Street, Seattle WA 98107; Rotator Staffing Services, PO Box 366, 557 Cranbury Rd, E. Brunswick NJ 08816 Times: All times are recorded in UTC Purpose: To provide NOAA with modern, accurate hydrographic survey data for the purpose of updating the relevant nautical charts of the assigned areas: Sheets A (H11554) and B (H11555) in Mid-Atlantic Corridor, Coast of Delaware.		

Table of Contents

	Page
A. EQUIPMENT.....	1
THE SURVEY VESSEL	1
SINGLE BEAM SYSTEMS AND OPERATIONS.....	2
MULTIBEAM SYSTEMS AND OPERATIONS	2
SIDE SCAN SONAR SYSTEMS AND OPERATIONS	3
SOUND SPEED PROFILES	6
DATA ACQUISITION AND PROCESSING SOFTWARE.....	7
B. QUALITY CONTROL.....	13
MULTIBEAM DATA PROCESSING.....	15
<i>Survey System Error Model</i>	15
<i>Multibeam Coverage Analysis</i>	17
SIDE SCAN SONAR DATA PROCESSING.....	17
<i>Side Scan Quality Review</i>	18
<i>Side Scan Coverage Analysis</i>	18
<i>Side Scan Contact Analysis</i>	19
C. CORRECTIONS TO ECHO SOUNDINGS	20
VESSEL CONFIGURATION PARAMETERS.....	20
STATIC AND DYNAMIC DRAFT MEASUREMENTS.....	21
<i>Static Draft</i>	21
<i>Settlement and Squat - Dynamic Draft</i>	22
SPEED OF SOUND	23
MULTIBEAM ACCURACY	24
MULTIBEAM CALIBRATIONS	25
<i>Timing Test</i>	25
<i>Multibeam Bias Calibration</i>	26
<i>Pitch Alignment (12 April 2006)</i>	27
<i>Roll Alignment (12 April 2006)</i>	28
<i>Heading Alignment (11 & 12 April 2006)</i>	29
TIDES AND WATER LEVELS.....	30

List of Tables

	Page
Table A-1. Survey Vessel Characteristics, <i>M/V Atlantic Surveyor</i>	2
Table A-2. ISS-2000 for Windows Product Version: 3.10	7
Table A-3. Survey Planning and SABER for Linux Machines, Product Version: 3.3.10	9
Table A-4. Survey Planning and SABER for Linux Machines, Product Version: 3.3.15	10
Software Modules Updated from version 3.3.10	10
Table A-5. Survey Planning and SABER for Linux Machines, Product Version: 3.4.5	10
Software Modules Updated from version 3.3.15	10
Table A-6. Survey Planning and SABER for Linux Machines, Product Version: 4.0.13	11
.....	11
Table A-7. Survey Planning and SABER for Linux Machines, Product Version: 4.0.14	12
Software Modules Updated from version 4.0.13	12
Table A-8. Survey Planning and SABER for Linux Machines, Product Version: 4.1.5	12
Software Modules Updated from version 4.0.14	12
Table A-9. Survey Planning and SABER for Linux Machines, Product Version: 4.1.6	12
Software Modules Updated from version 4.1.5	12
Table A-10. Survey Planning and SABER for Linux Machines, Product Version: 4.1.9	13
Software Modules Updated from version 4.1.6	13
Table B-1. 2006 <i>M/V Atlantic Surveyor</i> TPE Parameter File	16
Table B-2. Reson8101 Sonar Parameters	17
Table C-1. <i>M/V Atlantic Surveyor</i> Antenna and Transducer Locations (measurements in meters).....	21
Table C-2. <i>M/V Atlantic Surveyor</i> Settlement and Squat Determination	23
Table C-3. Junction Analysis of Cross versus Main Scheme	25
Table C-4. Alignment Biases Calculated Using Swath Alignment Tools	26
Table C-5. Tide Zone Parameters	30
Table C-6. Water Level Differences Across Zone Boundaries, Verified	31

List of Figures

	Page
Figure A-1. The <i>M/V Atlantic Surveyor</i>	1
Figure A-2. Geometry of Side Scan Towfish Position Calculations Using the Payout and Depth Method.	5
Figure C-1. Configuration of <i>M/V Atlantic Surveyor</i> during Survey Operations (Measurements in meters).....	20
Figure C-2. <i>M/V Atlantic Surveyor</i> Draft.....	22
Figure C-3. Survey Grid, Selected Soundings and Chart 12323	24
Figure C-4. Timing Test Results.....	26
Figure C-5. SAT Tool, Plan View Depicting +2.00 Pitch Bias.....	27
Figure C-6. SAT Tool, Depth vs. Distance Plot Depicting +2.00 Pitch Bias	27
Figure C-7. SAT Tool, Plan View Depicting +0.72 Roll Bias	28
Figure C-8. SAT Tool, Depth vs. Distance Depicting +0.72 Roll Bias.....	28
Figure C-9. SAT Tool, Plan View Depicting +2.0 Heading Bias.....	29
Figure C-10. SAT Tool, Depth vs. Distance Depicting +2.0 Heading Bias	29

ACRONYMS

<u>Acronym</u>	<u>Definition</u>
ASCII	American Standard Code for Information Interchange
CMG	Course Made Good
CTD	Conductivity, Temperature, Depth profiler
CUBE	Combined Uncertainty and Bathymetric Estimator
DAT	Digital Audio Tape
DGPS	Differential Global Positioning System
DPC	Data Processing Center
DR	Descriptive Report
EPF	Error Parameters File
GPS	Global Positioning System
GSF	Generic Sensor Format
GUI	Graphical User Interface
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
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
SABER	Survey Analysis and area Based Editor
SAIC	Science Applications International Corporation
SAT	Sea Acceptance Tests, or Swath Alignment Tool
SDF	Sonar Data Format
SSP	Sound Speed Profile
SV&P	Sound Velocity and Pressure Sensor
TPE	Total Propagated Error
TPU	Transceiver Processing Unit
UPS	Uninterruptible Power Supply
XTF	eXtended Triton Format

A. EQUIPMENT

Data Acquisition: Central to Science Applications International Corporation's (SAIC) survey system is the Integrated Survey System Computer (ISSC). The ISSC consists of a high-end dual processor computer with the Windows XP operating system, which runs SAIC's **ISS-2000** software. This software provides survey planning and real-time survey control in addition to data acquisition and logging for multibeam and navigation data. Klein 3000 side scan sonar data were acquired using Klein's **SonarPro** sonar software running on a computer with the Windows 2000 operating system.

Data Processing: Post-acquisition multibeam processing was performed both on board and in the Newport, RI, office using a high-end dual processor computer with the Linux operating system, which runs SAIC's **SABER** (Survey Analysis and Area Based Editor) software. Side scan sonar data were reviewed for targets and quality in Triton-Elics' **Isis** sonar software both on board and in the Newport, Rhode Island, office. Subsequently, side scan mosaics were created, and correlation between side-scan contacts and multibeam data were established in **SABER**.

THE SURVEY VESSEL

The platform used for data collection was the *M/V Atlantic Surveyor* (Figure A-1). The vessel is equipped with an autopilot, echo sounder, Differential Global Positioning System (DGPS), radars, and two 40 KW diesel generators. Accommodations for twelve surveyors are 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 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 Position Orientation System/Marine Vessels (POS/MV) Inertial Measurement Unit (IMU) was mounted below the main deck of the vessel, 0.39 meters port of centerline and 0.34 meters forward of, 0.12 meter starboard of and 1.64 meters above the RESON 8101 transducer. The multibeam sounder transducer was mounted on the hull 0.51 meters port of the keel. A Brook Ocean Technologies Moving Vessel Profiler 30 (MVP-30) was mounted on the starboard stern quarter. Configuration parameters, offsets, and installation diagrams are included in Section C of this report.

SINGLE BEAM SYSTEMS AND OPERATIONS

SAIC did not utilize single beam 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 5-6 survey days) in lieu of a single beam sonar comparison in accordance with the Statement of Work Attachment #6. 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 the Mid-Atlantic Corridor, Coast of New Jersey surveys includes one of each of the following unless further specified:

- Windows XP workstation (ISSC) for data acquisition, survey 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 with a Trimble Probeacon Differential Receiver
- Trimble 4000 GPS Receiver with a Leica MX-41R Differential Receiver

- MVP 30 Moving Vessel Profiler with interchangeable Applied Microsystem 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 19-01 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.

SIDE SCAN SONAR SYSTEMS AND OPERATIONS

The side scan system used for surveys H11554, H11555 includes one of each of the following:

- Klein 3000 digital side scan sonar towfish with a Klein K1 k-wing depressor
- Klein 3000 Windows 2000 computer for data collection and logging of side scan sonar data with Klein **SonarPro** version 9.6 software
- Klein 3000 Transceiver Processing Unit (TPU)
- McCartney sheave with cable payout indicator
- Sea Mac winch with remote controller
- Uninterrupted power supplies (UPS) for protection of the computer system

The backup side scan system maintained aboard includes:

- Klein 3000 digital side scan sonar towfish with a Klein K1 k-wing depressor
- Klein 3000 Windows 2000 computer
- Klein 3000 Transceiver Processing Unit (TPU)

The Klein 3000 is a conventional dual frequency side scan towfish. At a range scale of 50 meters, the ping rate of 15 pings/second is set by the transceiver, which allowed for a maximum survey speed of 9 knots. This maximum survey speed, based on the Klein 3000 range scale, ensured a minimum of three pings per meter in the along-track distance allowing for the detection of objects that measure 1.0 x 1.0 meters horizontally and 1.0 meter vertically (from shadow length measurements). Side scan operations were conducted in water depths ranging from 15.3 to 37.2 meters (50 to 122 feet). During the survey operations on all sheets, a range scale of 50-meters was consistently used.

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

Towfish positioning was provided by **ISS-2000** through a program module called "rtcatnry." This program was configured to use a Payout and Towfish Depth, Figure A-2, to compute towfish positions. The Payout and Depth method computed the position of the tow point using the offsets of the tow point from the POS/MV IMU and the vessel heading. The tow fish position was calculated from the position of the tow point using the cable out value 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. This method assumes that the cable is in a straight line therefore no catenary algorithm was used.

The ship's north and east velocity vectors are filtered to calculate the ship's CMG. The CMG is used to determine the azimuth from the tow block to the side scan towfish. The position for the side scan towfish was computed based on the vessel's heading, the reference position (POS/MV IMU), the measured offsets (X, Y, and Z) to the tow point, height of the tow point above the water, Course Made Good and the amount of cable out. This calculated towfish position was sent to the sonar data collection system 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.

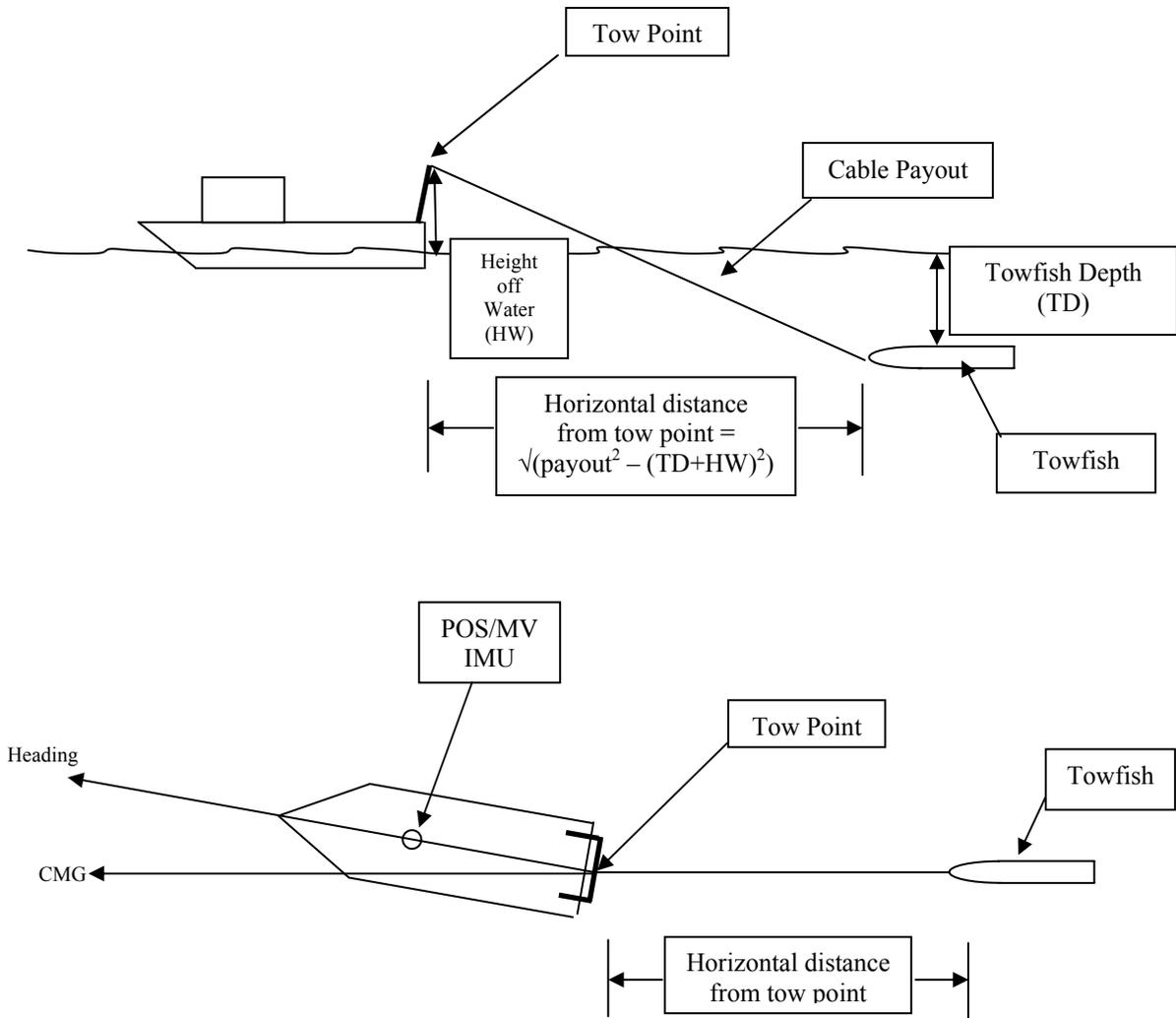


Figure A-2. Geometry of Side Scan Towfish Position Calculations Using the Payout and Depth Method.

Towfish altitude was maintained between 8% and 20% of the range (4m-10m), when conditions permit. For equipment and personnel safety as well as safe vessel maneuverability, data may have been 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 required that the altitude of the towfish be maintained outside the 8% to 20 % of the range to avoid refraction in the sonar data that would mask small targets in the outer sonar swath range. When the towfish altitude was either greater than 20% or less than 8%, 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. Confidence checks ensured the ability to detect one-meter high objects across the full sonar record range.

Another feature that affected the towfish altitude was the use of a K-wing depressor. The K-wing depressor was attached directly to the towfish and served to keep it below the

vessel wake, even at slower survey speeds of less than 6 knots. It also decreased the amount of cable out, which reduced the positioning error of the towfish. Another benefit to 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. The K-wing was not used in the shallower areas because the reduced cable out resulted in acoustic interference with the multibeam system.

Side scan data file names were changed automatically every hour and manually at the completion of a survey line.

SOUND SPEED PROFILES

A Brooke Ocean Technology Moving Vessel Profiler (MVP) with an Applied Microsystems SV&P Smart Sensor or a Seabird Electronics SBE-19 CTD were 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. Multiple casts were taken along a survey line to identify the rate and location of sound speed changes. Subsequent casts were made based on the observed trend of sound speed changes. As the sound speed profiles changed, cast frequency and location were modified accordingly. Confidence checks of the sound speed profile casts were conducted weekly by comparing two consecutive casts taken with different SV&P Smart Sensors or with a SV&P Smart 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: 24 March 2006 and 22 December 2006

Applied Microsystems Ltd., SV&P Smart Sensor, Serial Number 4880
Calibration Dates: 01 March 2006 (Sensor was damaged during survey operations. No post survey calibration available.)

Seabird Electronics, Inc., CTD, Serial Number 2710
Calibration Dates: 15 March 2006 and 01 November 2006

Seabird Electronics, Inc., CTD, Serial Number 0648
Calibration Dates: 28 February 2006 and 01 November 2006

Seabird Electronics, Inc., CTD, Serial Number 0565
Calibration Dates: 01 March 2006 and 03 November 2006

DATA ACQUISITION AND PROCESSING SOFTWARE

Data acquisition was carried out using the SAIC **ISS-2000** software on a Windows 2000 operating system to control real-time navigation, data time tagging and data logging. Table A-2 provides a complete list of all **ISS-2000** version 3.10 software modules for the Windows 2000 platform.

Survey planning, data processing and analysis were carried out using the SAIC **Survey Planning** and **SABER** software packages on LINUX operating systems. Table A-3 provides a complete list of all **Survey Planning** and **SABER** version 3.3.10 software. In December 2005, **SABER** was upgraded to version 3.3.15 in the office only. Table A-4 provides a list of **Survey Planning** and **SABER** version 3.3.15 updated software modules. In January 2006, **SABER** was upgraded to version 3.4.5 in the office and in September on boat. Table A-5 provides a list of **SABER** version 3.4.5 updated software modules. **SABER** versions 4.0.13 and 4.0.14 were distributed for use in December 2006. Table A-6 provides the complete list of all **SABER** modules in version 4.0.13, while Table A-7 lists the modules updated in version 4.0.14. Table A-8 lists the modules updated in **SABER** version 4.1.5, which was distributed for use in February 2007. **SABER** version 4.1.6 was also distributed for use in February 2007 and all modified components are listed in Table A-9. The final **SABER** release used for H11554 data processing was version 4.1.9, released in April 2007 (Table A-10).

SonarPro version 9.6, running on a Windows 2000 platform was used for side scan data acquisition.

Isis version 6.06, running on Windows 2000 and XP platforms was used for side scan data quality review, and contact identification.

Position data were recorded from both the POS/MV system and the Trimble 7400. Data from the POS/MV were used as the primary navigation and were merged with multibeam data. Daily vessel positioning confidence checks were done by comparing data recorded from the POS/MV to data recorded from the Trimble DGPS (see Horizontal and Vertical Control Report – SAIC Doc 06-TR-018).

Table A-2. ISS-2000 for Windows Product Version: 3.10

libcheckkey.dll Built at Version -vLIBCHKKEY 1.17	magynav.exe Built at Version -vMAGYNAV 2.4
libutility.dll Built at Version -vUTILITY 2.15	makeindx.exe Built at Version -vMAKEINDEX 2.6
libbancomm.dll Built at Version -vBANCOMM_2.2.2	mergserv.exe Built at Version - vMERGE SERVE 2.4
libproj.dll Built at Version -vPROJ_2.6	mbimagery.exe Built at Version - vMBIMAGERY 2.5
libnad.dll Built at Version -vPROJ 2.6	mbmgr.exe Built at Version -vMBMGR 2.11
libsnpgeo.dll Built at Version -vSNPGEO 2.4	mru6.exe Built at Version -vMRU6 2.3
libdbms.dll Built at Version -vDBMS 2.13	msgmgr.exe Built at Version -vMSGMGR 2.12
libnmea0183.dll Built at Version -vNMEA0183 2.4	mvp30.exe Built at Version -vMVP30 2.2
libsnpgprim.dll Built at Version -vSNPGPRIM 2.10	mvpout.exe Built at Version -vMVPOUT 2.5
libgsf.dll Built at Version -vGSF_2.04	navisounddttc.exe Built at Version - vNAVISOUNDDDTC 1.7

libbdb.dll Built at Version -vDBDB 2.5	nmea_apb.exe Built at Version -vNMEA_APB 2.4
libhmps.dll Built at Version -vHMPS_LIB 2.14	ntimesrv.exe Built at Version -vNTIMESRV 2.3
libsensors.dll Built at Version -vSENSORS 2.17	payout.exe Built at Version -vPAYOUT 2.5
libfilters.dll Built at Version -vFILTERS 2.5	phoenix.exe Built at Version -vPHOENIX 2.3
libgrid_io.dll Built at Version -vGRID_IO 3.15	phxovl.exe Built at Version -vPHOENIX_OVL 2.4
nutil.dll Built at Version -vNUTIL 2.1	pmv_3.exe Built at Version -vPMV3 2.13
libplotw.dll Built at Version -vPLOTWID 2.5	ptti.exe Built at Version -vPTTI 2.4
libdspgraph.dll Built at Version -vDSPGRAPH 2.7	resondtc.exe Built at Version -vRESONDTC 2.9
libhpgraph.dll Built at Version -vHPGRAPH 2.6	rtcatnry.exe Built at Version -vRTCATNRY 2.8
libsnpdraw.dll Built at Version -vSNPDRAW 2.21	rtkf.exe Built at Version -vRTKF 2.10
libpthreads.dll Built at Version -vPTHREAD 2.5	rtkflite.exe Built at Version -vRTKFLITE 2.4
libchildwatch.dll Built at Version -vLBLNAV 2.4	rttide.exe Built at Version -vRTTIDE 2.12
libsvputil.dll Built at Version -vSVPUTIL 2.14	sbdtc.exe Built at Version -vSBDTC 1.3
libsmemcom.dll Built at Version -vSMEMCOM 2.8.2	serialb.exe Built at Version -vSERIALB 2.5
libxutils.dll Built at Version -vXUTILS 2.6.1	sirpm.exe Built at Version -vSIRPM 2.7
libhtmlwid.dll Built at Version -vHTMLWID 2.4	srvfile.exe Built at Version -vHPRCAL 2.3
libsputil.dll Built at Version -vSPUTIL 2.16.1	stateb.exe Built at Version -vSTATEB 2.5
libunisips_io.dll Built at Version -vUNISIPS_IO 4.2	svpmon.exe Built at Version -vSVPMON 2.14
libdatamrge.dll Built at Version -vDATAMRGE 2.4	swathplt.exe Built at Version -vSWATHPLT 2.9
libmb_corr.dll Built at Version -vMB_CORR 1.9	synctime.exe Built at Version -vSYNCTIME 2.6
libmberr.dll Built at Version -vMBERR 2.5	syscon.exe Built at Version -vSYSCON 2.12
libctable.dll Built at Version -vCTABLE 2.5	taim.exe Built at Version -vTAIM 2.3.2
libdbx.dll Built at Version -vDBX 2.3	telrx.exe Built at Version -vTELWNT 2.5
libsim_util.dll Built at Version -vSIM_UTIL 2.1	teltx.exe Built at Version -vTELWNT 2.5
spmgr.exe Built at Version -vSPMGR 2.14.3	timechk.exe Built at Version -vTIMECHK 2.6
sysadmin.exe Built at Version -vSYSADMIN 2.9	tkpt2.exe Built at Version -vTRACKPT2 2.4
4rinex.exe Built at Version -vFORRINEX 1.1	tprobet.exe Built at Version -vTPROBET 2.2
ap9.exe Built at Version -vAP9 2.2	tss335b.exe Built at Version -vTSS335B 2.5
autoarch.exe Built at Version -vAUTO_ARCHIVE 2.10	utcmgs.exe Built at Version -vUTCMGS 1.3
bc635_detect.exe Built at Version -vBC635_DETECT 1.1	waterfal.exe Built at Version -vWATERFAL_2.9
bc635evt.exe Built at Version -vBC635EVT 2.3	whnav.exe Built at Version -vWHNAV 2.3
beacons.exe Built at Version -vBEACONS 2.7	xdp.exe Built at Version -vXDP 2.0.4
comtst.exe Built at Version -vCOMTST 2.4	xpdctl.exe Built at Version -vXPDCTL 2.0.4
cov_mon.exe Built at Version -vCOV_MON 2.12	xgpsmon.exe Built at Version -vXGPSMON 2.8
dpt_dtc.exe Built at Version -vNMEA_DPT_2.4	xnavmgr.exe Built at Version -vXNAV MGR 2.14.1
dtc_disp.exe Built at Version -vDTC_DISP 2.9	z12.exe Built at Version -vZ12 2.8
echodtc.exe Built at Version -vECHO_DTC 2.7	datamgr.exe Built at Version -vDATAMGR 2.10
envmgr.exe Built at Version -vENVMGR_2.11	datasumm.exe Built at Version -vDATASUMM 2.15
em_out.exe Built at Version -vEM_OUT 2.5.1	imprtdxf.exe Built at Version -vIMPRTDXF 2.13
em_rcv.exe Built at Version -vEM_RCV 2.11	tkproj.exe Built at Version -vTKPROJ 2.13
exammb.exe Built at Version -vEXAMMB 2.14	echo_raw.exe Built at Version -vECHO_RAW 1.0
file_mgr.exe Built at Version -vFILE_MGR 2.7	iem3000.exe Built at Version -vIEM3000 2.5.3
fishbath.exe Built at Version -vFISH_BATHY_2.11	inavisound.exe Built at Version -vINAVISOUND 1.1
focus.exe Built at Version -vFOCUS 2.4	inmeaapb.exe Built at Version -vINMEA_APB 2.1
helmmgr.exe Built at Version -vHELM MGR 1.2	inmeagps.exe Built at Version -vINMEAGPS 2.2
hpr309.exe Built at Version -vHPR309 2.3	irpm.exe Built at Version -vIRPM 2.1
hpr410.exe Built at Version -vHPR410_2.5	iss2000_sim_scripts.exe Built at Version -vISS2000_SIM_SCRIPTS 2.0
hprcal.exe Built at Version -vHPRCAL 2.3	navsim.exe Built at Version -vNAVSIM 2.2
innovatum.exe Built at Version -vINNOVATUM 2.4	pmv_3sim.exe Built at Version -vPMV3SIM 2.7

kflogfsh.exe Built at Version -vKFLOGFSH_2.5	replay_svy.exe Built at Version -vREPLAY_SVY_1.2
kflogshp.exe Built at Version -vKFLOGSHP_2.7	replay_xtf.exe Built at Version -vREPLAY_XTF_1.1
klein595.exe Built at Version -vKLEIN595_2.2	resonsim.exe Built at Version -vRESONSIM_1.2
kpdisplay.exe Built at Version -vKP_2.4	sbsim.exe Built at Version -vSBSIM_1.1
kvh.exe Built at Version -vKVH_2.3	supfiles.exe Built at Version -vISS2000_SUPPORT_2.16

Table A-3. Survey Planning and SABER for Linux Machines, Product Version: 3.3.10

ABE BYTESWAP LIB 1.0	GETJUNC 1.7	POSTEST 1.1
ABE CHARTS LIB 1.0	GETKPS 1.2	PROFEDIT 1.6
ABE MERGE LIB 1.2	GETLLPROF 1.2	PROFLBLS 1.1
ABE MISP LIB 1.1	GETPROF 1.9	RANGEFLT 1.2
ABE MOSAIC LIB 1.0	GET FEATURES 1.5	RAWREAD 1.2
ABE PFM LIB 4.70	GRIDGSF 1.15	RECON 1.8
ABE PROFEDIT LIB 1.1	GRID IO 3.14	REDOCAT 1.1
ABE SHOALS LIB 1.3	GSF2TXT 1.5	REFRMTRK 1.2
ABE SHOALS WAVE VIEW 1.0	GSF2XYZ 1.4	REGCHKGSF 1.2
ABE TARGET LIB 1.7	GSFBEAMEX 1.2	REMOTE 2.1
ABE UNISIPS LIB 1.0	GSFCAT 1.0	RESETFLG 1.3
ABE UTILITY LIB 1.5	GSFEDIT 1.1	RESONFLT 1.2
ACCUTEST 1.6	GSFNAVFIX 1.1	REVERSIT 1.1
ANX CROSSINGS 1.3	GSFSPLIT 1.1	RUNKEYMEM 1.6
APPCORS 2.5	GSFUPDATE 1.7	SABER APPLY TIDES 1.4
APPLYSQT 1.2	GSF 2.04	SABER BUILD TARGET 1.3
AUTO ARCHIVE 2.8	GSF FIND SQUAT 1.0	SABER EXCLUDE 1.0
BAG2COVGRD 1.1	GSF FIX HEAVE 1.0	SABER GRIDVIEW 1.2
BAGTASKS 1.1	GSF STRIP IMAGERY 1.0	SABER GSF CLASS 1.0
BATHYPROF 1.1	GXY2PFL 1.1	SABER MILES 1.0
BEAMHIST 1.1	HMPS LIB 2.14	SABER PFM2COV 1.0
CABLERUN 1.2	HMSCORRS 1.4	SABER PFM2RDP 1.1
CALC SLOPE ASPECT 1.0	HMSREPORT 1.5	SABER PFM2VRML 1.0
CELL TO PCX 1.15	HPGRAPH 2.4	SABER PFM BEAMSTATS 1.1
CHECKSQT 1.2	HTMLUTIL 1.2	SABER PFM DECONFLICT 1.0
CHECK DISK DIALOG 1.1	HTMLWID 2.4.1	SABER PFM EXTRACT 1.1
CHECK FEATURES 1.4	INGSIMRAD 2.9	SABER PFM LOADER 1.11
CHKKFP 1.1	ING CMAP 1.1	SABER PFM MISP 1.0
CHNLVOL 1.1	ING SEABM 1.2	SABER PFM MODSCALE 1.0
CLASS1 LAYER 1.1	ISIS2CTV 2.3	SABER PFM RECOMPUTE 1.2
COMBINE LAYERS 1.3	ISSUBPROF 1.4	SABER PFM RESIDUAL 1.0
CONTACT DXF 1.3	I ELAC 1.5	SABER PFM UNLOAD 1.2
CONTOUR LAYER 1.8	I SB2112 1.1	SABER SAT 1.5
CONV DXF 1.2	KEY DIALOG 1.1	SEL2HIST 1.1
COUNT SOUNDINGS 1.0	LIBBAG 1.1	SELSLOPE 1.3
COV2GRASS 1.0	LIBCHKKEY 1.16	SEL SOUND 1.20
CPWINDPRJ 1.1	MAGYPROF 1.1	SEND TELEGRAM 1.0
CRS2MTIF 1.1	MAKEEXTENTS 1.2	SENSORS 2.16
CTABLE 2.3	MAKEINDX 2.5	SETSOUND 1.6
DATAMRGE 2.3	MAKEKPS 1.2	SHADED RELIEF 1.0
DATASUMM 2.15	MAKELLPROF 1.3	SLOPEVOL 1.1

DBEXTRACT 1.2	MAKEMINMAXZ 1.3	SMEMCOM 2.8.1
DBMS 2.12	MAKETRK 1.5	SMOOTH PFL 1.1
DECITRK 1.4	MBERR 2.7.1	SMOOTH LAYER 1.0
DESIGNGRD 1.3	MBFILT 1.8	SNIPIT 1.2
DIFF_LAYER 1.4	MBHAT 2.37	SNPCHART 1.2
DSPGRAPH 2.7.1	MBHAT LIB 1.1	SNPDRAW 2.20.1
DUMP_GSF 1.1	MBIMAGERY 2.1.4	SNPGEO 2.3
DXF2MASK 1.1	MB CORR 1.8	SPMGR 2.14.1
EDITGRID 1.4	MERGE DIG 1.0	SPUTIL 2.16
EDIT_PFM 1.0	MKGMTPROF 1.1	SRV_RPT 1.4
ERRDISP 2.5	MOUNDGRD 1.1	SSCODES 1.1
ERRORS 1.3	MSGREAD 1.10	SUMMDATA 1.7
EXAMGYRO 1.2	MVE 4.14	SVPMON 2.14
EXAMMB 2.14	NAVUP 1.10	SVPUTIL 2.14
EXPRTGRD 1.10	NAV_EDIT 1.6	TARGET DXF 1.3
EXPRTSND 1.7	NMEAMSGS 1.7	TID2HMPS 1.14
EXRTPROF 1.5	NUTIL 2.1	TIFFLIB 1.0
EXRTPROF MAG 1.1	PCSS2TARG 1.2	TINGRID 1.3
EXTRACT HEAVE 1.0	PFM2BAG 1.1	TKPROJ 2.12\
FEATUREGSF 1.4	PFM2COVGRD 1.4	TRK2GXY 1.1
FEATURE CORRELATOR 1.9	PFM TASKS 1.7	UPDATECONT 1.4
FILLDBS 1.2	PIPE2DXF 1.1	UTILITY 2.11.4
FILTERS 2.4	PLATF2TRK 1.1	WRITE HIST 1.7
FIND CROSSINGS 1.3	PLIBEXTENTS 1.1	XGRAPH 1.2
GEOTIFFLIB 1.0	PLOTWID 2.4	XTF2GSF 1.6
GETDIFFS 1.1	POSGAPCHK 1.2	XTF IO 1.21
GETEXTENTS 1.3	POSRPLCNT 1.3	XUTILS 2.7

Table A-4. Survey Planning and SABER for Linux Machines, Product Version: 3.3.15 Software Modules Updated from version 3.3.10

APPCORS 2.6	MASCD 1.1
DATAMRGE 2.5	MBERR 2.8
EXAMMB 2.15	MBIMAGERY 2.1.5
GSF 2.04.2	RUNKEYMEM 1.7
HMPS LIB 2.15	SABER_PFM_LOADER 1.12
INGSIMRAD 2.10	SABER_PFM_RECOMPUTE 1.3
KEY_PROBE 1.0	SABER_SAT 1.6
LIBBAG 1.2	TEST_BEAM_FLAGS 1.0
LIBCHKKEY 1.18	TID2HMPS 1.15

Table A-5. Survey Planning and SABER for Linux Machines, Product Version: 3.4.5 Software Modules Updated from version 3.3.15

ABE_PFM_LIB 4.70.2
FEATURE CORRELATOR 1.10
ISIS2CTV 2.4
MBHAT 2.37.1
PFM_TASKS 1.8.1
SABER_PFM_LOADER 1.12.1
SNPDRAW 2.20.2

Table A-6. Survey Planning and SABER for Linux Machines, Product Version: 4.0.13

ACCUTEST 1.6	GSF2TXT 1.5	PROFEDIT 1.6
ANX_CROSSINGS 1.3	GSF2XYZ 1.4	PROFLBLS 1.1
APPCORS 2.6	GSFBEAMEX 1.2	RANGEFLT 1.2
APPLYSQT 1.2	GSFCAT 1.0	RAWREAD 1.2
AUTO_ARCHIVE 2.8	GSFEDIT 1.1	RECON 1.8
BAG2COVGRD 1.1	GSF_FIND_SQUAT 1.0	REDOCAT 1.1
BAGTASKS 1.2	GSF_FIX_HEAVE 1.0	REFRMTRK 1.3
BATHYPROF 1.1	GSFHIST2TXT 1.4	REGCHKGSF 1.2
BEAMHIST 1.1	GSFNAVFIX 1.1	REMOTE 2.1
CABLERUN 1.2	GSFSPLIT 1.1	RESETFLG 1.3
CALC_SLOPE_ASPECT 1.0	GSF_STRIP_IMAGERY 1.0	RESONFLT 1.2
CELL_TO_PCX 1.16	GSFUPDATE 1.7	REVERSIT 1.1
CHECK_DISK_DIALOG 1.1	GXY2PFL 1.1	SABER_APPLY_TIDES 1.4
CHECK_FEATURES 1.4	HMSCORRS 1.4	SABER_BUILD_TARGET 1.3
CHECKSQT 1.2	HMSREPORT 1.5	SABER_EXCLUDE 1.0
CHECK_TIDES 1.2	I_ELAC 1.5	SABER_GRIDVIEW 1.2
CHKGSF 1.3	IMPRTDXF 2.12	SABER_GSF_CLASS 1.0
CHKKFP 1.1	ING_CMAP 1.1	SABER_MILES 1.0
CHNLVOL 1.1	ING_SEABM 1.2	SABER_PFM2COV 1.1
CLASS1_LAYER 1.1	INGSIMRAD 2.10	SABER_PFM2RDP 1.1
COMBINE_LAYERS 1.3	INSTALL_SABER 1.14	SABER_PFM2VRML 1.0
CONTACT_DXF 1.3	INSTALL_SPMGR 1.1	SABER_PFM_BEAMSTATS 1.1
CONTOUR_LAYER 1.8	I_SB2112 1.1	SABER_PFM_DECONFLICT 1.0
CONV_DXF 1.2	ISIS2CTV 2.4	SABER_PFM_EXTRACT 1.1
COUNT_SOUNDINGS 1.0	ISSUBPROF 1.4	SABER_PFM_LOADER 1.13
COV2GRASS 1.0	KEY_DIALOG 1.1	SABER_PFM_MISP 1.0
CPWINDPRJ 1.1	MAGYPROF 1.1	SABER_PFM_MODSCALE 1.0
CRS2MTIF 1.1	MAKEEXTENTS 1.2	SABER_PFM_RECOMPUTE 1.4
DATASUMM 2.15	MAKEINDX 2.5	SABER_PFM_RESIDUAL 1.0
DBEXTRACT 1.2	MAKEKPS 1.2	SABER_PFM_UNLOAD 1.3
DECITRK 1.4	MAKELLPROF 1.3	SABER_SAT 1.6
DESIGNGRD 1.3	MAKEMINMAXZ 1.3	SEL2HIST 1.1
DIFF_LAYER 1.5	MAKETRK 1.5	SELSLOPE 1.3
DUMP_GSF 1.1	MASCD 1.1	SEL_SOUND 1.20
DXF2MASK 1.1	MBFILT 1.8	SEND_TELEGRAM 1.0
EDITGRID 1.4	MBHAT 2.39	SETSOUND 1.6
EDIT_PFM 1.0	MBIMAGERY 2.1.5	SHADED_RELIEF 1.0
ERRDISP 2.5	MERGE_DIG 1.0	ABE_SHOALS_WAVE_VIEW 1.0
ERRORS 1.4	MKGMTPROF 1.1	SLOPEVOL 1.1
EXAMGYRO 1.2	MONITOR 1.3	SMOOTH_LAYER 1.0
EXAMMB 2.15	MOUNDGRD 1.1	SMOOTH_PFL 1.1
EXPRTGRD 1.11	MSGREAD 1.10	SNIPIT 1.2
EXPRTSND 1.7	MSTNAV 1.2	SPMGR 2.14.1
EXRTPROF 1.5	MVE 5.1	SRV_RPT 1.4

EXRTPROF_MAG_1.1	NAV_EDIT_1.6	SSCODES_1.1
EXTRACT_HEAVE_1.0	NAVUP_1.11	SUMMDATA_1.7
FEATURE_CORRELATOR_1.10	PCSS2TARG_1.2	SVPMON_2.14
FEATUREGSF_1.4	PFM2BAG_1.4	TARGET_DXF_1.3
FILLDBS_1.2	PFM2COVGRD_1.5	TEST_BEAM_FLAGS_1.0
FIND_CROSSINGS_1.3	PFM_BAG_CHECK_1.0	TID2HMPS_1.15
GETDIFFS_1.1	PFM_CUBE_1.0	TINGRID_1.3
GETTEXTENTS_1.3	PFM_TASKS_1.9	TKPROJ_2.12
GET_FEATURES_1.6	PIPE2DXF_1.1	TRK2GXY_1.1
GETJUNC_1.7	PLATF2TRK_1.1	UPDATECONT_1.4
GETKPS_1.2	PLIBEXTENTS_1.1	WRITE_HIST_1.7
GETLLPROF_1.2	POSGAPCHK_1.2	XTF2GSF_1.6
GETPROF_1.9	POSRPLCNT_1.3	XTF_IO_1.21
GRIDGSF_1.15	POSTEST_1.1	

Table A-7. Survey Planning and SABER for Linux Machines, Product Version: 4.0.14 Software Modules Updated from version 4.0.13

INGSIMRAD_2.10.1
PFM_BAG_CHECK_1.1
SVPMON_2.14.1
TID2HMPS_1.16

Table A-8. Survey Planning and SABER for Linux Machines, Product Version: 4.1.5 Software Modules Updated from version 4.0.14

APPCORS_2.7	MBHAT_2.42
APPLYSQT_1.3	MVE_5.3
AUTO_ARCHIVE_2.10	PFM2BAG_1.5
BAGTASKS_1.4	PFM_BAG_CHECK_1.1
DATASUMM_2.17	PFM_CUBE_1.1
ERRDISP_2.6	REDOCAT_1.2
EXAMMB_2.17.1	S57GEN_1.0
FEATURE_CORRELATOR_1.12	SABER_PFM_LOADER_1.14
GSF2TXT_1.6	SABER_SAT_1.7
I_GEOSWATHCBF_1.1	SPMGR_2.14.4
INGSIMRAD_2.10.1	SVPMON_2.14.1
ISIS2CTV_2.6	SVPMON_2.14
MAKEINDX_2.6	TID2HMPS_1.16
MASCD_1.2	TKPROJ_2.13

Table A-9. Survey Planning and SABER for Linux Machines, Product Version: 4.1.6 Software Modules Updated from version 4.1.5

APPCORS_2.9
CELL_TO_PCX_1.17
I_GEOSWATHCBF_1.2
INGSIMRAD_2.10.1

MBHAT 2.43
PFM BAG CHECK 1.1
PFM TASKS 1.10
S57GEN 1.1
SEL_SOUND 1.21
SVPMON 2.14.1

Table A-10. Survey Planning and SABER for Linux Machines, Product Version: 4.1.9 Software Modules Updated from version 4.1.6

ACCUTEST 1.7
CHECK_HEAVE 1.0
ISIS2CTV 2.7
TID2HMPS 1.16
XTF IO 1.22

NOTE: Throughout this report wherever software is mentioned, it is inferred that the most current version of the software available was used. A complete list of all software versions and dates is provided in Section A of this report.

B. QUALITY CONTROL

A systematic approach to tracking data has been developed to maintain data quality and integrity. Several forms and checklists identify and track the flow of data as it is collected and processed. These forms are presented in the Separates section included with the data for each survey.

During data collection, the watch standers continuously monitor the systems, checking for errors and alarms. Thresholds set in the **ISS-2000** system alert the watch stander by displaying alarm messages when error thresholds or tolerances are exceeded. These alarms, displayed as they occur, are reviewed and acknowledged on a case-by-case basis. Alarm conditions that may compromise survey data quality are corrected and then 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 are addressed by the watch stander and automatically recorded into a message file. Approximately every 1-2 hours the real-time watch standers complete checklists to ensure critical system settings and data collection are valid.

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
- Second review and editing of multibeam data. 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 sounding grids
- Crossline checks
- Generation of preliminary side scan coverage mosaics

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 crossline analysis. Results of this analysis was reviewed to determine adequacy of data and sounding correctors.

- Main scheme, item, and holiday fill survey lines
- Crosslines using only near nadir (+/- 5° from nadir)

During port calls, a complete backup of all raw and processed multibeam data and side scan data was sent to the Newport Data Processing Center. Analysis of the data at the Newport facility includes the following steps:

- Generation of multibeam and side scan track line plots
- Generation of side scan Contact Files and Contact Plot
- Swath editing and review of multibeam data
- Calculation and application of verified tide correctors to multibeam data
- Application of delayed heave
- Calculation of Total Propagated Error
- Generation of a PFM CUBE surface
- Set designated soundings on wrecks and obstructions
- Convert PFM to BAG
- Generate S-57
- Coverage plots of multibeam data
- Crossline analysis of multibeam data
- Comparison with prior surveys
- Comparison with existing charts
- Quality control reviews of side scan data and contacts
- Final Coverage mosaic plots of side scan sonar data
- Correlation of side scan contacts with multibeam data
- Final quality control of all delivered data products

Processing and quality control procedures for multibeam and side scan data acquisition are described in detail in the following pages.

MULTIBEAM DATA PROCESSING

The multibeam data is initially 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. At the end of each survey line, all data files are closed and new files opened for data logging. The closed files were then auto-archived to the processing center where track lines were generated and the multibeam data file was reviewed to flag erroneous data such as noise, flyers, fish, etc. At the end of each survey day, both the raw and processed data were backed up onto 4mm tapes. These tapes 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 Data Processing Center (DPC), the initial step in processing 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 outermost boundaries of the survey area. When these criteria were met a second round of editing was performed with emphasis on verifying features and checking for erroneous flagging of data as invalid by the initial reviewer. Upon the completion of multibeam reviews, verified water levels and delayed heave were applied to the multibeam data and the **errors** program was run to attribute each beam with horizontal and vertical error estimates. If necessary, corrections to the draft were also made at this time.

All multibeam data were then processed into a 1-meter node **PFM CUBED Surface** for analysis using **SABER and MVE**. The CUBE standard deviation layer is useful for general review looking for depth discrepancies, especially swath to swath. The **set designated soundings** routine flags each node where the uncertainty of the sounding exceeds the allowable based on depth. These flagged soundings are examined to determine whether any additional editing of the multibeam data is required or if a designated sounding should be set to capture the shoalest depth on obstructions or wrecks. If any anomalies were found the multibeam files were re-examined and re-edited to resolve them, and the corrections were applied to the **PFM CUBED Surface**. When all multibeam files and the **PFM CUBED Surface** were determined to be satisfactory, the the **PFM CUBED Surface** was converted to a BAG for delivery.

For crossline analysis 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 crossline analysis. Results of this analysis are presented in the Descriptive Report for each survey.

- Main scheme, item, and holiday fill survey lines
- Crosslines using only near nadir (+/- 5° from nadir)

Survey System Error Model

The Total Propagated Error (TPE) model that SAIC has adopted has its genesis at the Naval Oceanographic Office (NAVOCEANO), and is based on years of work by Rob

Hare and others. The fidelity of any error model is coupled to the applicability of the equations that are used to estimate each of the components that contribute to the overall error that is inherent in each sounding. SAIC's approach to quantifying the TPE is to decompose the cumulative errors into their individual components and then compute their effects on the horizontal and vertical error components. The model then combines the horizontal and vertical error components to yield an estimate of the system error as a whole. This cumulative system error is the Total Propagated Error (TPE). By using this approach, SAIC can more easily incorporate future error 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 are 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 are also obtained from values recorded in the GSF file(s) during data collection and processing. While the input units vary, all error values that contribute to the cumulative TPE estimate are converted to meters by **SABER's Errors** program or have units of meters to begin with. The cumulative TPE estimates are separated into a horizontal and vertical component, and are recorded as the Horizontal Error and Vertical Error records in the GSF file. These error values are at the two sigma or 95% confidence level. The intent is to use these error estimates to gauge the accuracy of each sounding's coordinates and depth.

Tables B-4 and B-5 show the values entered in the errors parameter file. All parameter uncertainties in this file are 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. 2006 M/V Atlantic Surveyor TPE Parameter File

Parameter	Value	Units
static draft	2.32	Meters
draft_error (uncertainty)	0.01	Meters
squat_error (uncertainty)	0.02	Meters
fixed_heave_error_component (uncertainty)	0.05	Meters
perc_swellheave_err_component (uncertainty)	5.00	Percent
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)	0.016	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	4.59	Meters
positioning_device_xoffset_err (uncertainty)	0.05	Meters
positioning_device_y_offset	-0.54	Meters
positioning_device_yoffset_err (uncertainty)	0.05	Meters
positioning_device_z_offset	-8.02	Meters

Parameter	Value	Units
positioning_device_zoffset_err (uncertainty)	0.05	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)

Table B-2. Reson8101 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
sounder_latency	0.00	
sounder_latency_error (uncertainty)	1.00	milliseconds (msec)
range_sampling_res	0.05	Meters

Multibeam Coverage Analysis

The Mid-Atlantic Corridor, Coast of Delaware survey operations were conducted at line spacing optimized to achieve 200% side scan sonar coverage. Multibeam coverage was not required to be 100%. Main scheme lines were run at 40-meter line spacing while running the side scan at 50-meter range scale. The 1-meter node BAG made from the 1-meter node **PFM CUBED Surface** was also used for the demonstration of coverage. The **SABER Gapchecker** routine flagged multibeam data holidays exceeding the allowable three contiguous nodes. In addition the entire surface was visually scanned for holidays. Additional survey lines were run to fill any detected holidays. There were no remaining holidays greater than three contiguous nodes.

SIDE SCAN SONAR DATA PROCESSING

In real-time, the Klein 3000 digital side scan data were recorded in XTF format on the hard disk of the Klein's **SonarPro** acquisition system. After changing the file name at the end of each line, the closed side scan files were auto-archived to the on-board processing computer. Initial processing included generation of towfish track plots and generation of initial mosaics for coverage verification and quality control.

All original and processed side scan data files were backed up onto 4mm tapes in tar format for transfer to the Data Processing Center.

Once in Newport, initial processing included re-navigating the towfish to apply more accurate towfish positions using the **SABER navup** routine. This routine replaced the towfish position recorded in the original side scan XTF file with the towfish position recorded in the real-time catenary data file recorded by **ISS-2000**. It also computed a unique position and heading for each ping record. Each record in the catenary file includes:

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

During examination of side scan sonar data, a side scan review log was generated. This review log contains information about each file, including the line begin and line end times, survey line name, corresponding multibeam and side scan file names, line azimuth, data gap information, and notes pertaining to hazards of navigation (i.e. contacts), and other points of interest (e.g. large schools of fish that may partially obstruct data). Other pertinent information regarding the interpretation of the imagery was also logged in the spreadsheet. The contents of the processing log spreadsheet were later merged with the annotation file.

Side Scan Quality Review

A processor conducted a quality review of each side scan file using Triton **Isis** to replay the data. During this review the processor assessed the quality of the data and defined holidays in the data where the quality was insufficient to determine the presence of contacts. The times of these data holidays were entered into the side scan review log. 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)
- Turbidity clouds

Side Scan Coverage Analysis

A time window file listing the times of all valid online side scan data was created along with separate side scan file lists for 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 mosaics were viewed using tools in **SABER** to verify swath coverage and

to plan further survey lines to fill in any data holidays. These additional lines were run and appended to the mosaics. There were no remaining coverage holidays.

Side Scan Contact Analysis

During side scan review, sonar contacts were selected and measured using the **Isis Target** utility. Significant side scan contacts were chosen based on size and height or a unique sonar signature. In general, contacts with a height greater than or equal to 50 centimeters were selected. Where the survey passed through fish havens, unusually large or abnormally high (equal or greater than 1 m) contacts were selected, as well as any contact with a depth shoaler than the authorized minimum depth. Contacts with a unique sonar signature (e.g. size, shape, and reflectivity) were typically selected regardless of height. Contact information was saved in a “.CON” file, which included a snapshot of the image and the following information regarding the acquisition of the target data:

- 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)

Wreck and large objects were positioned at their highest point. 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. Additional information regarding objects not included as contacts but still noted in the side scan review log include descriptions of other man-made objects such as bottom fishing gear and non-significant objects. The side scan review log is included in Separates I of the Descriptive Report for each sheet.

After a second review of the side scan files was complete, the contact files were converted into a side scan contact (CTV) file using an SAIC proprietary program called **isis2ctv**. The resulting CTV is a text file that documents all of the contact attributes contained in the individual contact files. In addition a postscript image file is made of each individual contact sonar image. In **SABER**, the CTV file was directly loaded and viewed as a separate data layer. Once in the **SABER** system, side scan contacts were correlated to multibeam data by overlaying them on the gridded depth layer. By comparing multibeam bathymetry with the side scan contact data, permanent features were selected for the smooth sheet. Positions and depths of these features were determined directly from the multibeam data in SAIC’s **MVE** swath editor by flagging the shoalest depth as a feature. 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 are submitted fully corrected with uncertainties already associated with each sounding; therefore, the vessel file will be all zeros.

VESSEL CONFIGURATION PARAMETERS

The *M/V Atlantic Surveyor* sensor configuration is depicted in Figure C-1 **Error! Reference source not found.** 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. The reference point for the entire system is located at the POS/MV IMU.

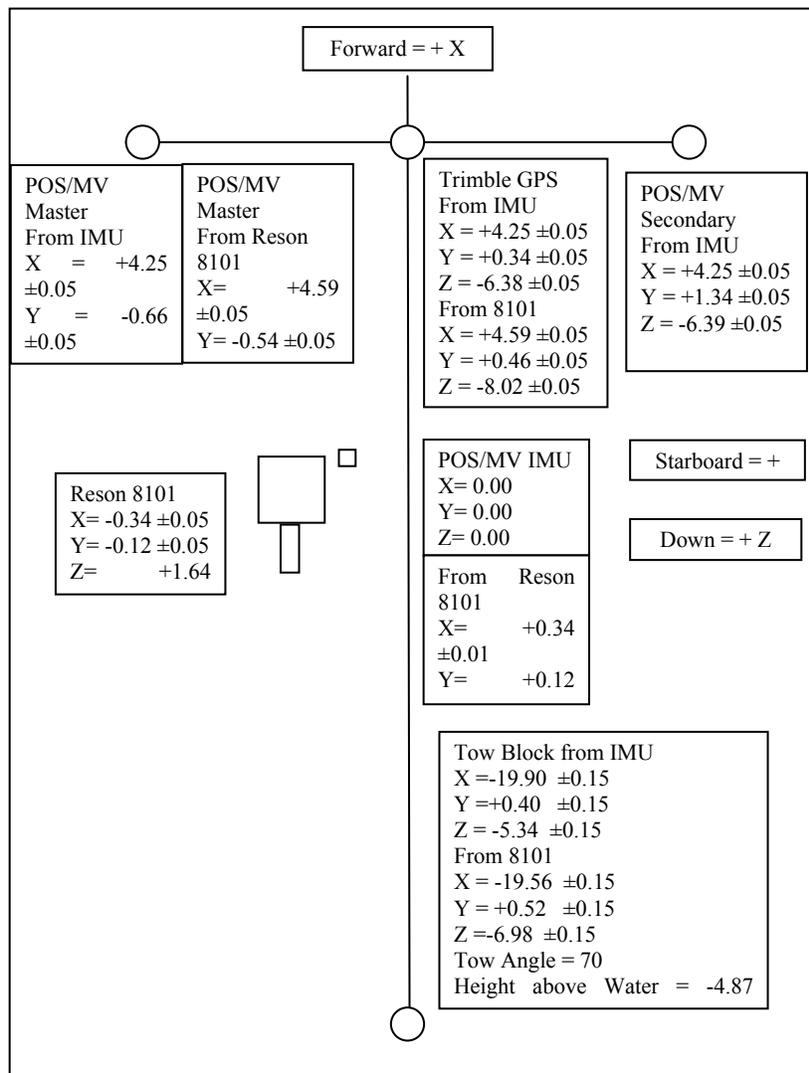


Figure C-1. Configuration of M/V Atlantic Surveyor during Survey Operations (Measurements in meters)

Table C-1. M/V Atlantic Surveyor Antenna and Transducer Locations (measurements in meters)

Sensor	Offset in ISS-2000		Offset in POS/MV	
Multibeam Reson 8101 Transducer Hull Mount			X	-0.34 ±0.05
			Y	-0.12 ±0.05
			Z	+1.64 ±0.05
Reference to Heave (POS/MV IMU)			X	0.00
			Y	0.00
			Z	0.00
POS/MV GPS Master Antenna			X	4.24 ±0.05
			Y	-0.66 ±0.05
			Z	-6.37 ±0.05
Reference to Vessel			X	-0.34 ±0.05
			Y	-0.12 ±0.05
			Z	+1.64 ±0.05
Trimble GPS Antenna	X	+4.59 ±0.05		
	Y	+0.46 ±0.05		
	Z	-8.02 ±0.05		
A-Frame Tow Block (Z = Height above the Water)	X	-19.56 ±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 are 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.

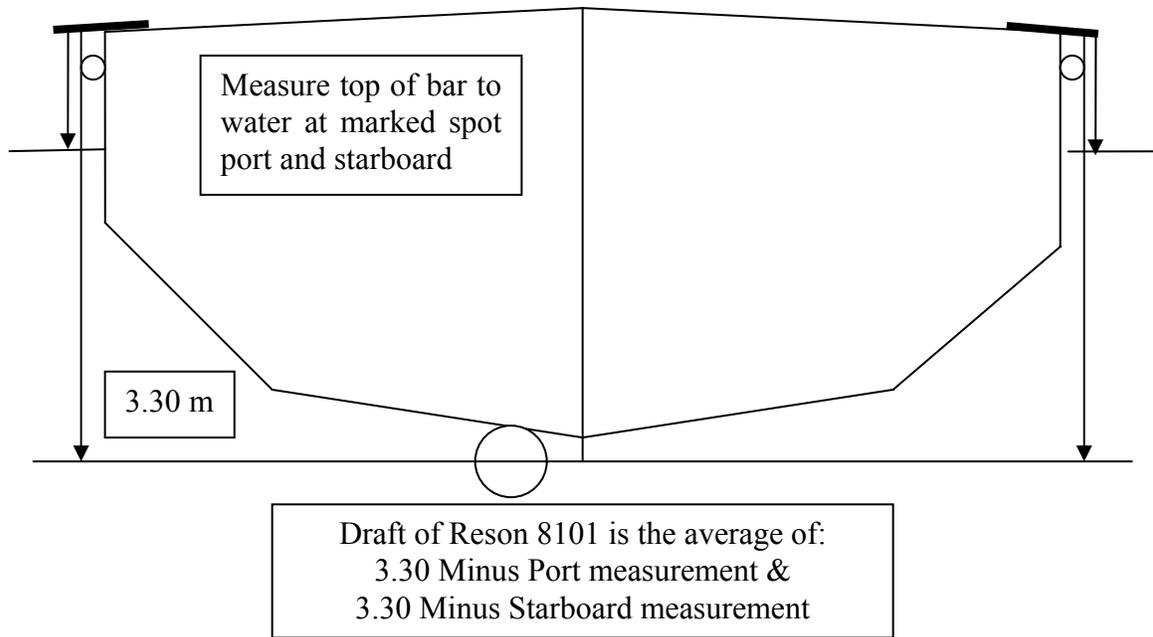


Figure C-2. M/V Atlantic Surveyor Draft

Settlement and Squat - Dynamic Draft

Settlement and Squat values were confirmed during the 2006 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 101. 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 2004 SAT entered into **ISS-2000**. This procedure is valid because the IMU and the multibeam transducer are 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. Data from JD101 were inconclusive and may have been skewed by tides. A second set of lines was run on Julian Day 102. Data from these lines show that the settlement and squat calculation made in 2004 were sufficient. Table C-2 summarizes the shaft RPM, Approximate speed, depth corrector 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 101		Julian Day 102	
0	0.00	0	asmba06101.d11		asmba06102.d79	
			Parallel	Perpendicular	Parallel	Perpendicular
140	0.00 ±0.02	4	asmba06101.d12 asmba06101.d 13	asmba06101.d26 asmba06101.d 27	asmba06102.d80	asmba06102.d93
180	-0.01 ±0.02	5	asmba06101.d14 asmba06101.d 15	asmba06101.d28 asmba06101.d 29	asmba06102.d99	asmba06102.d92
220	0.00 ±0.02	6	asmba06101.d16 asmba06101.d 17	asmba06101.d30 asmba06101.d 31	asmba06102.d98	asmba06102.d05
255	0.00 ±0.02	7	asmba06101.d18 asmba06101.d 19	asmba06101.d32 asmba06101.d 33	asmba06102.d97	asmba06102.d06
300	0.04 ±0.02	8	asmba06101.d20 asmba06101.d 21	asmba06101.d34 asmba06101.d 35	asmba06102.d96	asmba06102.d07
340	0.10 ±0.02	9	asmba06101.d22 asmba06101.d 23	asmba06101.d36 asmba06101.d 37	asmba06102.d95	asmba06102.d08
370	0.13 ±0.02	10	asmba06101.d24 asmba06101.d 25	asmba06101.d38 asmba06101.d 39	asmba06102.d94	asmba06102.d09

SPEED OF SOUND

A Moving Vessel Profiler (MVP), constructed by Brooke Ocean Technology Ltd., with an Applied Microsystems Ltd. SV&P Smart 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 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 CTD. After downloading the SSP casts, graphs and tabulated lists were used to compare the two casts for discrepancies.

During multibeam acquisition, SSP casts were copied to **ISS-2000** where the profiles were reviewed for quality and compared to the preceding cast. After review the cast was “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 include: shape and proximity of the coastline, sources and proximity of freshwater, seasonal changes, wind, sea state, cloud cover, and changes from the previous profile. 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 editor, were used to monitor how the sound speed affected the multibeam data. Severe effects due to improper sound speed profile 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 III of the Separates of each 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. Crossline comparisons based on predicted tides and preliminary zoning are presented in Table C-3. Comparisons of crossing data from this small survey show that 99% of comparisons are within 25 centimeters and 100% are within 30 centimeters.

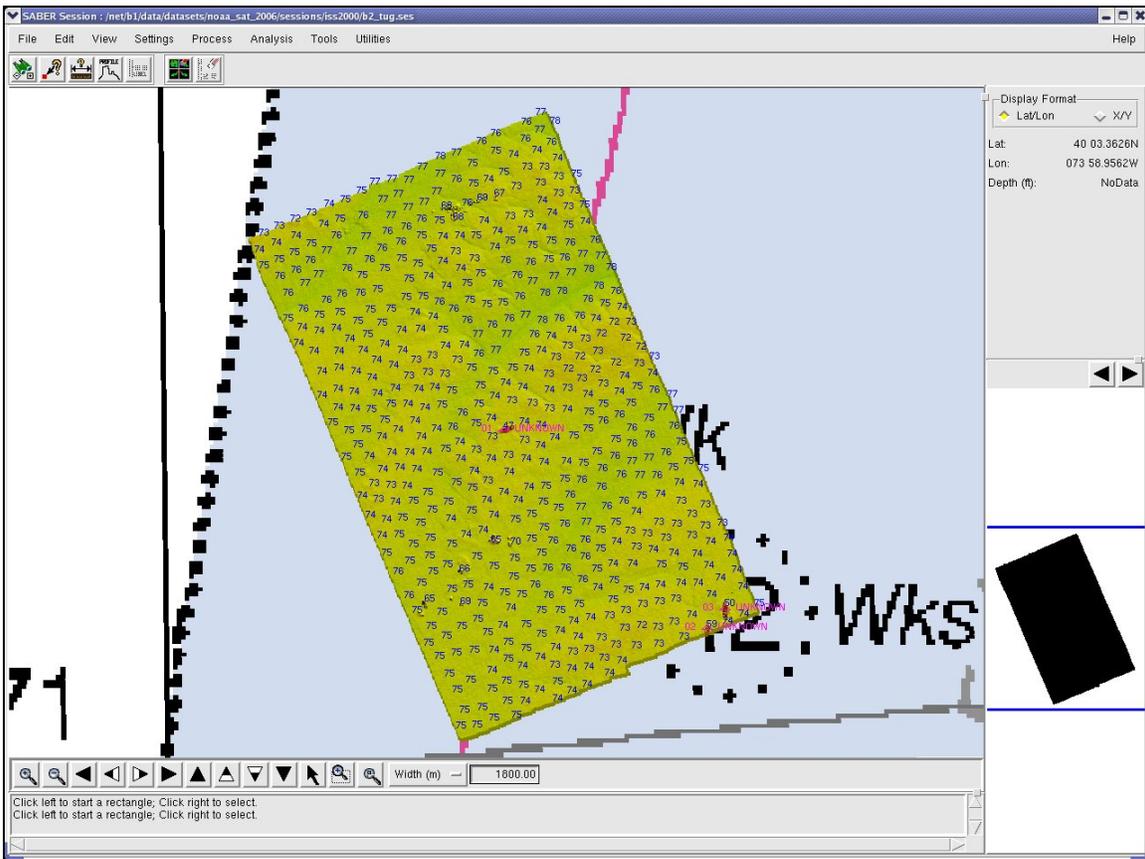


Figure C-3. Survey Grid, Selected Soundings and Chart 12323

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

Category	All		Positive		Negative		Zero
	Count	Percent	Count	Percent	Count	Percent	Count
0-5cm	902	32.12	586	24.83	219	62.39	97
5-10cm	995	67.56	899	62.92	96	89.74	
10-15cm	705	92.66	678	91.65	27	97.44	
15-20cm	140	97.65	131	97.20	9	100.00	
20-25cm	53	99.54	53	99.45	0	100.00	
25-30cm	12	99.96	12	99.16	0	100.00	
>30	1	100	1	100	0	199	

MULTIBEAM CALIBRATIONS

Navigation positioning, heading, heave, roll and pitch were provided by the Appalnix 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 0.011°, 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 10 April 2006 to verify that no timing errors exist 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 with a mean of 0.0 milliseconds and a standard deviation of 0.7 milliseconds. 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.

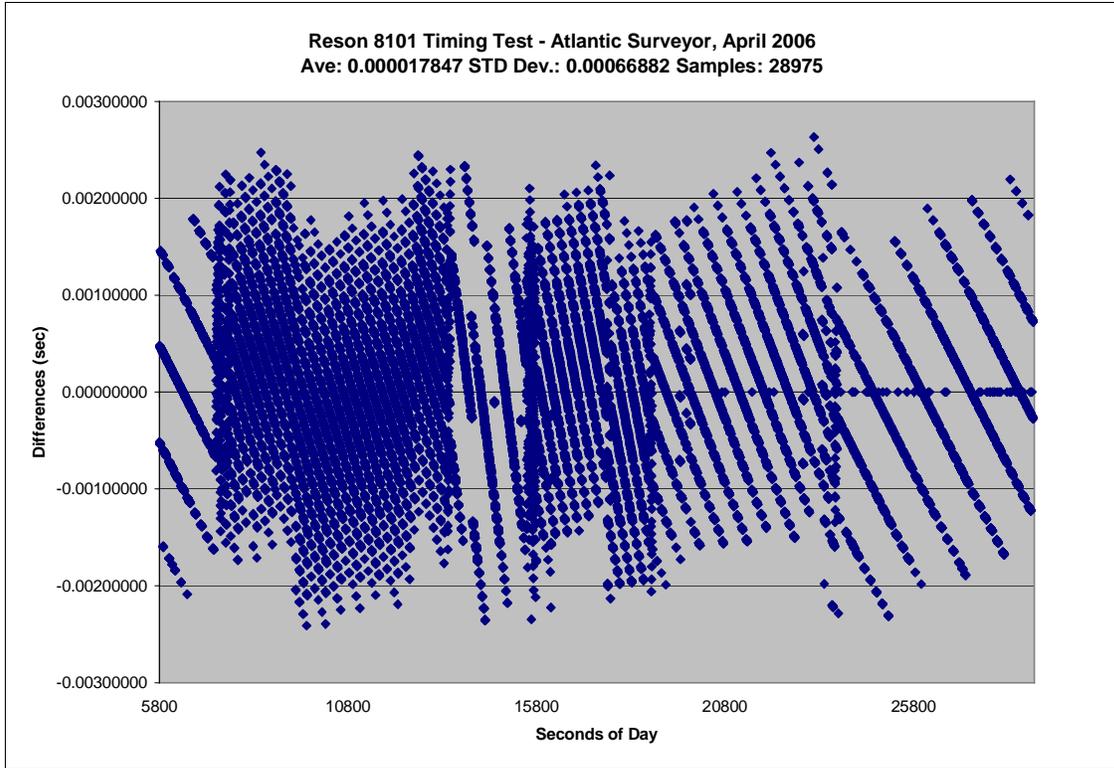


Figure C-4. Timing Test Results

Multibeam Bias Calibration

Multibeam alignment calibration was performed 11 April 2006 and 12 April 2006 (JD101 and 102) prior to commencing survey operations. The alignment was performed over a 47 foot wreck in 73 feet of water charted in 40° 03.3925’N 073° 59.5541’W (NAD83). The wreck is located in a fish haven approximately 6 kilometers southeast of Manasquan Inlet and was used in 2004 for alignment. 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 Tools

Component	Multibeam files (pairs)		Bias
Pitch	asmba06102.d02	asmba06102.d03	+2.0° ±0.02°
Roll	asmba06102.d02	asmba06102.d03	+0.72° ±0.02°
Gyro	asmba06101.d68	asmba02102.d01	+2.0° ±0.02°

Pitch Alignment (12 April 2006)

Two sets of lines were collected for pitch 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 pitch bias. Figure C-5 and Figure C-6 are images of the SAT tool depicting data collected with the +2.00 pitch bias entered in the ISS-2000 system; therefore the indicated bias is zero.

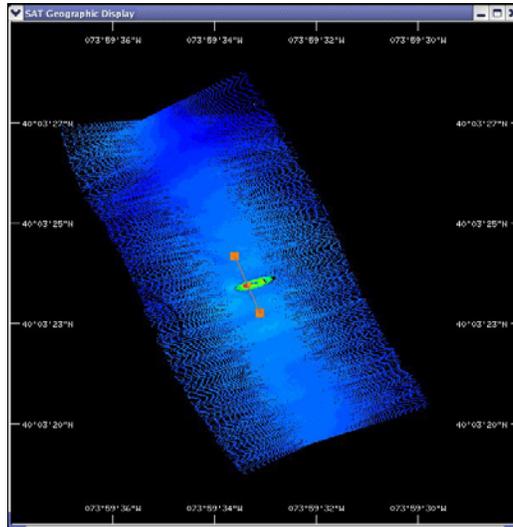


Figure C-5. SAT Tool, Plan View Depicting +2.00 Pitch Bias

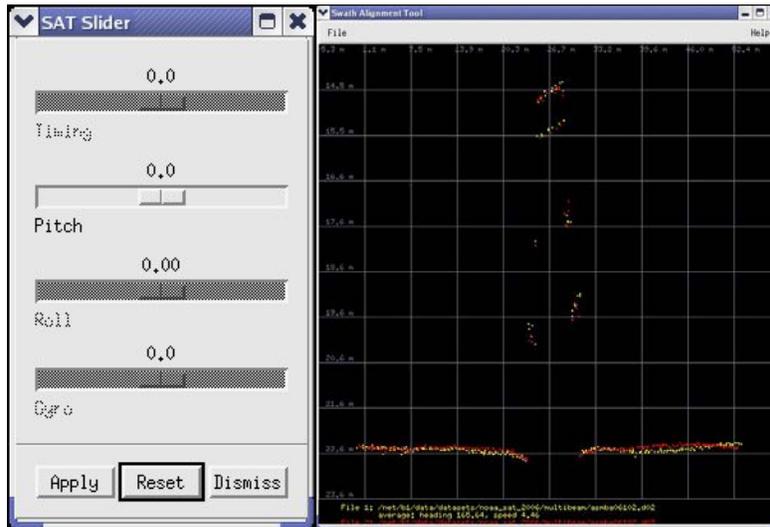


Figure C-6. SAT Tool, Depth vs. Distance Plot Depicting +2.00 Pitch Bias

Roll Alignment (12 April 2006)

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 +0.72 roll bias entered in the **ISS-2000** system; therefore the indicated bias is zero.

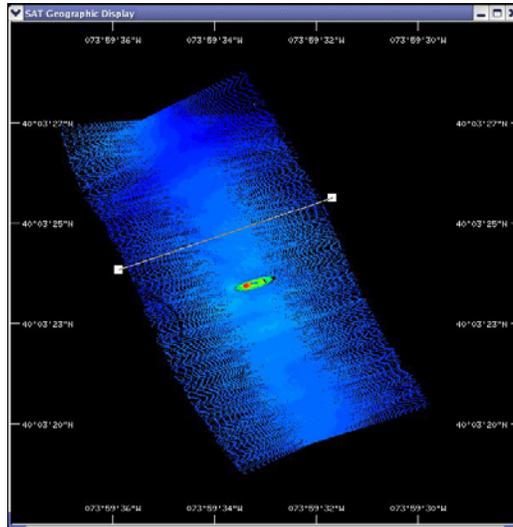


Figure C-7. SAT Tool, Plan View Depicting +0.72 Roll Bias

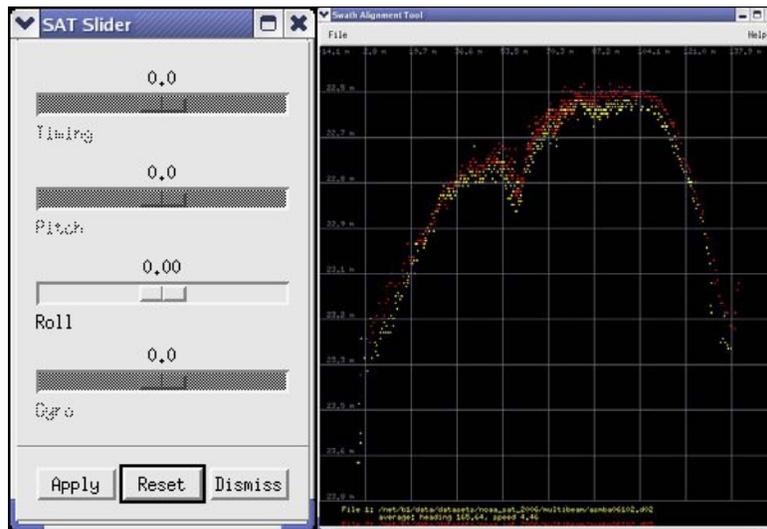


Figure C-8. SAT Tool, Depth vs. Distance Depicting +0.72 Roll Bias

Heading Alignment (11 & 12 April 2006)

Two sets of lines were collected for heading bias calculation. Lines were run on either side of a 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.

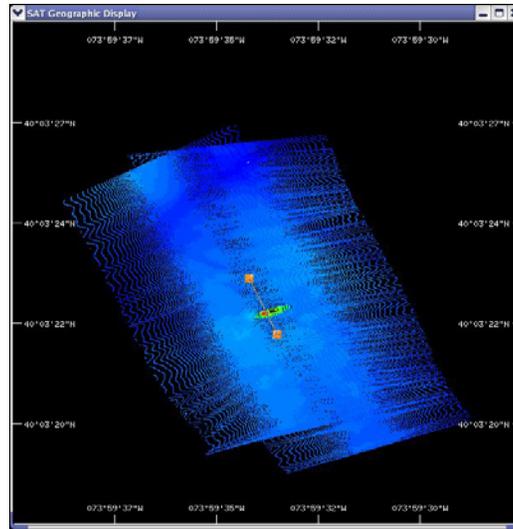


Figure C-9. SAT Tool, Plan View Depicting +2.0 Heading Bias

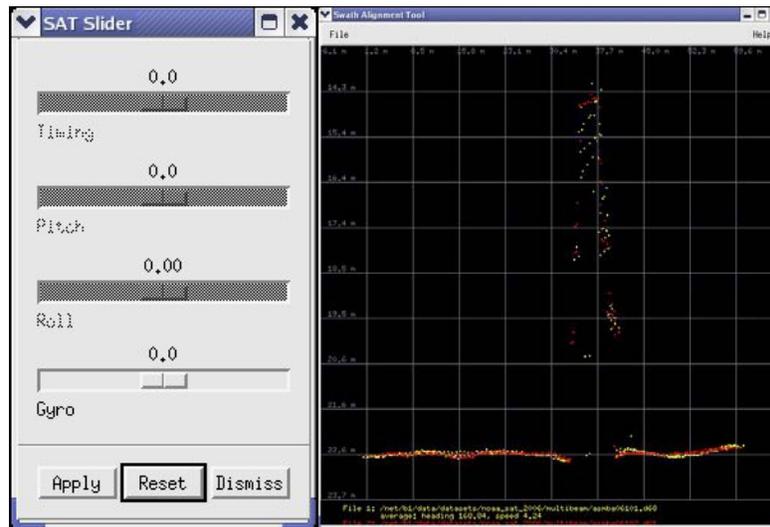


Figure C-10. SAT Tool, Depth vs. Distance Depicting +2.0 Heading Bias

TIDES AND WATER LEVELS

NOAA tide station in Lewes (8557380), DE was the source of final verified water level heights for the Mid-Atlantic Corridor, Coast of Delaware surveys. Preliminary and verified tide data for this station were downloaded from the NOAA CO-OPS web page (<http://tidesandcurrents.noaa.gov/>). All tide data were in meters and 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 tide correctors such as verified water levels to the GSF files, the program removed the previous tide 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. For quality assurance, the **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 the navigated swath editor, SAIC's **MVE**. In addition, crossline analysis using SAIC's **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 water level zoning parameters provided by NOS, Table C-5, were adequate for application of the observed verified water levels. Table C-6 shows a summary of water level differences across zone boundaries in meters using verified water levels from Lewes, DE 8557380.

Table C-5. Tide Zone Parameters

Zone	Time Corrector (mins)	Range Ratio	Reference Station
SA24	-78	x0.86	8557380
SA26	-72	x0.91	8557380
SA26A	-72	x0.86	8557380

Table C-6. Water Level Differences Across Zone Boundaries, Verified

26A-26	26A-24	
0.010	0.092	max
-0.089	-0.068	min
-0.037	0.000	average

APPROVAL SHEET

09 April 2007

LETTER OF APPROVAL

REGISTRY NUMBERS H11554, H11555

This Data Acquisition and Processing Report for Mid-Atlantic Corridor – OPR-C303_KR-06, Coast of Delaware is respectfully submitted.

Field operations and data processing contributing to the accomplishment of these surveys, H11554, H11555 were conducted under my direct supervision 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.

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

Gary R. Davis
Hydrographer
Science Applications International Corporation
Monday, 09 April 2007