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

DATA ACQUISITION AND PROCESSING REPORT
Vessel: Time Charter R/V Davidson
Launches R2, D2

Type of Surveys: Navigable Area

Time Frame: 2005 Field Season

2005

CHIEFS OF PARTY

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Data Acquisition and Processing Report To Accompany 2005 Hydrographic Surveys

NOAA Time Charter R/V Davidson Rotational Lead Hydrographers:

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Information and illustrations describing SAIC data acquisition and processing for this Data Acquisition and Processing Report have been included from NAVO/IVS/SAIC publication "*Innovative Partnerships for Ocean Mapping: Dealing with increasing data volumes and decreasing resources" and Hydrographic Surveying Using the SAIC ISS-2000 System.* The publications are included in Appendix III of this document.

Index

A. EQUIPMENT

A.1 Acquisition Platforms

All data were acquired from the NOAA Time Charter R/V DAVIDSON, and survey launches R2 and D2. The DAVIDSON was equipped with a 100 kHz mid-water multi-beam echo sounder, a 33 and 210 kHz vertical beam echo sounder, and a 455 kHz frequency side-scan sonar. Launch R2 was equipped with a shallow-water, high resolution 450 kHz multibeam echosounder, a 33 and 210 kHz vertical beam echo sounder, and a dual-frequency 100/500 kHz side-scan sonar. Launch D2 was equipped with a shallow-water, 220 kHz multibeam echosounder, a 33 and 210 kHz vertical beam echo sounder and a dual-frequency 100/500 kHz side-scan sonar. The DAVIDSON is 53.3 meters in length overall, with an 11.6 -meter beam and 5.4-meter draft. Launches R2 and D2 are 10-meter Bristol Bay aluminum launches. Refer to the *OCEAN SERVICES LLC 8111, 8101, 8125 Installation Report* and SAIC report *Sea Acceptance Test Report for the ISS-2000 and SABER Survey System Installed in the R/V Davidson* *and Launches R2 and D2 (6-10 January 2005)* for detailed vessel descriptions, equipment installation procedures and offset diagrams.

Figure A-1. R/V Davidson

Figure A-2. Survey Launch R2

Figure A-3. Survey Launch D2

A.2 Sounding Instruments

A.2.1 Vertical Beam Echo Sounders

A.2.1.1 DAVIDSON Reson Navisound 515 Echo Sounder

The ship was equipped with a Reson Navisound dual-frequency vertical-beam echo sounder systems (VBES) configured for 24 and 200 kHz operation. Sounding data were recorded in real time by the ISS2000 acquisition system and a full water-column trace was recorded separately in Reson .log format. Both frequencies were digitized and recorded at 5 Hz, however actual ping rates were dependent upon the depth of water. The DAVIDSON VBES system was available as the primary sounder or backup system to Reson 8111 MB echo sounder. All Navisound 515 VB data contained numerous speed jumps (> 2.5 m/sec) which was calculated to equate to less than 1 meter in position. The primary problem being the data sent from the Navisound 515 to ISS-2000 was asynchronous and could not be completely corrected by SAIC's ISS-2000 patches. *Refer to Appendix II pages A-17 to A-18 of the **Sea Acceptance Test (SAT) Report** for detailed descriptions of problems and resolutions concerning this system.* The problems encountered with this system resulted in removal and replacement during the scheduled vessel maintenance period from 5/28/05 - 6/14/05 with a Ross 875 Echo Sounder.

A.2.1.2 DAVIDSON Ross 875 Echo Sounder

System physically integrated during the scheduled vessel maintenance period from 5/28/05 - 6/14/05 to replace the DAVIDSON's Reson Navisound 515 Echo Sounder. ISS-C software patch for Ross 875 Echo Sounder implementation was installed and verified as part of the hardware exchange on 6/19/05.

A.2.1.3 Launches R2/D2 Navisound 515 Echo Sounders

The launches were equipped with Reson Navisound dual-frequency vertical-beam echo sounder systems (VBES) configured for 24 and 200 kHz operation. Sounding data were recorded in real time by the ISS2000 acquisition system and a full water-column trace was recorded separately in Reson .log format. Both frequencies were digitized and recorded at 5 Hz, however actual ping rates were dependent upon the depth of water. The VBES systems were utilized as a backup system to the launch MB echo sounders. All Navisound 515 VB data contained numerous speed jumps (> 2.5 m/sec) which was calculated to equate to less than 1 meter in position. The primary problem being the data sent from the Navisound 515 to ISS-2000 was asynchronous and could not be completely corrected by SAIC's ISS-2000 patches. *Refer to pages A-7 and A-17 to A-18 of the SAT Report for detailed descriptions of problems and resolutions concerning this system.* The problems encountered with this system resulted in removal during the scheduled vessel maintenance period from 5/28/05 - 6/14/05**.**

A.2.2 Multibeam Echo Sounders

A.2.2.1 DAVIDSON Reson 8111 Mid-water Multibeam Echo Sounder

The DAVIDSON is equipped with a RESON Seabat 8111 mid-water multibeam echo sounder system (MWMB). The MWMB is a 100 kHz multibeam sonar with a manufacturer's rated water depth range of 3 - 1200 meters. The 8111 utilizes an integrated transmit/receive head, which is mounted and faired on the keel-centerline of the vessel. The 8111 projects a single transmit pulse, which is formed on reception into 101 beams, each 1.5° across track by 1.0° along track.

During the first leg of acquisition in the survey area Jan-2005 a Reson 8111 data artifact was observed where the soundings were approximately 0.5 meters deeper than soundings collected by the Reson 8101 multibeam and DAVIDSON high frequency Navisound vertical beam data. The artifact was believed to be due to penetration of sound energy into the very soft sediment, which is typical of the survey area, with the near-vertical beams (Refer to Jan-2005 Ocean Services NS515 Reson Service Report for further information, Appendix III). Subsequently, although the depth variance was usually less than 0.5 meters for most data within the survey area, NOAA personnel determined that high frequency vertical beam data should be acquired as the primary bathymetry source with Reson 8111 multibeam being acquired for vertical beam quality control purposes only for the duration of the field season. Upon AHB office processing with the application of approved water levels and zoning and the generation of final base surfaces, the generalized surfaces reduced the depth variance to within IHO Order-1 specifications. Therefore, the decision was made to utilize the Reson 8111 multibeam data as the primary bathymetry source with the high frequency vertical beam data being retained for QC purposes only for the generation of all products.

A.2.2.2 D2 Launch Reson 8101 Shallow-water Multibeam Echo Sounder

The survey launch D2 is equipped with a RESON Seabat 8101 shallow-water multibeam echo sounder system (SWMB). The 8101 SWMB is a 220 kHz multibeam sonar designed for water depths of 0 - 240 meters and was primarily used to acquire soundings in depths from 0 – 120 meters. Full swath coverage was achieved in water depths to 120 meters. The 8101 utilizes an integrated transmit/receive head, which is mounted and faired on the keel-centerline of the vessel. The 8101 projects a single transmit pulse, which is formed on reception into 101 beams, each 1.5° across track by 1.0° along track. The 8111 has a maximum ping rate of 30 Hz.

A.2.2.3 R2 Launch Reson 8125 High-Res., Shallow-water Multibeam Echo Sounder

The survey launch R2 is equipped with a RESON Seabat 8125 high-resolution shallow-water multibeam echo sounder system (HRSWMB). The HRSWMB is a 455 kHz multibeam sonar designed for water depths of 0-120 meters and was primarily used to acquire soundings in depths from 0 - 60 meters. Full swath coverage was achieved in water depths to 60 meters. The 8125 utilizes an integrated transmit/receive head, which is mounted and faired on the keel of the vessel. The 8125 projects a single transmit pulse, which is formed on reception into 240 beams, each 0.5° across track by 1.0° along track. The 8125 has a maximum ping rate of 40 Hz.

A.2.2.4 Multibeam Echo Sounders Operation

All Reson MB systems transmit power levels and receiver time variable gain (TVG) controls were adjusted during acquisition to maximize bottom resolution. The depth and range filters were adjusted conservatively during acquisition to minimize false returns from water-column noise, multiple reflections, and fliers. During MB data acquisition, the ship and launches operated at speeds of approximately 4-6 knots. The MB systems generated digital sounding data that were recorded by the SAIC ISS-2000 DTC software.

The following recommendations concerning the operation of multibeam echo sounders from RESON's site visit (full report Appendix III) during the first port call (21-22 January 2005) were implemented to improve multibeam echo sounder performance:

> In very soft sediments, due to very low reflectivity of the surface at shallow grazing angles, there is a strong tendency for the nadir return energy coming into the side lobes of the outer beams, to capture the bottom detection for the beam. It is possible to largely overcome this tendency, through the use of much higher power and gain levels for multibeam sonars, putting the receivers into saturation.
>
> The data quality from the 8125 on the R2 launch, operating at normal survey speeds was improved by adding a "V" structure in front of the sonar to divert bubbles washed down from the bow to either side of the arrays.

A.2.3 Lead Line

A lead line was used to verify vessel static draft and accuracy of VBES and MB systems during the initial integration and at periodic intervals during the project. Static draft measurements were evaluated to verify draft correctors and were applied if applicable to correct soundings for differential loading. Lead lines were constructed by SAIC from low-stretch polyester line and mushroom-type anchors. Measurement indexes were marked on the lines using a steel tape.

A.2.4 Imaging Sonars

A.2.4.1 Side-Scan Sonar

A.2.4.1.1 Klein 5500 High Speed, High Resolution Side Scan Sonar

The Klein System 5500 was utilized aboard R/V Davidson for all side-scan sonar operations in a towed configuration. The Klein System 5500 includes the Model 5250 High Speed High Resolution Side Scan Sonar (HSHRSSS) towfish and the T5100 Transceiver Processing Unit (TPU). The Model 5250 towfish operates at a frequency of 455 kHz and has a vertical beam angle of 40°. The HSHRSSS contains the transducers, sonar processing and control electronics, attitude and heading sensors, the down-link de-multiplexer (for control signals), and the up-link multiplexer (for sonar and auxiliary sensor data). The T5100 TPU contains electronics to demultiplex the sonar signal from the HSHRSSS and multiplex the control signals transmitted to the HSHRSSS via the coaxial tow cable. The T5100 also contains a network card for transmission of the sonar data to the **Isis** acquisition computer.. The Klein System 5500 is unique in that each transducer simultaneously forms five dynamically focused beams per side (channel), allowing increased resolution along track (20–36 cm) and across track (7.5cm at 100 meter range scale). The Klein System 5500 multibeam transducer technology also enables higher tow speeds of up to ten knots. Typical tow speeds were 6-8 knots. The 50 meter range scale was used primarily with the 75 and 100 meter range scales being utilized early in the field season in an attempt to optimize data acquisition efficiency. It was determined that no greater than the 50 meter range scale was appropriate for most areas due to the weak return from very soft substrate and increased surface return in data records. All data that was not satisfactory was rejected and reacquired.

A.2.4.1.2 Klein 3000 Side Scan Sonars

Launches R2 and D2 utilized Klein 3000 dual frequency (100 kHz and 500 kHz) side-scan sonar (SSS) towfish in a towed configuration during SSS operations. Only the 500 kHz frequency data was converted to *.XTF for processing. The 50 meter range scale was used exclusively. Vessel speed was adjusted to ensure that an object one meter in characteristic size would be detected and clearly imaged across the sonar swath. Confidence checks were performed and noted frequently to ensure this standard of resolution was met.

A.3 Positioning and Attitude Sensors

A.3.1 Applanix POS/MV 320

The ship and launch primary positioning and attitude sensors were Applanix POS/MV Model 320 Ver. 3. These systems combine data from an inertial attitude sensor and carrier-phase GPS receivers to compute position, heading, heave, pitch, and roll. The three major components of the POS/MV are an Inertial Measurement Unit (IMU), mounted near the ship and launch centers of motion. Two GPS antennas were installed on the ship's mast, mounted parallel to the line of the ship centerline at approximately 2 meters spacing. Launch antennae were mounted athwart ship at approximately 2 meters spacing. A POS Computer System (PCS) processing unit was installed at the acquisition stations on the ship and launches.

A.3.1.1 Heading and Primary Positioning

The GPS receivers in the POS/MV processor compute heading by measuring the phase difference of the GPS signals arriving at the two antennas and computing simultaneous, millimeter-accuracy positions of the antenna phase centers. The POS system utilizes inertial data, Kalman filtering and the GAMS subsystem to resolve integer wave ambiguities of satellite signals and compute precise positions for antenna phase-center locations. Heading was computed from a vector approximation of the IMU orientation with respect to the primary antenna, satellite geometry and primary/secondary antenna separation. The primary antenna position was corrected with surveyed offsets for the IMU lever arm and the reference position (RP) to provide heading and a navigation solution (position). Data from the POS/MV were used as the primary navigation source and were merged with multibeam data. Daily vessel positioning confidence checks were performed by comparing data recorded from the POS/MV to data recorded from the Trimble MS 750 GPS receivers.

A.3.1.2 Differential Position Correction

Differential GPS beacon (DGPS) correctors were acquired with Furuno GR-80 differential beacon receivers and input to the POS/MV systems for calculation of the navigation solution.

A.3.1.3 Attitude Data

A3.1.3.1 POS/MV IMU

An array of solid-state sensing elements contained inside the POS/MV IMU measures the instantaneous linear accelerations and angular rates of turn of the survey platform. The IMU digitizes signals from the array and transmits them to the PCS for further processing to derive the angles of roll, pitch and vertical displacement (heave). Heave was computed by double integration of IMU acceleration in the vertical axis.

A3.1.3.2 IMU Installation
All IMU were installed on rigid mounts with alignment pins. Ideally, the IMU should be installed and aligned closely with the transducer - the location for which precise roll, pitch, heading and heave measurements are required. The DAVIDSON IMU was installed by SAIC on the existing foundation that was previously surveyed by Dowl, directly above the transducer and aligned with the ship reference frame and transducer. The launches POS/MV IMU's were installed by SAIC on a foundation welded to the keel in the bilge forward of the engine. This installation was aligned as nearly as possible with the vessel axes. SAIC measured the offsets from the IMU to the transducer (installed by Ocean Services) and to the antennae (installed by SAIC) during the initial mobilization in Seattle, WA (August-September 2004). Alignment correctors were measured through a system patch test. All attitude data were acquired in reference to the IMU RP and IMU reference frame and subsequently used to correct soundings to horizontal and vertical datums in real time by the SAIC ISS2000 acquisition DTC.

The *R/V Davidson* and Launches *R2* and *D2 IMU* sensor configurations are depicted in DAPR section *A.5.2 Vessel Offset Diagrams.*

A.3.2 Trimble MS 750 GPS Receiver
The ship and launch auxiliary positioning systems were Trimble MS 750 GPS receivers integrated with Furuno GR-80 differential beacon receivers. The MS 750 is an integrated DGPS receiver which combines a 12 channel L1 C/A code receiver with a 2 channel Differential Beacon receiver. The MS 750 is integrated as a redundant positioning system with the POS/MV. Confidence checks were recorded regularly and position output was monitored continuously for quality control. The DGPS beacon receiver was manually tuned to the most appropriate beacon receiver for the survey area to avoid unexpected and undocumented changes to differential position corrections.

A.4 Ancillary Instruments

A.4.1 Sound Velocity
Conductivity, temperature, and depth profiles were acquired using Seabird Seacat SBE-19 Plus Conductivity, Temperature, and Depth (CTD) profilers. The SBE-19 Plus is a self-contained, battery-powered unit with a serial interface for configuration and data download. Calibration data were used to initialize the HSTP Velocwin software for each CTD. Calibration files and certificates are included with the project submission.

Model	Serial Number	Calibration Date
SBE-19 Plus	4630	June 10, 2004
SBE-19 Plus	4633	June 21, 2004
SBE-19 Plus	4634	June 21, 2004
SBE-19 Plus	4642	June 24, 2004
SBE-19 Plus	4642	August 2, 2005
SBE-19 Plus	4633	August 2, 2005

During MBES data acquisition, CTD casts were conducted daily at the beginning of survey operations. Minimally, a CTD cast was acquired every 4 hours after the start of survey operations. Surface sound velocity was continuously monitored during acquisition on the DAVIDSON and R2 using the multibeam-integrated surface sound velocimeters, mounted in proximity to the multibeam transducer heads. A CTD cast was taken if the surface sound velocity was observed to change from the initial cast. Sound velocity errors were monitored in real time DTM at the junction overlapping lines and outer beams. A consistent offset between overlapping lines in outer beams was typically an indication of inaccurate sound velocity modeling and ray tracing used to calculate sounding values. Additional casts were acquired in areas of high freshwater input (e.g. proximal to glaciers), restricted channels and passages, and areas of high tidal exchange.

A.4.2 Surface Sound Velocity

Reson SVP-C Series fixed-mount sound velocity probes were installed at the transducer locations on the DAVIDSON and Launch R2. SVP-C probe models use direct “time of flight” technology to calculate sound velocity. Calibration certificates for these instruments are included with the project submission.

A.4.3 Bottom Samplers

Ponar Type Grab samplers were deployed to sample seafloor sediments of typical survey and anchorage areas such as sand, gravel and clay. This modified Van Veen type self-tripping sampler features center hinged jaws and a spring loaded pin that releases when the sampler makes impact with the bottom. It also includes an under-lip attachment that cleans gravel from the jaws that would normally prevent lateral loss of sample. The top is covered with a stainless steel screen with neoprene rubber flaps which allows water to flow through for a controlled descent and less interference with the sample. It is constructed of stainless steel with zinc plated steel arms and weights. A simple pin prevents premature closing. A lightweight model (1/8" stainless plate) was deployed from the ship and launches using the CTD winches.

A.5 System Installation

A.5.1 Vessel Configuration

A5.1.1 Coordinate Systems

The SAIC Integrated Survey System (ISS2000) and the RESON multibeam systems utilize different coordinate systems. The ISS2000 considers “z” to be positive down, while both the RESON and POS/MV consider “z” positive up. Both the ISS2000 and POS/MV consider “x” positive forward, the RESON considers “x” as positive athwart ships to starboard. The SAIC ISS2000 considers “y” positive athwart ships to starboard, the POS/MV considers “y” positive athwart ships to port and the RESON considers “y” as positive forward.

A.5.1.2 Caris Vessel Configuration Files and Device Models

A.5.1.2.1 Caris Vessel Configuration Files (*.hvf)

Echo Sounder Vessel Configuration Files

Caris Vessel Configuration Files (*.hvf with TPE calculation) were created to convert SAIC generic sensor format (GSF) to Caris HDCS_DATA without performing any additional corrector applications. Although all sensor raw data was included in GSF file structure, each sounding was provided as a fully corrected depth value. All Caris *.hvf files for multibeam and vertical beam sensors were created with null offsets for position, attitude and heave correction. Vessel offsets and sensor identification, and sensor installation accuracy were entered into the *.hvf for TPE calculation.

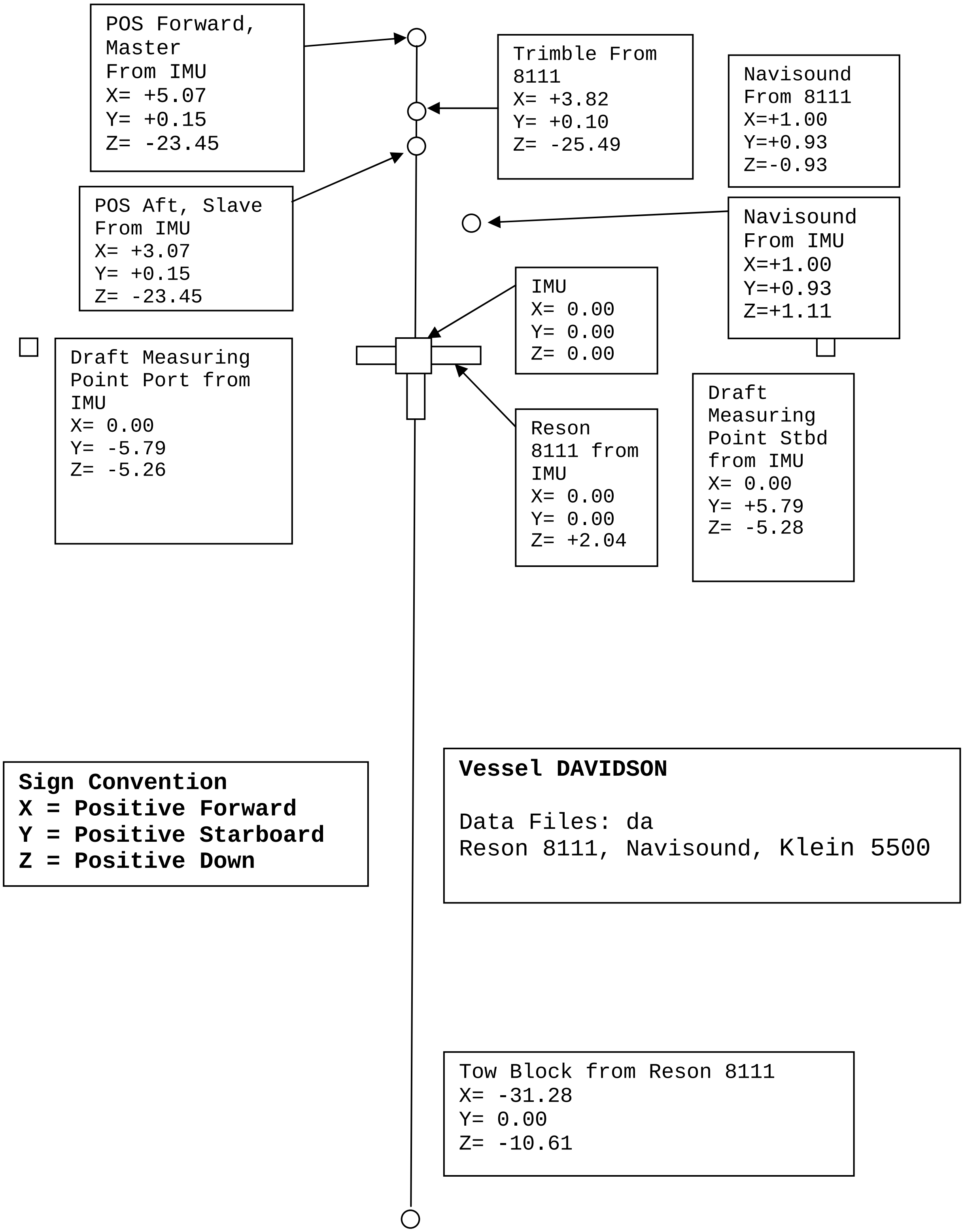
Side Scan Sonar Vessel Configuration Files

Caris Vessel Configuration Files (*.hvf) were created to convert SAIC extended triton format (XTF) to Caris HDCS_DATA without performing any additional corrector applications. Upon NOAA's request a beta version of the Caris convertxtf.dll was created by Caris to gain the functionality of retaining contacts, rejected data, and associated metadata from SAIC's SSS processing routine discussed in section D.1.1. The beta convertxtf.dll provided was utilized exclusively for all SSS data conversion.

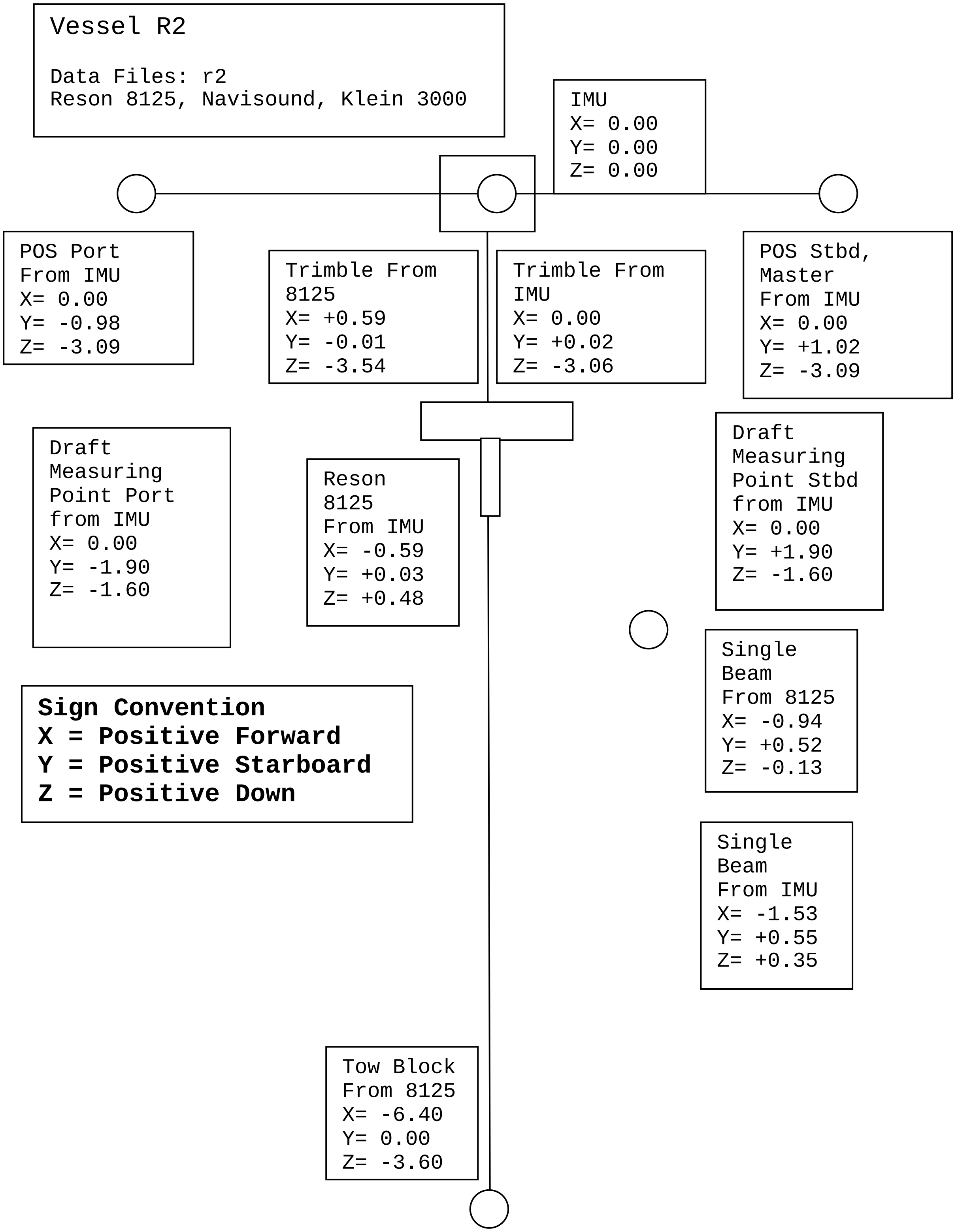
A.5.2.1.2 Device Models

The Reson 8125 and 8101 devices were configured from standard Reson devicemodel.xml. The device model for the DAVIDSON Reson 8111 was appended to the default file and configured to use pitch correction for TPE calculation. This pitch "switch" was not documented in the Caris manual but was observed in the devicemodel.xml. Pitch stabilization was applied to the data in ISS-2000 and a value of (1) in the device model is consistent with Caris and HSTP guidance.

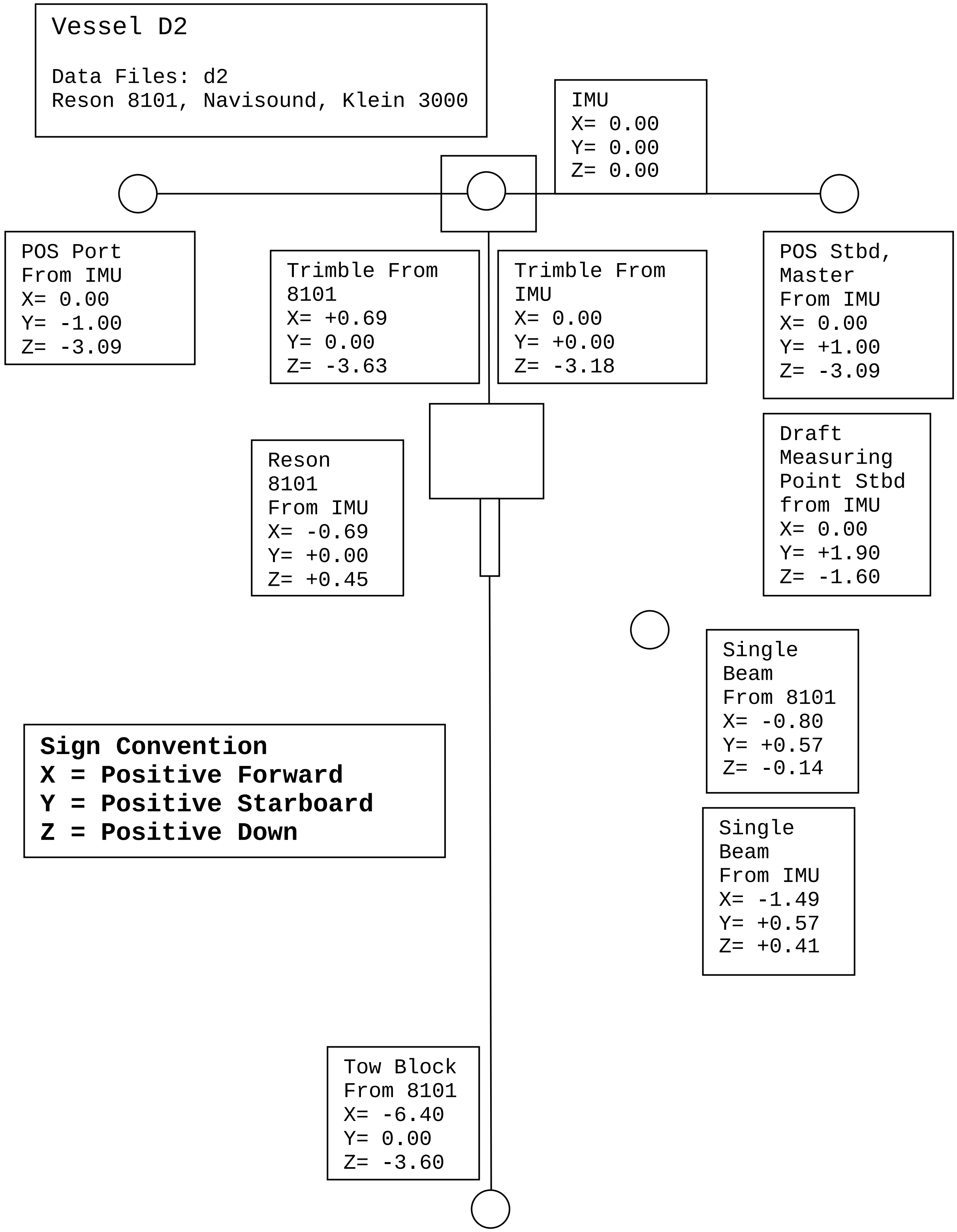
A.5.2 Vessel Offset Diagrams



Configuration of *R/V Davidson* (measurements in meters)



Configuration of *Launch R2* (measurements in meters)



Configuration of *Launch D2* (measurements in meters)

A.5.3 Sensor Offsets

***R/V Davidson* Antenna and Transducer Locations Entered in the ISS-2000 Real-Time System (measurements in meters)**				
Sensor	**Offset in ISS-2000**		**Offset in POS/MV**	
Multibeam Reson 8111 Transducer Hull Mount	X	0.0	X	0.00
	Y	0.0	Y	0.00
	Z	0.0	Z	+2.04
Reference to Heave			X	0.00
			Y	0.00
			Z	0.00
Reference to Vessel			X	0.00
			Y	0.00
			Z	+2.04
POS/MV GPS Master Antenna			X	+5.07
			Y	+0.15
			Z	-23.45
Trimble GPS Antenna	X	+3.82		
	Y	+0.10		
	Z	-25.49		
A-Frame Tow block	X	-31.28		
	Y	0.00		
	Z	-10.61		

Launch *R2* Antenna and Transducer Locations Entered in the ISS-2000 Real-Time System (measurements in meters)				
Sensor	**Offset in ISS-2000**		**Offset in POS/MV**	
Multibeam Reson 8125 Transducer Hull Mount	X	0.00	X	-0.59
	Y	0.00	Y	+0.03
	Z	0.00	Z	+0.48
Reference to Heave			X	0.00
			Y	0.00
			Z	0.00
Reference to Vessel			X	-0.59
			Y	+0.03
			Z	+0.48
POS/MV GPS Master Antenna			X	0.00
			Y	+1.02
			Z	-3.09
Trimble GPS Antenna	X	+0.59		
	Y	-0.01		
	Z	-3.54		
A-Frame Tow block	X	-6.40		
	Y	0.00		
	Z	-3.60		

Launch *D2* Antenna and Transducer Locations Entered in the ISS-2000 Real-Time System (measurements in meters)				
Sensor	**Offset in ISS-2000**		**Offset in POS/MV**	
Multibeam Reson 8101 Transducer Hull Mount	X	0.00	X	-0.69
	Y	0.00	Y	0.00
	Z	0.00	Z	+0.45
Reference to Heave			X	0.00
			Y	0.00
			Z	0.00
Reference to Vessel			X	-0.69
			Y	0.00
			Z	+0.45
POS/MV GPS Master Antenna			X	0.00
			Y	+1.00
			Z	-3.09
Trimble GPS Antenna	X	+0.69		
	Y	0.00		
	Z	-3.63		
A-Frame Tow block	X	-6.40		
	Y	0.00		
	Z	-3.60		

A.5.4 Multibeam Sensor Alignment

During SAT, conducted Jan-2005, patch tests to determine the alignment biases from the IMU to the transducer were run over a charted fish haven consisting of a flat bottom with a distinct feature (wreck). The patch test results are listed for *R/V Davidson*, Launch *R2*, and Launch *D2* in the following table. Bias values established during the August 2004 patch test were used during the January 2005 patch test. There was no indication that values established during the August 2004 patch test were not valid, therefore no changes were made to the bias values for any vessel. Refer to SAIC SAT Report in Appendix II for additional details of the SAIC alignment calibration.

Vessel	**Roll (deg.)**	**Pitch (deg.)**	**Yaw (deg.)**
DA	**+0.70**	**+0.70**	**-0.70**
R2	**-0.38**	**-2.60**	**-1.50**
D2	**+1.70**	**-1.10**	**+1.10**

A.5.5 Dynamic Draft (Settlement and Squat Determinations)

Settlement and squat must be measured at the IMU to avoid double correcting for the portion of remote heave computed through the lever arm from the IMU to the transducer. When the IMU is over the transducer, or nearly so, the multibeam soundings may be used to compute the settlement and squat. That was the case with *R/V Davidson* and Launches *R2* and *D2*. Each vessel's settlement and squat was recomputed during the January 2005 SAT for all three vessels. Settlement and Squat determinations for August-September 2004 were conducted without the application of delayed heave and did not have as flat a bottom over which to conduct the test. The vessels had also been altered somewhat between the de-mobilization from Alaska survey operations and the re-mobilization in Gulfport, Mississippi. The *R/V Davison* had engine work conducted that changed the rpm settings. *D2* had the addition of trim tabs and side scan cable was added to the side scan winch on *R2*. Each vessel was allowed to drift over a relatively flat bottom at 0 rpm to establish a reference surface for the settlement and squat measurements. A survey line was plotted along the center of each reference surface, and the vessel ran the line over its reference surface at increasing speed settings. Delayed heave was applied to the appropriate multibeam files prior to building a gridded surface for each pass. The resulting surfaces were averaged and each speed's surface was compared to the zero speed surface to determine the settlement and squat correctors for each vessel. The tables in sections **A.5.5.1 and A.5.5.2** show the resulting settlement and squat look up table that is installed in the ISS-2000 configuration file for each vessel. Refer to SAIC SAT Report in Appendix II for additional details of the SAIC dynamic draft calculations.

A.5.5.1 DAVIDSON Dynamic Draft

Speed settings, corresponding to a combination of rpm and blade pitch, were manually input to the ISS-2000 for use in the dynamic draft look up table in the ISS-2000 system. Approximate speeds in the tables are for reference only.

R/V Davidson Dynamic Draft ISS-2000, January 07, 2005		
Speed Setting	**Depth Corrector (SABER)**	**Approximate Speed, Knots**
0	0.00	0
3	0.01	3
7	0.02	7
8	0.05	8
10	0.13	9
11	0.15	10
12	0.17	11

A.5.5.2 Launches R2 and D2 Dynamic Draft

A shaft RPM counter provided automatic input to the dynamic draft look up table in the ISS-2000 system. Approximate speeds in tables are for reference only.

Launch R2 Dynamic Draft ISS-2000, January 07, 2005		
Speed Setting	**Depth Corrector (SABER)**	**Approximate Speed, Knots**
0	0.00	0
380	0.01	3

500	0.03	4
670	0.07	6
871	0.09	7
1012	0.10	8
1200	0.14	9

Launch D2 Dynamic Draft ISS-2000, January 07, 2005		
Speed Setting	**Depth Corrector (SABER)**	**Approximate Speed, Knots**
0	0.00	0
330	0.01	3
450	0.02	4
540	0.03	5
800	0.08	7
970	0.11	8
1324	0.09	9

A.6 Static Draft

Draft calculations were determined by measuring the distance from the water line to the draft measurement location on each vessel. This measurement was made on both port and starboard sides of the vessel. The resulting measurements were then subtracted from the calculated vertical distance between the draft measurement location and the sonar on each vessel. The final port and starboard measurements were averaged and entered into the ISS-2000. Refer to SAIC SAT Report in Appendix II for additional details of the SAIC static draft calculations.

Static Draft computations
Davidson: Reson 8111 draft = Average (7.30-Xp and 7.32-Xs) Navisound draft = Average (6.37 – Xp and 6.39 – Xs)
R2 launch: Xa = (Xp + Xs) / 2 Reson 8125 draft = 2.05m – Xa Navisound single beam draft = 1.75m –Xa
D2 launch: Xa = (Xp + Xs) / 2 Reson 8101 draft = 1.82m – Xa Navisound single beam draft = 1.68m –Xa

Static draft measurements were verified during the initial calibration with lead-line comparisons. The following tables present results of the comparisons.

Static draft for R/V Davidson was calculated from the results of the SAIC survey, and was verified by lead line comparison on January 07 & 20, 2005, Table-1.

Table-1. *R/V Davidson* Lead Line Comparison

LEADLINE COMPARISON					DRAFT ENTERED IN COMPUTER =	4.53			files			
DAY	7				DRAFT ON HULL =	4.53		port	damba05007.d03			
DATE	01/07/05				SQUAT DEPTH CORRECTOR LEFT IN =	0.00		stbd	damba05007.d03			
					DRAFT CORRECTOR =	0.00						
					PORT DECK TO WATER SURFACE =	2.67						
					STBD DECK TO WATER SURFACE =	2.89	0.00	<=TIDE CORRECTOR LEFT IN				
cast #	time taken port UTC	port deck to bottom meters	port cast depth meters	multibeam depth port	corrected multibeam depth port	time talen starboard UTC	stbd deck to bottom meters	stbd cast depth meters	multibeam depth starboard	corrected multibeam depth stbd	port difference meters	starboard difference meters
1	2:20:00	14.19	11.52	11.05	11.05	2:25:30	13.63	10.74	10.48	10.48	0.470	0.260
2	2:20:10	14.2	11.53	11.05	11.05	2:25:40	13.63	10.74	10.85	10.85	0.480	-0.110
3	2:20:20	14.19	11.52	11.04	11.04	2:25:50	13.64	10.75	10.91	10.91	0.480	-0.160
4	2:20:30	14.19	11.52	11.01	11.01	2:26:00	13.63	10.74	10.47	10.47	0.510	0.270
5	2:20:40	14.2	11.53	11.03	11.03	2:26:10	13.64	10.75	10.60	10.60	0.500	0.150
6	2:20:50	14.19	11.52	10.98	10.98	2:26:20	13.65	10.76	10.55	10.55	0.540	0.210
7	2:21:00	14.21	11.54	11.01	11.01	2:26:30	13.64	10.75	10.46	10.46	0.530	0.290
8	2:21:10	14.2	11.53	11.03	11.03	2:26:40	13.65	10.76	10.49	10.49	0.500	0.270
9	2:21:20	14.2	11.53	11.03	11.03	2:26:50	13.68	10.79	10.58	10.58	0.500	0.210
10	2:21:30	14.2	11.53	10.98	10.98	2:27:00	13.68	10.79	10.50	10.50	0.550	0.290
										Mean	0.506	0.168
										StdDev	0.027	0.166

LEADLINE COMPARISON					DRAFT ENTERED IN COMPUTER =	4.45			files			
DAY	20				DRAFT ON HULL =	4.45		port	damba05020.d12			
DATE	01/20/05				SQUAT DEPTH CORRECTOR LEFT IN =			stbd	damba05020.d12			
					DRAFT CORRECTOR =	0.00						
					PORT DECK TO WATER SURFACE =	2.87						
					STBD DECK TO WATER SURFACE =	2.85		<=TIDE CORRECTOR LEFT IN				
cast #	time taken port UTC	port deck to bottom meters	port cast depth meters	multibeam depth port	corrected multibeam depth port	time talen starboard UTC	stbd deck to bottom meters	stbd cast depth meters	multibeam depth starboard	corrected multibeam depth stbd	port difference meters	starboard difference meters
1	16:45:00	10.3	7.43	7.31	7.31	16:48:00	10.2	7.35	7.22	7.22	0.120	0.130
2	16:45:05	10.32	7.45	7.31	7.31	16:48:05	10.2	7.35	7.28	7.28	0.140	0.070
3	16:45:10	10.23	7.36	7.29	7.29	16:48:10	10.27	7.42	7.34	7.34	0.070	0.080
4	16:45:15	10.36	7.49	7.30	7.30	16:48:15	10.2	7.35	7.34	7.34	0.190	0.010
5	16:45:20	10.3	7.43	7.31	7.31	16:48:20	10.18	7.33	7.29	7.29	0.120	0.040
6	16:45:25	10.3	7.43	7.34	7.34	16:48:25	10.13	7.28	7.30	7.30	0.090	-0.020
7	16:45:30	10.2	7.33	7.32	7.32	16:48:30	10.07	7.22	7.30	7.30	0.010	-0.080
8	16:45:35	10.22	7.35	7.31	7.31	16:48:35	10.3	7.45	7.29	7.29	0.040	0.160
9	16:45:40	10.3	7.43	7.28	7.28	16:48:40	10.26	7.41	7.32	7.32	0.150	0.090
10	16:45:45	10.2	7.33	7.31	7.31	16:48:45	10.32	7.47	7.30	7.30	0.020	0.170
										Mean	0.095	0.065
										StdDev	0.059	0.080

Static draft for ***Launch R2*** was calculated from the results of the SAIC survey, and was verified by lead line comparison on January 07, 2005, Table-2.

Table-2. Launch *R2* Lead Line Comparison.

LEADLINE COMPARISON			DRAFT ENTERED IN COMPUTER =			0.86			files			
DAY	7				DRAFT ON HULL =	0.86		port	r2mba05007.d03			
DATE	01/07/05	SQUAT DEPTH CORRECTOR LEFT IN =				0.00		stbd	r2mba05007.d03			
					DRAFT CORRECTOR =	0.00						
		PORT DECK TO WATER SURFACE =				1.18						
		STBD DECK TO WATER SURFACE =				1.20		<=TIDE CORRECTOR LEFT IN				
cast #	time taken port UTC	port deck to bottom meters	port cast depth meters	multibeam depth port	corrected multibeam depth port	time talen starboard UTC	stbd deck to bottom meters	stbd cast depth meters	multibeam depth starboard	corrected multibeam depth stbd	port difference meters	starboard difference meters
1	1:23:20	11.82	10.64	10.82	10.82	1:18:00	12.12	10.92	11.04	11.04	-0.180	-0.120
2	1:23:25	11.83	10.65	10.85	10.85	1:18:05	12.12	10.92	11.03	11.03	-0.200	-0.110
3	1:23:30	11.82	10.64	10.84	10.84	1:18:10	12.13	10.93	11.06	11.06	-0.200	-0.130
4	1:23:35	11.84	10.66	10.80	10.80	1:18:15	12.13	10.93	11.02	11.02	-0.140	-0.090
5	1:23:40	11.82	10.64	10.82	10.82	1:18:20	12.12	10.92	11.00	11.00	-0.180	-0.080
6	1:23:45	11.84	10.66	10.82	10.82	1:18:25	12.12	10.92	11.07	11.07	-0.160	-0.150
7	1:23:50	11.84	10.66	10.81	10.81	1:18:30	12.12	10.92	11.04	11.04	-0.150	-0.120
8	1:23:55	11.84	10.66	10.83	10.83	1:18:35	12.14	10.94	11.05	11.05	-0.170	-0.110
9	1:24:00	11.82	10.64	10.80	10.80	1:18:40	12.13	10.93	11.00	11.00	-0.160	-0.070
10	1:24:05	11.83	10.65	10.83	10.83	1:18:45	12.14	10.94	11.07	11.07	-0.180	-0.130
										Mean	-0.172	-0.111
										StdDev	0.020	0.025

Static draft for ***Launch D2*** was calculated from the results of the SAIC survey, and was verified by lead line comparison on January 07, 2005, Table-3.

Table-3. Launch *D2* Lead Line Comparison.

LEADLINE COMPARISON			DRAFT ENTERED IN COMPUTER =			0.65			files			
DAY	7				DRAFT ON HULL =	0.65		port	d2mba05007.d07			
DATE	01/07/05	SQUAT DEPTH CORRECTOR LEFT IN =				0.00		stbd	d2mba05007.d07			
					DRAFT CORRECTOR =	0.00						
		PORT DECK TO WATER SURFACE =				1.22						
		STBD DECK TO WATER SURFACE =				1.13	0.00	<=TIDE CORRECTOR LEFT IN				
cast #	time taken port UTC	port deck to bottom meters	port cast depth meters	multibeam depth port	corrected multibeam depth port	time talen starboard UTC	stbd deck to bottom meters	stbd cast depth meters	multibeam depth starboard	corrected multibeam depth stbd	port difference meters	starboard difference meters
1	4:41:20	11.43	10.21	10.30	10.31	4:38:40	11.57	10.44	10.52	10.53	-0.095	-0.085
2	4:41:25	11.44	10.22	10.31	10.32	4:38:45	11.56	10.43	10.50	10.51	-0.095	-0.075
3	4:41:30	11.43	10.21	10.33	10.34	4:38:50	11.57	10.44	10.49	10.50	-0.125	-0.055
4	4:41:35	11.43	10.21	10.42	10.43	4:38:55	11.58	10.45	10.48	10.49	-0.215	-0.035
5	4:41:40	11.44	10.22	10.33	10.34	4:39:00	11.58	10.45	10.45	10.46	-0.115	-0.005
6	4:41:45	11.45	10.23	10.34	10.35	4:39:05	11.59	10.46	10.52	10.53	-0.115	-0.065
7	4:41:50	11.44	10.22	10.29	10.30	4:39:10	11.57	10.44	10.45	10.46	-0.075	-0.015
8	4:41:55	11.43	10.21	10.28	10.29	4:39:15	11.57	10.44	10.49	10.50	-0.075	-0.055
9	4:42:00	11.44	10.22	10.34	10.35	4:39:20	11.57	10.44	10.47	10.48	-0.125	-0.035
10	4:42:05	11.43	10.21	10.30	10.31	4:39:25	11.58	10.45	10.48	10.49	-0.095	-0.035
										Mean	-0.113	-0.046
										StdDev	0.040	0.026

B SURVEY PLANNING

B.1 NOAA Survey Planning and Survey Direction

NOAA personnel conducted initial and daily survey planning using MapInfo GIS. Multiple source data were compiled, compared and analyzed to produce maps and models used to enhance survey operations and promote safety.

B.1.1 Nautical Chart

The largest scale digital raster chart (BSB .kap) or ENC were used as the base layer for additional data types. Cartographic generalization to scale decreased the usefulness of the chart for surveying inshore areas and features. Therefore, chart use was limited to reference purposes and NOS product evaluation.

B.1.2 Prior Survey Soundings

There are no prior surveys completed within the past five years over the survey area. Existing prior surveys date back to 1935. Prior survey smooth sheet raster images provided by HSD Operations were geo-referenced and viewed in MapInfo for comparison with project data in accordance with section 8.1.3., D.2 of the HSSDM.

C DATA AQUISITION

C.1 SAIC Data Acquisition

C.1.1 Personnel

SAIC staffed the DAVIDSON data acquisition station and launches R2 and D2 with two operators having at least one year experience using shallow-water multibeam, side scan sonar, and ancillary systems.

C.1.2 Survey Execution

NOAA provided line plans and directed survey operations via close communications with the SAIC lead hydrographer and OS master. In general, most of the main scheme data acquisition was performed by surveying pre-drawn survey lines.

C.1.3 ISS-2000 Acquisition System

Echo sounder, attitude, and position sensor data were acquired using SAIC proprietary ISS-2000 Integrated Survey System. All software patches applied to the ISS-2000 software and the dates of application were recorded and archived with SAIC Quality Assurance documents. All data were re-processed with tested patches in a static software release before final submission.

C.1.4 Navigation and Acquisition Logs

During data collection, the operators continuously monitored the system for errors and alarms. Thresholds set in the ISS-2000 system alert the operator by displaying an alarm message when error thresholds or tolerances were exceeded. Alarm conditions that may compromise survey data quality were corrected and annotated in electronic navigation log and the message file. 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 operator and automatically recorded to a message file.

C.1.5 Sound Velocity Data

C.1.5.1 Water Column Sound Velocity Data
Sound velocity measurements were acquired using Seabird SBE-19 Plus CTD. A cast was performed at the beginning of every survey day and applied in real time to subsequent echo sounder data. Additional casts were performed minimally at 4-hour intervals. Casts were performed more frequently if the operator observed changing water column conditions indicated by surface sound velocity measurements and line-to-line and outer-beam artifacts observed in real-time DTM.

C.1.5.2 Surface Sound Velocity Data
Surface sound velocity data were acquired on the DA and R2 with Reson SVP-C probes. Surface sound velocity was applied in real time and monitored for changing condition on the ISS-2000 and Reson acquisition displays.

C.1.6 Bathymetry

C.1.6.1 VBES

C.1.6.2 MBES
The Reson 81-P Sonar Processor received and demultiplexed digitized hydrophone signals from the 8101, 8125 and 8111 sonar heads. The Processor beamforms the sonar signals and resolves bottom detection for sounding calculations. Sounding data were displayed locally on a dedicated sonar display and exported via Ethernet communications to the ISS-2000 acquisition system. Multibeam echo sounder data and all ancillary sensor correctors were recorded and maintained in Generic Sensor Format (GSF) binary files. ISS-2000 generates a real-time DTM that can be used for display of multibeam data on acquisition platforms.

C.1.7 Side Scan Sonar
The 50 meter range scale was used throughout survey operations with the exception of some 75 meter range scale data being acquired at the onset of survey operations during trials to maximize survey productivity. It was determined that sharp thermoclines, soft substrate, and surface noise present in the survey area prohibited using range scales greater than 50 meters for the duration of the project.

A towfish altitude of eight to twenty percent of the range scale was maintained during data acquisition. SSS altitude for towed operations is adjusted by the amount of deployed tow cable, and to a lesser degree by vessel speed.
Confidence checks were performed daily by observing changes in linear bottom features (i.e. trawl scours) extending to the outer edges of the digital side scan image, features on the bottom in the survey area, and by passing offshore oil platform structures and aids to navigation.

C.1.8 Bottom Samples

In general, bottom samples were collected to identify seafloor areas suitable for anchorage and meet requirements specified in NOS Hydrographic Surveys Specifications and Deliverables Manual. Bottom samples were acquired by SAIC personnel using equipment described in Section A.4.3. Sample position and depth were recorded with each sample. Sediment characteristics were observed and recorded in accordance with standard NOAA classification and abbreviations.

C.1.9 Water-level correction

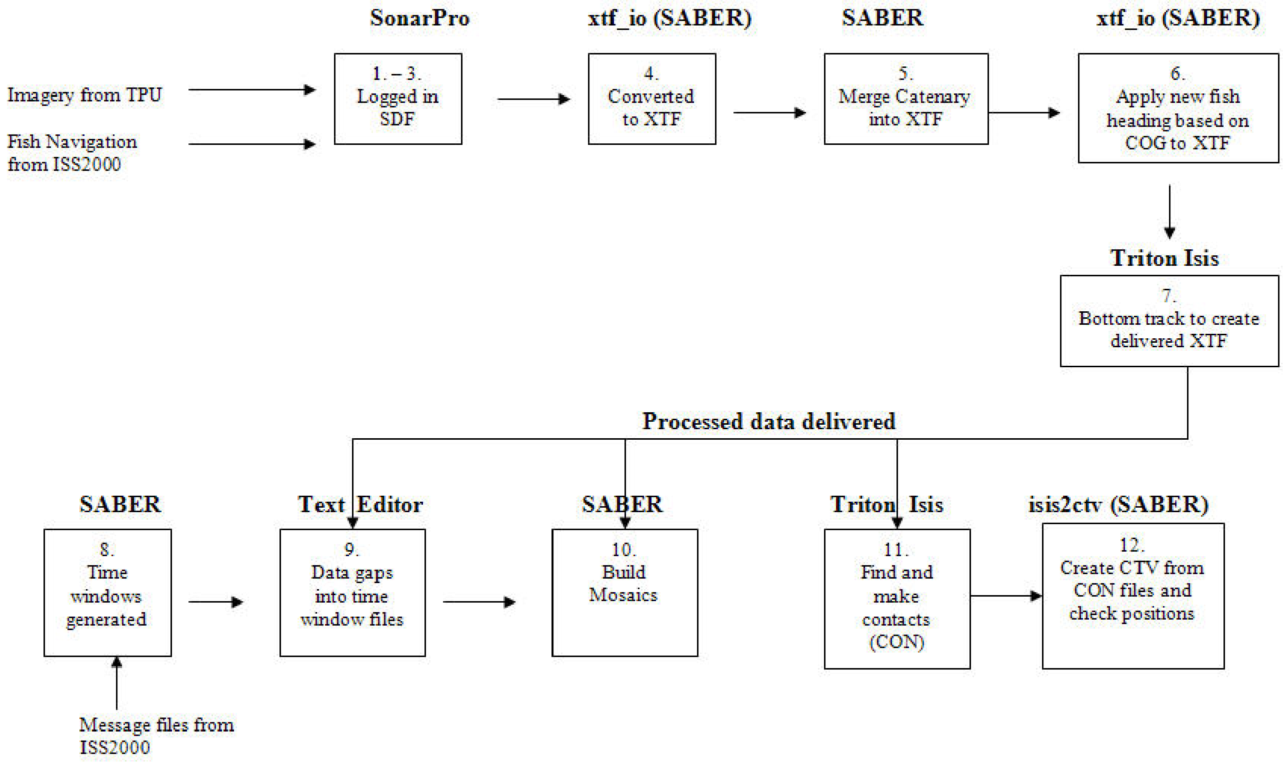
Predicted water levels and preliminary zoning were applied to all sounding data in post-processing by SAIC personnel. Bathymetry data deliveries made by SAIC to NOAA were corrected with Preliminary unverified water levels and preliminary zoning as part of the batch process conversion from *.GSF to Caris HDCS_DATA. Upon receipt of approved water levels and zoning at the NOAA Atlantic Hydrographic Branch, water levels from the primary tide gauge were applied by NOAA personnel to soundings. Soundings from crosslines and overlapping lines are examined using 3-D sounding subsets and base surfaces to identify temporal variation of water level modeling. In general, there was no sign of significant water level correction errors visible in line-to-line comparisons or the final base surfaces.

D DATA PROCESSING

D.1 SAIC Data Processing

Daily and weekly backups were made onboard the DAVIDSON. A complete backup of all raw and processed data were sent to the Newport Data Processing Center during port calls.

D.1.1 SAIC Side Scan Sonar Processing



1. Side scan data are logged by Klein SonarPro software in SDF format. Navigation is sent at 1 Hz from ISS2000 to the side scan acquisition system.
2. The ship sensor and fish sensor navigation fields are both populated with the fish navigation that came in at 1 Hz during real time acquisition.
3. Both the Klein 3000 and Klein 5500 SDF files use two bytes to save each sample, but only 12 of the 16 bits are populated with data.
4. Raw side scan data (SDF) are converted to XTF format using a command line SABER program called *xtf_io*. At this time data are down sampled decreasing the number of samples per channel. The method of grouping samples is averaging. For Klein 3000 data the number of samples is decreased by factor of 2 and for 5500 data, a factor of 3 is used. These settings allow for file sizes to be close to the same for a given period of time. The Klein 3000 data is also gained by a factor of 16 upon conversion.
5. Next the catenary files of fish position (logged in ISS2000 as ASCII) are merged on to the fish sensor field of the XTF files using SABER (*Merge Navigation*). During this navigation update an interpolation between 1 Hz. samples is used to give each ping a unique position.
6. Then fish heading is recalculated based on fish COG and replaces the heading from the real time acquisition heading sensor in the fish. The field in the XTF that is changed is fish sensor heading. This action is also a function of xtf_io.
7. The altitude on both systems is generally good due to the acquisitions system’s bottom tracking ability, however, bottom tracking is still verified and re-tracked in post processing where necessary. This operation is performed in Triton Isis. Once bottom tracking is complete, the XTF file is ready for delivery.

8. Time windows are generated from SABER using the message files (created in ISS2000). The message files contain start and end times of lines which are extracted and placed in a single file by SABER. This file is then split into the first and second 100% files. The time windows essentially depict when there is good side scan data.
9. Start and end times of when the data are out of specification are found by viewing data in Isis. The time window files created in step 8 above are then modified in a text editor to reflect the loss of quality data.
10. The final time windows and XTF data are used to generate mosaics in SABER typically at 1m resolution. Both TVG and fixed gains are applied to the side scan data upon mosaicing. The gains or TVG applied affect only the output mosaic however and do not change the XTF files. A 10 sample average of the altitude is used to smooth any small spikes which may be left after QC of bottom tracking. There is also a small part of the edges of the 3000 data which are black. This can be seen in the raw data as well. In order to ensure that these black stripes don't make it to the final mosaic, the 3000 data is clipped on the edges for ~0.5% of the slant range (49.7m for 50m range scale and 74.5m for 75m range scale data).
11. Contacts are found in the XTF data and made into CON files using Target, a program within Isis. Length, width, height and position of the contact are determined by this program.

The CON files then have the information necessary for a sonar contact file (CTV) extracted and concatenated via isis2ctv (a command line program within SABER). There is also a quality control process on the contacts position that is reported in ancillary ASCII files created by the program.

D.1.2 SAIC Multibeam Echo sounder Data Processing

Analysis and processing of the data on the DAVIDSON by SAIC include but were not limited to the following:

- Generation of track line plots
- Maintenance of Contact Files
- Swath editing and review of multibeam data
- Maintenance of Feature File List
- Coverage plots of multibeam data
- Generation of supporting documentation

SAIC data processing and analysis was performed using SAIC SABER software with a LINUX operating system. Processing and quality control procedures for multibeam data are described in detail in the following paragraphs.

D.1.2.1 Swath Angle Filtering

SAIC filtered all soundings to 60 degrees of nadir for mutibeam echo sounder bathymetry to increase confidence in sounding accuracy and minimize sound velocity errors.

D.1.2.2 Initial Processing
Initial processing was performed on the vessel after line acquisition including:

Echosounder Data
- Initial editing of multibeam and vertical beam data
- Flagging unacceptable data "offline"
- Annotation and flagging of significant features, obstructions and wrecks
- Track plots
- Coverage DTM

The multibeam data were initially edited onboard the acquisition vessel using SAIC's MVE (Multi View Editor) program. This tool is a geo-referenced editor, which allows for both plan and profile views with each beam in its true geographic position and depth. Each data file was edited to flag noise, fish, fliers and invalid soundings. At the end of each day, both the raw and processed data was backed up onto 4mm tape and transferred to the central data server on the DAVIDSON. Preliminary data were transferred to the server and extracted to local machines. Track lines were created and reviewed for navigation errors. After preliminary cleaning and review, a shoal-biased grid was generated from the multibeam sounding data and exported on a daily basis as Eastings, Northings and Depths for delivery to NOAA in ASCII text format. Extraordinary and navigationally significant features observed in the multibeam data were identified and notification was delivered to NOAA as a contact file.

D.1.2.3 Area Based Editing
The second stage of editing was performed using an area based editor (SABER ABE). This second review ensured that at least two people reviewed every multibeam file for both quality and features. During the second review additional emphasis was placed on data that was flagged as invalid by the initial reviewer. If necessary, corrections to draft were made at this time.

D.1.2.4 3-D Review and Editing
Final review and editing was performed in Interactive Visualization System's Fledermaus, integrated in the SABER software suite. Interactive 3D visualization allowed the SAIC Lead Hydrographers to review PFM binned data, based on a geographic area of the survey, and interactively analyze characteristics and attributes of the data in a 3D environment. PFM surfaces are based upon various parameters (shallow, average, deep, filtered, or unfiltered) and highlighted by various attributes (density, standard deviation, class, etc.). For editing purposes, there is full access to all the data in the individual native format data files contributing to the PFM binned surfaces. Full resolution GSF sounding data can be evaluated and edited (flagged) from a selected an area of the 3D surface, either directly in the 3D environment or from a linked window of the ABE. Any edited data are then dynamically updated in both the PFM file and the data visualized in the Fledermaus 3D environment. In addition to sounding data, operators can drape additional georeferenced, high-resolution datasets (i.e., nautical chart, imagery, or side scan sonar data) over PFM surfaces. Additional capabilities include profiling across a surface or surfaces in the 2D and 3D environment, interactive contouring of the surface in the 3D environment, and calculation and analysis of differences between surfaces from overlapping lines of soundings.

D.2 NOAA Data Processing

D.2.1 NOAA Side Scan Sonar Processing

All side scan sonar data were delivered fully processed in 16-bit XTF format and converted to 16-bit CARIS HDCS_DATA format using the CARIS beta version *convert_xtf.dll* created on 1/13/2005 using appropriate vessel configuration files. The beta *convert_xtf.dll was utilized in order to* retain contacts and *.tif images processed by SAIC as well as the added functionality of using time windows to retain offline data as rejected.

After conversion, the data was opened in CARIS Navigation Editor, Attitude Editor, and Side Scan Editor. Vessel attitude, gyro, and sonar height were checked. Vessel navigation data was manually checked for speed, course made good, and speed jumps greater than 2 kts. Data showing speed jumps were rejected with interpolation.

Side scan sonar data was scanned in CARIS Side Scan Editor. NOAA personnel corrected errors in bottom tracking, slant range corrected the imagery at default resolution (0.1m), and scanned the data for additional significant contacts not selected by SAIC personnel. Contacts deemed "significant" included, but were not limited to, contacts with a shadow indicating a contact height of 1 m or greater in water depths of 20m or less or contact heights 10% of the water depth in water deeper than 20m. All contacts were descriptively labeled and TIF format images of all contacts were saved. All contacts were then imported to a single Pydro Preliminary Smooth Sheet (PSS). for correlation with other feature contacts and bathymetry and were evaluated for further investigation.

D.2.2 Multibeam Data Processing

Sounding data were delivered fully processed and corrected to survey datum using predicted tides and preliminary tide zoning provided on the project CD. NOAA processing included conversion to Caris HIPS HDCS_DATA format, the re-correction of sounding data with preliminary or verified tides and minimal editing for residual fliers. Total propagated error (TPE) was calculated for each sounding and BASE surfaces were created with all available node attributes including depth, TPE, standard deviation, shoal value, deep value and sounding density. All final BASE surfaces were created from soundings that met **IHO Order 1** data error criteria. Critical soundings were flagged as "Designated" during Caris subset review to identify significant features or depths. Specific data quality and editing notes were recorded and included with respective survey Descriptive Reports and S-57 format feature attributes.

D.2.3 Vertical Beam Data Processing

Sounding data were delivered fully processed and corrected to survey datum using predicted tides and preliminary tide zoning provided on the project CD. NOAA processing included conversion to Caris HIPS HDCS_DATA format, the re-correction of sounding data with preliminary or verified tides and minimal editing for residual fliers.

D.2.4 Multibeam Sonar Data Conversion

All multibeam sounding data were converted from SAIC Generic Sensor Format (*.gsf) to Caris HIPS HDCS_DATA format. Sounding data were converted without any additional corrections to echo sounder, attitude or horizontal data.

D.2.5 Vertical Beam Sonar Data Conversion

All vertical beam sounding data were converted from SAIC Generic Sensor Format (*.gsf) to Caris HIPS HDCS_DATA format. Sounding data were converted without any additional corrections to echo sounder, attitude or horizontal data.

D.2.6 Total Propagated Error (TPE) Calculation

TPE was calculated in Caris HIPS and a value of horizontal and vertical uncertainty was assigned to each sounding. TPE is derived from a combination of many error sources within the context of specific sonar model characteristics (provided in the Caris system file devicemodel.xml). Each vessel configuration file (.hvf, delivered with survey data) estimates errors from the following system installation parameters:
• nav/gyro/heave/pitch/roll/tide errors
• latency error estimate
• sensor offset error estimates

D.2.7 Caris BASE Surfaces

D.2.7.1 QC Review BASE Surfaces

Caris QC-review BASE surfaces were created at 5-meter resolution for ship soundings and 2 meter resolution for the launch soundings. BASE surfaces were used to focus full-density sounding evaluations and editing in areas of high standard deviation and total propagated error (TPE). Sounding subsets were evaluated in areas of high topographic relief to ensure that the depth BASE surface accurately represented shoal soundings and features. Significant soundings were designated from full raw data to ensure representation in the final BASE surface models.

D.2.7.2 Branch Deliverable Base Surfaces

BASE surfaces were prepared in accordance with section 4.2.6.3 of the Field Procedures Manual (FPM. Each of the final field sheets contains 1-, 2-, and 5-meter resolution BASE surfaces.

D.2.8 Designated Soundings

Significant SSS contacts and shoal features were reviewed in full-density sounding subsets and least-depth soundings were designated for navigationally significant items to make sure they would be identified to the branch cartographer. Designated soundings are preserved in all the final base surfaces and were converted to bathymetry features in the pydro PSS. Additional remarks and attributes were updated in Pydro. Navigationally significant, dangerous shoal soundings were identified and reported as DtoN's.

D.2.9 Tide Data Processing and Sounding Correction

D.2.10 Observed Tide Data

Observed water levels were delivered daily via e-mail from HSTP Tidebot software. Daily tide data were copied to the survey Caris tide folder, concatenated to a master file and converted to COWLIS (*.tid) format using HSTP Hydro MI software. Tide data were loaded to Caris survey line data with preliminary zoning files (*.zdf) and subsequently corrected through the Caris Merge process.

D.2.11 Verified Tide Data

During AHB final data processing, HDCS sounding data were reduced to mean lower-low water (MLLW) using approved tides from the primary station at Eugene Island, LA (876-4311) and secondary station at Galveston Pleasure Pier, TX (877-1510), adjusted for zoned range and amplitude correctors provided by CO-OPS.

D.2.12 Feature Data Processing

D.2.12.1 Designated Soundings

HSTP's Pydro software was used for feature integration, evaluation and attribution, and reporting. Pydro creates features from all designated soundings upon import from HDCS data. Designated soundings and features were inserted into the Pydro Preliminary Smooth Sheet (PSS). Pydro attributes features with 4 flags: "Significant", "Chart", "Investigate", and "DTON". In addition, Pydro provides "Primary" and "Secondary" flags for grouping correlated features.

All soundings and side scan sonar contacts were assessed to determine chart and navigational significance. In areas of highly complex or variable bathymetry, shoal soundings were evaluated and designated to preserve the least depth on critical features. Features that were added, modified or deleted in comparison to source or charted data were attributed and retained in the Pydro PSS .xml data. Features that posed special significance to vessel traffic were attributed and reported as "DTONS".

SSS features were initially categorized by significance. Contacts that meet the standard of significance criteria were marked as such; those contacts which are deemed insignificant are marked "Resolved" and not investigated further. Also, multiple contacts representing the same physical feature are grouped. The contact that the hydrographer believes best represents the feature (typically, the most clear SSS image) is selected as the "Primary" contact, while the rest are flagged as "Secondary."

Bathymetry was submitted as a collection of finalized BASE surfaces. The finalize step applies designated soundings which have been chosen by the Hydrographer in order to preserve the least depth over navigationally significant features. Designating a sounding forces the nearest BASE surface grid node to the depth of the designated sounding in the finalized BASE surface. The finalize step also allows for a depth threshold to be applied to the BASE surface, in effect cutting out just the section of the BASE surface with a specified depth range. In this way, the survey area was covered by a collection of finalized BASE surfaces, each of which preserves the highest possible resolution for the given depth ranges.

D.2.13 Sound Velocity Data Processing

All sound velocity correction was performed by SAIC in ISS-2000 software. No sound velocity data was applied by NOAA. The Caris vessel configuration files prepared and delivered for this project are not appropriate for sound velocity correction from raw data.

CTD casts were processed through HSTP Velocwin software to produce NODC archive files and Caris compatible sound velocity correctors. Raw CTD data and processed sound velocity profiles were archived and submitted with survey data.

Sound velocity profiles were collected often to characterize the variable and complex water column conditions in the survey area. Surface sound velocity was monitored continuously on Survey Launch R2 to ensure correct beam formation by the RESON 8125 echosounder system. Surface sound velocity was used by the 8125 system for correct beam formation on the flat-faced transducer for directional accuracy. Changes in surface sound velocity were also evaluated as an indicator of changes in the water column sound velocity. In general, there was good agreement of depths between overlapping outer beams of survey lines. There is no indication of significant sound velocity errors.

E. QUALITY CONTROL

E.1 System Certification and Calibration

E.1.1 System Certification and Calibration

Sea Acceptance Tests (SAT) for all platforms were conducted by SAIC as part of the Time Charter mobilization in Gulfport, Mississippi. Included was the establishment of a reference surface over a charted fish haven consisting of a flat bottom with a distinct feature (wreck) to assess operational and system capabilities on January 6-8, 2005. Results of the survey demonstrated that the survey systems were capable of acquiring data to meet specifications provided in NOAA Hydrographic Survey Specifications and Deliverables and requirements specified in the Project Letter Instructions for OPR-K354-TC05. Required acquisition, processing, and operational improvements were identified and resolved prior to survey data acquisition and final data submission. Refer to SAIC SAT Report in Appendix II for additional details.

E.2 Data Quality Control

E.2.1 SAIC Data Quality Control

SAIC uses a series of integrated checklists and tracking logs to ensure the quality and accuracy of its hydrographic data collection and processing. Several forms identify and track the flow of data as it was collected and processed. For the Hydro Survey Services contract, one of each of the documents listed below was created for each vessel working on each sheet. Refer to Appendix V for example copies of forms.

Acquisition:

Real-time Watchstander Daily Checklists
Sidescan Watchstander Daily Checklists
Start of Watch Informational Checklist
End of Watch Checklists
Daily Data Backup Tracking Log
Weekly Data Backup Tracking Log

Processing:
Multibeam Processing Checklist & Log
Vertical Beam Processing Checklist & Log
Sidescan Processing Checklist & Log
Ping Edit Sheets

E.3.2 Crossline Analysis
Preliminary crossline analysis was conducted by SAIC. SAIC uses the SABRE Accutest utility to evaluate beam to beam soundings from orthogonal lines. The Accutest software compares each beam of each line and generates a report of statistical variation of depth. Crossline analyses were performed, reviewed and delivered to NOAA with the multibeam data. Final crossline analyses were performed by NOAA to confirm that survey data meets IHO Order I specifications as per the NOS Hydrographic Surveys Specifications and Deliverables Manual.

E.3.3 NOAA Data Quality Review and Acceptance

E.3.3.1 SAIC Navigation and Processing Logs
Daily logs of acquisition conditions and processing observations were recorded and submitted by SAIC. Navigation and processing logs were combined with NOAA processing checksheets and referenced during data quality review.

E.3.3.2 VBES Data Review
SAIC GSF sounding data were delivered as fully corrected and positioned depth values calculated to the survey datum with predicted tides and preliminary zoning provided on the Project CD. Vertical beam sonar data were converted from GSF format to CARIS using appropriate vessel configuration files. All corrector data was recorded and preserved in the GSF file format, however, no subsequent raw-data sound velocity, offset or attitude correction was performed in Caris.

After conversion, data were examined in CARIS Navigation Editor, Attitude Editor, and reviewed and edited in Caris Single Beam Editor. Vertical beam sonar data were for quality control purposes only and are not included in the generation of final BASE surfaces for H-cell production.

E.3.3.3 Multibeam Sonar Data Review
SAIC GSF sounding data were delivered as fully corrected and positioned depth values calculated to the survey datum with predicted tides and preliminary zoning provided on the Project CD. Multibeam sonar data were converted from GSF format to CARIS using appropriate vessel configuration files. All corrector data was recorded and preserved in the GSF file format, however, no subsequent raw-data sound velocity, offset or attitude correction was performed in Caris.
After conversion, data were examined in CARIS Navigation Editor, Attitude Editor, Swath Editor, and Subset Editor to look for systematic errors. Attitude data were checked for unnatural patterns (i.e. straight lines, gaps) and vertical offsets. Vessel navigation data were checked for speed jumps, horizontal offsets, gaps and heading deviation. CARIS Swath Editor was used to evaluate soundings in a ping or time reference frame. Subset Editor was used to examine features, designate soundings,

locate and edit fliers, and scrutinize data for sound velocity, water level correction, and unacceptable data artifacts.

E.3.3.4 Side Scan Sonar Data Review
Refer to section *D.2.1 NOAA Side Scan Sonar Processing*.

E.3.3.5 Caris Base Surface Review
Caris BASE grid surfaces were created from full-density HDCS data at 2-meter resolution for launch data and 5-meter resolution for ship data. BASE surfaces were evaluated for sounding density, depth, standard deviation, and total propagated error (TPE).

E.3.3.5.1 Sounding Density
In general, sounding density was dependent upon water depth and system beam characteristics; however, noise and excessive motion also affected sounding density. Sounding density surfaces were evaluated for coverage and feature detection. Caris sounding subsets were evaluated in navigationally significant shoal areas and over features to ensure adequate ensonification, resolution and least depth determination.

E.3.3.5.2 Depth
BASE surfaces were evaluated and used to generate DTM, soundings and contours.

E.3.3.5.3 Standard Deviation
Standard deviation was evaluated to locate features which were shoal compared to surrounding depths. In these areas, full-density sounding data were evaluated in 3D subsets for sounding resolution and coverage on features. Least depths on significant features were designated and processed through BASE surface and Pydro processing. High standard deviation along track, between lines and on outer beams also indicated invalid correctors for sound velocity, offsets, attitude and positioning.

E.3.3.5.4 Total Propagated Error (TPE)
Raw soundings were not filtered for TPE. BASE surfaces were created from soundings filtered for TPE values that met IHO Order 1 tolerance. TPE filtering increased the confidence of sounding accuracy based upon system parameter settings in the Caris Vessel Configuration File (*.hvf). Caris configuration files were created from manufacturer system performance specifications and offsets provided by SAIC from the Sea Acceptance Test (SAT). TPE was viewed in Caris surface models to evaluate sounding accuracy and confidence for significant features and final coverage. All designated soundings were qualified with an associated TPE confidence value.

F CORRECTIONS TO ECHO SOUNDINGS

Sounding data were delivered to NOAA fully corrected to survey datum using zoned, predicted tides from the primary tide station. All sounding component sensor data were acquired and logged in raw format and preserved with submitted GSF data. Field-submitted base surfaces and HDCS sounding data were reduced to mean lower-low water (MLLW) using approved tides from the primary station at Eugene Island, LA (876-4311) and secondary station at Galveston Pleasure Pier, TX (877-1510), adjusted for zoned range and amplitude correctors provided by CO-OPS as specified in the project instructions.

F.1 Vessel Offsets

Refer to section A.5.4, the *OCEAN SERVICES LLC 8111, 8101, 8125 Installation Report* and SAIC report *Sea Acceptance Test Report for the ISS-2000 and SABER Survey System Installed in the R/V Davidson and Launches R2 and D2* for detailed vessel descriptions, equipment installation procedures and offset diagrams. Offset corrections were performed in the Applanix POS/MV controller software to translate motion and attitude references to the IMU frame. Raw correctors and fully corrected soundings were delivered to NOAA in GSF format.

F.2 Static Draft and Dynamic Draft

Refer to SAIC report *Sea Acceptance Test Report for the ISS-2000 and SABER Survey System Installed in the R/V Davidson and Launches R2 and D2* for a description of the static and dynamic draft determination and corrections. Draft corrections were performed in ISS-2000. Raw correctors and fully corrected soundings were delivered to NOAA in GSF format.

F.3 Attitude and Heave

Refer to **Section A3**. All attitude and heave corrections were performed in ISS-2000. SAIC implemented a delayed heave algorithm in ISS-2000 to improve the accuracy of heave corrections and minimize induced error caused by vessel motion and sensor lever arms. Raw correctors and fully corrected soundings were delivered to NOAA in GSF format. Applanix ***True Heave*** data were delivered in binary format with deliverables.

F.4 Sound Velocity Profile

Refer to **Section A.4.1.** Sound velocity correction was performed in ISS-2000 and fully corrected soundings were delivered to NOAA in GSF format. Raw SVP data were delivered to NOAA with deliverables. SVP casts were processed through HSTP Velocwin software to produce NODC archive files and Caris compatible sound velocity correctors. No sound velocity corrections were performed for GSF formatted deliverables.

F.5 Water Levels

ISS-2000 applied predicted, zoned tides in real time during acquisition. Soundings were corrected to Mean Lower Low Water using preliminary, unverified tides for NOAA data quality review. Verified tides when available were applied according to the procedure described in **Section D.2.11**. All raw tide data from the primary gauge were corrected using zoning provided with the project instructions.