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

DATA ACQUISITION AND PROCESSING REPORT

Type of Survey	**Hydrographic**
Project Number	**OPR-J311-KR-16**
Contract Number	**EA-133C-14-CQ-0037**
Task Order Number	**T0003**
Time Frame	**August 2016**

LOCALITY

State	**Louisiana and Mississippi**
General Locality	**Southeastern Vicinity of the Chandeleur Islands**

2016

CHIEF OF PARTY

Jonathan L. Dasler, David Evans and Associates, Inc.

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S/V *Blake*
David Evans and Associates, Inc.
Chief of Party: Jonathan L. Dasler, PE, PLS, CH

INTRODUCTION

This report applies to the OPR-J311-KR-16 project area that includes surveys H12920, H12921, H12922, H12923, H12924, H12925, H12926, H12953, H12954 and H12955. Survey H12920 covers sections of the Breton Sound Alternate Route while all other assigned survey areas are located south and east of the Chandeleur Islands. All surveys meet requirements defined in the *Statement of Work* (July 7, 2016), *Hydrographic Survey Project Instructions* (July 15, 2016), and National Ocean Service (NOS) *Hydrographic Surveys Specifications and Deliverables* (HSSD) (March 2016).

The project's survey purpose, which was defined in the Project Instructions, is "to provide contemporary surveys to update National Ocean Service (NOS) nautical charting products. This project includes two survey areas totaling 263 SNM of which 226 SNM are classified as emerging critical areas, 32 SNM as priority two areas and 2 SNM as priority three as identified in the 2012 NOAA Hydrographic Survey Priorities. The first area is a narrow corridor located to the west of the Chandeleur Islands and extends from Baptiste Collette, LA towards Gulfport, MS. This corridor will serve as an alternate traffic route during the August 2016 closure of the INHC Lock in New Orleans. The second area, located to the east of the Chandeleur Islands, is a heavily trafficked area and encompasses approximately 262 SNM with multiple oil platforms and well heads."

All references to equipment, software or data acquisition and processing methods were accurate at the time of document preparation. All changes to data acquisition and processing methods will be specifically addressed in the Descriptive Report for each project survey.

A. EQUIPMENT

For this project, David Evans and Associates, Inc. (DEA) implemented state-of-the-art data acquisition systems on board the Survey Vessel (S/V) *Blake* in accordance with National Oceanic and Atmospheric Administration (NOAA) standards and modern remote sensing techniques. Operational systems used to acquire survey data and redundant systems that provided confidence checks are described in detail in this section and are listed in Table 1.

Table 1. S/V *Blake* Hardware

Instrument	Manufacturer	Model	Serial No.	Function
Side Scan Sonar				
Deck Unit	**EdgeTech**	701-DL	35323	Topside side scan interface and digital sensors
Towfish	**EdgeTech**	4200-HF	42627	300/600 kHz side scan towfish for seafloor imaging
Towfish	**EdgeTech**	4200-HF	43188	Spare 300/600 kHz side scan towfish for seafloor imaging
Side Scan Sonar Cable Counter				
Cable Counter	**Measurement Technology Northwest**	LCI-90	0350	Continuous digital output of deployed side scan tow cable length for layback calculations
Multibeam Echosounder				
Sonar	**RESON**	SeaBat 7125-SV2 SPU G5	TX 3313070 RX 0214073	Multibeam sonar
Deck Unit	**RESON**	FP4 V6.0.0.11	18340714125	Multibeam sonar processor
Sound Speed				
MVP30-350 Sound Speed Profiler	**Rolls Royce/AML Oceanographic**	Micro SV&P	Sensor: 5110	Primary sound speed profiler until 9/3/2016
MVP30-350 Sound Speed Profiler	**Rolls Royce/AML Oceanographic**	MVP X	8704	Primary sound speed profiler after 9/3/2016
Surface Sound Speed	**AML Oceanographic**	Micro SV Xchange	Housing: 8083 Sensor: 201647	Sound speed at MBES
Sound Speed Profiler	**Sea-Bird Electronics, Inc.**	SBE 19-03 SeaCAT	2691	Secondary sound speed profiler
Navigation				
Deck Unit	**Applanix**	POS MV 320 V5, Firmware: 5.03	7342	Integrated Differential Global Positioning System (DGPS) and inertial reference system for position, heading, heave, roll, and pitch data
IMU	**Applanix**	POS MV V5	750	
Port Antenna	**Trimble**	GA830	7337	
Starboard Antenna	**Trimble**	GA830	7347 7235	Until 8/21/2016 After 8/21/2016
DGPS Receiver	**Trimble**	SPS351	5418D53021	Secondary DGPS positioning system
DGPS Antenna	**Trimble**	GA530	5280	

A1. Survey Vessel

The S/V *Blake*, owned and operated by DEA (Figure 1), was the survey vessel for the project. The S/V *Blake* is a 92-ton United States Coast Guard (USCG) Subchapter T inspected vessel, Official Number 1256966, and Hull Number 213. She is an 83-foot aluminum catamaran with 27-foot beam and a draft of 4.5 feet. The vessel is equipped with wave-piercing bows, Tier-3 diesel engines, twin 55-kilowatt generators, centerline moon pool with hydraulic multibeam strut, stern mounted A-frame, bow mounted knuckle boom crane, climate-controlled equipment and server closet, two data acquisition stations, and two data processing stations. The S/V *Blake* supports a hydrographic crew of six and is supported by four ship crew for 24-hour survey operations.

Figure 1. S/V *Blake*

A2. Side Scan Sonar Systems

Side scan sonar imagery was acquired with an Edgetech 4200-HF (300/600 kHz) dual frequency side scan sonar. The sonar was operated at 600 kHz using 50-meter and 75-meter range scales. Data acquired for survey H12920, which was all collected at the 50-meter range scale, were logged in high definition mode. Side scan data for the remaining surveys areas were logged in high speed mode.

Side scan sonar imagery was logged as eXtended Triton Format (XTF) (16 bit, 2048 pixels/channel) in Triton Isis SS-Logger. In addition to the imagery, vessel heading, pitch, roll, position, towfish depth and altitude, and computed towfish position from layback calculations were also recorded to the XTF.

The side scan sonar towfish was either deployed from the bow or stern of the vessel. For each configuration, the horizontal offset of the tow point relative to the vessel reference point was entered into Hypack. The tow point position calculated in Hypack was sent to SS-Logger and used as the raw towfish position. When using the cable-out method, an LCI-90 cable payout interface was used to measure cable-out during stern tow and a fixed cable-out was used for bow tow. The cable-out, along with the measured tow point height above the waterline and towfish depth, was used by SS-Logger to compute layback. When using the fixed layback method, the cable-out on the bow or stern was set at a fixed distance and the horizontal distance from the tow point to the towfish was measured. This horizontal layback was entered into SS-Logger as a positive value as the towfish was always aft of the tow point.

To confirm adequate target resolution at the outer limits of the selected range, confidence checks were conducted on a daily basis during acquisition and noted in the acquisition logs. In deteriorating conditions, confidence checks were performed more frequently to confirm detection of features at the outer range limits.

A3. Multibeam System

The S/V *Blake* was equipped with a Reson SeaBat 7125-SV2 SPU G5 dual frequency multibeam sonar capable of operating at 200 kHz or 400 kHz and integrated AML Micro SV Xchange sound velocity sensor. The multibeam was deployed with a center lift-mount through a moon pool. For all surveys, the sonar was operated with FP 4 in Equi-Angle Beam mode at 400 kHz using a 140-degree swath width. Mainscheme acquisition typically used 256 beams while investigations were acquired with 512 beams. In some instances, 512 beams were acquired during mainscheme when node density was of concern.

All multibeam data were acquired with the 400 kHz SV2 bracket (PN85160026C02) selected in the hardware configuration. Multibeam data were output using the 7006 datagram, which references all soundings with respect to the 7125 sonar reference point. Range adjustments were made during acquisition as dictated by changes in water depth. HYPACK HYSWEEP was used to acquire multibeam data in HYSWEEP HSX file format and snippets in 7K file format.

A4. Position, Heading and Motion Reference Systems

The S/V *Blake* was outfitted with a POS/MV 320 version 5 with GPS and inertial reference system, which was used to measure attitude, heading, heave, and position. The system was comprised of an Inertial Motion Unit (IMU), dual frequency (L1/L2) GPS antennas, and a data processor.

A Trimble SPS351 DGPS acquired corrections from the USCG beacon English Turn, Louisiana (293 kHz) and provided these corrections to the POS/MV. In addition, the Trimble SPS351 DGPS receiver was used as a redundant positioning system to provide secondary DGPS corrected positions for quality control purposes.

Positions from all systems were displayed in real-time using Hypack and continuously compared during survey operations.

A weekly position comparison between the primary and secondary positioning system was observed and documented while the vessel was either secured in port or within the extents of the survey area. Logged position data were extracted from the Hypack RAW file and entered into an Excel file for comparison. Position check reports can be found in Separate I *Acquisition and Processing Logs* of each survey's Descriptive Report.

Position, timing, heading, and motion data were output to the Hypack acquisition system using the POS/MV real-time Ethernet option at 25 Hz.

The POS/MV provided time synchronization of sonar instruments and data acquisition computers using a combination of outputs. The Reson processors and Hypack acquisition computers were provided a Pulse Per Second (PPS) and National Marine Electronics Association (NMEA) Global Positioning System Timing Message (ZDA) to achieve synchronization with the POS/MV. The Isis SS-Logger acquisition computer synchronized its time using the proprietary Trimble Universal Time Coordinated (UTC) message provided by the POS/MV. All messages contained time strings that enabled the acquisition computers and sonars to synchronize to the time contained within the message. Time offsets between the instruments and computers, relative to the times contained in POS/MV network packets, were typically sub-millisecond.

Using the Ethernet logging controls, the POS/MV was configured to log all of the raw observable groups needed to post process the real-time sensor data. The POS/MV logged 64 megabyte .000 files, which resulted in multiple files created per day. The TrueHeave™ data group was also logged to these files.

A5. Sound Speed Measurement Systems

Sound speed sensors were calibrated prior to the start of acquisition. Factory calibration results are included in Appendix IV *Sound Speed Sensor Report* of this report.

An AML Micro X SV sensor mounted on the Reson 7125 sonar head was input into the Reson 7-P processor and speeds from the sensor were used in real-time during acquisition for beam forming on the 7125's flat array. A Rolls Royce MVP 30-350 equipped with AML Oceanographic Micro SV&P sensors was used as the primary sound speed sensor for the S/V *Blake*. A Seabird SBE 19-03 SeaCAT was used as the secondary sound speed sensor. All sound speed calculations from the Sea-Bird Conductivity, Temperature, and Depth (CTD) profiler used the Chen-Millero equation. These profiles were used solely for confidence checks with the primary sensor.

A6. Acquisition and Processing System

The acquisition stations were custom-installed and integrated on the S/V *Blake* by DEA and consisted of a HYPACK HYSWEEP multibeam acquisition and navigation computer, an MVP computer, and a computer for digital logs and general administration. The S/V *Blake* had an additional Triton Isis SS-Logger side scan sonar data acquisition computer and two processing computers.

Data collected from the S/V *Blake* were logged locally on each acquisition computer and continuously backed up to a QNAP network attached storage (NAS) device. A secondary QNAP NAS was used to perform backups of the primary QNAP. At each vessel port call, acquisition and processing data from the primary QNAP were transferred to the Gulfport, MS and Vancouver, WA offices via two external USB 3.0 hard drives.

The software and version numbers used throughout the survey are listed in Table 2.

Table 2. Acquisition and Processing Software

Name	Manufacturer	Version
Acquisition		
Hypack	Hypack, Inc.	14.0.0.23
Hypack Survey	Hypack, Inc.	14.0.9.47
Hysweep	Hypack, Inc.	14.0.9.0
SeaBat	Reson	Blake FP4 V6.0.0.11
Isis SS-Logger	Triton Imaging, Inc.	7.3.623.51
Discover 4200-MP	Edgetech	33.0.1.109
LineLog	David Evans and Associates, Inc. Marine Services Division	2.0.7
MV-POSView	Applanix Corporation	5.1.0.2
ODIM MVP Controller	ODIM Brooke Ocean	2.45
SeaTerm	Sea-Bird Electronics, Inc.	1.59
SBE Processing	Sea-Bird Electronics, Inc.	7.23.1
Processing		
HIPS	CARIS 64-bit	9.1.5 9.1.6 *Installed 8/20/2016*
Base Editor	CARIS 64-bit	4.1.0 4.2.8 *Installed 8/20/2016*
ArcGIS	ESRI	10.2.2.3552
Triton SS-Logger (ISIS)	Triton Imaging, Inc.	7.3.623.51
SonarWiz	Chesapeake Technology, Inc. 64-bit	6.004.0006 6.004.0009 *used until 10/06/16*
POSPac MMS	Applanix	7.2.5934.15637
Photoshop CS3	Adobe	10.0
SVP Convert	David Evans and Associates, Inc.	2.0.4
Other		
Microsoft Office Suite	Microsoft	2013
Beyond Compare	Beyond Compare	4.0.7

Sonarwiz version 6.06.0006 was used for initial file import and conversion, initial review and processing, and initial contact generation for the entire project. Sonarwiz version 6.06.0009 was used for quality review, final contact generation, and final exports until 10/06/16 when the software was reverted back to version 6.004.0006.

A7. Survey Methodology

A7.a Mobilization

Mobilization of the S/V *Blake* occurred from July 25 to July 27, 2016. System calibrations, a start of project patch test, and a squat confirmation test were performed in Mississippi Sound on July 28, 2016 (DN210). Results from the squat test were consistent with results from the prior test which was performed on November 14, 2014, in support of NOAA project OPR-J311-KR-14. The prior values were held and used for this project. Vessel offsets and associated measurement uncertainties for the S/V *Blake* were calculated from a vessel offset survey performed at Geo Shipyard in New Iberia, LA on September 23-24, 2014. There have been no changes to the hardware offsets since the initial vessel offset survey. All survey points were positioned using a terrestrial land survey total station, from a minimum of two locations, which allowed a position uncertainty to be determined. Vessel offsets and uncertainties were used in the HIPS HVF.

A7.b Survey Coverage

Survey coverage requirements varied by survey area. Surveys H12920 and H12921 required Object Detection Coverage using 200% side scan sonar coverage with concurrent multibeam bathymetry. The remaining areas (H12922, H12923, H12924, H12925, H12926, H12953, H12954 and H12955) required Complete Coverage using 100% side scan sonar with concurrent multibeam bathymetry. All multibeam acquisition included time series backscatter.

In areas where a charted feature was found not to exist, a second 100% coverage was acquired in order to meet feature disproval requirements. Multibeam data was acquired during feature and side scan contact developments as required by the HSSD. Additional multibeam data was acquired within a 50-meter disproval radius for assigned wellheads which were included in the project's Composite Source File (CSF).

The effective range of the side scan sonar was reduced to 12.5 times the towfish height when height was less than 8% of range scale. Additional coverage was acquired to fill any associated holidays created by reducing the range.

The Project Reference File (PRF) OPR-J311-KR-16_PRF.000 and CSF OPR-J311-KR-16_CSF.000 used for the project was sent to DEA via email on July 15, 2016.

A7.c Side Scan Sonar Operations

The side scan sonar was operated at 50-meter and 75-meter range scales at survey speeds and ping rates that enabled the sonar to detect 1 meter targets in the along track direction.

During the survey, the side scan sonar was operated in the 600 kHz high-frequency mode at 50-meter and 75-meter range scales. H12920 data was acquired in high definition mode at the 50-meter range scale. All other data was acquired in high speed mode.

The EdgeTech 4200 series sonar has a ping rate of 30 Hz at the 50-meter range and 20 Hz at the 75-meter range, while operating in the high speed mode. High speed mode makes use of the optional Multi-Pulse (MP) technology, which places two sound pulses in the water at a time rather than the traditional one pulse, and allows for tow speeds upwards of 8 knots. High definition mode, which was used during H12920 acquisition, has a ping rate of 15 Hz at the 50-meter range scale. In accordance with the 2016 HSSD, vessel speed was monitored to allow for the acquisition of a minimum of three pings per meter. The side scan was towed from either the bow or stern of the S/V *Blake* during acquisition.

The side scan sonar operator was assigned the task of analyzing the digital sonogram and keeping the towfish height within specification by adjusting cable-out. The operator also called out contacts and daily confidence checks, which were entered into the digital acquisition log. When weather or sea conditions degraded side scan sonar imagery, operations were suspended.

A7.d Multibeam Sonar Operations

The multibeam sonar was operated at different range scales throughout the survey by adjusting the depth range to obtain the best coverage in varying depths of water. Gain and power were adjusted to record a strong bottom return capable of supporting quality depth and backscatter data.

Multibeam investigations occurred over significant features after examining parameters such as coverage, density, feature or contact height, depth, and navigational significance.

Table 3 lists the typical 7125 sonar settings for the survey.

Table 3. Typical Reson 7125 Sonar Settings

7125 Parameter	Pulse Type: FM
Operation Depth	>25m
Range	Variable, depth dependent
Receive Gain	10-40
Transmit Power	200-220 dB
Spreading	30 dB
Absorption	110 dB/km
Ping Rate	20 p/s max
Pulse Width	400 µs

A7.e Bottom Sampling

Bottom samples were acquired as specified in the *Hydrographic Survey Project Instructions* in accordance with section 7.2.2 of the 2016 HSSD. Approximate bottom sample locations were provided by NOAA in the final PRF. The final sampling plan used these locations with some modification of position to assure that they were acquired with a suitable distance away from charted pipelines in the survey area.

A8. Quality Assurance

Acquisition and processing methods followed systematic and standardized workflows established by DEA. These systems include, but are not limited to, staff training and mentoring, a formalized project management program, record and log keeping standards, software version management, and a multilevel review process.

Multibeam survey data were converted and processed in CARIS HIPS version 9.1. Data processing methodologies followed standard CARIS HIPS workflows for multibeam data.

The default *CUBE Parameters.XML* was replaced with *CUBEParams_NOAA.xml* which was issued by the Hydrographic Surveys Division (HSD) prior to the start of the project with version 5.4 of the CARIS support files. This updated XML file uses the resolution dependent maximum propagation distance values required in the NOS HSSD.

Side scan contacts, which were created on items with measured target heights of at least 0.75 meters, were developed with multibeam according to coverage requirements for each survey sheet. In order to streamline the process, contact investigations were typically performed to meet feature development requirements. This technique is shown in Figure 2.

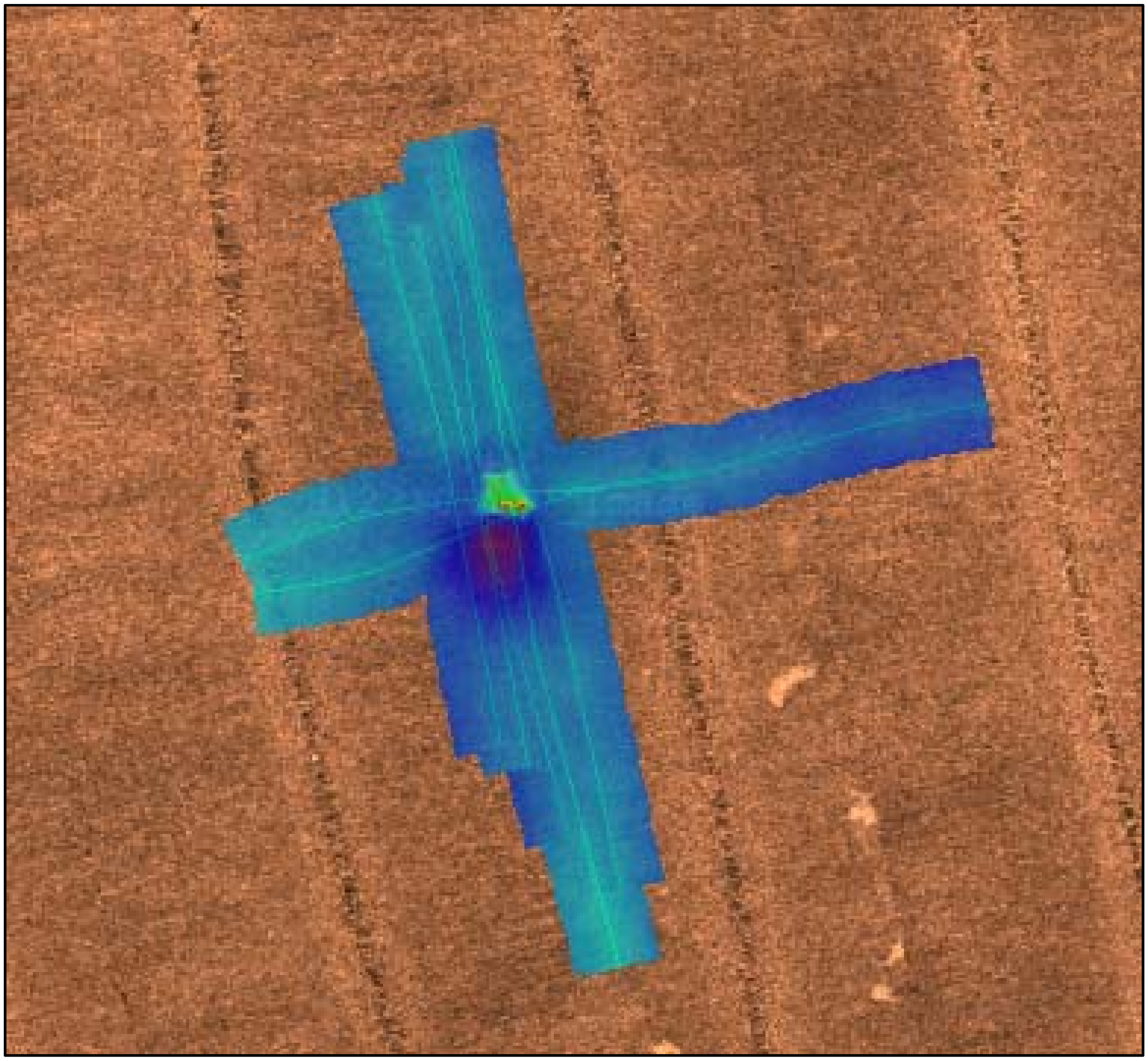

Figure 2. Example of Multibeam Development of Side Scan Contact

B. QUALITY CONTROL

B1. Data Acquisition

B1.a Side Scan Sonar

Triton Isis SS-Logger acquisition software was used to record side scan sonar data in XTF format. Adjustments to towfish height were made during stern tow data acquisition as necessary and logged in Isis SS-Logger to meet specifications and provide the best image quality possible. Changes to cable-out values, sensor settings, offset configurations, data quality, and contacts were recorded in the daily acquisition log. Typical windows for monitoring raw sensor information included a waterfall display for the sonar imagery, tow fish motions, cable-out and layback, sonar signal voltage display, and I/O port monitor. Data were displayed on a 30-inch LCD flat panel monitor mounted vertically at the acquisition station. The large format display allowed for increased time to analyze online contacts. Contacts were selected in real-time and during post-processing.

To aid in the consistency of contact identification, a table was posted at the side scan acquisition station listing slant range and towfish altitude to determine minimum shadow heights for 0.75-meter contacts at range. Contacts were created on bottom features if their estimated height was 0.75 meters or greater. The 0.75 meter height threshold was used to allow for measurement uncertainty around the 1 meter HSSD requirement.

When towing the side scan sonar from the stern of the vessel and using the cable-out method for layback calculation, efforts to maintain towfish altitude at 8% to 20% of the range was tasked to the side scan operator, who also controlled the winch operation. The operator could view the towfish altitude above the seafloor on the Isis SS-Logger display and adjust cable-out accordingly to maintain the towfish at the required height. When towing the side scan sonar in shallow regions of the survey area, the towfish was deployed with a fixed cable-out with the layback value from the tow point entered into SS-Logger.

The digital cable-out value was confirmed by stopping pay out of the tow cable when the 5-meter mark on the cable was at the top of the block sheave. Using this method, the cable-out meter was calibrated during each deployment and continuously during tow operations.

B1.b Multibeam

Multibeam data were acquired in HYPACK HYSWEEP file format (HSX). Adjustments to the sonar, including changes in range, power, and gain, were made as necessary in order to acquire the best bathymetric data quality. Additionally, vessel speed was adjusted in accordance with the HSSD to meet the required along track coverage. Typical windows for monitoring raw sensor information included timing synchronization, vessel motion, number of satellites, HDOP, and PDOP. Raw attitude and nadir depth were also recorded in HYPACK RAW format, as a supplementary backup. Multibeam snippets were logged in Hypack 7K format.

The HYPACK acquisition station operator monitored and tuned the multibeam sonar, tracked vessel navigation, and maintained the digital line log. Operators monitored primary and secondary navigation systems to verify quality position data were acquired at all times.

B2. Methodology Used to Maintain Data Integrity

The acquisition systems and survey protocols were designed with some redundancy to demonstrate that the required accuracy was being achieved during the survey and provide a backup to the primary systems. Data integrity was monitored throughout the survey through system comparisons. Two positioning systems were used to provide real-time monitoring of position data. Position confidence checks, multibeam bar checks, and sound speed comparison checks were conducted regularly to confirm required accuracy was being maintained. Regular comparison checks were performed by comparing profiles from the primary and secondary sound speed sensors that were acquired concurrently. Sound speed profiles were computed for each of the sensors and compared to confirm instrumentation was functioning within required tolerances.

A flow diagram of the data acquisition and processing pipeline is presented in Figure 3. This diagram graphically illustrates the data pipeline and processing workflow from acquisition to delivery.

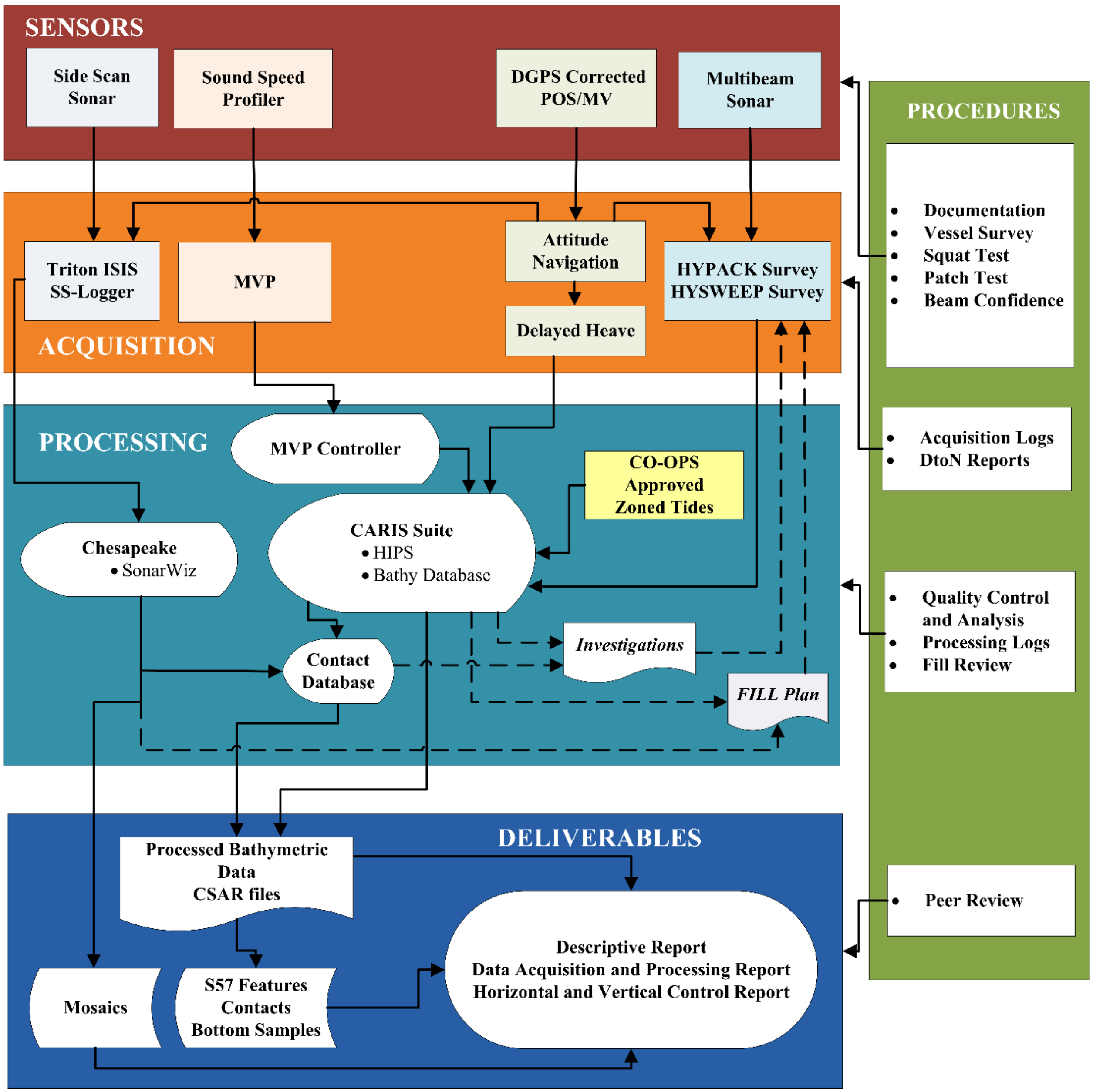

Figure 3. Flowchart of Data Acquisition and Processing Pipeline

B2.a HIPS Conversion

Multibeam data were converted from RAW and HSX format to CARIS HDCS format using the HYPACK conversion wizard. HIPS ground coordinates (UTM NAD 83 Zone 16N) were selected in the Conversion Wizard dialogue.

When converting multibeam data, the device numbers fields were left blank since there were no duplicate sensors logged in the HSX files. No data were rejected based on quality flags during conversion.

The CARIS output window was reviewed for failures during conversion.

B2.b Vessel Files

The HIPS vessel file listed in Table 4 contains all offsets and system biases for the survey vessel and its systems, as well as error estimates for latency, sensor offset measurements, attitude and navigation measurements, and draft measurements.

Table 4. HIPS Vessel Files

HIPS Vessel File	HIPS Converter
OPR-J311-KR-16_MBES_BL	Hypack 9.1.5.0 Hypack 9.1.6.0 *Installed 8/20/2016*

Sensor offsets for the S/V *Blake* were calculated from the vessel survey and dynamic draft values were calculated through the use of post-processed GPS observations. Draft (water line) was measured and entered daily from draft sight tubes located in the port and starboard sponsons abeam of the multibeam sonar and vessel reference point. Draft changes, relative to the vessel reference point, were entered into the multibeam vessel configuration file. These corrections are listed in tabular and graphical format in Appendix I *Vessel Reports*.

Best estimates for Total Propagated Uncertainty (TPU) values were entered into the vessel files based on current knowledge of the TPU/CUBE processing model. The manufacturers' published values were entered into the static sensor accuracy fields. Other values were either calculated or estimated.

Navigation and transducer separation distances from the motion sensor were computed relative to the phase center, vice the top hat, of the motion sensor; therefore, the vessel file standard deviation offsets will not exactly match the sensor offset values. TPU values for the S/V *Blake* are listed in Table 5.

Table 5. Hydrographic Vessel File TPU Values

Input Values for Total Propagation Uncertainty Computation HIPS Vessel File (HVF)*		
		S/V Blake
Motion Sensor		POS/MV
Position System 1		POS/MV Model 320 V 5
Position System 2		SPS351
Gyro – Heading		
	Gyro (°)	0.020
Heave		
	Heave % Amplitude	5.000
	Heave (m)	0.050
Roll and Pitch		
	Roll (°)	0.020
	Pitch (°)	0.020
Navigation		
	Position Navigation (m)	1.000
Latency		
	Timing Trans (s)	0.005
	Nav Timing (s)	0.005
	Gyro Timing (s)	0.005
	Heave Timing (s)	0.005
	Pitch Timing (s)	0.005
	Roll Timing (s)	0.005
Measurement		
	Offset X (m)	0.030
	Offset Y (m)	0.030
	Offset Z (m)	0.030
Speed		
	Vessel Speed (m/s)	0.030
Draft and Loading		
	Loading	0.037
	Draft (m)	0.010
	Delta Draft (m)	0.016
Physical Alignment Errors*		
Alignment		
	MRU align Stdev gyro	0.039
	MRU align roll/pitch	0.080
*All values given as 1 sigma.		

Sonar uncertainty, which was logged to the Hypack HSX file for each sounding, was read into CARIS HIPS at time of conversion. Real-time delayed heave uncertainty was loaded into HIPS along with the delayed heave signal. These real-time uncertainty values were applied when TPU was computed.

A tide uncertainty consisting of both measurement and zoning errors was provided in the OPR-J311-KR-16 *Tides and Water Levels Statement of Work.* Tide uncertainty values provided by NOAA were at the 95% confidence interval. The total tide uncertainty was entered in the HIPS Tide Value Zoning field during TPU computation at 1-sigma. Sound speed and tide TPU values are listed in Table 6.

Table 6. TPU Values for Tide and Sound Speed

Total Propagation Uncertainty Computation in CARIS HIPS	
Tide Values	**1-Sigma Uncertainty (m)**
Tide Value Measured	0.000
Tide Value Zoning	0.112
Sound Speed Values	**1-Sigma Uncertainty (m/s)**
Sound Speed Measured	1.00
Surface Sound Speed	0.50

B2.c Static Draft

The S/V *Blake* was built with draft dampening tubes in each hull providing a means to monitor vessel static draft. Static draft readings from the port and starboard side draft sight tubes were recorded and averaged every 12 hours during 24-hour operations, when sea conditions permitted.

The average draft value best approximates the true draft value at the vessel reference point during acquisition due to loading changes from fuel consumption during transit to and from the survey area, at the start and end of each day, or from ballast changes due to water consumption. Ultimately, the daily and 12-hour draft values were used to calculate draft relative the HIPS reference point which was entered into the “Waterline Height” field in the CARIS HVF files.

B2.d Sound Speed

Sound speed profiles were applied to each line using the nearest in distance within time (one hour) option in the CARIS Sound Velocity Profiler (SVP) correct routine. During acquisition, profiles were taken at frequent intervals through the use of the MVP30-350. Final sound speed correctors were computed from the up cast portion of each profile.

B3. Bathymetric Data Processing

Multibeam data processing followed the standard HIPS workflow for CUBE editing by primarily using the Hypothesis count layer to direct necessary edits to the multibeam data.

Below is the list of correctors and filters applied to the bathymetric data in HIPS. Several of the steps are interim processes (such as the water levels) and were re-applied as needed. The TPU was re-computed for the multibeam data as needed to reflect changes in the correctors.

- Convert data from Hypack HSX

- Import Auxiliary data (delayed heave and delayed heave uncertainty)
- Load zoned tide
- Review attitude
- Review navigation
- Apply daily concatenated sound speed profiles
    - "Nearest in distance within time 1 hour"
- Merge
    - "Apply delayed heave"
- Compute TPU via values listed in Tables 5 and 6
- Filter soundings with poor quality flags (0 and 1)
- Data reviewed and fliers removed in Swath Editor and/or Subset Editor
- Create CUBE surface:
    - "CUBE" weighted surface of appropriate resolution for water depth
        - International Hydrographic Organization (IHO) S-44 Order 1a
        - Density & Local Disambiguation method
        - Advanced configuration using the 2015 NOAA field unit parameters of the appropriate resolution surface
- Review CUBE surface and child layers with tiles with reference surface on

One surface was created to correspond to each survey. CUBE surfaces were created over the entire survey area using grid-resolution thresholds and resolution dependent maximum propagation distances for as specified in the NOS HSSD. Surfaces were reviewed for artifacts indicative of systematic errors, data fliers impacting the surface, and for consistency with the grid requirements set in the HSSD.

Node density was evaluated to verify that at least 80% of soundings were populated with at least five soundings. Multibeam investigation coverage was specifically reviewed to confirm that side scan contact and feature development criteria were met.

All of the multibeam data collected were reviewed in HIPS 3D subset editor with the in-house defined shoal biased reference surface active.

Soundings rejected by quality filters were displayed during editing and any feature removed by a filter was manually re-accepted. Fliers making the CUBE surface shoaler than expected by more than the allowable IHO 1a vertical error were rejected. Designated soundings were used as necessary in order to force the finalized depth surface through reliable shoaler soundings. Soundings were designated when the difference between the surface and sounding met the depth based total vertical uncertainty threshold and the sounding was greater than 1 meter proud of the surrounding depths. In addition, data processors reviewed sounding data and CUBE surfaces for excessive motion artifacts or systematic biases. All cross lines were manually reviewed for high internal consistency between the datasets and comparison statistics were also computed using the HIPS QC Report tool.

Contacts exported from the side scan sonar contact database were displayed in the HIPS background as a Drawing Exchange Format (DXF) file and reviewed for multibeam coverage and significance. Designated soundings were created to denote the least depth of each submerged feature included in a survey's Final Feature File.

A large portion of the data processing, QC, and review was performed on the S/V *Blake* during survey acquisition. Dangers to Navigation were reported directly to the DEA project manager via Iridium satellite broadband connection in order to expedite submission to the processing branch. This workflow is shown in Figure 4.

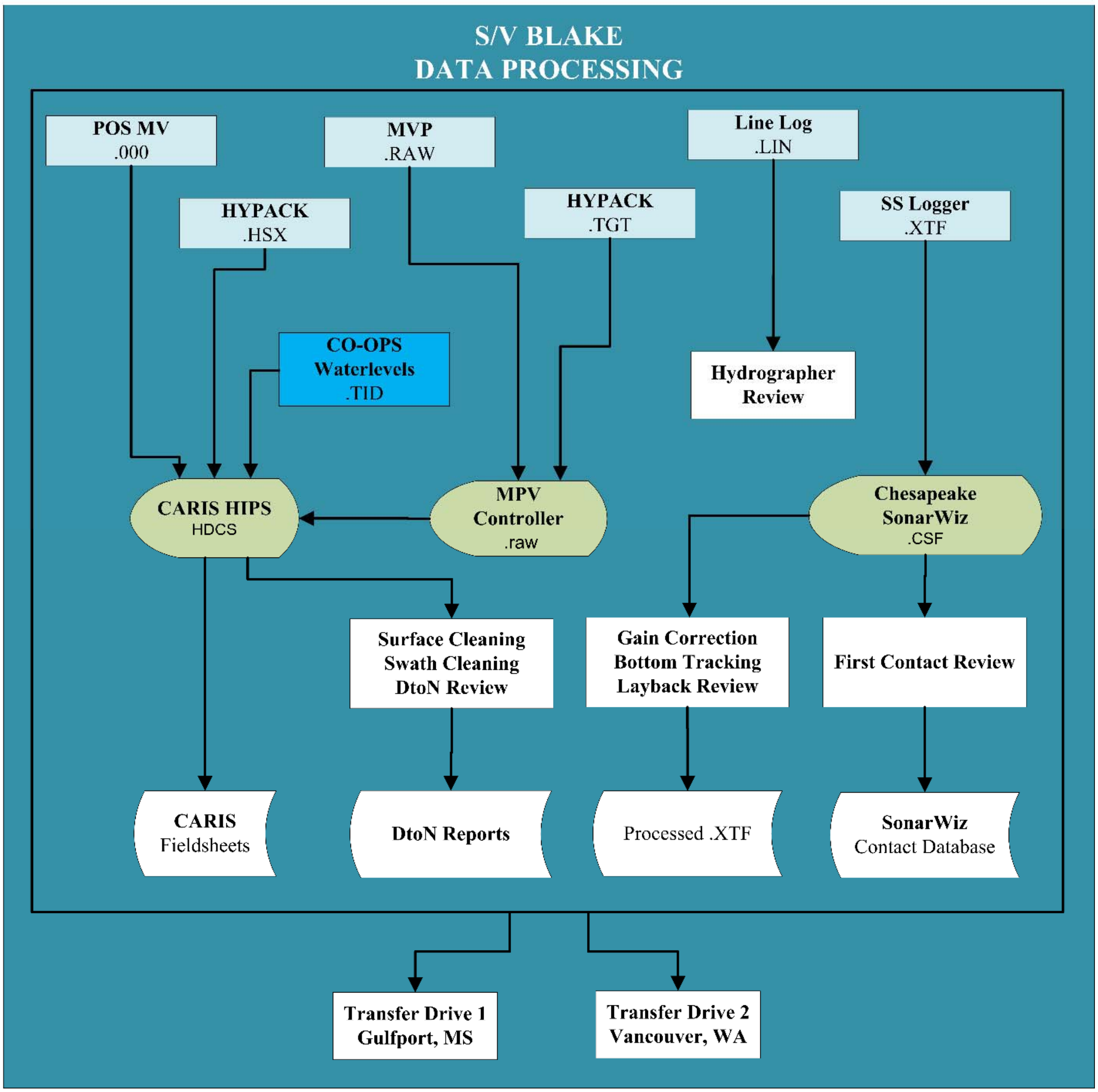

Figure 4. Flowchart of S/V *Blake* Data Processing Pipeline

B4. GPS Post-processing

Applanix POSPac MMS software was used to create a post-processed navigation solution for all patch test lines. The post-processed solution included new position, height, heading, and attitude measurements in Smoothed Best Estimate of Trajectory (SBET) format. The SBET file was applied to the patch test data using the HIPS Import Auxiliary Data tool during patch test processing and analysis.

B5. Final Bathymetric Processing

Upon the completion of editing multibeam data in HIPS, finalized CUBE grids were generated using the "greater of the two" option for the final uncertainty value. Selected soundings and contours were generated from the surfaces and used for chart comparison purposes, but are not included with the deliverables.

Designated soundings were used as a starting point for S-57 feature creation. Designated soundings that were determined to be obstructions, rocks, wrecks, or other significant features were imported into the S-57 feature files and attributed. S-57 objects were created for all new and incorrectly charted baring features.

All features were created using the NOAA Profile object catalogue version 5.3.4 which references the NOAA Extended Attributes defined in the NOS HSSD. All mandatory feature attributes have been populated. In addition, the images attribute has been used to provide multibeam and side scan screen shots of features.

B6. Side Scan Processing

After acquisition the XTF files were imported into Chesapeake Technologies Inc. (CTI) SonarWiz and gain corrected. The side scan bottom track was then reviewed and losses of bottom or incorrect bottom track areas were re-digitized. Altitude, tow point offset, and cable-out were applied. The processed lines then underwent two independent reviews to identify significant contacts. In most cases, side scan contacts were determined to be significant if the measured height was within 25 centimeters of the 1 meter height requirement to allow for contact measurement error. Contacts were also created on objects with minimal shadow heights in areas deemed to be critical to navigation or if they appeared to be mounds or other geologic structures which cast little or no shadow.

Sonar contacts were processed using CTI SonarWiz software. Management of side scan sonar contacts was accomplished by utilizing an in-house utility created for contact tracking and meeting the requirements of the HSSD. The database was maintained and stored in Microsoft Access using the .MDB file format. Contacts were added into the database on a daily basis upon completion of the side scan review and contact identification. The use of the .MDB format allowed direct geographic display of contacts and spatial queries within ESRI ArcGIS, where contacts were correlated and compared to the chart and other survey data.

Side scan mosaics were created using CTI SonarWiz. Georeferenced mosaics were generated in Tagged Image File Format (TIF) with an associated world file (TWF) at 1 meter.

C. CORRECTIONS TO ECHO SOUNDINGS

C1. Static Draft

A detailed description of the static draft corrections can be found in section B2.c of this report. The daily and 12-hour draft values were used to calculate draft relative to the HIPS reference point which was entered into the "Waterline Height" field in the CARIS HVF files.

C2. Dynamic Draft

A settlement and squat test for the S/V *Blake* using post-processed GPS height observations was performed near Gulfport, MS on November 14, 2014. Values from this test were confirmed with a squat confirmation test prior to the survey. Dynamic draft values from the 2014 squat test were used in the survey's HVF and are included in Appendix I *Vessel Reports*.

The settlement and squat values were obtained by computing an average of GPS height values at different ship speeds, measured in knots and revolutions per minute (RPM). Transects were run twice at each RPM interval along opposing headings. With the vessel at rest, static GPS height observations were recorded between each RPM interval, in order to obtain a baseline GPS height value not affected by tide changes during the test. These values were linearly interpolated to determine the baseline GPS height at the time of the dynamic draft measurement. The difference between the GPS height while the vessel was in motion and the interpolated static GPS height was used to calculate the dynamic draft for each transect. An average dynamic draft corrector was then calculated from the average of the two values for each RPM interval. The average speed for each RPM interval and the average dynamic draft corrector were entered into the HIPS vessel file. Uncertainty estimates for dynamic draft were calculated by taking the average of the standard deviation for all dynamic draft calculations per transect.

C3. Bar Check Comparisons

Weekly bar checks were performed to confirm that the multibeam sonar was functioning properly and static draft was accurately documented. A Ross Laboratories Inc. Model 5150 lead target ball attached to the end of a wire cable and chain, marked at 3 meters, was used to bar check the multibeam on the S/V *Blake*. The 3-meter marks were checked periodically with a measuring tape. The individual bar check device was lowered to 3 meters depth below the water surface, a point above the natural bottom, where it could be clearly ensonified. The depth of the bar was compared to the depth of the bar reported by the sonars. Observations were recorded in a comparison log. Tabulated bar check comparisons may be found in the Weekly Bar Check logs included in Appendix II *Echosounder Reports*.

C4. Heave, Roll, and Pitch Corrections

An Applanix POS/MV 320 V5 integrated dual frequency GPS and inertial reference system was used for the motion sensor for this survey. The POS/MV 320 is a 6-degree of freedom motion unit, with a stated accuracy of 0.05 meters or 5% for heave, 0.02 degrees for roll, pitch, and heading. Real-time displays of the vessel motion accuracy were monitored throughout the survey with the MV-POSView controller program. If any of the vessel motion accuracy degraded to greater than 0.05 degrees root mean square (RMS), survey operations would be suspended until the inertial unit was able to regain the higher degree of accuracy. Manufacturer reported accuracies, as published on the CARIS HIPS TPU website (http://www.caris.com/tpu/), were entered into the HVF and used for TPU computations for multibeam data acquired by the S/V *Blake*. Schematics of the vessel and sensor set-up for the S/V *Blake* are located in Appendix I *Vessel Reports*.

C5. Patch Tests

Multibeam patch tests were conducted for the S/V *Blake* to measure alignment offsets between the IMU sensor and the multibeam transducer and to determine time delays between the time-tagged sensor data. Multiple patch tests were performed throughout the project to verify the adequacy of the system biases. Patch tests were performed periodically throughout the project including at the beginning of the project, after any system replacement, and at the end of the project. Each patch test consisted of a series of lines run in a specific pattern, which were then used in pairs to analyze roll, pitch, and heading alignment bias angles.

A precise timing latency test was performed by running a single line over a flat bottom with induced vessel motion. The line was then opened in the HIPS calibration editor (after applying tide and SVP corrections) and a small along-track slice of data was evaluated in the outer swath of the line for motion artifacts. Incremental changes to the roll time offset were made to evaluate the performance of the precise timing setup and to determine if a latency correction was needed.

Roll alignment was determined by evaluating the reciprocal lines run over a flat bottom used for the latency test. The pitch tests consisted of set of reciprocal lines located on a steep slope or over a submerged feature. The yaw error was determined by running parallel lines over the same area as the pitch tests. All lines were run at approximately 3 knots to 6 knots. Patch tests were run in Mississippi Sound near Gulfport, MS. Selected pairs of lines were then analyzed in HIPS Calibration editor to measure the angular sensor bias values. Visual inspection of the data confirmed each adjustment.

All patch test data were processed using post processed Applanix POSPac MMS SBET positions.

Sonar offsets and alignment angles computed during patch tests were entered into the HVF. Sonar roll and pitch values were entered in HVF SVP1 field rather than the Swath1 field in order for the HIPS Sound Velocity correction to work correctly. Daily roll test lines were acquired to monitor the stability of the multibeam sonar’s pole mount. Roll values from these test were included alongside the values from standard patch test in order to account for minor variations in roll.

Uncertainty estimates for the MRU alignment for gyro, pitch, and roll were calculated by taking the average of the standard deviation on multiple iterations of patch test lines.

C6. Tide and Water Level Corrections

The primary water level stations used for the surveys were Dauphin Island, Alabama (8735180) and Pascagoula, Mississippi (8741533).

NOAA HSD provided the HIPS Zone Definition File (ZDF) J311KR2016RevCORP.zdf which was used to apply zoned tides to the bathymetric data. The primary water level stations experienced no down time during periods of hydrographic survey up to the delivery of this report.

C7. Sound Velocity Correction

During data acquisition, the MVP30-350 was deployed as needed to obtain an adequate number of sound velocity profiles to properly correct the multibeam data during data processing. Casts were taken at approximately 15-minute intervals. The location of casts along the survey track lines were varied to ensure adequate spatial coverage. If significant cast-to-cast variability was observed, the time between casts was decreased. Casts extended to at least 80% of water depth, with at least one deep cast (extending to 95% of depth) taken per day.

Checks were completed to verify pressure sensor and sound speed instrument performance. Corrections for the speed of sound through the water column were computed for each sensor. Sound speed profiles were imported and overlaid for comparison into an Excel file. All comparisons were well within survey specification. Sound speed check results are included in Separate II *Sound Speed Data Summary* of the Descriptive Reports.

The sound speed correction was applied to each line using the nearest in distance within time (one hour) option in the HIPS SVP correct routine. All casts were concatenated into a HIPS SVP file for each survey day. Time, position, depth, and sound speed for each profile were included in the HIPS file.

D. APPROVAL SHEET

The letter of approval for this report follows on the next page.

DAVID EVANS AND ASSOCIATES INC.

LETTER OF APPROVAL

OPR-J311-KR-16
DATA ACQUISITION AND PROCESSING REPORT

This report and the accompanying data are respectfully submitted.

Field operations contributing to the accomplishment of OPR-J311-KR-16 were conducted under my direct supervision with frequent personal checks of progress and adequacy. This report and associated data have been closely reviewed and are considered complete and adequate as per the OPR-J311-KR-16 *Statement of Work* (July 7, 2016) and *Hydrographic Survey Project Instructions* (July 15, 2016).

Digitally signed by Jon Dasler
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Date: 2016.10.10 14:06:48 -07'00'

Jonathan L. Dasler, PE, PLS, CH
NSPS/THSOA Certified Hydrographer
Chief of Party

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Charting Manager/Project Manager

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Tim McClinton, Ph.D.
Gulf Coast Operations Manager

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Kathleen Schacht
MBES Data Processing Manager

David Evans and Associates, Inc.
August 2016

E. TABLE OF ACRONYMS

AML	Applied Microsystems, Ltd
CTD	Conductivity, Temperature, Depth
CTI	Chesapeake Technologies, Inc.
CUBE	Combined Uncertainty and Bathymetry Estimator
DEA	David Evans and Associates, Inc.
DGPS	Differential Global Positioning System
DXF	Drawing Exchange Format
GPS	Global Positioning System
HIPS	Hydrographic Information Processing System
HSD	Hydrographic Surveys Division
HSSD	Hydrographic Survey Specifications and Deliverables
HSX	Hypack Hysweep File Format
HVF	HIPS Vessel File
IHO	International Hydrographic Organization
IMU	Inertial Motion Unit
MBES	Multibeam Echo Sounder
MP	Multi Pulse
MVP	Moving Vessel Profiler
NAS	Network Attached Storage
NMEA	National Marine Electronics Association
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
POS/MV	Position and Orientation System for Marine Vessels
PPS	Pulse per Second
PRF	Project Reference File
RMS	Root Mean Square
RPM	Revolutions per Minute
SBET	Smoothed Best Estimate of Trajectory
S/V	Survey Vessel
SVP	Sound Velocity Profiler
TIF	Tagged Image File Format
TPU	Total Propagated Uncertainty
TWF	World File
USCG	United States Coast Guard
UTC	Universal Time Coordinated
XTF	Extended Triton Format
ZDA	Global Positioning System Timing Message
ZDF	Zone Definition File