U.S. DEPARTMENT OF COMMERCE

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

NATIONAL OCEAN SERVICE

DATA ACQUISITION AND PROCESSING REPORT

Type of Survey	**Hydrographic**
Project	**OPR-K370-KR-15**
Contract No	**EA-133C-14-CQ-0031**
Task Order No	**T0003**
Time Frame	**June 2015 - December 2015**

State	**Texas**
General Locality	**Port Mansfield, TX**

2015

CHIEF OF PARTY

David R. Neff, C.H.

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Date

NOAA FORM 77-28 (11-72)

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

HYDROGRAPHIC TITLE SHEET

REGISTRY No
H12761
H12762
H12763
H12764
H12765

INSTRUCTIONS - The Hydrographic Sheet should be accompanied by this form, filled in as completely as possible, when the sheet is forwarded to the office.

FIELD No
eTrac Inc.

State	Texas		
General Locality	Port Mansfield, TX		
Sub-Locality	Approaches to Port Mansfield, TX		
Scale	1:40,000	Date of Survey	June 5 to August 12, 2015
Instructions Dated	June 23, 2015	Project No.	OPR-K370-KR-15
Vessel	M/V Jab, R/V Benthos, R/V Taku		
Chief of Party	David R. Neff, C.H.		
Surveyed by	eTrac Inc.		
Soundings by echo sounder	R2 Sonic 2024		
Graphic record scaled by	N/A		
Graphic record checked by	N/A	Automated Plot	N/A
Verification by	Atlantic Hydrographic Branch		
Soundings in	Meters at MLLW		

REMARKS:

NAD 83, UTM Zone 14, Times are in UTC
The purpose of this contract is to provide NOAA with modern, accurate hydrographic survey data with which to update the nautical charts of the assigned area.

SUBCONSULTANTS:

Geodynamics, LLC, 310A Greenfield Drive, Newport, NC 28570
Theory Marine, LLC, 777 Viewcrest Drive, Ventura, CA 93003

NOAA FORM 77-28 SUPERSEDES FORM C&GS-537

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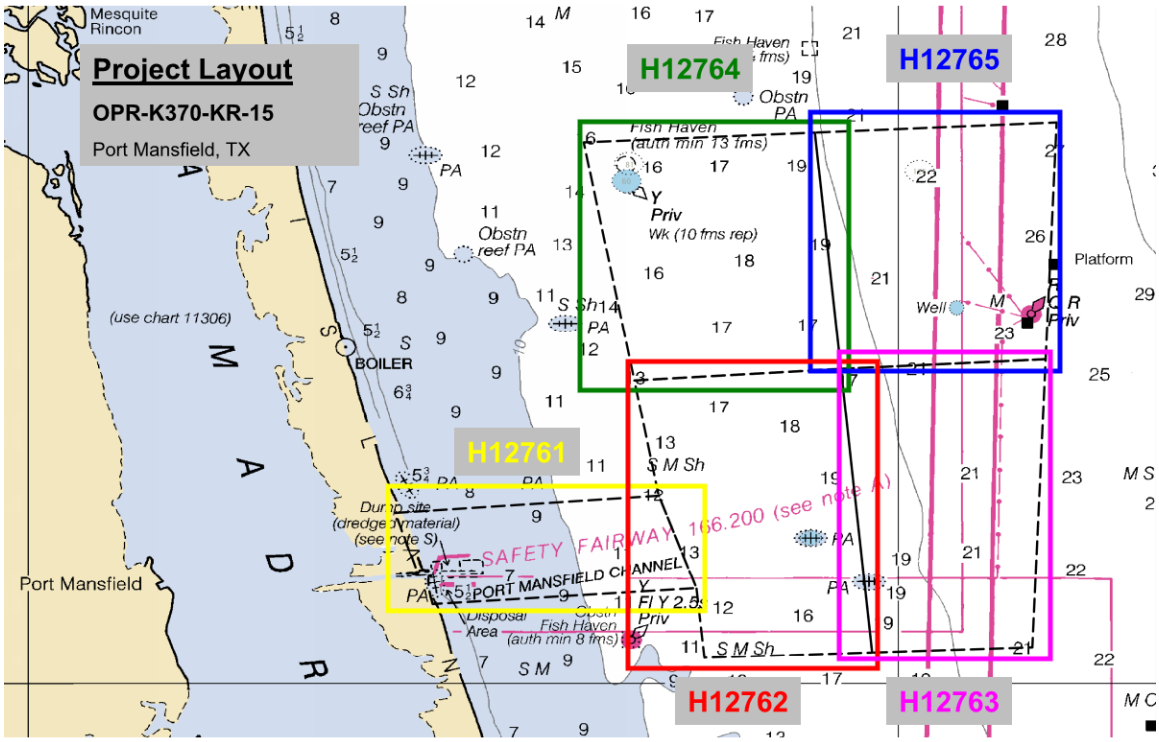


Figure 1: OPR-K370-KR-15 (North Up)

A. EQUIPMENT

A.1. Vessels

A.1.1. M/V Jab

eTrac Inc. leased the M/V Jab for hydrographic survey operations on OPR-K370-KR-15. The M/V Jab is a 44 foot Catamaran built by Armstrong Marine (2010). The M/V Jab has the following specifications:

Overall Length:	44 Ft.
Beam:	15.5 Ft.
Draft:	2.5 Ft.
Moonpool:	42"L x 25"W with lifting and mounting mechanism for MBES
Propulsion:	Twin Cummins QSC 8.3 Liter 500HP Diesel Engines
Drives:	Hamilton 322 Jet Drives
Fuel Capacity:	600 Gal Diesel
Winches:	Sidescan winch with cable, SVP winch with Spectra line
Generator:	8KW Westerbeke Marine Generator 50AMP
Bridge Equipment:	Furuno Radar/Chartplotter/Echosounder, DGPS, AIS, VHF

Figure 2: M/V Jab

A full static vessel survey of the M/V Jab was performed on January 13th, 2015 directly before the mobilization of OPR-J357-KR-14. A series of previously established punch marks were surveyed using a Trimble 5000 precision robotic total station. The static survey data were used to establish a fixed vessel reference frame, vessel reference point, sensor mounting locations, and draft reference measurement points.

Table 1: M/V Jab Hardware

Instrument	Function	Manufacturer	Model	Serial Number	Function
Side Scan Sonar					
Deck Unit	Imagery	EdgeTech	701-DL	50128	Used 6/1 - 8/11
Towfish	Imagery	EdgeTech	4200 MP	39893	Used 6/1 - 8/11
Side Scan Sonar Hardware					
Cable Counter	SSS Positioning	Hydrographic Survey Products	Smart Sensor Display v3	N/A	
Sheave	SSS Positioning	Cambell Specialty CO	N/A	N/A	
Winch	SSS Towing	Kinematics	Twister	N/A	
Slip Ring	Imagery	IEC Corp.	BXSN-2-MS2-2FT	33332-0215	Primary
Slip Ring	Imagery	IEC Corp.	BXAN-2-MS2-2FT	33331-0215	Spare
Bottom Sampler					
Stainless Steel Grab	Bottom Sampler	WILDCO	Standard Ponar	N/A	Used 7/13
Stainless Steel Grab	Bottom Sampler	WILDCO	Petite Ponar	N/A	Used 7/13 - 8/12
Multibeam Echosounder					
Deck Unit	Bathymetry	R2Sonic	2024	103757	Used 6/1 - 8/12
Receiver	Bathymetry	R2Sonic	2024	806376	Used 6/1 - 8/12
Projector	Bathymetry	R2Sonic	2024	101004	Used 6/1 - 8/12
Sound Speed					
Surface Sound Speed	Bathymetry	Valeport	miniSVS	39252	Beam formation and steering
Sound Speed Profiler	Bathymetry	AML	Base.X	25004	Secondary SV profiler
SV sensor	Bathymetry	AML	SV.Xchange	204672	Removable SV sensor on Base.X
Pressure sensor	Bathymetry	AML	P.Xchange	304098	Removable Pressure Sensor on Base.X
Sound Speed Profiler	Bathymetry	AML	Minos.X	8487	Primary SV profiler
SV sensor	Bathymetry	AML	SV.Xchange	204646	Removable SV sensor on Minos.X
Pressure sensor	Bathymetry	AML	P.Xchange	300250	Removable Pressure Sensor on Minos.X
Navigation					
Deck Unit	Position/Attitude/ Heading	Applanix	POSMV 320 V5	7035	Integrated Differential Global Positioning System (DGPS) and inertial reference system for position, heading, heave, roll, and pitch data.
IMU	Position/Attitude/ Heading	Applanix	IMU 17	310	
Starboard Antenna	Position/Attitude/ Heading	Trimble	Zephyr model 2	7985	
Port Antenna	Position/Attitude/ Heading	Trimble	Zephyr model 2	7979	
Receiver	DGPS / Secondary Position	Trimble	DSM232	255105428	Differential radio for primary position system.
Antenna	DGPS / Secondary Position	Trimble	Trimble Zephyr GA530	5105	

A.1.2. R/V Benthos

Subcontractor Geodynamics LLC provided the R/V Benthos for hydrographic survey operations on OPR-K370-KR-15. The R/V Benthos is a 34 foot Catamaran built by Armstrong Marine. The R/V Benthos has the following specifications:

Overall Length:	34 Ft.
Beam:	10.5 Ft.
Draft:	2 Ft.
Sonar Mount:	Custom hydraulic pole mount port side
Propulsion:	Twin Yamaha F300 outboard Engines
Drives:	N/A
Fuel Capacity:	248 Gal Gas, 30 Gal Diesel
Winches:	A-Frame hydraulic winch, SVP Downrigger winch, PL2 sidescan winch with Spectra line
Generator:	8KW Westerbeke Marine Generator 50AMP with PTO for hydraulics
Bridge Equipment:	Simrad NSS Radar/Chartplotter/Echosounder, AIS, VHF, Weather

Figure 3: R/V Benthos

A full static vessel survey of the R/V Benthos was performed on January 13th, 2015 directly before the mobilization of OPR-J357-KR-14. A series of previously established punch marks were surveyed using a Trimble 5000 precision robotic total station. The static survey data were used to establish a fixed vessel reference frame, vessel reference point, sensor mounting locations, and draft reference measurement points.

Table 2: R/V Benthos Hardware

Instrument	Function	Manufacturer	Model	Serial Number	Function
Multibeam Echosounder					
Deck Unit	Bathymetry	R2Sonic	2024	100259	Used 6/1 - 8/1
Receiver	Bathymetry	R2Sonic	2024	100392	Used 6/1 - 6/7
Projector	Bathymetry	R2Sonic	2024	8060002	Used 6/1 - 6/7
Receiver	Bathymetry	R2Sonic	2024	101061	Used 6/8 - 8/1
Projector	Bathymetry	R2Sonic	2024	806747	Used 6/8 - 8/1
Deck Unit	Bathymetry	R2Sonic	2024	103575	Used 8/2 - 8/9
Receiver	Bathymetry	R2Sonic	2024	100192	Used 8/2 - 8/9
Projector	Bathymetry	R2Sonic	2024	8000013	Used 8/2 - 8/9
Sound Speed					
Surface Sound Speed	Bathymetry	Valeport	miniSVS	31057	Beam formation and steering
Sound Speed Profiler	Bathymetry	AML	Base.X	25101	Primary SV profiler on Base.X
SV Sensor	Bathymetry	AML	SV.Xchange	200936	Removable SV sensor on Base.X
Pressure Sensor	Bathymetry	AML	P.Xchange	304496	Primary pressure sensor on Base.X
Wifi Data exchanger	Bathymetry	AML	Data.Xchange	70047	Wifi Data exchanger
Navigation					
Deck Unit	Position/Attitude/Heading	Applanix	POSMV 320 V5	6619	Integrated Differential Global Positioning System (DGPS) and inertial reference system for position, heading, heave, roll, and pitch data.
IMU	Position/Attitude/Heading	Applanix	IMU 38	2916	
Starboard Antenna	Position/Attitude/Heading	Trimble	AeroAntenna	7190	
Port Antenna	Position/Attitude/Heading	Trimble	AeroAntenna	7186	
Receiver	DGPS/Secondary Position	Trimble	SPS 461	5432D53008	Differential radio for primary position system.
Antenna	DGPS/Secondary Position	Trimble	Trimble Zephyr GA530	5359	

A.1.3. R/V Taku

eTrac Inc. provided the R/V Taku for hydrographic survey operations on OPR-K370-KR-15. The R/V Taku is a 33 foot Catamaran built by Armstrong Marine. The R/V Taku has the following specifications:

Overall Length:	33 Ft.
Beam:	10.5 Ft.
Draft:	3 Ft.
Sonar Mount:	Universal Sonar Mount (OTS – Starboard Side)
Propulsion:	Twin Honda 225 outboard Engines
Drives:	N/A
Fuel Capacity:	240 Gal Gas, 30 Gal Diesel
Winches:	Kinematics hydraulic winch with cable
Generator:	8KW Westerbeke Marine Generator 50AMP with PTO for hydraulics
Bridge Equipment:	Garmin NSS Radar/Chartplotter/Echosounder, AIS, VHF, Weather

Figure 4: R/V Taku

A full static vessel survey of the R/V Taku was performed on June 1st, 2015 directly before the mobilization of OPR-K370-KR-15. A series of previously established punch marks were surveyed using a Trimble 5000 precision robotic total station. The static survey data were used to establish a fixed vessel reference frame, vessel reference point, sensor mounting locations, and draft reference measurement points.

Table 3: R/V Taku Hardware

Instrument	Function	Manufacturer	Model	Serial Number	Function
Multibeam Echosounder					
Deck Unit	Bathymetry	R2Sonic	2024	103575	Used 6/1 to 8/1
Receiver	Bathymetry	R2Sonic	2024	100192	Used 6/1 to 8/1
Projector	Bathymetry	R2Sonic	2024	8000013	Used 6/1 to 8/1
Sound Speed					
Surface Sound Speed	Bathymetry	Valeport	miniSVS	48352	Beam formation and steering
Sound Speed Profiler	Bathymetry	AML	Base.X	25114	Primary SV profiler on Base.X
SV Sensor	Bathymetry	AML	SV.Xchange	204352	Removable SV sensor on Base.X
Pressure Sensor	Bathymetry	AML	P.Xchange	304564	Primary pressure sensor on Base.X
Navigation					
Deck Unit	Position/Attitude/Heading	Applanix	POSMV 320 V5	7033	Integrated Differential Global Positioning System (DGPS) and inertial reference system for position, heading, heave, roll, and pitch data.
IMU	Position/Attitude/Heading	Applanix	IMU 36	0723	
Starboard Antenna	Position/Attitude/Heading	Trimble	AeroAntenna	0329	
Port Antenna	Position/Attitude/Heading	Trimble	AeroAntenna	0493	
Receiver	DGPS/Secondary Position	Trimble	DSM232	0728	Differential radio for primary position system.
Antenna	DGPS/Secondary Position	Trimble	Trimble Zephyr GA530	0366	

Refer to Appendix I for additional vessel information.

A.2. Sounding Equipment

A.2.1. Multibeam Echosounders

A.2.1.1. R2Sonic 2024 MBES

All vessels were equipped with an R2Sonic 2024 Multibeam Echosounder System (MBES). The 2024 utilizes 256 discretely formed beams over a selectable sector up to 160°. At 400kHz the 2024 focuses an across-track and along-track beamwidth of 0.5° and 1° respectively. The 2024 operates at a maximum ping rate of 60Hz and is designed to comply with IHO standards for depth measurement to a maximum range of 500 meters.

The M/V Jab hosts the R2Sonic 2024 via moonpool installation. The moonpool is located on the vessel centerline aft of COG. Daily deployment of the MBES system consists of lowering the fully assembled mounting system through the moonpool and locking into place with 14 stainless steel bolts to ensure repeatable deployments.

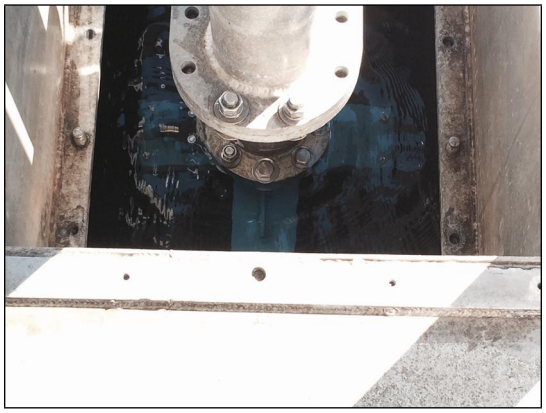


Figure 5: R2Sonic 2024 - M/V Jab - Midway Through Moonpool Deployment

A.2.2. Sidescan Sonar

A.2.2.1. Edgetech 4200 SSS

Sidescan Sonar (SSS) imagery was acquired through the use of an Edgetech 4200 duel frequency towfish operating at 300kHz and 600kHz. The Edgetech 4200 was towed at an altitude between 8% and 20% of the system's range setting at all times during survey acquisition. The Edgetech 4200 SSS system is capable of detecting seafloor objects measuring 1 meter cubed. The system was exclusively mobilized on the M/V Jab and was solely responsible for all SSS data collected on OPR-K370-KR-15. The sidescan system was operated at 25, 35, and 50 meter range scales. The system is comprised of the following components:

- Edgetech 701-DL topside unit
- 10m deck cable

- Hydraulic winch with slip ring
- 100m coaxial armored steel tow cable
- Cable payout Meter with hall effect sensing tow block
- Edgetech 4200 Sidescan Sonar (300kHz/600kHz)

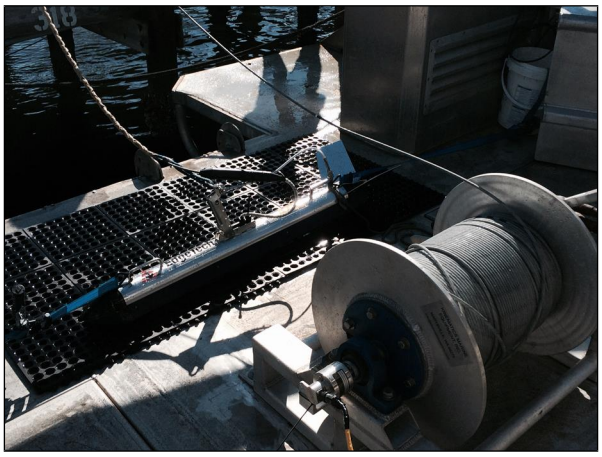


Figure 6: Edgetech 4200 SSS Mobilized on M/V Jab

A.3. Positioning Equipment

A.3.1. Applanix POSMV

M/V Jab, R/V Benthos, and R/V Taku were mobilized with an Applanix POSMV 320 V5 Global Positioning and Inertial Reference System. The POSMV was used to acquire position, attitude, and heading throughout the entire survey. The POSMV is comprised of a rack mount processor, dual GPS antenna baseline, and an inertial motion unit. Position, attitude, and heading data were broadcast to QPS QINSy acquisition software over ethernet/UDP at 50Hz.

The POSMV provided precise timing of sonar instrumentation and acquisition software/hardware through a number of outputs. Timing of the multibeam data was handled at the R2Sonic topside unit. A PPS (Pulse Per Second) via BNC cable connection, as well as a NMEA ZDA message via DB9 serial cable at 1Hz, were sent from the POSMV to the R2Sonic topside unit. The NMEA ZDA 1Hz message was additionally sent to QPS QINSy acquisition software.

A.3.2. DGPS Differential Corrections

A.3.2.1. Trimble SPS461

DGPS corrections on the R/V Benthos were provided by a Trimble SPS461 positioning system receiving corrections from the U.S. Coast Guard beacon located at (Aransas Pass, 304kHz, ID: 816). RTCM corrections were relayed to the POSMV via DB9 serial cable in realtime.

A.3.2.2. Trimble DMS232

DGPS corrections on the R/V Taku and M/V Jab were provided by a Trimble DMS232 positioning system which received corrections from the U.S. Coast Guard beacon located at (Aransas Pass, 304kHz, ID: 816). RTCM corrections were relayed to the POSMV via DB9 serial cable in realtime.

A.3.3. Secondary Positioning System

A.3.3.1. Trimble SPS461

In addition to providing DGPS corrections, the Trimble SPS461 also functioned as the secondary positioning system on the R/V Benthos. As a frequent quality control measure, the differential position derived by the Trimble SPS461 was compared to the position derived by the POSMV. Comparisons between the 2 systems were performed weekly on each vessel in the field and logged per the Hydrographic Survey Specifications and Deliverables 2015 (HSSD 2015).

A.3.3.2. Trimble DMS232

In addition to providing DGPS corrections, the Trimble DMS232 also functioned as the secondary positioning system on the R/V Taku and M/V Jab. As a frequent quality control measure, the differential position derived by the Trimble DSM232 was compared to the position derived by the POSMV. Comparisons between the 2 systems were performed weekly on each vessel in the field and logged per the HSSD 2015.

A.3.4. SSS Cable Out Measurement System

During SSS operations, towfish cable payout was measured with the Hydrographic Survey Products, Inc. SCC Smart Sensor Version 3. The system is comprised of a Campbell Specialty Co. A1418B-RB-UL sheave block fitted with the SCC sensor and 2 magnets. The sheave block is coupled with the SCC display interface. Cable payout messages were sent via DB9 serial cable to the CTI SonarWiz 5 SSS acquisition software for realtime integration into the layback calculation.

A.4. Sound Speed Equipment

All sound speed sensors used on the project were calibrated within 6 months of survey commencement per the HSSD 2015. Manufacturer certified calibration sheets can be referenced in Appendix IV of this document.

A.4.1. Surface Sound Speed Measurement

The R2sonic 2024 utilizes a Valeport miniSVP located at the sonar head for surface sound speed measurement. The Valeport miniSVP is a time of flight SV sensor and is powered through the R2Sonic topside unit via RS232 serial cable connection. Sound speed measurements (measured in meters per second) are output through the same serial connection at 1Hz.

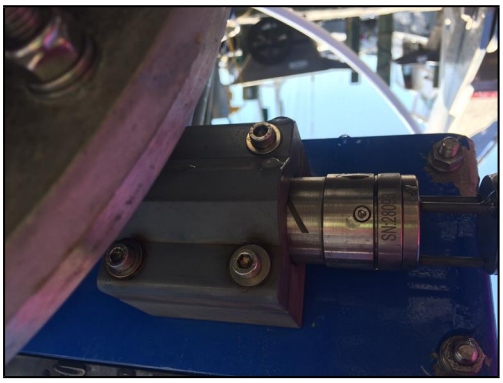


Figure 7: Valeport miniSVP Sensor Mobilized on R2Sonic 2024

A.4.2. Sound Speed Profilers

A.4.2.1. AML Base•X Profiler

The AML Base•X sound speed profiler is a high accuracy time of flight sound speed sensor capable of measuring sound speed in depths up to 1000 meters. The Base•X is capable of transferring data via DB9 serial cable or via WiFi connection when using the Data•X WiFi transfer adapter. AML SeaCast software is run on the acquisition computer to facilitate the data transfer and profile formatting.

A.4.2.2. AML Minos•X Profiler

The AML Minos•X sound speed profiler is a high accuracy time of flight sound speed sensor capable of measuring sound speed in depths up to 1000 meters. The Minos•X is capable of transferring data via DB9 serial cable or via WiFi connection when using the Data•X WiFi transfer adapter. AML SeaCast software is run on the acquisition computer to facilitate the data transfer and profile formatting.

A.4.2.3. AML Data•X WiFi Transfer Adapter

The AML Data•X WiFi Transfer Adapter is a small wireless transmit adapter that connects and remains connected to either the AML Base•X or the AML Minos•X throughout the profiling process. A topside computer running AML SeaCast software hosts a USB WiFi adapter in which the Data•X automatically connects. Once the profile has been taken and the profiler has emerged from the water, the WiFi adapter begins transmitting data. The host computer running the SeaCast software receives the new cast and automatically places it in a predetermined folder.

A.5. Bottom Sample Equipment

A.5.1. Stainless Steel Grab

A.5.1.1. WILDCO Standard Ponar Grab

The WILDCO Standard Ponar Grab is a self closing stainless steal grab sampler. The Standard Ponar Grab sample volume is 8200mL and measures 9”W X 9”L. The system was exclusively mobilized on the M/V Jab, and was used for bottom sample collection on OPR-K370-KR-15.

A.5.1.2. WILDCO Petite Ponar Grab

The WILDCO Petite Ponar Grab is a self closing stainless steal grab sampler. The Petite Ponar Grab sample volume is 2400mL and measures 6”W X 6”L. The system was exclusively mobilized on the M/V Jab, and was used for bottom sample collection on OPR-K370-KR-15.

A.6. Computer Hardware

A.6.1. Acquisition Computer Hardware

Six acquisition computers were mobilized on the project. All acquisition computers were custom built rack mount chassis with identical hardware makeup. Power to all computers was supported through uninterruptible power sources (UPS) to guard against loss of data in the event of an interruption to ships’ power. A table of acquisition computer information is shown below.

Table 4: Acquisition Computer Hardware

Acquisition Computer Hardware					
Name	**Make**	**Processor**	**OS**	**Location**	**Function**
Chewy	Advantech	4 Core i7	Windows 7	M/V Jab	MBES
Lando	Advantech	4 Core i7	Windows 7	M/V Jab	SSS
Yoda	Advantech	4 Core i7	Windows 7	M/V Jab	Spare
Han Solo	Advantech	4 Core i7	Windows 7	R/V Benthos	MBES
Luke	Advantech	4 Core i7	Windows 7	R/V Taku	MBES
Leia	Advantech	4 Core i7	Windows 7	R/V Taku	Spare

A.6.2. Processing Computer Hardware

Processing computers were mobilized in the project field office during the data collection effort. These computers were networked locally to a server hosting a redundant backup raid array. Additionally, project data were synced nightly to an external USB terabyte drive. As a final measure, data were periodically synced to a backup folder at eTrac Inc.’s main office via FTP. Upon completion of the field effort, the same computers were transferred to eTrac Inc.’s main office for use in final data processing. A table of processing computer information is shown below.

Table 5: Processing Computer Hardware

Processing Computer Hardware					
Name	**Make**	**Processor**	**OS**	**Location**	**Function**
Jaba	Dell	4 Core i7	Windows 7	Office	MBES Processing
Boba	Dell	4 Core i7	Windows 7	Office	MBES/SSS Processing
Greedo	Dell	4 Core i7	Windows 7	Office	MBES Processing
Greivous	Dell	4 Core i7	Windows 7	Office	MBES Processing
Vader	Dell	4 Core i7	Windows 7	Office	MBES Processing
Dooku	Dell	4 Core i7	Windows 7	Office	MBES Processing
Deathstar	Dell	4 Core i7	Windows 7	Office	Data Server

A.7. Computer Software

A.7.1. Acquisition Software

Table 6: Acquisition Software

Acquisition Software			
Manufacturer	Name	Version	Installation Date
QPS	QINSy	8.10	7/1/2014
R2Sonic, LLC	R2Sonic 2024	6/27/2014	6/27/2014
R2Sonic, LLC	R2Sonic 2024 Firmware (SIM)	2/6/2014	2/6/2014
AML Oceanographic	Seacast	4.1.0	5/1/2015
Applanix	MV-POSView	8.32	5/1/2015
Applanix	PosMV 320 Firmware	1.4-12	5/1/2015
Chesapeake Technology, Inc.	SonarWiz5	V5.07.0012	10/24/2014
Edgetech	Edgetech Discover	4200	1/10/2015
Trimble	Trimble SPS Controller	SPS461	1/10/2015
Trimble	Trimble DMS Controller	DSM1.0.3	5/1/2015
Microsoft	Microsoft Excel	2003	5/1/2015
Google	Google Drive		
eTrac Inc.	FleeTrac	1.0	12/29/2014

A.7.1.1. QPS QINSy

QPS QINSy was used as the main data collection and line tracking software. The following realtime data inputs were combined and recorded into raw XTF data files in QINSy:

- Applanix POSMV Ethernet Packets (50Hz)

- R2Sonic Ethernet Packets
- NMEA ZDA Message (1Hz)

Dual 27" monitors display a number of realtime data quality and coverage monitoring windows available through QINSy. The following display windows were monitored by the hydrographer during data collection:

- **Coverage Display** (Shows realtime depth colored coverage grid)
- **QC Display** (Shows realtime coverage grid colored by standard deviation)
- **Alerts** (Monitors systems throughout data collection and alerts the hydrographer in the event of data loss)
- **Precise Timing** (Displays precise timing data to ensure no latency in recorded data)
- **Survey Metrics** (Displays various realtime metrics of the survey including speed, distance to go, time to go, current line name, and logging status)

A.7.1.2. R2Sonic (Sonic Controller)

The R2Sonic Sonic Controller was utilized to control the R2Sonic 2024. Realtime sonar data was viewed within the controller. Sonar settings are controlled through the Sonic Controller. Roll stabilization of the sonar data viewed in the Sonic Controller is achieved through a serial connection accepting binary motion data from the POSMV at 200Hz.

A.7.1.3. AML SeaCast

AML SeaCast software was run on the data collection computers for configuring and transferring data from the AML Base•X and Minos•X probes. Cast data were downloaded directly after each cast and saved on the data collection computer.

A.7.1.4. Applanix POSView

Applanix POSView controller software was utilized to configure, monitor, and record the data provided by the POSMV inertial aided GNSS navigation system. System status was monitored realtime throughout data collection. Alerts were configured to display when accuracies dropped below acceptable values, which alerted the hydrographer to the degradation of various accuracies including position, heading, attitude, and heave.

A.7.1.5. Chesapeake Technology, Inc. SonarWiz 5

Chesapeake Technology, Inc. SonarWiz 5 was utilized to configure, display, and record sidescan sonar (SSS) imagery from the Edgetech 4200 towfish. A number of inputs were configured in CTI SonarWiz 5 including navigation and timing data from the POSMV, depth information from the towfish pressure sensor, and cable out measurement from the cable counter.

CTI SonarWiz 5 was configured to display both the High (600kHz) and the Low (300kHz) frequencies of the Edgetech 4200 sidescan sonar system. Both frequencies were displayed in their own slant range corrected waterfalls. Waterfalls were monitored

realtime for data quality and target detection. When an object was observed in the sidescan waterfall, a target would be taken in CTI SonarWiz 5 and given a unique NOAA format ID. A note including the unique ID and the hydrographers' field description/determination would be made in the digital field log.

A.7.1.6. Edgetech Discover

Edgetech Discover was configured to operate as a data pass-through between the 4200 towfish and CTI SonarWiz 5. Uncorrected data were displayed and monitored in a waterfall format.

A.7.1.7. Trimble SPS Controller

The Trimble SPS Controller was utilized during project mobilization to configure the Trimble SPS461 DGPS receiver to send differential corrections to the POSMV, as well as to operate as a stand alone secondary positioning system.

A.7.1.8. Trimble DMS Controller

The Trimble DMS Controller was utilized during project mobilization to configure the Trimble DMS232 DGPS receiver to send differential corrections to the POSMV, as well as to operate as a stand alone secondary positioning system.

A.7.1.9. Microsoft Excel

Microsoft Excel was utilized during data collection as the host software of the digital field log. Log entries were time tagged at time of entry per statement. Every aspect of field data collection is logged in the digital field log in order to maintain a historical log of daily operations, as well as aid the processing office.

A.7.1.10. Google Drive

Google Drive is an online cloud based data hosting environment. Google Drive was utilized in order to maintain spreadsheets and reporting items such as weekly checks and project tracking materials.

A.7.1.11. FleeTrac

FleeTrac is a web based tracking application developed by eTrac Inc. for realtime tracking of survey operations. Pinpoint vessel location and metrics are logged within the eTrac Inc. tracking box. Tracked metrics including time, location, speed, and heading information are broadcast via internet connection to the eTrac Inc. cloud. FleeTrac accesses the cloud and displays the vessel information and tracklines in an online map environment. The system operates in realtime, as long as the vessel is in cellular range. For periods when the vessel is outside of cellular range, the tracking data is logged and stored within the eTrac Inc. tracking box. Upon re-entering cellular range, logged tracking data is updated in the cloud and FleeTrac displays the updated tracklines.

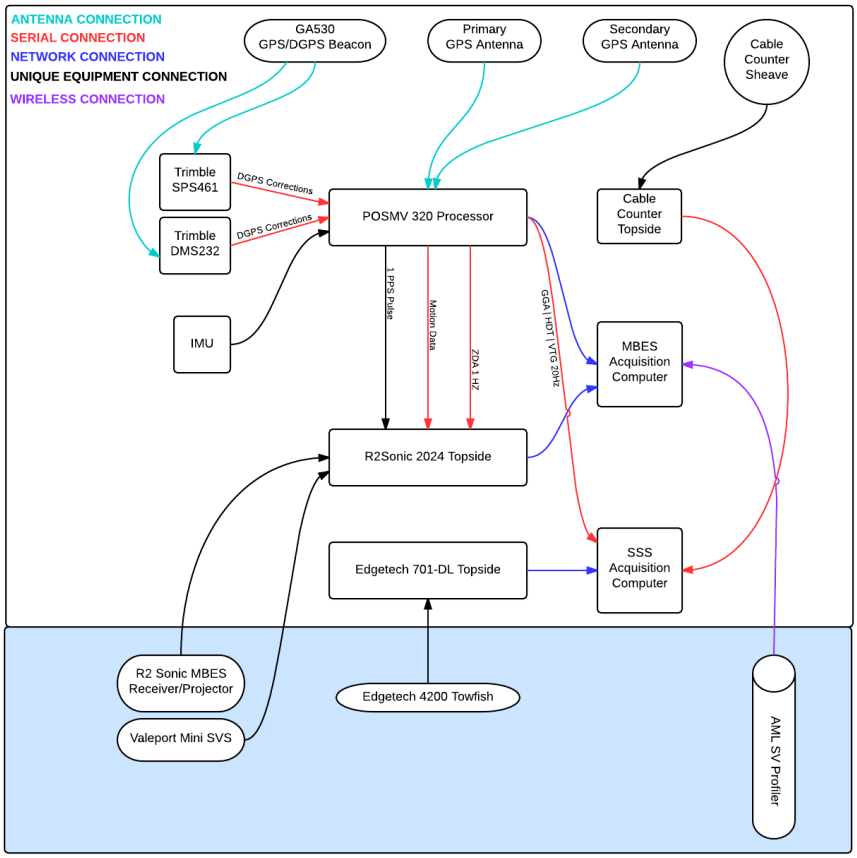


Figure 8: Acquisition Systems Diagram

A.7.2. Processing Software

Table 7: Processing Software

Processing Software			
Manufacturer	Name	Version	Installation Date
Caris	HIPS	9.0.13	6/1/2015
Caris	HIPS	9.0.14	6/2/2015
Caris	HIPS	9.0.15	7/3/2015
Caris	HIPS	9.0.16	7/29/2015
Chesapeake Technology, Inc.	SonarWiz5	V5.07.0012	10/24/2014
Applanix	POSPac MMS	6.2	10/24/2014
Google	Google Drive		
eTrac Inc.	XML DR	1.0	4/15/2015
eTrac Inc.	Density Trac	1.0	3/1/2015
eTrac Inc.	SVPTrac	1.0	2/2/2015
eTrac Inc.	FlierTrac	1.0	10/14/2015

A.7.2.1. Caris HIPS and SIPS 9.0

Caris HIPS and SIPS 9.0 is a bathymetric processing and analysis program. HIPS and SIPS 9.0 was utilized in the processing workflow as the exclusive MBES processing software. MBES data were converted from XTF format to HDCS format, and processed within Caris HIPS and SIPS 9.0.

In addition to MBES processing procedures, Caris HIPS and SIPS 9.0 was utilized to create, maintain, and deliver an S-57 feature file of navigationally significant objects identified from the MBES data. In addition to new features, existing assigned features were included in the S-57 Final Feature File (FFF) with updated charting recommendations.

A.7.2.2. Applanix POSPac MMS

Applanix POSPac MMS is a position post-processing software package designed for use with trajectory data collected by the Applanix POSMV systems. POSPac MMS was utilized in the data pipeline only during mobilization and calibration procedures. Specifically POSPac MMS was utilized to create Smooth Best Estimate of Trajectory (SBET) from position data collected during Squat Testing and Patch Testing procedures. Using trajectory data logged from the POSMV, along with reference station data logged from a temporary local GPS base station that was established by eTrac Inc. only for use during mobilization of OPR-K370-KR-15, SBET's were created and applied in Caris HIPS and SIPS 9.0.

A.7.2.3. Chesapeake Technology, Inc. SonarWiz 5

Chesapeake Technology, Inc. SonarWiz 5 is a sidescan sonar (SSS) acquisition and post-processing package. CTI SonarWiz 5 was utilized in the office to review logged SSS data, generate targets, attribute targets with measurements (length, width, estimated height, etc.), and to create SSS mosaics. Once targets were finalized, S-57 objects were exported from CTI SonarWiz 5 for use in Caris HIPS and SIPS 9.0 for determining contact correlation and necessity of further MBES investigation.

A.7.2.4. Google Drive

Google Drive was used across the project as the cloud storage area for a variety of project related documents and spreadsheets. Processing checklists, spreadsheets, SOPs, informational documents are all hosted on the drive. Each processor and employee has access to the documents, and permissions are determined as needed. The entirety of the Google Drive project folder is backed up locally every 24 hours. There are many advantages of maintaining the project documents in a cloud based environment including version control, extended document history recording, and realtime collaboration.

A.7.2.5. DensityTrac

DensityTrac is a program developed by eTrac Inc. to determine density statistics of a dataset provided in ASCII CSV format (Easting,Northing,Density). An ASCII CSV file is created with the density attribute of the chosen surface as the 3rd value in the string. The file is then loaded into the DensityTrac program and statistics along with a visual histogram are created. This aids the operator in determining if the density specification has been met for a particular surface of defined resolution.

A.7.2.6. SVPTrac

SVPTrac is a program developed by eTrac Inc. to aid in the evaluation of SVP profiles collected throughout the project. Multiple SVP files can be loaded in the Caris SVP format. Individual casts can be plotted against each other. Attributes of each plotted cast can be modified interactively including, color, line type, and line thickness. By viewing SVP data in SVPTrac, multiple profiles can be colored uniquely in a number of scenarios helpful to the user. SVPTrac is helpful in determining confidence in SVP equipment, as well as understanding environmental effects on sound speed readings.

A.7.2.7. FlierTrac

FlierTrac is a program developed by eTrac Inc. to aid in data processing by discovering fliers within a dataset provided in ASCII CSV format (Easting,Northing,Depth). FlierTrac delivers the results in a Caris SVP format, which can be loaded into Caris HIPS and SIPS 9.0 to view the location of potential fliers. An ASCII CSV file is created with the depth attribute of the chosen surface as the 3rd value in the string. The file is then loaded into the FlierTrac program, which compares the depth of each node to adjacent nodes within a user defined radius. Depth differences exceeding a user defined threshold

are flagged. FlierTrac creates a Caris SVP format file of these flagged outliers, which can then be loaded into Caris HIPS and SIPS 9.0. Using the locations from the created SVP format file, the operator can further evaluate the flagged nodes.

A.7.3. Reporting Software

A.7.3.1. XML DR

XML DR is a program developed by eTrac Inc. to create each descriptive report in an XML and/or PDF format. The program organizes the descriptive report into categories with fields for descriptive inputs, which includes the metadata, area surveyed, data acquisition and processing, vertical and horizontal control, results and recommendations, and approval sheet. Each category is divided into sub-categories for corresponding information and images to compile. Once all fields for descriptive inputs are completed, the program can create a finalized XML and/or PDF formatted descriptive report.

A.8. Survey Methodology

A.8.1. Mobilization

Mobilization for vessels M/V Jab, R/V Benthos, and R/V Taku occurred simultaneously June 2nd through June 4th, 2015. Mobilization occurred at the Port Mansfield Marina in Port Mansfield, TX. M/V Jab was brought via waterways and R/V Benthos and R/V Taku were brought via roadways on trailers to Port Mansfield Marina. All vessels were located next to one another in the marina for efficient simultaneous mobilization.

Figure 9: Vessel Mobilization

Full vessel surveys were performed on both M/V Jab and R/V Benthos by Buchanan & Harper, Inc. on January 13th, 2015. Traditional land survey methods using a Trimble 5000

robotic total station were utilized by Buchanan & Harper, Inc. during the field measurements. Each vessel was pre-established with a number of punch marks located at various locations on the vessel (i.e. IMU Plate, GPS Antennae locations, Port and Starboard draft reference points, etc.). A full list of measured vessel points can be found in the vessel reports in Appendix I of this report. These vessel points were surveyed by Buchanan & Harper, Inc. and relative locations were provided in reference to a single vessel point mark for each vessel.

Upon completion of the vessel survey, lever arms were derived from the vessel point locations provided by Buchanan & Harper, Inc. within each vessels frame. These lever arms along with their associated uncertainties were entered into the Caris HIPS and SIPS 9.0 vessel configuration files (HVF). Lever arms were additionally re-confirmed with hand tape measurements prior to calibration efforts.

A full vessel survey was performed on R/V Taku by Buchanan & Harper, Inc. on June 3rd, 2015. Traditional land survey methods using a Trimble 5000 robotic total station were utilized by Buchanan & Harper, Inc. during the field measurements. Each vessel was pre-established with a number of punch marks located at various locations on the vessel (i.e. IMU Plate, GPS Antennae locations, Port and Starboard draft reference points, etc.). A full list of measured vessel points can be found in the vessel reports in Appendix I of this report. These vessel points were surveyed by Buchanan & Harper, Inc. and relative locations were provided in reference to a single vessel point mark for the vessel.

Upon completion of the vessel survey, lever arms were derived from the vessel point locations provided by Buchanan & Harper, Inc. within each vessels frame. These lever arms along with their associated uncertainties were entered into the Caris HIPS and SIPS 9.0 Vessel Files (HVF). Lever arms were additionally reconfirmed with hand tape measurements prior to calibration efforts.

A.8.2. Survey Coverage

Survey coverage was based on the survey limits set forth in the Hydrographic Survey Project Instructions OPR-K370-KR-15, Port Mansfield, TX. H12761, H12762, H12763, H12764 and H12765 were covered entirely with no reduction of survey limits.

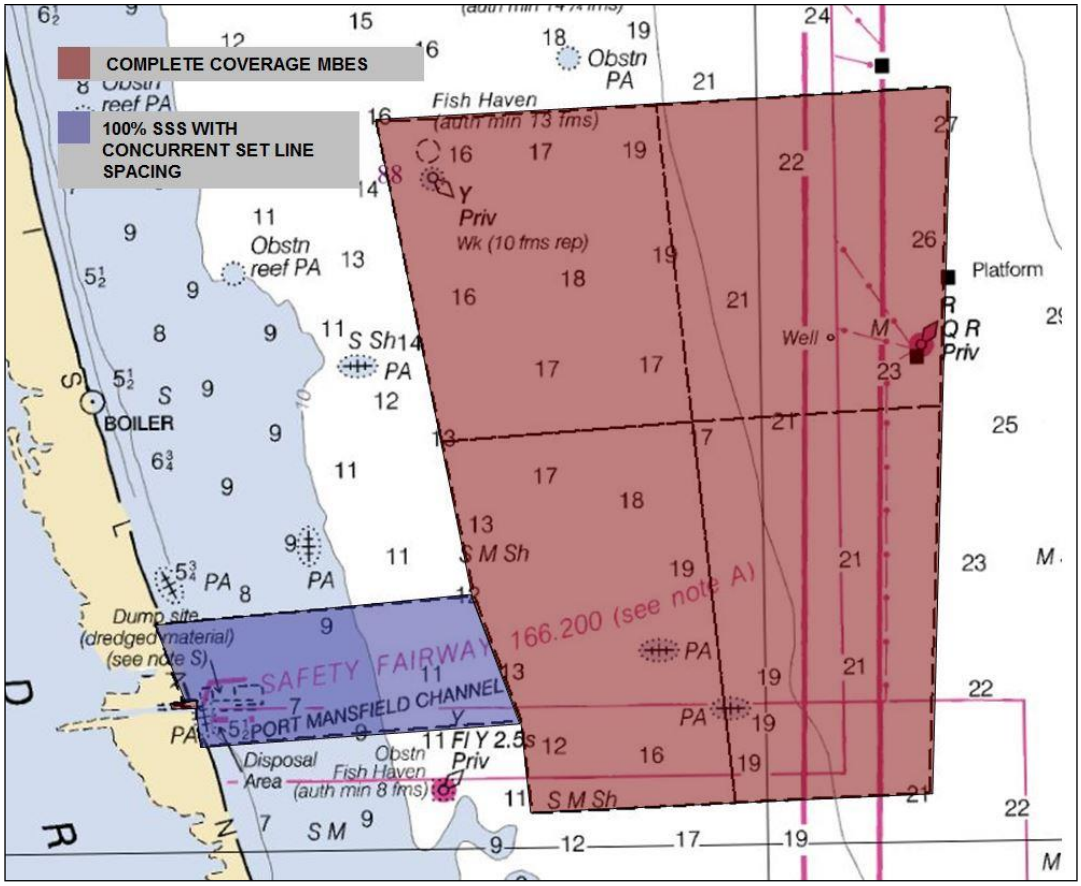


Figure 10: OPR-K370-KR-15 Survey Coverage Types

A.8.3. Multibeam Sonar Operations

Multibeam coverage was in accordance with the Project Instructions and HSSD 2015. The majority of OPR-K370-KR-15 was covered using "Complete Coverage MBES with backscatter" standards. The majority of H12761 was covered using "100% SSS with concurrent set line spacing MBES with backscatter" standards. M/V Jab, R/V Benthos, and R/V Taku were mobilized with an R2Sonic MBES system and participated in MBES collection.

A.8.4. Sidescan Sonar Operations

In areas where "100% SSS with concurrent set line spacing MBES with backscatter" was the chosen coverage type, sidescan sonar data was collected simultaneously in order to meet feature detection requirements. The M/V Jab exclusively collected all SSS data for OPR-K370-KR-15. A sidescan sonar system was not mobilized on the R/V Benthos or on the R/V Taku.

B. Quality Control

B.1. Data Acquisition

Data acquisition and processing throughout the entire project were overseen by the Chief of Party. Field acquisition was performed under the direct, onsite, supervision of a Lead Hydrographer and a Senior Hydrographer, both with well over 3 years of experience conducting hydrographic survey operations.

Line plans were established prior to survey operations. Line orientations were based on historical sea state, wind direction, and swell direction in order to avoid a "beam to" scenario where the vessel would be running survey lines in a direction perpendicular to the direction of the swell. Throughout the entire survey, there was never a need to revise the line orientation.

MBES line spacing for Complete Coverage MBES operations were based upon charted depths as well as coverage requirements set forth in the Project Instructions and the HSSD 2015. Line Spacing for Concurrent SSS/MBES operations were based upon SSS range settings. 50m, 30m, and 25m SSS range settings were utilized during operations. Vessel speed was monitored and maintained throughout survey operations in order to meet along track coverage requirements.

B.1.1. Horizontal and Vertical Control

Horizontal and Vertical control methodology for OPR-K370-KR-15 is in accordance with the HSSD 2015, the Project Instructions, and the accompanying Tides Statement of Work.

B.1.1.1. Horizontal Control

During calibration procedures, POSMV data were logged and post-processed in POSPac MMS to output a Smoothed Best Estimate of Trajectory (SBET). The SBET was applied in Caris HIPS and SIPS 9.0 in order to reduce the THU of the calibration data and achieve a higher accuracy of patch test values.

During main acquisition on the R/V Benthos, a Trimble SPS461 was used to receive DGPS corrections from the Aransas Pass USCG Differential Station (Aransas Pass, 304kHz, ID: 816). During main acquisition on the R/V Taku and M/V Jab, a Trimble DMS232 was used to receive DGPS corrections from the Aransas Pass USCG Differential Station (Aransas Pass, 304kHz, ID: 816). Corrections were transmitted to the POSMV via serial connection to achieve sub-meter horizontal accuracies. DGPS corrections were monitored during data acquisition to ensure no dropouts occurred and the POSMV maintained differential accuracies throughout the survey.

B.1.1.2. Vertical Control

In accordance with the Project Instructions, water level data from the Corpus Christi, TX tide station (NWLON 8775870) were used for vertical control. Station 8775870 was

added to the Hydro Hotlist prior to the start of the project. Prior to the start of data collection, predicted tides were downloaded from the CO-OPS website and used for preliminary processing efforts. Preliminary tides were downloaded in the field office at the beginning of each day and reviewed for any tide data gaps. No data gaps were present during field operations for OPR-K370-KR-15. Final verified tides were downloaded and applied to the data during final processing efforts.

B.1.2. Multibeam Bathymetry (MBES)

Initial settings for the R2Sonic 2024 systems can be seen below in Tables 8, 9, and 10

Table 8: MBES Settings for R2Sonic Mobilized on M/V Jab

M/V JAB MBES SETTINGS	
2024 Parameter	**Value**
Range	Variable, depth dependent
Gain	1- 6 dB
Power	221 dB
Spreading	20 dB
Absorption	154 dB
Ping Rate	Variable, range dependent
Pulse Width	35 µs

Table 9: MBES Settings for R2Sonic Mobilized on R/V Benthos

R/V BENTHOS MBES SETTINGS	
2024 Parameter	**Value**
Range	Variable, depth dependent
Gain	1 - 6 dB
Power	221 dB
Spreading	20 dB
Absorption	154 dB
Ping Rate	Variable, range dependent
Pulse Width	35 µs

Table 10: MBES Settings for R2Sonic Mobilized on R/V Taku

R/V TAKU MBES SETTINGS	
2024 Parameter	**Value**
Range	Variable, depth dependent
Gain	1- 6 dB
Power	221 dB
Spreading	20 dB
Absorption	154 dB
Ping Rate	Variable, range dependent
Pulse Width	35 µs

Incremental adjustments to the range, gain, and pulse width were made during the survey and were dependent on water depth, and seabed composition (bottom type). Every effort was made to tune the sonar to provide the highest quality of both bathymetric and backscatter data, with bathymetry being the primary focus. The R2Sonic 2024 was monitored realtime during all MBES acquisition efforts. Raw MBES information, including intensity, surface sound velocity, time synchronization, and ping rate, were displayed and monitored in the R2Sonic Sonic Controller Interface during acquisition.

Prior to survey operations, offsets from the POSMV reference point to the acoustic center of the R2Sonic 2024, on all vessels, were determined from the static vessel surveys performed by Buchanan & Harper, Inc. and were verified using a metal hand tape. Offsets were entered into the Sensor 1 lever arm of the POSMV. The Sensor 1 navigation group (Group 102) was broadcast via Ethernet port 5602 for use in QPS QINSy.

Roll stabilization and precise timing were achieved through a combination of outputs from the POSMV. The 1PPS pulse from the POSMV is sent via BNC cable to the PPS input of the R2Sonic SIM. Additionally, a NMEA ZDA message at 1Hz is transferred from a POSMV serial port to the R2Sonic SIM via standard DB9 serial cable. For roll stabilization, the TSS1 binary motion string is transferred from the POSMV to the R2Sonic via DB9 Serial connection at 200Hz.

Prior to survey operations, draft reference points were pre-established with punch marks on the port and starboard gunnels of each vessel. Draft reference marks were located on the port and starboard gunnels as close as possible to the location of the MBES sonar when fully deployed. Static draft measurements were determined from the average of 2 measurements, one at the port draft reference mark and the other at the starboard draft reference mark.

To confirm static draft, bar checks were preformed before the start of data collection on both vessels and also approximately midway through the data collection field effort for OPR-K370-KR-15. Bar checks were performed at 3, 4, and 5 meter intervals. Results of

the bar checks confirmed the draft measurements and showed excellent confidence in the MBES systems. Bar check results can be referenced in Appendix II of this report.

In addition to performing the confidence checks on each separate vessel, a performance test between the 3 vessels was also performed as an added quality assurance measure. On DN177 vessels ran an identical hatched line plan in the area. All vessels acquired sound velocity casts independently using the AML Base•X or AML Minos•X sound velocity probes assigned to each respective vessel. Data were processed through the proposed processing pipeline and comparisons were made between the 3 independent datasets. The data showed excellent agreement and added further confidence to the mobilized survey systems.

Figure 11: Vessel to Vessel Comparison (Survey Lines)

Figure 12: M/V Jab and R/V Benthos Vessel to Vessel Comparison (Difference Surface)

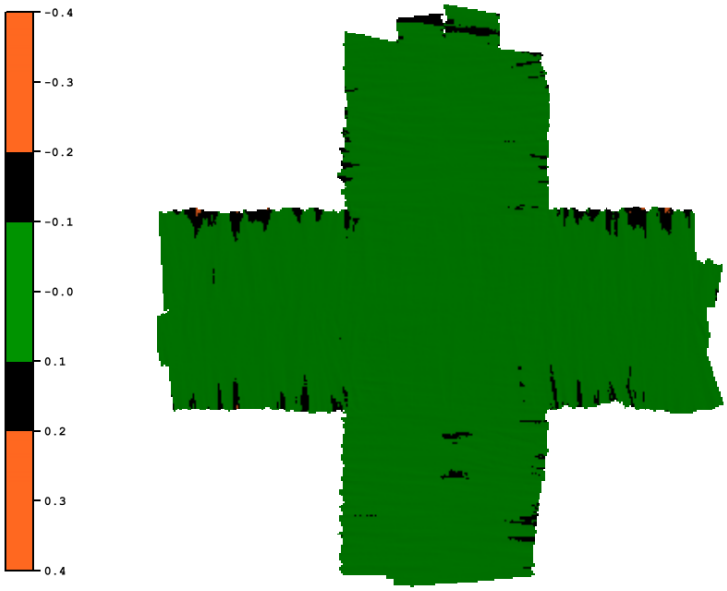


Figure 13: M/V Jab and R/V Taku Vessel to Vessel Comparison (Difference Surface)

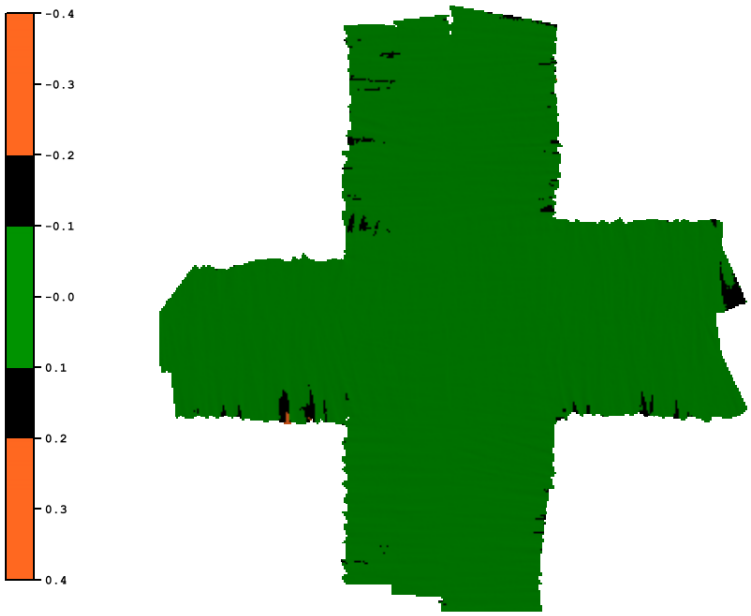


Figure 14: R/V Benthos and R/V Taku Vessel to Vessel Comparison (Difference Surface)

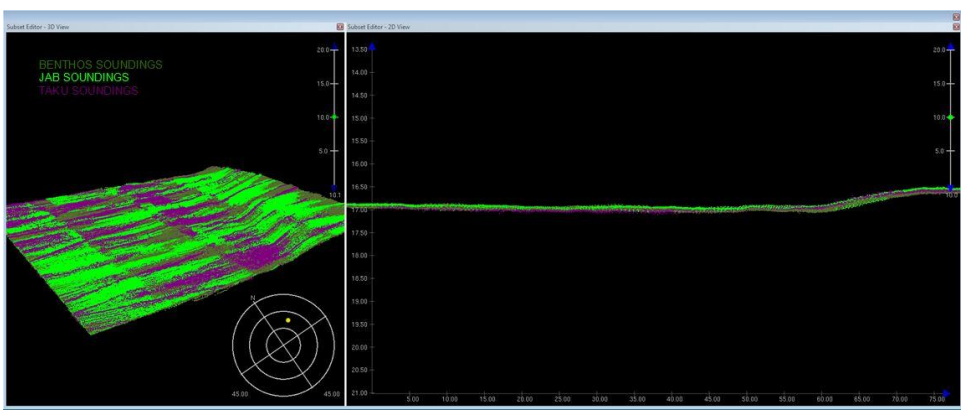


Figure 15: Vessel to Vessel Comparison (Subset Colored by Vessel)

B.1.3. Seafloor Imagery (SSS)

Prior to sidescan sonar (SSS) survey operations, the offset from the POSMV reference point to the towpoint sheave on the M/V Jab was determined from the static vessel survey performed by Buchanan & Harper, Inc. and was verified using a metal hand tape. The offset was entered into the SonarWiz 5 setup utility in order to calculate an accurate towfish layback.

Chesapeake Technology, Inc. (CTI) SonarWiz 5 was utilized as the SSS acquisition and processing software for the project. SonarWiz 5 was hosted on an acquisition computer separate from the MBES acquisition computer. The Edgetech 4200 is interfaced with SonarWiz through a series of connections. The 4200 towfish connects to the Edgetech 701-DL topside unit through a coaxial cable spool. The 701-DL transfers SSS profiles via Ethernet to the SSS acquisition computer hosting Edgetech Discover software. Edgetech Discover acts as a data pass through to CTI SonarWiz 5, where SSS data is collected and stored in XTF format.

A mark using white electrical tape was made on the tow cable at 10m. During deployment and recovery of the towfish, the 10m mark was used to verify the cable counter payout reading. The cable counter was calibrated multiple times throughout the survey using the 10m payout mark.

Ship position information was acquired by the POSMV and transferred to CTI SonarWiz 5 via serial connection. NMEA position and information strings including GGA, VTG, and HDT were output by the POSMV and brought into CTI SonarWiz. The layback calculation is performed using the position of the SSS towpoint sheave as the starting point. The Edgetech 4200 houses an onboard pressure sensor for depth determination. Using the depth determined from the pressure sensor and the cable out reading from the digital cable counter, a layback calculation is performed and sidescan profiles are positioned at the towfish.

Prior to the production of SSS operations, a series of calibration/confidence lines were performed in order to verify layback calculations. Reciprocal SSS lines were run adjacent to a seafloor object. The object was targeted in each separate line and the distance between the 2 targets was measured. The targets showed excellent positional agreement, within 1m.

During acquisition, the SSS waterfall is displayed on a vertically mounted monitor. The SSS operator monitors the SSS waterfall for data quality and object detection. If an object is witnessed by the operator, a target is marked using the SonarWiz targeting tool and a note is made within the digital field log. Vessel speed was maintained between 5 and 7 knots to ensure object detection density specifications were met. Cable out payment was adjusted throughout survey operations in order to maintain a towfish height of 8% to 20% or the SSS range. No extreme SV clines were noted during survey operations to justify deviation from the towfish height specification.

B.1.4. Sound Speed Acquisition

All sound speed measurements were collected in accordance with specifications set forth in the HSSD 2015.

B.1.4.1. Sound Speed Profile Acquisition

Sound speed profiles were collected using AML Base•X and AML Minos•X SV profiling units. On the M/V Jab, SV profilers were lowered on spectra line using the A-frame

mounted Pullmaster PL2 hydraulic winch. On both the R/V Benthos and R/V Taku, SV Profilers were hand deployed and lowered. SV profiles were taken immediately prior to daily survey operations, as well as approximately every 2 hours during survey operations. In addition to planning SV casts around a 2 hour time interval, positional variance was considered when suspending survey operations to perform an SV cast. At least 1 cast each day was planned in a location where the probe could be lowered to a depth equal to the deepest depth surveyed that day.

Once a cast was completed and the SV profiler was back onboard, data was downloaded either through serial or wireless data communications, and saved as a CSV on the MBES acquisition computer. Then, the CSV was imported to QPS QINSy acquisition software for use online. Once imported into the QPS QINSy software, the cast data was exported into the Caris HIPS and SIPS .SVP format for use in office processing at a later date. In addition to SV vs. depth information, the Caris .SVP exported format included date, time, and position (Lat/Long) of each cast.

Surface sound speed measured by the Valeport miniSVS, located at the sonar head, was compared in realtime against the corresponding SV from the most current cast entered into QINSy. An alarm was set to notify the operator if the difference between the 2 SV readings exceeded 2m/s. If the difference was ever in consistent excess of 2m/s, survey operations were suspended and a new velocity cast was performed.

Sound velocity comparison checks were performed weekly by simultaneously lowering the SV probes next to each other and recording casts. SV casts were compared and logged in the weekly SV comparison spreadsheet. The results of the weekly SV comparisons can be found in Appendix II of this report.

B.1.4.2. Surface Sound Speed Acquisition

Surface sound speed was measured at 1Hz during all MBES operations using the Valeport miniSVS. The Valeport miniSVS is installed using the R2Sonic provided mounting bracket and installed just above the face of the MBES receiver. Surface sound speed was transmitted at 1Hz to the R2Sonic topside SIM box and subsequently transmitted with the MBES data to QPS QINSy, where it was permanently logged in the raw XTF files. As mentioned above, surface sound speed was additionally utilized during online operations as a QC comparison to sound speed profile data.

B.2. Data Processing

B.2.1. Uncertainty Modeling

Uncertainty values for positioning, sounding, and sound speed equipment were compiled and tabulated for each vessel. Values were determined from manufacturer's specified/suggested values and/or calibration methodology/accuracy. Uncertainty values were entered into each vessel's HIPS Vessel File (HVF).

Table 11: TPU Values Used in Caris HIPS Processing

Accuracy Values for Total Propagation Error Computation			
HIPS Vessel File (HVF)			
Vessel	**R/V BENTHOS**	**R/V JAB**	**R/V TAKU**
Motion Sensor	PosMV 320	PosMV 320	PosMV 320
Position System 1	PosMV 320	PosMV 320	PosMV 320
MBES System	R2Sonic 2024	R2Sonic 2024	R2Sonic 2024
Gyro - Heading			
Gyro (°)	0.020	0.020	0.020
Heave % Amplitude	5%	5%	5%
Heave (m)	0.050	0.050	0.050
Roll and Pitch			
Roll (°)	0.020	0.020	0.020
Pitch (°)	0.020	0.020	0.020
Latency			
Timing Trans (s)	0.000	0.000	0.000
Nav Timing (s)	0.010	0.010	0.010
Gyro Timing (s)	0.010	0.010	0.010
Heave Timing (s)	0.010	0.010	0.010
Pitch Timing (s)	0.010	0.010	0.010
Roll Timing (s)	0.010	0.010	0.010
Measurment			
Offset X (m)	0.003	0.003	0.003
Offset Y (m)	0.003	0.003	0.003
Offset Z (m)	0.001	0.001	0.001
Speed			
Vessel Speed (m/s)	0.030	0.030	0.030
Draft and Loading			
Loading	0.013	0.027	0.025
Draft (m)	0.012	0.012	0.012
Delta Draft (m)	0.019	0.014	0.011
Physical Alignment Errors*			
Alignment			
MRU align Stdev gyro	0.096	0.142	0.067
MRU align roll/pitch	0.058	0.025	0.045
*All values given as 1 sigma.			

Total Propagated Uncertainty Computation in Caris HIPS			
Tide Values*			
Tide Value Measured	0.110	0.110	0.110
Tide Value Zoning	0.000	0.000	0.000
*All values given as 1 sigma.			
Sounding Speed Values			
Sound Speed Measured	4.00	4.00	4.00
Surface Sound Speed	2.00	2.00	2.00

B.2.2. HIPS Vessel Files (HVF)

A HIPS Vessel File (HVF) was created for each vessel. The vessel files contain sensor offsets and biases, static and dynamic draft corrections, and uncertainty values to aid in Total Propagated Uncertainty (TPU) calculations. The Applanix POSMV on each vessel was configured to output position and motion data at the acoustic center of the MBES sensor. This configuration yields an HVF with (0,0,0) offsets for positioning and MBES systems.

B.2.3. Static Draft

Static draft measurements were taken before and after data collection each day and also before any fueling occurred.

B.2.3.1. M/V Jab Static Draft

Prior to data collection, punch marks located on the port and starboard gunnels of the M/V Jab were surveyed by Buchanan & Harper, Inc. Port and starboard draft marks were utilized as an elevation reference point for draft measurements. Measurements were taken using a carpenter level and hand held metal tape marked with millimeter resolution. Raw tape measurements were input into the draft calculation table of the daily field log, and the resulting static draft was calculated and logged.

B.2.3.2. R/V Benthos Static Draft

Prior to data collection, punch marks located on the port and starboard gunnels of the R/V Benthos were surveyed by Buchanan & Harper, Inc. Draft marks were painted on the port and starboard sides of the R/V Benthos in reference to the port and starboard surveyed punch marks. Draft marks were painted in white marine grade paint on a black background. Draft measurements were taken by observing water level versus painted draft mark while docked in the calm marina environment. Draft marks were input into the draft calculation table of the daily field log, and the resulting static draft was calculated and logged.

B.2.3.3. R/V Taku Static Draft

Prior to data collection, punch marks located on the port and starboard gunnels of the R/V Taku were surveyed by Buchanan & Harper, Inc. Port and starboard draft marks were utilized as an elevation reference point for draft measurements. Measurements were taken using a carpenter level and hand held metal tape marked with millimeter resolution. Raw tape measurements were input into the draft calculation table of the daily field log, and the resulting static draft was calculated and logged.

B.2.4. Caris HIPS and SIPS 9.0

Caris HIPS and SIPS 9.0 was exclusively utilized for MBES processing throughout the entire project. Processing steps and procedures are detailed below in Figure 14.

The first part (PART 1 in Figure 16) of the processing pipeline consists of a series of standard HIPS processing procedures, which are completed using the batch processor. In order to ensure each process has been completed, detailed line queries are performed and reviewed after the batch process.

The second part (PART 2 in Figure 16) of the HIPS processing pipeline consists of detailed review and cleaning of data, as well as project specific tasks such as investigating assigned charted features or preparing DTON reports for submittal.

The third part (PART 3 in Figure 16) of the HIPS processing pipeline is performed once data collection has been completed for an entire H-Cell sheet. Zoned Verified tides are applied to the data in Caris HIPS and SIPS 9.0, and BASE surfaces are recomputed. The least depth of each feature in the Final Feature File (FFF) is updated and the feature is reviewed a final time. BASE surfaces are finalized by using the "finalize" option in Caris HIPS and SIPS 9.0.

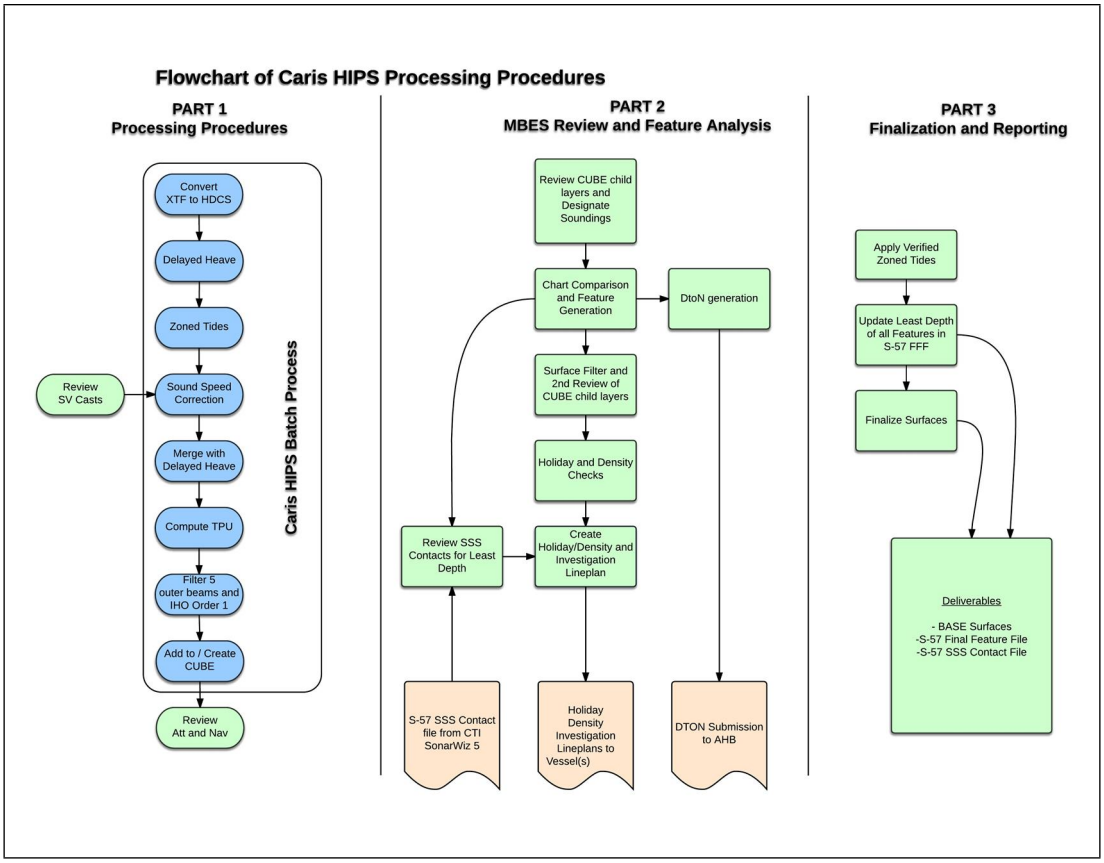


Figure 16: Caris HIPS Processing Procedures

B.2.5. Chesapeake Technology, Inc. SonarWiz 5

Chesapeake Technology, Inc. SonarWiz 5 was exclusively utilized for SSS processing throughout the entire project. SSS data from the acquisition vessel were imported into CTI SonarWiz 5 in the field office. The SSS processing steps are detailed in Figure 17 below.

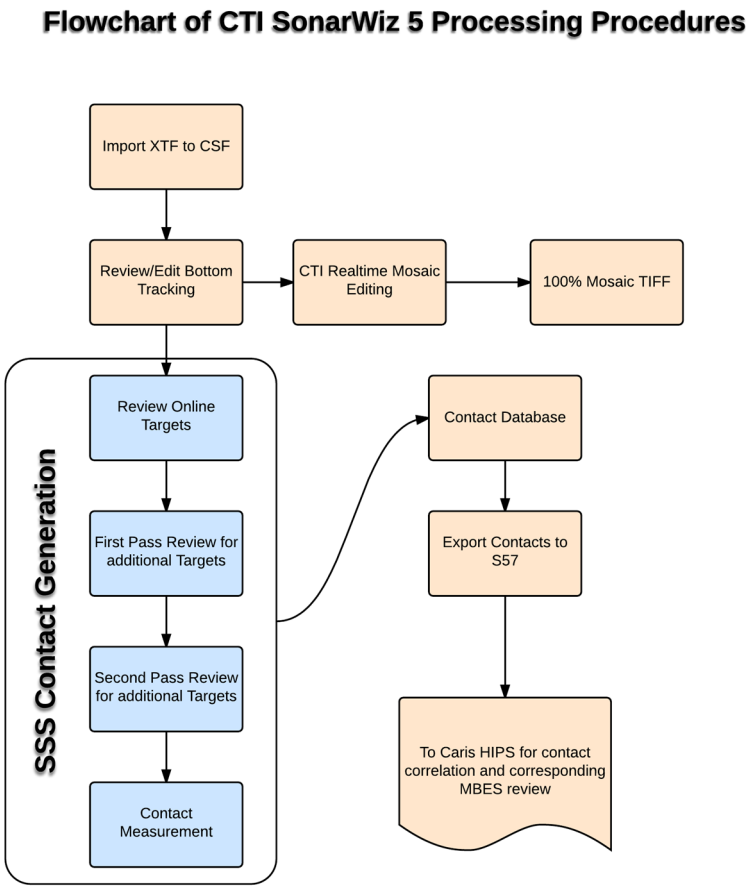


Figure 17: CTI SonarWiz 5 Processing Procedures

C. Corrections to Echo Soundings

C.1. Vessel Offsets

As mentioned previously, a static vessel survey was performed on the M/V Jab, R/V Benthos, and the R/V Taku prior to data collection. From the data provided in the vessel surveys, offsets were computed for sensor locations of the mobilized equipment on each vessel. Offsets were additionally confirmed using a hand tape to ensure no blunders had occurred during the static vessel survey. A systems diagram of each vessel can be found in Appendix I of this report.

Table 12: M/V Jab Vessel Offsets

M/V JAB Vessel Offsets			
Description	X (Bow +)	Y (Stbd +)	Z (Down +)
IMU Target (REF Point)	0.000	0.000	0.000
Primary GPS Antenna	0.664	-1.185	-3.194
Secondary GPS Antenna	0.672	1.117	-3.170
DMS232 Beacon/GPS Antenna	0.667	-0.035	-3.198
R2Sonic 2024 Acoustic Center	-0.768	0.053	1.937
Port Draft Reference Mark	-1.055	-2.189	-1.020
Starboard Draft Reference Mark	-1.041	2.172	-1.034

Table 13: R/V Benthos Vessel Offsets

R/V Benthos Vessel Offsets			
Description	X (Bow +)	Y (Stbd +)	Z (Down +)
IMU Target (REF Point)	0.000	0.000	0.000
Primary GPS Antenna	0.839	0.748	-2.947
Secondary GPS Antenna	0.840	2.750	-2.849
SPS461 Beacon/GPS Antenna	0.730	2.450	-2.818
R2Sonic 2024 Acoustic Center	0.334	-0.002	0.599
Port Draft Reference Mark	-0.150	0.111	-0.426
Starboard Draft Reference Mark	-0.148	3.263	-0.341

Table 14: R/V Taku Vessel Offsets

R/V Taku Vessel Offsets			
Description	X (Bow +)	Y (Stbd +)	Z (Down +)
IMU Target (REF Point)	0.000	0.000	0.000
Primary GPS Antenna	0.028	-1.117	-2.976
Secondary GPS Antenna	0.042	0.858	-2.904
DMS232 Beacon/GPS Antenna	0.027	-0.580	-2.892
R2Sonic 2024 Acoustic Center	-1.445	1.760	1.316
Port Draft Reference Mark	-2.013	-1.651	-0.921
Starboard Draft Reference Mark	-1.978	1.412	-0.922

C.2. Vessel HVFs

Caris HIPS Vessel Files (HVFs) were created for each vessel. Offsets for sensor locations, as well as uncertainty values, were entered into the HVF. Vessel HVFs were used within the Caris HIPS processing pipeline for converting and processing MBES data collected by M/V Jab, R/V Benthos, and R/V Taku. The HVF files are included with the digital data deliverable for each survey within OPR-K370-KR-15.

C.3. System Alignment

Multibeam patch tests were performed on each vessel prior to commencing data collection. A multibeam patch test is performed in order to measure the mounting/alignment biases between the MBES sensor and the inertial motion unit (IMU). In addition to mounting/alignment biases, a patch test is also performed to determine latency between MBES and position sensor data.

Latency patch tests were performed by running reciprocal survey lines at varying speeds over a local charted wreck.

Roll patch tests were performed by running reciprocal survey lines at equal speeds over a flat bottom.

Pitch patch tests were performed by running reciprocal survey lines at equal speed over a local charted wreck and prominent rock outcropping.

Yaw patch tests were performed by running parallel survey lines at equal speeds over a prominent rock outcropping.

Each pair of specific survey lines were analyzed in Caris HIPS and SIPS 9.0 Calibration Editor. Sensor biases were determined and entered into the HVF. Patch test data was analyzed independently by 5 hydrographers for crosscheck, and also to determine an accurate uncertainty value for the mounting/alignment biases.

All calibration data is included in the digital data deliverable. Determined patch test values are detailed below in Table 15.

Table 15: Vessel Alignment and Timing Biases

Vessel Alignment and Timing Biases					
Platform	DN	Latency	Pitch	Yaw	Roll
M/V Jab	154	0.000	0.260	1.580	-0.280
M/V Jab	215	0.000	0.320	1.610	-0.260
R/V Benthos	154	0.000	0.130	0.090	0.800
R/V Benthos	159	0.000	0.380	-0.290	0.810
R/V Benthos	200	0.000	0.280	-0.150	0.810
R/V Benthos	214	0.000	-0.060	0.340	0.780
R/V Taku	155	0.000	1.000	0.370	0.560
R/V Taku	177	0.000	0.390	0.270	0.560

C.4. Static Draft

Caris HIPS and SIPS 9.0 HVF files were updated daily with draft values from the digital field log (reference B.2.3.2). Draft values were entered into the waterline portion of each HVF prior to preliminary data processing.

C.5. Dynamic Draft

Dynamic draft tables were developed for each vessel through a post-processed kinematic method. The POSMV was used to log vessel trajectory data which contains ellipsoid heights and vessel speed. A series of reciprocal survey lines were run at incrementally increasing survey speeds (0.5 knot increase per line). Each survey line was run for a length of 1000 meters to ensure vessel settlement had occurred at each speed. At the end of each line, a "float" line was performed. During the float lines, data was collected with the engines at idle. The data collected during the float lines were utilized in office processing to eliminate changes in measured ellipsoid heights due to tidal influence.

Once data was collected through the range of possible survey speeds, data were transferred to the field and processed in POSPac MMS Post-Processing Kinematic software package designed for use with Applanix POSMV systems. Data were reduced by averaging the height values for each line. Tidal influence was accounted for using average height calculations from the series of float lines logged during acquisition. A 3rd order polynomial regression was implemented to create the dynamic draft table from the data trends.

Dynamic draft tables for each vessel were entered into their respective HIPS Vessel Files (HVF) and applied during HIPS processing.

Dynamic Draft processing reports can be found in Appendix I or this report. The dynamic draft tables for each vessel are provided in Table 16 below.

Table 16: Dynamic Draft Values

Dynamic Draft Values					
R/V BENTHOS		*R/V JAB*		*R/V TAKU*	
Speed (m/s)	**Squat (m)**	**Speed (m/s)**	**Squat (m)**	**Speed (m/s)**	**Squat (m)**
1.672	0.005	1.826	0.005	1.749	0.012
1.929	0.014	2.130	0.021	2.083	0.010
2.083	0.02	2.418	0.033	2.444	0.017
2.212	0.024	2.706	0.045	2.778	0.029
2.444	0.031	2.891	0.053	3.009	0.039
2.675	0.038	3.110	0.063	3.318	0.050
2.752	0.04	3.236	0.070	3.601	0.056
2.675	0.038	3.362	0.077	3.935	0.056
2.958	0.046	3.542	0.089	4.141	0.050
3.19	0.051	3.745	0.104		
3.292	0.054	4.010	0.128		
3.575	0.06	4.175	0.146		
3.678	0.062	4.370	0.171		
3.91	0.066	4.591	0.204		
4.038	0.068				
4.193	0.07				
4.244	0.071				
Uncertainty	***0.019***	**Uncertainty**	***0.014***	**Uncertainty**	***0.011***

C.6. Position and Attitude

An Applanix POSMV 320 V5 was mobilized on each vessel as the primary positioning and attitude measurement system. Prior to calibration, lever arms calculated from the static vessel survey of the R/V Benthos and M/V Jab, performed on January 13th, 2015, and the R/V Taku, performed on June 3rd, 2015, were entered into the POSMV configuration, including primary GPS antenna to reference point (RP), GPS baseline (distance between GPS antennae), inertial motion unit to RP, sensor 1 to RP, and center of rotation to RP.

A Geometric Azimuth Measurement System (GAMS) calibration was performed with the heading accuracy threshold set to 0.5 degrees.

POSMV Calibration reports can be found in Appendix III of this report.

C.7. True Heave

During acquisition, trajectory data was logged by the Applanix POSMV. This recorded trajectory data includes delayed heave, or "True Heave". True Heave data is a more accurate representation of vessel heave as it filters heave data using a recursive zero phase response filter over a 30 second range, rather than a traditional linear heave filter. However, unlike traditional heave data, True Heave cannot be incorporated into the sounding data in real time and must be applied in post-processing.

True Heave data were applied in Caris HIPS and SIPS 9.0 during the batch processing portion of the processing pipeline detailed in section B.2.4.

C.8. Waterlevel Corrections

In accordance with the Project Instructions, water level data from the Corpus Christi, TX tide station (NWLON 8775870) were applied to all project data in order to reduce soundings to MLLW navigation datum. Predicted water level data were used during preliminary data processing. For final data processing efforts, verified water level correctors were downloaded from the CO-OPS website and applied in Caris HIPS and SIPS 9.0. Time and range ratio corrections were applied to water level data from station 8775870 during preliminary and final data processing procedures in Caris HIPS and SIPS 9.0.

C.9. Sound Speed Corrections

Sound speed profiles collected in the field were applied to the MBES data as part of the Caris HIPS and SIPS 9.0 batch processing routine. The "Nearest in Distance Within Time" option was chosen in order to limit the effects of spatial variation in sound speed correctors. Surface sound speed was collected at the R2Sonic transducer face, and sent via serial connection directly to the R2Sonic topside unit in order to facilitate beam steering.

D. Approval Sheet

OPR-K370-KR-15

Registry Nos.
H12761
H12762
H12763
H12764
H12765

Data Acquisition and Processing Report

This report and the accompanying data are respectfully submitted.

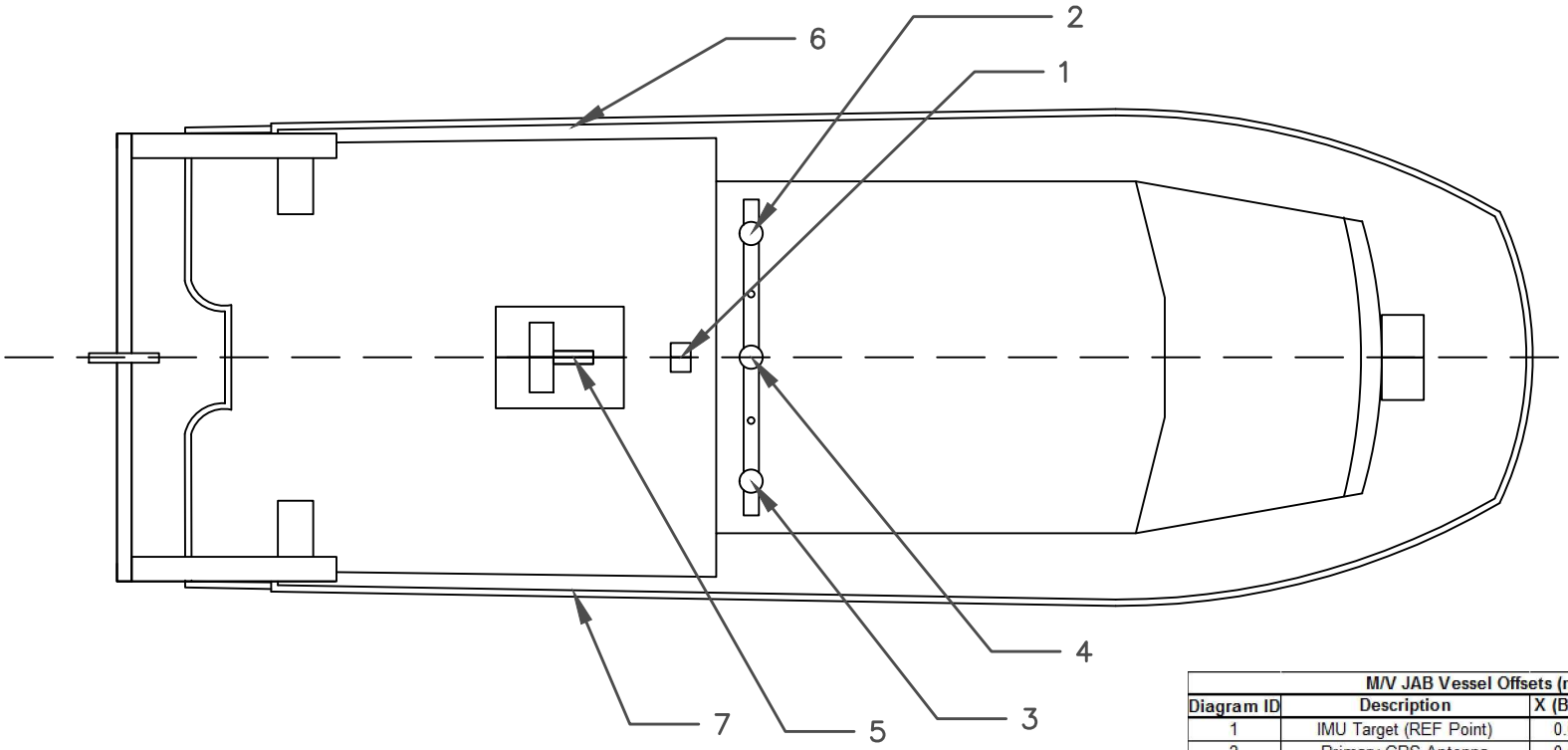
Field operations contributing to the accomplishment of Surveys H12761, H12762, H12763, H12764, and H12765 were conducted under my direct supervision with frequent personal checks of progress and adequacy. This report and associated data have been closely reviewed and are considered complete and adequate as per the Statement of Work.

Digitally signed by David R. Neff
DN: C=US, E=david@etracinc.com, O=eTrac Inc., CN=David R. Neff
Reason: I attest to the accuracy and integrity of this document
Date: 2015.12.01 16:01:30-08'00'

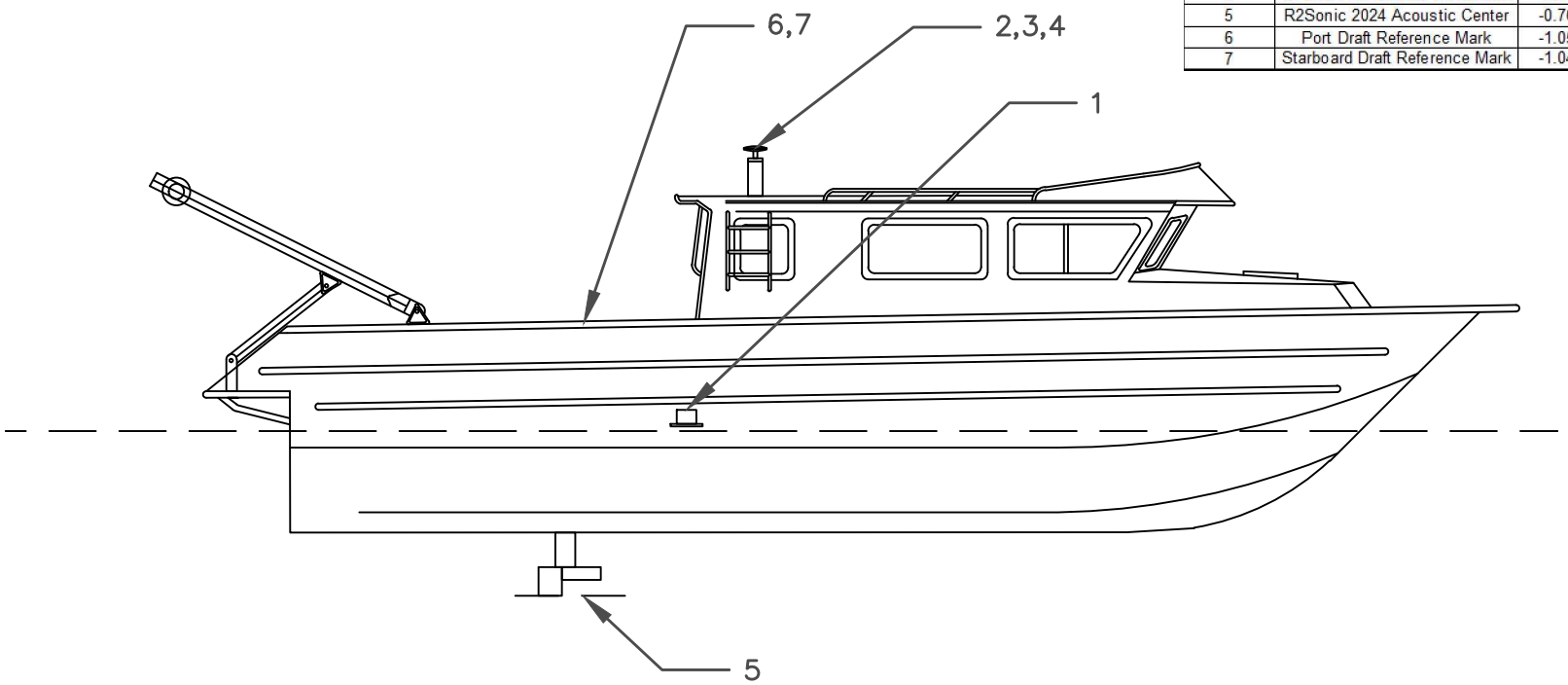
David R. Neff | eTrac Inc. | Lead Hydrographer | December 1, 2015

eTrac Inc.
December 2015

APPENDIX I
VESSEL REPORTS



M/V JAB Vessel Offsets (meters)				
Diagram ID	Description	X (Bow +)	Y (Stbd +)	Z (Down +)
1	IMU Target (REF Point)	0.000	0.000	0.000
2	Primary GPS Antenna	0.664	-1.185	-3.194
3	Secondary GPS Antenna	0.672	1.117	-3.170
4	SPS461 Beacon/GPS Antenna	0.667	-0.035	-3.198
5	R2Sonic 2024 Acoustic Center	-0.768	0.053	1.937
6	Port Draft Reference Mark	-1.055	-2.189	-1.020
7	Starboard Draft Reference Mark	-1.041	2.172	-1.034

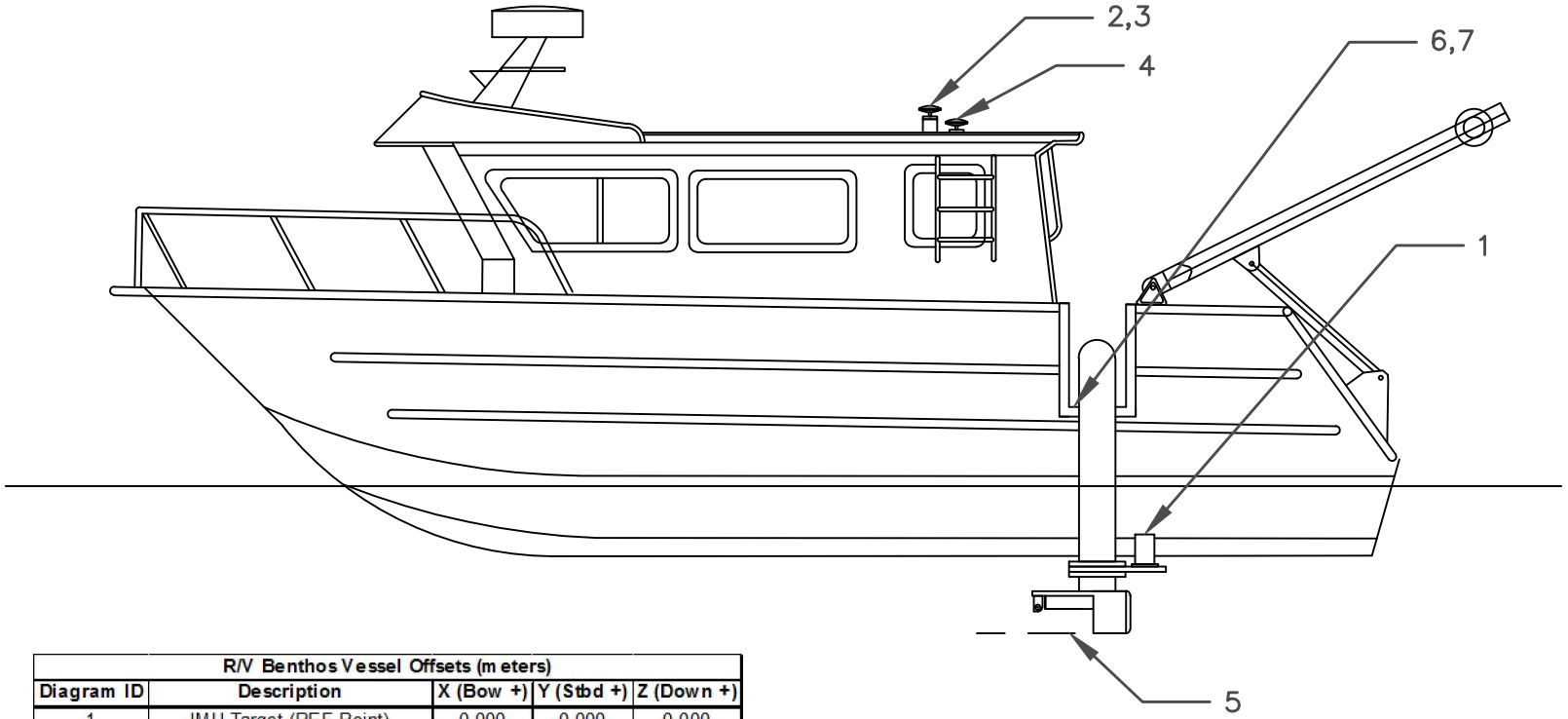


VESSEL NAME: M/V JAB
MAKE: ARMSTRONG CAT
LENGTH: 43FT
BEAM: 15FT
HOME PORT: VENICE, LA
PLOT DATE: 5/07/15

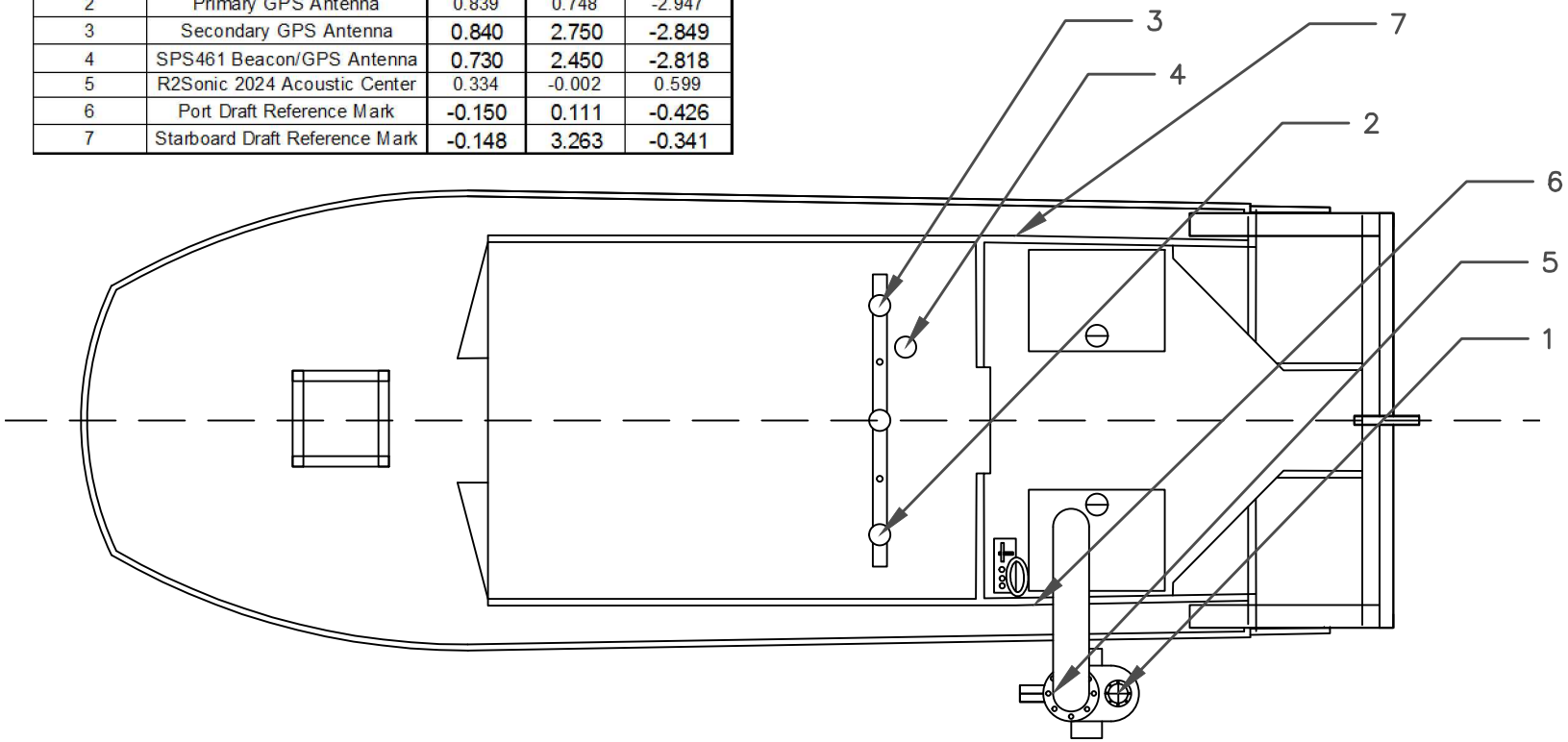
VESSEL OFFSET DIAGRAM

637 LINDARO STREET
SUITE 100
SAN RAFAEL, CA 94901
415.462.0421
eTracInc.com

eTrac



R/V Benthos Vessel Offsets (meters)				
Diagram ID	Description	X (Bow +)	Y (Stbd +)	Z (Down +)
1	IMU Target (REF Point)	0.000	0.000	0.000
2	Primary GPS Antenna	0.839	0.748	-2.947
3	Secondary GPS Antenna	0.840	2.750	-2.849
4	SPS461 Beacon/GPS Antenna	0.730	2.450	-2.818
5	R2Sonic 2024 Acoustic Center	0.334	-0.002	0.599
6	Port Draft Reference Mark	-0.150	0.111	-0.426
7	Starboard Draft Reference Mark	-0.148	3.263	-0.341

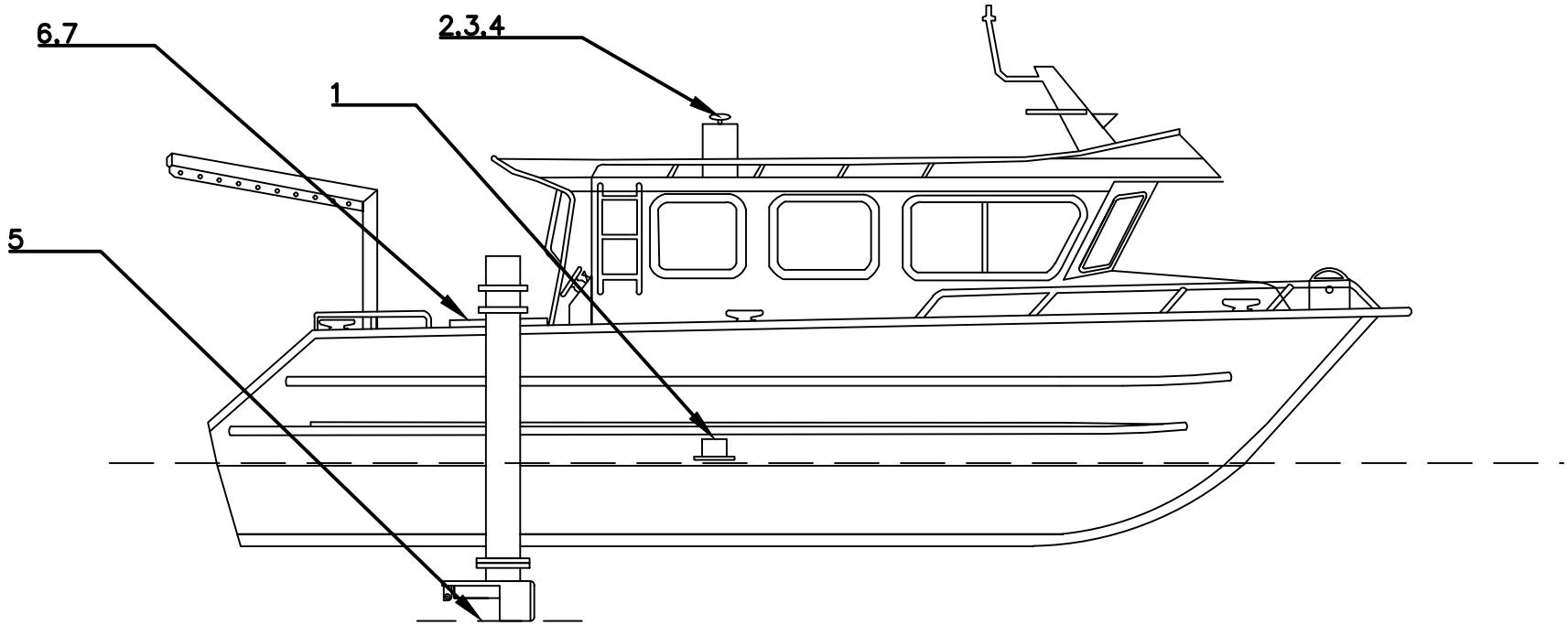


VESSEL NAME: R/V BENTHOS
MAKE: ARMSTRONG CAT
LENGTH: 30FT
BEAM: 9FT
HOME PORT: Morehead City, NC
PLOT DATE: 5/07/15

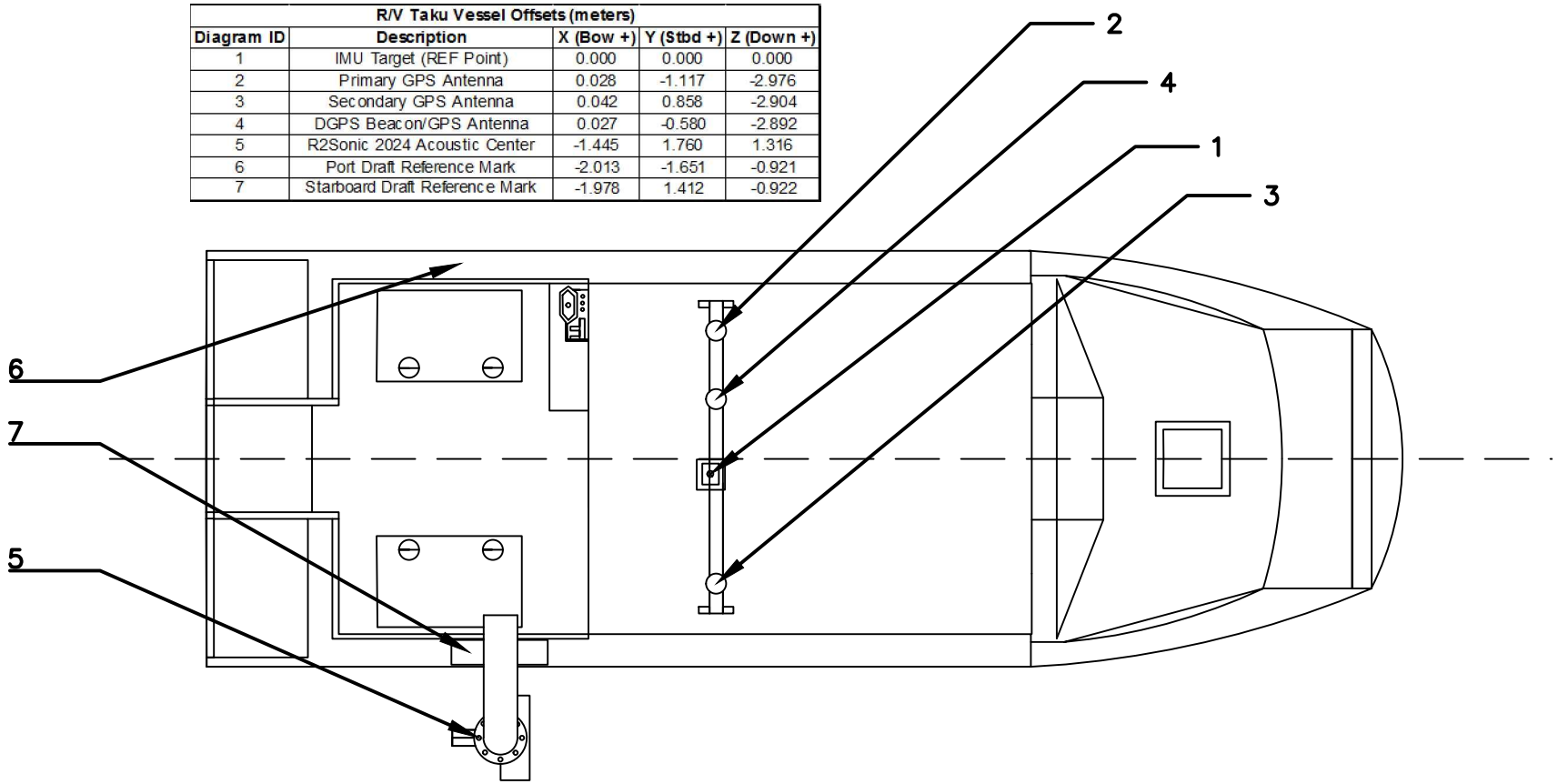
VESSEL OFFSET DIAGRAM

637 LINDARO STREET
SUITE 100
SAN RAFAEL, CA 94901
415.462.0421
eTracInc.com

eTrac



R/V Taku Vessel Offsets (meters)				
Diagram ID	Description	X (Bow +)	Y (Stbd +)	Z (Down +)
1	IMU Target (REF Point)	0.000	0.000	0.000
2	Primary GPS Antenna	0.028	-1.117	-2.976
3	Secondary GPS Antenna	0.042	0.858	-2.904
4	DGPS Beacon/GPS Antenna	0.027	-0.580	-2.892
5	R2Sonic 2024 Acoustic Center	-1.445	1.760	1.316
6	Port Draft Reference Mark	-2.013	-1.651	-0.921
7	Starboard Draft Reference Mark	-1.978	1.412	-0.922



VESSEL NAME: R/V TAKU
MAKE: Armstrong
LENGTH: 28FT
BEAM: 9FT
HOME PORT: Sausalito, CA
PLOT DATE: 9/24/15

VESSEL OFFSET DIAGRAM

637 LINDARO STREET
SUITE 100
SAN RAFAEL, CA 94901
415.462.0421
eTracInc.com

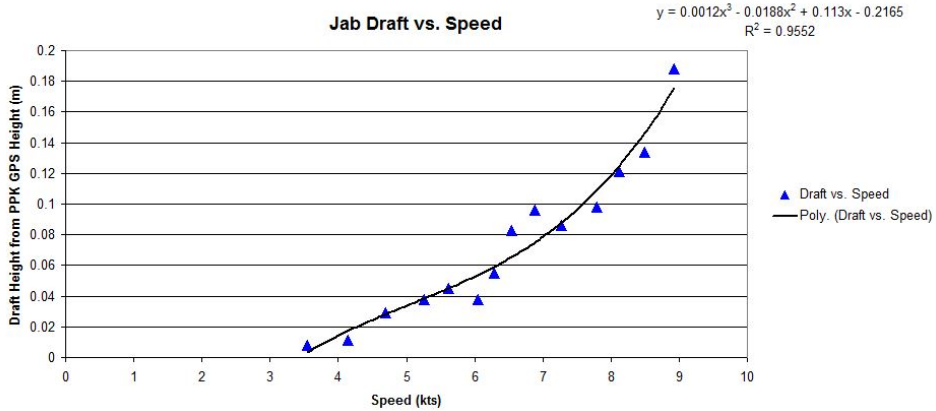
eTrac

eTrac Inc.
637 Lindaro St.
Suite 100
San Rafael, CA 94901
888-410-3890

OPR-K370-KR-15
M/V JAB Dynamic Draft REPORT

JAB

Speed				Residual	
X (kts)	m/s	Y - Draft from Survey Speed GPS Height - Floating GPS Height	Polynomial (3rd order)	meters	feet
3.55	1.826	0.008	0.005	0.003	0.008
4.14	2.130	0.011	0.021	-0.010	-0.032
4.70	2.418	0.029	0.033	-0.004	-0.012
5.26	2.706	0.038	0.045	-0.007	-0.022
5.62	2.891	0.045	0.053	-0.008	-0.025
6.05	3.110	0.038	0.063	-0.025	-0.082
6.29	3.236	0.055	0.070	-0.015	-0.050
6.54	3.362	0.083	0.077	0.006	0.020
6.89	3.542	0.096	0.089	0.007	0.024
7.28	3.745	0.086	0.104	-0.018	-0.059
7.80	4.010	0.098	0.128	-0.031	-0.100
8.12	4.175	0.121	0.146	-0.026	-0.084
8.50	4.370	0.134	0.171	-0.037	-0.121
8.93	4.591	0.188	0.204	-0.016	-0.053
			Standard Deviation =>	*0.014*	*0.045*

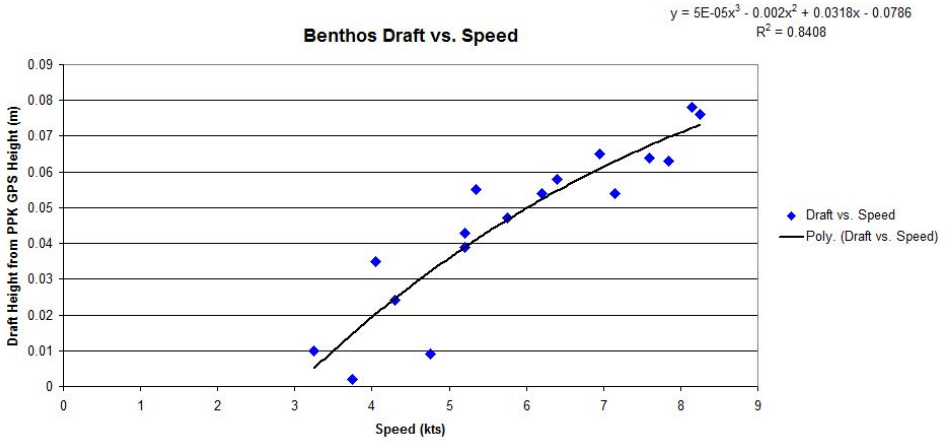


eTrac Inc.
637 Lindaro St.
Suite 100
San Rafael, CA 94901
888-410-3890

OPR-K370-KR-15
R/V Benthos Dynamic Draft REPORT

BENTHOS

Speed				Residual	
X (kts)	m/s	Y - Draft from Survey Speed GPS Height - Floating GPS Height	Polynomial (3rd order)	meters	feet
3.25	1.672	0.01	0.005	0.005	0.018
3.75	1.929	0.002	0.014	-0.012	-0.04
4.05	2.083	0.035	0.02	0.015	0.05
4.3	2.212	0.024	0.024	0	0
4.75	2.444	0.009	0.031	-0.023	-0.074
5.2	2.675	0.039	0.038	0.001	0.004
5.35	2.752	0.055	0.04	0.015	0.05
5.2	2.675	0.043	0.038	0.005	0.017
5.75	2.958	0.047	0.046	0.002	0.005
6.2	3.19	0.054	0.051	0.003	0.011
6.4	3.292	0.058	0.054	0.004	0.014
6.95	3.575	0.065	0.06	0.005	0.018
7.15	3.678	0.054	0.062	-0.008	-0.025
7.6	3.91	0.064	0.066	-0.002	-0.007
7.85	4.038	0.063	0.068	-0.005	-0.016
8.15	4.193	0.078	0.07	0.008	0.025
8.25	4.244	0.076	0.071	0.004	0.014
			Standard Deviation =>	*0.019*	*0.061*



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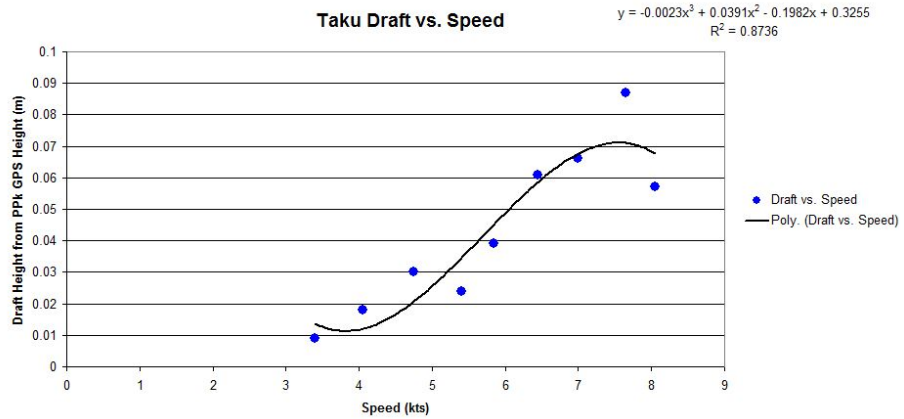
OPR-K370-KR-15
M/V TAKU Dynamic Draft REPORT

TAKU

Speed				Residual	
X (kts)	m/s	Y - Draft from Survey Speed GPS Height - Floating GPS Height	Polynomial (3rd order)	meters	feet
3.40	1.750	0.009	0.012	-0.003	-0.011
4.05	2.080	0.018	0.010	0.008	0.026
4.75	2.440	0.030	0.017	0.013	0.042
5.40	2.780	0.024	0.029	-0.005	-0.017
5.85	3.010	0.039	0.039	0.001	0.002
6.45	3.320	0.061	0.050	0.011	0.037
7.00	3.600	0.066	0.056	0.010	0.032
7.65	3.940	0.087	0.056	0.031	0.103
8.05	4.140	0.057	0.050	0.007	0.024
			Standard Deviation =>	0.011	0.036



Layback Calibration

A single towpoint location was utilized for the entirety of the SSS data collected. The stern center A-Frame towpoint was used as the single towpoint location. A Hydrographic Survey Products, Smart Sensor V3 was used in combination with a Cambell Specialty CO Sheave towblock. Tape marks were located on the cable at 5 meter increments in order to calibrate and QC cable out measurements throughout the SSS survey acquisition effort. Layback was calculated in CTI SonarWiz with variables including towfish depth, cable out measurement, and the towpoint offset (measurement from vessel RP to towpoint). Layback was recorded in XTF files as well as frequently logged in vessel field logs.

APPENDIX II
ECHOSOUNDER REPORTS

eTrac Inc.
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OPR-K370-KR-15 Approaches to Port Mansfield

R/V Jab Bar Checks

Week of	DN	Line Name	Bar Depth (m)	Draft (m)	MBES Depth (m)	Difference	Comments
6/1/2015	155	2015JA1552236.XTF	5	1.562	5	0	
7/12/2015	193	2015JA1931205.XTF	5	1.652	5	0	
7/12/2015	193	2015JA1931204.XTF	4	1.652	4	0	
					Mean	0.00	
					Std Dev	0.00	

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OPR-K370-KR-15 Approaches to Port Mansfield

R/V Benthos Bar Checks

Week of	DN	Line Name	Bar Depth (m)	Draft (m)	MBES Depth (m)	Difference	Comments
6/1/2015	155	2015BE1552153.XTF	5	0.948	5	0	
					Mean	0.00	
					Std Dev	0.00	

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OPR-K370-KR-15 Approaches to Port Mansfield

R/V Taku Bar Checks

Week of	DN	Line Name	Bar Depth (m)	Draft (m)	MBES Depth (m)	Difference	Comments
6/1/2015	155	2015TA1552208.XTF	5	1.098	5	0	
					Mean	0.00	
					Std Dev	0.00	

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OPR-K370-KR-15 Port Mansfield

Weekly SVP Comparison

Week of	DN	JAB	Benthos	Taku	Spare	JAB Average SVP	Benthos Average SVP	Taku Average SVP	Spare Average SVP	Difference	Comments
6/1/2015	155	AML Minos SN:8487	AML Base X SN:25101	AML Base X SN:25114		1,534.33	1,534.32	1,534.24		0.06	
6/8/2015	162	AML Minos SN:8487	AML Base X SN:25101	AML Base X SN:25114		1,536.23	1,536.05	1,536.23		0.12	
6/15/2015	169	AML Minos SN:8487	AML Base X SN:25101	AML Base X SN:25114		1,540.10	1,539.85	1,539.62		0.32	
6/22/2015	177	AML Minos SN:8487	AML Base X SN:25101	AML Base X SN:25114		1,537.52	1,537.62	1,537.37		0.17	
7/1/2015	182	AML Minos SN:8487	AML Base X SN:25101	AML Base X SN:25114		1,535.43	1,535.50	1,535.33		0.12	
7/6/2015	189	AML Minos SN:8487	AML Base X SN:25101	AML Base X SN:25114		1,540.82	1,540.94	1,540.64		0.20	
7/6/2015	189	Valeport SN:31057	Valeport SN:39252	Valeport SN:48352		1,540.80	1,541.30	1,540.30		0.67	
7/13/2015	197	AML Minos SN:8487	AML Base X SN:25101	AML Base X SN:25114	AML Base X SN:2500	1,544.71	1,544.88	1,544.57	1,544.94	0.21	
7/20/2015	203	AML Base X SN:25192	AML Base X SN:25101	AML Base X SN:25114		1,546.82	1,546.91	1,546.56		0.23	
7/27/2015	211	AML Base X SN:25192	AML Base X SN:25101	AML BaseX SN:25114		1,551.84	1,551.93	1,551.55		0.25	
8/3/2015	218	AML Base X SN:25192	AML Base X SN:25101			1549.121	1,549.18			0.06	
8/10/2015	224	AML Base X SN:25193	AML Base X SN:25102			1550.074	1550.248			0.17	
									AVERAGE	**0.21**	

APPENDIX III
POSITIONING AND ATTITUDE SYSTEM REPORTS

eTrac Inc.
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San Rafael, CA 94901
888-410-3890

OPR-K370-KR-15

RV BENTHOS POS MV CALIBRATION REPORT

All values in meters, time in UTC, julian day

SYSTEM INFORMATION

Vessel: RV Benthos
Date: 6/3/2015
Personnel: D. Neff, M. Castle, B. Sumners

PCS Serial # 6619
IP Address: 192.168.53.100

POSView Version MV-POSView Version 8.01
POS Version POSMV 320 V5

GPS Receivers
Primary Reciever Trimble SPS 461
Secondary Receive Trimble SPS 461

CALIBRATION AREA

Location: Port Mansfield, TX

Approximate Position:

	Deg	Min	Sec
Lat:	26	31	22.21585
Long:	97	9	0.155627

GPS Corrections

DGPS Beacon Station: 816
Frequency: 304

RTK/VRS Station: Aransas Pass
Correction Type: CMRP
Coordinates:

	Deg	Min	Sec
Lat:			
Long:			
Ellips. Height:			

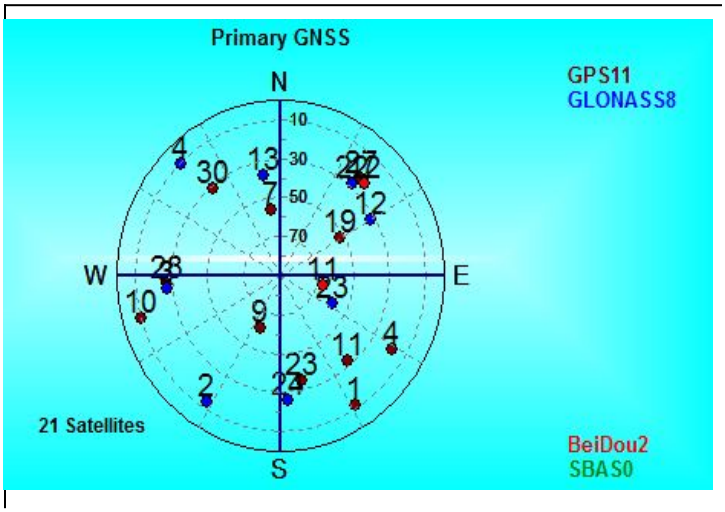
Satellite Constellation

Primary GPS (Port Antenna

HDOP: 0.525
VDOP 0.982
Satellites in Use: 21

PDOP:

Notes:



POS MV CONFIGURATION

Settings

GAMS Parameter Setup

User Entries, Pre-Calibratio		Baseline Vector	
2.000	Two Antenna Separation (m)	0.00	X Component (m)
0.500	Heading Calibration Threshold	0.00	Y Component (m)
0.000	Heading Corrections	0.00	Z Component (m)

Notes:

POS MV CALIBRATION

Calibration Proceedure

Start Time: 17:10:00 *UTC* | x | *Mark "x" here when start*

End Time: 17:17:00 *UTC* | x | *Mark "x" here when end*

Heading accuracy achieved for calibration: _____

Calibration Results

GAMS Parameter Setup

POS MV Post Calibration Values		Baseline Vector	
2.000	Two Antenna Separation (m)	0.008	X Component (m)
0.500	Heading Calibration Threshold	2.000	Y Component (m)
0.000	Heading Corrections	0.027	Z Component (m)

GAMS Status Online? **YES**

Save Settings? **YES**

Notes:

Save POS Settings

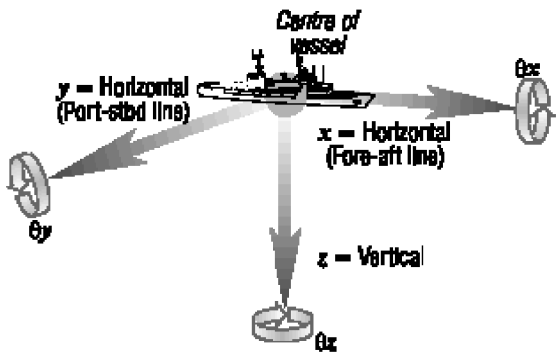
Filename: NOAA_150114_Benthos.nvm

GENERAL GUIDANCE

The POS MV uses a Right-Hand Orthogonal System

The right-hand orthogonal system defines the following:

- The x-axis is in the fore-aft direction in the appropriate reference frame
- The y-axis is perpendicular to the x-axis and points towards the right (starboard) side in the appropriate reference frame
- The z-axis points downwards in the appropriate reference frame



Frames of Reference

The IMU frame of reference includes the vertical and the horizontal axis of the IMU with which the orthogonal array of sensing elements aligns. These are fixed relative to the IMU and are identified by a label on the IMU housing.

By convention, POS MV uses the right-hand orthogonal co- ordinate system, with its origin centred on the black and yellow circle on the top of the IMU.

The sensor 1 reference frame includes the vertical and the horizontal axis of the multi-beam transducer. These axis are fixed relative to the multi-beam transducer.

By convention, POS MV uses the right-hand orthogonal coordinate system, with its origin at the sensing centre of the multi-beam transducer.

The vessel reference frame co-aligns with your chosen reference frame.

Tate-Bryant Rotation Sequence

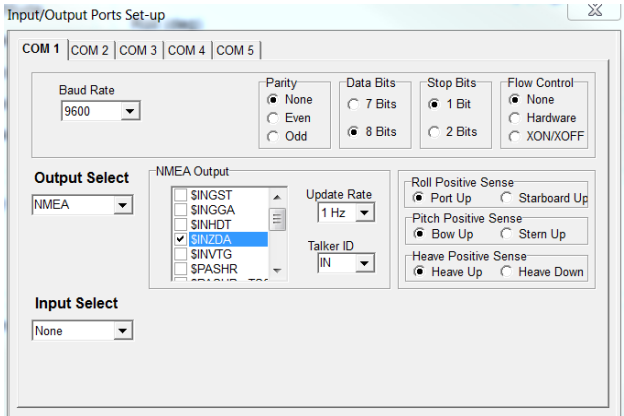
Apply the rotation in the following order to bring the two frames of reference into complete alignment:

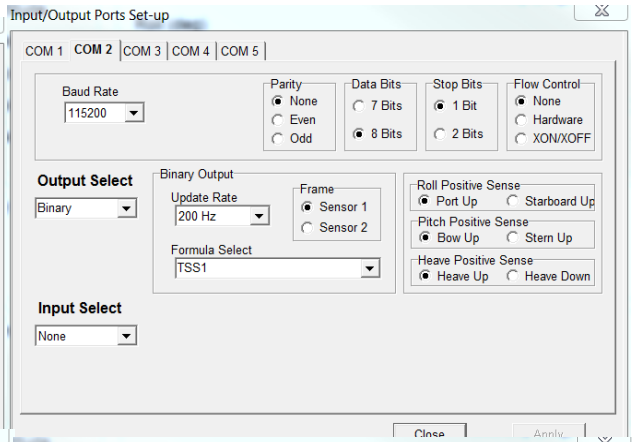
- Heading rotation - apply a right-hand screw rotation `z about the z-axis to align one frame with the other
- Pitch rotation - apply a right-hand screw rotation `y about the once-rotated y-axis to align one frame with the other
- Roll rotation - apply a right-hand screw rotation `x about the twice-rotated x-axis to align one frame with the other

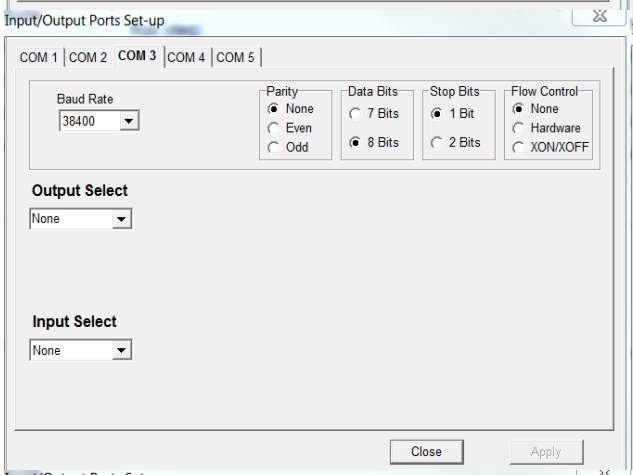
SETTINGS

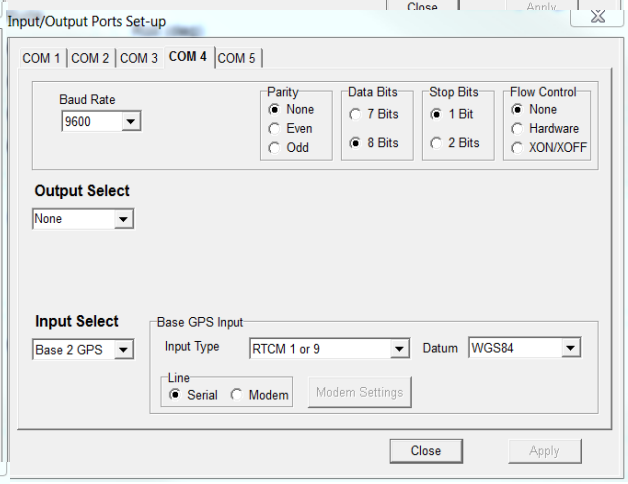
Insert screen-grabs here

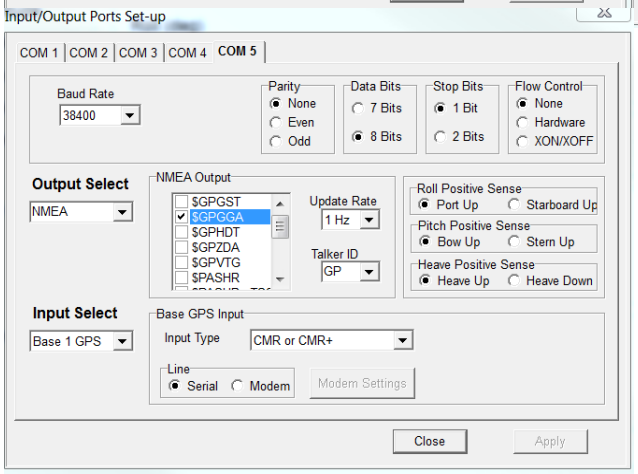
Input / Output Ports



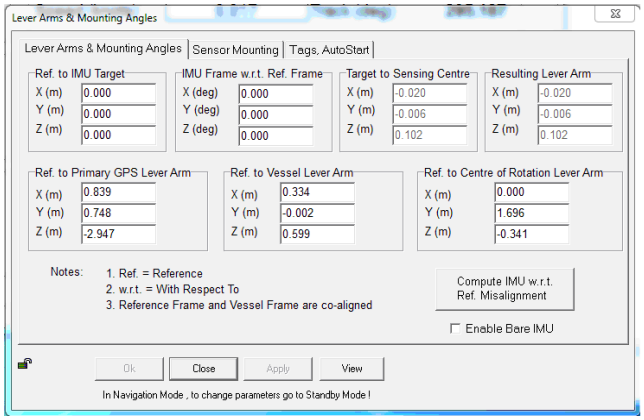


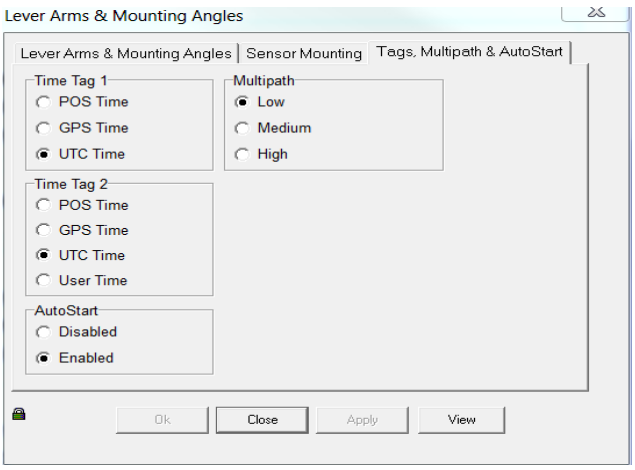


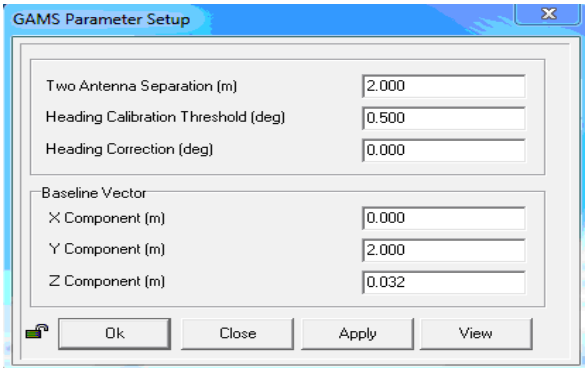




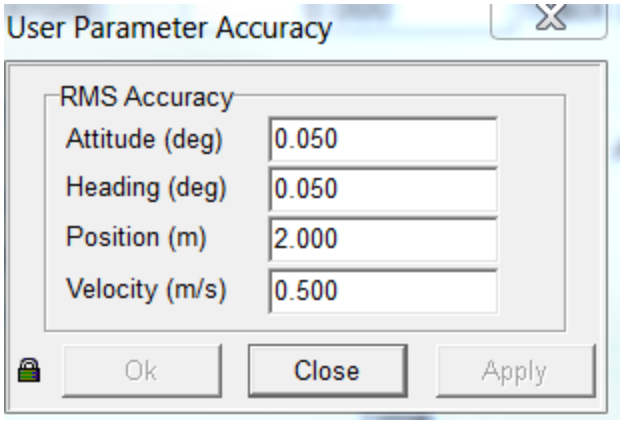
Installation



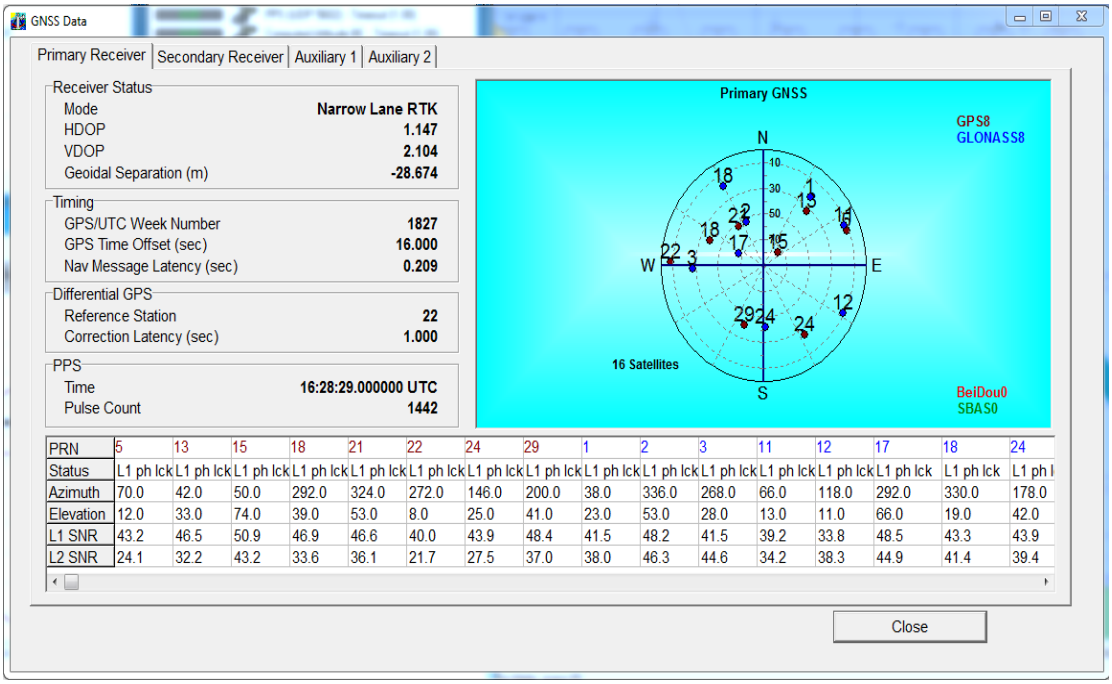




User Accuracy



GPS Reciever Configuration



PRN	5	13	15	18	21	22	24	29	1	2	3	11	12	17	18	24
Status	L1 ph lck	L1 ph lck	L1 ph lck	L1 ph lck	L1 ph lck	L1 ph lck	L1 ph lck	L1 ph lck	L1 ph lck	L1 ph lck	L1 ph lck	L1 ph lck	L1 ph lck	L1 ph lck	L1 ph lck	L1 ph l
Azimuth	70.0	42.0	50.0	292.0	324.0	272.0	146.0	200.0	38.0	336.0	268.0	66.0	118.0	292.0	330.0	178.0
Elevation	12.0	33.0	74.0	39.0	53.0	8.0	25.0	41.0	23.0	53.0	28.0	13.0	11.0	66.0	19.0	42.0
L1 SNR	43.2	46.5	50.9	46.9	46.6	40.0	43.9	48.4	41.5	48.2	41.5	39.2	33.8	48.5	43.3	43.9
L2 SNR	24.1	32.2	43.2	33.6	36.1	21.7	27.5	37.0	38.0	46.3	44.6	34.2	38.3	44.9	41.4	39.4

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OPR-J357-KR-14

MV JAB POS MV CALIBRATION REPORT

All values in meters, time in UTC, julian day

SYSTEM INFORMATION

Vessel: MV JAB
Date: 6/3/2015
Personnel: C. Ham, T. Intaphan

PCS Serial # 2292
IP Address: 129.100.1.231

POSView Version MV-POSView Version 8.01
POS Version POSMV 320 V5

GPS Receivers
Primary Reciever Trimble DSM232
Secondary Receive Trimble DSM232

CALIBRATION AREA

Location: Port Mansfield, TX

Approximate Position:

	Deg	Min	Sec
Lat:	26	31	22.21585
Long:	97	9	0.155627

GPS Corrections

DGPS Beacon Station: 816
Frequency: 304

RTK/VRS Station: Aransas Pass
Correction Type: CMRP
Coordinates:

	Deg	Min	Sec
Lat:			
Long:			
Ellips. Height:			

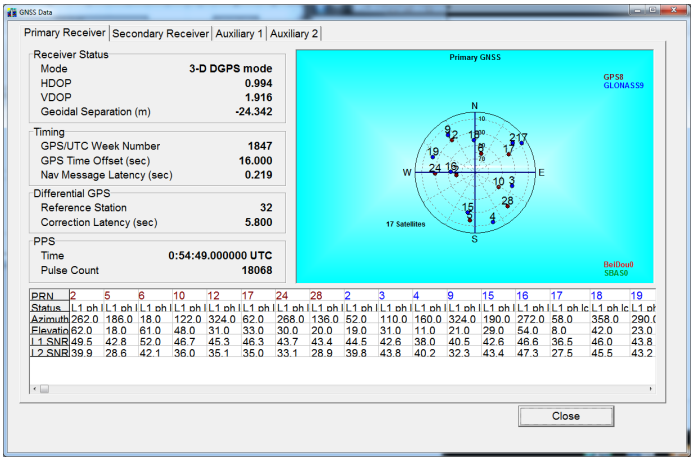
Satellite Constellation

Primary GPS (Port Antenna

HDOP: 0.994
VDOP 1.916
Satellites in Use: 17

PDOP:

Notes: Check skyplot of Secondary



POS MV CONFIGURATION

Settings

GAMS Parameter Setup

User Entries, Pre-Calibratio		Baseline Vector	
2.303	Two Antenna Separation (m)	0.00	X Component (m)
0.5	Heading Calibration Threshold	0.00	Y Component (m)
0	Heading Corrections	0.00	Z Component (m)

Notes:

POS MV CALIBRATION

Calibration Procedure

Start Time: 14:23:00 *UTC* | x | *Mark "x" here when start*

End Time: 14:40:00 *UTC* | x | *Mark "x" here when end*

Heading accuracy achieved for calibration: _____

Calibration Results

GAMS Parameter Setup

POS MV Post Calibration Values		Baseline Vector	
2.303	Two Antenna Separation (m)	-0.025	X Component (m)
0.5	Heading Calibration Threshold	2.303	Y Component (m)
0	Heading Corrections	-0.005	Z Component (m)

GAMS Status Online? **YES**

Save Settings? **YES**

Notes:

Save POS Settings

Filename: NOAA_150114_JAB.nvm

Centre of

GENERAL GUIDANCE

The POS MV uses a Right-Hand Orthogonal System

The right-hand orthogonal system defines the following:

- The x-axis is in the fore-aft direction in the appropriate reference frame
- The y-axis is perpendicular to the x-axis and points towards the right (starboard) side in the appropriate reference frame
- The z-axis points downwards in the appropriate reference frame

Frames of Reference

The IMU frame of reference includes the vertical and the horizontal axis of the IMU with which the orthogonal array of sensing elements aligns. These are fixed relative to the IMU and are identified by a label on the IMU housing.

By convention, POS MV uses the right-hand orthogonal co- ordinate system, with its origin centred on the black and yellow circle on the top of the IMU.

The sensor 1 reference frame includes the vertical and the horizontal axis of the multi-beam transducer. These axis are fixed relative to the multi-beam transducer.

By convention, POS MV uses the right-hand orthogonal coordinate system, with its origin at the sensing centre of the multi-beam transducer.

The vessel reference frame co-aligns with your chosen reference frame.

Tate-Bryant Rotation Sequence

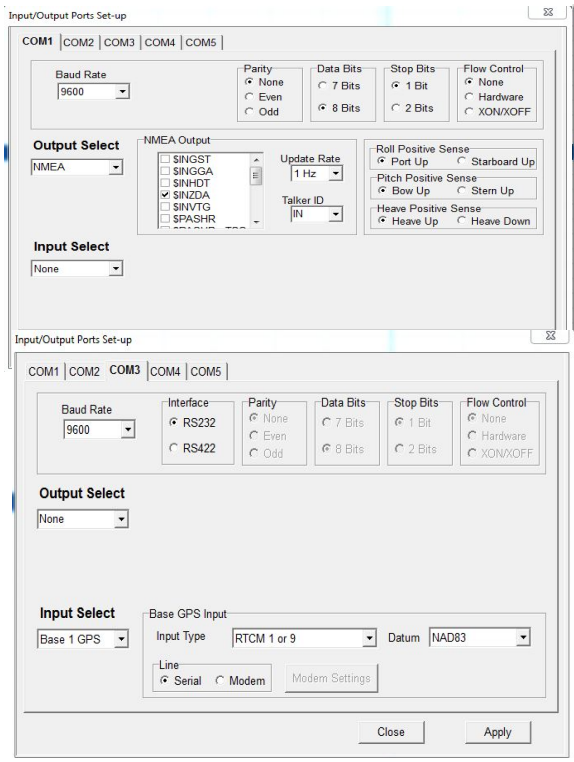
Apply the rotation in the following order to bring the two frames of reference into complete alignment:

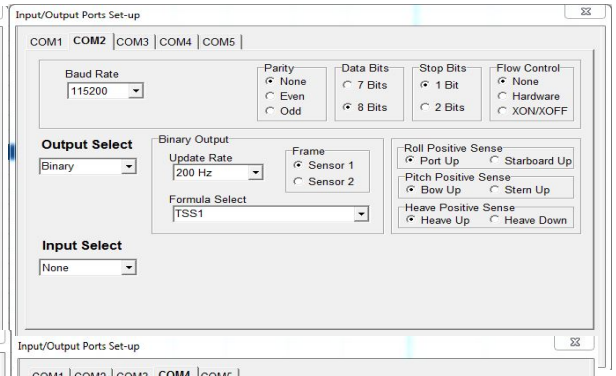
- Heading rotation - apply a right-hand screw rotation `z about the z-axis to align one frame with the other
- Pitch rotation - apply a right-hand screw rotation `y about the once-rotated y-axis to align one frame with the other
- Roll rotation - apply a right-hand screw rotation `x about the twice-rotated x-axis to align one frame with the other

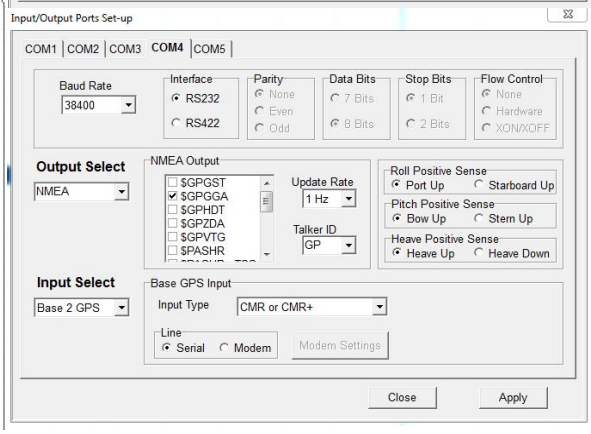
SETTINGS

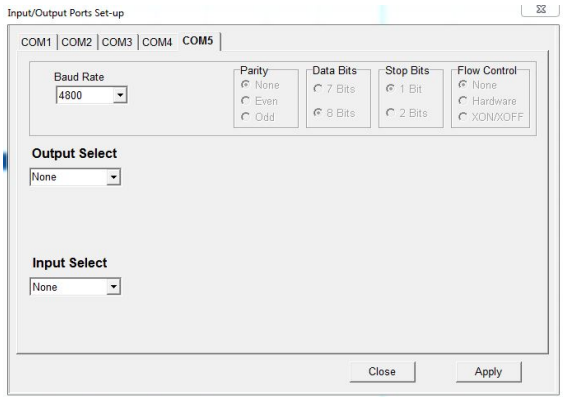
Insert screen-grabs here

Input / Output Ports

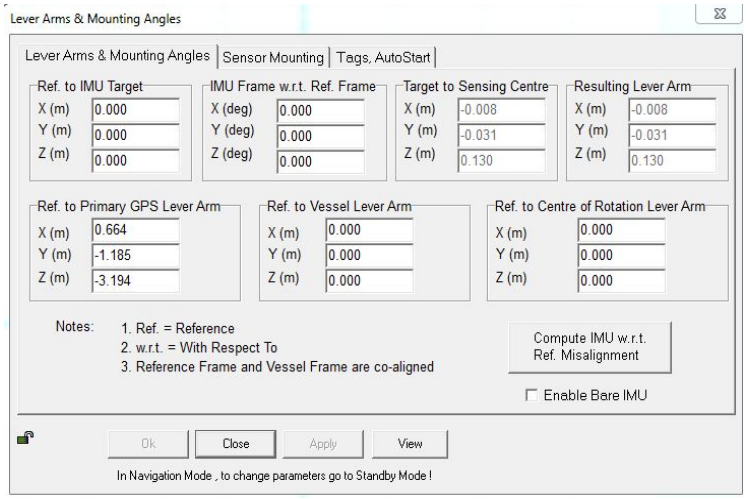


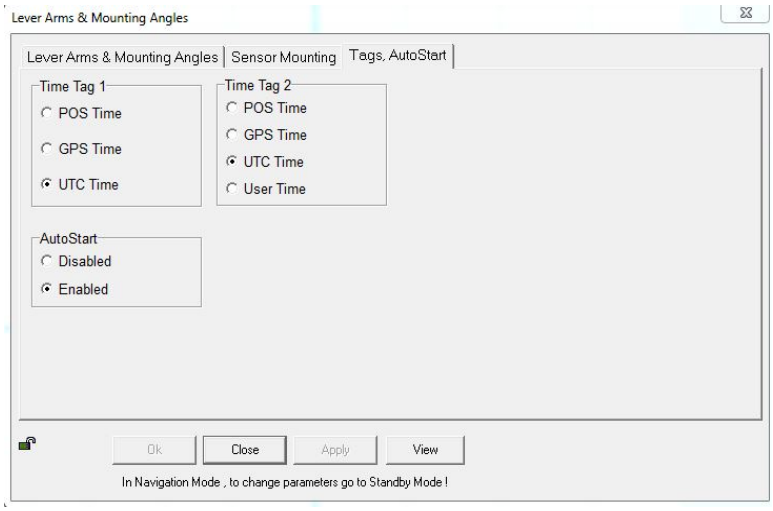




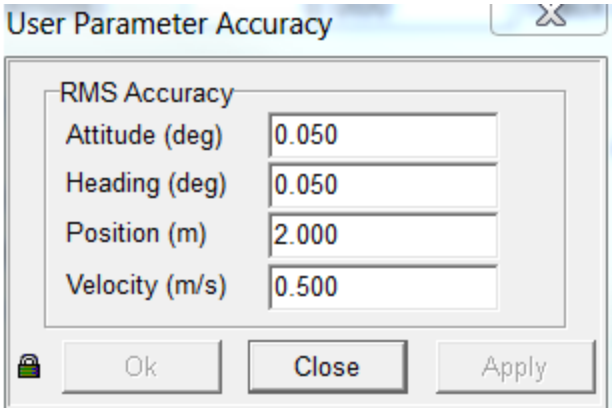


Installation

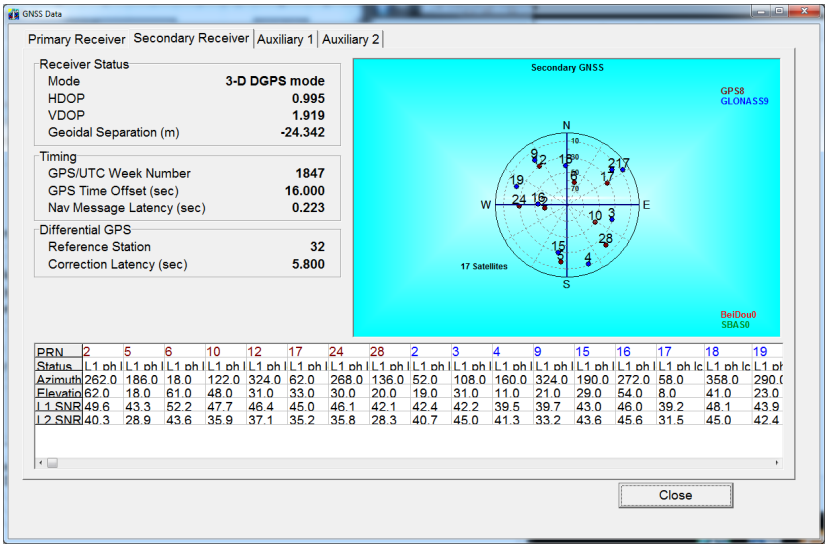




User Accuracy



GPS Reciever Configuration



PRN	2	5	6	10	12	17	24	28	2	3	4	9	15	16	17	18	19
Status	L1 ph	L1 ph	L1 ph	L1 ph	L1 ph	L1 ph	L1 ph	L1 ph	L1 ph	L1 ph	L1 ph	L1 ph	L1 ph	L1 ph	L1 ph	L1 ph	L1 ph
Azimuth	262.0	186.0	18.0	122.0	324.0	62.0	268.0	136.0	52.0	108.0	160.0	324.0	190.0	272.0	58.0	358.0	290.0
Elevatio	62.0	18.0	61.0	48.0	31.0	33.0	30.0	20.0	19.0	31.0	11.0	21.0	29.0	54.0	8.0	41.0	23.0
L1 SNR	49.6	43.3	52.2	47.7	46.4	45.0	46.1	42.1	42.4	42.2	39.5	39.7	43.0	46.0	39.2	48.1	43.9
L2 SNR	40.3	28.9	43.6	35.9	37.1	35.2	35.8	28.3	40.7	45.0	41.3	33.2	43.6	45.6	31.5	45.0	42.4

eTrac Inc.
637 Lindaro St.
Suite 100
San Rafael, CA 94901
888-410-3890

OPR-K370-KR-15

RV TAKU POS MV CALIBRATION REPORT

All values in meters, time in UTC, julian day

SYSTEM INFORMATION

Vessel: RV TAKU
Date: 6/3/2015
Personnel: K. Schultz, T. Cappanelli

PCS Serial # 7033
IP Address: 192.168.53.100

POSView Version MV-POSView Version 8.01
POS Version POSMV 320 V5

GPS Receivers
Primary Reciever Trimble DSM 232
Secondary Receive Trimble DSM 232

CALIBRATION AREA

Location: Port Mansfield, TX

Approximate Position:

	Deg	Min	Sec
Lat:	26	31	22.21585
Long:	97	9	0.155627

GPS Corrections

DGPS Beacon Station: 816
Frequency: 304

RTK/VRS Station: Aransas Pass
Correction Type: CMRP
Coordinates:

	Deg	Min	Sec
Lat:			
Long:			
Ellips. Height:			

Satellite Constellation

Primary GPS (Port Antenna

HDOP: 0.54
VDOP 1.41
Satellites in Use: 18

PDOP:

Notes: Check skyplot of Secondary

Insert screen grab of Pri.GPS Skyplot

POS MV CONFIGURATION

Settings

GAMS Parameter Setup

User Entries, Pre-Calibratio		Baseline Vector	
1.981	Two Antenna Separation (m)	0.00	X Component (m)
0.500	Heading Calibration Threshold	0.00	Y Component (m)
0.000	Heading Corrections	0.00	Z Component (m)

Notes:

POS MV CALIBRATION

Calibration Procedure

Start Time: 18:40:00 *UTC* | x | *Mark "x" here when start*

End Time: 18:52:00 *UTC* | x | *Mark "x" here when end*

Heading accuracy achieved for calibration: _____

Calibration Results

GAMS Parameter Setup

POS MV Post Calibration Values		Baseline Vector	
1.981	Two Antenna Separation (m)	0.004	X Component (m)
0.500	Heading Calibration Threshold	1.981	Y Component (m)
0.000	Heading Corrections	0.009	Z Component (m)

GAMS Status Online? **YES**

Save Settings? **YES**

Notes:

Save POS Settings

Filename: NOAA_150603_TAKU.nvm

Centre of

GENERAL GUIDANCE

The POS MV uses a Right-Hand Orthogonal System

The right-hand orthogonal system defines the following:

- The x-axis is in the fore-aft direction in the appropriate reference frame
- The y-axis is perpendicular to the x-axis and points towards the right (starboard) side in the appropriate reference frame
- The z-axis points downwards in the appropriate reference frame

Frames of Reference

The IMU frame of reference includes the vertical and the horizontal axis of the IMU with which the orthogonal array of sensing elements aligns. These are fixed relative to the IMU and are identified by a label on the IMU housing.

By convention, POS MV uses the right-hand orthogonal co- ordinate system, with its origin centred on the black and yellow circle on the top of the IMU.

The sensor 1 reference frame includes the vertical and the horizontal axis of the multi-beam transducer. These axis are fixed relative to the multi-beam transducer.

By convention, POS MV uses the right-hand orthogonal coordinate system, with its origin at the sensing centre of the multi-beam transducer.

The vessel reference frame co-aligns with your chosen reference frame.

Tate-Bryant Rotation Sequence

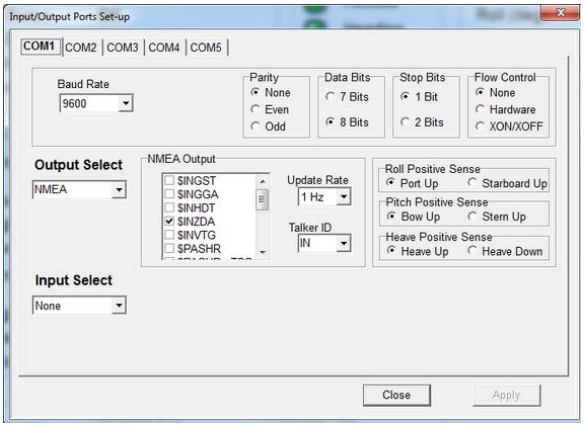
Apply the rotation in the following order to bring the two frames of reference into complete alignment:

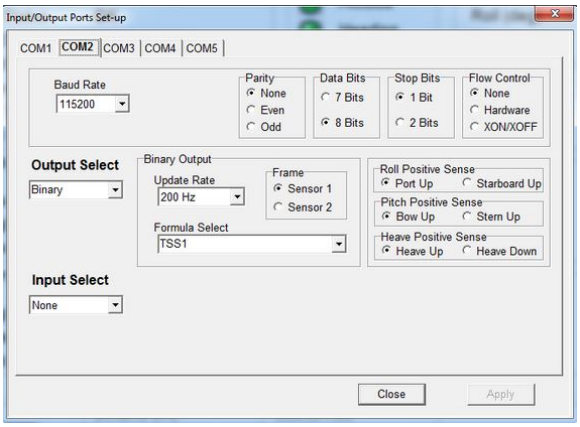
- Heading rotation - apply a right-hand screw rotation `z about the z-axis to align one frame with the other
- Pitch rotation - apply a right-hand screw rotation `y about the once-rotated y-axis to align one frame with the other
- Roll rotation - apply a right-hand screw rotation `x about the twice-rotated x-axis to align one frame with the other

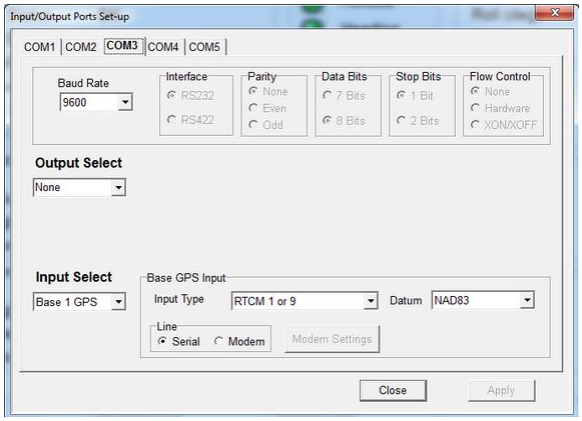
SETTINGS

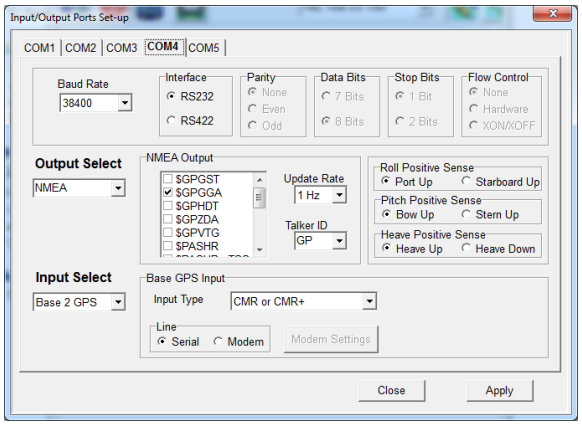
Insert screen-grabs here

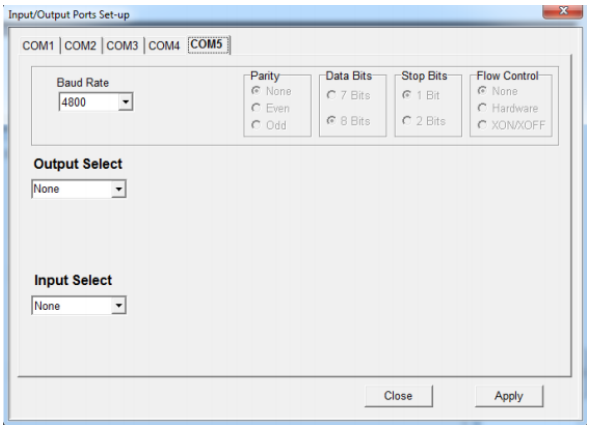
Input / Output Ports



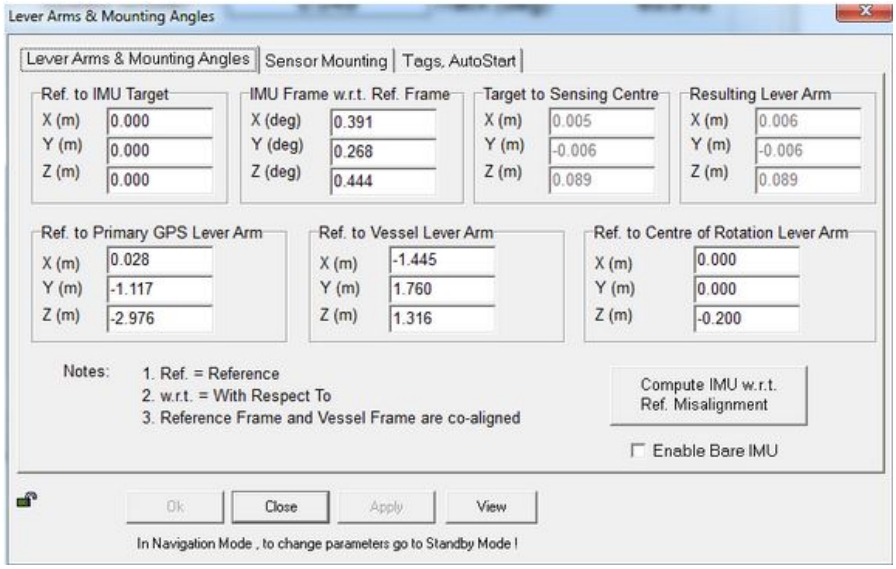


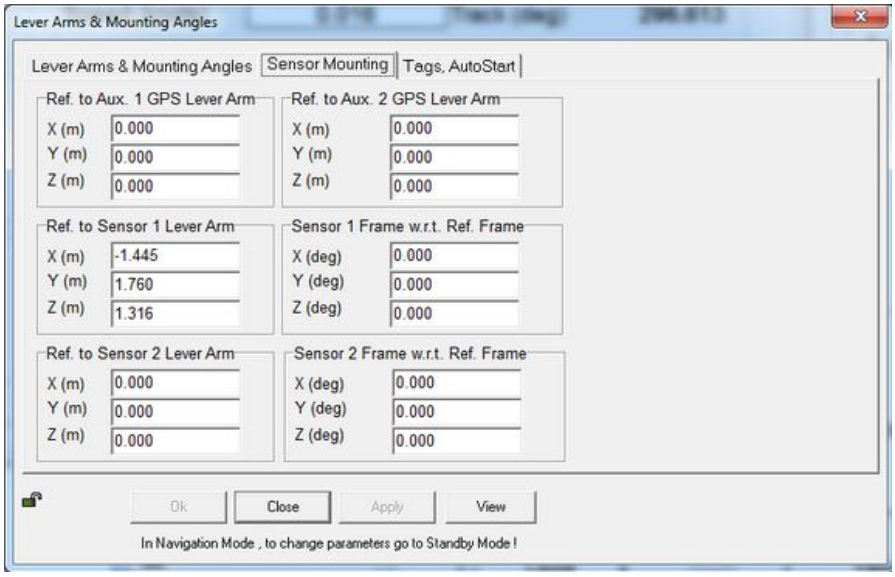


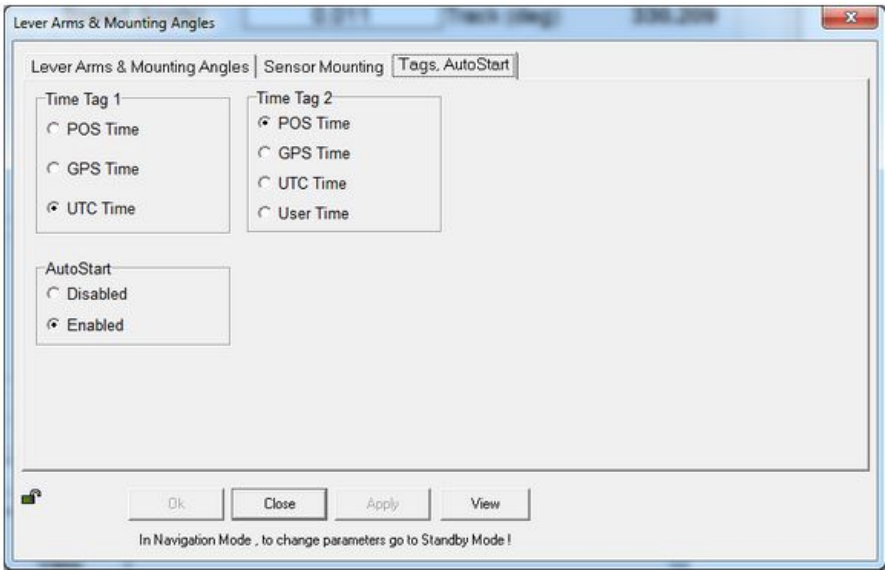




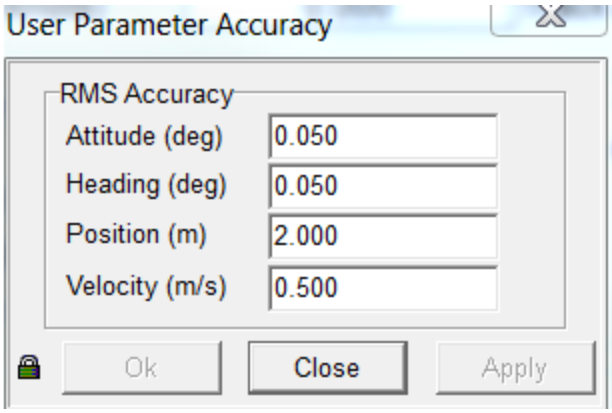
Installation







User Accuracy



GPS Reciever Configuration

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637 Lindaro St., Suite 100
San Rafael, CA 94901
888-410-3890

OPR-K370-KR-15 Port Mansfield

Weekly Position Confidence Check

				Geographic		UTM Zone 14		
Week of	**DN**	**Time (CT)**	**Positioning System**	**Latitude**	**Longitude**	**X**	**Y**	**Comments**
Using POS Primary Antenna on dock mark								
			OPUS/RTK-GPS check	**enter in published value**	**enter in published value**	**enter in published value**	**enter in published value**	**Dock Mark**
6/1/2015	155	19:30	POSMV - JAB	26.552697	-97.428685	656522.52	2937853.61	
			POSMV - TAKU	26.552704	-97.428702	656520.66	2937854.54	
			POSMV - BENTHOS	26.552700	-97.428703	656521.54	2937852.94	
					AVERAGE	**1.24**	**1.07**	**1.15**
6/8/2015	163	18:30	POSMV - JAB	26.552701335	-97.42869193	656521.56	2937853.95	
			POSMV - TAKU	26.552697808	-97.42868304	656522.45	2937853.57	
			POSMV - BENTHOS	26.552706402	-97.42869609	656521.14	2937854.51	
					AVERAGE	**0.87**	**0.63**	**0.75**
6/15/2015	169	17:00	POSMV - JAB	26.552701	-97.428689	656521.25	2937854.67	
			POSMV - TAKU	26.552701	-97.428688	656521.92	2937853.93	
			POSMV - BENTHOS	26.552694	-97.428694	656521.27	2937853.94	
					AVERAGE	**0.45**	**0.49**	**0.47**
6/22/2015	177	18:00	POSMV - JAB	26.552704	-97.428686	656522.15	2937854.23	
			POSMV - TAKU	26.552701	-97.428703	656520.39	2937853.97	
			POSMV - BENTHOS	26.552701	-97.428693	656521.43	2937853.94	
					AVERAGE	**1.17**	**0.19**	**0.68**
6/29/2015	182	16:00	POSMV - JAB	26.55270051	-97.4286821	656522.53	2937853.75	
			POSMV - TAKU	26.55270052	-97.4286898	656521.77	2937853.86	
			POSMV - BENTHOS	26.55270517	-97.4286995	656520.81	2937854.37	
					AVERAGE	**1.15**	**0.41**	**0.78**
7/6/2015	187	16:00	**OPUS**			656521.75	2937854.35	
			Average of all boats			656521.56	2937853.99	
					AVERAGE	**0.19**	**0.36**	**0.28**

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OPR-K370-KR-15 Port Mansfield

Weekly Position Confidence Check

				Geographic		UTM Zone 14		
Week of	**DN**	**Time (CT)**	**Positioning System**	**Latitude**	**Longitude**	**X**	**Y**	**Comments**
					Std Dev	**0.13**	**0.26**	
7/6/2015	189	13:28	POSMV - JAB	26.55270238	-97.42868685	656522.07	2937854.07	
			POSMV - TAKU	26.552705	-97.4286819	656522.56	2937854.32	
			POSMV - BENTHOS	26.552701	-97.42869974	656520.79	2937853.89	
					AVERAGE	**1.18**	**0.29**	**0.73**
Using DGPS Antenna on dock mark								
7/13/2015	197	17:00	POSMV - JAB	26.55272817	-97.4286922	656521.50	2937853.68	
			POSMV - TAKU	26.55270767	-97.42869083	656521.66	2937854.65	
			POSMV - BENTHOS	26.55270468	-97.4286886	656521.89	2937854.33	
					AVERAGE	**0.26**	**0.65**	**0.45**
7/20/2015	203	18:00	POSMV - JAB	26.552732333	-97.428680333	656521.51	2937854.39	
			POSMV - TAKU	26.552709667	-97.428686667	656521.52	2937854.42	
			POSMV - BENTHOS	26.552703986	-97.428693739	656521.38	2937854.24	
					AVERAGE	**0.09**	**0.12**	**0.11**
7/27/2015	211	17:15	POSMV - JAB	26.552696045	-97.428697886	656520.97	2937854.00	
			POSMV - TAKU	26.552695225	-97.428688964	656521.86	2937853.92	
			POSMV - BENTHOS	26.552697302	-97.428689036	656521.85	2937854.15	
					AVERAGE	**0.59**	**0.15**	**0.37**
8/3/2015	218	17:30	POSMV - JAB			656521.56	2937853.80	
			POSMV - BENTHOS			656521.34	2937854.17	
					AVERAGE	**0.22**	**0.37**	**0.30**
8/10/2015	222	16:30	POSMV - BENTHOS	26.552704133	97.42869063	656521.69	2937854.26	
	222	18:11	POSMV - JAB	26.552703000	-97.42868700	656521.20	2937854.20	
					AVERAGE	**0.24**	**0.03**	**0.14**

AVERAGE	**0.54**

APPENDIX IV
SOUND SPEED SENSOR REPORTS

This document certifies that the instrument detailed below has been calibrated according to Valeport Limited's Standard Procedures, using equipment with calibrations traceable to UKAS or National Standards.

Calibration Certificate Number:	**41342**
Instrument Type:	**miniSVS - SV only**
Instrument Serial Number:	**39252**
Calibrated By:	**L.Bicknell**
Date:	**26/03/2015**
Signed:	

Full details of the results from the calibration procedure applied to each fitted sensor are available, on request, via email. This summary certificate should be kept with the instrument.

Valeport Ltd | St Peter's Quay | Totnes | Devon | TQ9 5EW | UK
T: +44 (0) 1803 869292 | F: +44 (0) 1803 869293
E: sales@valeport.co.uk | www.valeport.co.uk

This document certifies that the instrument detailed below has been calibrated according to Valeport Limited's Standard Procedures, using equipment with calibrations traceable to UKAS or National Standards.

Calibration Certificate Number:	**40921**
Instrument Type:	**miniSVS - SV only**
Instrument Serial Number:	**48352**
Calibrated By:	**L.Bicknell**
Date:	**16/02/2015**
Signed:	

Full details of the results from the calibration procedure applied to each fitted sensor are available, on request, via email. This summary certificate should be kept with the instrument.

Valeport Ltd | St Peter's Quay | Totnes | Devon | TQ9 5EW | UK
T: +44 (0) 1803 869292 | F: +44 (0) 1803 869293
E: sales@valeport.co.uk | www.valeport.co.uk

VALEPORT

Calibration Certificate Number: **40922**

This document certifies that the instrument detailed below has been calibrated according to Valeport Limited's Standard Procedures, using equipment with calibrations traceable to UKAS or National Standards.

Instrument Type:	**miniSVS - SV only**
Instrument Serial Number:	**31057**
Calibrated By:	**L.Bicknell**
Date:	**2/16/15**
Signed:	

Full details of the results from the calibration procedure applied to each fitted sensor are available in separate documents. This summary certificate should be kept with the instrument.

Valeport Limited, St. Peter's Quay, Totnes, Devon, TQ9 5EW. U.K.
Tel: +44 (0)1803 869292 Fax: +44 (0)1803 869293
E-mail: sales@valeport.co.uk Web: www.valeport.co.uk

Certificate of Calibration

Customer:	Geodynamics LLC
Asset Serial Number:	200936
Asset Product Type:	SV•Xchange™ Calibrated Sensor
Calibration Type:	Sound Velocity
Calibration Range:	1375 to 1625 m/s
Calibration RMS Error:	.0058
Calibration ID:	200936 888888 200936 190515 090131
Installed On:	

Coefficient A:	0.000000E+0	Coefficient H:	1.945445E-7
Coefficient B:	0.000000E+0	Coefficient I:	0.000000E+0
Coefficient C:	1.179695E-6	Coefficient J:	0.000000E+0
Coefficient D:	1.945983E-7	Coefficient K:	0.000000E+0
Coefficient E:	-1.825497E-5	Coefficient L:	0.000000E+0
Coefficient F:	1.954585E-7	Coefficient M:	0.000000E+0
Coefficient G:	1.405890E-6	Coefficient N:	0.000000E+0

Calibration Date (dd/mm/yyyy): 19/5/2015

Certified By:

Robert Haydock

President, AML Oceanographic

AML Oceanographic certifies that the asset described above has been calibrated or recalibrated with equipment referenced to traceable standards. Please note that Xchange™ sensor-heads may be installed on assets other than the one listed above; this calibration certificate will still be valid when used on other such assets. If this instrument or sensor has been recalibrated, please be sure to update your records. Please also ensure that you update the instrument's coefficient values in any post-processing software that you use, if necessary. Older generation instruments may require configuration files, which are available for download at our Customer Centre at www.AMLoceanographic.com/support

AML Oceanographic
2071 Malaview Avenue, Sidney B.C. V8L 5X6 CANADA
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Certificate of Calibration

Customer:	eTrac Engineering, LLC
Asset Serial Number:	204646
Asset Product Type:	SV•Xchange™ Calibrated Sensor
Calibration Type:	Sound Velocity
Calibration Range:	1375 to 1625 m/s
Calibration RMS Error:	-.0173
Calibration ID:	204646 888888 204646 210515 091405
Installed On:	010858

Coefficient A:	0.000000E+0	Coefficient H:	1.942642E-7
Coefficient B:	0.000000E+0	Coefficient I:	0.000000E+0
Coefficient C:	-9.022187E-9	Coefficient J:	0.000000E+0
Coefficient D:	1.942720E-7	Coefficient K:	0.000000E+0
Coefficient E:	-1.842651E-5	Coefficient L:	0.000000E+0
Coefficient F:	1.948410E-7	Coefficient M:	0.000000E+0
Coefficient G:	8.818460E-8	Coefficient N:	0.000000E+0

Calibration Date (dd/mm/yyyy): 21/5/2015

Certified By:

AML Oceanographic

Robert Haydock

President, AML Oceanographic

AML Oceanographic certifies that the asset described above has been calibrated or recalibrated with equipment referenced to traceable standards. Please note that Xchange™ sensor-heads may be installed on assets other than the one listed above; this calibration certificate will still be valid when used on other such assets. If this instrument or sensor has been recalibrated, please be sure to update your records. Please also ensure that you update the instrument's coefficient values in any post-processing software that you use, if necessary. Older generation instruments may require configuration files, which are available for download at our Customer Centre at www.AMLoceanographic.com/support

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Certificate of Calibration

Customer:	eTrac Engineering, LLC
Asset Serial Number:	204672
Asset Product Type:	SV•Xchange™ Calibrated Sensor
Calibration Type:	Sound Velocity
Calibration Range:	1375 to 1625 m/s
Calibration RMS Error:	-.0092
Calibration ID:	204672 999999 204672 120515 110706
Installed On:	010818

Coefficient A:	0.000000E+0	Coefficient H:	1.948570E-7
Coefficient B:	0.000000E+0	Coefficient I:	0.000000E+0
Coefficient C:	9.115320E-8	Coefficient J:	0.000000E+0
Coefficient D:	1.948989E-7	Coefficient K:	0.000000E+0
Coefficient E:	-1.862249E-5	Coefficient L:	0.000000E+0
Coefficient F:	1.955012E-7	Coefficient M:	0.000000E+0
Coefficient G:	3.066962E-7	Coefficient N:	0.000000E+0

Calibration Date (dd/mm/yyyy): 12/5/2015

Certified By:

AML Oceanographic

Robert Haydock

President, AML Oceanographic

AML Oceanographic certifies that the asset described above has been calibrated or recalibrated with equipment referenced to traceable standards. Please note that Xchange™ sensor-heads may be installed on assets other than the one listed above; this calibration certificate will still be valid when used on other such assets. If this instrument or sensor has been recalibrated, please be sure to update your records. Please also ensure that you update the instrument's coefficient values in any post-processing software that you use, if necessary. Older generation instruments may require configuration files, which are available for download at our Customer Centre at www.AMLoceanographic.com/support

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Certificate of Calibration

Customer:	R2Sonic, LLC
Asset Serial Number:	204352
Asset Product Type:	SV•Xchange™ Calibrated Sensor
Calibration Type:	Sound Velocity
Calibration Range:	1375 to 1625 m/s
Calibration RMS Error:	.005
Calibration ID:	204352 000000 000000 060115 094412
Installed On:	025114

Coefficient A:	0.000000E+0	Coefficient H:	1.948978E-7
Coefficient B:	0.000000E+0	Coefficient I:	0.000000E+0
Coefficient C:	2.433080E-8	Coefficient J:	0.000000E+0
Coefficient D:	1.949272E-7	Coefficient K:	0.000000E+0
Coefficient E:	-1.914048E-5	Coefficient L:	0.000000E+0
Coefficient F:	1.956965E-7	Coefficient M:	0.000000E+0
Coefficient G:	1.755543E-7	Coefficient N:	0.000000E+0

Calibration Date (dd/mm/yyyy): 6/1/2015

Certified By:

AML Oceanographic

Robert Haydock

President, AML Oceanographic

AML Oceanographic certifies that the asset described above has been calibrated or recalibrated with equipment referenced to traceable standards. Please note that Xchange™ sensor-heads may be installed on assets other than the one listed above; this calibration certificate will still be valid when used on other such assets. If this instrument or sensor has been recalibrated, please be sure to update your records. Please also ensure that you update the instrument's coefficient values in any post-processing software that you use, if necessary. Older generation instruments may require configuration files, which are available for download at our Customer Centre at www.AMLoceanographic.com/support

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Certificate of Calibration

Customer:	eTrac Engineering, LLC
Asset Serial Number:	204352
Asset Product Type:	SV•Xchange™ Calibrated Sensor
Calibration Type:	Sound Velocity
Calibration Range:	1375 to 1625 m/s
Calibration RMS Error:	-.0092
Calibration ID:	204352 999999 204352 140915 121148
Installed On:	025114

Coefficient A:	0.000000E+0	Coefficient H:	1.947764E-7
Coefficient B:	0.000000E+0	Coefficient I:	0.000000E+0
Coefficient C:	2.685702E-7	Coefficient J:	0.000000E+0
Coefficient D:	1.948043E-7	Coefficient K:	0.000000E+0
Coefficient E:	-1.872965E-5	Coefficient L:	0.000000E+0
Coefficient F:	1.955550E-7	Coefficient M:	0.000000E+0
Coefficient G:	4.203175E-7	Coefficient N:	0.000000E+0

Calibration Date (dd/mm/yyyy): 14/9/2015

Certified By:

AML Oceanographic

Robert Haydock
President, AML Oceanographic

AML Oceanographic certifies that the asset described above has been calibrated or recalibrated with equipment referenced to traceable standards. Please note that Xchange™ sensor-heads may be installed on assets other than the one listed above; this calibration certificate will still be valid when used on other such assets. If this instrument or sensor has been recalibrated, please be sure to update your records. Please also ensure that you update the instrument's coefficient values in any post-processing software that you use, if necessary. Older generation instruments may require configuration files, which are available for download at our Customer Centre at www.AMLoceanographic.com/support

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