U.S. DEPARTMENT OF COMMERCE

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

NATIONAL OCEAN SERVICE

DATA ACQUISITION AND PROCESSING REPORT

Type of Survey	**Hydrographic**
Project	**S-P958-KR-18**
Contract No	**EA-133C-14-CQ-0031**
Task Order No	**T0009**
Time Frame	**DECEMBER 2018 - FEBRUARY 2019**

State	**Alaska**
General Locality	**Anchorage and Nikiski**

2018

CHIEF OF PARTY

David R. Neff, C.H.

LIBRARY & ARCHIVES

Date

NOAA FORM 77-28
(11-72)

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

REGISTRY No

F00763
F00764

HYDROGRAPHIC TITLE SHEET

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	Alaska		
General Locality	Alaska		
Sub-Locality	Vicinity of Achhorage and Nikiski		
Scale	20000	**Date of Survey**	August - December 2018
Instructions Dated	December 12, 2018	**Project No.**	S-P958-KR-18
Vessel	R/V Resolution, M/V Glacier Wind		
Chief of Party	David R. Neff, C.H.		
Surveyed by	eTrac Inc.		
Soundings by echo sounder	R2 Sonic 2022, R2 Sonic 2020		
Graphic record scaled by	N/A		
Graphic record checked by	N/A	**Automated Plot**	N/A
Verification by	Pacific Hydrographic Branch		
Soundings in	Meters at MLLW		

REMARKS:

NAD 83 (2011), UTM Zone 5

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:

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

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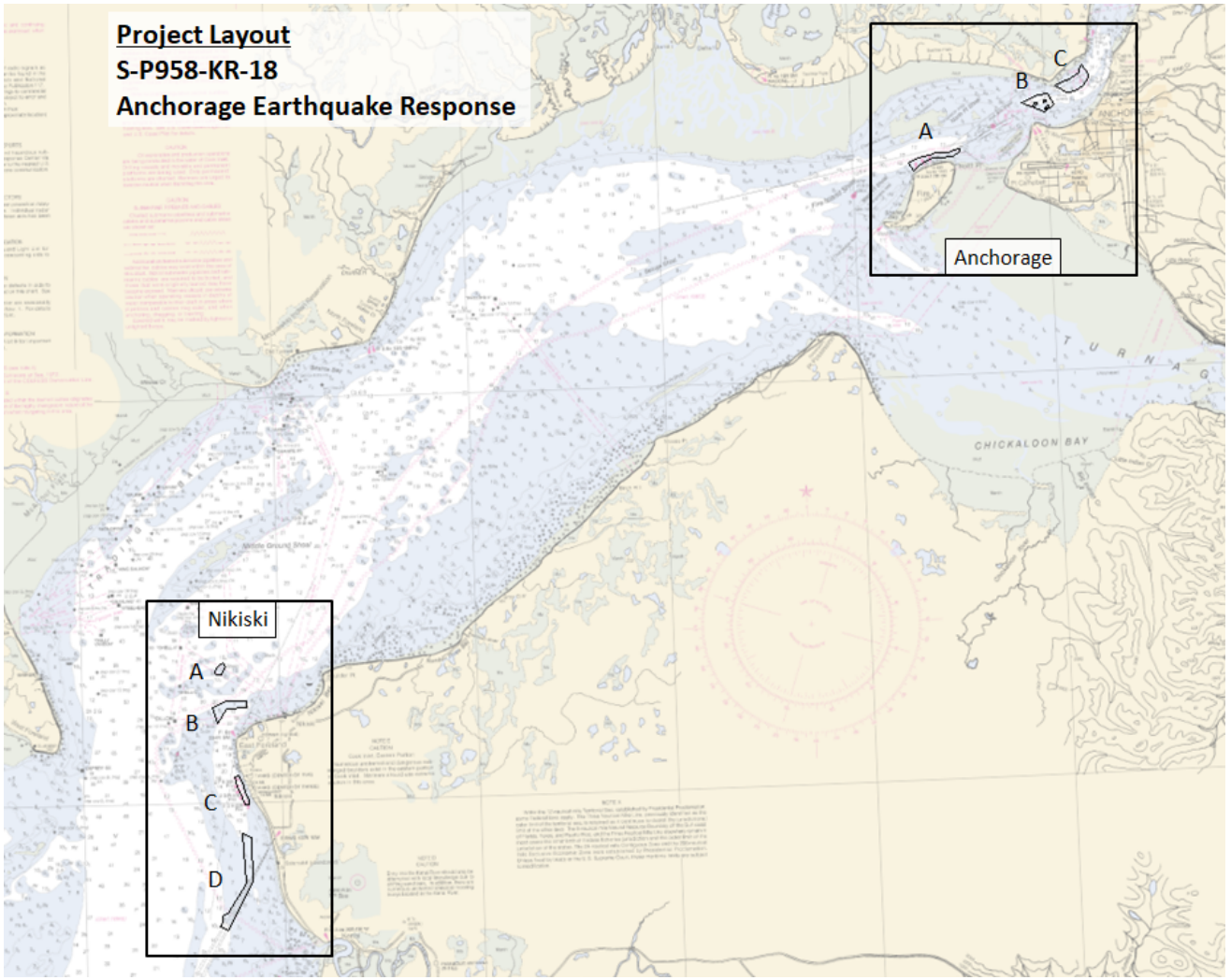


Figure 1: S-P958-KR-18

A. EQUIPMENT

A.1. Vessels

A.1.1. R/V Resolution

eTrac Inc. provided the R/V Resolution for hydrographic survey operations on S-P958-KR-18. The R/V Resolution is a 26 foot Catamaran with the following specifications:

Overall Length:	26 ft.
Beam:	8.5 ft.
Draft:	3 ft.
Sonar Mount:	Single Side Mounted Universal Sonar Mount
Propulsion:	Twin 150hp Suzuki Outboards
Drives:	Outboard Prop's
Fuel Capacity:	120 Gal Gas
Generator:	Yamaha 2000kw portable gas generator
Bridge Equipment:	Garmin Chartplotter, Radar, (2) VHF radios, Epirb, 6 person life raft

Figure 2: R/V Resolution

Table 1: R/V Resolution Hardware

Instrument	Function	Manufacturer	Model	Serial Number	Function
Multibeam Echosounder					
Deck Unit	Bathymetry	R2Sonic	2022	100259	MBES
Receiver	Bathymetry	R2Sonic	2022	100540	MBES
Projector	Bathymetry	R2Sonic	2022	800083	MBES
Sound Speed					
Surface Sound Speed	Bathymetry	AML	MicroX	31057	Beam formation and steering
SV Sensor	Bathymetry	AML	SV.Xchange	203209	Removable SV sensor on MicroX
Sound Speed Profiler	Bathymetry	AML	BaseX	25081	Primary SV profiler on MicroX
SV Sensor	Bathymetry	AML	SV.Xchange	201439	Removable SV sensor on MicroX
Pressure Sensor	Bathymetry	AML	P.Xchange	305099	Primary pressure sensor on MicroX
Navigation					
Deck Unit	Position/Attitude/Heading	Applanix	POSMV 220 V5	4108	GPS and inertial reference system for position, heading, heave, roll, and pitch data.
IMU	Position/Attitude/Heading	Applanix	IMU 36	0444	
Starboard Antenna	Position/Attitude/Heading	Trimble	Zephyr Model2	5049K19100	
Port Antenna	Position/Attitude/Heading	Trimble	Zephyr Model2	5052K20123	
DGPS Becon Receiver	DGPS Becon Receiver	Hemisphere	MBX-4	2327	

Refer to Section A.8.1- Mobilization & Appendix I for additional vessel information.

A.1.2. M/V Glacier Wind

eTrac Inc. contracted the M/V Glacier Wind for hydrographic survey operations on S-P958-KR-18. The M/V Glacier Wind is a 65 ft Offshore Supply Vessel with the following specifications:

Overall Length:	65 ft
Beam:	26 ft
Draft:	12 ft
Sonar Mount:	Custom Sonar Mount (moon pool)
Propulsion:	Diesel Propeller
Drives:	Cummins KTA 38MO
Fuel Capacity:	USG Diesel
Generator:	Cummins KTA 38
Bridge Equipment:	GPS, Fathometer, Rader, Plotter, Sat Phone, Gyro, Auto Pilot, Ice Classed Rated Hull

Figure 3: M/V Glacier Wind

Table 2: M/V Glacier Wind Hardware

Instrument	Function	Manufacturer	Model	Serial Number	Function
Multibeam Echosounder					
Deck Unit	Bathymetry	R2Sonic	2020	104344	MBES
Receiver	Bathymetry	R2Sonic	2020	300142	MBES
Projector	Bathymetry	R2Sonic	2020	300142	MBES
Sound Speed					
Surface Sound Speed	Bathymetry	AML	MicroX	31057	Beam formation and steering
SV Sensor	Bathymetry	AML	SV.Xchange	203209	Removable SV sensor on MicroX
Sound Speed Profiler	Bathymetry	AML	BaseX	25081	Primary SV profiler on BaseX
SV Sensor	Bathymetry	AML	SV.Xchange	201439	Removable SV sensor on BaseX
Pressure Sensor	Bathymetry	AML	P.Xchange	305099	Primary pressure sensor on BaseX
Navigation					
Deck Unit	Position/Attitude/Heading	R2Sonic	I2NS	104344	GPS and inertial reference system for position, heading, heave, roll, and pitch data.
IMU	Position/Attitude/Heading	R2Sonic	I2NS	501107	
Starboard Antenna	Position/Attitude/Heading	Trimble	Zephyr Model2	9876	
Port Antenna	Position/Attitude/Heading	Trimble	Zephyr Model2	9878	
DGPS Becon Receiver	DGPS Becon Receiver	Hemisphere	MBX-4	2327	

Refer to Section A.8.1- Mobilization & Appendix I for additional vessel information.

A.2. Sounding Equipment

A.2.1. Multibeam Echosounders

A.2.1.1. R2Sonic 2020 MBES

M/V Glacier Wind was equipped with a R2Sonic 2020 Multibeam Echosounder System (MBES). The2020 utilizes 256 discretely formed beams and produces 1024 soundings in Ultra-High-Density mode, over a selectable sector up to 130°. At 400kHz the 2020 focuses an across-track and along-track beamwidth of 2° and 1° respectively. The 2020 operates at a maximum ping rate of 65Hz and is designed to comply with IHO standards for depth measurement to a maximum range of 100+ meters.

A.2.1.1. R2Sonic 2022 MBES

R/V Resolution was equipped with a R2Sonic 2022 Multibeam Echosounder System (MBES). The 2022 utilizes 256 discretely formed beams over a selectable sector up to 160°. At 400kHz the 2022 focuses an across-track and along-track beamwidth of 1° and 1° respectively. The 2022 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.

A.3. Positioning Equipment

A.3.1. Applanix POSMV

R/V Resolution was mobilized with an Applanix POSMV 220 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 for R/V Resolution.

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 RS232 serial connection 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. R2Sonic I2INS

M/V Glacier Wind was mobilized with a R2Sonic I2NS. The R2Sonic I2NS is a combined Applianix POSMV 220 and R2Sonic topside unit. The POSMV portion of the I2NS was used to acquire position, attitude, and heading throughout the entire survey. The POSMV 220 integrates a 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 for R/V Resolution.

A.4. Sound Speed Equipment

All sound speed sensors used on the project were calibrated within 1 year of survey commencement per the HSSD 2018. Manufacturer certified calibration sheets can be referenced in Appendix IV of this document.

A.4.1. Surface Sound Speed Measurement

The R2sonic 2020 and 2022 utilize an AML Micro•X located at the sonar head for surface sound speed measurement. The AML Micro•X is a time of flight SV sensor and is powered through the R2Sonic topside or powered directly from a 12 volt power source via RS232 serial cable connection. Sound speed measurements (measured in meters per second) are output through the same serial connection at 1Hz.

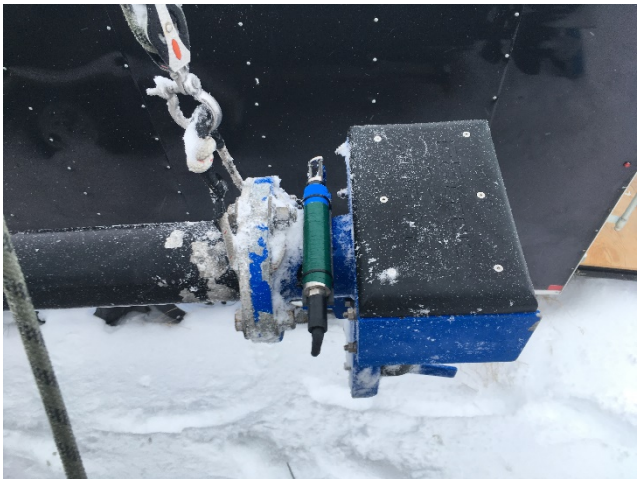


Figure 4: AML Micro•X Sensor Mobilized on an R2Sonic 2022

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 100 meters. The Base•X is capable of transferring data via RS-232 serial cable. AML SeaCast software is run on the acquisition computer to facilitate the data transfer and profile formatting.

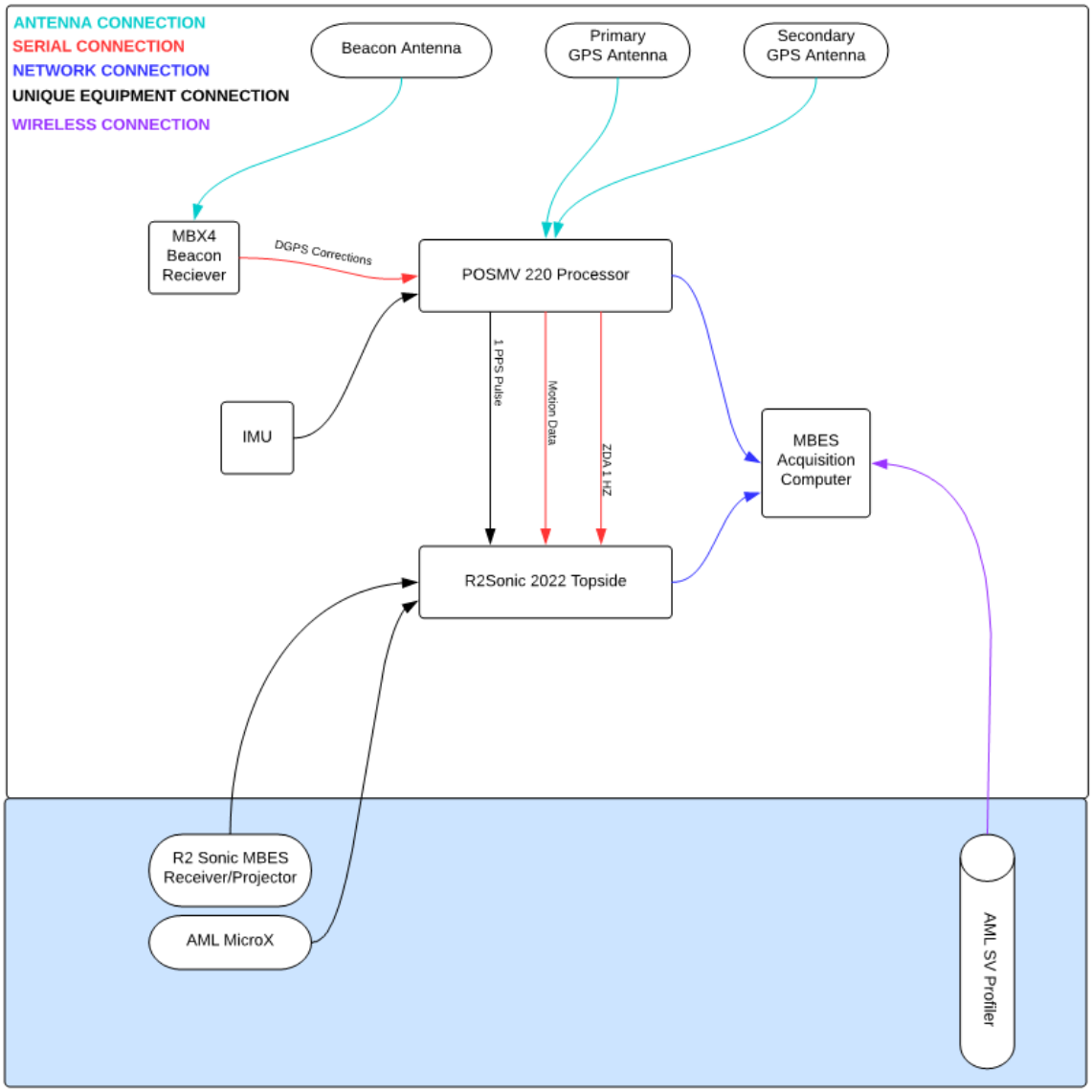


Figure 5: R/V Resolution Acquisition Systems Diagram

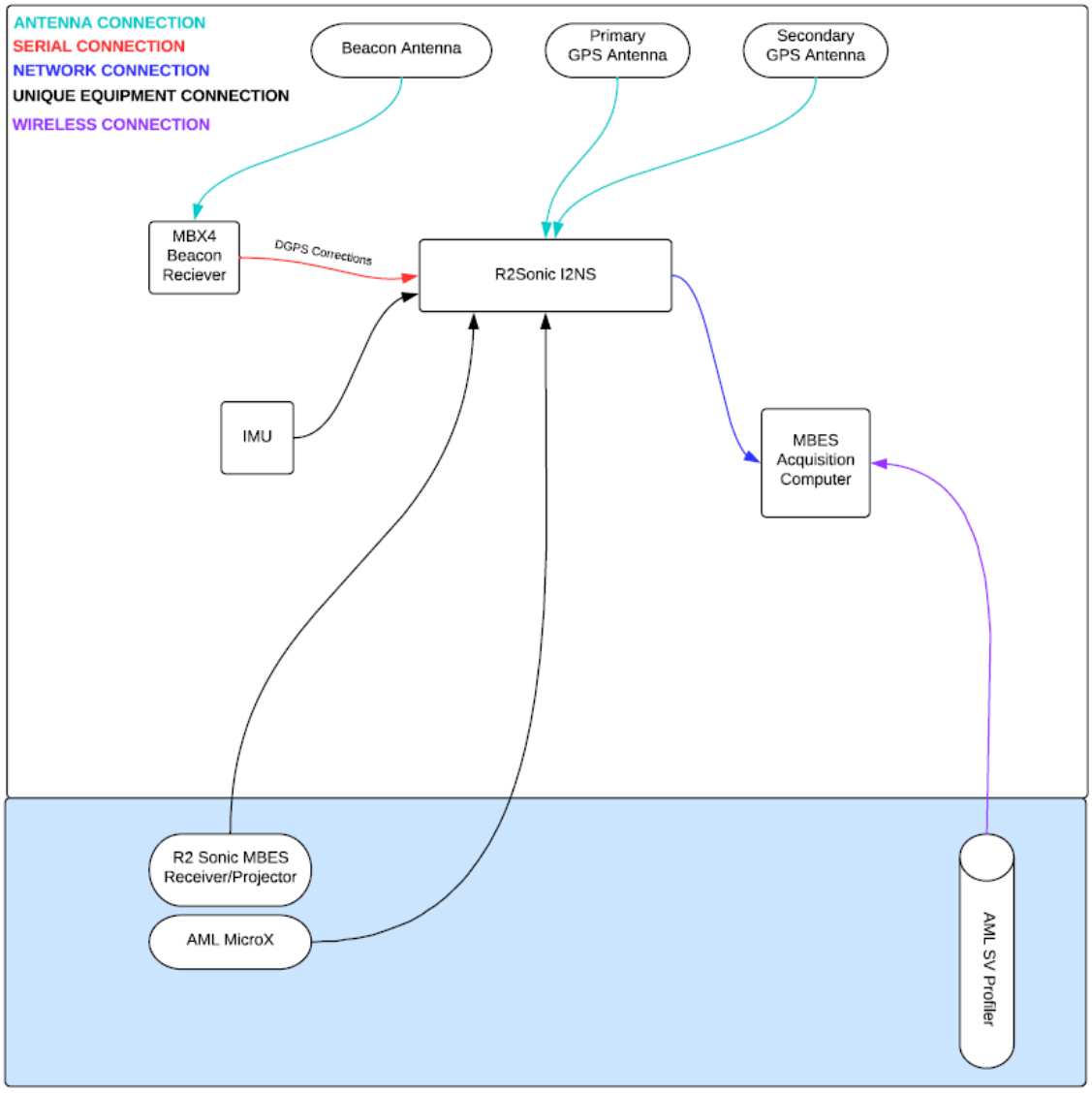


Figure 6: M/V Glacier Wind Acquisition Systems Diagram

A.6. Computer Hardware

A.6.1. Acquisition Computer Hardware

Two 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 vessels' power. A table of acquisition computer information is shown below.

Table 3: Acquisition Computer Hardware

Acquisition Computer Hardware					
Name	**Make**	**Processor**	**OS**	**Location**	**Function**
Field 1	Advantech	4 Core i7	Windows 10	R/V Resolution	MBES
Field 2	Advantech	4 Core i7	Windows 10	M/V Glacier Wind	MBES

A.6.2. Processing Computer Hardware

Processing computers were mobilized in the Alaska office in Anchorage, on M/V Glacier Wind, and in the main office in San Rafael. 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 shipped hard drives. Final data processing was completed in San Rafael. A table of processing computer information is shown below.

Table 4: Processing Computer Hardware

Processing Computer Hardware					
Name	**Make**	**Processor**	**OS**	**Location**	**Function**
Boba	Dell	Intel Core i7	Windows 10	M/V Glacier Wind	MBES Processing
Jaba	Dell	Intel Core i7	Windows 10	San Rafael Office	MBES Processing

A.7. Computer Software

A.7.1. Acquisition Software

Table 5: Acquisition Software

Acquisition Software			
Manufacturer	**Name**	**Version**	**Installation Date**
QPS	Qinsy	8.17	8/15/2017
R2Sonic, LLC	R2Sonic	4/13/2017	6/21/2017
R2Sonic, LLC	R2Sonic 2024 Firmware (SIM)	4/21/2017	6/21/2017
AML Oceanographic	Seacast	4.3.1	6/20/2017
Applanix	MV-POSView	8.60	7/12/2016
Applanix	PosMV 320 Firmware	8.63	7/12/2016
Microsoft	Microsoft Excel	2003	5/1/2015
Google	Google Drive	1.31	5/1/2015

A.7.1.1. QPS QINSy

QPS QINSy was used as the main data collection and line tracking software on all vessels. Additionally, QPS QINSy was also used on each vessel for realtime quality control of the survey data.

The following realtime data inputs were combined and recorded into raw DB data files in QINSy on R/V Resolution and M/V Glacier Wind:

- Applanix POSMV Ethernet Packets (50Hz)
- R2Sonic Ethernet Packets
- DGPS (1Hz)
- AML Micro SV Surface Sound Speed data (1Hz)
- AMLBaseX Sound Speed Profile data

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 on R/V Resolution and M/V Glacier Wind:

- **Coverage Display** (Shows realtime depth colored coverage grid)
- **QC Display** (Shows realtime coverage grid colored by standard deviation)
- **Backscatter Display** (Shows realtime intensity of backscatter colored by relative hardness of bottom)
- **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 2020 and R2Sonic 2022. 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. Raw Water Column data collection can be enabled within the Sonic Controller during acquisition.

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 probes. Cast data were downloaded directly after each cast and saved on the data collection computer.

A.7.1.4. ApplanixPOSView

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. Microsoft Excel

Microsoft Excel was utilized during data collection as the host software of the digital field log. Every major aspect of field data collection was noted in the digital field log with a time-tag in order to maintain a historical record of daily operations, as well as aid the processing office.

A.7.2. Processing Software

Table 6: Processing Software

Processing Software			
Manufacturer	**Name**	**Version**	**Installation Date**
QPS	Qimera	1.7.4	11/14/2018
QPS	FMGeocoder Toolbox	7.7.8	8/1/2017
Applanix	POSPac MMS	8.2.1	6/29/2016

A.7.2.1. QPS Qimera

QPS Qimera is a bathymetric processing and analysis program. Qimera was utilized in the processing workflow as the exclusive MBES processing software. MBES data were acquired in DB format and processed within Qimera.

In addition to MBES processing procedures, Qimera 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, assigned charted features were included in the S-57 Final Feature File (FFF) with updated charting recommendations.

A.7.2.2. QPS FMGeocoder Toolbox

QPS FMGeocoder Toolbox (FMGT) is a program designed to process, view, and analyze backscatter data. FMGT was utilized in the processing workflow as the exclusive snippets/backscatter processing software to confirm that snippets were collected during all MBES data collection to meet Complete Coverage requirements as specified in the HSSD. Snippets data from Qinsy Paired (DB/QPD) files or XFs (exported from DBs)were brought into FMGT and processed into backscatter mosaics daily to confirm backscatter complete coverage.

A.7.2.3. ApplanixPOSPac 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 during daily processing efforts as well as mobilization and calibration procedures. Specifically POSPac MMS was utilized to create Smooth Best Estimate of Trajectory (SBET) from position data collected during daily operating procedures. As detailed in the HVCR, using trajectory data logged from the POSMV, along with CORS station base files, SBET's were created and quality checked in POSPac MMS. Upon thorough review, the SBETs were then applied in QPS Qimera.

A.7.3. Reporting Software

Table 7: Reporting Software

Processing Software			
Manufacturer	**Name**	**Version**	**Installation Date**
Google	Google Drive	1.31	5/1/2015
eTrac Inc.	DensityTrac	1.0.0.17	9/15/2017
eTrac Inc.	XML DR	1.1.0.14	11/14/2017
NOAAHydrOffice	QC Tools	2.6.7	9/1/2018
CARIS	HIPS and SIPS	10.2.2	8/1/2018

A.7.3.1. 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 were all hosted on the drive. Each data processor and employee had access to the documents with permissions determined as needed. The entirety of the Google Drive project folder was backed up locally every 24 hours. There were many

advantages of maintaining the project documents in a cloud based environment including version control, extended document history recording, and realtime collaboration.

A.7.3.2. DensityTrac

DensityTrac is a program developed by eTrac Inc. to determine density statistics of a dataset provided in BBHformat. 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.7.3.3. 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.7.3.4. NOAA HydrOffice – QC Tools

QC Tools is a program developed by NOAA's HydrOffice to improve data quality issues and to compute statistics of various measurements. The CUBE surface is exported as a bag file and loaded into QC Tools. Within QC Tools, there are options to identify and/or calculate depth statistics, TPU statistics, holidays and fliers. QC Tools was used throughout data collection as well as on our final CUBE surface.

A.7.3.5. Caris HIPS and SIPS

Caris HIPS and SIPS was used to assist in reporting tasks which QPS Qimera currently lacks. HIPS and SIPS was used to create shoal biased soundings in order to complete the chart comparisons.

A.8. Survey Methodology

A.8.1. VesselMobilization

R/V Resolution was located at the Port of Anchorage in Anchorage, Alaska.The mobilization of R/V Resolution occurred at the Port of Anchorage on December 10th, 2018. M/V Glacier Wind was located at the Port of Anchorage in Anchorage, Alaska. The mobilization of M/V Glacier Wind occurred at the Port of Anchorage on December 18th, 2018.

Figure 6: R/V Resolution Mobilization

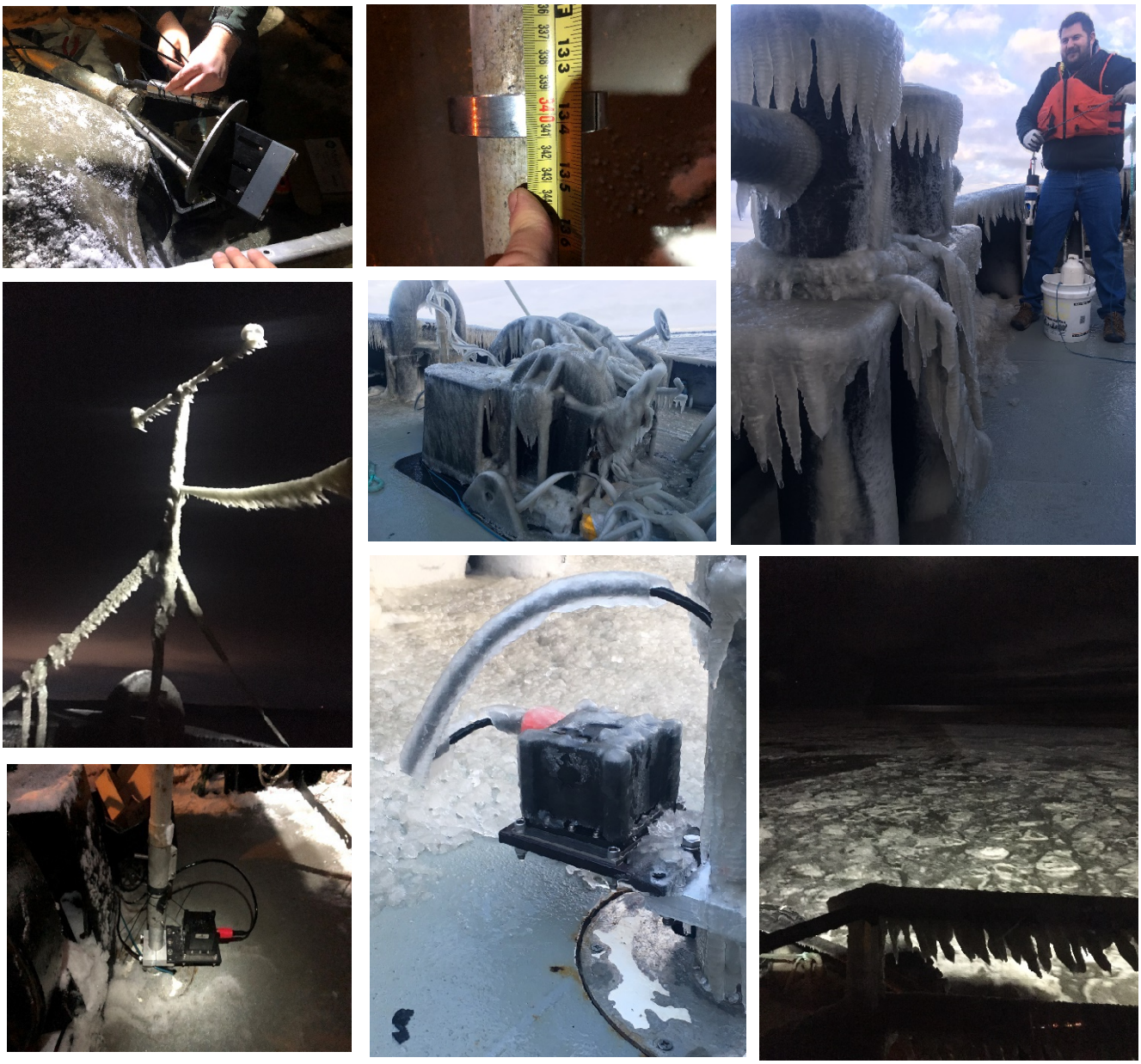


Figure 7: M/V Glacier Wind Mobilization

A full vessel survey was performed on R/V Resolution by eTrac Inc. on December 10th, 2018. Traditional land survey methods using a Trimble 5000 robotic total station were utilized by eTrac Inc. during the field measurements. The 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.). Precise measurements with a hand-held measuring tape to confirm and adjust the previously measured offsets were performed on December 10th, 2018. 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 eTrac Inc. Professional Surveyors and confirmed by eTrac Inc. hydrographers. 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 within each vessels frame. These lever arms along with their associated uncertainties were entered into the QINSy vessel configuration template database files (vessel template DB).

M/V Glacier Wind was mobilized on December 18th, 2018 in Anchorage Alaska. A custom bracket was fabricated to secure the R2Sonic 2020 in a moonpool tube penetration already present through the center of the Bow of the Ice Class Tug. The GPS antennas were located on a 2m spreader bar directly above the sonar. The Inertial Motion Unit (IMU) was located on a custom bracket fixed to the same pole as the GPS and Sonar. Measurements were taken with a hand held metal tape with millimeter resolution. Measurements were performed by multiple hydrographic technicians for quality control cross check purposes.

A.8.2. Survey Coverage

Survey coverage was based on the survey limits set forth in the Project Instructions forS-P958-KR-18.

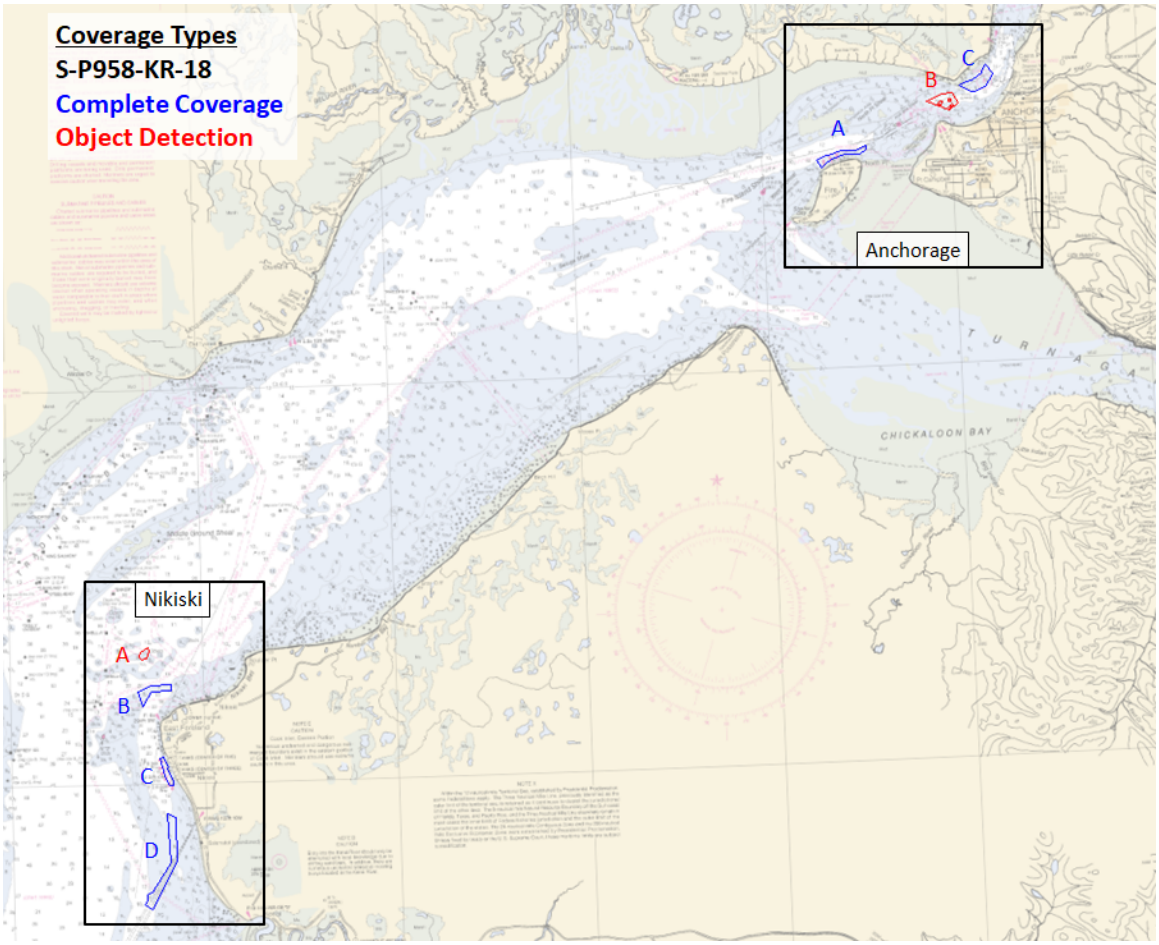


Figure 8: S-P958-KR-18 Survey Coverage Types

A.8.3. Multibeam Sonar Operations

Multibeam coverage was in accordance with the Project Instructions and HSSD 2018. S-P958-KR-18 was covered using "Complete Coverage MBES with Backscatter" standards for area A and C within the Vicinity of Anchorage and area B, C and D within the Vicinity of Nikiski, as well as "Object Detection with Backscatter" for area B within the Vicinity of Anchorage and area A within the Vicinity of Nikiski.

B. Quality Control

B.1. Data Acquisition

Data acquisition and processing throughout the entire project was 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 plan 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. Line orientation was modified in the field in several instances due to adverse conditions in the Cook Inlet including heavy ice flows, strong winds, changing currents and tides.

MBES line spacing for Complete Coverage MBES and Object Detection MBES operations were based upon charted depths as well as coverage requirements set forth in the Project Instructions and the HSSD 2018.

B.1.1. Horizontal and Vertical Control

Horizontal and Vertical control methodology for S-P958-KR-18 is in accordance with the ERS standards within HSSD 2018 and the Project Instructions. A complete description of the Horizontal and Vertical control used on S-P958-KR-18 can be referenced in the HVCR.

B.1.1.1. Horizontal Control

During acquisition, R/V Resolution and M/V Glacier Windreceived USCG DGPS corrections. POSPac vessel trajectory data was logged during acquisition and post processed using CORS station base files. For the Anchorage areas, the CORS station TSEA was utilized. For the Nikiski areas, the CORS station KEN6 was utilized.

B.1.1.2. Vertical Control

In accordance with the Project Instructions, S-P958-KR-18 was an Ellipsoidally Referenced (ERS) survey. On both R/V Resolution and M/V Glacier Wind, POSPac vessel trajectory data were logged during acquisition and post processed using CORS station base files. For the Anchorage areas, the CORS station TSEA was utilized. For the Nikiski areas, the CORS station KEN6 was utilized. A Smoothed Best Estimate of Trajectory (SBET) was exported from Applanix POSPac MMS. The SBETs were referenced to the NAD83 Ellipsoid.

Using VDatum, a vertical separation model was provided by the Project COR to transform the ellipsoidally referenced data from NAD83 to MLLW. This separation model was applied in QPS Qimera to reduce the data to MLLW.

B.1.2. Multibeam Bathymetry (MBES)

Initial settings for the R2Sonic 2022 and 2020 systems can be seen below in Tables 8 and 9.

Table 8: MBES Settings for R2Sonic 2022 Mobilized on R/V Resolution

R/V RESOLUTION	
2022 Parameter	**Value**
Range	Variable, depth dependent
Gain	Variable, depth dependent
Power	209-221 dB
Spreading	Variable , depth dependent
Absorption	126 dB/km
Ping Rate	Variable, range dependent
Pulse Width	Variable, depth dependent

Table 9: MBES Settings for R2Sonic 2020 Mobilized on M/V Glacier Wind

M/V Glacier Wind	
2020 Parameter	**Value**
Range	Variable, depth dependent
Gain	Variable, depth dependent
Power	191-207 dB
Spreading	Variable , depth dependent
Absorption	126 dB/km
Ping Rate	Variable, range dependent
Pulse Width	Variable, depth dependent

For the R2 Sonic, 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 sonars to provide the highest quality of both bathymetric and backscatter data, with bathymetry being the primary focus. The R2Sonic 2020 and R2Sonic 2022 were 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 on the vessel were determined from the static vessel surveys performed at varying times and were verified using a metal hand tape. These offsets were entered into QPS QINSy for use during data acquisition on M/V Glacier Wind and R/V Resolution.

The R2Sonic's 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 SIM via DB9 Serial connection at 200Hz.

B.1.3. Sound Speed Acquisition

All sound speed measurements were collected in accordance with specifications set forth in the HSSD 2018.

B.1.3.1. Sound Speed Profile Acquisition

Sound speed profiles were collected using an AML Base•X profiling unit.SV profilers were lowered on a data cable by hand. 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.

Once a cast is acquired, the profiler data is then saved as a CSV on the MBES acquisition computer. Then, the CSV was imported to QPS QINSy acquisition software for use online and is stored in each .DB file. Once imported into the QPS QINSy software, the cast data was exported into the .SVP format for use in office processing at a later date if needed. Application of .SVP files to R/V Resolution data was typically not required in post processing because the applied SVP is stored in the .DB file.

Surface sound speed measured by the AML Micro•X, 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 two SV readings exceeded 2m/s. If the difference was ever in consistent excess of 2m/s and persisted longer than a designated time threshold, survey operations were suspended and a new sound velocity cast was performed.

B.1.3.2. Surface Sound Speed Acquisition

Surface sound speed was measured at 1Hz during all MBES operations using the AML Micro•X. The AML Micro•X is installed using the AML or R2Sonic provided mounting bracket and installed just above the face of the MBES receiver. On M/V Glacier Wind and R/V Resolution, 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 .DB 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 Template Database File (vessel DB).

Table 9: TPU Values Used in Qimera Processing

Accuracy Values for Total Propagation Error Computation		
Vessel	**R/V RESOLUTION**	**M/V GLACIER WIND**
Motion Sensor	PosMV 220	R2Sonic I2NS
Position System 1	PosMV 220	R2Sonic I2NS
MBES System	R2Sonic 2022	R2Sonic 2020
Gyro - Heading		
Gyro (°)	0.020	0.020
Heave % Amplitude	5%	5%
Heave (m)	0.050	0.050
Roll and Pitch		
Roll (°)	0.010	0.010
Pitch (°)	0.010	0.010
Measurment		
Offset X (m)	0.003	0.01
Offset Y (m)	0.003	0.01
Offset Z (m)	0.001	0.01
Speed		
Vessel Speed (m/s)	0.030	0.030
Position / Nav		
Position (m)	0.100	0.100
Physical Alignment Errors*		
Alignment		
MRU align Stdev gyro	0.050	0.050
MRU align roll/pitch	0.020	0.020
*All values given as 1 sigma.		
Total Propagated Uncertainty Computation in CARIS HIPS		
Tide Values		
Tide Value Measured	0.0960	0.0960
Sounding Speed Values		
Sound Speed Measured	0.05	0.05
Surface Sound Speed	0.05	0.05

B.2.2. QPS Vessel Template Database

A QPS Vessel Template Database file (DB) was created for each vessel. The vessel files contain sensor offsets and biases, and uncertainty values to aid in Total Propagated Uncertainty (TPU) calculations.

The R2Sonic I2NS on M/V Glacier Wind was configured to output position and motion data at the IMU. Offsets to the acoustic center of the echosounder were input in the QINSy Vessel DB. The POSMV 220 on R/V Resolution was configured to output position and motion data at the vessel reference point. Offsets to the acoustic center of the echosounder were input in the QINSy Vessel DB.

B.2.3. Qimera

Qimera was exclusively utilized for MBES processing throughout the entire project. Processing steps and procedures are detailed below in Figure 17.

The first part (PART 1 inFigure 17) of the processing pipeline consists of a series of standard Qimera processing procedures, which are completed using the Qimera process toolbar and auto processing prompts. In order to ensure each process has been completed, processes are reviewed in the output window.

The second part (PART 2 in Figure 17) of the Qimera processing pipeline consists of detailed review and cleaning of data, as well as project specific tasks such as investigating features or preparing DTON reports for submittal.

The third part (PART 3 in Figure 17) of the Qimera processing pipeline is performed once data collection has been completed for an entire F-Cell sheet. CUBE surfaces are "finalized" by choosing the option to override the CUBE hypothesis with any flagged soundings. This finalized surface then represents the least depth of features and designated soundings.

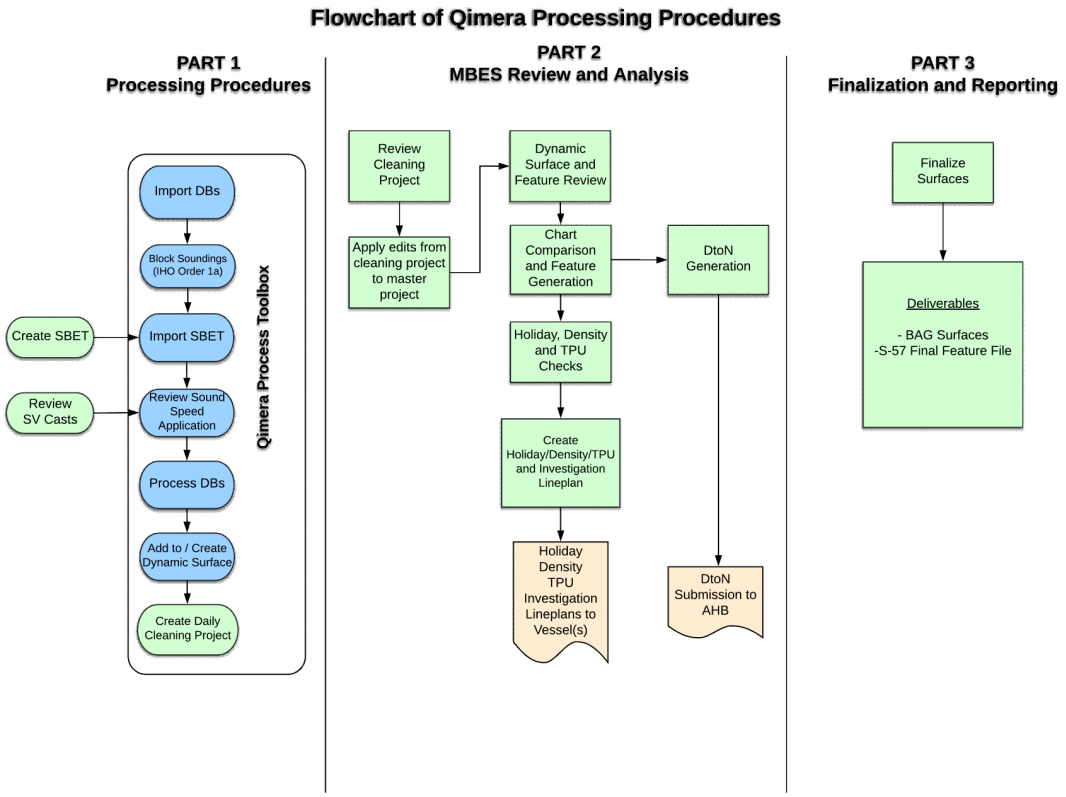


Figure 9: Qimera Processing Procedures

C. Corrections to Echo Soundings

C.1. Vessel Offsets

As mentioned previously, a static vessel survey was performed on R/V Resolution prior to data collection. From the data provided in the vessel surveys, offsets were computed for sensor locations of the mobilized equipment on both R/V Resolution and M/V Glacier Wind. Offsets were additionally confirmed on R/V Resolution 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.

C.2. 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 local charted wreck and prominent rock outcropping.

For both M/V Glacier Wind and R/V Resolution, each pair of specific survey lines were analyzed in Qimera Patch Test Tool. Sensor biases were determined and entered into the QPS Vessel Template Database file.

Patch test data were 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.

Table 13: VesselAlignment Biases

R/V RESOLUTION				
DN	Latency	Pitch	Roll	Yaw
DN342	0.00	1.41	1.05	0.50

R/V GLACIER WIND				
DN	Latency	Pitch	Roll	Yaw
DN356	0.00	-0.65	-0.13	-13.50

C.3. Dynamic and Static Draft

As this project utilized an ERS workflow, dynamic and static draft was not utilized in final sounding computations.

C.4. Position and Attitude

An R2Sonic I2NS was mobilized on M/V Glacier Windas the primary positioning and attitude measurement system. An Applanix POSMV 220 V5 was mobilized on R/V Resolution as the primary positioning and attitude measurement system. Prior to calibration, lever arms were calculated from the static vessel survey and hand-held measuring of R/V Resolution and M/V Glacier Wind. All values were confirmed andentered into the POSMV configuration, including primary GPS antenna to reference point (RP), inertial motion unit to RP, sensor 1 to RP, and center of rotation to RP.

A GNSS Azimuth Measurement Sub-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.5. Delayed Heave

During acquisition, trajectory data was logged through Applanix POSView and post-processed with reference station data in POSPac MMS to output a SBET.

Delayed heave data (SBETs) were applied in Qimera during the processing pipeline detailed in section B.2.4.

C.7. Waterlevel Corrections

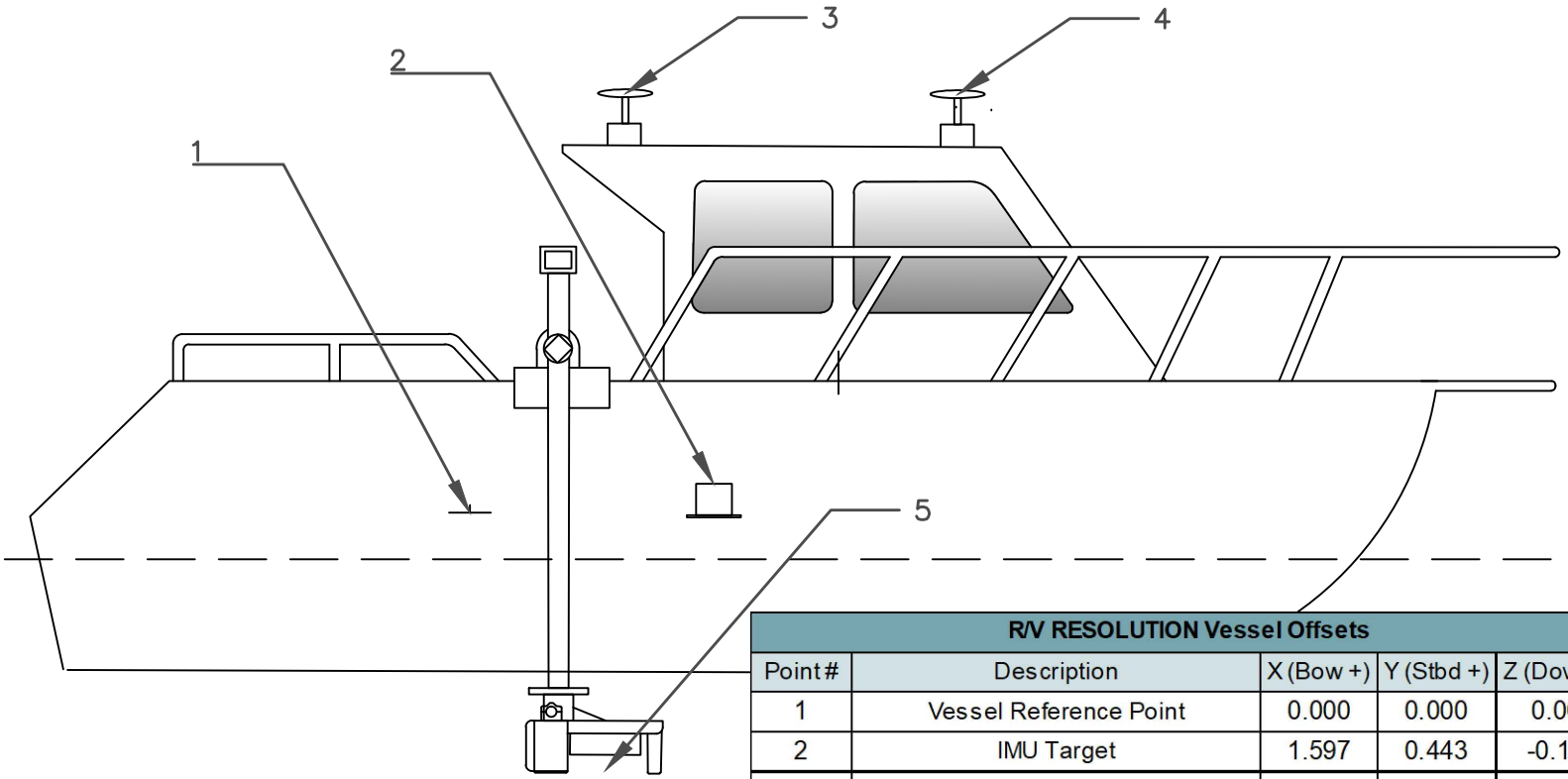
In accordance with the Project Instructions, a separation model was applied to all project data in order to reduce the ellipsoidally referenced sounding data to MLLW navigation datum. The separation model between the NAD83 Ellipsoid and the MLLW navigation surface was supplied by the Project COR. This model was carried through the entire pipeline from acquisition to final deliverables.

C.8. Sound Speed Corrections

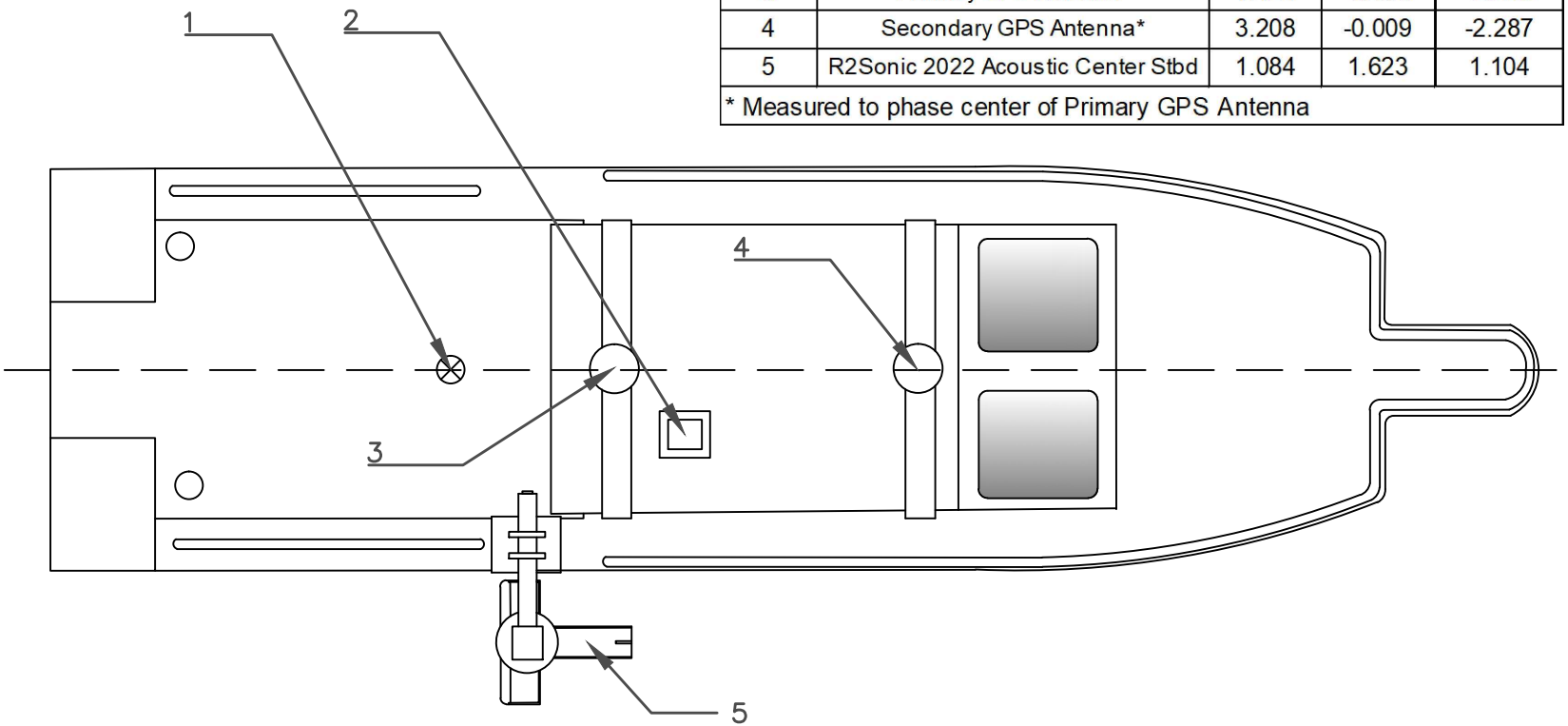
Sound speed profiles collected in the field were applied to the MBES data in realtime. On each vessel, raw Qinsy .DB files store sound speed profile data real-time for each separate line of data. In Qimera, sound speed data is imported simultaneously with each respective raw DB file.

Surface sound speed was collected at the R2Sonic transducer faceand sent via serial connection directly to the R2Sonic topside unit in order to facilitate beam steering.

APPENDIX I
VESSEL REPORTS



R/V RESOLUTION Vessel Offsets				
Point #	Description	X (Bow +)	Y (Stbd +)	Z (Down +)
1	Vessel Reference Point	0.000	0.000	0.000
2	IMU Target	1.597	0.443	-0.198
3	Primary GPS Antenna*	1.124	-0.009	-2.249
4	Secondary GPS Antenna*	3.208	-0.009	-2.287
5	R2Sonic 2022 Acoustic Center Stbd	1.084	1.623	1.104
* Measured to phase center of Primary GPS Antenna				

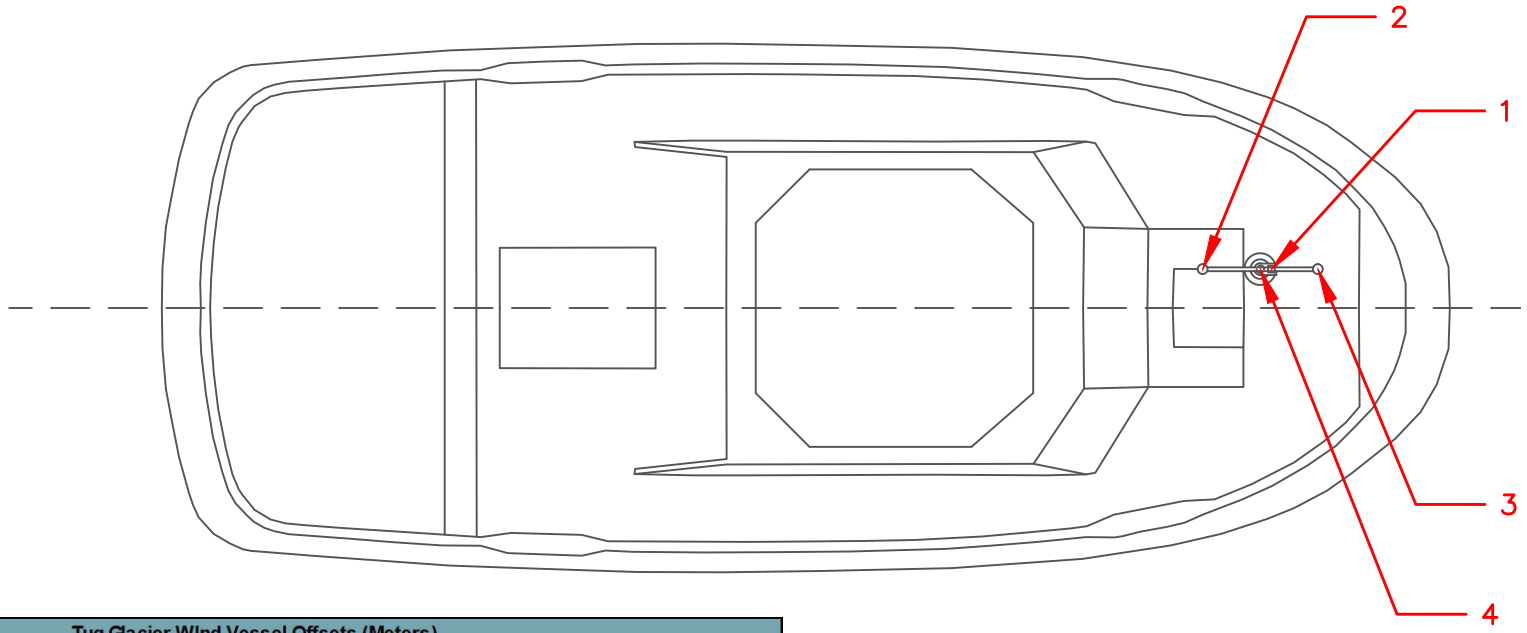


VESSEL NAME: R/V RESOLUTION
MAKE:
LENGTH: 29FT
BEAM: 8.5FT
HOME PORT: Anchorage, AK
PLOT DATE: 12/17/18

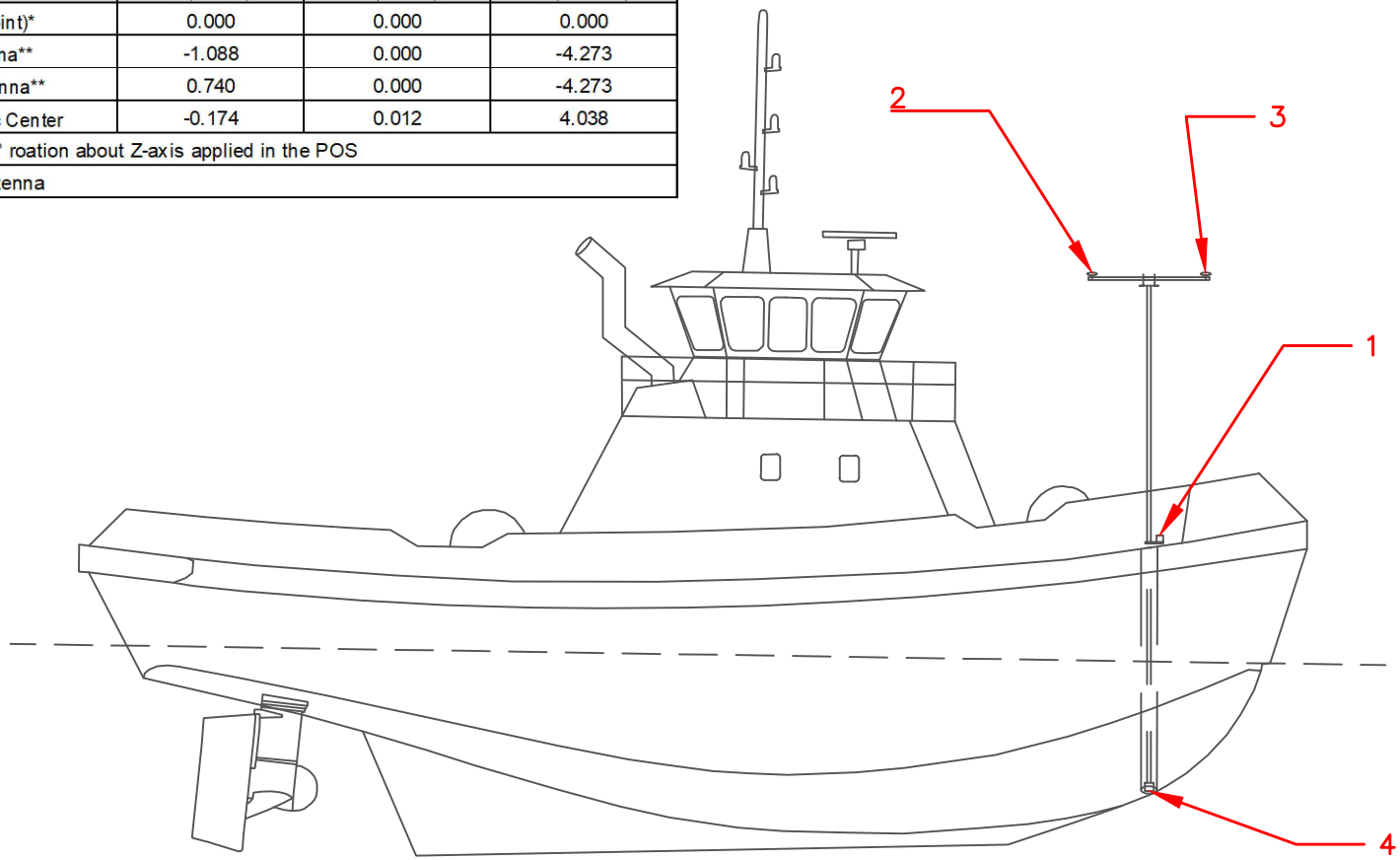
VESSEL OFFSET DIAGRAM

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

eTrac



Tug Glacier Wind Vessel Offsets (Meters)				
Point #	Description	X (Bow +)	Y (Stbd +)	Z (Down +)
1	IMU Target (REF Point)*	0.000	0.000	0.000
2	Primary GPS Antenna**	-1.088	0.000	-4.273
3	Secondary GPS Antenna**	0.740	0.000	-4.273
4	R2Sonic 2020 Acoustic Center	-0.174	0.012	4.038
* IMU mounted backward on Z pole, 180° roation about Z-axis applied in the POS				
** Measured to phase center of GPS Antenna				



VESSEL NAME: Glacier Wind
MAKE: Tractor Tug - Ice Class
LENGTH: 65FT
BEAM: 26FT
HOME PORT: Anchorage, AK
PLOT DATE: 12/27/2018

VESSEL OFFSET DIAGRAM

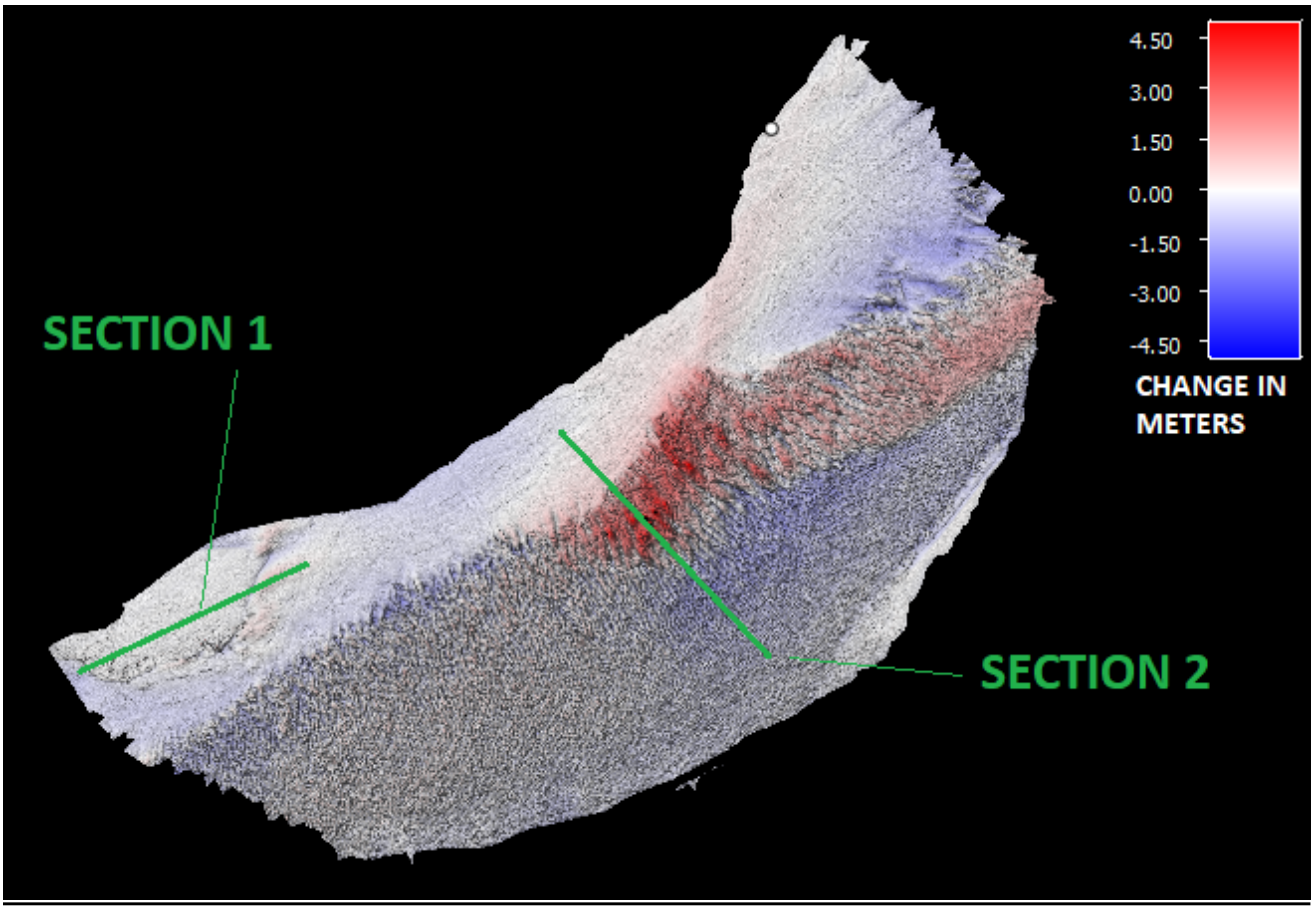
637 LINDARO STREET
SUITE 100
SAN RAFAEL, CA 94901
415.462.0421
eTracInc.com

APPENDIX II
ECHOSOUNDER REPORTS

October 2018 / December 2018 Comparison

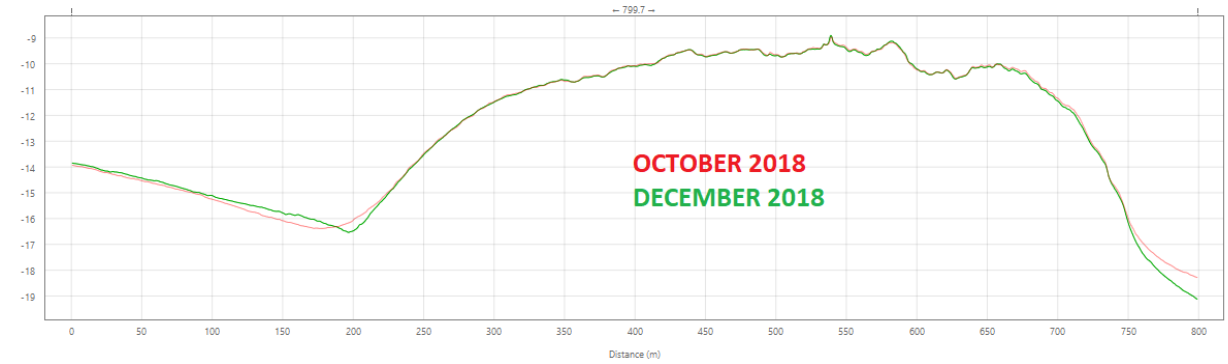
Due to the emergency nature of S-P958-KR-18 and the adverse environmental conditions within the cook inlet during the time of survey, a traditional bar check was not possible. However, eTrac has performed many surveys in the Cook Inlet. Pt. McKenzie shoal was surveyed in October 2018 for USACE before the earthquake event. This data was used to QC against the data collected in December for S-P958-KR-18. The results can be seen below:

October 2018 vs. December 2018



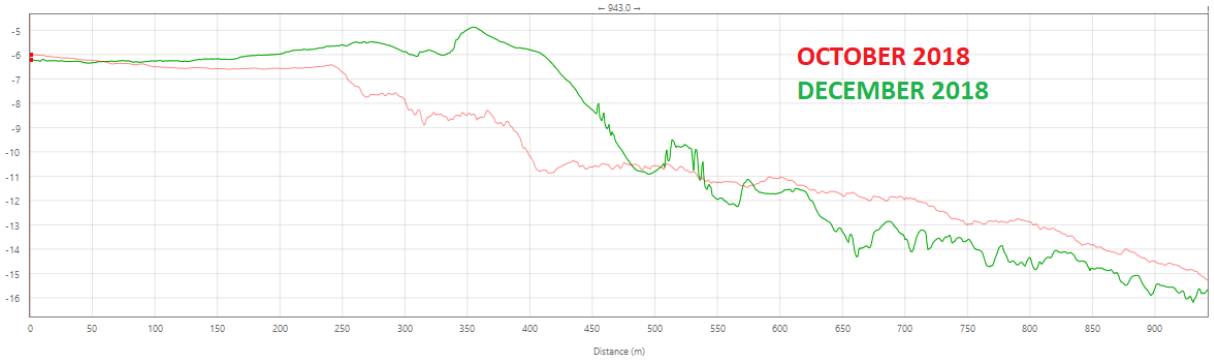
Section 1

By running a cross section across the 2 datasets over areas of hard material / bedrock, it can be seen that the data has excellent repeatability and agreement. This lends confidence and quality assurance to the December mobilization.



Section 2

By running a cross section across the 2 datasets over areas of soft / transient material, significant accretion can be seen in the McKenzie Pt. area. The material in this section of the survey area has been observed to change significantly within a single tide cycle.



APPENDIX III
POSITIONING AND ATTITUDE SYSTEM REPORTS

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

S-P958-KR-18

M/V Glacier Wind POS MV CALIBRATION REPORT

All values in meters, time in UTC, julian day

SYSTEM INFORMATION

Vessel:	M/V Glacier Wind	**POSView Version**	9.12
Date:	12/19/2018	**POS Version**	I2NS
Personnel:	R Goughnour, K Johnson		
		GPS Receivers	
PCS Serial #	7900	**Primary Reciever**	Trimble Aero
IP Address:	10.0.0.44	**Secondary Receiver**	Trimble Aero

CALIBRATION AREA

Location: Anchorage Alaska

Approximate Position:

	Deg	Min	
Lat:	**61**	**15**	**5.00823**
Long:	**149**	**53**	**36.7654**

GPS Corrections

DGPS Beacon Station	**NA/PPK**	**RTK/VRS Station:**	**Anchorage POA**
Frequency:	**NA/PPK**	**Correction Type:**	**CMR**

Coordinates:

	Deg	Min	Sec
Lat:	**61**	**14**	**22.15540**
Long:	**149**	**53**	**16.54575**
Altitude	**24.5300 m**		

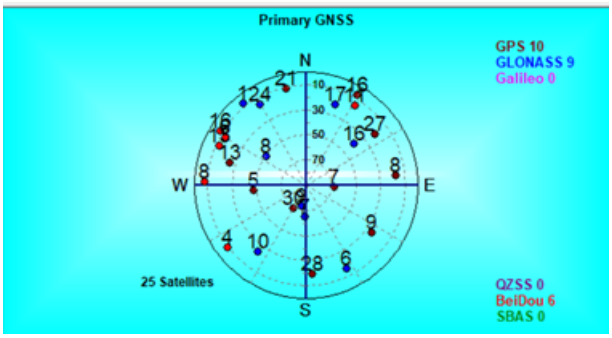
Satellite Constellation

Primary GPS (Port Antenna)

HDOP: 0.521
VDOP 0.607
Satellites in Use: 18

PDOP:

Notes:



POS MV CONFIGURATION

Settings

GAMS Parameter Setup

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

Notes:

POS MV CALIBRATION

Calibration Procedure

Start Time: 1615 *UTC* | x | *Mark "x" here when start*

End Time: 1622 *UTC* | x | *Mark "x" here when end*

Heading accuracy achieved for calibration: 0.022

Calibration Results

GAMS Parameter Setup

POS MV Post Calibration Values		Baseline Vector	
1.828	Two Antenna Separation (m)	1.828	X Component (m)
0.500	Heading Calibration Threshold	-0.085	Y Component (m)
0.000	Heading Corrections	-0.007	Z Component (m)

GAMS Status Online? **YES**

Save Settings? **YES**

Notes:

Save POS Settings

Filename:

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

S-P958-KR-18

R/V RESOLUTION POS MV CALIBRATION REPORT

All values in meters, time in UTC, julian day

SYSTEM INFORMATION

Vessel:	R/V Resolution	**POSView Version**	8.46
Date:	12/8/2018	**POS Version**	320 V5
Personnel:	Robert G. Jake R.		
		GPS Receivers	
PCS Serial #	4108	**Primary Reciever**	BD960
IP Address:	10.0.0.55	**Secondary Receiver**	BD960

CALIBRATION AREA

Location: Anchorage Alaska

Approximate Position:

	Deg	Min	
Lat:	**61**	**13**	**31.09**
Long:	**149**	**54**	**21.31**

GPS Corrections

DGPS Beacon Station	**NA/PPK**	**RTK/VRS Station:**	**Anchorage POA**
Frequency:	**NA/PPK**	**Correction Type:**	**CMR**

Coordinates:

	Deg	Min	Sec
Lat:	**61**	**14**	**22.15540**
Long:	**149**	**53**	**16.54575**
Altitude	**24.5300 m**		

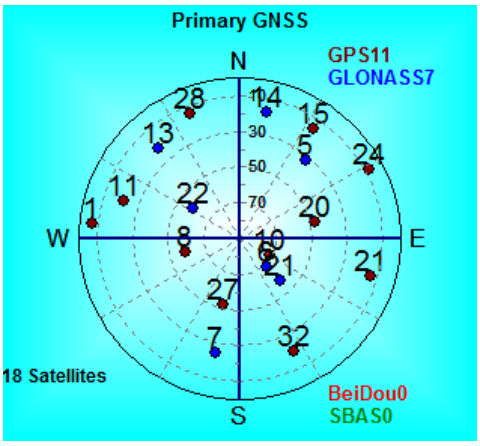
Satellite Constellation

Primary GPS (Port Antenna)

HDOP: 0.521
VDOP 0.607
Satellites in Use: 18

PDOP:

Notes:



POS MV CONFIGURATION

Settings

GAMS Parameter Setup

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

Notes:

POS MV CALIBRATION

Calibration Procedure

Start Time: 1705 *UTC* | x | *Mark "x" here when start*

End Time: 1721 *UTC* | x | *Mark "x" here when end*

Heading accuracy achieved for calibration: 0.027

Calibration Results

GAMS Parameter Setup

POS MV Post Calibration Values		Baseline Vector	
2.079	Two Antenna Separation (m)	2.079	X Component (m)
0.500	Heading Calibration Threshold	-0.014	Y Component (m)
0.000	Heading Corrections	-0.014	Z Component (m)

GAMS Status Online? **YES**

Save Settings? **YES**

Notes:

Save POS Settings

Filename:

APPENDIX IV
SOUND SPEED SENSOR REPORTS

AML OCEANOGRAPHIC
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Certificate of Calibration

Asset Serial Number:	201439
Calibration Type:	Sound Velocity
Certification Date:	November 26, 2018
Calibration Range:	1413.9 to 1509 m/s
Sensor Range:	1375 to 1625 m/s
Residual (RMSE):	0.001 m/s
Standards:	Hart 1560/4067

Coefficients

Coefficient A:	0.000000E+0	**Coefficient H:**	1.944529E-7
Coefficient B:	0.000000E+0	**Coefficient I:**	0.000000E+0
Coefficient C:	1.418373E-6	**Coefficient J:**	0.000000E+0
Coefficient D:	1.944213E-7	**Coefficient K:**	0.000000E+0
Coefficient E:	-1.713801E-5	**Coefficient L:**	0.000000E+0
Coefficient F:	1.950328E-7	**Coefficient M:**	0.000000E+0
Coefficient G:	1.341980E-6	**Coefficient N:**	0.000000E+0

Robert Haydock
President, AML Oceanographic

AML Oceanographic certifies that the asset described above has been calibrated or recalibrated with equipment referenced to traceable standards. If this instrument or sensor has been re-calibrated, please be sure to update your records. Please also

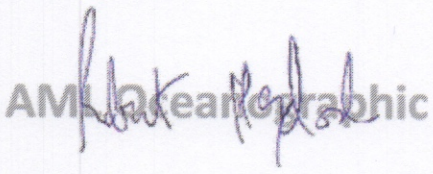
AML
OCEANOGRAPHIC
Xchange your old ideas

Certificate of Calibration

Asset Serial Number:	203209
Calibration Type:	Sound Velocity
Certification Date:	November 20, 2018
Calibration Range:	1413.8 to 1509 m/s
Sensor Range:	1375 to 1625 m/s
Residual (RMSE):	0.001 m/s
Standards:	Hart 1560/4067

Coefficients

Coefficient A:	0.000000E+0	Coefficient H:	1.946624E-7
Coefficient B:	0.000000E+0	Coefficient I:	0.000000E+0
Coefficient C:	9.098238E-7	Coefficient J:	0.000000E+0
Coefficient D:	1.946893E-7	Coefficient K:	0.000000E+0
Coefficient E:	-1.788346E-5	Coefficient L:	0.000000E+0
Coefficient F:	1.954105E-7	Coefficient M:	0.000000E+0
Coefficient G:	1.049877E-6	Coefficient N:	0.000000E+0



Robert Haydock
President, AML Oceanographic

AML Oceanographic certifies that the asset described above has been calibrated or recalibrated with equipment referenced to traceable standards. If this instrument or sensor has been re-calibrated, 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.

AML Oceanographic Ltd. 2071 Malaview Avenue Sidney, B.C. V8L 5X6 CANADA Tel: +1 250-656-0771 Fax: +1 250-655-3655

D. Approval Sheet

S-P958-KR-18

Registry Nos.
F00763
F00764

Data Acquisition and Processing Report

This report and the accompanying data are respectfully submitted.

Field operations contributing to the accomplishment of Surveys F00763 and F00764 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 Neff
Date: 2019.03.05
22:56:00-08'00'

David R. Neff | eTrac Inc. | Lead Hydrographer January 30, 2019

eTrac Inc.
January 2019