DSSV Pressure Drop: Data Acquisition & Processing Report

Japan Trench Mission

July 28-29, 2020

Report developed for Caladan Oceanic by Cassie Bongiovanni

Internal Use Only

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A. Equipment

A.1 Vessel

A.1.1 DSSV Pressure Drop

Figure 1: DSSV Pressure Drop at sea (image: Atlantic Productions).

The DSSV Pressure Drop (Figure 1) is a privately-owned ~225-foot vessel built in the 1980s. This vessel is propeller powered with a hull-mounted gondola where the Kongsberg EM 124 system is mounted. The vessel reference frame is: +x bow forward, +y to starboard, and +z down (towards the seafloor). All points are referenced to the reference point (0,0,0) which is located at the MRU on the 1st deck of the ship.

A.1.2 Vessel Data Flow

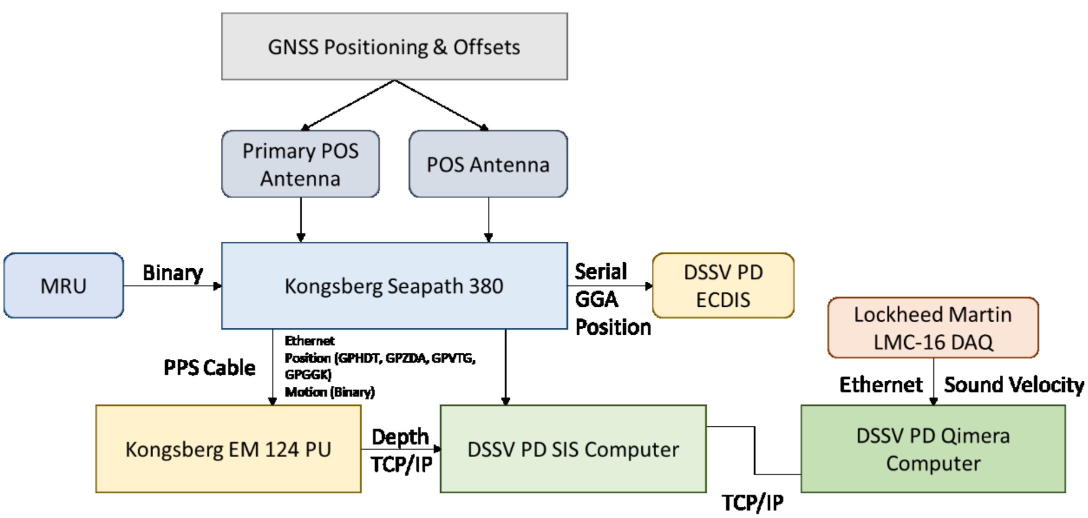

Figure 2: DSSV Pressure Drop data flow diagram.

A.2 Depth Measurement Equipment

A.2.1 Kongsberg EM 124 Multibeam Echosounder

Figure 3: Kongsberg EM 124 gondola attached to the hull of the DSSV Pressure Drop (image: Tony Dahlheim).

The EM 124 was installed on a steel gondola attached to the center of the DSSV Pressure Drop hull. The EM124 sits ~1 m below the hull and a total of ~9 m below the vessel reference point. The EM 124 is a dual-swath system with sixteen-sector angular coverage capabilities and the ability to map the deepest parts of the ocean. Data from this sonar come with a new datagram and file format .KMall, accepted by Qimera (discussed in section A.6.1).

Instrument	Kongsberg EM 124 (1^{o} x 2^{o})		
Manufacturer	Kongsberg Underwater Technology, INC.		
Installation Technician	Tony Dahlheim	**Contact:**	Tony.dahlheim@km.kongsberg-us.com
Installation Contractor	Brian Gamet	**Contact:**	brian@geosight3d.com; 01722 442302
Reference Frame Sub-Contractor	Robert Howard	**Contact:**	rob@trueposition.net; 262-689-9744
Runtime Specifications	Mounted		DSSV PD hull-mounted gondola
	Frequency		12kHz
	Ping Rate		Every ~20-29 seconds in deep water
	Swath Width		2km-20km
	Yaw Stabilized		Yes
	Pitch Stabilized		Yes
	Dual Swath		Yes, in shallow, No in deep
	Sector Mode		Yes
	Beam Spacing		Equidistant
	Max Coverage		~20km

	Backscatter	Yes
	Sonar Active Mode	No
	Water Column	Yes

Table 1: Kongsberg EM 124 description and specifications.

A.3 Positioning Equipment

A.3.1 Seapath 380+ Processing Unit and GNSS antennas

Figure 4: Kongsberg Seapath 380 in the systems rack of the electronics lab on the DSSV Pressure Drop.

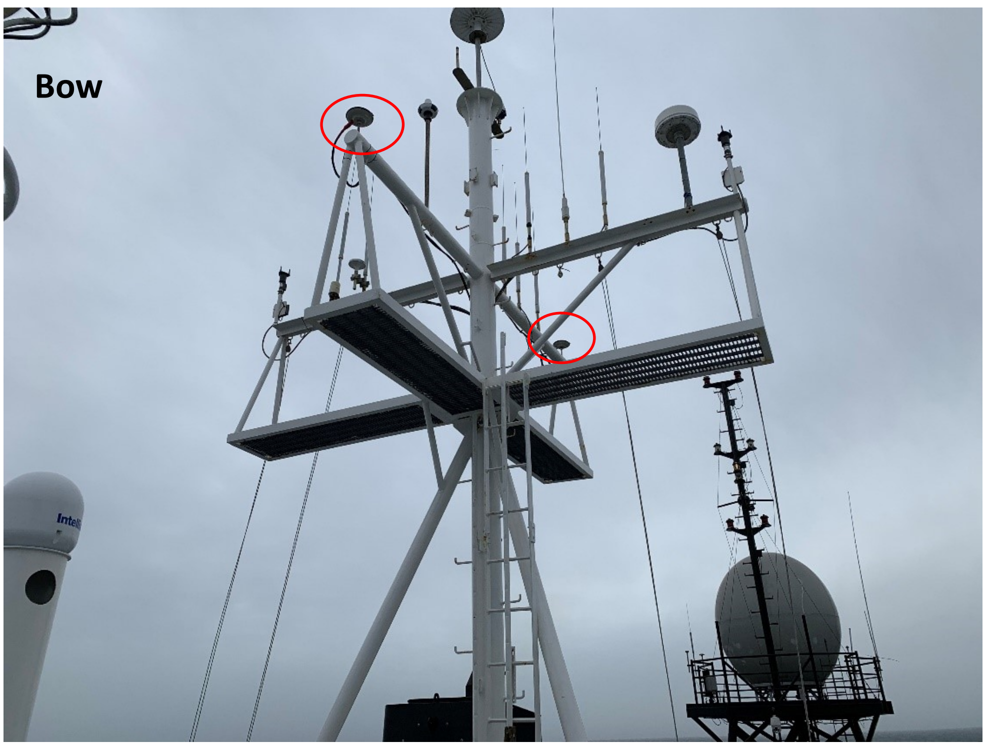

Figure 5: GPS antennas mounted at the top of the ship near the bow.

Instrument	Seapath 380	
Manufacturer	Kongsberg Maritime	
Description	The Seapath 380 provides accurate position and motion data. These data are utilized by the EM 124 for sonar beam steering corrections.	
Specifications	Roll & Pitch Accuracy for ±5° amplitude	0.02° RMS
	Heading accuracy w/ 2.4 m antenna baseline	0.075° RMS
	Heading accuracy w/ 4 m antenna baseline	0.05° RMS
	Scale factor error in Roll, Pitch, Heading	0.08% RMS
	Heave accuracy	5 cm or 5% (highest)
	Heave motion periods (real-time output)	0-20 seconds
	Heave motion periods (delayed signal)	0-50 seconds
	Position accuracy w/ DGPS/GLONASS	0.5m RMS or 1m 95% CEP
	Position accuracy w/ SBAS	0.5m RMS or 1m 95% CEP
	Position accuracy w/ RTK (floating ambiguity)	0.15m RMS or 0.35m 95% CEP
	Velocity accuracy	0.03m/s RMS or 0.07m/s 95% CEP

Table 2: Kongsberg Seapath 380 system description and specifications.

A.4 Sound Speed Equipment

A.4.1 Reson SVP70 Fixed Mount at Transducer

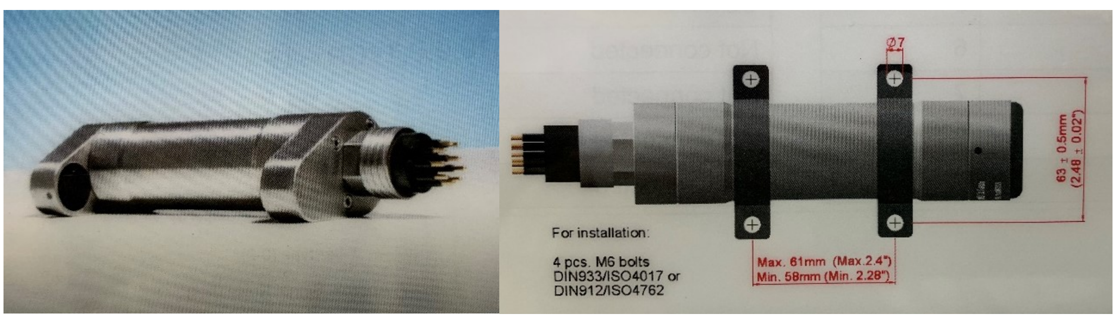

Figure 6: Reson SVP70 used for sound speed at the transducer.

The Reson SVP70 sound speed profiler was secured at the EM 124 transducer to ensure accurate sound speed measurements at the transducer head. These measurements are used by the EM 124 PU for beam corrections.

Instrument	**SVP 70**	
Manufacturer	Reson	
Description	Transducer-mounted sound velocity probe to allow for accurate bathymetry data in deep water.	
Serial Number		
Specifications	Sound Speed Accuracy	± 0.05 m/s
	Baud Rate	115200 baud

	Supply	9V to 55V <1.5W
	Depth Rating	6000 m
	Sampling Time	50 ms to 10 s
	Weight	1.0 kg

Table 3: Reson SVP70 specifications

A.4.2 Lockheed Martin (Sippican) XBTs

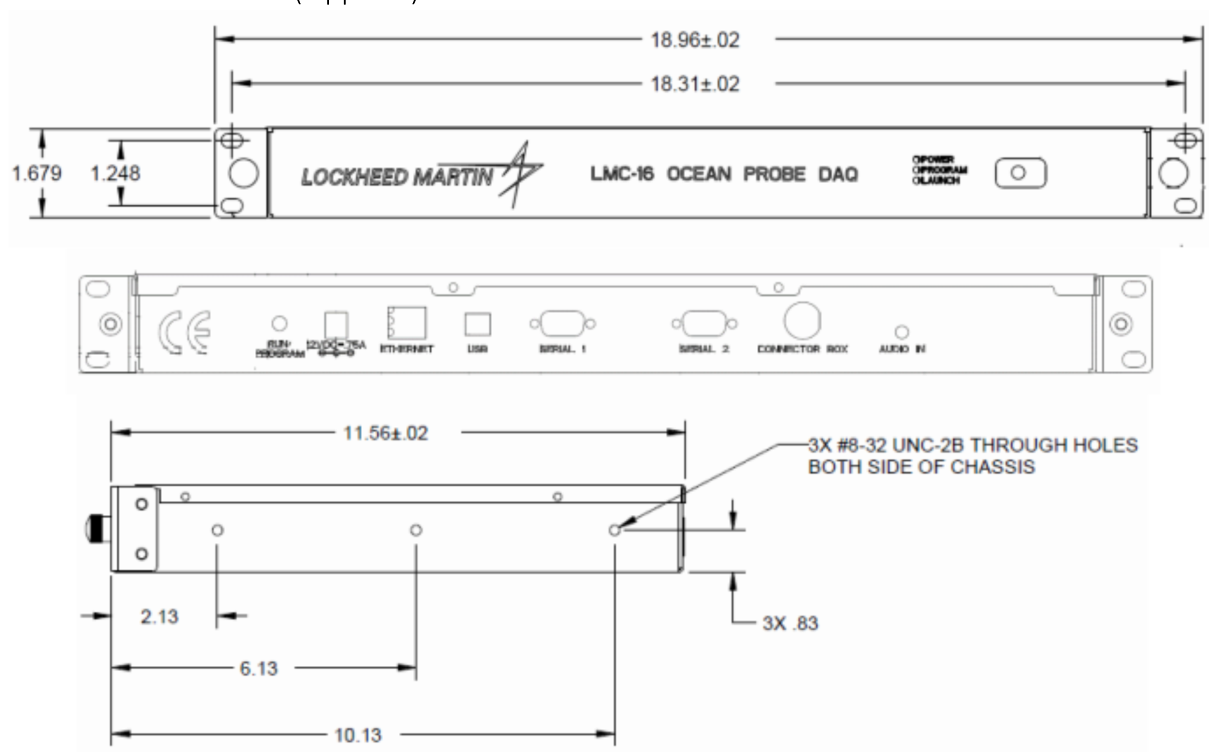

Figure 7: Lockheed Martin (Sippican) DAQ dimensions.

XBTs (or expendable bathymetric temperature gauge) measure temperature in the upper water column which are used to update sound speed profiles. Coupling XBTs and Sound Speed Manager (A.5.4), surveying can continue without the need to completely stop to take a full-depth profile. Profiles collected in this manner will be integrated into the Kongsberg acquisition software (SIS) upon collection. XBTs were launched using a hand-held launcher off the stern. The DAQ was connected via ethernet connection to the processing computer at the mapping workstation.

Probe Type	Sippican P/N	Max Depth	Max Vessel Speed
T-5	211105-1	1830m	6 knots

Table 4: Lockheed Martin (Sippican) XBT T-5 information.

Expendable Ocean Probes

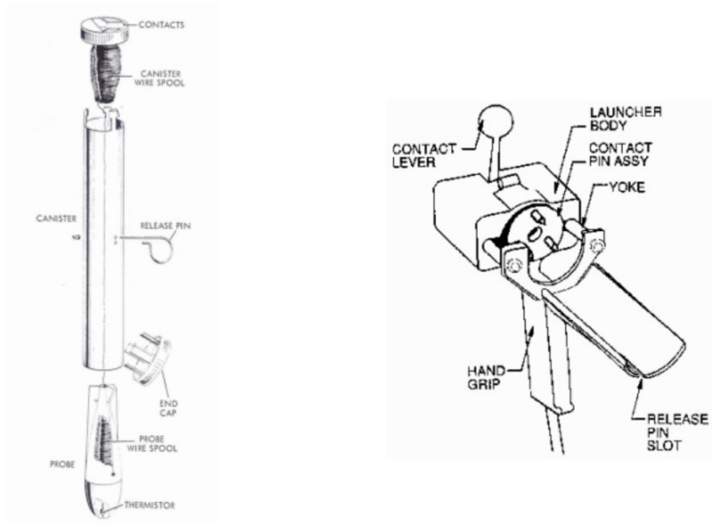

Figure 8: Lockheed Martin (Sippican) XBT T-5 and hand-held launcher dimensions and outlines.

A.4.3 Seabird SBE49 CTD

Figure 9: Seabird SBE49 FastCAT CTD

Instrument	**Seabird SBE49 FastCAT CTD**	
Manufacturer	Seabird Oceanorgaphic	
Serial Number	49-0456	
Description	This was attached to the Limiting Factor submersible as full-ocean depth sound velocity probe. Data was taken from this probe for post-processing sound velocity corrections in the trench.	
Specifications	Sampling Speed	16 Hz (16 samp/sec)
	Depths	10,500m (max)
	Conductivity Accuracy	± 0.0003 S/m
	Temperature Accuracy	± 0.002 °C
	Pressure Accuracy	± 0.1% of full-scale range
	Conductivity Resolution	0.00005 S/m
	Temperature Resolution	0.0001°C
	Pressure Resolution	0.002% of full scale range

Table 5: Seabird SBE 49 Fast CAT CTD sensor specifications.

A.5 Data Acquisition Software

The following software was used to collect accurate bathymetric (mapping) data.

Name	Manufacturer	Version	Installation Date
ArcMap/ArcGIS	ESRI	10.7.1	10/18/2019
SIS- Seafloor Information System	Kongsberg	5.3.1.278	02/03/2020
Seapath 380	Kongsberg SeaTex	1.11.0	12/03/2018
Sound Speed Manager	CCOM	2018.1.50	12/08/2018
Sippican WinMK21	Lockheed Martin	7.4.0.5	01/24/2019

Table 6: Data acquisition software information.

A.5.1 ESRI ArcGIS *(personal license)*

ESRI (Environmental Systems Research Institute) ArcGIS was used with a personal license to help with line planning, data visualization, and big-picture project organization.

A.5.2 Kongsberg SIS – Seafloor Information System

SIS was used to collect EM 124 MBES data, apply lever-arms and water lines, patch test offsets, motion corrections, and real-time sound speed corrections.

A.5.2.1 Installation Parameters

The angular and location offsets for the EM 124 were entered in SIS as shown in Figure 10. The waterline was visually inspected and determined before leaving the dock in San Juan, Puerto Rico.

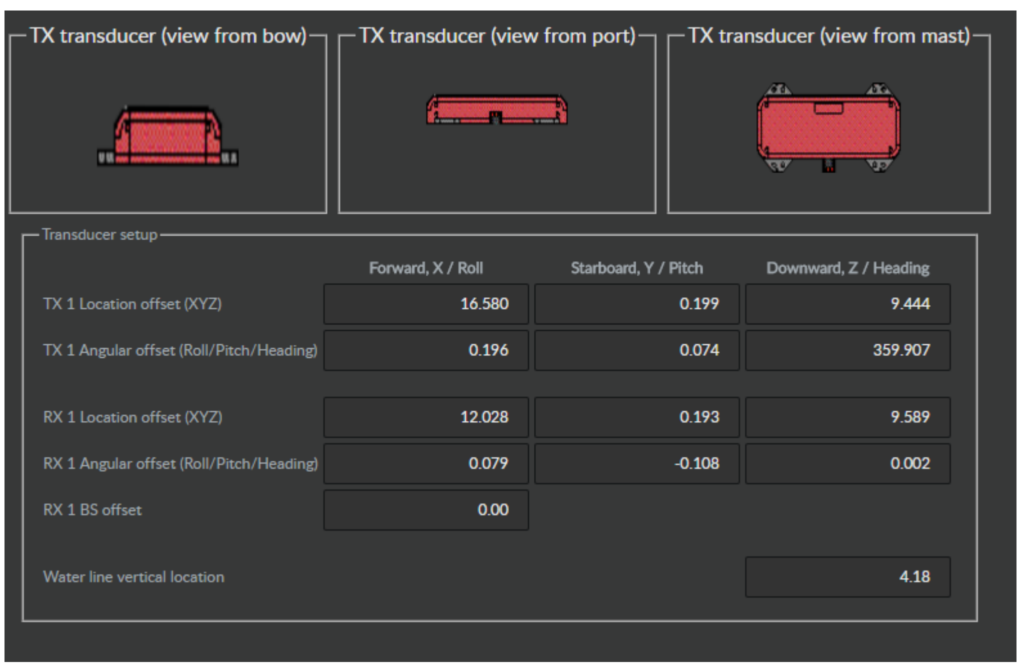

Figure 10: Kongsberg SIS 5 transducer offsets.

The input settings for each of the systems necessary to run the multibeam are shown in Figure 11.

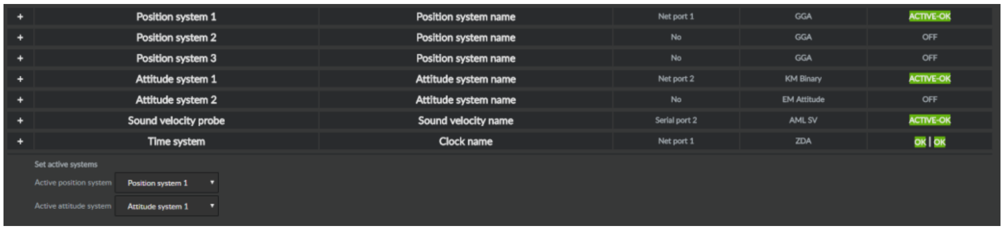

Figure 11: Kongsberg SIS 5 input parameters.

Position settings in SIS 5 are described in Figure 12 and are pulled from the Seapath 380. These were not changed for the duration of the mission.

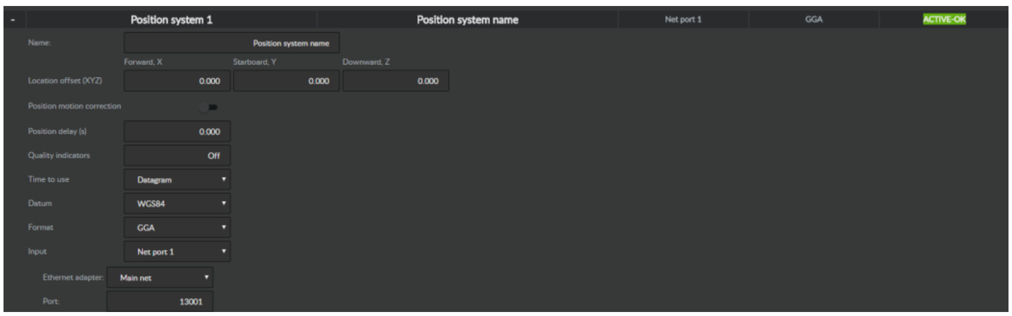

Figure 12: Kongsberg SIS 5 Position System input settings.

Attitude settings entered in SIS 5 described in Figure 13 and are pulled from the Seapath 380 which obtains this from the MRU. These settings were not changed for the duration of the mission.

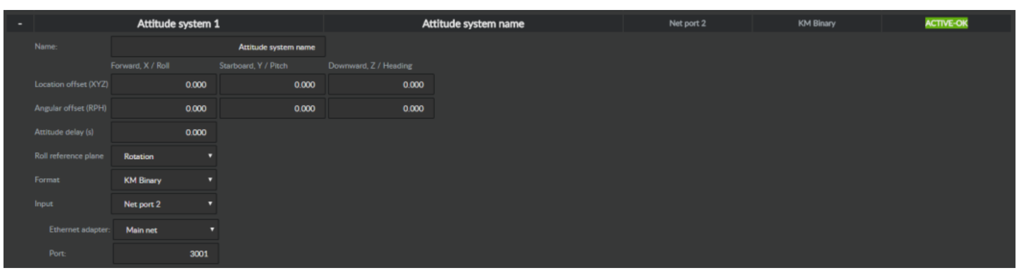

Figure 13: Kongsberg SIS 5 Attitude System input settings.

The sound velocity probe settings are outlined in Figure 14 and were not changed for the duration of the mission.

Figure 14: Kongsberg SIS 5 sound velocity probe input settings.

The time system input settings are outlined in Figure 15 and show that time was being pulled from the position datagram.

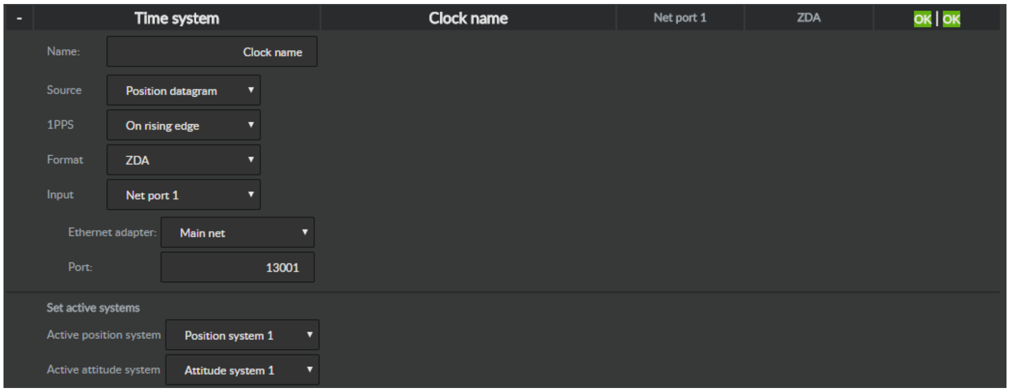

Figure 15: Kongsberg SIS 5 Time System input settings.

A.5.2.2 Output Settings

SIS output settings are outlined in Figure 16 and were not changed for the duration of the mission.

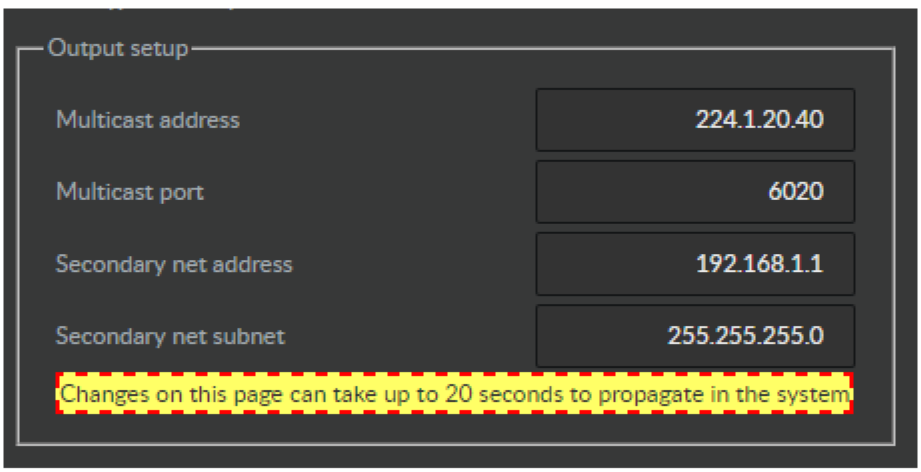

Figure 16: Kongsberg SIS 5 output settings.

A.5.2.3 Runtime Parameters

Runtime parameters changed frequently depending on what water depth we were operating in. For example, depths less than 500m needed to have a depth setting of ‘Shallow Mode’ and depths greater than 5000m needed to be in ‘Very Deep Mode’, but depths between could be in ‘Auto’. Similarly, port and starboard angles were changed depending on weather and coverage – but were generally between 50-65 degrees on each side of nadir. Beam spacing was set to ‘Equidistance’ continuously with a maximum distance on either side of nadir set to 20 km. Dual Swath was set to ‘Dynamic’ (though was automatically turned off when ‘Very Deep’ depth mode was on) and pitch stabilization was always enabled. The pulse was set CW/FM mixed and not changed throughout the mission. To produce more accurate selections of the seafloor when noise was observed in the port side of the water column view, the transmit angle was set to 2° and sometimes changed to 3-4° when necessary. Sonar Mode OFF for the entire mission.

A.5.3 Seapath Software

Kongsberg Seapath software was used to provide real-time GPS location and DGPS corrections via SBAS corrections (coverage permitting) to SIS, the bridge, and Triton sub navigation.

A.5.3.1 GNSS Geometry

The following image shows the lever arms entered in the Seapath and shows the vessel reference frame information. These values were measured and determined by a third-party contractor listed in Table 1 and explained in further detail in the attached supplemental report.

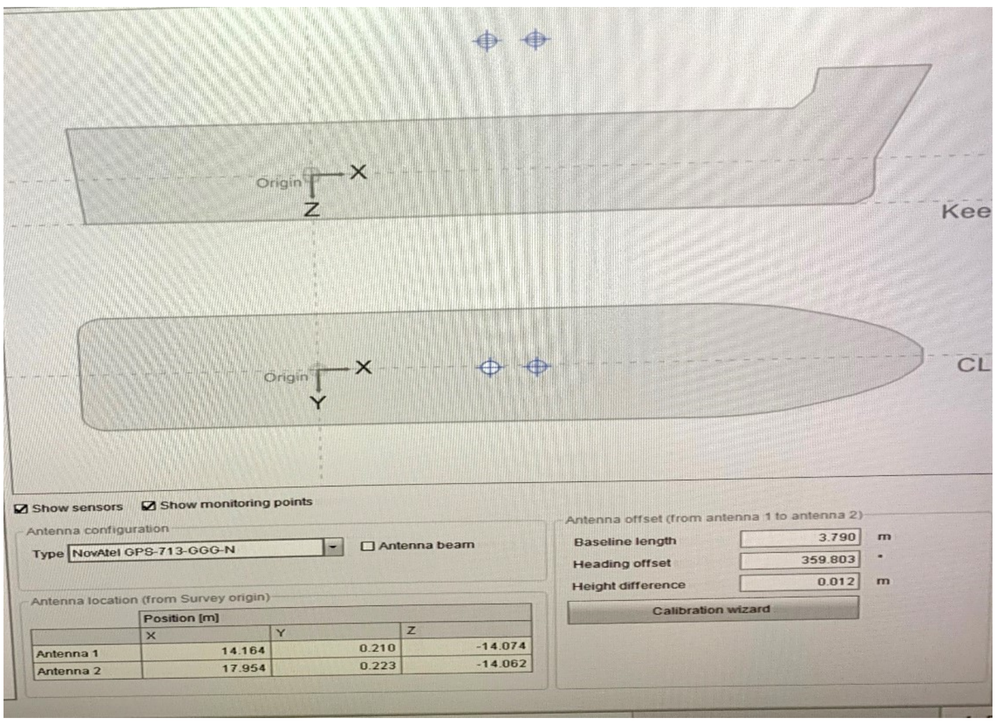

Figure 17:Seapath input geometry and offsets.

A.5.3.2 GNSS Processing

GNSS processing parameters entered in the Seapath configuration are shown in Figure 18. These parameters were not altered for the duration of the mission.

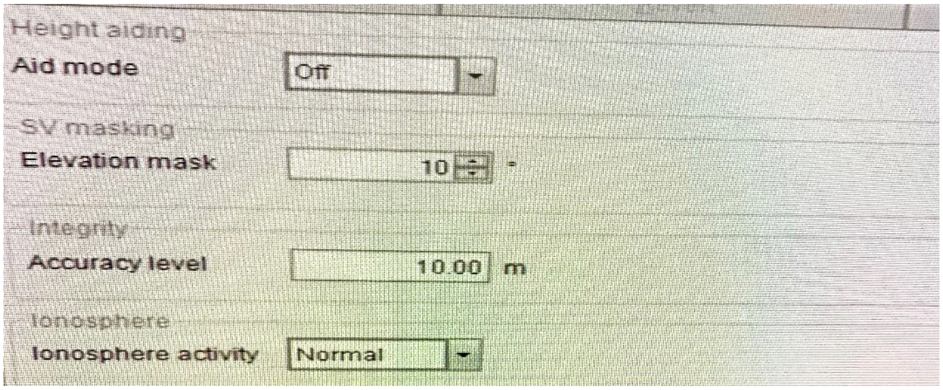

Figure 18: Seapath GNSS processing parameters.

A.5.3.3 GNSS Attitude Processing

GNSS attitude processing settings as set in the Seapath are shown in Figure 19 and were not altered for the duration of the mission.

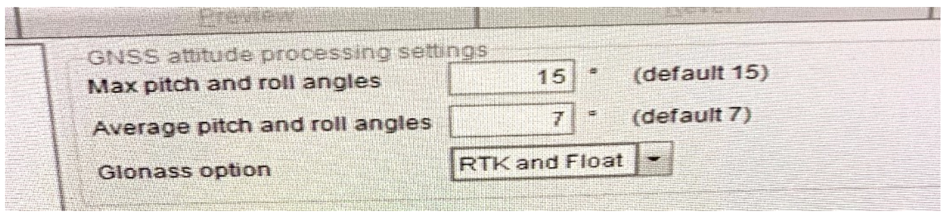

Figure 19: Seapath GNSS attitude processing parameters.

A.5.3.4 MRU Geometry

The MRU geometry angle offsets are recorded in the Seapath configuration settings as shown in Figure 20. These angles were measured by a third-party contractor as outlined in Table 1 and detailed further in the supplemental report included in this submission.

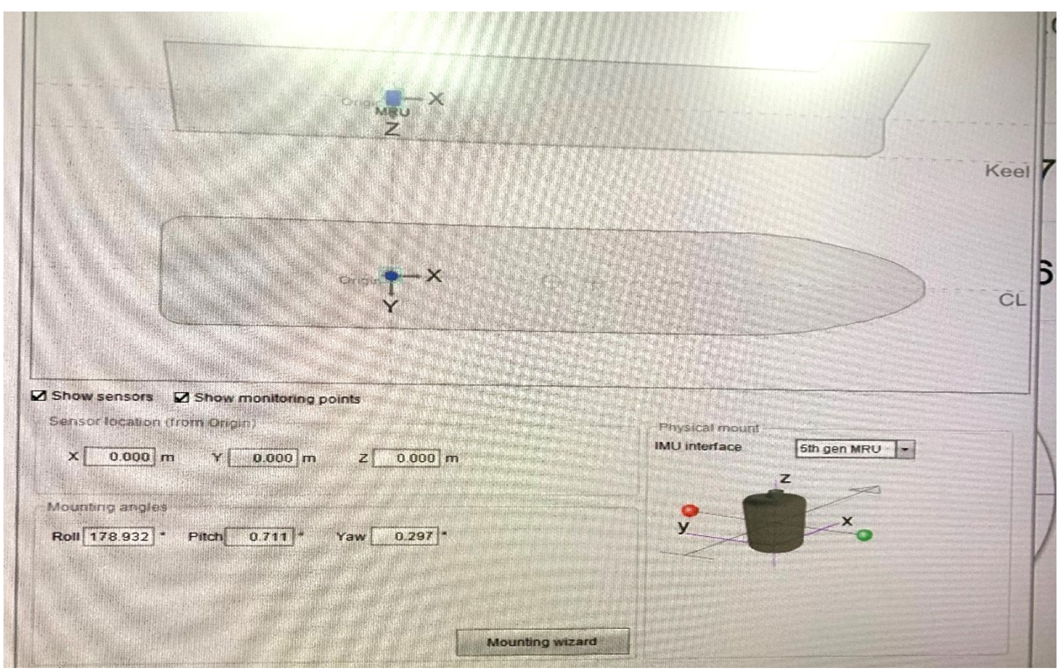

Figure 20: Seapath MRU input geometry - angles and offsets.

A.5.3.5 MRU Heave Configuration

The MRU heave information was set to 'Hydrographic survey' with a ten-second period as shown in Figure 21. These parameters were not changed for the duration of the mission.

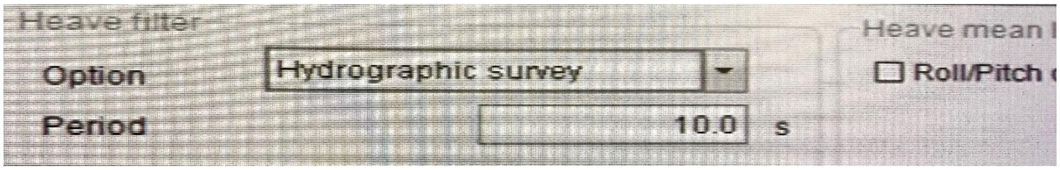

Figure 21: Seapath MRU heave configuration.

A.5.3.6 Input/Output

As shown in Figure 22, the GNSS antennas and MRU are connected via serial connections whereas positioning and attitude are relayed via ethernet connections to the EM 124 and the SIS computer. Similarly, a serial connection allows for the positioning and attitude information to be used by the DSSV Pressure Drop ECDIS for navigation. Nothing was changed for the duration of the mission. The TelegramOut1 which was changed in February 2019 is shown in Figure 24 but is not reflected in Figure 22.

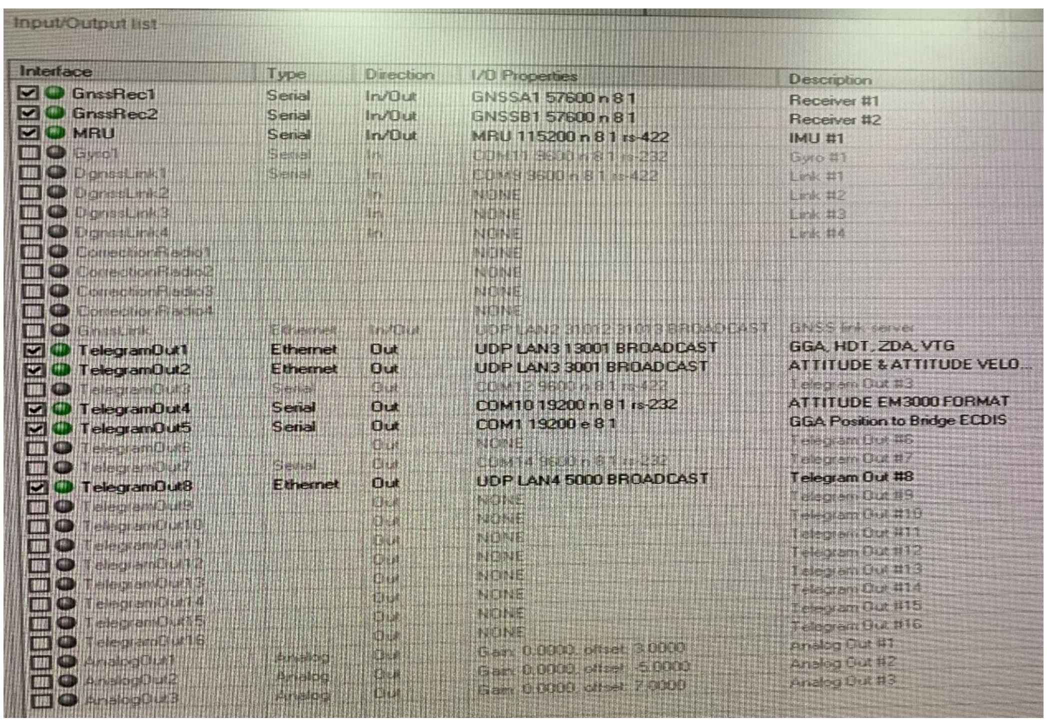

Figure 22: Seapath input and output information.

The TelegramOut1 settings were changed from those outlined in Figure 23 to those in Figure 24. Once this change was made, the POS-PU time delay was drastically improved.

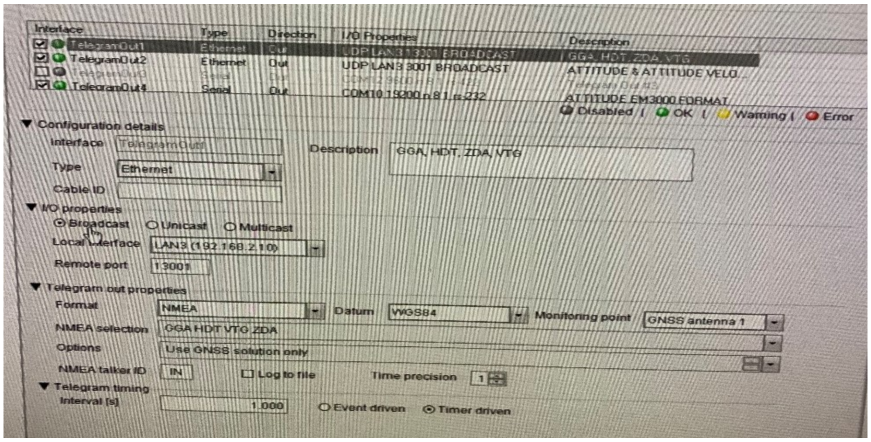

Figure 23:Original TelegramOut1 settings.

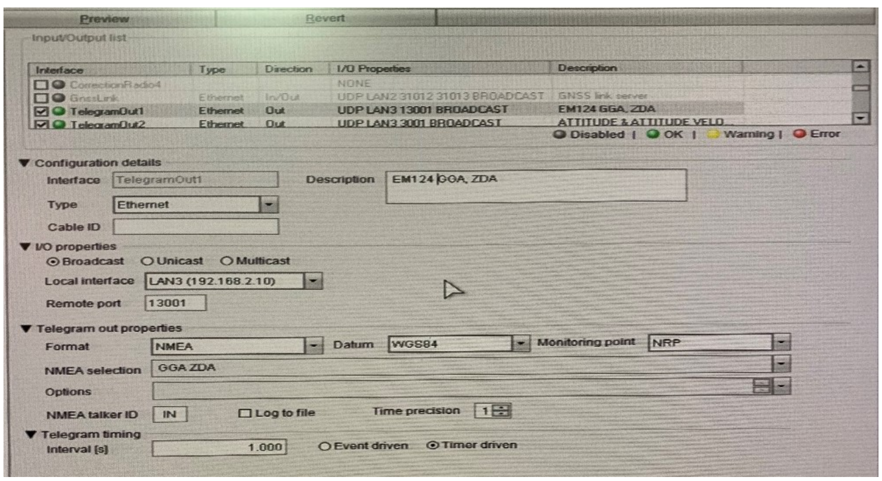

Figure 24: Updated TelegramOut1 settings.

The NMEA string and the monitoring point were changed as suggested by Kongsberg support.

A.5.3.7 Serial Port Extender

The Seapath serial port extender parameters are shown in Figure 25 and were not altered for the duration of the mission.

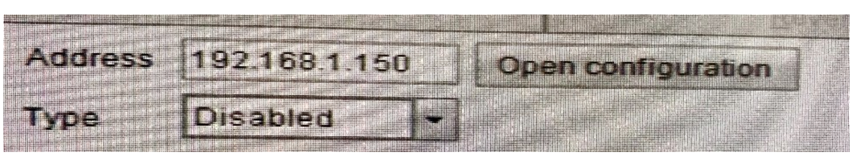

Figure 25: Seapath serial port extender input parameters.

A.5.3.8 Data Pool

The Seapath data pool parameters are shown in Figure 26 and were not altered for the duration of the mission.

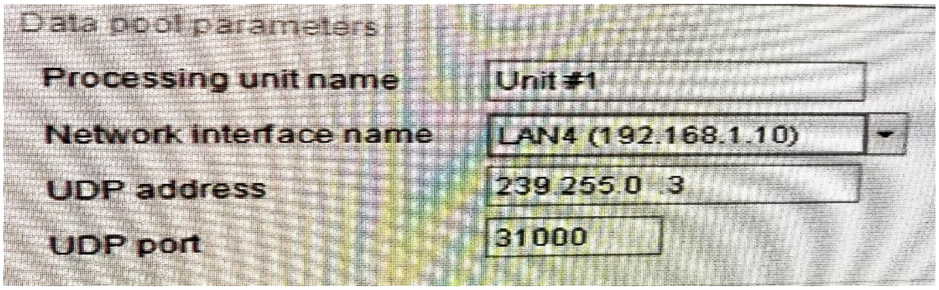

Figure 26: Seapath data pool input parameters.

A.5.4 Sound Speed Manager

Sound Speed Manager was used to create synthetic sound speed profiles during the mission when real casts were not able to be acquired. Additionally, this program was used to extend shorter profiles using archive data from the 2009 World Ocean Database. Data were able to be compared to previous casts and exported to the appropriate file format for SIS and Qimera processing.

A.5.5 Sippican WinMK21

Sippican WinMK21 is the software used to collect XBT (expendable bathythermograph) data. The XBT is fired off the back deck of the ship and the data is recorded through the LMC-16 Ocean Probe DAQ and visible in real-time in the WinMK21 software. Profiles were exported through the messaging window and brought into sound speed manager to be extended using World Ocean Atlas 2009.

A.6 Data Processing Software

Name	Manufacturer	Version	Installation Date
Qimera	QPS	1.7.5	12/04/2018
Hydro Office Sound Speed Manager	UNH CCOM/ Hydro Office	2018.1.50	12/06/2018
Matlab*	Matlab	R2018a	09/18/2018
Fledermaus & FMGT	QPS	7.8	12/04/2018
ArcMap/ArcGIS*	ESRI	10.7.1	10/18/2019

*Table 7: Data processing software and versions. *personal license*

A.6.1 QPS Qimera 1.7.5

Qimera is used for all MBES data processing, line cleaning, and CUBE surface creation. Additionally, some of these end-product maps will be shared with Kongsberg (per user agreement) via the cloud. A connection was created by Kongsberg on the processing computer for this purpose.

A.6.2 Hydro Office Sound Speed Manager

Sound Speed Manager (SSM) was used for synthetic sound velocity profile generation during transits and extending Sippican XBT profiles. These profiles were exported as .asvp files for a direct input into Kongsberg SIS.

A.6.3 Matlab R2018a

Matlab *(personal license)* was used to parse the sub-collected CTD data to a manageable size and determine the deepest recorded depth by converting pressure (dbar) to depth (m). The parsed sound speed profile was saved and uploaded into Qimera.

A.6.4 QPS Fledermaus and FMGT

Fledermaus was used to create fly-throughs of the data and FMGT was used to create backscatter products.

A.6.5 ESRI ArcGIS 10.6.1

ESRI ArcGIS *(personal license)* was used to calculate statistics on final bathymetric surfaces, compare these data to previous estimates, and create final figures for reports.

A.7 Survey Methodology

A.7.1 Mobilization

Mobilization occurred in port in Tokyo on July 25-26, 2020. Vessel offsets and associated measurement uncertainties were calculated by a third-party contractor Robert Howard at True Position in December 2018 and were not changed for this mission. Any offsets and uncertainties were added to the QPS Qimera Vessel Configuration File as they were found. More information can be found in the associated descriptive reports.

A.7.2 Patch Test Results

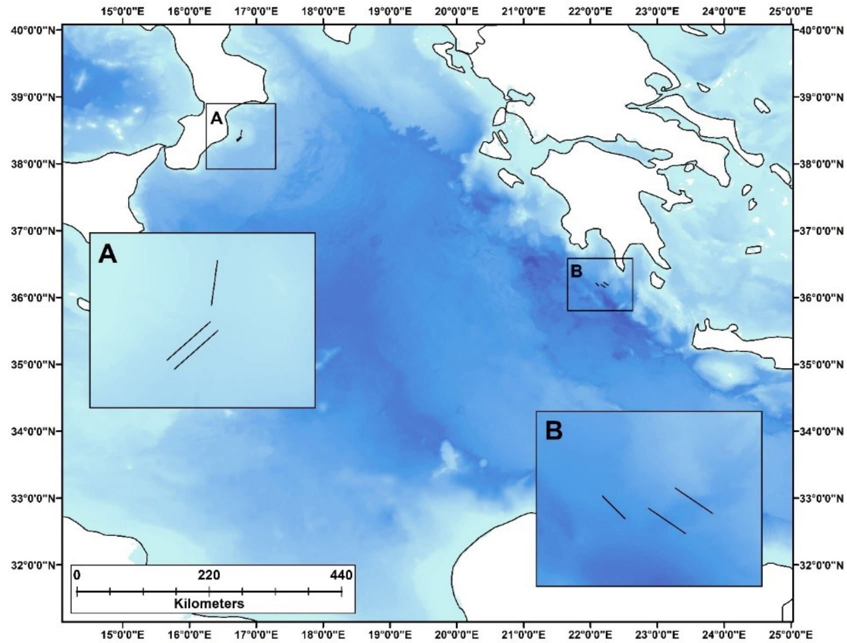

Figure 27: Patch Test locations for both shallow and deep patch tests. Shallow patch site shown in 'A' and deep in 'B'. Both tests were performed in the Mediterranean Sea in February 2020.

For start of Caladan Oceanic's 2020 field season, patch test data were collected twice. Once on 02/05/2020 in shallow water (450-700m) and again on 02/07/2020 in deep water (+2500m). Both sets of survey lines were processed in QPS Qimera using the Patch Test toolbox. The shallow water lines were run first and were then used to determine the offsets applied to the deep lines during collection. The deep patch was performed to make sure that the offsets remained true. Ultimately, the results from the deep patch test will be the final offsets as the system primarily operates in deep water. It is believed that they represent a more realistic estimate of the true system offsets resulting from their amplification in deep water in addition to a calmer weather day during the deep patch collection.

Calibration	Shallow	Deep
[redacted]		

Table 8: Patch test offset results.

An additional latency offset of **0.163 seconds** was determined later.

A.7.3 Survey Coverage

Survey coverage for each mapping area are discussed in more details in the location-appropriate report.

Location Name	North Western Corner	South Eastern Corner	Area (km^2)
Japan Trench	41°9'50.097"N	35°46'12.961"N	9,746
	142°27'9.54"E	144°59'21.198"E	

Table 9: Survey locations and areas.

A.7.4 Depth Measurement Operations

Mapping operations for the Japan Trench surveys were run between 8-10kts from 07/28/20 to 07/29/20. These data were collected for scientific purposes. DSSV Pressure Drop single beam was turned off for all mapping operations.

Processing was completed immediately in Qimera after each line was collected to minimize the time for feature identification and the time required for post-processing. The vessel configuration files and projection information were populated based on the information stored in the SIS raw datagram, but edited based on the 2020 patch test. The SVPs applied during acquisition were stored and are visible in Qimera for editing. CUBE surfaces for each project were created. Data were cleaned and edited to their final stages and exported as: BAG, ascii, .xyz, and geotiffs.

More information on data results and processes are outlined in their respective DRs.

B. Quality Control

B.1 Multibeam Echosounder Data

B.1.1 Acquisition Operations

Line plans were created in ESRI ArcGIS 10.7.1 to maximize survey coverage in the time allotted. Way points were given to the bridge and a new survey project is created in SIS for each mission. More information is included in the associated descriptive reports.

B.1.2 MBES Processing Workflow

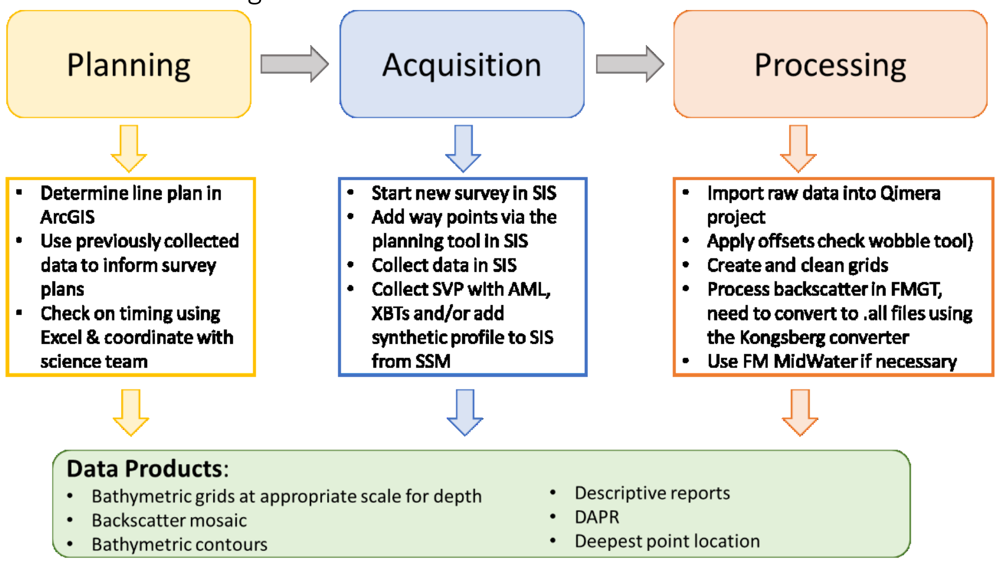

Figure 28: Multibeam processing workflow.

B.2 Backscatter Workflow

B.2.1 Backscatter Processing Workflow

Currently, QPS FMGT does not support the newest SIS output files (.kmall). As such, a Kongsberg KMALLtoALL converter is used to help with this process. Data were then brought into FMGT as source files. Due to the new file format, backscatter is saved differently, causing errors upon import that were typically resolved by adjusting the processing parameters for the backscatter acceptable dB range and applying the backscatter beam pattern correction. However, with the newest version of SIS, we have had issues getting accurate backscatter products.

The .kmall and .all data files are provided, but no final backscatter products have been made.

B.3 Feature Data

B.3.1 Hydrographic Features

More information detailed in the descriptive report.

C. Corrections to Data

C.1 Vessel Corrections

C.1.1 Static Offsets

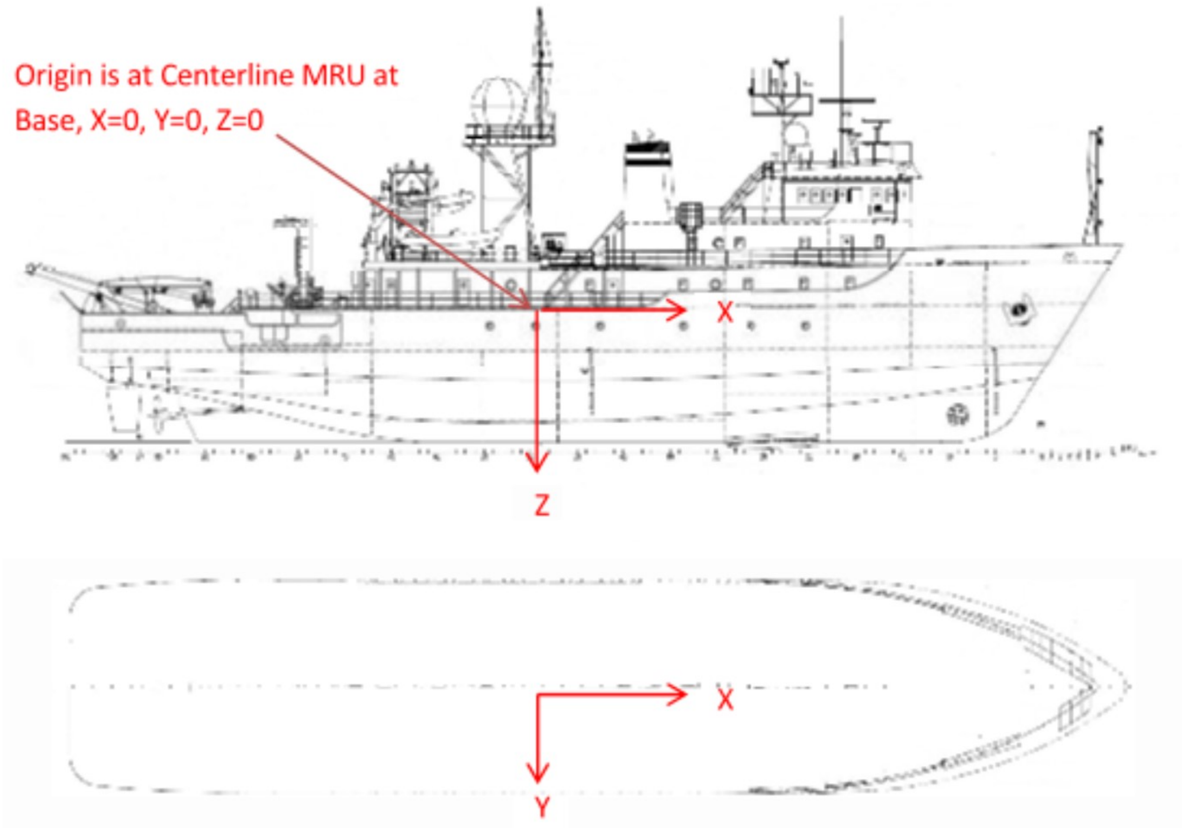

Figure 29: Vessel reference frame from DSSV Pressure Drop Report (attached).

The DSSV Pressure Drop vessel reference frame is: + x bow forward, + y to starboard, and +z down. The offsets outlined in the following table were calculated by a third-party contractor (IMTEC – Industrial Measurement Technology Engineering Consultants) and are described in more detail in the supplemental report.

	Forward (X) m	Starboard (Y) m	Downward (Z) m
EM 124 Tx	16.580	0.199	9.444
Tx angles	0.196	0.074	359.907
EM 124 Rx	12.028	0.193	9.589
Rx angles	0.079	-0.108	0.002
FWD GPS	17.954	0.223	-14.062
AFT GPS	14.164	0.210	-14.074

Table 10: DSSV Pressure Drop EM 124 (grey) and GPS antenna (white) locations within the vessel reference frame with respect to the reference point.

C.1.2 Dynamic Offsets

The data are referenced to the geoid, dynamic offsets were not applied.

C.1.3 Patch Test Biases

Patch test biases are entered directly in to Qimera. More information on the patch test results can be found in the DSSVPD Patch Report.

C.2 Sound Speed

Synthetic profiles were used on all transit legs. XBTs were collected during the beginning of trench operations and extended with synthetic profiles from the Word Ocean Atlas 2009. Full-ocean depth sound speed profiles were acquired with the two CTDs attached to the Limiting Factor and were used to verify depths.

C.3 Horizontal and Vertical Control and Corrections

Horizontal Reference:	World Geodetic System 1984
Realization:	WGS84
Geoid:	EGM96

Table 11: Horizontal reference information.

No horizontal and vertical corrections were applied. Data are referenced to the Geoid as the undulation (or difference) between the ellipsoid and the geoid at this location is -65 m, with the ellipsoid being lower (Figure 30).

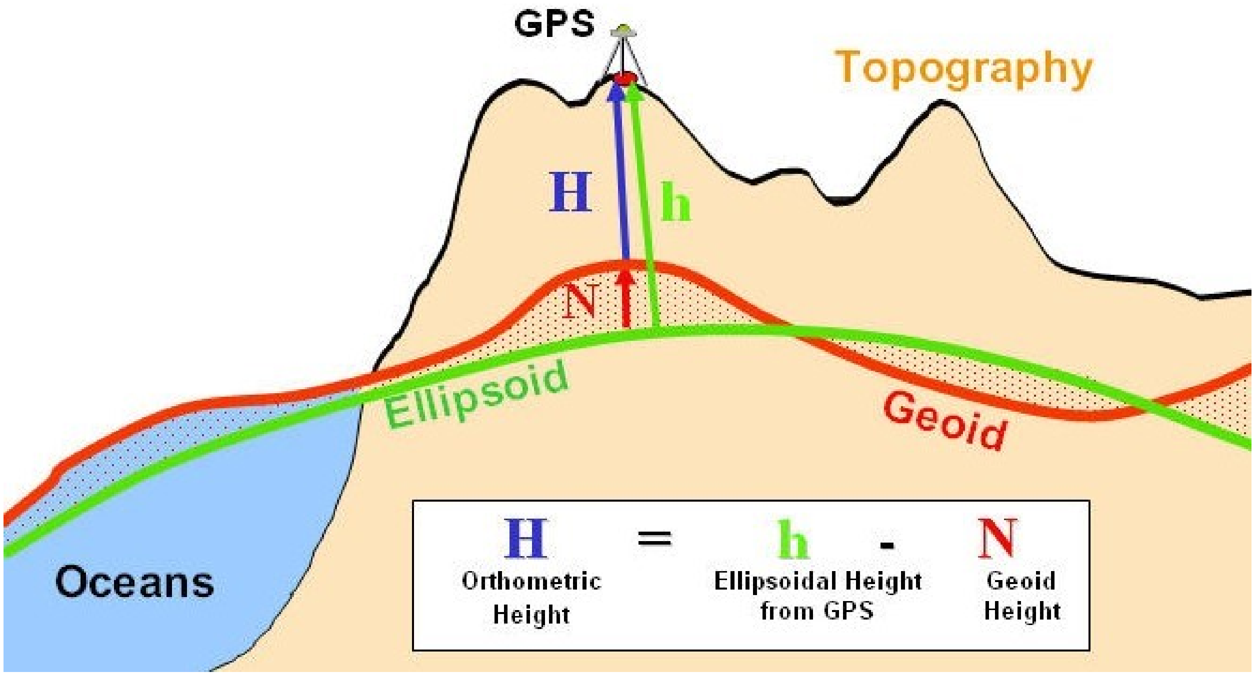

Figure 30: Geodetic vertical reference systems over land and sea to see how they change – image from google.