DSSV Pressure Drop: Data Acquisition & Processing Report

Pacific Ocean Transit

June-July 2019

Report developed for Five Deeps Expedition by Cassie Bongiovanni

Internal Use Only

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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

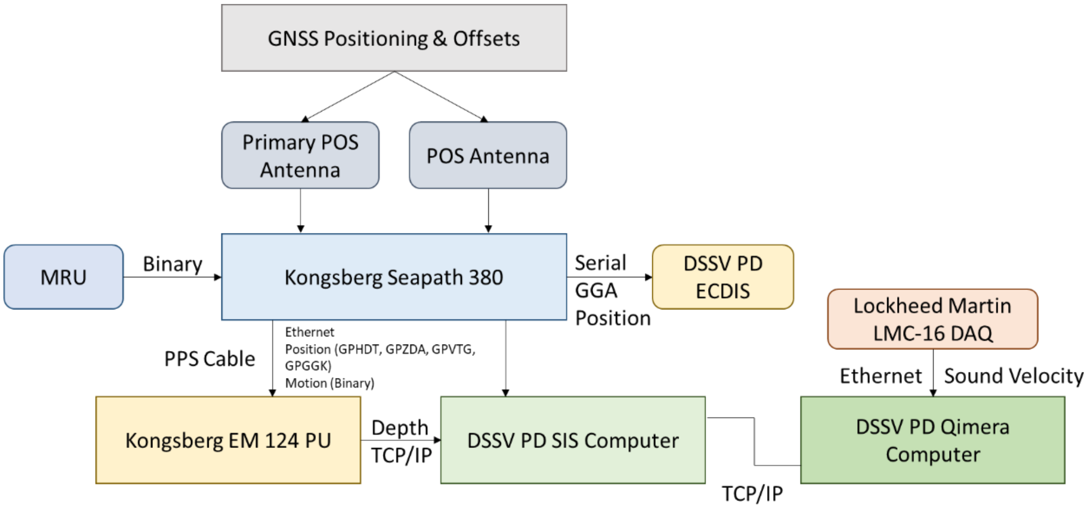


Figure 2: DSSV Pressure Drop data flow diagram.

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, currently only accepted by Qimera (discussed in section A.6.1).

Instrument	Kongsberg EM 124 (1° x 2°)		
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.

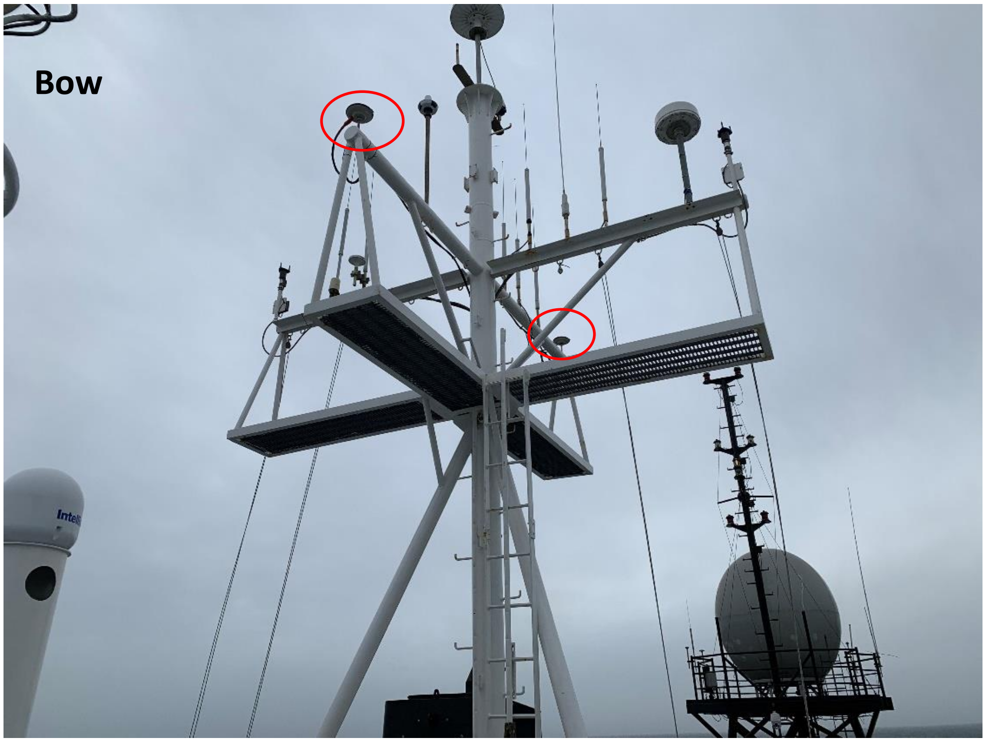


Figure 5: GPS antennas mounted at the top of the ship near the bow.

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

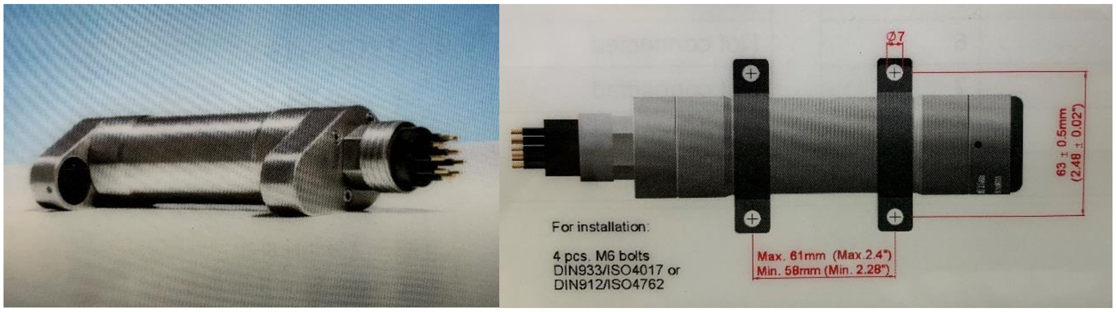


Figure 6: Reson SVP70 used for sound speed at the transducer.

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.5 Data Acquisition Software

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

Name	Manufacturer	Version	Installation Date
ArcMap/ArcGIS	ESRI	10.6.1	09/18/2018
SIS- Seafloor Information System	Kongsberg	5.1.1.153	12/03/2018
Seapath 380	Kongsberg SeaTex	1.11.0	12/03/2018
Sound Speed Manager	CCOM	2018.1.50	12/08/2018

Table 4: Data acquisition software information.

A.5.1 ESRI ArcGIS *(personal license)*

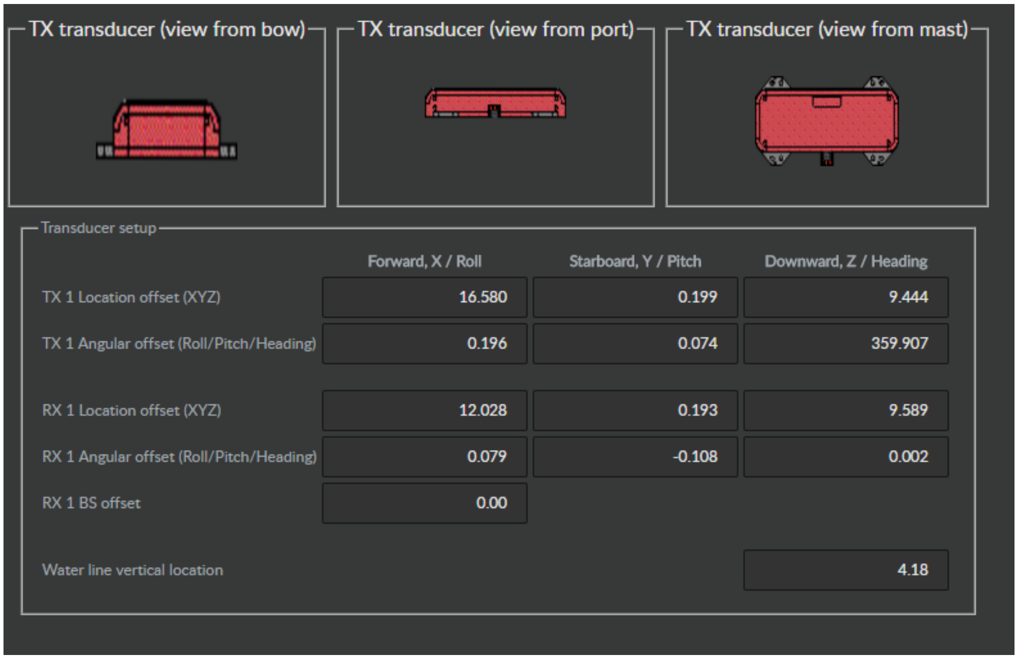
ESRI (Environmental Systems Research Institute) ArcGIS was used with a personal license to help with line planning, data visualization, and big-picture project organization.

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 7. The waterline was visually inspected and determined before leaving the dock in San Juan, Puerto Rico.

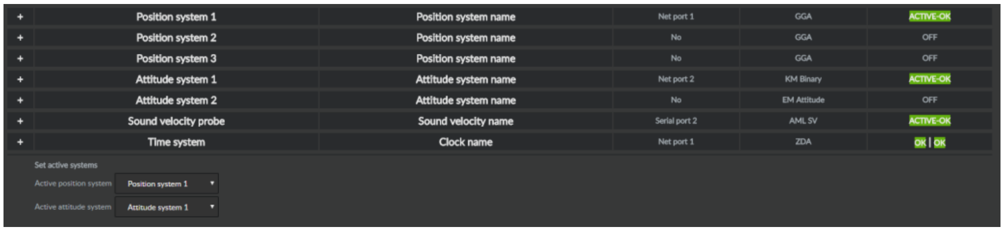


Transducer setup

	Forward, X / Roll	Starboard, Y / Pitch	Downward, Z / Heading
TX 1 Location offset (XYZ)	16.580	0.199	9.444
TX 1 Angular offset (Roll/Pitch/Heading)	0.196	0.074	359.907
RX 1 Location offset (XYZ)	12.028	0.193	9.589
RX 1 Angular offset (Roll/Pitch/Heading)	0.079	-0.108	0.002
RX 1 BS offset	0.00		
Water line vertical location			4.18

Figure 7: Kongsberg SIS 5 transducer offsets.

The input settings for each of the systems necessary to run the multibeam are shown in Figure 8.

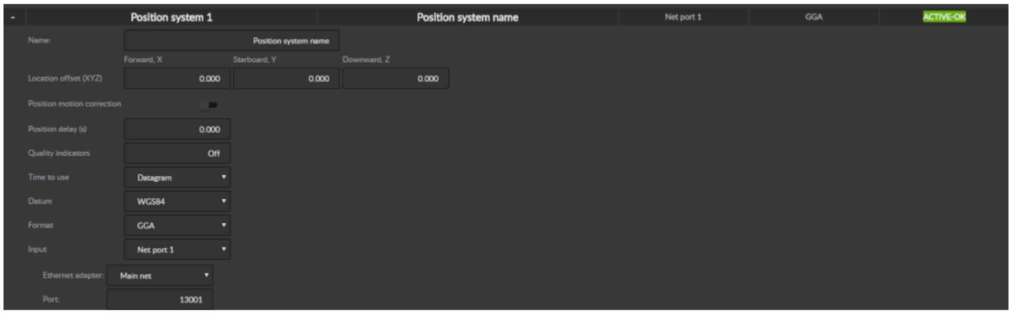


+	Position system 1	Position system name	Net port 1	GGA	ACTIVE-OK
+	Position system 2	Position system name	No	GGA	OFF
+	Position system 3	Position system name	No	GGA	OFF
+	Attitude system 1	Attitude system name	Net port 2	KM Binary	ACTIVE-OK
+	Attitude system 2	Attitude system name	No	EM Attitude	OFF
+	Sound velocity probe	Sound velocity name	Serial port 2	AML SV	ACTIVE-OK
+	Time system	Clock name	Net port 1	ZDA	OK | OK

Set active systems
Active position system: Position system 1
Active attitude system: Attitude system 1

Figure 8: Kongsberg SIS 5 input parameters.

Position settings in SIS 5 are described in Figure 9 and are pulled from the Seapath 380. These were not changed for the duration of the mission.



-	Position system 1	Position system name	Net port 1	GGA	ACTIVE-OK

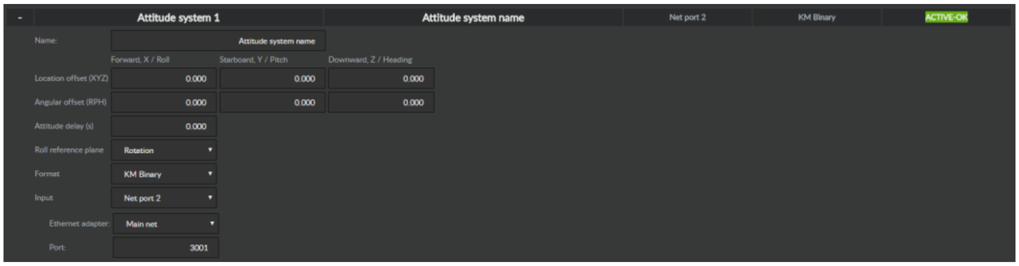
Name: Position system name

	Forward, X	Starboard, Y	Downward, Z
Location offset (XYZ)	0.000	0.000	0.000

Position motion correction
Position delay (s): 0.000
Quality indicators: Off
Time to use: Datagram
Datum: WGS84
Format: GGA
Input: Net port 1
Ethernet adapter: Main net
Port: 13001

Figure 9: Kongsberg SIS 5 Position System input settings.

Attitude settings entered in SIS 5 described in Figure 10 and are pulled from the Seapath 380 which obtains this from the MRU. These settings were not changed for the duration of the mission.



Attitude system 1 | Attitude system name | Net port 2 | KM Binary | ACTIVE-OK

Name: Attitude system name

	Forward, X / Roll	Starboard, Y / Pitch	Downward, Z / Heading
Location offset (XYZ)	0.000	0.000	0.000
Angular offset (RPH)	0.000	0.000	0.000

Attitude delay (s): 0.000
Roll reference plane: Rotation
Format: KM Binary
Input: Net port 2
Ethernet adapter: Main net
Port: 3001

Figure 10: Kongsberg SIS 5 Attitude System input settings.

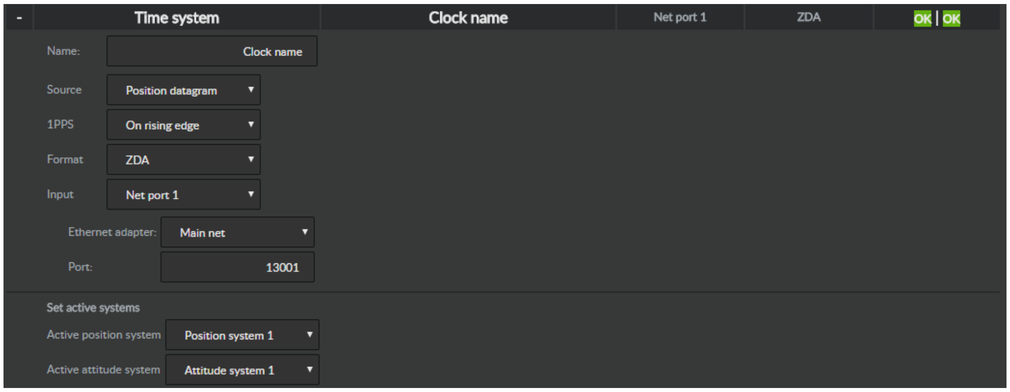
The sound velocity probe settings are outlined in Figure 11 and were not changed for the duration of the mission.

Sound velocity probe | Sound velocity name | Serial port 2 | AML SV | ACTIVE-OK

Name: Sound velocity name
Format: AML SV
Input: Serial port 2
Interface 2: RS232
Baud rate: 9600
Data bit: 8
Stop bit: 1
Parity: None

Figure 11: Kongsberg SIS 5 sound velocity probe input settings.

The time system input settings are outlined in Figure 12 and show that time was being pulled from the position datagram.



Time system | Clock name | Net port 1 | ZDA | OK | OK

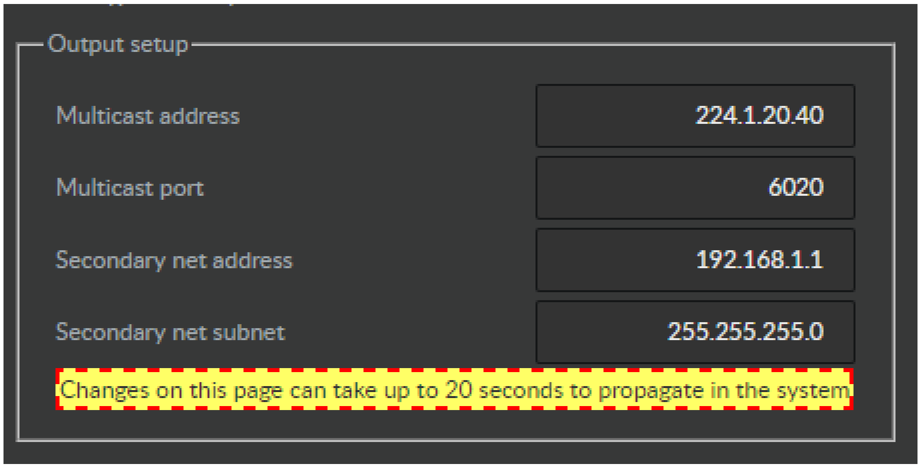
Name: Clock name
Source: Position datagram
1PPS: On rising edge
Format: ZDA
Input: Net port 1
Ethernet adapter: Main net
Port: 13001

Set active systems
Active position system: Position system 1
Active attitude system: Attitude system 1

Figure 12: Kongsberg SIS 5 Time System input settings.

A.5.2.2 Output Settings

SIS output settings are outlined in Figure 13 and were not changed for the duration of the mission.



Output setup

Multicast address: 224.1.20.40

Multicast port: 6020

Secondary net address: 192.168.1.1

Secondary net subnet: 255.255.255.0

Changes on this page can take up to 20 seconds to propagate in the system

Figure 13: Kongsberg SIS 5 output settings.

A.5.2.3 Runtime Parameters

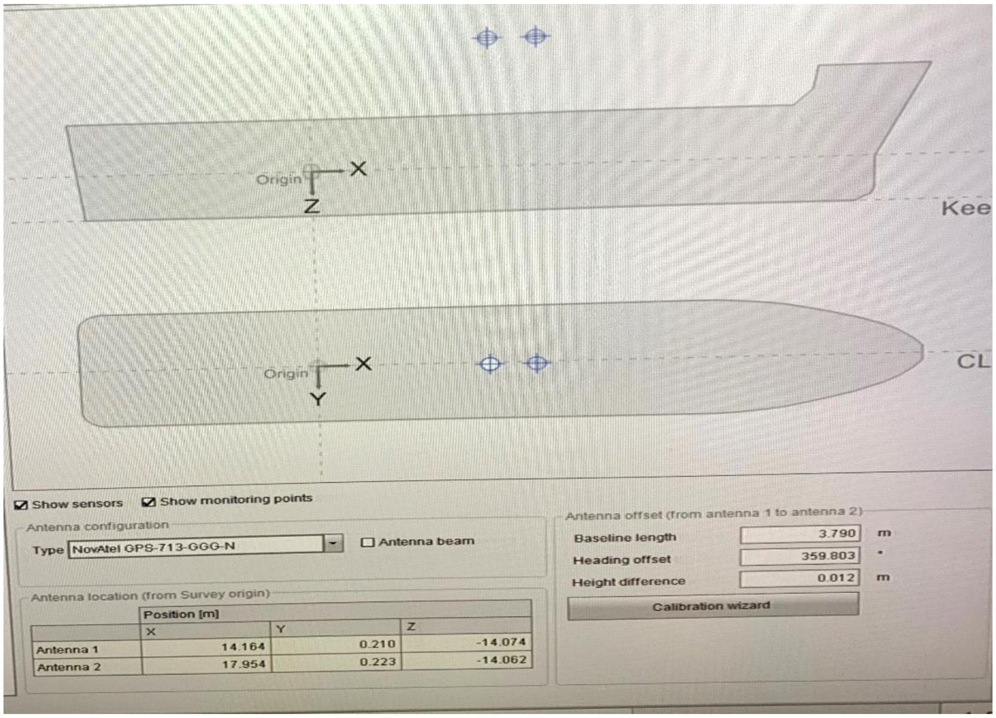
Runtime parameters changed frequently depending on what water depth we were operating in. For example, depths less than 500m needed to have a depth setting of ‘Shallow Mode’ and depths greater than 5000m needed to be in ‘Very Deep Mode’, but depths between could be in ‘Auto’. Similarly, port and starboard angles were changed depending on weather and coverage – but were generally between 60-70 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.



☑ Show sensors ☑ Show monitoring points

Antenna configuration

Type: NovAtel GPS-713-GGG-N ☐ Antenna beam

Antenna location (from Survey origin)

	Position [m]		
	X	Y	Z
Antenna 1	14.164	0.210	-14.074
Antenna 2	17.954	0.223	-14.062

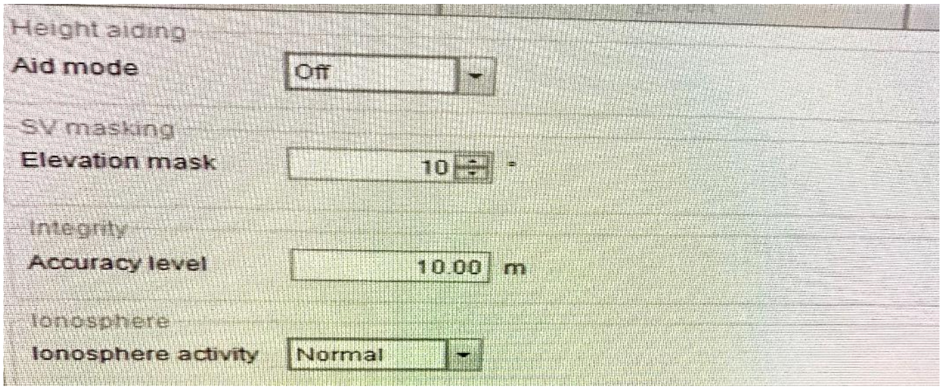
Antenna offset (from antenna 1 to antenna 2)

Baseline length	3.790	m
Heading offset	359.803	°
Height difference	0.012	m

Figure 14:Seapath input geometry and offsets.

A.5.3.2 GNSS Processing

GNSS processing parameters entered in the Seapath configuration are shown in Figure 15. These parameters were not altered for the duration of the mission.



Height aiding

Aid mode: Off

SV masking

Elevation mask: 10 °

Integrity

Accuracy level: 10.00 m

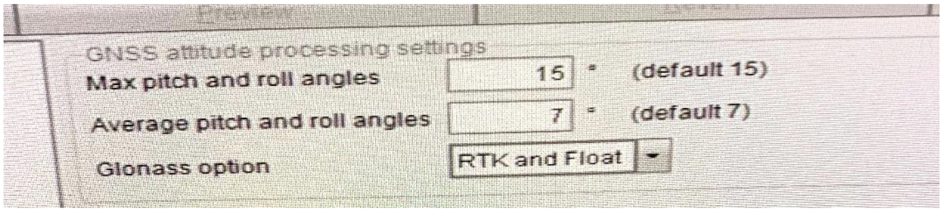
Ionosphere

Ionosphere activity: Normal

Figure 15: Seapath GNSS processing parameters.

A.5.3.3 GNSS Attitude Processing

GNSS attitude processing settings as set in the Seapath are shown in Figure 16 and were not altered for the duration of the mission.



GNSS attitude processing settings

Max pitch and roll angles 15 ° (default 15)

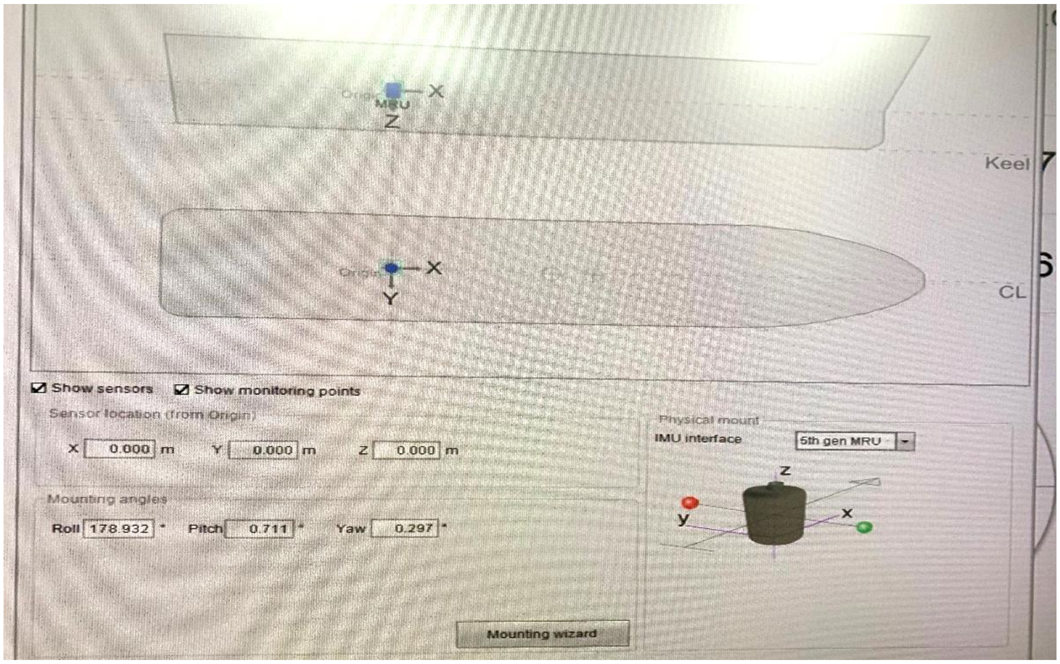
Average pitch and roll angles 7 ° (default 7)

Glonass option RTK and Float

Figure 16: 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 17. 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.



☑ Show sensors ☑ Show monitoring points

Sensor location (from Origin)

X 0.000 m Y 0.000 m Z 0.000 m

Mounting angles

Roll 178.932 ° Pitch 0.711 ° Yaw 0.297 °

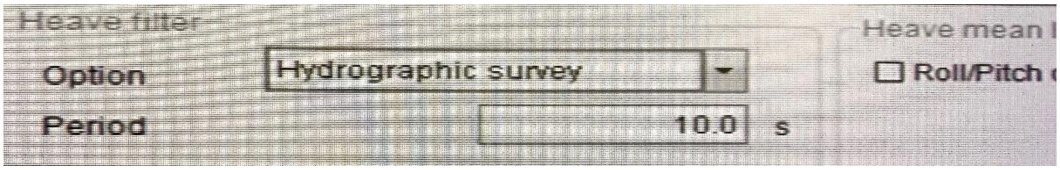
Physical mount

IMU interface 5th gen MRU

Figure 17: 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 18. These parameters were not changed for the duration of the mission.



Heave filter

Option Hydrographic survey

Period 10.0 s

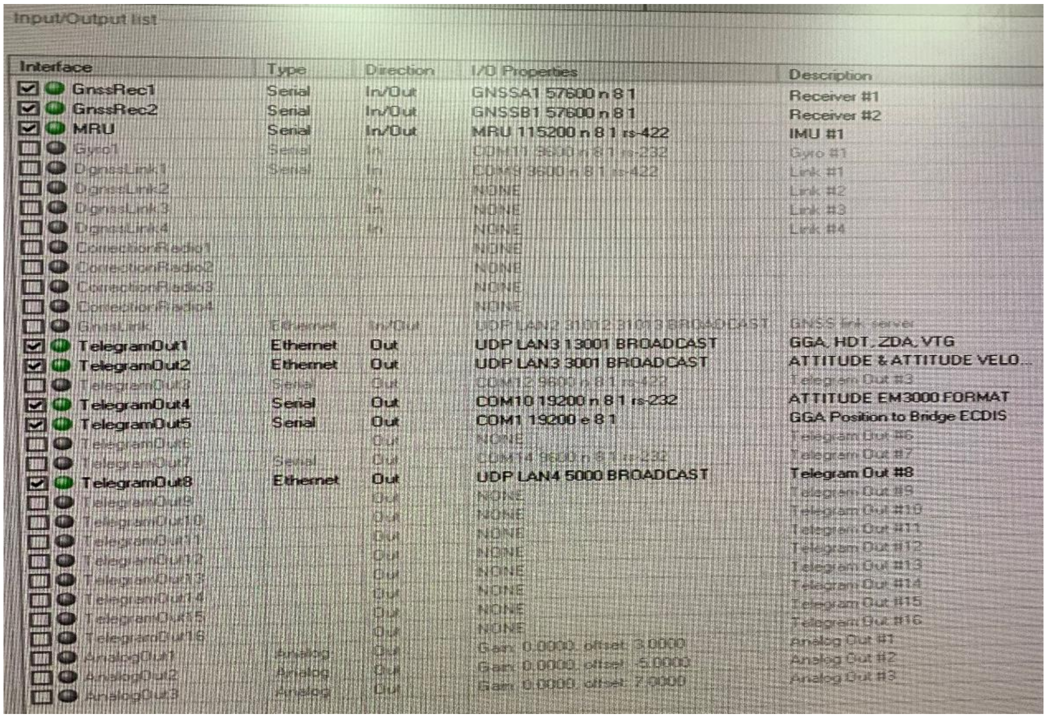
Heave mean

☐ Roll/Pitch

Figure 18: Seapath MRU heave configuration.

A.5.3.6 Input/Output

As shown in Figure 19, 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 is shown in Figure 21 but is not reflected in Figure 19.

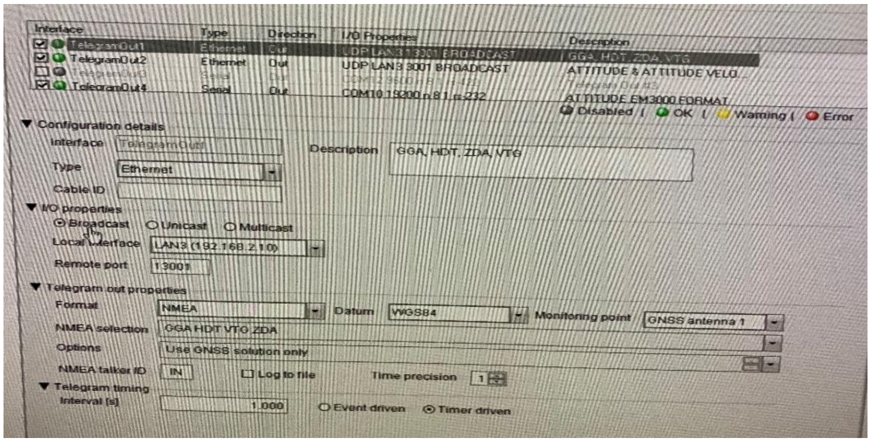


Input/Output list

Interface	Type	Direction	I/O Properties	Description
☑ GnssRec1	Serial	In/Out	GNSSA1 57600 n 8 1	Receiver #1
☑ GnssRec2	Serial	In/Out	GNSSB1 57600 n 8 1	Receiver #2
☑ MRU	Serial	In/Out	MRU 115200 n 8 1 rs-422	IMU #1
☐ Gyro1	Serial	In	COM11 9600 n 8 1 rs-232	Gyro #1
☐ DgnssLink1	Serial	In	COM9 9600 n 8 1 rs-422	Link #1
☐ DgnssLink2		In	NONE	Link #2
☐ DgnssLink3		In	NONE	Link #3
☐ DgnssLink4		In	NONE	Link #4
☐ CorrectionRadio1			NONE	
☐ CorrectionRadio2			NONE	
☐ CorrectionRadio3			NONE	
☐ CorrectionRadio4			NONE	
☐ GnssLink	Ethernet	In/Out	UDP LAN2 31012 31013 BROADCAST	GNSS link server
☑ TelegramOut1	Ethernet	Out	UDP LAN3 13001 BROADCAST	GGA, HDT, ZDA, VTG
☑ TelegramOut2	Ethernet	Out	UDP LAN3 3001 BROADCAST	ATTITUDE & ATTITUDE VELO...
☐ TelegramOut3	Serial	Out	COM12 9600 n 8 1 rs-422	Telegram Out #3
☑ TelegramOut4	Serial	Out	COM10 19200 n 8 1 rs-232	ATTITUDE EM3000 FORMAT
☑ TelegramOut5	Serial	Out	COM1 19200 e 8 1	GGA Position to Bridge ECDIS
☐ TelegramOut6		Out	NONE	Telegram Out #6
☐ TelegramOut7	Serial	Out	COM14 9600 n 8 1 rs-232	Telegram Out #7
☑ TelegramOut8	Ethernet	Out	UDP LAN4 5000 BROADCAST	Telegram Out #8
☐ TelegramOut9		Out	NONE	Telegram Out #9
☐ TelegramOut10		Out	NONE	Telegram Out #10
☐ TelegramOut11		Out	NONE	Telegram Out #11
☐ TelegramOut12		Out	NONE	Telegram Out #12
☐ TelegramOut13		Out	NONE	Telegram Out #13
☐ TelegramOut14		Out	NONE	Telegram Out #14
☐ TelegramOut15		Out	NONE	Telegram Out #15
☐ TelegramOut16		Out	NONE	Telegram Out #16
☐ AnalogOut1	Analog	Out	Gain: 0.0000, offset: 3.0000	Analog Out #1
☐ AnalogOut2	Analog	Out	Gain: 0.0000, offset: -5.0000	Analog Out #2
☐ AnalogOut3	Analog	Out	Gain: 0.0000, offset: 7.0000	Analog Out #3

Figure 19: Seapath input and output information.

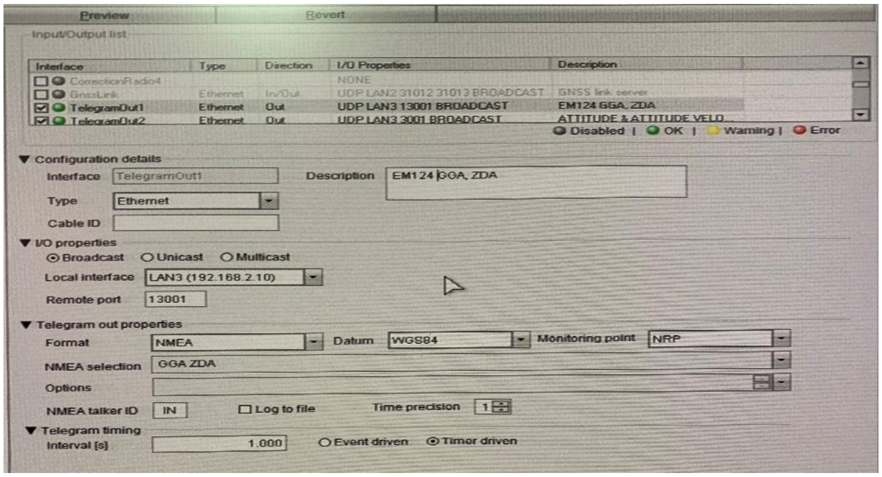
The TelegramOut1 settings were changed from those outlined in Figure 20 to those in Figure 21. Once this change was made, the POS-PU time delay was drastically improved.



Interface	Type	Direction	I/O Properties	Description
☑ TelegramOut1	Ethernet	Out	UDP LAN3 13001 BROADCAST	GGA, HDT, ZDA, VTG
☑ TelegramOut2	Ethernet	Out	UDP LAN3 3001 BROADCAST	ATTITUDE & ATTITUDE VELO...
☐ TelegramOut3	Serial	Out	COM12 9600 n 8 1 rs-422	Telegram Out #3
☑ TelegramOut4	Serial	Out	COM10 19200 n 8 1 rs-232	ATTITUDE EM3000 FORMAT

▼ Configuration details
Interface: TelegramOut1
Description: GGA, HDT, ZDA, VTG
Type: Ethernet
Cable ID:
▼ I/O properties
● Broadcast ○ Unicast ○ Multicast
Local interface: LAN3 (192.168.2.10)
Remote port: 13001
▼ Telegram out properties
Format: NMEA
Datum: WGS84
Monitoring point: GNSS antenna 1
NMEA selection: GGA HDT VTG ZDA
Options: Use GNSS solution only
NMEA talker ID: IN
☐ Log to file
Time precision: 1
▼ Telegram timing
Interval [s]: 1.000
○ Event driven ● Timer driven

Figure 20:Original TelegramOut1 settings.



Interface	Type	Direction	I/O Properties	Description
☐ CorrectionRadio4			NONE	
☐ GnssLink	Ethernet	In/Out	UDP LAN2 31012 31013 BROADCAST	GNSS link server
☑ TelegramOut1	Ethernet	Out	UDP LAN3 13001 BROADCAST	EM124 GGA, ZDA
☑ TelegramOut2	Ethernet	Out	UDP LAN3 3001 BROADCAST	ATTITUDE & ATTITUDE VELO...

▼ Configuration details
Interface: TelegramOut1
Description: EM124 GGA, ZDA
Type: Ethernet
Cable ID:

▼ I/O properties
● Broadcast ○ Unicast ○ Multicast
Local interface: LAN3 (192.168.2.10)
Remote port: 13001

▼ Telegram out properties
Format: NMEA
Datum: WGS84
Monitoring point: NRP
NMEA selection: GGA ZDA
Options:
NMEA talker ID: IN
☐ Log to file
Time precision: 1

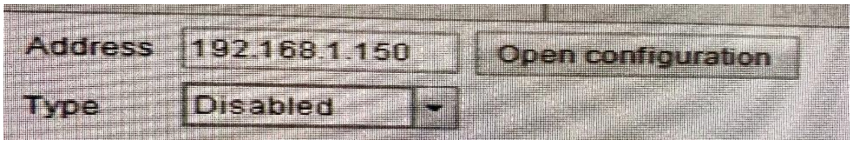
▼ Telegram timing
Interval [s]: 1.000
○ Event driven ● Timer driven

Figure 21: 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 22 and were not altered for the duration of the mission.

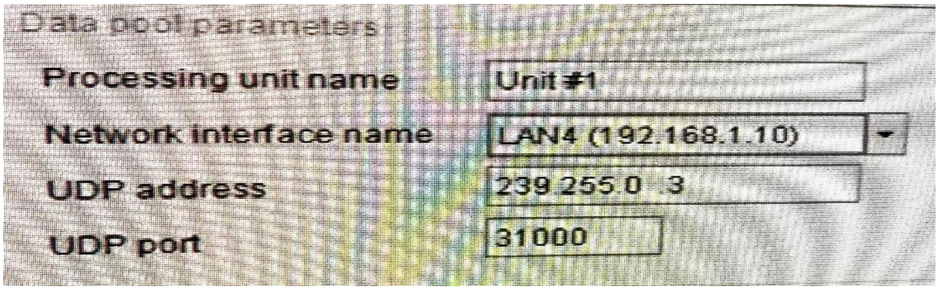


Address: 192.168.1.150
Type: Disabled

Figure 22: Seapath serial port extender input parameters.

A.5.3.8 Data Pool

The Seapath data pool parameters are shown in Figure 23 and were not altered for the duration of the mission.



Processing unit name: Unit #1
Network interface name: LAN4 (192.168.1.10)
UDP address: 239.255.0.3
UDP port: 31000

Figure 23: 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.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
Fledermaus & FMGT	QPS	7.8	12/04/2018
ArcMap/ArcGIS*	ESRI	10.6.1	09/18/2018

*Table 5: 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 QPS Fledermaus and FMGT

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

A.6.4 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 at port in Tonga in June2019. 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 DSSVPD Pacific Ocean DR.

A.7.2 Sonar Acceptance Test

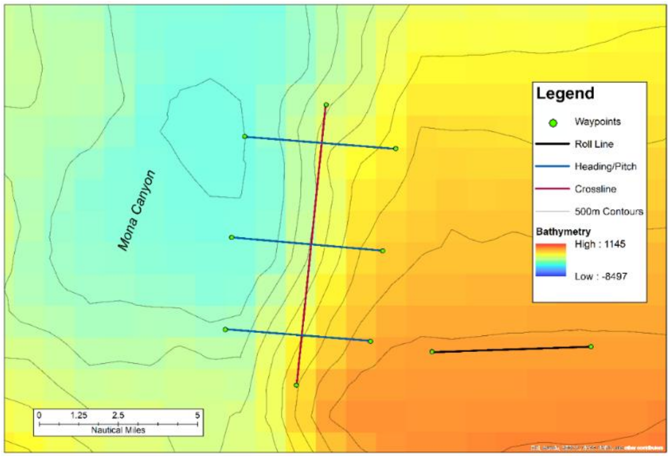


Figure 24: Sonar Acceptance Test (SAT) plan in the Mona Canyon offshore Puerto Rico and near the Puerto Rico Trench.

Shortly after the sonar was installed, a Sonar Acceptance Test (SAT) was performed by Kongsberg technicians, Kongsberg engineers, and Cassie Bongiovanni. The test calibrates the sonar for pitch, heading, and roll as time is already established by the Seapath. The SAT was performed on the eastern half of the Mona Canyon where the slope is > 20°. A full sound speed profile (>5000m depth) was collected using the CTD sensors on the science lander, XBTs were used as needed to update the upper water column.

Correction	Value	Input Value
Pitch 1	0	0
Pitch 2	0	
Heading 1	0	0
Heading 2	0	
Roll 1	0	0
Roll 2	0	

Table 6: SAT offset results.

The SAT was performed in December 2018.

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)
Transit Pacific Ocean	6°51'27.159"N	20°52'36.667"S	85,790
	173°0'53.57"W	80°8'29.497"W	

Table 7: Survey locations and areas.

A.7.4 Depth Measurement Operations

Transit mapping occurred 24/7 at 9-10kts from Tonga Trench (06/11/19) until arrival at the Panama Canal (07/05/19). These data were collected opportunistically by DSSV *Pressure Drop* crew member Erlend Currie. Some guidance by Cassie Bongiovanni (offshore) was provided as needed, but mostly the EM 124 was just running on its own. DSSV Pressure Drop single beam was turned off for all mapping operations.

Processing was completed in Qimera after the transit was completed. The vessel configuration files and projection information were populated based on the information stored in the SIS raw datagram. 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 10.6.1 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 Tonga Trench descriptive report.

B.1.2 MBES Processing Workflow

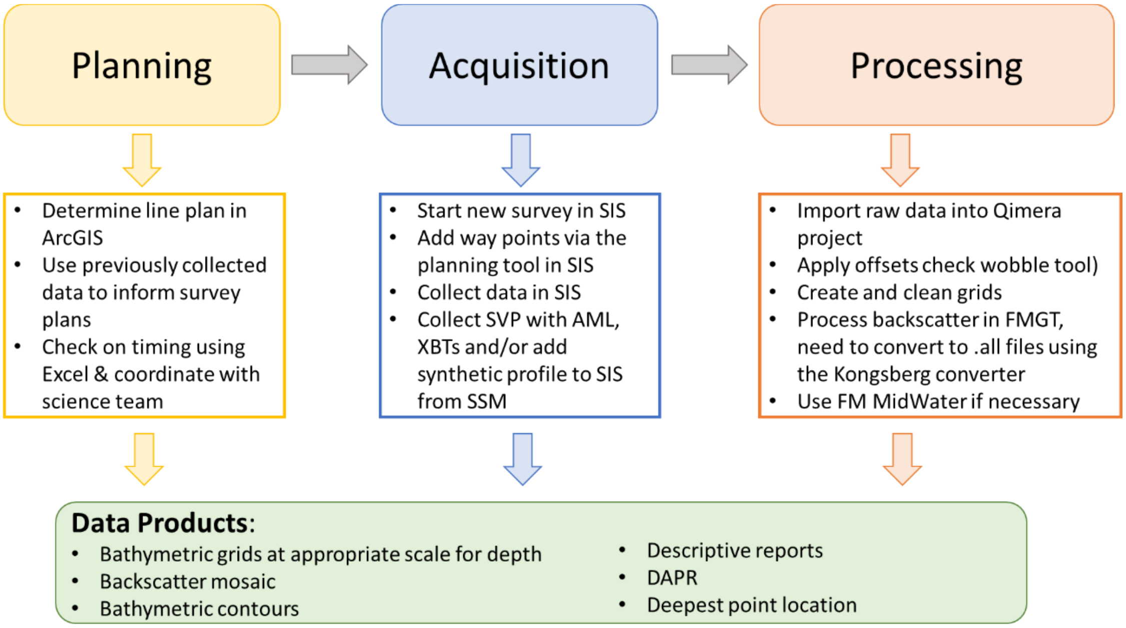


Figure 25: Multibeam processing workflow.

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. Backscatter mosaics were then created and exported as floating point geotiffs.

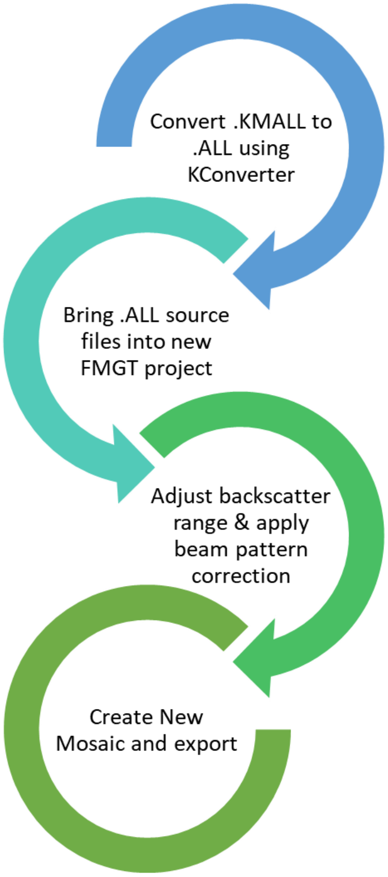


Figure 26: Backscatter mosaic workflow.

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

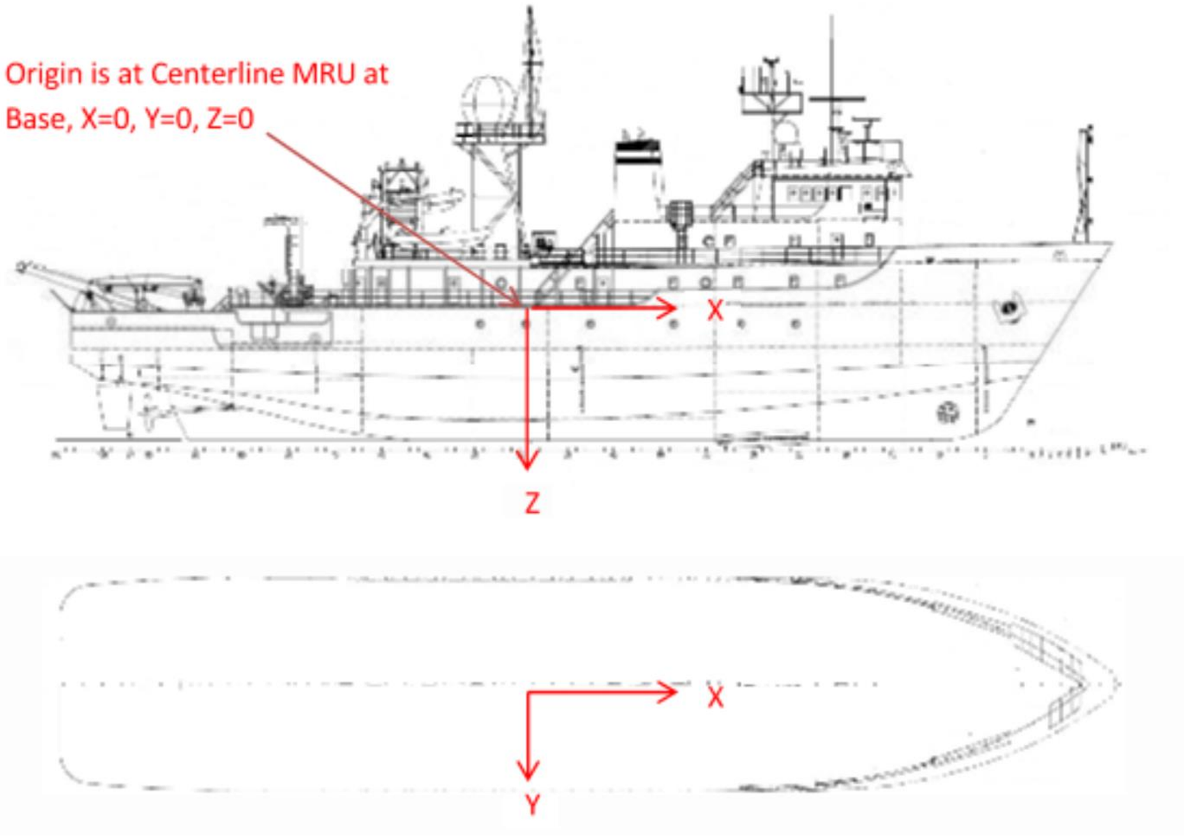


Figure 27: Vessel reference frame from DSSV Pressure Drop Report (attached).

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 8: 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

SAT biases were identified as 0,0,0 for pitch, heading, and roll during the December 2018 SAT. These were calculated twice using two different calibration software – SIS and Qimera, both were quite close.

C.2 Sound Speed

Synthetic profiles were used on all transit legs using World Ocean Atlas 2009.

C.3 Horizontal and Vertical Control and Corrections

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

Table 9: 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 28).

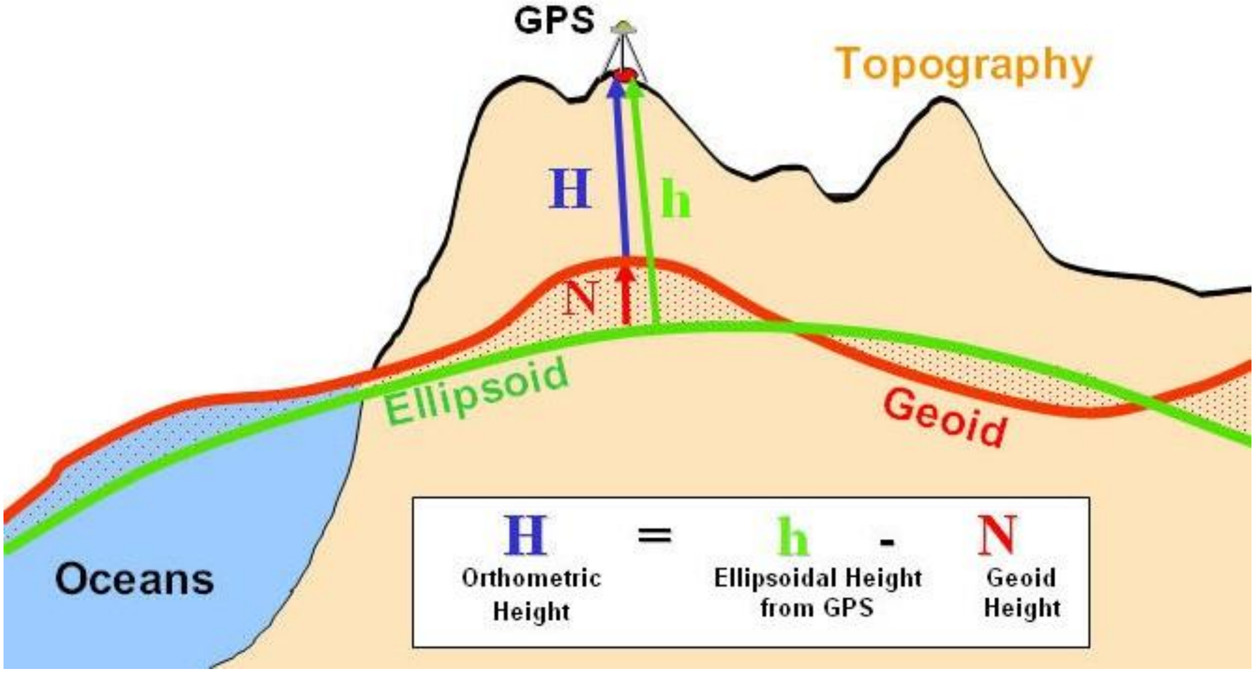


Figure 28: Geodetic vertical reference systems over land and sea to see how they change – image from google.