Appendix A.
Mobilization, verifications and calibrations reports

Most files have been anonymized, Some distinct projects information is deliberately left out.
The name of the client rep. is replaced by the schools intern manager F.P.J de Haan.
All onboard acquired documents are approved for use by the Party chef P. Miller.

SUBSECTION	***CONSISTS OF***	***REF. IN***
I. Alongside standard GNSS Navigation check	a. DGPS Static Verification Report MIWB b. Geodesy Report_ED50_UTMzone31N c. Geodesy Validation d. Positioning Comparison Report MIWB e. Transformation Report_ED50_UTMzone31N_to_WGS84	Soc Wiki, Internship report & HS3.
II. Heading Verification via SunShot Azimuth	a. MIWB_Heading Alignment Check Hydrins 20191231 b. MIWB_Heading Alignment Check Octans 20191231	Soc Wiki, Internship report & HS3.
III. MBES – Patch Test Verification	MIWB_FP_MBE_Verification MIWB_FP_MBE_Calibration	Soc Wiki, Internship report & HS3.
IV. SBP – Field comparison	Hull Mounted Pinger v.s. Innomar	Soc Wiki, Internship report & HS3.
V. SSS – Rub Test	MIWB_SSS_SN49135 - primary	Soc Wiki, Internship report & HS3.
VI. USBL – Position verification	SSS Box-in - USBL Verification	Soc Wiki, Internship report & HS3.

Approved by Bart Jan Tijmes on behalf of Fugro NL Marine - 27/01/2020

A.I. Alongside standard GNSS Navigation check

Location: “Het Nieuwe Diep” Port of Den Helder. All postions are left un modified because the test location where the GNSS test / verifications are conducted is not in the direct project vicinty.

DGPS STATIC VERIFICATION BY TOTAL STATION METHOD

Project Details

Project Number	MIWB
Client	MIWB NHL – Stenden
Vessel	Fugro Pioneer

Report Details

Total Station Name (Serial no)	Leica TS15 (03316601)
Device	Fugro Pioneer / DGPS 3
Start Time	01 Jan 2020, 08:46:58Z (Local)
End Time	01 Jan 2020, 08:57:08Z (Local)
Total Station Location	D105 (619,431.108m E, 5,869,222.763m N)
Reference Object Location	D106 (619,426.594m E, 5,869,262.258m N)
Reference Object Backsight Angle	354.90°
Datum/Projection	ED50 / UTM zone 31N [UKOOA-CO]

Results using 20 of 25 observations

Mean of Calculated Position	619,466.538m E, 5,869,225.887m N
Mean of Observed Position	619,466.579m E, 5,869,225.870m N
Calculated - Observed (C-O)	0.05m(Range) & 291.9° N(Azimuth)
Std Deviation	±0.01m(Range) & ±16.66°(Azimuth)

Observations

Observation		Antenna Observations			Calculated Position		Observed Position		Results (C-O)			
Time (Local)	Used	Horizontal Angle	Vertical Angle	Slant Range	Easting	Northing	Easting	Northing	dE	dN	Range	Azimuth
08:46:58	Yes	086°22'48"	073°33'36"	37.09m	619,466.536m E	5,869,225.888m N	619,466.580m E	5,869,225.875m N	-0.04m	0.01m	0.05m	285.45°
08:47:40	Yes	086°26'49"	073°34'12"	37.16m	619,466.610m E	5,869,225.852m N	619,466.645m E	5,869,225.851m N	-0.03m	0.00m	0.03m	272.16°
08:48:06	No	086°28'30"	073°30'36"	37.18m	619,466.621m E	5,869,225.836m N	619,466.681m E	5,869,225.798m N	-0.06m	0.04m	0.07m	302.15°
08:48:43	Yes	086°25'12"	073°34'48"	37.02m	619,466.476m E	5,869,225.857m N	619,466.501m E	5,869,225.855m N	-0.03m	0.00m	0.03m	275.73°
08:49:13	Yes	086°21'32"	073°33'00"	37.03m	619,466.473m E	5,869,225.895m N	619,466.494m E	5,869,225.877m N	-0.02m	0.02m	0.03m	310.73°
08:49:40	Yes	086°23'24"	073°33'00"	37.11m	619,466.558m E	5,869,225.883m N	619,466.597m E	5,869,225.867m N	-0.04m	0.02m	0.04m	292.92°
08:50:12	Yes	086°28'52"	073°31'12"	37.14m	619,466.578m E	5,869,225.828m N	619,466.625m E	5,869,225.817m N	-0.05m	0.01m	0.05m	283.29°
08:50:31	Yes	086°31'48"	073°31'12"	37.15m	619,466.589m E	5,869,225.799m N	619,466.634m E	5,869,225.767m N	-0.05m	0.03m	0.05m	304.85°

MIWB Intership Report L. Blauw
DGPS STATIC VERIFICATION BY TOTAL STATION METHOD

Observations

Observation		Antenna Observations			Calculated Position		Observed Position		Results (C-O)			
Time (Local)	Used	Horizontal Angle	Vertical Angle	Slant Range	Easting	Northing	Easting	Northing	dE	dN	Range	Azimuth
08:50:53	Yes	086°32'38"	073°31'48"	37.18m	619,466.624m E	5,869,225.793m N	619,466.680m E	5,869,225.802m N	-0.06m	-0.01m	0.06m	260.91°
08:51:16	Yes	086°18'18"	073°32'24"	37.12m	619,466.558m E	5,869,225.936m N	619,466.619m E	5,869,225.939m N	-0.06m	0.00m	0.06m	267.08°
08:51:38	Yes	086°16'26"	073°34'12"	37.14m	619,466.580m E	5,869,225.958m N	619,466.621m E	5,869,225.917m N	-0.04m	0.04m	0.06m	314.67°
08:52:01	Yes	086°25'52"	073°30'00"	37.15m	619,466.582m E	5,869,225.860m N	619,466.622m E	5,869,225.850m N	-0.04m	0.01m	0.04m	283.21°
08:52:24	Yes	086°20'53"	073°32'24"	37.17m	619,466.608m E	5,869,225.914m N	619,466.646m E	5,869,225.905m N	-0.04m	0.01m	0.04m	283.60°
08:52:47	Yes	086°19'19"	073°33'00"	37.09m	619,466.530m E	5,869,225.923m N	619,466.573m E	5,869,225.912m N	-0.04m	0.01m	0.04m	284.40°
08:53:10	Yes	086°17'53"	073°31'48"	37.07m	619,466.508m E	5,869,225.936m N	619,466.533m E	5,869,225.917m N	-0.03m	0.02m	0.03m	307.25°
08:53:34	Yes	086°18'36"	073°34'12"	37.08m	619,466.521m E	5,869,225.930m N	619,466.567m E	5,869,225.895m N	-0.05m	0.03m	0.06m	306.31°
08:53:56	Yes	086°18'43"	073°32'24"	37.10m	619,466.540m E	5,869,225.930m N	619,466.593m E	5,869,225.900m N	-0.05m	0.03m	0.06m	299.96°
08:54:16	Yes	086°20'10"	073°31'48"	37.07m	619,466.504m E	5,869,225.912m N	619,466.559m E	5,869,225.893m N	-0.05m	0.02m	0.06m	289.12°
08:54:46	No	086°19'48"	073°31'48"	37.07m	619,466.511m E	5,869,225.917m N	619,466.562m E	5,869,225.877m N	-0.05m	0.04m	0.07m	307.55°
08:55:08	No	086°23'53"	073°32'24"	37.08m	619,466.528m E	5,869,225.876m N	619,466.587m E	5,869,225.833m N	-0.06m	0.04m	0.07m	305.81°
08:55:30	Yes	086°22'55"	073°31'48"	37.05m	619,466.496m E	5,869,225.883m N	619,466.535m E	5,869,225.858m N	-0.04m	0.03m	0.05m	303.31°
08:55:51	No	086°21'25"	073°31'12"	37.04m	619,466.475m E	5,869,225.897m N	619,466.516m E	5,869,225.840m N	-0.04m	0.06m	0.07m	323.72°
08:56:17	Yes	086°20'31"	073°30'00"	36.98m	619,466.421m E	5,869,225.901m N	619,466.450m E	5,869,225.855m N	-0.03m	0.05m	0.05m	327.67°
08:56:44	No	086°23'46"	073°31'12"	37.03m	619,466.476m E	5,869,225.872m N	619,466.516m E	5,869,225.813m N	-0.04m	0.06m	0.07m	326.49°
08:57:08	Yes	086°24'58"	073°31'12"	37.02m	619,466.461m E	5,869,225.859m N	619,466.501m E	5,869,225.847m N	-0.04m	0.01m	0.04m	285.39°

Paul Miller
Party Chief
FSBV (Fugro Survey B.V.)

F. P. J de Haan
Client Representative
MIWB NHL Stenden

Table 1: Geodetic Parameters

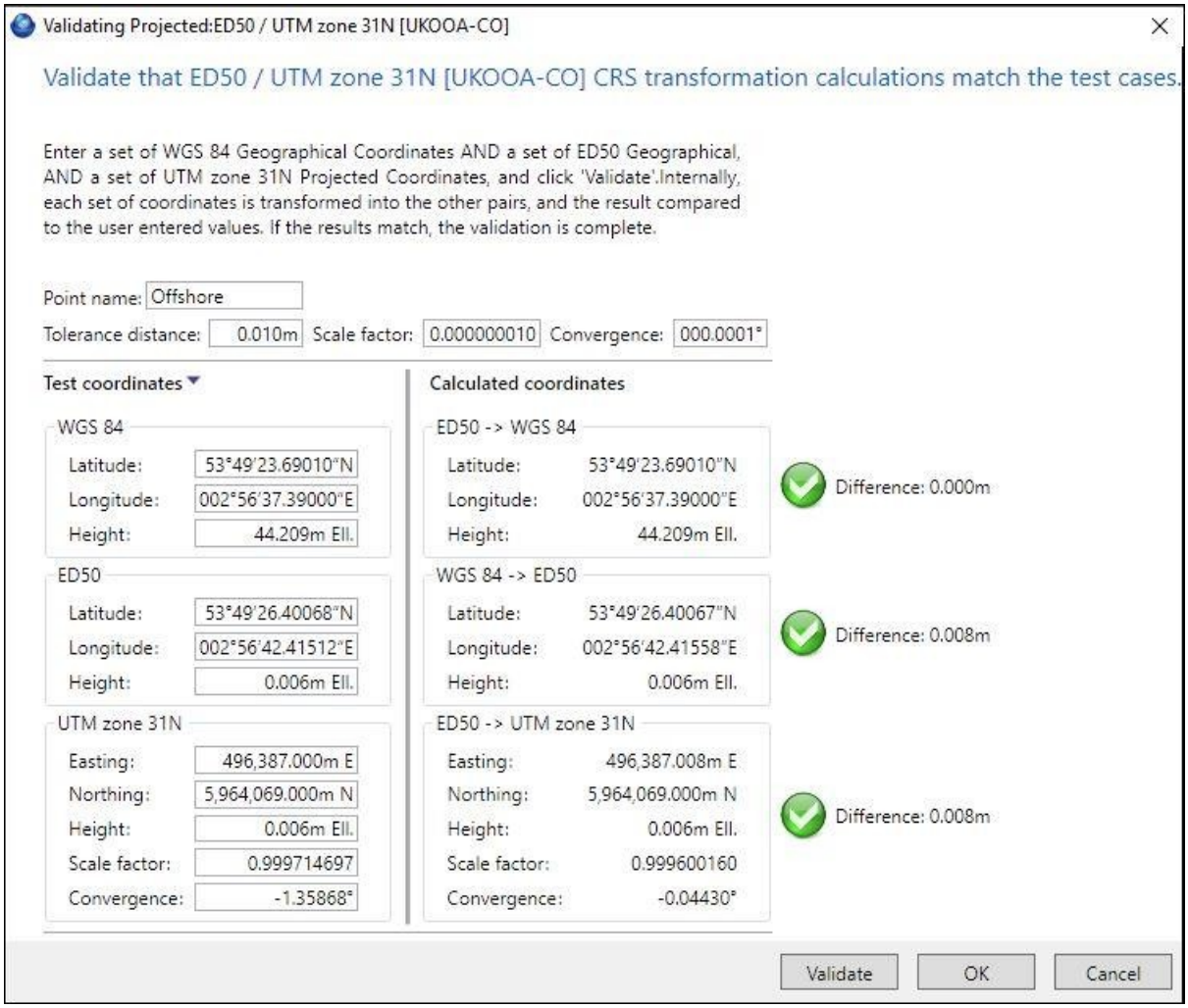
Name: ED50 / UTM zone 31N [UKOOA-CO]		
EPSG Code	EPSG::23031	
***Global Navigation Satellite System (GNSS) Geodetic Parameters**		
Datum	World Geodetic System 1984	EPSG::6326
Ellipsoid	WGS 84	
Semi major axis	a = 6,378,137.000 m	
Inverse flattening	1/f = 298.257223563	
Local Geodetic Datum Parameters		
Datum	European Datum 1950	EPSG::6230
Ellipsoid	International 1924	
Semi major axis	a = 6,378,388.000 m	
Inverse flattening	1/f = 297	
Datum Transformation Parameters from WGS 84 to ED50		
X-axis translation 89.5 m	X-axis rotation 0 "	Scale difference -1.2 ppm
Y-axis translation 93.8 m	Y-axis rotation 0 "	Coordinate Frame rotation
Z-axis translation 123.1 m	Z-axis rotation -0.156 "	EPSG::1311
Local Projection Parameters		
Map Projection	Transverse Mercator	
Grid System	UTM zone 31N	EPSG::16031
Latitude Origin	00°00'00.000"N	
Central Meridian	003°00'00.000"E	
Scale Factor on Central Meridian	0.9996	
False Easting	500,000 m	
False Northing	0 m	

Table 2: Validation Calculation

WGS 84	**Test Point [Offshore]**	**Computed Point**
Latitude	53°49'23.69010"N	53°49'23.69010"N
Longitude	002°56'37.39000"E	002°56'37.39000"E
Ellipsoidal Height	44.209m Ell.	44.209m Ell.
ED50		
Latitude	53°49'26.40068"N	53°49'26.40067"N
Longitude	002°56'42.41512"E	002°56'42.41558"E
Ellipsoidal Height	0.006m Ell.	0.006m Ell.
UTM zone 31N		
Easting	496,387.000m	496,387.008m
Northing	5,964,069.000m	5,964,069.000m
Ellipsoidal Height	0.006m	0.006m
Point Scale Factor	0.999714697	0.999600160
Convergence	-1.35868°	-0.04430°

PROJECT COORDINATE REFERENCE SYSTEM
30 DECEMBER 2019 - 03:31:41

Subcontractor	Contractor	Company
Comments:	**Comments:** P. Miller (Party Chief) Fugro	**Comments:** F.P.J. de Haan MIWB NHL – Stenden
Signature:	**Signature:** 	**Signature:**
Date:	**Date:** 01-01-2020	**Date:**


Validating Projected:ED50 / UTM zone 31N [UKOOA-CO]
Validate that ED50 / UTM zone 31N [UKOOA-CO] CRS transformation calculations match the test cases.
Enter a set of WGS 84 Geographical Coordinates AND a set of ED50 Geographical, AND a set of UTM zone 31N Projected Coordinates, and click 'Validate'.Internally, each set of coordinates is transformed into the other pairs, and the result compared to the user entered values. If the results match, the validation is complete.
Point name: Offshore
Tolerance distance: 0.010m Scale factor: 0.000000010 Convergence: 000.0001°
Test coordinates
Calculated coordinates
WGS 84
Latitude: 53°49'23.69010"N
Longitude: 002°56'37.39000"E
Height: 44.209m Ell.
ED50 -> WGS 84
Latitude: 53°49'23.69010"N
Longitude: 002°56'37.39000"E
Height: 44.209m Ell.
Difference: 0.000m
ED50
Latitude: 53°49'26.40068"N
Longitude: 002°56'42.41512"E
Height: 0.006m Ell.
WGS 84 -> ED50
Latitude: 53°49'26.40067"N
Longitude: 002°56'42.41558"E
Height: 0.006m Ell.
Difference: 0.008m
UTM zone 31N
Easting: 496,387.000m E
Northing: 5,964,069.000m N
Height: 0.006m Ell.
Scale factor: 0.999714697
Convergence: -1.35868°
ED50 -> UTM zone 31N
Easting: 496,387.008m E
Northing: 5,964,069.000m N
Height: 0.006m Ell.
Scale factor: 0.999600160
Convergence: -0.04430°
Difference: 0.008m
Validate
OK
Cancel

L. Blauw Internship Report
POSITIONING COMPARISON REPORT

Fugro Project ID:	**20200101_MIWB_POS-com-rep**	**Client:**	**NHL – Stenden MIWB**
Fugro Personnel:	**Paul Miller**		
Vessel:	**Fugro Pioneer**		
Comments:			

Session Name: 20200101-043039-v1
Start Time: 01 Jan 2020, 04:31:31Z
End Time: 01 Jan 2020, 05:31:31Z

Units and Format: Local grid (World Standard)

(Session Length 1 hrs - No. Obs. 3600)

Positioning System CRS and Offsets

	System	CRS	X (m)	Y (m)	Z (m)
1	DGPS 3-Starfix.G2 Plus 38603	WGS 84	-0.75	4.00	12.13
2	DGPS 4-Starfix.G2 Plus 6903	WGS 84	-3.16	5.09	12.13

Sensor Data (mean values over data periods)

	Antenna Positions	Easting (m)	SD	Northing (m)	SD	Height (m)	SD	Obs
1	DGPS 3-Starfix.G2 Plus 38603	619,466.719	±0.15m	5,869,226.003	±0.11m	12.029	±0.07m	3600
2	DGPS 4-Starfix.G2 Plus 6903	619,469.330	±0.16m	5,869,226.126	±0.12m	12.050	±0.06m	3600

	Heading Sensors	Obs °T	Obs °G	Conv	SD	(C-O)°	Calc °T	Calc °G	Diff°	Records
1	Hydrins	154.3	152.9	1.41967	0.40	0.00	154.3	152.9	0.00	3599
2	Octans	154.3	152.9	1.41967	0.39	0.00	154.3	152.9	-0.05	3599

	Pitch Sensors	Observed °	SD	(C-O)°	Computed °	Difference°	Records
1	Hydrins	-0.08	0.00	0.00	-0.08	0.00	3599
2	Octans	0.00	0.00	0.00	0.00	-0.08	3599

	Roll Sensors	Observed °	SD	(C-O)°	Computed °	Difference°	Records
1	Hydrins	0.19	0.02	0.00	0.19	0.00	3599
2	Octans	0.35	0.02	0.00	0.35	-0.16	3599

Results (Computed CRP position Comparison) UTM zone 31N

	Name	Easting (m)	Northing (m)	Height (m)	TPE (m)	d.Easting (m)	d.Northing (m)	d.Height (m)	Obs
1	DGPS 3-Starfix.G2 Plus 38603	619,464.257	5,869,229.248	-0.102	0.16	0.00	0.00	0.00	3600
2	DGPS 4-Starfix.G2 Plus 6903	619,464.227	5,869,229.246	-0.081	0.16	-0.03	0.00	0.02	3600

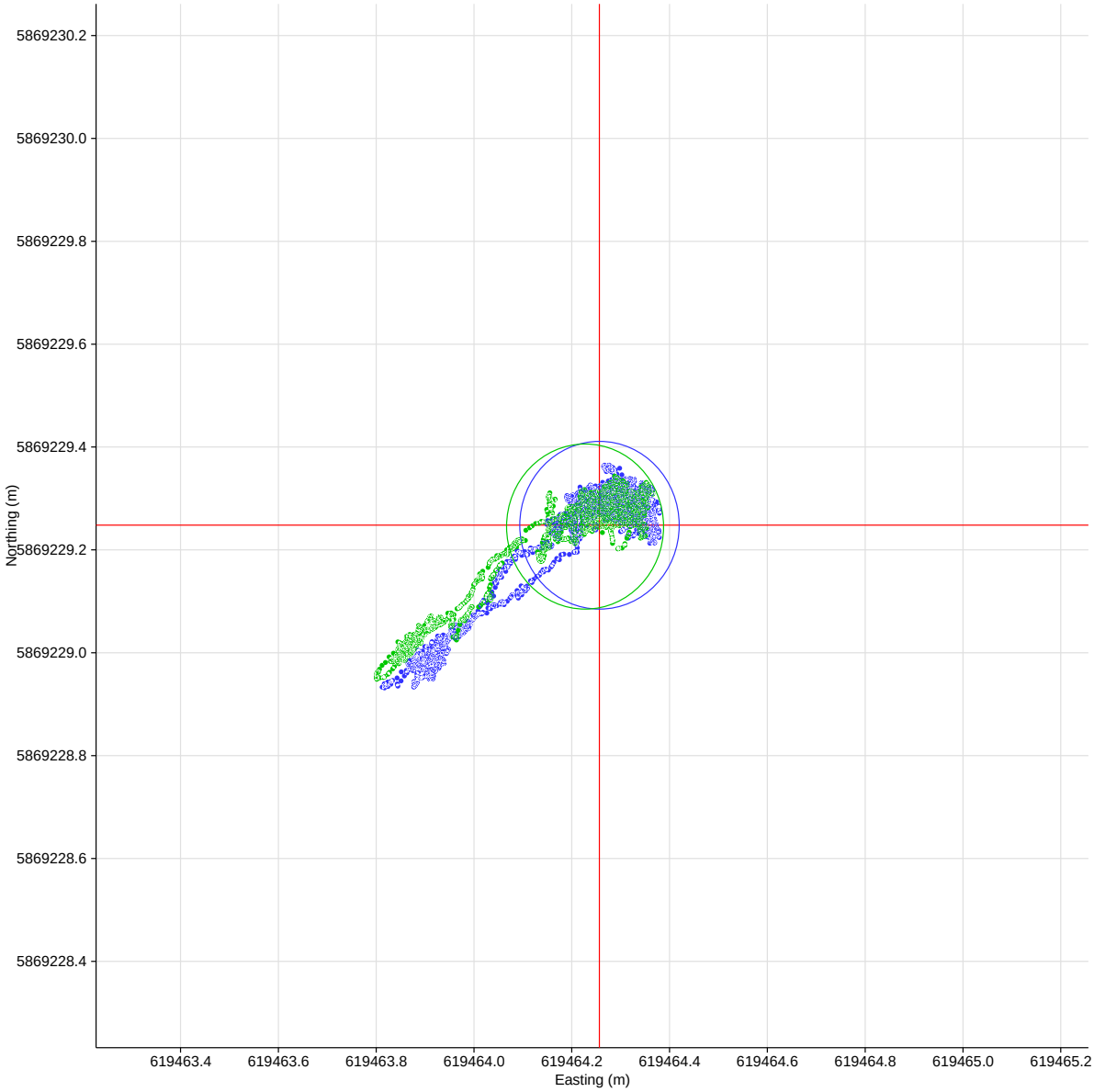
Paul Miller
Party Chief
FSBV (Fugro Survey B.V.)

F.P.J. de Haan
Client Representative
MIWB

Geodetic Parameters

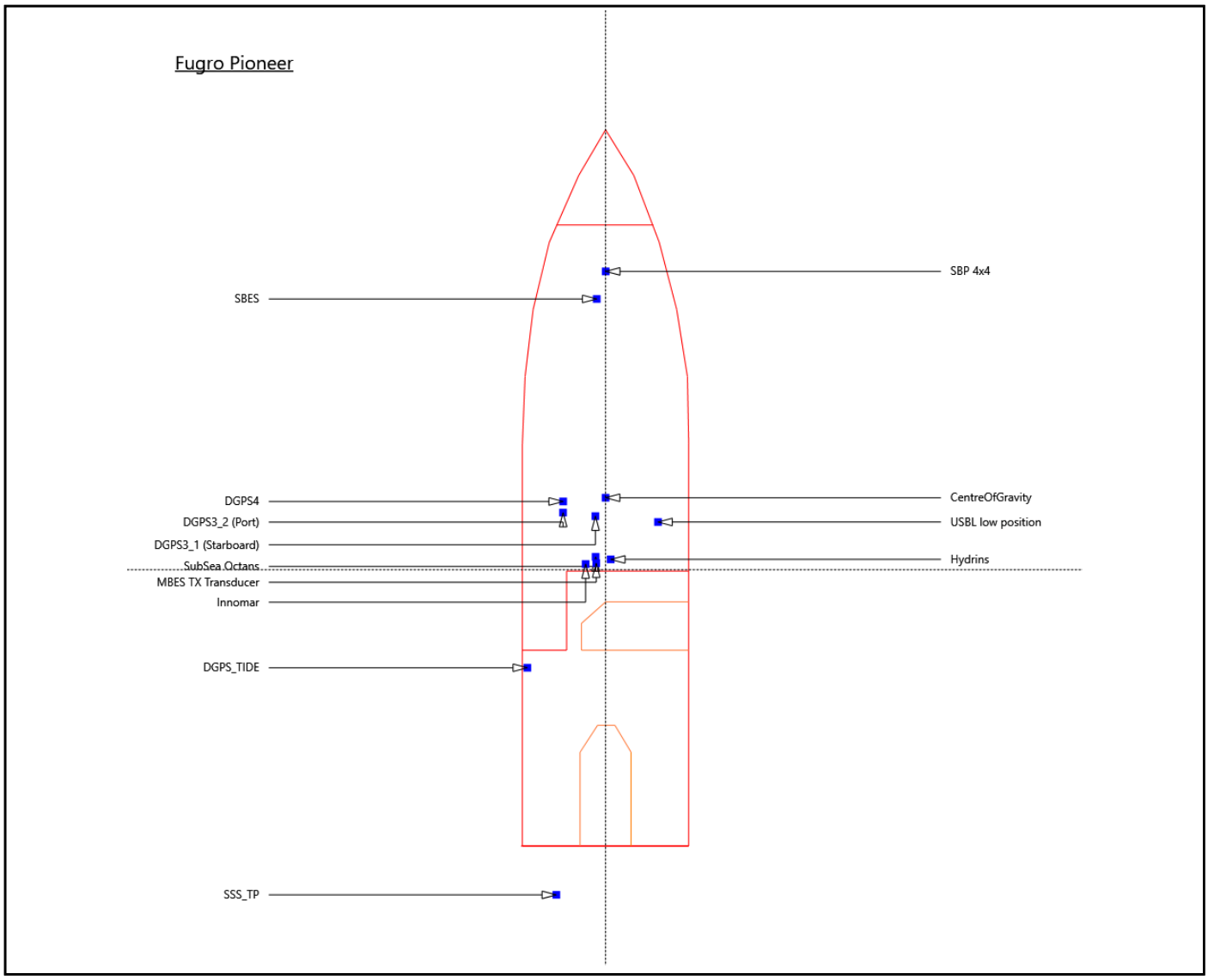
Name : ED50 / UTM zone 31N [UKOOA-CO]		
EPSG Code	EPSG::23031	
Global Navigation Satellite System (GNSS) Geodetic Parameters*		
Datum	World Geodetic System 1984	EPSG::6326
Ellipsoid	WGS 84	
Semi major axis	a = 6,378,137.000 m	
Inverse flattening	1/f = 298.257223563	
Local Geodetic Datum Parameters		
Datum	European Datum 1950	EPSG::6230
Ellipsoid	International 1924	
Semi major axis	a = 6,378,388.000 m	
Inverse flattening	1/f = 297	
Datum Transformation Parameters from WGS 84 to ED50		
X-axis translation 89.5 m	X-axis rotation 0 ”	Scale difference -1.2 ppm
Y-axis translation 93.8 m	Y-axis rotation 0 ”	Coordinate Frame rotation
Z-axis translation 123.1 m	Z-axis rotation -0.156 ”	EPSG::1311
Local Projection Parameters		
Map Projection	Transverse Mercator	
Grid System	UTM zone 31N	EPSG::16031
Latitude Origin	00°00’00.000”N	
Central Meridian	003°00’00.000”E	
Scale Factor on Central Meridian	0.9996	
False Easting	500,000 m	
False Northing	0 m	

Position Scatter Plot



Sensor Group	Fugro Pioneer Mean Position at CommonReferencePoint	Delta Easting	Delta Northing	Delta Height
	UTM zone 31N CM 3° E			
DGPS 3-Starfix.G2 Plus 38603	619,464.257m E, 5,869,229.248m N, -0.102m Ell.	0.00m	0.00m	0.00m
DGPS 4-Starfix.G2 Plus 6903	619,464.227m E, 5,869,229.246m N, -0.081m Ell.	-0.03m	0.00m	0.02m

Vessel Outline and Offsets



Fugro Pioneer - Defined Offsets

Name	Purpose	X Offset	Y Offset	Z Offset
CentreOfGravity	CentreOfGravity	0.00m	5.37m	-0.91m
CommonReferencePoint	CommonReferencePoint	0.00m	0.00m	0.00m
DGPS3_1 (Starboard)	DGNSSAntenna1	-0.75m	4.00m	12.13m
DGPS3_2 (Port)	DGNSSAntenna4	-3.17m	4.26m	12.13m
DGPS4	DGNSSAntenna2	-3.16m	5.09m	12.13m
DGPS_TIDE	DGNSSAntenna3	-5.83m	-7.31m	7.89m
Hydrins	INSsensor, MotionSensor1, GyroCompass1	0.39m	0.77m	0.46m
Innomar	Pinger	-1.49m	0.42m	-5.73m
MBES TX Transducer	MultibeamSounder1	-0.70m	0.49m	-6.05m
SBES	SingleBeamSounder1	-0.66m	20.19m	-5.79m
SBP 4x4		0.01m	22.24m	-5.73m
SSS_TP	SideScanTowPoint	-3.67m	-24.24m	3.72m
SubSea Octans	MotionSensor2, GyroCompass2	-0.74m	0.96m	-5.33m
USBL low position	USBLtransducerpole1	3.91m	3.56m	-6.96m

Table 1: Geodetic Parameters

Source CRS	ED50 / UTM zone 31N		**Target CRS**	WGS 84	
Area of use	Netherlands		Area of use	World	
Projected CRS	ED50 / UTM zone 31N	EPSG:: 23031	**Geographic 2D CRS**	WGS 84	EPSG::4326
Map Projection	UTM zone 31N	EPSG:: 16031	Geodetic Datum	World Geodetic System 1984	EPSG::6326
Projection Method	Transverse Mercator		Prime Meridian	Greenwich	
Central Meridian	003°00'00.000"E		Ellipsoid	WGS 84	EPSG::7030
Latitude Origin	00°00'00.000"N		)Semi-major axis(a	6,378,137.000 m	
Scale Factor on Central Meridian	0.9996		Inverse)flattening(1/f	298.257223563	
False Easting	500,000 m				
False Northing	0 m				
Geographic 2D CRS	ED50	EPSG::4230			
Geodetic Datum	European Datum 1950	EPSG::6230			
Prime Meridian	Greenwich				
Ellipsoid	International 1924	EPSG::7022			
)Semi-major axis(a	6,378,388.000 m				
Inverse)flattening(1/f	297				
Transformation	ED50 to WGS 84)18(	WGS 84 to ED50			
Version	UKOOA-CO	EPSG::1311			
Operation method	Position Vector transformation	Coordinate Frame rotation			
X-axis translation	-89.5 m	89.5 m			
Y-axis translation	-93.8 m	93.8 m			
Z-axis translation	-123.1 m	123.1 m			
X-axis rotation	0 "	0 "			
Y-axis rotation	0 "	0 "			
Z-axis rotation	-0.156 "	-0.156 "			
Scale difference	1.2 ppm	-1.2 ppm			

Table 2: Transformation Point - Offshore

WGS 84		**WGS 84**	
Latitude	53°49'23.69010"N	Latitude	53°49'23.69010"N
Longitude	002°56'37.38954"E	Longitude	002°56'37.38954"E
Ellipsoidal Height	44.209m Ell.	Ellipsoidal Height	44.209m Ell.
ED50			
Latitude	53°49'26.40068"N		
Longitude	002°56'42.41512"E		
Ellipsoidal Height	0.006m Ell.		
UTM zone 31N			
Easting	496,387.000m		
Northing	5,964,069.000m		
Ellipsoidal Height	0.006m		
Scale Factor	0.999600160		
Convergence	-0.04430°		

Table 3: Difference: Source CRS - Target CRS

Global CRS	
Distance:	0.00m Geodetic
Azimuth forward	0.0° T
Height offset	0.0m

EPSG geodetic dataset version: 9.7.2 Date: 2019-09-03

Subcontractor	**Contractor**	**Company**
Comments:	**Comments:** P. Miller (Party Chief) Fugro	**Comments:** F. P. J. de Haan MIWB NHL – Stenden
Signature:	**Signature:** 	**Signature:**
Date:	**Date:** 01-01-2020	**Date:**

A.II. Heading Verification via SunShot Azimuth

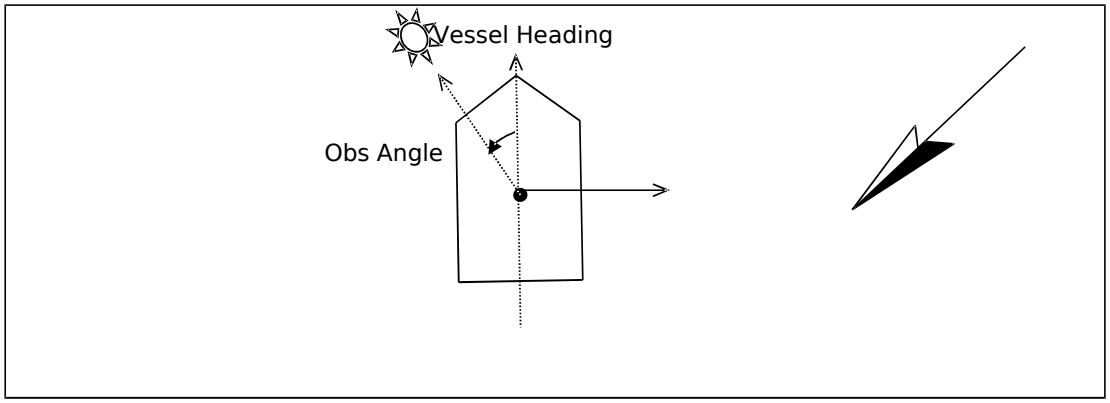
GYRO CALIBRATION FROM SUN OBSERVATIONS

Intership Report L. Blauw

Project no:	MIWB	Gyro name:	Hydrins
Vessel:	Fugro Pioneer	Date :	31-dec-19
Position :	52° 57' 26.9"	Location :	Den Helder
	004°46'37.5"	Datum :	ED50
		Projection :	UTM31
		CM :	3° E
		Hemisphere :	North

Obs. vessel north		
Deg	Min	Sec
0	0	0

Fix	UTC	Observed Sun			Calc Sun Azimuth			Obs. Gyro	Calc. Vessel	C-O
No.	hh:mm:ss	Deg	Min	Sec	Deg	Min	Sec	deg true	deg true	deg
1	08:41:44	343	41	24	138	52	24	155.082	155.18	0.10
2	08:43:16	344	6	0	139	11	33	155.004	155.09	0.09
3	08:44:12	344	16	44	139	23	14	155.028	155.11	0.08
4	08:44:52	344	22	5	139	31	34	155.07	155.16	0.09
5	08:46:01	344	35	30	139	45	59	155.076	155.17	0.10
6	08:46:42	344	45	20	139	54	33	155.058	155.15	0.10
7	08:47:21	344	60	38	140	2	43	154.953	155.03	0.08
8	08:48:12	345	27	4	140	13	24	154.681	154.77	0.09
9	08:48:58	345	41	55	140	23	2	154.604	154.69	0.08
10	09:07:08	349	18	14	144	13	48	154.807	154.93	0.12
11	09:07:24	349	23	44	144	17	14	154.805	154.89	0.09
12	09:07:45	349	27	35	144	21	43	154.813	154.90	0.09
13	09:08:03	349	33	42	144	25	34	154.802	154.86	0.06
14	09:08:19	349	34	26	144	28	60	154.826	154.91	0.08
15	09:08:34	349	38	59	144	32	12	154.817	154.89	0.07
16	09:08:50	349	42	35	144	35	38	154.809	154.88	0.08
17	09:09:13	349	51	28	144	40	34	154.768	154.82	0.05
18	09:09:33	350	3	0	144	44	51	154.632	154.70	0.07
19	09:09:57	350	16	46	144	49	60	154.545	154.55	0.01
20	09:10:20	350	18	0	144	54	56	154.544	154.62	0.07
									Average:	0.08
									St. dev.	0.02



For Fugro Survey B.V.

P. Miller

For Client

F. P. J. de Haan

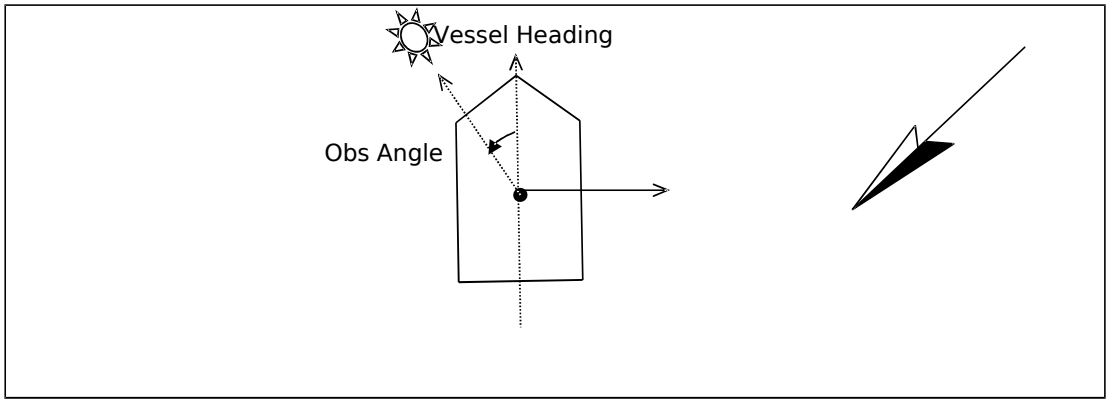
GYRO CALIBRATION FROM SUN OBSERVATIONS

Intership report L Blauw

Project no:	MIWB	Gyro name:	Octans
Vessel:	Fugro Pioneer	Date :	31-dec-19
Position :	52° 57' 26.9"	Location :	Den Helder
	004°46'37.5"	Datum :	ED50
		Projection :	UTM31
		CM :	3° E
		Hemisphere :	North

Obs. vessel north		
Deg	Min	Sec
0	0	0

Fix No.	UTC hh:mm:ss	Observed Sun Deg	Min	Sec	Calc Sun Azimuth Deg	Min	Sec	Obs. Gyro deg true	Calc. Vessel deg true	C-O deg
1	08:41:44	343	41	24	138	52	24	155.063	155.18	0.12
2	08:43:16	344	6	0	139	11	33	154.985	155.09	0.11
3	08:44:12	344	16	44	139	23	14	155.055	155.11	0.05
4	08:44:52	344	22	5	139	31	34	155.058	155.16	0.10
5	08:46:01	344	35	30	139	45	59	155.076	155.17	0.10
6	08:46:42	344	45	20	139	54	33	155.043	155.15	0.11
7	08:47:21	344	60	38	140	2	43	154.94	155.03	0.09
8	08:48:12	345	27	4	140	13	24	154.667	154.77	0.11
9	08:48:58	345	41	55	140	23	2	154.588	154.69	0.10
10	09:07:08	349	18	14	144	13	48	154.765	154.93	0.16
11	09:07:24	349	23	44	144	17	14	154.764	154.89	0.13
12	09:07:45	349	27	35	144	21	43	154.762	154.90	0.14
13	09:08:03	349	33	42	144	25	34	154.783	154.86	0.08
14	09:08:19	349	34	26	144	28	60	154.783	154.91	0.13
15	09:08:34	349	38	59	144	32	12	154.779	154.89	0.11
16	09:08:50	349	42	35	144	35	38	154.768	154.88	0.12
17	09:09:13	349	51	28	144	40	34	154.733	154.82	0.09
18	09:09:33	350	3	0	144	44	51	154.597	154.70	0.10
19	09:09:57	350	16	46	144	49	60	154.509	154.55	0.04
20	09:10:20	350	18	0	144	54	56	154.505	154.62	0.11
									Average:	0.10
									St. dev.	0.03



For Fugro Survey B.V.

P. Miller

For Client

F. P. J. de Haan

A.III. MBES – Calibration and Verification

Multibeam Echo Sounder Verification Report Fugro Pioneer

MIWB Intership report L. Blauw, North Sea

MIWB_FP_MBE_Verification 01 | 1 December 2019

MIWB NHL – stenden

1. Introduction

The purpose of the multi-beam echo sounder verification is:

- To verify that the results of the multi-beam echo sounder calibration conducted on the 1st of December 2019 are within the specifications.
- To demonstrate the capability of the system to achieve the primary dataset requirements.

2. Scope of Work

The MBES verification consisted of running two lines in opposite direction over a Side-Tap which was used for the SSS/USBL verification as well

Error! Reference source not found. presents the details of the reference point.

Table 1: Reference Point Position

Location	Easting (m)	Northing (m)
ST-WGT (as delivered by MBES)	x	y

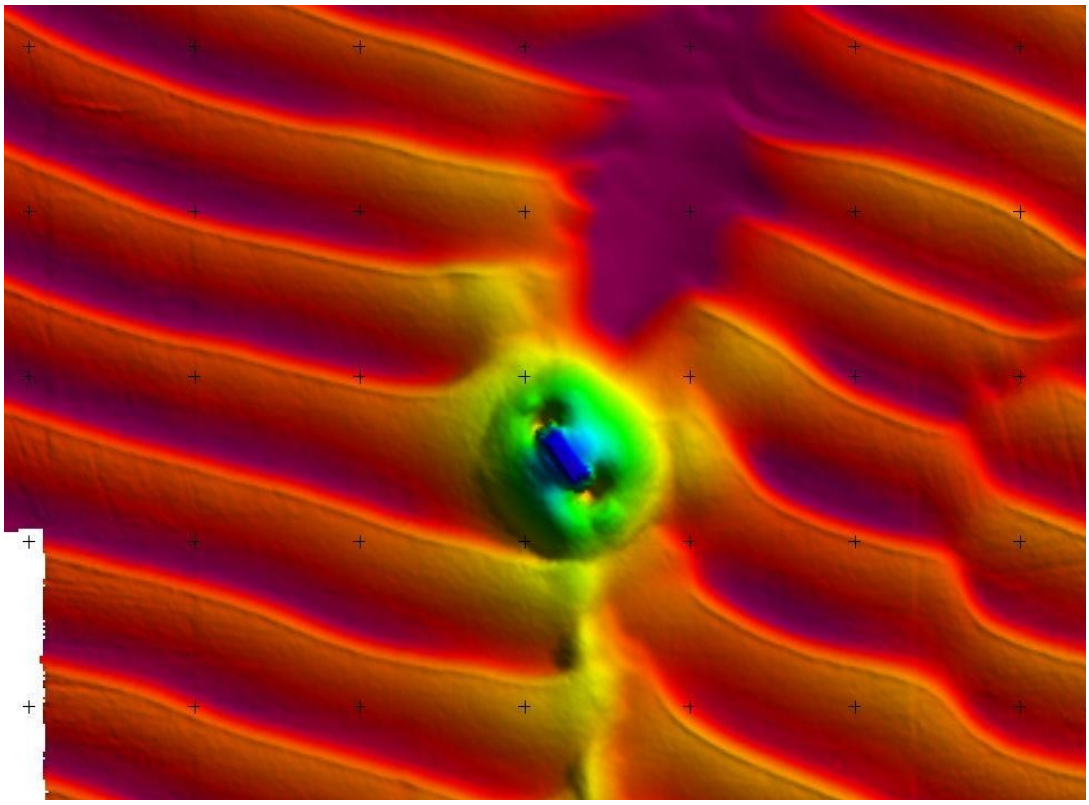


Figure 1: Location of MBE Verification

3. Operations

The MBE Verification was completed during the SSS/USBL Verification. This was conducted over Side-Tap 64-ST where generic pipeline-A to WGT 12" Pipeline meets K13-A to Den Helder 36" Pipeline (coordinates in Table 1).

Table 1: Position and Navigation information

Positioning and Navigation	MBES Kongsberg EM2040
	Water depth approximately 29m
	Multibeam Draft 3.61 m, Water Line (CRP to MBES) 2.44m
	Speed of sound in water at surface 1492.69 m/s from CTD probe
	Speed of sound in water at seabed 1493.20 m/s from CTD probe
	Hydrins Gyrocompass and Hydrins Motion Sensor

4. Results

The tables below indicate the results of the MBE Verification.

Table 2: Post Calibration System Values

Post Calibration System Values		
Receiver	**Rx PORT**	**Rx STBD**
Latency	+0.000 sec	+0.000 sec
Pitch	-0.830°	-0.830°
Roll	-0.085°	+0.220°
Yaw	+0.070°	+0.070°

Table 3: Post Verification System Values

Post Verification System Values		
Receiver	**Rx PORT**	**Rx STBD**
Latency	+0.000 sec	+0.000 sec
Pitch	-0.830°	-0.830°
Roll	-0.085°	+0.220°
Yaw	+0.070°	+0.070°

The print screens from Caris HIPS & SIPS and WorkBench (processing software) below presents a swath profile from the alignment verification lines. The data was calibrated for pitch, roll, latency and yaw. The X axis is in metres along the profile and the Y axis is in metres of water depth.

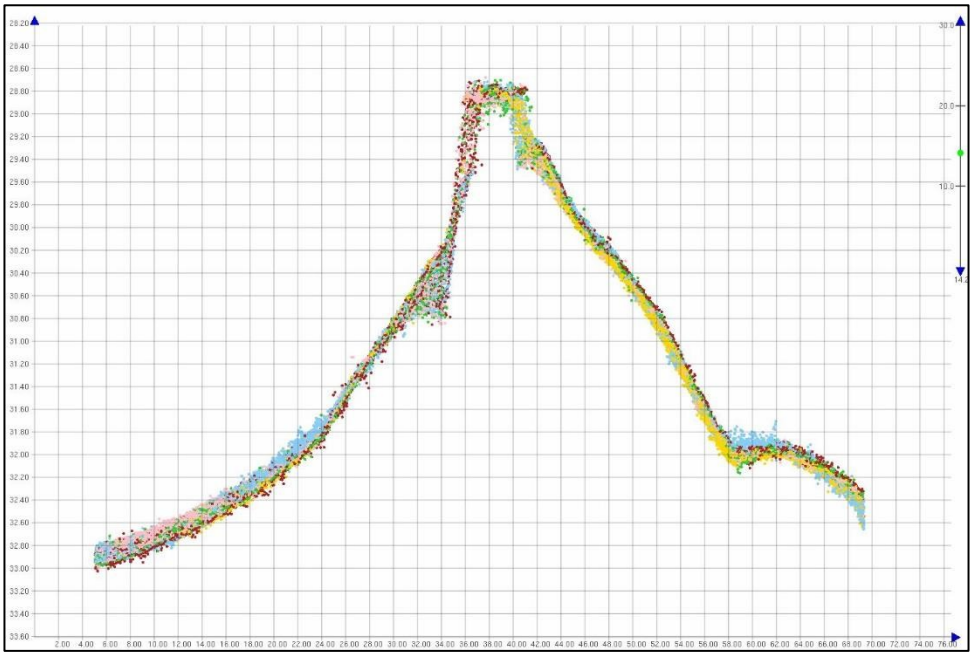


Figure 2: Cross profile lines over the target with calibration values

5. Conclusion

Results show that the MBES Kongsberg EM2040 was successfully calibrated and verified to within <0.1° deviation acceptance of the client.

6. HSE

No safety or HSE incidents were reported.

Signed:		Signed:	
	P. Miller **Party Chief** **(Fugro Pioneer)**		**F. P. J. de Haan** **Client Representative** **MIWB NHL – Stenden**

Multibeam Echo Sounder Calibration Report Fugro Pioneer

Internship Report L. Blauw, North Sea

MIWB_FP_MBE_Calibration 01 | 1 December 2019

MIWB NHL – Stenden

1. Introduction

The purpose of the multi-beam echo sounder calibration is:

- To determine the Pitch, Roll, Yaw and Latency corrections required for calibrate the Kongsberg EM 2040, dual head system for bathymetric survey purposes.

2. Scope of Work

The calibration comprised of six lines run in a traditional patch test manner. Two lines run with an offset of 35 m from either side of centreline in same direction; two centrelines on top of each other with same direction, one centreline in opposite directions with same speed and the last one at double speed. See Table 1 for the survey line configuration for multibeam corrections.

Table 1: Survey Line Configuration for Multibeam Corrections

Correction	Survey line configuration
System Latency	Two lines run in the same direction at different survey speeds over the feature (4.0 knots and 8.0 knots).
Pitch	Two lines run at the same speed in opposite directions over the feature.
Roll	Three lines run at the same speed in opposite directions over a flat seabed
Yaw	Three lines run at the same speed in same direction over the feature

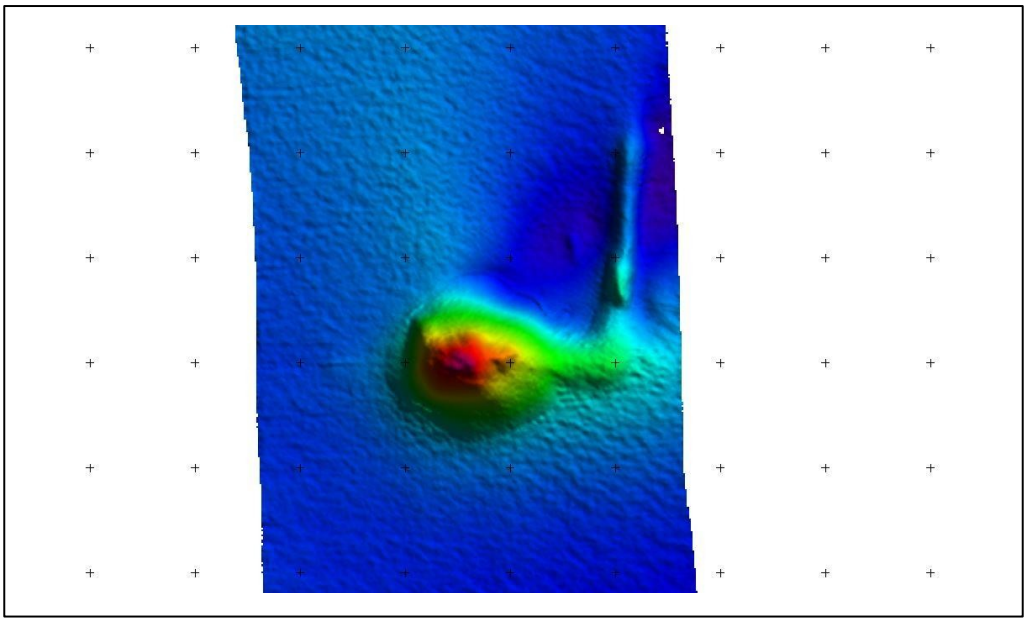


Figure 1: Colour mapped seabed as background

3. Operations

The calibration was carried out onboard the vessel MV Fugro Pioneer on 01st of December 2019 to determine corrections for the multibeam echo sounder acquisition system.

The calibration was conducted on a side-tap on NP-001 at KP 20.4, which is located at LAT a N and Lon a E (ED50 Zone 31N) in approximately 25 metres water depth.

Before commencement of the patch test, the previous calibration values in SIS were removed:

Table 1: SIS Values before Patch Test

SIS values before Patch Test		
Receiver	**Rx PORT**	**Rx STBD**
Latency	+0.000 sec	+0.000 sec
Pitch	+0.000°	+0.000°
Roll	+40.000°	-40.000°
Yaw	+0.000°	+0.000°

Table 3: Position and Navigation information

Positioning and Navigation	MBES Kongsberg EM2040
	Water depth approximately 25m
	Multibeam Draft 3.61 m, Water Line (CRP to MBES) 2.44m
	Speed of sound in water at surface 1493.33 m/s from CTD probe
	Speed of sound in water at seabed 1493.79 m/s from CTD probe
	Hydrins Gyrocompass and Hydrins Motion Sensor

4. Results

The tables below indicate the results of the MBE Calibration.

Table 4: Calibration System Values

Calibration System Values		
Receiver	**Rx PORT**	**Rx STBD**
Latency	+0.000 sec	+0.000 sec
Pitch	-0.830°	-0.830°
Roll	-0.085°	+0.220°
Yaw	+0.070°	+0.070°

Table 5: Mounting Angles Values

Mounting Angles Values		
Receiver	**Rx PORT**	**Rx STBD**
Latency	+0.000 sec	+0.000 sec
Pitch	-0.830°	-0.830°
Roll	+40.085°	-39.780°
Yaw	+0.070°	+0.070°

The Kongsberg SIS screen prints below show profiles of the grid data from the alignment calibration. The data was corrected for pitch, roll, latency and yaw. The X axis is in metres along the profile and the Y axis is in metres of water depth.

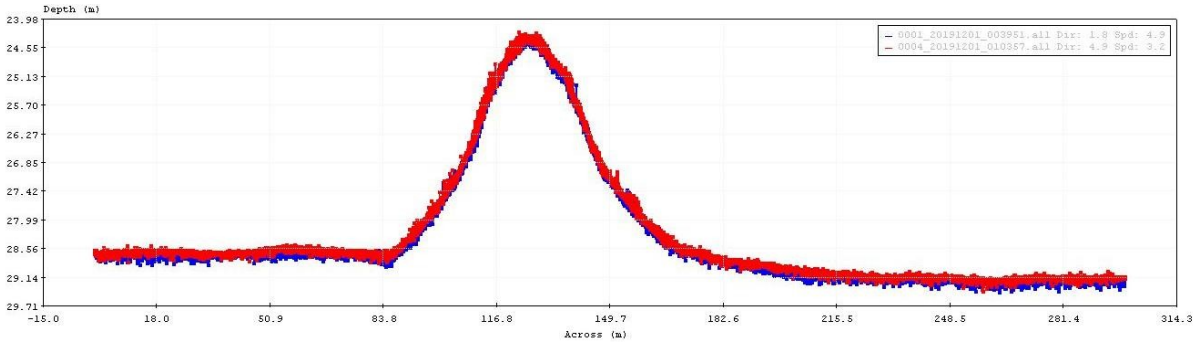


Figure 2: Profile of Latency Lines Uncorrected, Both Heads (Latency = 0 second)

A comparison of the latency profile shows no offset between the two lines run at different speeds. A Starpack positioning system was used, and no positioning latency was observed.

For the Kongsberg EM2040 system, pitch and yaw is calculated from the transducer head, therefore, the corrections for pitch and yaw for both receiver heads are the same respectively. Roll however, is corrected separately for each port and starboard receiver

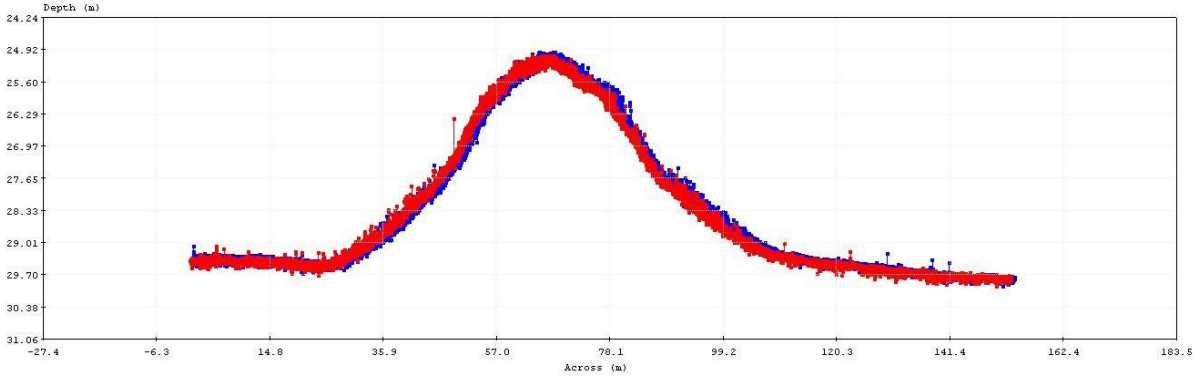


Figure 3: Profile from Pitch Lines Uncorrected, Port and Starboard Head (Pitch = 0.000°)

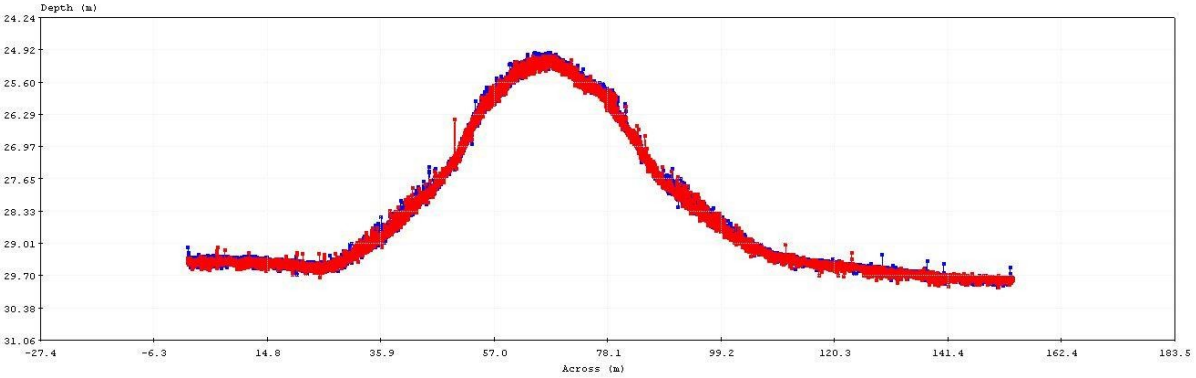


Figure 4: Profile from Pitch Lines Corrected, Port and Starboard Head (Pitch = -0.830°)

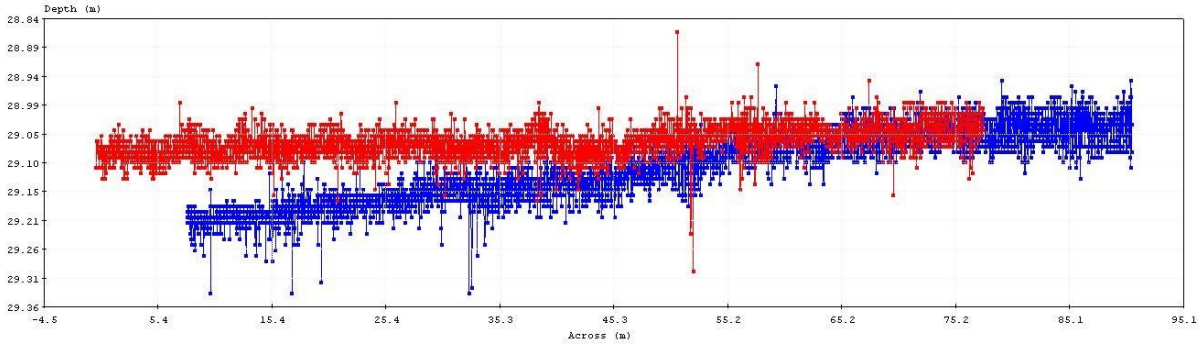


Figure 5: Profile from Roll Lines Uncorrected, Port Head (Roll = 0.000°)

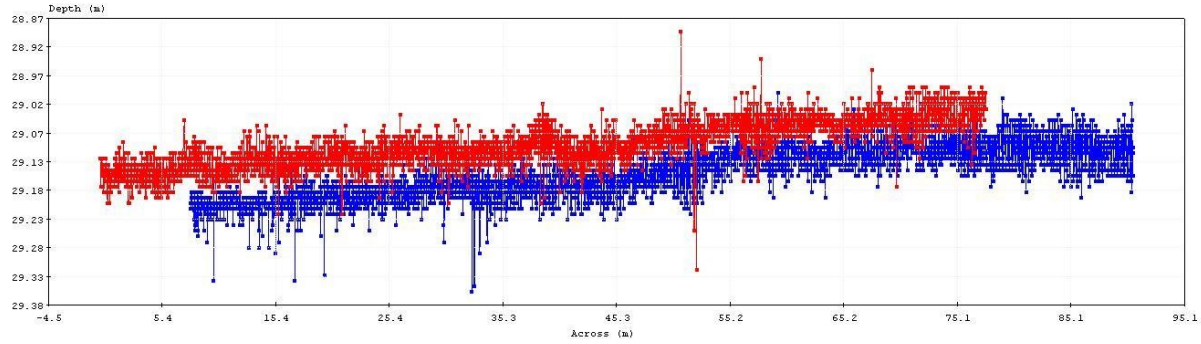


Figure 6: Profile from Roll Lines Corrected, Port Head (Roll Correction Value -0.085°)

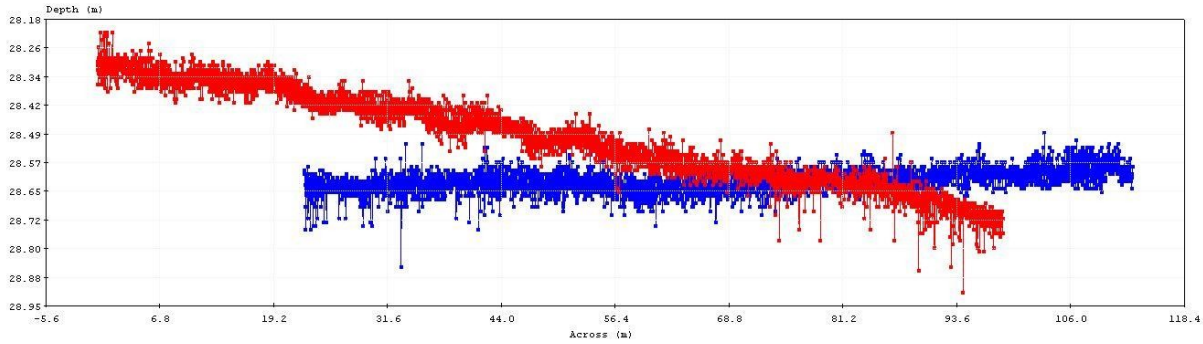


Figure 7: Profile from Roll Lines Uncorrected, Starboard Head (Roll = 0.000°)

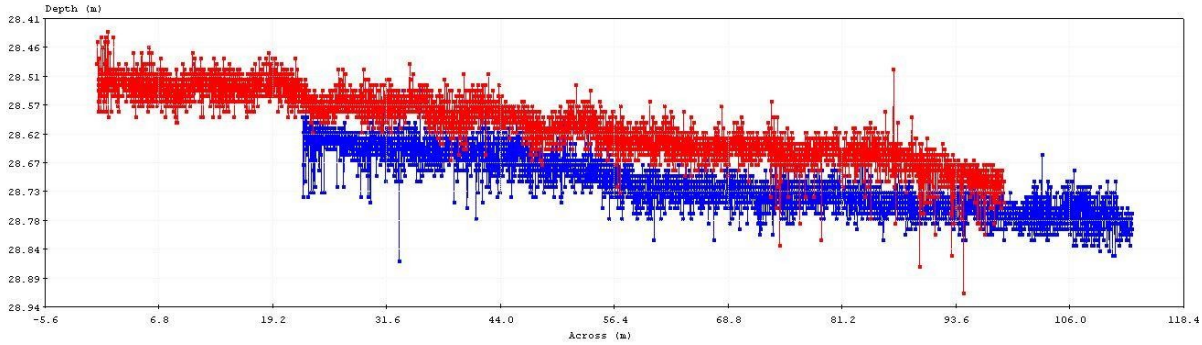


Figure 8: Profile from Roll Lines Corrected, Starboard Head (Roll Correction Value 0.220°)

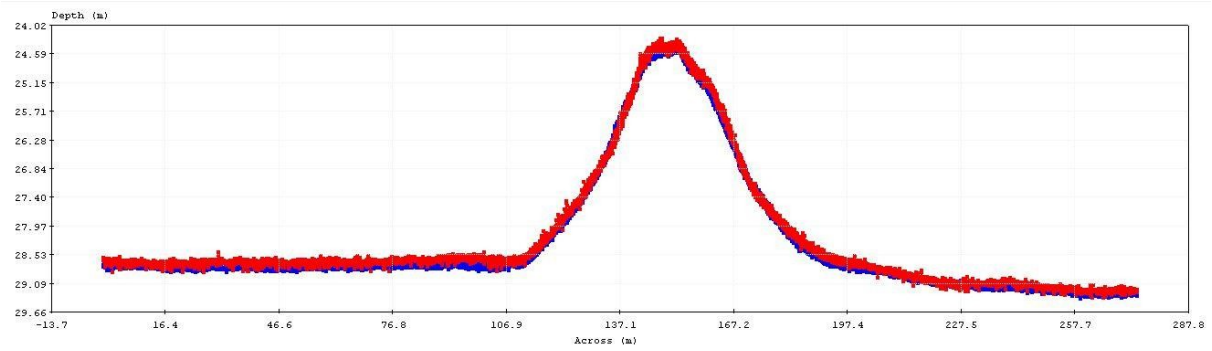


Figure 9: Profile from Yaw Lines Uncorrected, Port Head (Yaw = 0.000°)

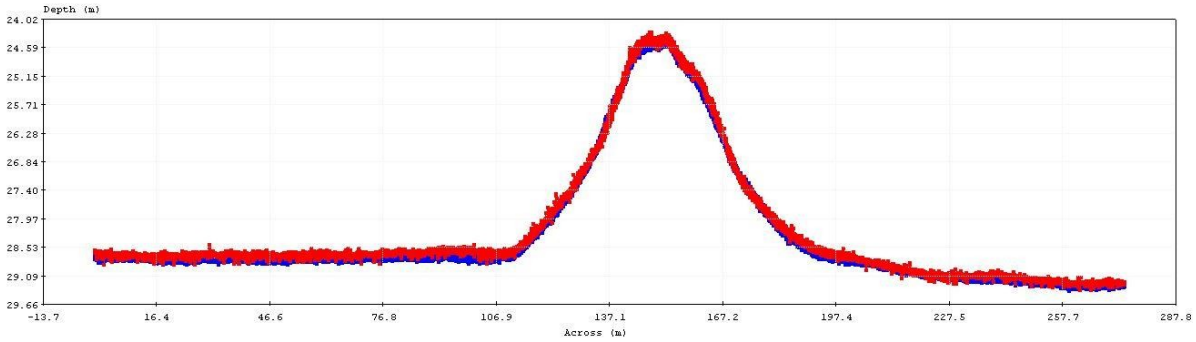


Figure 10: Profile of Yaw Lines Corrected, Port Head (Yaw = 0.070°)

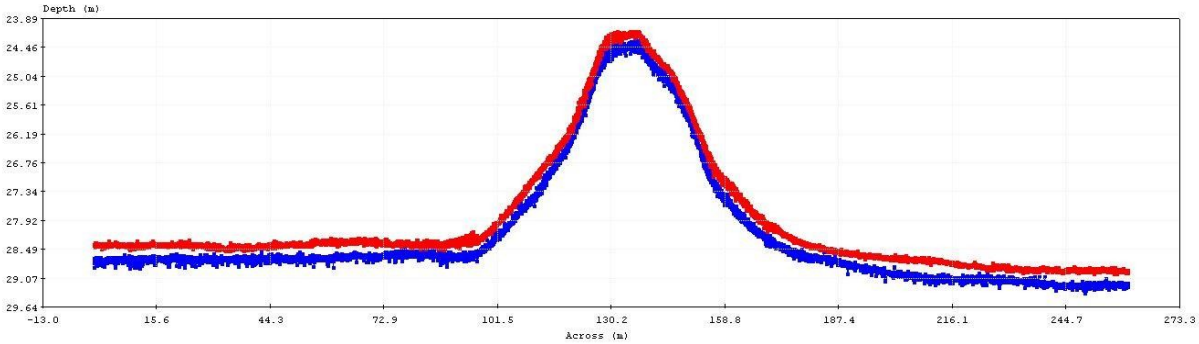


Figure 11: Profile from Yaw Lines Uncorrected, Starboard Head (Yaw = 0.000°)

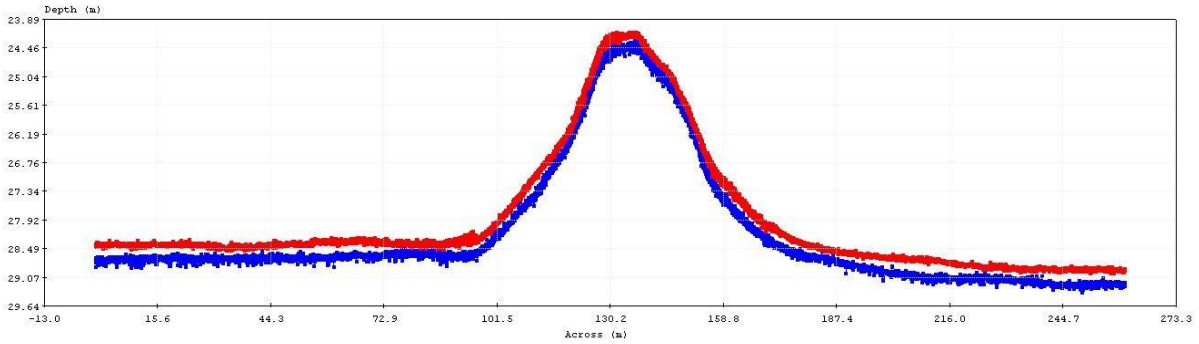


Figure 12: Profile of Yaw Lines Corrected, Starboard Head (Yaw = 0.070°)

5. Conclusion

The multibeam system was calibrated to within the system tolerances as based on the project specification.

6. HSE

No safety or HSE incidents were reported.

Signed:		Signed:	
	P. Miller **Party Chief** **(Fugro Pioneer)**		**F. P. J. de Haan** **Client Representative** **MIWB NHL – Stenden**

A.IV. SBP – Field Comparison

Sub Bottom Profiler Comparison

Luke Blauw (intern, Fugro Pioneer)

1.1 Objective

The CDD has asked the Fugro Pioneer to conduct Sub Bottom Profiler field tests running several test cross lines on a pipeline located in the Dutch sector of the North Sea.
The inspected pipeline is a 36" gas pipeline.
The geology in the test area is composed of unconsolidated sediments, mainly sand.

Subject to testing where two Sub Bottom Profilers: the Innomar SES2000, in variating frequency's and settings and the Massa TR-1075 ran in "Pipeliner mode".

1.2 Deliverables

The following is sent alongside this report:

- Seismic files in SES3 and SEGY.
- The SES2000 record log file (included in SES3).
- Screenshots of the SESWIN settings used for each line.
- The figures used in this report.

Not included:

- Record full-waveform (RAW files). The option to record raw files has been removed out from newer version of Innomar software.

1.3 As run line sequence

All Sub Bottom Profiler Comparison cross lines where run in the evening of 21 Dec. 19.
At KP 123.6 (the designated test site). All X-lines where conducted, in the same spot in the same direction, from North to South during optimal weather conditions.

Table 1: Sub Bottom Profiler field tests

Cross lines	MBES sync.	Frequency	Ping rate
1: X0123.6 @ 18:56 – 18:57 **Massa TR-1075 -** Hull Mounted Pinger, "Pipeliner mode"	N/A	3.5 kHz	Highest as possible
2: SBP_01 @ 19:17 – 19:19 **Innomar SES 2000 –** Attached to Moonpool, "Standard settings"	Yes	8 kHz	Highest as possible
3: SBP_02 @ 19:27 – 19:29 **Innomar SES 2000 –** Attached to Moonpool, "MBES independent"	No	8 kHz	Highest as possible
4: SBP_03 @ 19:37 – 19:39 **Innomar SES 2000 –** Attached to Moonpool, "Improved PINS detection"	No	4 kHz	Highest as possible
5: SBP_04 @ 19:49 – 19:50 **Innomar SES 2000 –** Attached to Moonpool, "Low frequency with MBES on"	Yes	4 kHz	Highest as possible

1.4 Data

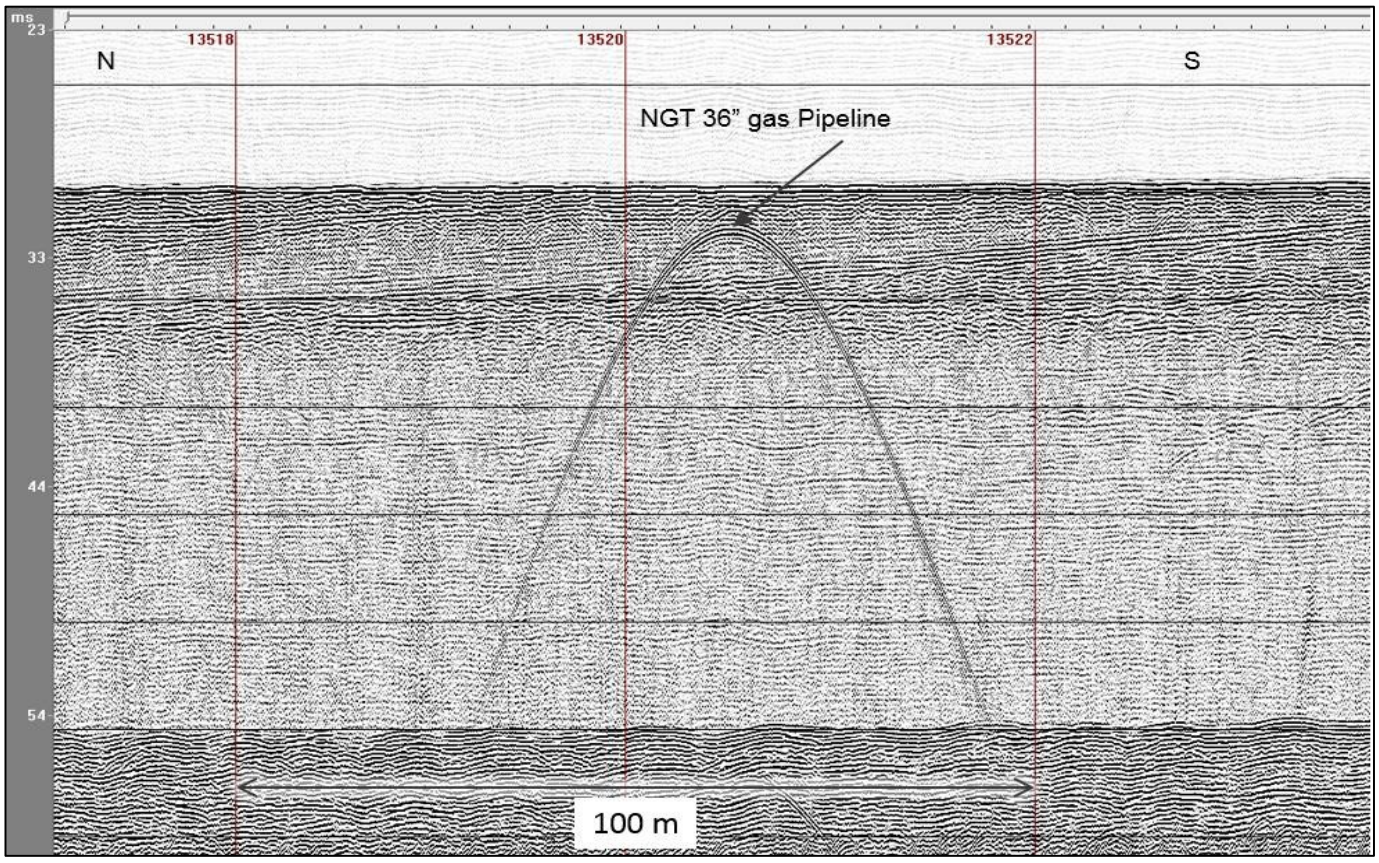


Figure 1: Massa TR-1075 data (3.5 kHz, MBES N/A)

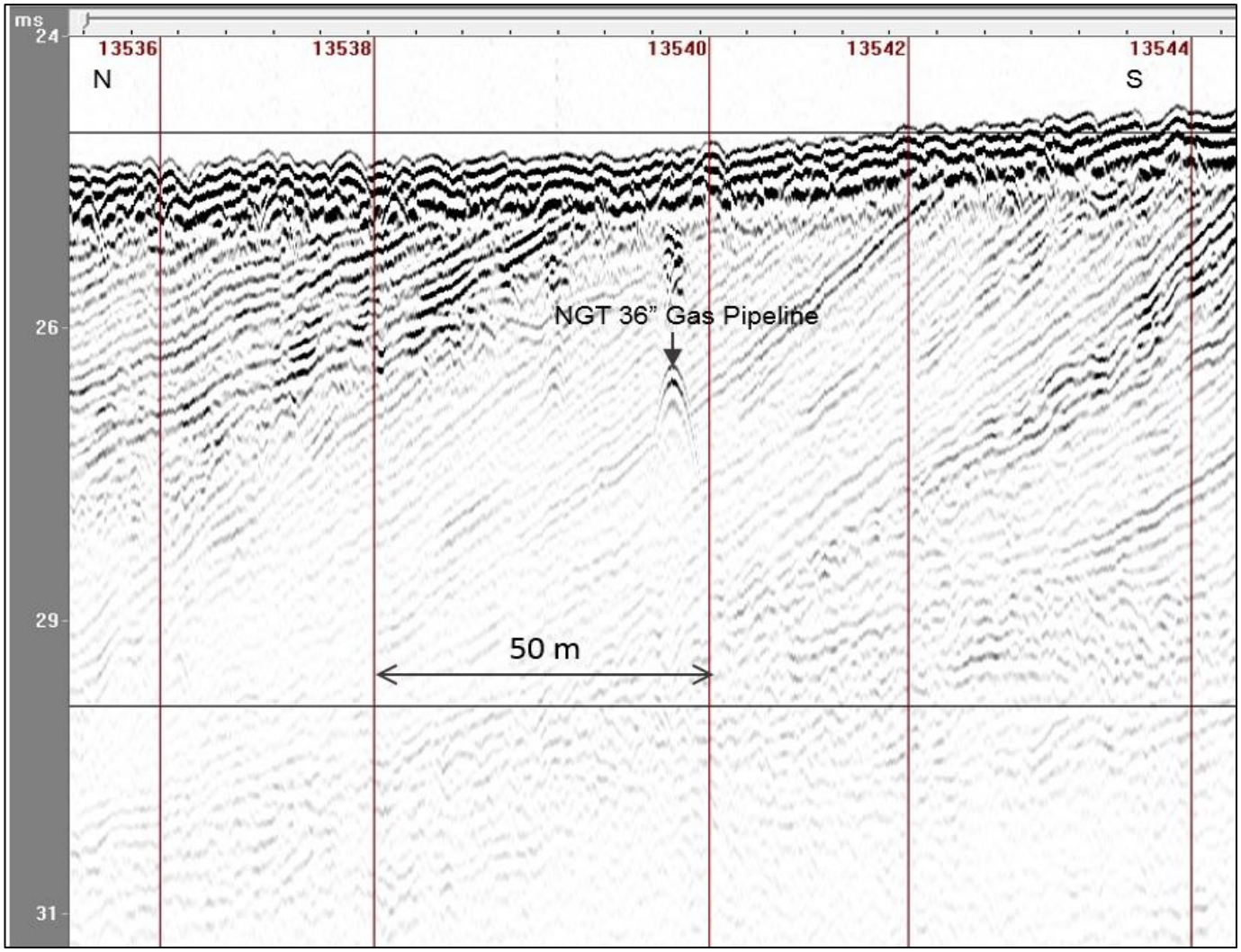


Figure 2: SBP_01 Innomar data (8 kHz, MBES on)

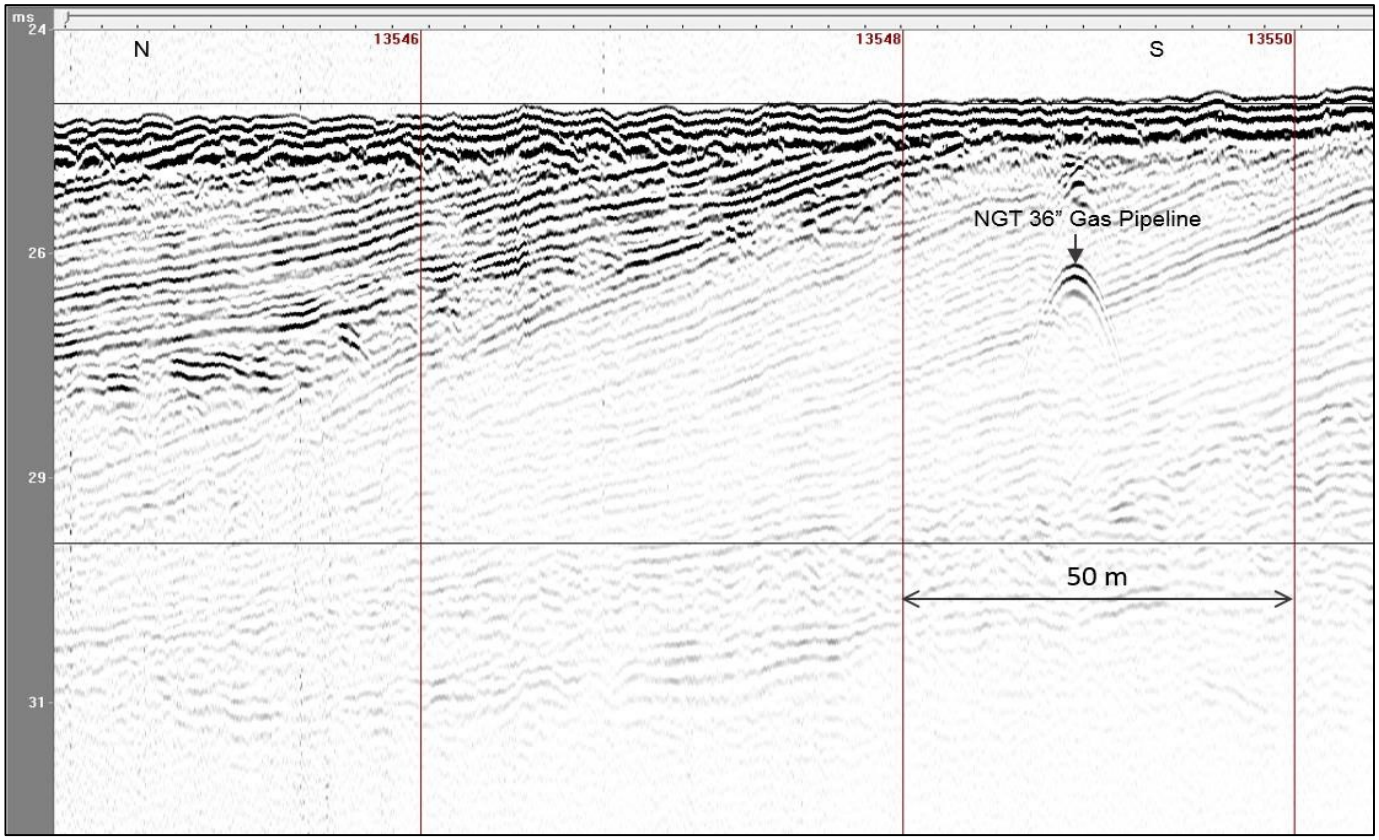


Figure 3: SBP_02 Innomar data (8 kHz, MBES off)

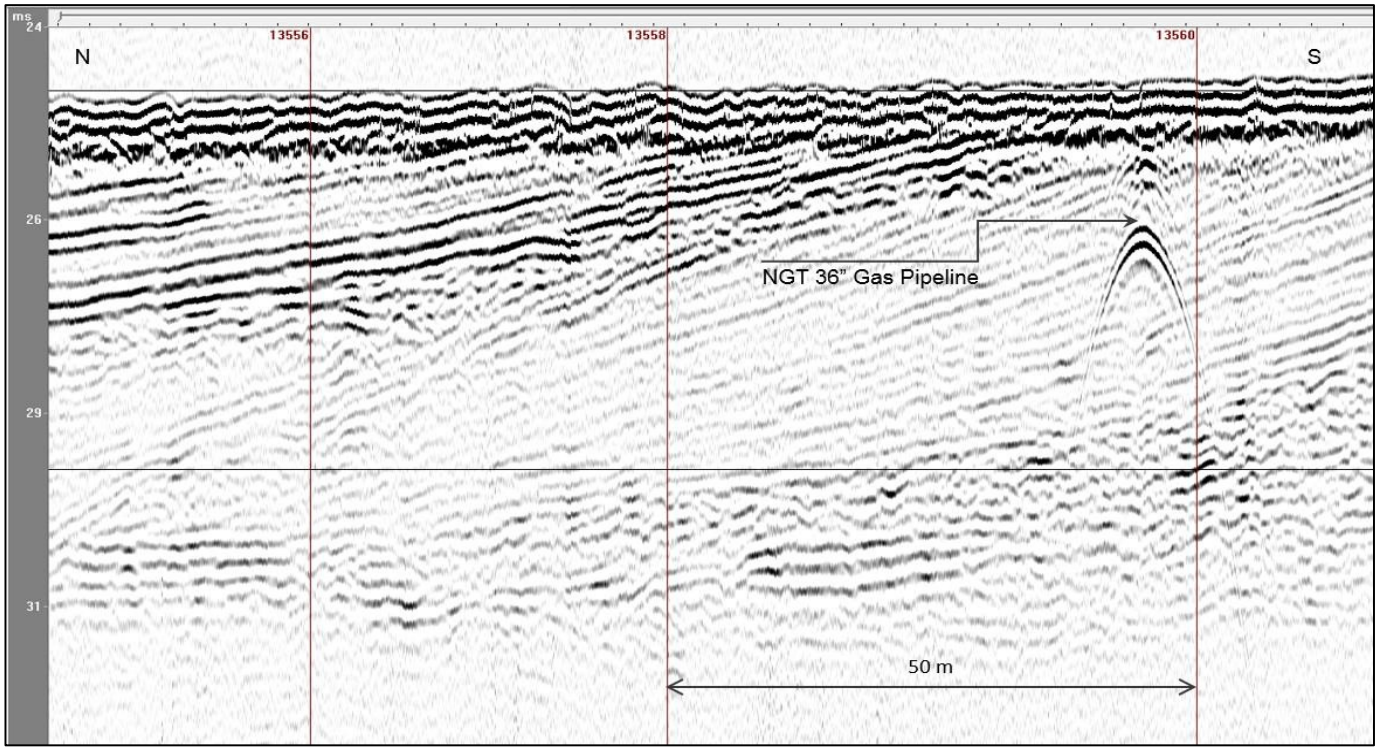


Figure 4: SBP_03 Innomar data (4 kHz, MBES off)

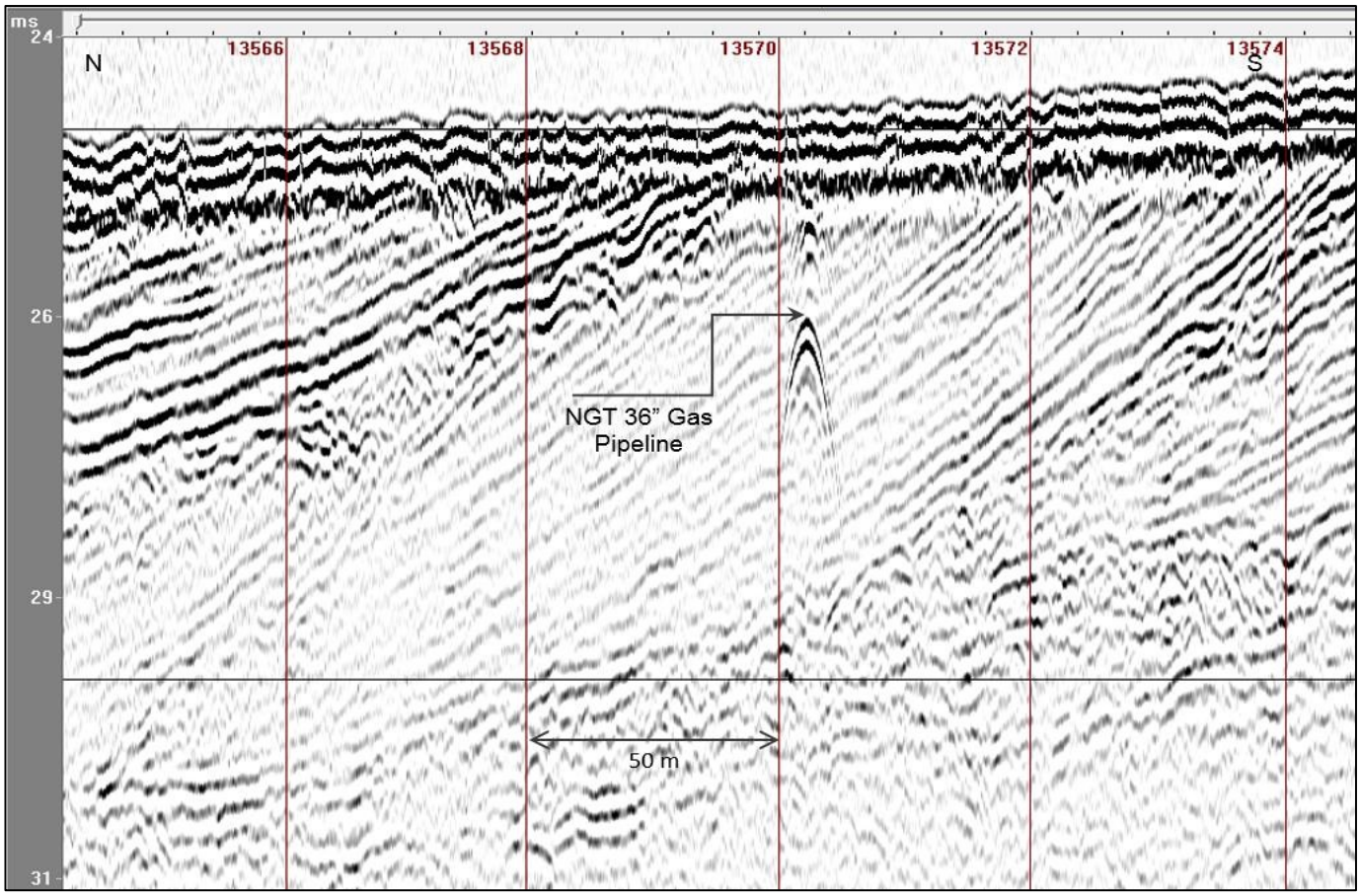


Figure 5: SBP_04 Innomar data (4 kHz, MBES on)

1.5 Conclusion

All data is visualised in Starfix Interp.

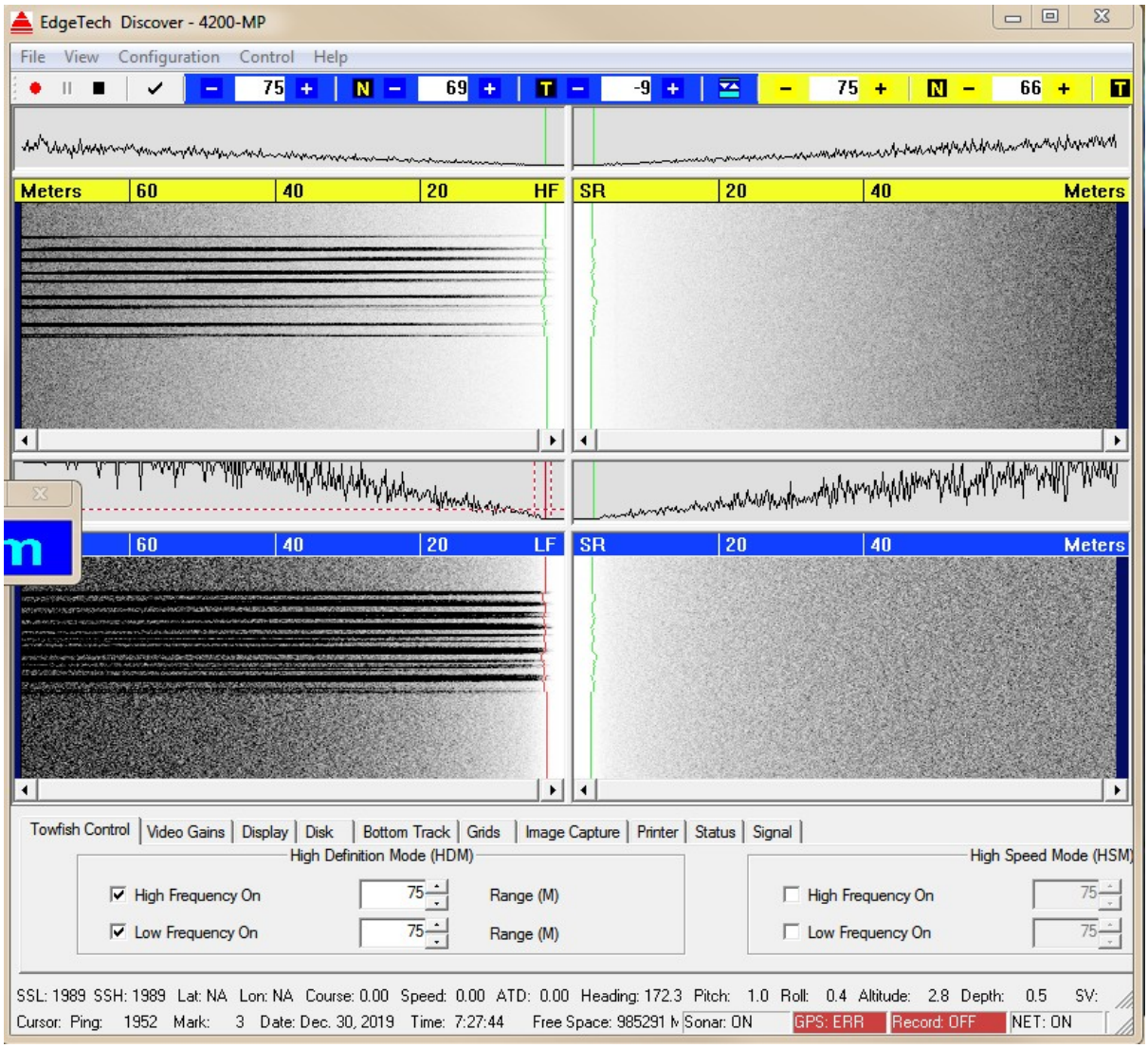
For inspecting this specific pipeline, with the ran settings, the Massa TR-1075 Hull mounted Pinger on “Pipeliner mode” is the preferred type of equipment. Looking at the data visualizations, figure 1, of this system versus the Innomar SES 2000, figures 2-5, this is clear. Running the Innomar with a lower frequency does not substantially increase the overall quality of the data visualization.

In the used configuration the Massa Hull mounted Pinger has a broader beam width which makes it a better suited tool for Pipeline Inspections. The Pings are distributed over a wider area wich results in a lower resolution. This makes the pipeline more distinguishable regarding the geology.

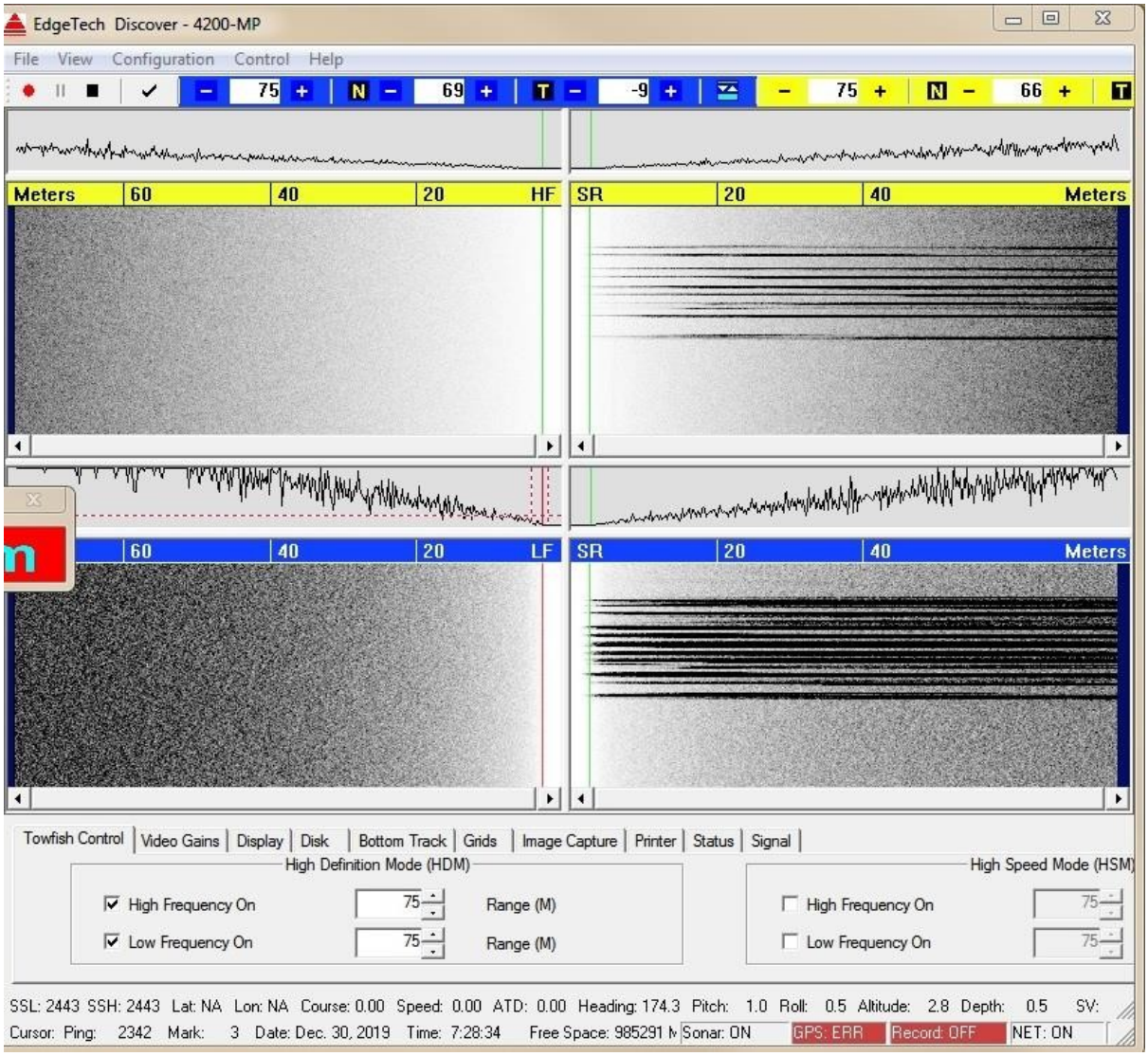
The Innomar SBP has a smaller beam (~2°) width which results in a high-resolution image, for pipeline inspections this is not that suitable, it is harder to interpretate the data in contrast of the Hull Mounted Pinger data output.

A.V. SSS – Rub Test

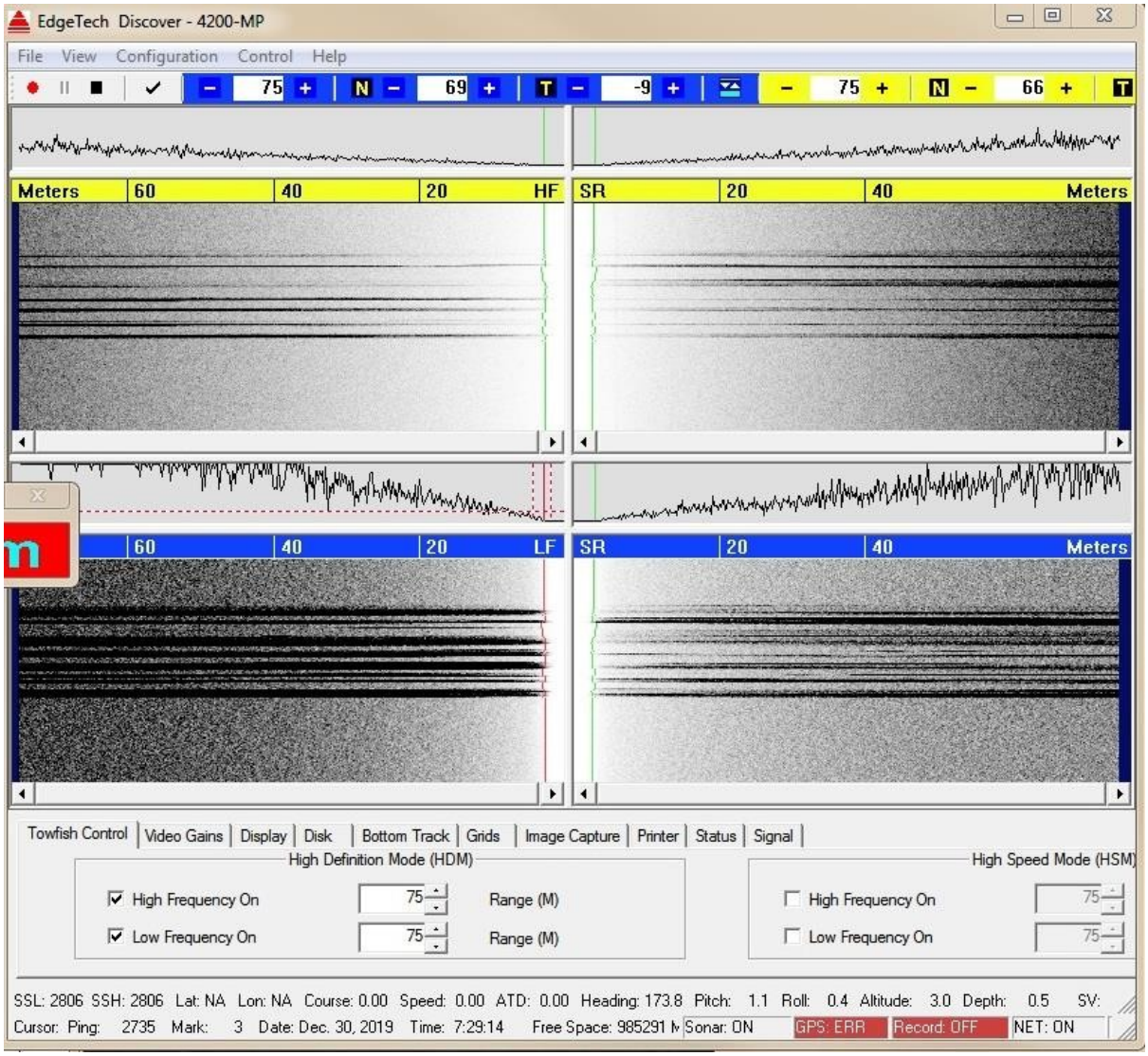
MIWB_SSS_SN49135_Port_rub



MIWB_SSS_SN49135_stbd_rub



MIWB_SSS_SN49135_both_rub



A.VI. USBL/SSS – Position Verification

USBL/SSS Position Verification Report Fugro Pioneer

Internship Report L. Blauw

MIWB_GEOP_SSS_Verification_PIO | 30 December 2019

MIWB NHL – Stenden

1. Introduction

The purpose of the USBL verification was:

- To confirm the accuracy of the HiPAP USBL system, installed onboard, Fugro Pioneer.

2. Scope of Work

The verification was performed by carrying out a box-in survey around the center of a known pipeline side-tap position. The box-in was done by surveying:

- two (2) lines in Northwest – Southeast direction at an offset of 25m from the center of the side-tap;
- two (2) lines in Northeast – Southwest direction at an offset of 35m from the center of the side-tap.

The center of the side tap was interpreted from all four of the lines.

These positions were compared within Fugro's in-house software Starfix Workbench against the MBES derived position and the positional error was calculated.

Table 2.1 presents the details of the reference point.

Table 2.1: Side-tap Center Location and Reference Point Positions

Location	Easting (m)	Northing (m)
ST-WGT center location (as delivered by MBES)	X1	Y1
Reference point 1 position (as delivered by MBES)	x2	Y2
Reference point 2 position (as delivered by MBES)	X3	Y3

3. Operations

The SSS and positioning data used for verification was acquired onboard Fugro Pioneer on 01 December 2019. All four (4) lines were sailed at approximately the same speed and a USBL beacon was installed on the tow cable, 1.050 m in front of the sidescan sonar fish. The fish was towed behind the vessel from the tow point located at vessel aft.

4. Results

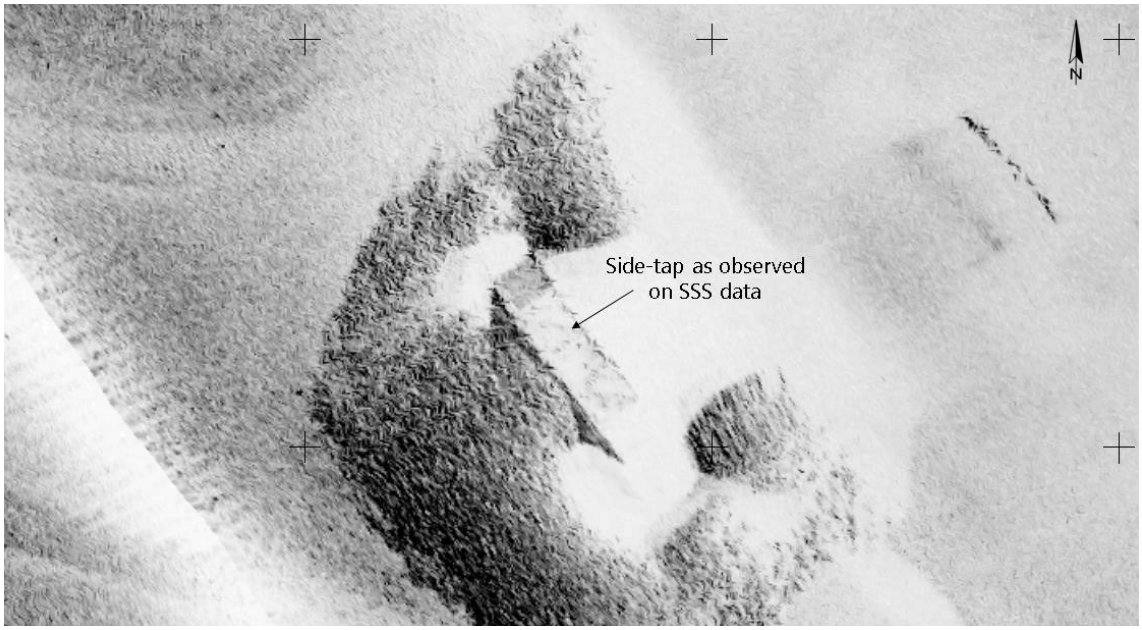


Figure 4.1: North-up Sidescan Sonar Mosaic of Side-tap

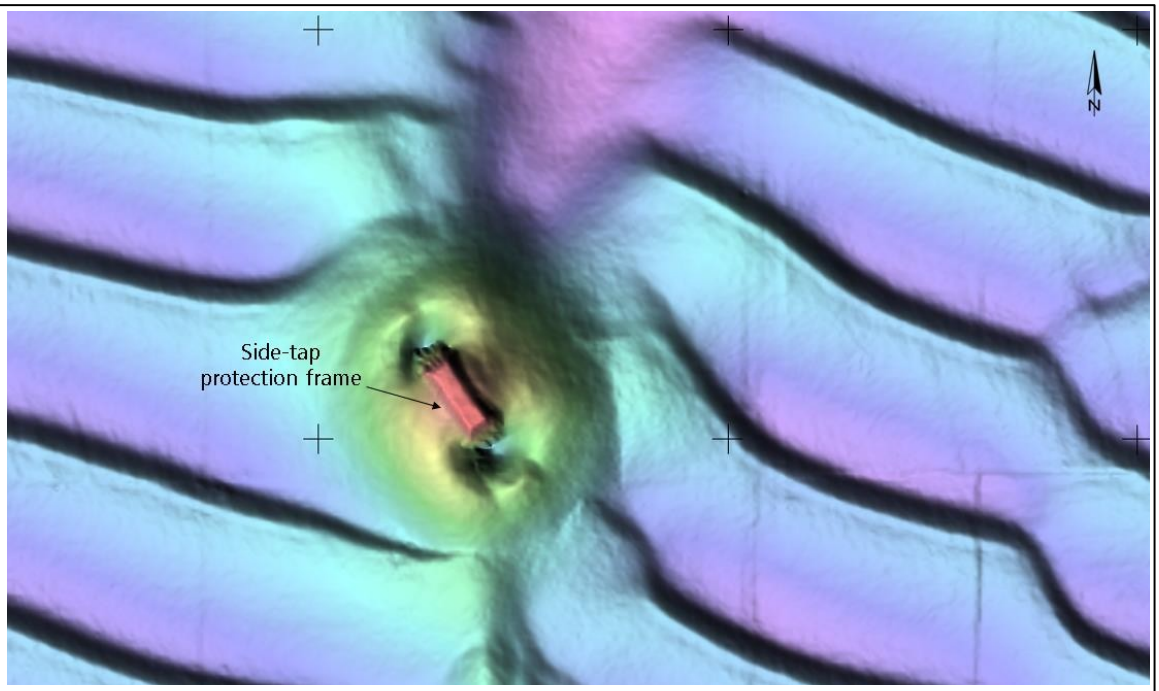


Figure 4.2: North-up MBES Image of Side-tap

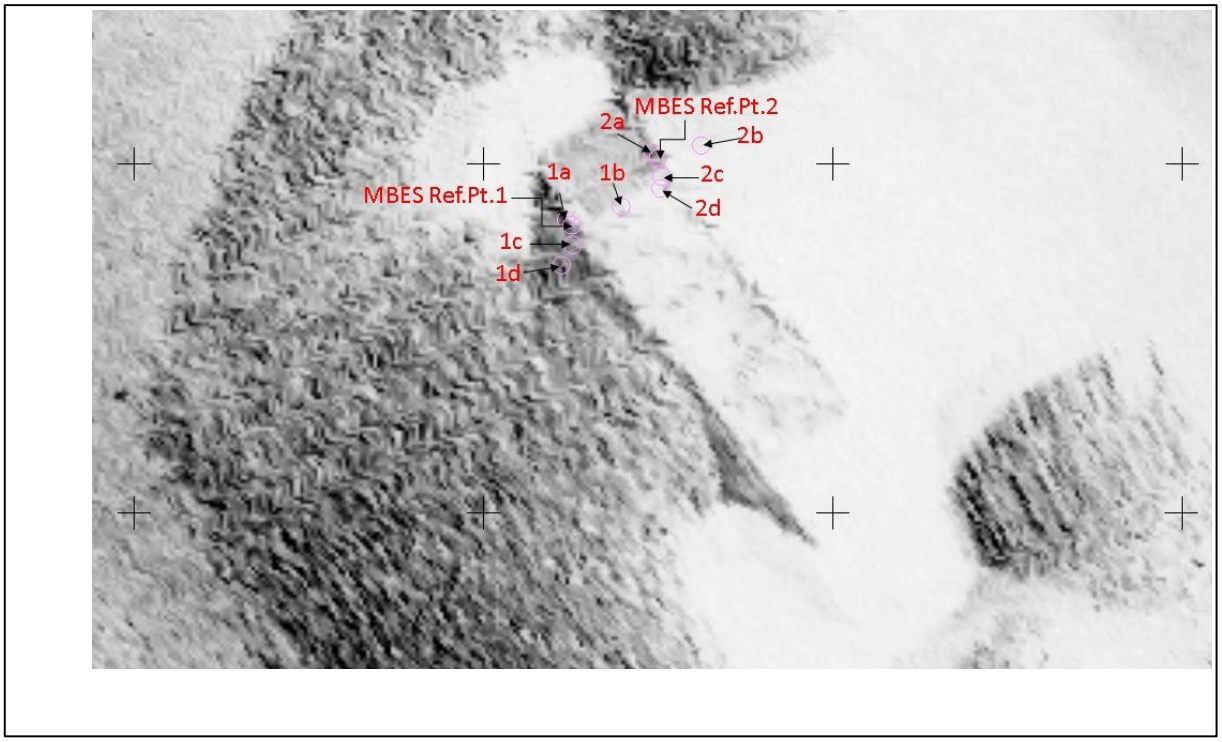


Figure 4.3: North-up MBES Image of Side-tap with Reference Points delivered from four SSS lines

Table 4.1: SSS Positions from Verification Lines of Reference Point 1

Line	Location	Easting (m)	Northing (m)	Difference with MBES position (m)
SSS_Ver_SE_A	1a	X1a	Y1a	0.213
SSS_Ver_NW_B	1b	X1b	Y1b	1.511
SSS_Ver_NE	1c	X1c	Y1c	0.565
SSS_Ver_SW	1d	X1d	Y1d	1.181
Average position from SSS		**Xave**	**Yave**	**0.362**

Table 4.2: SSS Positions from Verification Lines of Reference Point 2

Line	Location	Easting (m)	Northing (m)	Difference with MBES position
SSS_Ver_SE_A	2a	X2a	Y2a	0.205
SSS_Ver_NW_B	2b	X2b	Y2b	1.289
SSS_Ver_NE	2c	X2c	Y2c	0.552
SSS_Ver_SW	2d	X2d	Y2d	0.881
Average position from SSS		**Xave**	**Yave**	**0.393**

Table 4.3: Differences Between Average SSS Position and MBES position

	dX (m)	dY (m)	Range (m)
Reference Point 1 (C-O)	0.250	-0.262	0.362
Reference Point 2 (C-O)	0.318	-0.230	0.393

5. Conclusion

Based on the obtained results, the USBL system was verified to be within the requested tolerance of 2 m and therefore is deemed fit for survey.

6. HSE

No safety or HSE incidents were reported.

Signed:		Signed:	
	P. Miller **Party Chief** **(Fugro Pioneer)**		**F. P. J. de Haan** **Client Representative** **MIWB NHL – Stenden**