Survey for Njord A at Halsnøyfjorden

Survey Report | 13 to 15 February 2021 | Halsnøyfjorden

161637-07-REP-001 Issue 1 | 26 February 2021
Issued to client
Equinor ASA

Document Control

Document Information

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Client	Equinor ASA
Client Address	Forusbeen 50, 4035 Stavanger
Client Contact	Trond Olav Groven
Client Reference	2021-746

Revision History

Issue	Date	Status	Comments on Content	Prepared By	Checked By	Approved By
1	26 February 2021	Issued to client	First issue	IH	DV	JKLH

Project Team

Initials	Name	Role
SOR	Svein Ove Rundhovde	Project Manager
IH	Ingvill Hermansen	Surveyor
DV	Daniel Van Der Straeten	Survey Supervisor
JKLH	Jonas Karl Lian Hansen	Project Support Team Leader

Project Location

Executive Summary

Fugro positioned the Skandi Vega and its ROV during the survey operations for the Njord A in Halsnøyfjorden. The project took place from 13 to 15 February 2021.

Scope of Work

The scope of work comprised positioning the Skandi Vega and its ROV during the survey of eight mooring-line corridors and the attempt to locate two cables at Halsnøyfjorden prior to prelay operation for the Njord A.

Methodology

Fugro positioned the Skandi Vega using Fugro's Starfix high performance positioning services. The primary and secondary positioning solutions were Starfix.G2+ and Starfix.XP2 respectively. Fugro used the StarPack GNSS Heading solution as the primary heading sensor; we also interfaced any other available azimuth sensors into the navigation system. The vessel's USBL system was used for subsea positioning. Fugro interfaced all navigation sensors into the Starfix Suite.

Summary of Operations

Fugro personnel arrived onboard the Skandi Vega on 13 February 2021. The vessel arrived at Halsnøyfjorden on 14 February 2021, and performed the ROV survey from 07:08 to 22:34.Fugro departed the vessel on 15 February 2021.

Results

All eight mooring line corridors were visually surveyed without findings; the inspection of the seabed indicated soil characteristics consisting of soft clay.

Only weak and sporadic signals were detected when using a pipe tracker along the Telenor telecommunications cable in the chart, and it was not possible to confirm if the signals indicated the cable or noise or from other objects underneath the seabed.

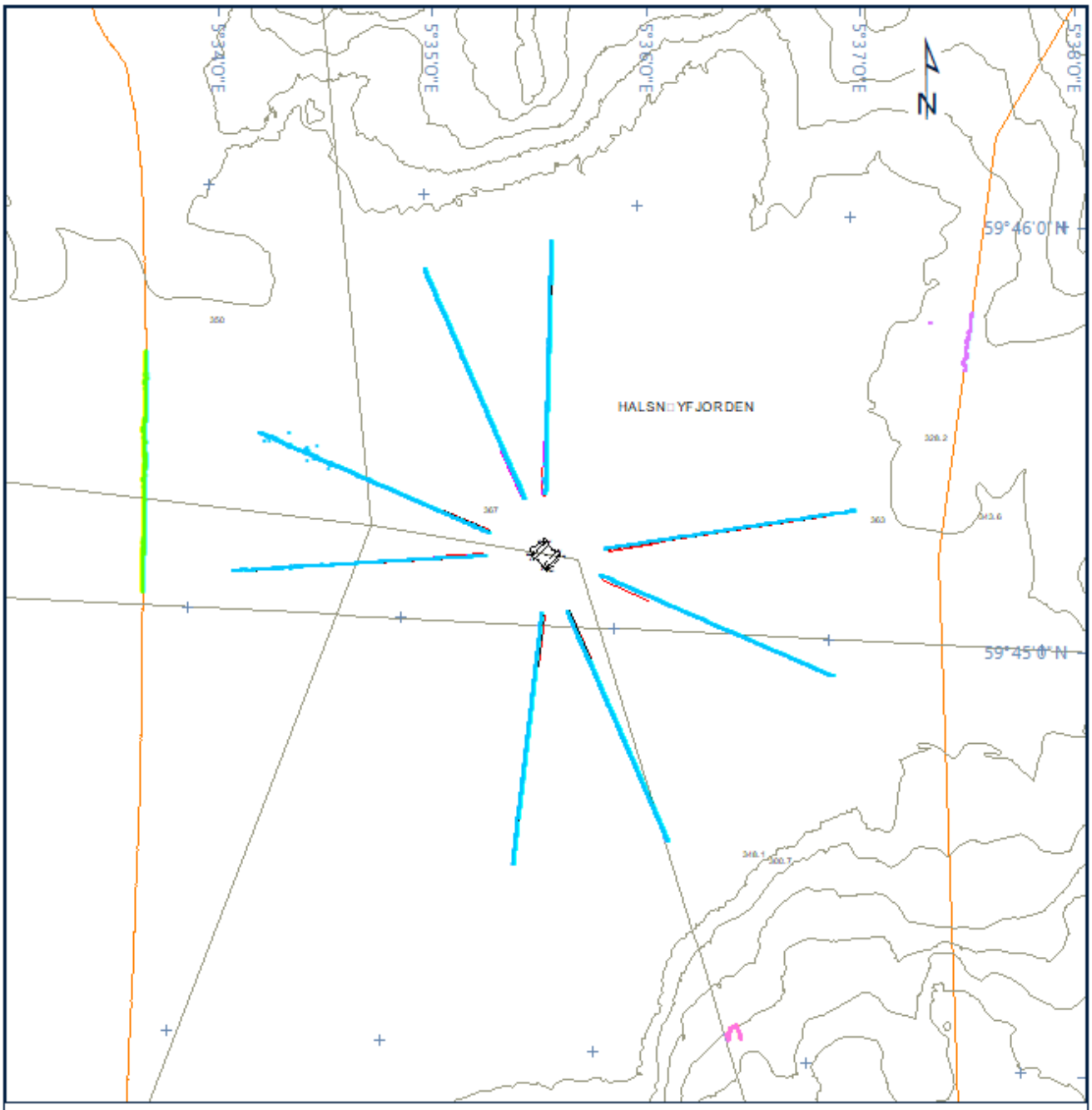
The SOW included a map indicating another possible route for the Telenor telecommunication cable; the pipe-tracker received signals at one location, but it was not possible to conclude whether this was the actual cable.

The survey of the BKK fibre optic cable on the west side of the planned mooring-spread location, aligned well with the electronic background chart.

Conclusions and Recommendations

The navigation system performed well during the project. The route of the Telenor telecommunication cable described in the SOW, should have been included in the background chart.

Survey Plot



ROV Survey Overview at Halsnøyfjorden for Njord A

- Intended Mooring lines
- Cables
- Intended Rig Outline
- ROV Survey at possible Telenor Cable
- ROV/TSS track at BKK cable
- ROV at TSS signal
- ROV track at Intended Mooring lines

Chart Information

Scale 1:30,000 at A4 page size
ETRS 1989 UTM 32N
Date: 26 February 2021
Drawn: D.VANDERSTRAETEN

FUGRO

FUGRO

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Appendices

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1. Introduction

1.1 Scope of Work

Equinor ASA contracted the Skandi Vega to survey eight mooring line corridors for the Njord A at Halsnøyfjorden.

Equinor ASA contracted Fugro to provide positioning of the Skandi Vega and its ROV during the prelay and survey operations. Fugro was also to report the results of the ROV survey.

1.2 Reference Documents

Table 1.1 lists the reference documents that we used during the project.

Table 1.1: Reference Documents

Document Number	Title
GM-0691-0941-R199 R02	Njord Future – Towing, mooring installation and connection of Nord A and B 2018-2021
0691-0941-NJA-2021-SK-301-Inshore ML-Pre Hook-Up	Inshore ML-Pre Hook-Up DWG file
2021-746	Fugro Bestilling 2021-746 Njord A ROV support @ Klosterfjorden
EUAF-FNAS-MPCS-PR-001	General Positioning Procedure

1.3 Definitions

Table 1.2 lists the parties involved in the project.

Table 1.2: Definitions

Role	Company
Client	Equinor ASA
Survey Contractor	Fugro
ROV Operator	DOF Subsea

1.4 Personnel

Table 1.3 lists the personnel involved in the project.

Table 1.3: Personnel

Position	Company	Name
Marine Representative	Equinor ASA	Jan Petter Leirvåg
Survey Party Chief	Fugro	Ingvill Hermansen
Surveyor	Fugro	Endre Riise

1.5 Vessels

Table 1.4 lists the vessels and ROVs involved in the project.

Table 1.4: Vessels

Type	Name
Anchor Handling Vessel	Skandi Vega
ROV	Supporter

2. Project Summary

2.1 Operational Summary

Fugro personnel arrived onboard the Skandi Vega on 13 February 2021. The vessel arrived at Halsnøyfjorden on 14 February 2021, and started ROV survey at 07:08; the operation was finished by 22:34 on 14 February 2021.

Fugro personnel departed the vessel on 15 February 2021.

Table 2.1 lists the key events during the execution of the project.

Table 2.1: Key Events

Event	Date	Time [UTC+1]
Fugro personnel boarded the vessel	13 February 2021	19:00
Survey equipment mobilised	13 February 2021	21:50
Skandi Vega arrived at Halsnøyfjorden	14 February 2021	06:30
Started survey at Halsnøyfjorden	14 February 2021	07:08
Finished survey at Halsnøyfjorden	14 February 2021	22:34
Started mooring corridor surveys at Halsnøyfjorden	14 February 2021	14:09
Finished mooring corridor surveys at Halsnøyfjorden	14 February 2021	19:45
Skandi Vega arrived at port of demobilisation	15 February 2021	10:15
Fugro personnel departed the Skandi Vega	15 February 2021	12:30

Appendix A contains the daily log which covers the entire execution of the project.

2.2 Project Experience

The background chart did not include the expected route of the Telenor telecommunication cable on the east side of the planned mooring spread. The pipe-tracker only detected weak and sporadic signals from this cable, and it was not possible to conclude either way if the signals indicated the telecommunication cable or other objects underneath the seabed.

The BKK fibre optical cable was traced with a clear and strong signal. The findings aligned well with the provided information.

No obstructions or corals were detected during the survey of mooring line corridors.

2.3 Technical Experience

All Fugro positioning equipment performed well throughout the project.

3. Position Reference Data

3.1 Geodetic Parameters used at Halsnøyfjorden

Table 3.1 describes the project coordinate reference system (CRS) and any transformations used at Halsnøyfjorden, while Table 3.2 presents the test point used to validate the corresponding settings in the navigation system.

Table 3.1: Coordinate Reference System Details

Name : ETRS89 / UTM zone 32N [EPSG-eur]		
EPSG Code	EPSG::25832	
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 Terrestrial Reference System 1989	EPSG::6258
Ellipsoid	GRS 1980	
Semi major axis	a = 6,378,137.000 m	
Inverse flattening	1/f = 298.257222101	
Datum Transformation Parameters from WGS 84 to ETRS89		
X-axis translation	0 m	
Y-axis translation	0 m	
Z-axis translation	0 m	EPSG::1149
Local Projection Parameters		
Map Projection	Transverse Mercator	
Grid System	UTM zone 32N	EPSG::16032
Latitude Origin	00°00'00.000"N	
Central Meridian	009°00'00.000"E	
Scale Factor on Central Meridian	0.9996	
False Easting	500,000 m	
False Northing	0 m	

Table 3.2: Geodetic Test Point

WGS 84	**Test Point [Position]**	**Computed Point**
Latitude	59°45'09.96000"N	59°45'09.96000"N
Longitude	005°35'40.14000"E	005°35'40.14000"E
ETRS89		
Latitude	59°45'09.96000"N	59°45'09.96000"N
Longitude	005°35'40.14000"E	005°35'40.14000"E
UTM zone 32N		
Easting	308,688.000m	308,688.183m
Northing	6,628,792.000m	6,628,791.597m

3.2 Provided Location Information

3.3 Intended Locations

Table 3.3 contains the intended position of Njord A at Halsnøyfjorden.

Table 3.3: Intended Rig Position at Halsnøyfjorden

Latitude	59° 45′ 09.973″ N
Longitude	005° 35′ 40.127″ E
Easting	308 688.00 m
Northing	6 628 792.00 m

Notes:
Geodetic Parameters: ETRS89 / UTM zone 32N [EPSG-eur]

Table 3.4 contains the intended anchor positions at Halsnøyfjorden.

Table 3.4: Intended Anchor Positions at Halsnøyfjorden

Anchor Number	Easting [m]	Northing [m]	Distance [m]	Bearing [°]	Source of Position
3	309 940.43	6 628 968.09	1265	082.0	Scope of work
4	309 851.48	6 628 298.13	1264	113.0	Scope of work
5	309 181.87	6 627 628.51	1264	157.0	Scope of work
6	308 555.72	6 627 533.67	1265	186.0	Scope of work
12	307 423.95	6 628 725.75	1266	267.0	Scope of work
13	307 524.83	6 629 285.74	1264	293.0	Scope of work
14	308 194.27	6 629 955.16	1264	337.0	Scope of work
15	308 710.10	6 630 057.91	1266	001.0	Scope of work

Notes:
All bearings are relative to grid north
Geodetic Parameters: ETRS89 / UTM zone 32N [EPSG-eur]

4. Equipment and Verifications

4.1 Skandi Vega Positioning Equipment

Table 4.1 and Table 4.2 list the positioning equipment installed onboard the Skandi Vega and its ROV, respectively.

Table 4.1: Skandi Vega Positioning Equipment

System	Manufacturer	Type or Solution
Primary Positioning Solution	Fugro	Starfix.G2+
Secondary Positioning Solution	Fugro	Starfix.XP2
GNSS Positioning and QC	Fugro	StarPack
Primary Heading Source	Fugro	StarPack GNSS Heading
Secondary Heading Source	Sperry Marine	Navigat X MK1
Navigation Software	Fugro	Starfix Suite 2018 SP1 R20

Table 4.2: ROV Positioning Equipment

System	Manufacturer	Type or Solution
Primary Positioning Solution	Kongsberg	MST 319
Secondary Positioning Solution	Kongsberg	MST 319
Primary Heading Source	CDL	TOGS
Pressure Sensor	SAIV	TD303
Pipe-tracker	TSS	TSS

4.2 Verification Results

4.2.1 GNSS Verification

Fugro performed a GNSS health-check through StarfixNG's positioning comparison report on 13 February 2021 while the Skandi Vega was at Bergen. We logged the primary and secondary positioning systems for 15 minutes and compared the results. Table 4.3 summarises the results, and Appendix B.1 contains the full report.

Table 4.3: GNSS Verification at Bergen

Positioning Source	Easting [m]	SD Easting [m]	Northing [m]	SD Northing [m]	Delta Easting [m]	Delta Northing [m]
GNSS Fwd Starfix.G2+	296 722.211	0.01	6 700 219.851	0.02	NA	NA
GNSS Stbd Starfix.XP2	296 722.353	0.01	6 700 219.833	0.02	0.14	–0.01
Notes: SD = Standard deviation Geodetic parameters : ETRS89 / UTM zone 32N [EPSG-eur]						

4.2.2 Heading Verification

Fugro logged a heading verification on 13 February 2021, while the vessel was at Bergen. We logged heading data for 40 minutes and calculated the results using Fugro's GNSS and Heading Verifications Spreadsheet. The output of a StarPack's GNSS Heading solution was used as the computed heading; see Appendix D.1.2 for details on the solution.

Table 4.4 summarises the results, and Appendix B.2 contains the full report.

Table 4.4: Heading Verification Results

Heading Sensor	C-O [°]	C-O SD [°]
StarPack GNSS Heading	–351.41	NA
Vessel Gyro 1	–0.79	0.06
Vessel Gyro 2	–1.96	0.04

Notes:
C-O = Computed minus observed
SD = Standard deviation

5. Results

5.1 ROV Survey at Intended Mooring Lines

All eight mooring line corridors were visually surveyed without any boulders, pockmarks, scars, or corals found. The inspection of the seabed indicated soil characteristics consisting of soft clay.

The mooring line corridors were extended behind each planned anchor location, to allow for line lengths to be extended if needed.

5.2 ROV Survey at Telenor Cable

A TSS pipe tracker was installed on the ROV, and a survey along the route of the Telenor telecommunication cable indicated on electronic chart was attempted. Only weak and sporadic signals were detected, and it was not possible to confirm if the signals indicated the cable or noise or from other objects underneath the seabed.

The SOW included a map indicating another possible route for the Telenor telecommunication cable, which was not included in the electronic chart. Based on water depth, elevations and known features, another attempt was made to locate the cable. At one location the pipe-tracker received signals that could align with the Telenor communication cable, but it is not possible to make this conclusion.

5.3 ROV Survey at BKK Fibre Optic Cable

The survey of the BKK fibre optical cable on the west side of the planned mooring-spread location aligned well with the electronic background chart. The signal from the pipe-tracker was clear throughout the surveyed route, and the cable was also exposed for a few metres along the route.

No noticeable debris was detected during the survey.

5.4 Survey Plot Overview at Halsnøyfjorden

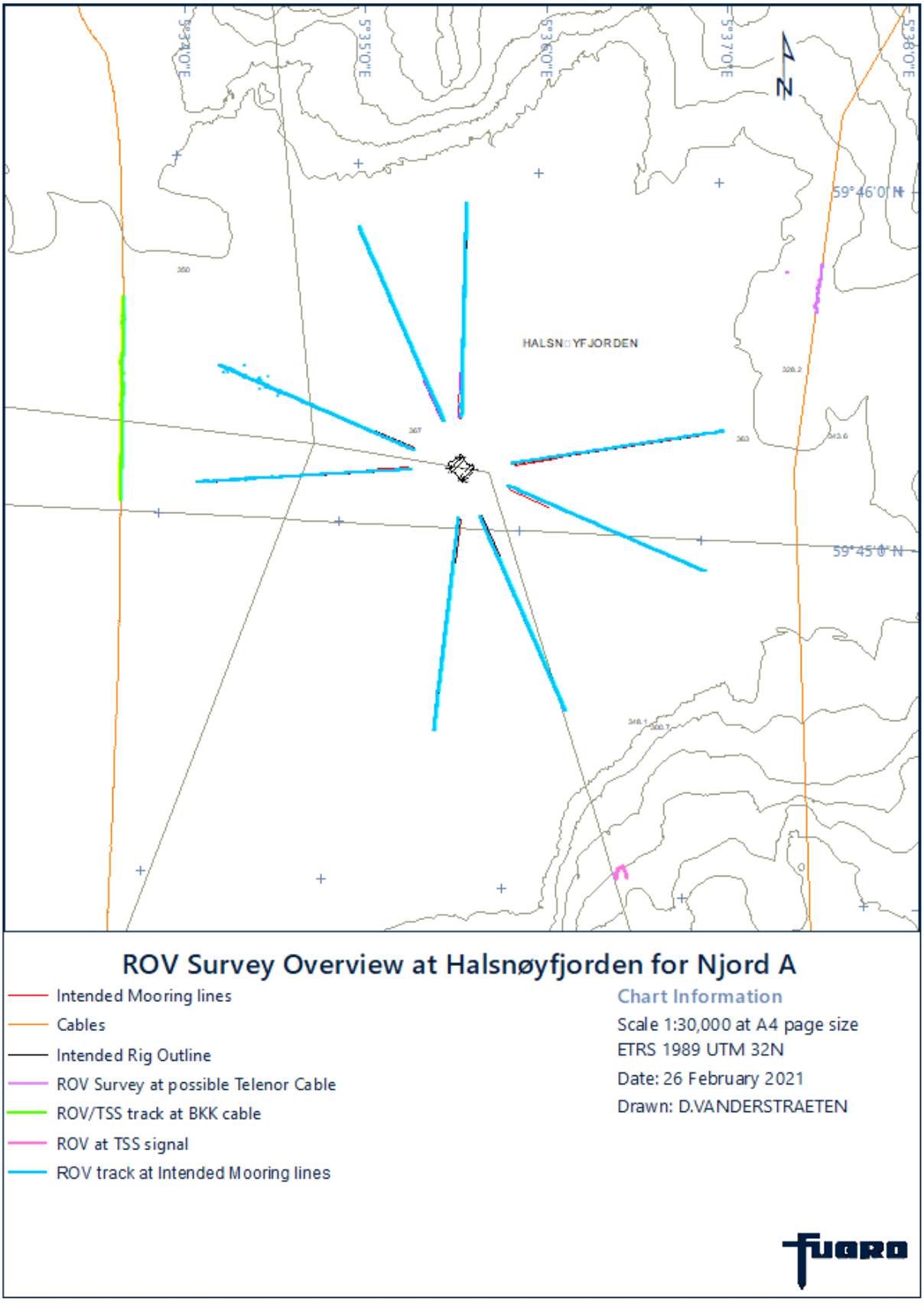


Figure 5.1: Survey Plot Overview at Halsnøyfjorden

6. Health and Safety

All Fugro personnel attended a safety induction where they were made familiar with the vessel's safety equipment and routines.

Before starting to work, Fugro reviewed the generic risk assessment for offshore work along with the planned work scope. The risk assessment is available in Appendix E.1. Any hazards or risks which were not covered in the generic risk assessment were addressed though Fugro's task risk assessments (TRAs), and control measures were put in place so that the operation could be completed in a safe manner.

All Fugro personnel held job specific toolbox talks before starting work to remind all personnel of the hazards and control measures required for the task at hand. Any changes to the work environment, the risks, or the task since the review of the risk assessment were also discussed in the toolbox talk.

Table 6.1: Project HSE Statistics

Activity	Number	Comments
Personnel inductions	0	
Project HSE briefings	0	
Risk assessments	0	
Toolbox talks	0	
Safety observations	0	
Undesired events	0	
Emergency drills	0	
Safety meetings	0	

Appendix A

Daily Log

A.1 Daily Log for the Skandi Vega

Equinor

Daily Progress Report

Document Control			
Project Name	Survey Halsnoyfjorden		
Project Number	161637-07	**Client**	Equinor
Date	13 February 2021	**Client Reference**	2021-746
Document Number	161637-07-DPR-001	**Client Representative**	NA

Project Details			
Vessel Name	Skandi Vega	**Equipment Status**	Mobilised
Location	Halsnoyfjorden	**Est. Date of Demobilisation**	13 February 2021
Weather	SE3, b2		
Fugro Personnel	Endre Riise, Ingvill Hermansen		
Last 24 Hours	Arrived on-board the vessel, mobilized		
Next 24 Hours	Transit to location, start survey		

QHSSE Summary			
HSE Activity	**Number**	**Total**	**Comments**
Inductions	0	0	
HSE Briefings	0	0	
Risk Assessments	0	0	
Toolbox Talks	0	0	
Safety Observations	0	0	
Undesired Events	0	0	
Emergency Drills	0	0	
Safety Meetings	0	0	

Signed Fugro	Signed Client
Ingvill Hermansen	

13 February 2021	
Time [UTC+1]	**Event**
19:00	Endre Riise and Ingvill Hermansen arrived onboard the Skandi Vega
19:10	Started mobilising the navigation system
21:07	Started logging gyros
21:11	Started logging Positioning Comparison
21:26	Stopped logging positioning comparison
21:47	Stopped gyro logging
21:50	Navigation equipment and software configured for job

Signed Fugro	Signed Client
Ingvill Hermansen	

Equinor

Daily Progress Report

Document Control			
Project Name	Survey Halsnoyfjorden		
Project Number	161637-07	**Client**	Equinor
Date	14 February 2021	**Client Reference**	2021-746
Document Number	161637-07-DPR-002	**Client Representative**	NA

Project Details			
Vessel Name	Skandi Vega	**Equipment Status**	Mobilised
Location	Halsnoyfjorden	**Est. Date of Demobilisation**	15 February 2021
Weather	SE6, c2		
Fugro Personnel	Endre Riise, Ingvill Hermansen		
Last 24 Hours	Transit to location, start survey		
Next 24 Hours	Transit to Sløvåg		

QHSSE Summary			
HSE Activity	**Number**	**Total**	**Comments**
Inductions	0	0	
HSE Briefings	0	0	
Risk Assessments	0	0	
Toolbox Talks	0	0	
Safety Observations	0	0	
Undesired Events	0	0	
Emergency Drills	0	0	
Safety Meetings	0	0	

Signed Fugro	Signed Client
Ingvill Hermansen	

14 February 2021	
Time [UTC+1]	**Event**
00:40	VL departure Bergen. Start transit to Survey Halsnoyfjorden
06:00	IH on shift
06:30	Started general logging
07:08	ROV off deck
07:11	ROV deployed
07:19	ROV out of the TMS
07:23	ROV on seabed, prepare pipe tracker for survey
07:37	ROV move towards Cable east side, Telenor
08:20	Started searching for cable east side
08:39	No indication of cable from pipe tracker, started to follow cable on map south
08:43	Located cable started Instruments logging started
09:02	Move closer to survey area. Stopped Instruments logging
10:22	No evidence of cable. ROV fly off track to calibrate pipe tracker
11:23	Stop survey, not able to locate cable with pipe-tracker
11:35	ROV recovered, vessel move towards cable west-side
11:59	Vessel in position for pipe-tracker survey of BKK Digital fibre-cable
12:00	ROV deployed
12:09	ROV out of TMS, started re-calibrating pipe-tracker
12:35	ROV located cable with pipe-tracker. Start Instruments logging
13:07	Cable exposed approx. 10 m
13:20	Pipe-tracker survey completed. Stopped Instruments logging
13:23	ROV in the TMS
13:29	ROV recovered
13:37	ROV started to disconnect pipe-tracker
13:55	Vessel in position for coral survey in Njord A planned mooring-line corridor 12
14:08	ROV off deck
14:09	ROV deployed
14:21	Started survey mooring line 12. Started instruments logging
14:52	Survey mooring line 12 completed. Stopped instruments logging
14:56	Started survey mooring line 13. Started instruments logging
15:30	Survey mooring line 13 completed. Stopped instruments logging
15:38	ROV recovered

Signed Fugro	Signed Client
Ingvill Hermansen	

14 February 2021	
Time [UTC+1]	Event
15:50	Vessel at mooring line 14, ROV deployed
16:02	Started survey mooring line 14. Started instruments logging
16:25	Survey mooring line 14 completed. Stopped instruments logging
16:32	Started survey mooring line 15. Started instruments logging
16:56	Survey mooring line 15 completed. Stopped instruments logging
16:59	ROV in TMS, recover to LARS
17:03	ROV in LARS, VL relocate to Start N6
17:20	Vessel at mooring line 6, ROV deployed
17:28	Started survey mooring line 6. Started instruments logging
17:50	Photo taken of small object on seabed
17:52	Survey mooring line 6 completed. Stopped instruments logging
18:00	Shift handover, IH off shift, ER on shift
17:59	Started survey mooring line 5. Started instruments logging
18:24	Survey mooring line 5 completed. Stopped instruments logging
18:26	ROV in TMS, recover to LARS
18:30	ROV in LARS, VL relocate to Start N3
18:40	Vessel at mooring line 3, ROV deployed
18:49	Started survey mooring line 3. Started instruments logging
19:15	Survey mooring line 3 completed. Stopped instruments logging
19:22	Started survey mooring line 4. Started instruments logging
19:45	Survey mooring line 4 completed. Stopped instruments logging
19:48	ROV in TMS, recover to LARS
19:53	ROV on deck, reconfigure for TSS Telenor Cable search
19:54	VL relocate to N5 anc position
20:05	VL in position
20:37	ROV off deck
20:40	ROV deployed
20:49	ROV out of the TMS
20:51	ROV on seabed, prepare pipe tracker for survey
21:06	ROV start searching for Cable Telenor, Hdg. SSE
21:49	Signal on TSS 309483.3mE, 6626661.1mN
21:53	Log on ROV Cable East. Possible cable Hdg. 309 483 mE, 6 626 661mN

Signed Fugro	Signed Client
Ingvild Hermansen	

14 February 2021	
Time [UTC+1]	**Event**
21:55	Lost TSS signal. move back to find TSS signal
22:10	Log off. Not possible to find anything with TSS pipetracker. ROV recover
22:14	ROV in TMS
22:24	Stop StarfixNG logging
22:34	ROV on deck
23:59	VL preparing for transit

Signed Fugro	Signed Client
Ingvild Hermansen	

Equinor

Daily Progress Report

Document Control			
Project Name	Survey Halsnoyfjorden		
Project Number	161637-07	**Client**	Equinor
Date	15 February 2021	**Client Reference**	2021-746
Document Number	161637-07-DPR-003	**Client Representative**	NA

Project Details			
Vessel Name	Skandi Vega	**Equipment Status**	Mobilised
Location	Halsnoyfjorden	**Est. Date of Demobilisation**	15 February 2021
Weather	NA		
Fugro Personnel	Endre Riise, Ingvill Hermansen		
Last 24 Hours	Transit to Sløvåg, demobilisation		
Next 24 Hours	NA		

QHSSE Summary			
HSE Activity	**Number**	**Total**	**Comments**
Inductions	0	0	
HSE Briefings	0	0	
Risk Assessments	0	0	
Toolbox Talks	0	0	
Safety Observations	0	0	
Undesired Events	0	0	
Emergency Drills	0	0	
Safety Meetings	0	0	

Signed Fugro	Signed Client
Ingvill Hermansen	

15 February 2021	
Time [UTC+1]	**Event**
01:30	VL start transit to Sløvåg. ETA 10:00.
10:15	Alongside Sløvåg
12:20	IH departed vessel, ER stayed on-board for next project

Signed Fugro	Signed Client
Ingvill Hermansen	

Appendix B

Calibrations, Verifications and Offsets

B.1 GNSS Verification

equinor

SURVEY HALSNOYFJORDEN
POSITIONING COMPARISON REPORT

FUGRO

Fugro Project ID:	**161637-07**	**Client:**	**Equinor ASA**
Fugro Personnel:	**Ingvill Hermansen, Endre Riise**		
Vessel:	**Skandi Vega**		
Remarks:			

Session Name: 20210213-201028-v1
Start Time: 13 Feb 2021, 21:11:46+01:00
End Time: 13 Feb 2021, 21:26:45+01:00

Units and Format: Local grid (World Standard)

(Session Length 0.25 hrs - No. Obs. 898)

Positioning System CRS and Offsets

	System	CRS	X (m)	Y (m)	Z (m)
1	StarPack FWD-10.10.10.199-Starfix.G2 Plus 10301	WGS 84	0.10	31.49	27.67
2	StarPack STBD200-10.10.10.200-Starfix.XP2 10221	WGS 84	1.92	19.42	33.16

Sensor Data (mean values over data periods)

	Antenna Positions	Easting (m)	SD	Northing (m)	SD	Height (m)	SD	Obs
1	StarPack FWD-10.10.10.199-Starfix.G2 Plus 10301	296,700.058	±0.01m	6,700,242.229	±0.01m	73.399	±0.02m	898
2	StarPack STBD200-10.10.10.200-Starfix.XP2 10221	296,710.008	±0.01m	6,700,234.945	±0.01m	78.838	±0.02m	898

	Heading Sensors	Obs °T	Obs °G	Conv	SD	(C-O)°	Calc °T	Calc °G	Diff°	Records
1	StarPack STBD200-10.10.10.200	303.3	306.5	-3.20816	0.02	-351.41	311.9	315.1	0.00	897

Results (Computed CRP position Comparison) UTM zone 32N

	Name	Easting (m)	Northing (m)	Height (m)	TPE (m)	d.Easting (m)	d.Northing (m)	d.Height (m)	Obs
1	StarPack FWD-10.10.10.199-Starfix.G2 Plus 10301	296,722.211	6,700,219.851	45.726	0.02	0.00	0.00	0.00	898
2	StarPack STBD200-10.10.10.200-Starfix.XP2 10221	296,722.353	6,700,219.833	45.676	0.02	0.14	-0.01	-0.05	898

Ingvill Hermansen
Party Chief
FNAS (Fugro Norway AS)

Client
Client Representative
Equinor ASA

13/02/2021 21:28:26 (UTC+01:00) Positioning Comparison Report (Skandi Vega) (CommonReferencePoint) (v0) Page 1 of 7

B.2 Heading Verification

Skandi Vega Jekteviken, 13/02/21

Precise Relative Position Engine Heading Verifications

Skandi Vega, 13 February 2021
Time of logging: 21:07 - 21:47

Summary

System	System	Serial No.	C-O [°]
Gyro #1	Vessel Gyro 1		-0.79
Gyro #2	Vessel Gyro 2		-1.96
Gyro #3			

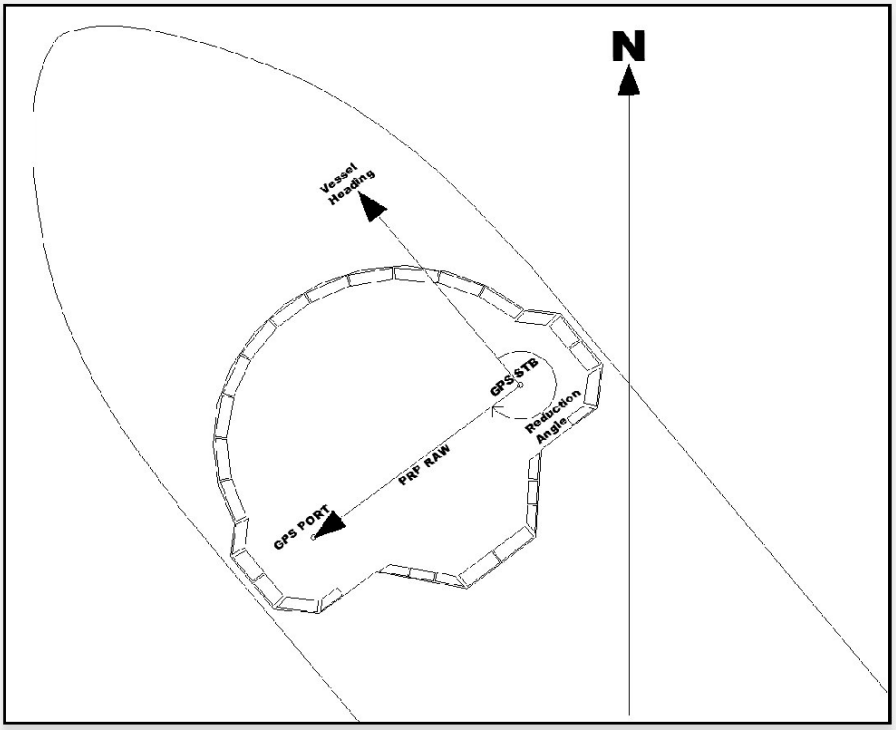
GNSS Antenna Offsets

	Offset Name	X [m]	Y [m]
From	Stb GNSS	1.92	19.42
To	Fwd	0.10	31.49

Applied correction angle: -351.41°

C-O statistics

	GNSS Heading [°]	Gyro #1 [°]	Gyro #2 [°]	Gyro #3 [°]
Minimum	311.86	-0.93	-2.11	
Maximum	312.20	-0.59	-1.82	
Average	311.96	-0.79	-1.96	
SD	0.08	0.06	0.04	

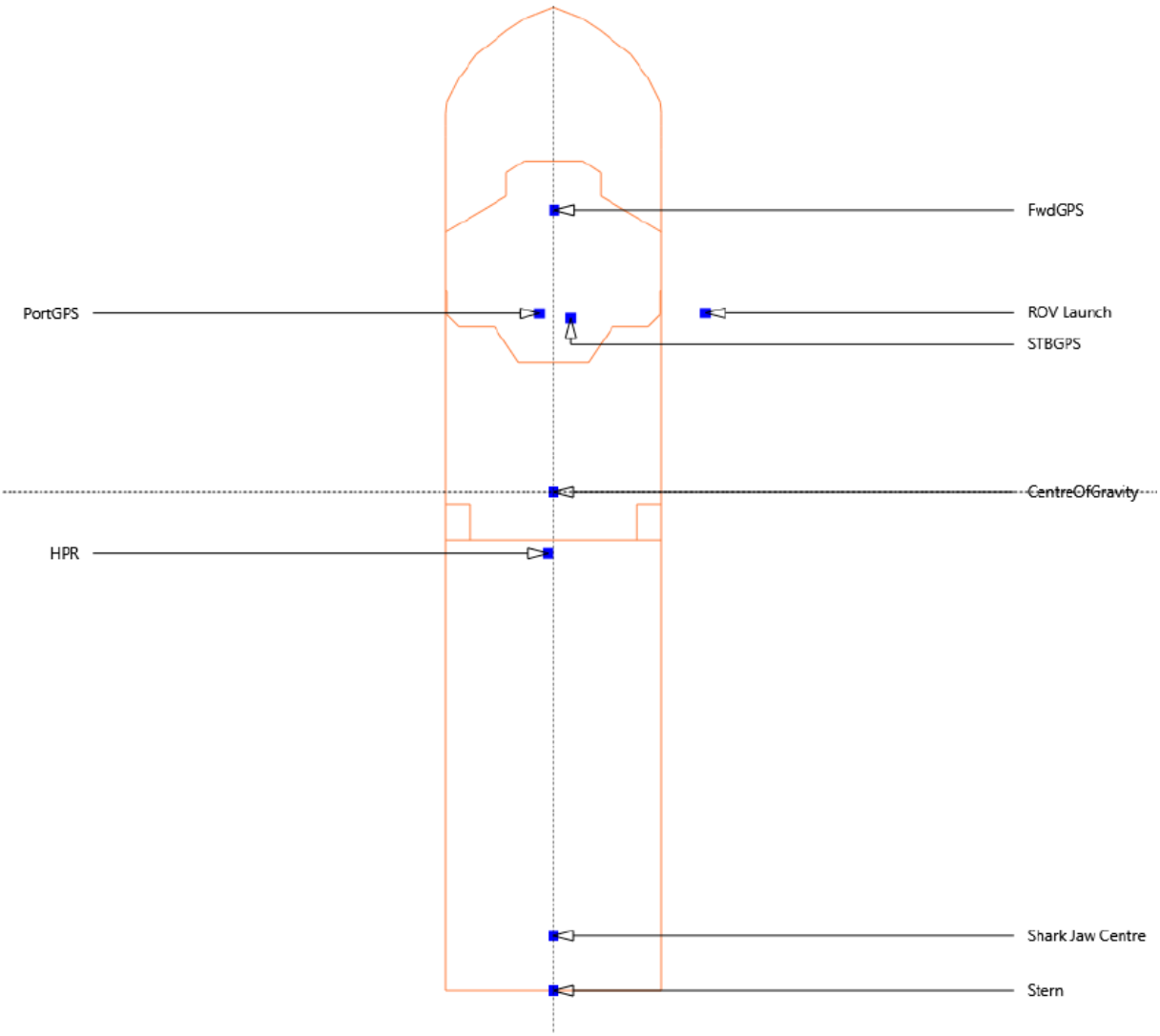


Fugro Signed: Ingvild Hermansen

For Client Signed:

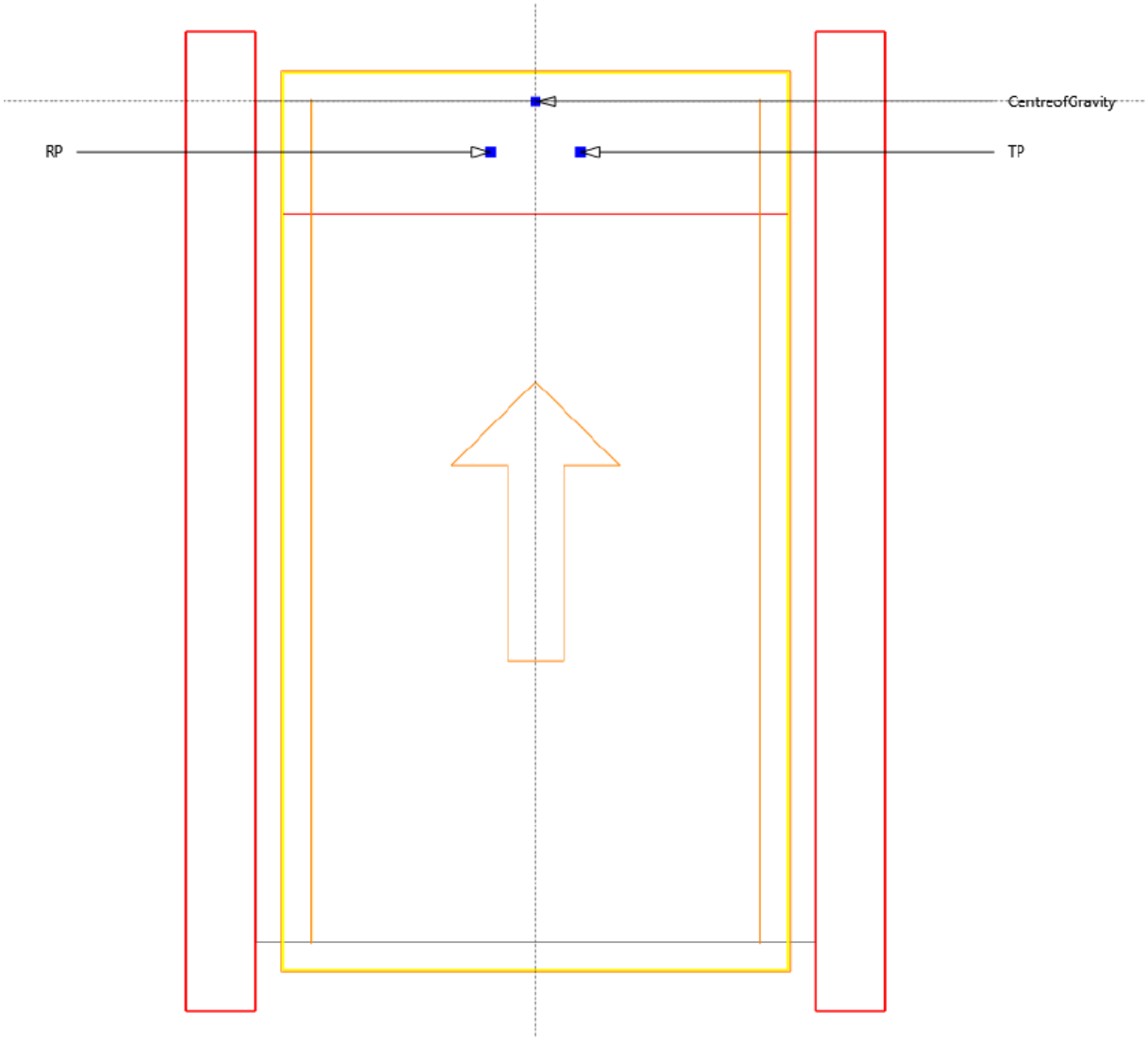
B.3 Offsets

B.3.1 Skandi Vega Offsets



Point	X [m]	Y [m]	Z [m]
CommonReferencePoint	0.00	0.00	0.00
Fwd GNSS	0.10	31.49	27.67
HPR	–0.60	–6.83	–10.05
Prt GNSS	–1.57	19.96	33.17
Stb GNSS	1.92	19.42	33.16
Stern	0.00	–55.62	0.00

B.3.2 Skandi Vega ROV Offsets



Point	X [m]	Y [m]	Z [m]
CommonReferencePoint	0.00	0.00	0.00
RP	–0.16	–0.18	1.90
TP	0.16	–0.18	1.90

Appendix C

Field Memo

Equinor ASA

ROV Survey for Njord A at Halsnøyfjorden

Project Name	Survey Halsnøyfjorden
Client	Equinor ASA
Issued From	Skandi Vega
Date	15 February 2021
Fugro Project Number	161637-07
Document Number	161637-07-MEM-001 Issue 1
Subject	Survey Halsnøyfjorden

Introduction

The semi-submersible drilling rig Njord A is planned moored at Halsnøyfjorden this spring. Before installing the pre-lay mooring system, the location would be surveyed to identify suitability and to highlight any potential obstructions for the operation. Two subsea cables, a fibre-optic cable on the west side and a telecommunication cable on the east side, was to be surveyed in proximity to the proposed anchor locations.

Summary of Events

The vessel departed Bergen on 14 February at 00:40. The survey was carried out from 07:08 to 22:34 on 14 February 2021. The vessel departed Halsnøyfjorden on 15 February at 01:30.

Results

Reference Documents

Table 1 lists the reference documents used during the project.

Table 1: Reference Documents

Document Number	Title
GM-0691-0941-R199 R02 Signed	Njord Future – Towing, mooring installation and connection of Njord A and B 2018-2021
Dwg-file	0691-0941-NJA-2021-SK-301-Inshore ML-Pre Hook-Up

Results

All eight mooring line corridors were visually surveyed without any boulders, pockmarks, scars, or corals found. The inspection of the seabed indicated soil characteristics to consist of soft clay.

The mooring-line corridors were extended behind each planned anchor location, to allow for line lengths to be extended if needed.

Equinor ASA

A TSS pipe-tracker was installed on the ROV, and a survey along the route of the Telenor telecommunication cable indicated on electronic chart was attempted. Only weak and sporadic signals were detected, and it was not possible to confirm if the signals stemmed from the cable, from noise or from other objects underneath the seabed.

Appendix B in the SOW included a map indicating another possible route for the Telenor telecommunication cable, that was not included in the electronic chart. Based on water-depth, elevations, known features etc. another attempt was made to locate the cable. At one location the pipe-tracker received signals that could align with the Telenor communication cable, but it is not possible to make this conclusion.

The survey of the BKK fibre optical cable on the west side of the planned mooring-spread location, aligned well with the electronic background chart. The signal from the pipe-tracker was clear throughout the surveyed route, and the cable was also exposed for a few metres along the route.

No noticeable debris was detected during the survey.

Figure. shows a print screen form the navigation software showing TSS track and map from SOW.

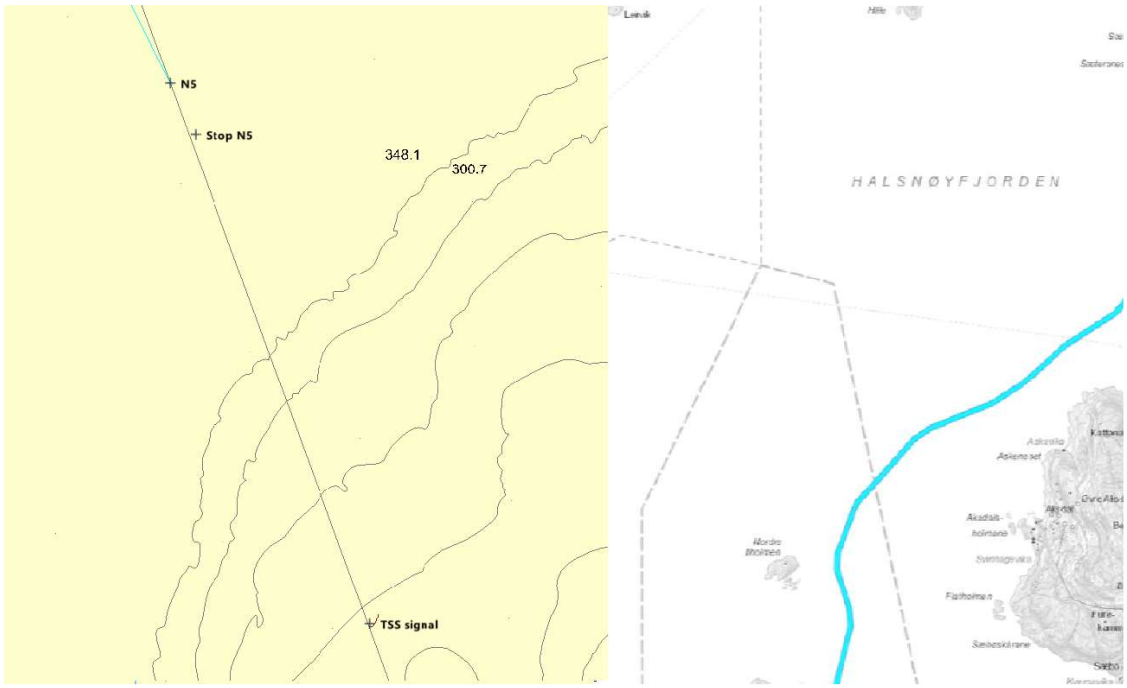


Figure.1: Print screen from navigation software and map from SOW

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Figure. shows a print screen form the navigation software showing ROV/TSS track.

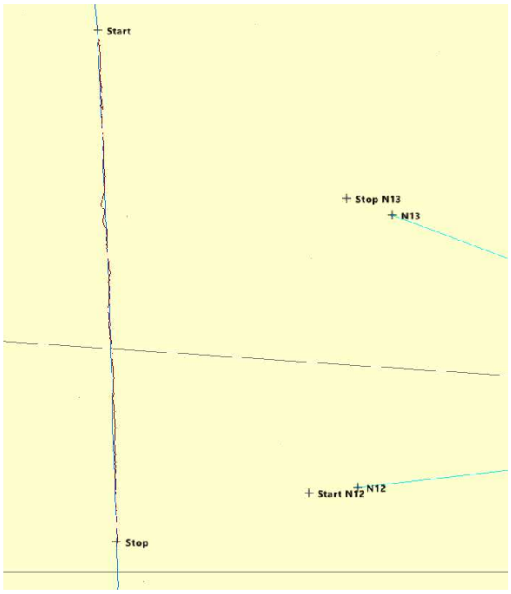

Figure.2: Print screen from navigation software

Signatures

Signed Fugro	Signed Client
Ingvill Hermansen	
I.Hermansen Fugro Norway Field engineer	Trond Olav Groven Equinor Rig Move Operation

Appendix D

System Descriptions

D.1 Positioning and Heading Systems

D.1.1 StarPack

A StarPack unit consists of a survey grade GNSS receiver and powerful processor, running the Linux multi-tasking operating system. The receiver can track all current satellites (GPS, GLONASS) and is Galileo ready. A StarPack can be extended with a second receiver (in the same unit), or two units can be networked together to provide accurate, GNSS derived heading.

Computational features of the StarPack are:

- Input of multiple corrections sources;
- Two independent calculation engines – developed by two different Fugro development centres;
- Multiple position calculations and outputs, including, Starfix.G2, Starfix.XP2 and Starfix.L1;
- A heading solution between two GNSS antennas.

For configuration and computational QC, the StarPack provides a web interface.

D.1.2 GNSS Heading

Fugro's StarPacks use a precise relative positioning (PRP) engine to calculate the real-time heading between two GNSS antennas; the accuracy of the solution is better than 0.1° for baselines longer than three metres. The StarPacks' GNSS Heading Solution outputs the result of the PRP engine. To determine at the rig's true heading, Fugro applies a correction angle to the output heading based on the known offset coordinates of the GNSS antennas.

D.1.3 Starfix.G2

Fugro's Starfix.G2 is a GPS and GLONASS (Russian Global Satellite Navigation System) positioning system that is based on orbit and clock corrections generated from Fugro's own expanded network of dual system reference stations. Starfix G2 uses precise point positioning (PPP) technology, which distinguishes itself from the traditional differential approach as satellite errors are not lumped together but estimated at the source on a per satellite basis. The GPS, GLONASS, Galileo and BeiDou orbit and clock corrections are computed separately, free of ionospheric and tropospheric effects. The system has positional accuracies of better than 10cm and 20cm (2σ) in the horizontal and vertical planes respectively.

D.1.4 Starfix.XP2

Fugro's Starfix.XP2 is a GPS and GLONASS positioning system that is based on orbit and clock corrections obtained from a third party supplier. Starfix.XP2 also utilises Precise Point Positioning (PPP) technology, but apart from that it is 100% independent to Starfix.G2. Further positional enhancements are undertaken in Fugro's software resulting in positional accuracies of better than 10cm and 20cm (2σ) in the horizontal and vertical planes respectively;

D.1.5 Starfix.G2+ Ultra-Precise Corrections and Computations

Fugro's Starfix.G2+ is an ultra-precise GPS and GLONASS Global Positioning Service, using Clock and Orbit Corrections enhanced with carrier-phase corrections. Starfix.G2+ is an enhancement of Fugro's highly regarded Starfix.G2 service and utilises advanced GNSS augmentation algorithms developed in-house by our leading GNSS augmentation experts. Fugro's worldwide network of reference stations monitors the code and carrier-phase signals transmitted by GPS and GLONASS satellites. These observations are processed centrally in real-time using the company's proprietary algorithms to generate precise corrections, which are used to augment the standard signals broadcast by GPS and GLONASS satellites. Customers receive corrections via seven high-powered communications satellites, providing at least two independent Starfix.G2+ data sources. The resulting positional accuracies are better than 3cm and 6cm (2σ) in the horizontal and vertical planes respectively.

D.1.6 EuroDrone

The EuroDrone is Fugro Norway's remote target tracking device. All modules are integrated in a single masthead unit and include an Integrated GPS heading device, L-band receiver, processor and radio modem. The EuroDrone is the main part of a portable system for remote target tracking and it contains satellite RF receiving and signal processing components. Ancillary equipment is plugged into the ethernet connector of a computer.

D.2 Software Systems

D.2.1 StarfixNG

StarfixNG is Fugro's software platform for offshore survey operations. It has been built using the latest development tools and techniques. Flexibility and scalability on top of a robust layer of common positioning, navigation and QC functions allow StarfixNG to be adapted to any type of job. With its 'solution' approach, specific functionality is available as building blocks to be used as needed.

The software:

- Covers a wide range of offshore survey job types. Dedicated solutions for specific tasks can be configured in any combination, which allows seamless transition between activities on the same job;
- Has extensive hardware support. A large database with sensor codecs and vessels are included. Fugro hardware like StarPack and StarPort is automatically detected and can be configured once connected. The diagram style hardware configuration offers an intuitive user interface;
- Integrates with Starfix Real time Suite. The internal message protocol is compatible with Starfix Real time Suite, providing the flexibility to exchange data with existing modules and run them simultaneously;

- Uses industry standards. StarfixNG uses various industry standards like the EPSG Geodesy database and ENC background maps. Also de-facto standards like Autocad .dwg for exchange of CAD data are well supported.

Appendix E

Health and Safety

E.1 Fugro Norway AS Generic Risk Assessment for Positioning and Construction Support Field Work

EUAF-FNAS-QSE-FO-002-Generic Risk Assessment - Positioning and Constructions Support Field Work — Major Change March 2019 as per input from Field Staff Annual Field Staff Induction

Steps	Hazard		Assessment Category	Initial Risk	Control Measures	Residual Risk
Job Steps for task	Hazard Description and Effect	Population at risk	P,E,A,R	Likelihood & Severity	List all Controls Required	Likelihood & Severity
1) Travel	Accidents by transportation/driving	All personnel involved in the task / Any persons in vicinity	People, Assets	C4	Fugro Norway Vehicle Driving Policy, Fugro Golden Rules of Safety no 2 Driving	B4
	Flight; Cardiovascular disease aboard a plane might cause death to the passenger. Tight schedule might cause health issues when travelling long distances	All personnel involved in the task	People	C4	Consider own age, use blood thinning remedies, use socks adequate for long plane rides, be conscious to stretch legs during flight, medical checkup. Try to schedule flights for arrival the day before mobilization . Consider time difference.	B4
	Risk of illness, may cause death	All personnel involved in the task	People	C4	Fugro Gropup Travel Policy and Travel Guidelines on FugroInsite; Vaccines, hygiene, contact info for emergency medical help, preparedness, emergency card	A4
	Food poisoning, rarely serious, but can put someone on the sideline for a while, unable to work	All personnel involved in the task	People	C3	Fugro Gropup Travel Policy and Travel Guidelines on FugroInsiteHygiene, food ingestion advice, remedies for stomach and bowel disease during travel	B3
	Work Site/Hotel: Fire, explosions, terror, natural disasters	All personnel involved in the task	People, Assets	C4	Fugro Group Travel Policy and Travel Guidelines on FugroInsite; Follow on-site HSE procedures, familiarize with emergency exits, attention, Choose the right/sensible hotel, modern with restricted car traffic and extra security, /local contact	B4
2) General Job Execution	Working long hours	All personnel involved in the task / Any persons in vicinity	People	C4	Sensible planning of Shift Rotation night/day. Line Management Follow up - Supervision. Minimum 8 hour rest per 24 hour.	A4
	Working at height.				Follow Working at Height procedure EUAF-MALA-QHSE-PR-018; Develop Task Risk Assessment/Rescue Plan/Suitable PPE, Fall Protection Equipment, Permit to Work.	
	Noise				Avoid exposure to loud noise or noise over an extended period of time. Appropriate PPE to be worn at all times, Ref. EUAF-MALA-QSE-PR-022 Personal Protective Equipment Procedure	
	Working with Chemicals				Fugro Golden Rules of HSSE no 6: Hazardous Substances. Assessment and Substituion Guidance Fugro Academy HSE E-Handing og Chemicals. EUAF-MALA-QSE-PR-006-Hazardous Substances Procedure. Product sheets in near vicinity.	
	Adverse weather: Cold/Hot				Appropriate PPE to be worn at all times, Ref. EUAF-MALA-QSE-PR-022 Personal Protective Equipment Procedure	
3) Transfer of equipment to vessel / required location / Unloading container and moving equipment to control room	Manual Handling	All personnel involved in the task / Any persons in vicinity	People / Assets	C3	Personnel trained in manual handling techniques. HSE-E-203 The Principles of Safe Manual Handling -	B3
	Lift boxes up / down stairs / across deck				Weight of boxes to be assessed before attempting to lift them. Use two-person lift where necessary.	
	Pinch from movement of container doors.				Empty heavy boxes rather than lift them	
	Slips trips and falls				Ensure area is clear to work and SIMOPS are not ongoing. Ask if a PTW is required from the rig operator. Golden Rules of HSSE no 10 Simultaneous Operations (SIMOPS)	
	SIMOPS				Use crane to lift equipment to bridge area if possible, vessel personnel to manage / check lifts before lifting	
					Use forklift / Pallet lifter to move items on deck if possible/get help	
					Appropriate PPE to be worn at all times, Ref. EUAF-MALA-QSE-PR-022 Personal Protective Equipment Procedure	
					Secure swinging doors using chains/straps	
	Resulting in: Injury to people and damage to assets				Ensure Proper Packing	
					One hand to be kept free at all times when going up or down stairs	

4) Installation / Removal of external survey equipment (antennas, cables etc.)	Slips, trips and falls on stairways / walkways. Trip hazards from cables. Dropped objects Working at height. SIMOPS. Poor housekeeping Resulting in: Injury to people and damage to assets	All personnel involved in the task / Any persons in vicinity	People /Reputation/ Assets/	C4	Appropriate PPE to be worn at all times, Ref. EUAF-MALA-QSE-PR-022 Personal Protective Equipment Procedure Good communication between all personnel involved in the task All equipment installed to be made secure, no loose cables. Route cables under walkways if possible. Mandatory Fugro Academy Dropped Objects, wire to secure antenna Liaise with rig to ensure no conflicting helicopter operations Fit helideck antenna to HLO guidelines. Liaise with rig for access to monkey islands, bridge roof etc. When working above 2m; Follow Working at Height procedure EUAF-MALA-QHSE-PR-018; Develop Task Risk Assessment/ Rescue Plan/Suitable PPE, Fall Protection Equipment, Permit to Work. Plan outside work when weather conditions are best. Consider light levels, wind, rain, cold. Plan breaks so hands are not cold. Ensure area is clear to work and SIMOPS are not ongoing. Ask if a PTW is required from the rig operator. Be aware of high power systems in the vicinity and make all staff involved aware Inspect work area and plan cable routes safely and economically paying attention to any emergency equipment / procedures Ensure all cables are safely secured and if required, highlighted to vessel crew Work in a tidy, safe and courteous manner at all times Appropriate PPE to be worn at all times, Ref. EUAF-MALA-QSE-PR-022 Personal Protective Equipment Procedure	A4
5) Installation / removal of internal survey equipment (PCs, Gyros etc.)	Slips, trips and falls especially while crossing through doorways, stairs etc. Trip hazards from untidy work area. Potential for blocking emergency equipment / routes. Loss of accommodation pressure (gas risk) while running cables Injury to people including Cuts, bruises and broken bones. Equipment moves during opera Resulting in: Injury to people and damage to assets	All personnel involved in the task. Any persons in vicinity	People /Reputation/ Assets/	C3	Work area to be kept tidy at all times One hand to be kept free at all times when going up or down stairs Be aware of surrounding personnel and operations. Golden Rules of HSSE no 10 Simultaneous Operations (SIMOPS) Inspect work area and plan layout and routes safely and economically paying attention to any emergency equipment / procedures Check if PTW required to have doorways open to test eurodrones. Check bulkhead fittings for cable runs. Equipment to be secured appropriately for anticipated movement	A3
	Software / Hardware Failure	All Personnel involved in the task	Asset, Reputation	C3	Test, Maintenance and Repair Procedure, Installation Work Instructions and Check Lists	B3
	Dropped equipment. Equipment moves during operation Resulting in: Asset Damage	All personnel involved in the task. Any persons in vicinity	Assets	C3	Fugro Golden Rules of HSSE no 11 Working at Height. Mandatory Fugro Academy Dropped Objects Visual inspection of all equipment to be carried out before powering up, check for cable / socket damage, water.	B3

6) Installation / removal of internal survey equipment (PCs, Gyros etc.)	Electric shock from damaged equipment as it is powered up and used or removed. Resulting in: Injury to people and damage to assets	All Personnel involved in the task	People /Reputation/ Assets/	B4	Report/repair any obvious faults before use Liaise with local electrician where necessary Golden Rules of HSSE no 3: Equipment/System Isolation	A4
7) Installation / removal of electrical equipment.	Electric shock from damaged equipment as it is powered up Incorrect connection to existing power or data cables	All Personnel involved in the task	People, Reputation	B4	Visual inspection of all equipment to be carried out before powering up, check for cable / socket damage, water. Report / repair any obvious faults before use Liaise with OOW / vessel electrician for information on survey data connection points, vessel network patch panels. When working above 2m; Follow Working at Height procedure EUAF-MALA-QHSE-PR-018; Develop Task Risk Assessment/ Rescue Plan/Suitable PPE, Fall Protection Equipment, Permit to Work.	A4
8) Installation / removal of survey equipment onto ROVs	Slips, trips and falls. Trip hazards from untidy work area. Working at height (ladders) Simultaneos operations work with ROV crew Manual handling in confined spaces Electrical tool use (drills,grinders) Resulting in: Injury to people,	All personnel involved in the task. Any persons in vicinity	People	C4	Appropriate PPE to be worn at all times, Ref. EUAF-MALA-QSE-PR-022 Personal Protective Equipment Procedure Work area to be kept tidy at all times Ensure area is clear to work and SIMOPS are not ongoing. Ask if a PTW is required from the operator. Involve multiple personnel during measurements Mounting and securing of equipment onto ROV to be performed by ROV personnel (incl bracket manufacture / modification). Survey to check. Comply with vessel PTW system for work at height / hot work.	A4
9) Antenna offset measurement / other measurements	Slips, trips and falls on stairways / walkways resulting in: Working at height Resulting in: Injury to people	All personnel involved in the task. Any persons in vicinity	People	C4	Appropriate PPE to be worn at all times, Ref. EUAF-MALA-QSE-PR-022 Personal Protective Equipment Procedure Work area to be kept tidy at all times Ensure area is clear to work and SIMOPS are not ongoing. Ask if a PTW is required from the operator. Involve multiple personnel during measurements When working above 2m; Follow Working at Height procedure EUAF-MALA-QHSE-PR-018; Develop Task Risk Assessment/ Rescue Plan/Suitable PPE, Fall Protection Equipment, Permit to Work.	B4
10) Incorrect software configuration : geodesy / offsets / alignment values	Incorrect navigation system display Resulting in: Injury to people Asset Damage Loss of reputation	All Personnel involved in the task	All	B5	Check all offset measurements. Complete geodesy verifications Use approved spreadsheets to complete C-O calculations. Complete heading and position verifications, or have client sign off that they are not required. Mobilisation Check List to be checked and signed by Party Chief, client and emailed to Project Manager for QC.	A5

11) Survey/Calibration Operations	Excessive working Hours Fatigue / lack of concentration causing mistakes and accidents. Resulting in: Injury to personnel Asset damage	All Personnel involved in the task	All	C3	Operation Manager to plan for rest if long travel time to mobilization site Client and Party Chief to manage working hours and concentration levels. Adjust hours where necessary and work as a team. Fugro Golden Rules of HSSE no 4: Fitness for Work. Maintain professional behaviour	A3
12) Use of outside survey equipment including total stations and Sector Scan Sonar	Slips, trips and falls on stairways / walkways. Trip hazards from poorly laid cables. Dropped equipment Electric shock from damaged equipment Resulting in: Injury to people	All personnel involved in the task. Any Persons in vicinity	All	C4	Appropriate PPE to be worn at all times, Ref. EUAF-MALA-QSE-PR-022 Personal Protective Equipment Procedure. Use of life jackets if required Good communication between all personnel involved in the task Liaise with rig to ensure no conflicting operations Be aware of surrounding personnel and operations. Golden Rules of HSSE no 10 Simultaneous Operations (SIMOPS) Keep away from edges and potential falls Run interface cables in a safe manner Take care using total station and observe laser safety techniques Hot work - Laser Trigger Flare detectors & non-ex units: Check work site for hazards before and during survey. Keep good lookout for new / inexperienced personnel and take extra time to brief them about upcoming operations	A4
13) Sea Fastening	Asset Damage and injury to people due to vessel motion	All Personnel involved in the task	Assets/People	C4	Sea-fasten all equipment (spare and in-use) and empty boxes appropriately. Use suitable fastenings. Plan outside work when weather conditions are best. Consider light levels, wind, rain, cold. Plan breaks so hands are not cold. Weather proof outdoor equipment and cables if required.	A4
14) Rig/Vessel Monitoring Package	System fails after personnel depart rig/vessel.		Reputation	B5	Follow guidelines to configure system. Test system before departing	A5