PINNGORTITALERIFFIK · GRØNLANDS NATURINSTITUT

Tusass Connect Marine Route Survey report

Seabed survey feasibility study in Nuuk archipelago

Technical Report no. 126
Greenland Institute of Natural Resources

tusass

PINNGORTITALERIFFIK
GRØNLANDS NATURINSTITUT
GREENLAND INSTITUTE OF NATURAL RESOURCES

Title:	Tusass Connect Marine Route Survey report. Seabed survey feasibility study in Nuuk archipelago.
Authors:	Karl Brix Zinglersen Aqqaluk David Sørensen
Publisher:	Greenland Institute of Natural Resources
Date of publication:	11th April, 2023
Financial support:	Greenland Institute of Natural Resources Tusass A/S
Cover photo:	R/V TARAJOQ near Nuuk in 2022. Karl Brix Zinglersen
ISSN:	1397-3657
ISBN:	978-87-972977-9-7
EAN:	9788797297797
Web:	https://natur.gl/forskning/rapporter/
Citation:	Zinglersen, K.B., Sørensen, A.D., 2023: Tusass Connect Marine Route Survey report. Seabed survey feasibility study in Nuuk archipelago. Technical report no. 126, Greenland Institute of Natural Resources, Greenland. ISBN: 978-87-972977-9-7.

Document: GINR Tusass Nuuk-AC61 Survey report.docx

Cruise leaders:	Karl Zinglersen and Aqqaluk Sørensen
Survey period:	03/12-2022 to 05/12-2022
Project number:	N20001 (N61014)
Project manager:	Helle Siegstad
Contact information:	Pinngortitaleriffik, Greenland Institute of Natural Resources Kivioq 2, P.O. 570, GL-3900 Nuuk, Greenland Web: https://natur.gl/ email: info@natur.gl tel: +299 361200

Document Revision List

Rev.	**Date**	**File Name**	**Description**
Draft 0	2022-12-19	Tusass Connect Nuuk Skærgård and Ring Survey report - preliminary v0.docx	Preliminary report
Draft 1	2023-01-09	Tusass Connect Nuuk Skærgård and Ring Survey report - preliminary v1.docx	Preliminary report, revised after first commenting

Table of contents

List of tables

List of figures

List of appendices

1. Vessel specification
2. Survey equipment and general arrangement of sensors
3. List of key personnel
4. Daily reports
5. Summary of equipment breakdown or repairs
6. Bibliography
7. Pipeline Crossing Report

Table 1: List of acronyms

Term	Description
DGPS	Differential Global Positioning System
DGNSS	Differential Global Navigation Satellite System
GAMS	GPS Azimuth Measurement Subsystem
GINR	Greenland Institute of Natural Resources
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
IMU	Inertial Measurement Unit
LAT	Lowest Astronomical Tide
MBES	Multi Beam Echo Sounder
MLW	Mean Low Water
MRS	Marine Route Survey
NTRIP	Network Transport of RTCM via Internet Protocol
R/V	Research Vessel
PDS2000	Teledyne RESON Navigation Software
RPL	Route Position List
RTCM	Radio Technical Commission for Maritime Services
RTX	Real Time Kinematic global modelling technology (Trimble)
RTK	Real Time Kinematic
SVS	Sound Velocity Sensor
SVP	Sound Velocity Profile
UTM	Universal Transverse Mercator
WGS84	World Geodetic System 1984

Table 2: Unit abbreviations

Term	Description
d	Degree(s)
cm	Centimeter(s)
Nm	Nautical mile(s)
hr	Hour(s)
kHz	Kilohertz
km	Kilometer(s)
km2	Square Kilometer(s)
kts	Knots
m	Meter(s)
m/pixel	Meter(s) per pixel
m/s	Meter(s) per second
mL	Milliliter(s)
mm	Millimeter(s)

Summary

This report covers a survey of the seabed to find a suitable route for installing submarine cables from the Atlantic to Nuuk.

The survey on board R/V Tarajoq was conducted over 48 hours starting and ending in Nuuk. Due to bad weather along the west coast of Greenland, it was not possible to cover the remaining areas. During the study, the coverage and data quality obtained were verified as suitable for the purpose.

Naalisarneqarnera

Immap naqqanik misissuisoqarsimanera uani nalunaarusiarineqarsimavoq, Atlantikup imartaaniit Nuummut kabelilersuisoqassappat aqqutigisinnaasaanik piukkunnartorsiornissaq angalanerup siunertarisimavaa.

R/V Tarajoq-mik angalaneq akunnerit 48it sipporlugit sivisussuseqarsimavoq, Nuuk avalaffigeriarlugu utimut tulaffigeqqinneqarsimavoq. Kalaallit Nunaata kitaani silarlunnera pissutaalluni sumiiffiit sinnerisa misissuiffigineqarnissaat pisinnaasimanngilaq. Angalanermi misissukkat nalunaarsuutillu pitsaassusaat aallaavigalugit umiarsuaq suliassamut piukkunnaateqarluartoq uppernarsarneqarpoq.

Sammenfatning

Denne rapport dækker en undersøgelse af havbunden for at finde en egnet rute til installation af undersøiske kabler fra Atlanterhavet til Nuuk.

Undersøgelsen ombord på R/V Tarajoq blev gennemført over 48 timer med start og slut i Nuuk. På grund af dårligt vejr langs Grønlands vestkyst var det ikke muligt at dække de resterende områder. Under undersøgelsen blev den opnåede dækning og datakvalitet verificeret som egnet til formålet.

1. Introduction

1.1. Background

The national Greenland telecommunication company Tusass A/S is planning on expanding their network of subsea telecommunication cables. Greenland Institute of Natural Resources (GINR) has been requested to assist with a marine survey of for the passage between the capital Nuuk and existing stations in the Atlantic Ocean (Skærgårdsruten) as well as a short section between Nuuk Harbor to the town's suburb Qinngorput.

1.2. Objectives

The main objective of the survey is to establish a bathymetric data set and relevant sea bottom coverage for the future installation of the planned telecommunication cable route from the Qinngorput headland at Start HDD to the point AC 61. To support the main objective, several subsidiary objectives are needed including calibration, correctional data, processing, interpretation, map production, and reporting. The results of the process, data retrieved and processed, analysis and reporting are also to be evaluated.

1.3. Specific objectives

1. Mobilization of R/V TARAJOQ and calibration at sea of instruments.
2. Survey with multi beam instrument from Nuuk landing near Qinngorput (Start HDD) to point AC 61 off Kangerluarsoruseq and return to a coverage fit for purpose within limits of planned survey time.
3. Sound velocity profiling at sea for corrections during processing
4. Recording of POSPac DGNSS measurements at sea for corrections during processing
5. Interim survey report
6. Processing of data to a relevant degree
7. Interpretation of survey results and preparation of report fit for cable installation.
8. Evaluation of project process.

1.4. Survey route and area summary

The initial survey plan was based on the proposed route plan layout provided by Tusass established by desktop studies and delivered as a list of coordinates.

The survey followed the proposed route plan layout's centerline in a southernly progression except for positions placed on shallow grounds or on land.

After conducting the first line along the centerline, further broadening of the coverage of the corridor to the sides of c. 1000 m width were established where possible considering hazards to navigation (shallow areas, rocks, land, and severe weather).

The survey route plan was traversed from north to south multiple times to a satisfactory coverage. The route parts were not surveyed in smaller sections or blocks within 24-hours periods like the GNC 2014 survey but in almost full length due to the operation of the relatively large survey vessel (61 m) in the narrow archipelago waters and to minimize sharp turns possibly degrading signal quality and decelerating sailing speed.

Start and end point of survey was both Nuuk harbor.

Figure 1: Geological map 1:500.000 from GEUS. Yellow: Orthogneiss, mainly granodioritic to tonalitic; Light brown: Tonalitic to granodioritic gneiss, locally agmatitic; Dark Brown: Mica schist; Pink: Qôrqut granite complex; Green: Amphibolite; Black lines: Faults

General description and overview of the area

The Baseline, the 3 NM line, and 12 NM of the sea territory of Greenland, the Danish Realm, runs along the coast and cross the proposed route plan. The southern end of the conducted survey approaches the Baseline tightly.

The survey area covered is the coastal region between Nuuk and Kangerluarsoruseq and a route southwest off the fjord Kangerluarsoruseq through the archipelago, which includes several small and larger islands, and charted and uncharted areas with numerous rocks hazardous to navigation.

Geologically, the region is built of primarily Archaean hard bedrock, predominantly metamorphic rock types of Early Archaean gneiss but also mica schist and amphibolite and parties of granite. A larger NE-SW going fault, the Ivinnguit fault, crosses the northern part of the route.

Finer grain materials are washed from the fjords Nuup Kangerlua (Godthåbsfjord), Ameralik, Kangerluarsunnguaq (Buksefjorden) and Kangerluarsoruseq, and expected to be deposited together with biological material in smaller and larger basins along the survey route.

In the Narsakkortariaa (Narsaq Løb), on a relatively flat area, numerous sand waves running in the direction from NE-SW were observed in depths of c. 150 m. No sand banks were observed.

Offshore, the planned route runs between the banks of Fyllas Banke and Danas Banke, mainly consisting of gravel, sand, and other sediments.

The route corridor covers depth gradients between c. 10 and 300 m below keel.

Navigational charts in Greenland are generally sparse. However, a modern chart exists for the area: *The West Coast of Greenland, Kangerluarsoruseq – Nuuk, Chart no. 1310*.

Not all soundings in the chart are of modern origin, and mariners should take care in particularly the planned and proposed route.

The navigational chart states a caution: *Sounding tracks in the inshore routes is of reconnaissance nature only. Mariners are therefore urged to exercise due caution*.

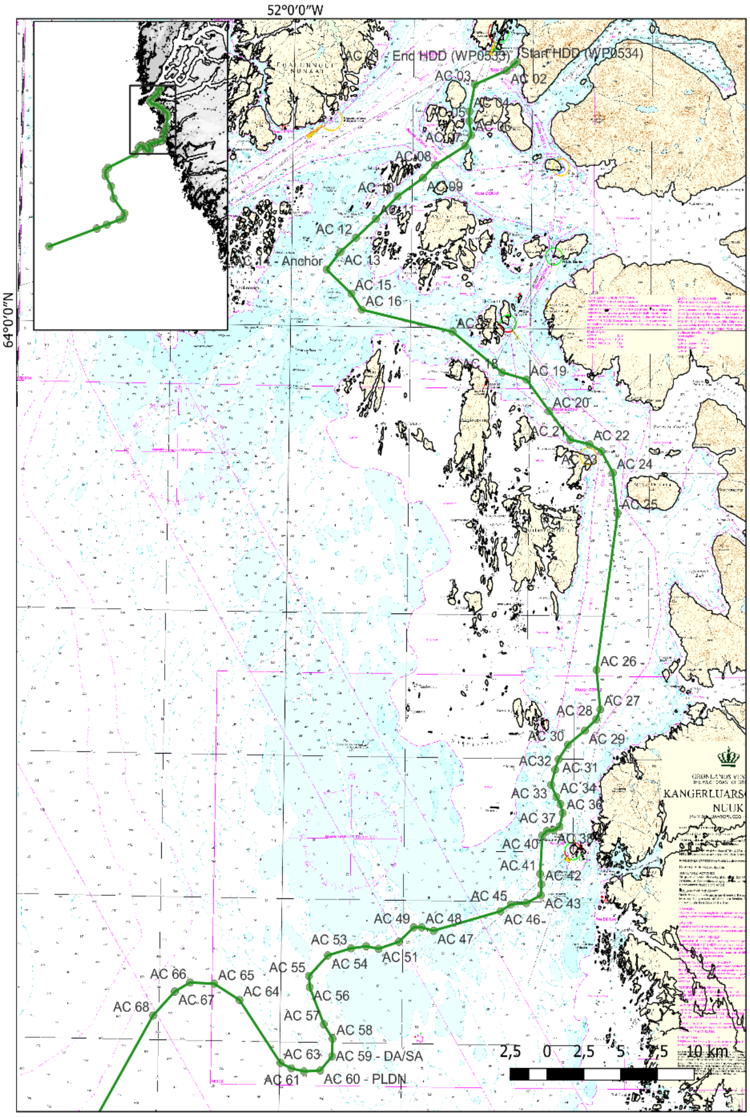


Figure 2: Planned survey area on navigational chart with marked shipping lanes and territorial borders. Map source: Danish Geodata Agency Chart 1310

1.5. Restricted areas

The route navigates near restricted areas for the protection of certain seabirds. During the annual period 15th of April to 15th of September is any sailing above 3 knots not allowed in the restricted areas. The protection zone varies from 200 m for eider category birds to 1000 m for murre category birds.

The island Akilia is a protected geological site including signs of the earliest formation on Earth. The waters surrounding are not protected, and consequently not an obstruction to survey or cable installation.

The surveyed corridor or the vessel's track did not at any time cross a protection zone and was conducted outside the designated period.

It is advised to consult the relevant authority, Mineral Resources Authority of the Government of Greenland (govmin.gl) for evaluation.

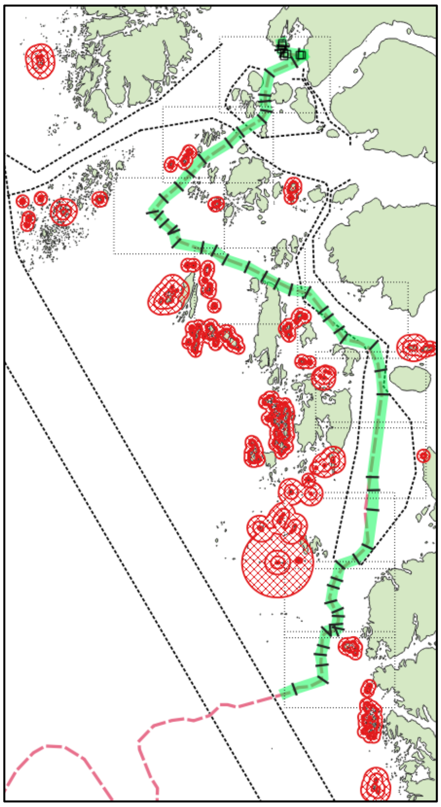


Figure 3: Map of protection zones around bird colonies or areas (red) w. Route lines (red and green lines).

2. Operational summary

2.1. Mobilization and testing summary

The mobilization and patch test procedures identified major problems with the initial offset values of the equipment relative to vessel reference coordinate system established by the instrument provider. New offset calculations were required, using the dimensional survey report from Anko Maritime AS, and configure settings in Applanix MV POSView and Teledyne PDS before a new patch test could be conducted. The renewed patch test and analysis was successful, and operations could begin Saturday the 3rd of December 2022 at c. 12:00 local time. It was initially planned to start cruise Friday the 2nd of December at 12:00 local time, so the cruise was 24 hours delayed. Therefore, it was only possible to have one Tusass representative (external advisor from Baltic Offshore, Sweden) onboard due to time limitations.

2.2. Survey instruments and software

During operations, the following types of data was recorded:

1) Positions in three dimensions from GNSS antennas, aided by online corrections to c. 0.04 m accuracy, in UTM Zone 22 WGS84 and additional Inertial Motion data from Applanix OceanMaster IMU
    a. Recorded in multi beam acquisition system PDS2000 as .pds and .s7k files
    b. Recorded in MV POSView system as .00 files
2) Multi beam sonar recordings of sea floor morphology with Seabat 7160 Tx and Rx instruments.
    a. Recorded in multi beam acquisition system PDS2000 as .pds and .s7k files.
3) Sub-bottom profiling of sea bottom upper geology characteristics.
    a. Recording with Innomar SES-2000 Medium-100 SBP instrument
    b. Recorded in SESWIN software to .ses3 file format.
4) Sound velocity profiling of water properties
    a. Recorded with online SVS situated near the multi beam sonar
    b. Recorded on selected positions with over-the-side SVS from HY Hangar winch.
    c. Received digitally with Valeport DataLog X2 in .txt format

2.3. Survey summary

The first stretch was 75 % coverage of the Nuuk Ring route, the final 25% planned to be by the end of the survey. Subsequently started the northern part of Nuuk Skærgård route from Qingorput crossing Malenebugten through the archipelago south and west of Nuuk towards the end of line offshore near Færingehavn. Due to severe storms during the entire cruise, it was not possible at any time to cover the last part of the planned survey route offshore from AC46 and further west, and by agreement with the Tusass representative a fuller coverage in the archipelago was achieved.

The bend of the route at AC13 was difficult to measure due to limited space, numerous rocks, and shallow grounds, and similarly difficult to find a fully optimal route.

The cruise was planned for 48 hours by agreement between GINR and Tusass. Due to the weather situation and time restrictions, the route between AC 46 and AC 61 was not surveyed.

During survey operations, no downtime from weather or failures happened. By the end of the cruise, Monday the 5th of December at 12:00, a six-hour delay was introduced by lack of harbor slots.

During the survey, all online and to the ship attached instruments worked without failures.

The multibeam acquisition software PDS2000 failed to record information from the Applanix POSMV positioning and motion sensing server during c. 1 hour of operation. The problem was identified, and measures were taken to re-traverse the stretch. Backup recording of positions and motions in Applanix POSPac applied in office was also able to reestablish the positioning of multibeam data.

During operation of the over-the-side Sound Velocity Sensor for profiling, the instrument failed recording three times. Measures have been taken during post-processing to level recordings from other sound velocity profiles.

The severe weather with strong wind, waves and swells highly affected the 3D positioning of multi beam recordings.

The result hereof is a degradation of quality in the multi beam bathymetry and backscatter models. In particular, it is distinguishable in the backscatter mosaic with artifacts perpendicular to the along-track direction, particularly in the open waters near the coast. It is suspected that the artifacts are introduced during strong pitch motions when the vessel's bow is above the water line, and air bubbles are in the water.

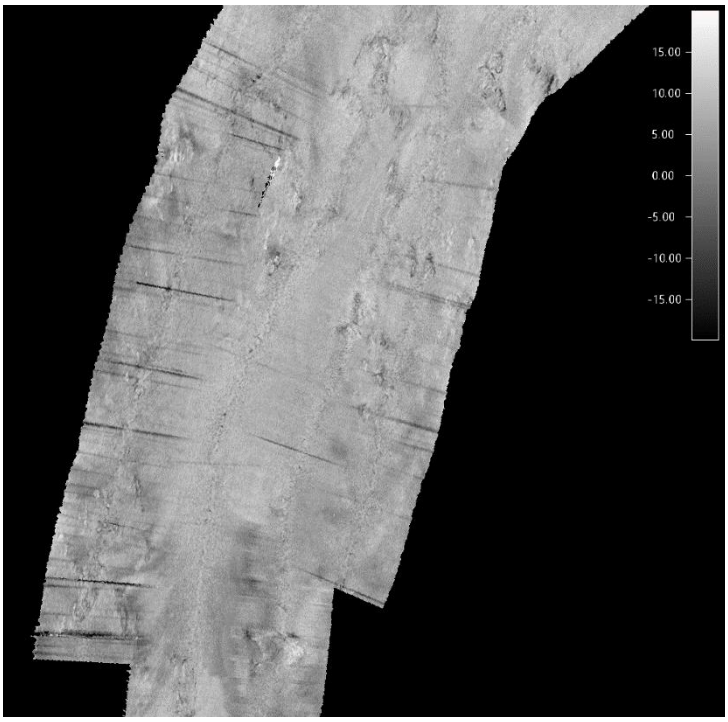


Figure 4: Snapshot of backscatter results from the southern part of the survey affected by swells and waves. Black lines perpendicular to the sailed route can be distinguished and will minimize the analytical possibilities

Mitigation strategies to avoid lowering quality and including perpendicular artifacts should be further investigated.

2.4. General cruise log

For detailed log, see appendix

Day	Date	Comment
1	2022-11-30	Mobilization. Patch test off Nuuk. Identification of issues.
2	2022-12-01	Mobilization. New test off Nuuk. Further controls and tests in office.
3	2022-12-02	Cruise preparation. Identification of solution, recalculation of reference frame and offsets, insertion in onboard system software packages.
4	2022-12-03	Morning: Renewed patch test and GAMS calibration off Nuuk. Insertion of patch test offset results. Acknowledgement of quality by Tusass representative. 14:00 local. Start of survey of Nuuk Ring, finishing at 16:00 local time. 16:00 local time. Start of survey of Nuuk Skærgård starting near Qinngorput. Hereafter, measurements in Malenebugten. SVP recording in Malenebugten. 17:00 local time. Continuing through the sound between islands following the planned survey centerline towards the ocean. SVP recording. Issue with positioning and swath mapping in PDS. Decision to re-cover the missing stretch. (note: in office it was regarded that registered POSPac GNSS/IMU recordings could reestablish the positioning of the files)
5	2022-12-04	03:00. End of survey line near AC 45 near Meqquisoq (Skinderhvalen) due to severe weather (gale) and c. 5-6 m waves/swells resulting in air bubbles under sonar disturbing the signal. Returning towards Nuuk. 07:30. End at AC13 and return south again. 10:00. Meeting with Tusass representative from Baltic Offshore. Identifying possible alternative routes to map and coverage to be extended. 11:45. End south near AC32, returning north. Rest of the day: expanding the coverage along track. 22:00. End in south due to large waves. Returning north.
6	2022-12-05	Expanding coverage along track. Trying alternative routes at difficult areas near AC13. Going through narrow channel near Nuuk. Last lines of Nuuk Skærgård towards Qinngorput. Last line of Nuuk Ring on north side. Yaw/heading calibration on strong slope south of Nuuk. End of survey. Long waiting for Sikuki harbor service for at place in the harbor without luck. 17:00 boat transport from Tarajoq to harbor.

Table 3: Cruise log

2.5. Navigation report

According to the ship's logbook R/V Tarajoq was berthed at Feeder Quay and sailed from Nuuk on the 3rd of December 2022 at 10:30 (UTC +3) on a voyage for multi beam survey. Every hour a GPS position was recorded in the logbook.

At 10:00 AM every day the captain reported the current position and plans to the Aasiaat Radio authorities. A snow shower was recorded Saturday 3rd of December 2022 at 21:00 (UTC +3).

Sunday early morning, the logbook notices wind 6-7 m/s from SE, cloudy, +1˚C and 1026 hPA. Position and plans communicated to Aasiaat Radio at 10:00. Monday of similar properties, however 4˚C and wind from SSE, at 13:00 local time finished survey awaiting moorage. At 16:30 there was a Man Over Board boat exercise. At 17:00 waiting at Nuuk Roadsted unloading 6 PAX, 17:10 return to Nuuk Roadsted, at 17:30 anchoring N of Rypeø, still awaiting moorage.

2.6. Fishery activities and other offshore activities observed

During operation, a small orange buoy, possibly with a subsea net attached, was observed, and avoided. Smaller fishing vessels were observed at different times, however not in operation, probably due to weather circumstances.

It is recommended to perform an analysis of recorded fishery activities from sources of AIS and the Greenland Fisheries License Control. GINR can be of assistance in such analysis.

No offshore activities, e.g., dredging, dumping, drilling, construction, or charting, were observed during navigation.

It is recommended to consult the Danish Maritime Authority, the local harbor and eventually the Ministry of Minerals before cable installation activities to establish an overview of possible activities during operation.

2.7. Shipping activities observed

The Nuuk Ring and northern part of Nuuk Skærgård is situated in and in proximity to the busiest harbor of Greenland with intense traffic of dinghies, trawlers, smaller fishing vessels and large container ships. Their operations were monitored visually and on AIS screen during navigation, however not recorded.

A large part of the route is in a narrow strait with only a little traffic from dinghies and smaller fishing vessels. The northern and southern parts of the route are in the shipping lane towards Nuuk and consequently with normally more vessel traffic, however only little during survey due to the severity of weather. Offshore a large container vessel was observed having difficulties in heading further south due to severe headwind.

It is recommended to perform an analysis of the general traffic pattern by using satellite AIS data. GINR can assist in such analysis, however not within the scope of the current report. An interim overview from November 2022 can be seen below. It reveals that the shipping lanes in general are used and correspond with the southern route of the cable. The map also reveals a more direct southern going route between the islands West of the outlaid lane, likely used for smaller vessels.

The planned and proposed survey route is used for maritime traffic.

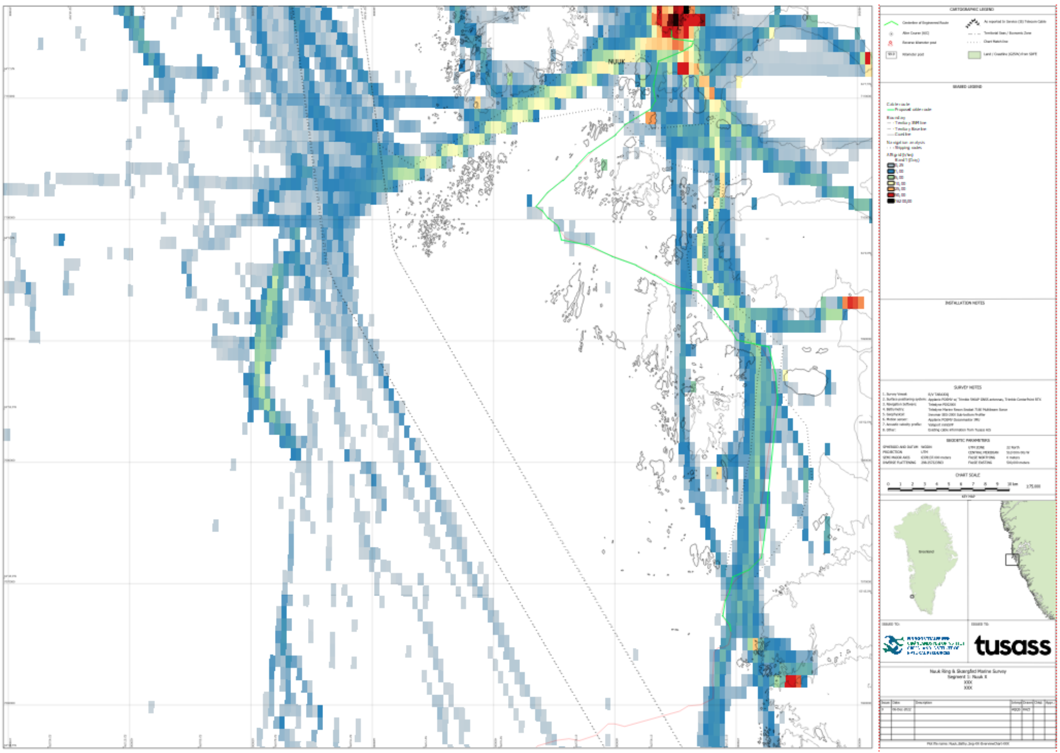


Figure 5: Vessel traffic from AIS recordings in November 2022. Green to black cells: Monthly hours pr km² ship traffic activity, not equally distributed. Source: Global Maritime Traffic Density Service (GMTDS)

3. Survey technical information

3.1. Calibrations and verifications

In Spring 2022, when the new vessel was received from production shipyard in Spain and before commencing fishery surveys in West and East Greenland, a new dimensional control survey was conducted at Søviksnes Yard in Norway and a patch test and GAMS maneuver near Nuuk upon arrival. The instrument provider of GINR, Teledyne Marine RESON, established the coordinate reference system of the vessel and instruments from information in the dimensional control survey report, and calculated the offset values from the patch test and GAMS maneuvers to their satisfaction.

After end of fishery cruise season, the vessel arrived at Nuuk few days before the cable survey for Tusass. The survey team of GINR conducted a patch test on the 30th of November but identified a horizontal offset of c. 80 meters in the sailing direction over a steep slope, which was assessed as a severe issue before commencing further survey. In the office, the instrument provider was contacted for identification of the source of the issue, and the GINR survey team independently sought and tested different possible sources of failures.

A lack of clock synchronization between instruments was suggested, and a new test over the same steep slope was conducted with slightly better but not exact results. Consequently, further testing scenarios and calculations were done in the office.

The instrument provider did not provide other relevant options for finding the source of the offset, so the GINR survey team contacted the US partners of CCOM, University of New Hampshire. Together, they recalculated and moved the reference coordinate system of vessel and instruments, and inserted the new values in the instrument software, Applanix PosView positioning software and Teledyne PDS acquisition software. The new reference point (0,0,0) for the coordinate system is the top mark of the Applanix OceanMaster IMU. Because of the changes the previously acquired data fell into place with only limited offsets to be calibrated in a new patch test and GAMS calibration.

3.2. Verification at harbor

The vessel is newly built, so full mobilization had not been completed well before the vessel's arrival to Nuuk. The screen system on bridge was re-configured to display content from multi beam computer, computers were moved to server room and network reconfigured, backup procedures established, updates of software and operating system conducted, and connection to SVP probe altered.

Before calibration at sea, it was verified that the acquisition computer and PDS software could receive GNSS positioning and inertial motion sensing data via Applanix POSMV and Seabat 7160 sonar, and Applanix PosView could receive online GNSS network RTK positioning from Trimble CenterPoint™ RTX real time kinematic satellite service (RTX) over the NTRIP protocol.

Innomar Sub-Bottom Profiler was configured to the project and working. Valeport Datalog X2 for sound velocity probing was working and could connect to probe. Online sensing of sound velocity for hull-mounted probe RESON SVP70 AML was working.

The license for conducting hydrographic survey received from the Danish authority, Danish Geodata Agency, was provided to the captain in case of being required from the Arctic Command coast guard authority when at sea.

3.3. Calibrations at sea

The calibration of instruments was completed at sea:

- Check of systems at sea.
- Patch test to resolve static biases of roll, heading, time delay, pitch and sound velocity.
- GAMS calibration of GNSS positioning
- Final patch test at end of cruise

Checklist:

Item	**Description**
Multibeam software and instruments	In Sonar computer Check of Seabat 7160 MBES in SonarUI of system health and general measurements. Startup of Seabat 7160 CW pulse mode, 44 kHz, full power, 200 µs pulse length, 0 gain, 20 dB spreading, 20 dB absorption, 1.5˚ beam width. Clock synchronization in 7K IO Module, normalization check, Check of sonar image wedge display, Trigger output activation between Seabat sonar and Innomar SBP
PosView software and instruments	In Multibeam acquisition PC. Check of Lever Arms & Mounting Angles configuration. Check in POSView of POSMV online data receiving: POS Mode = Nav Full, IMU Status = OK, Nav Status = Pri. Trimble RTX, GAMS = Online, Ethernet log = Logging, Attitude = green, Heading = green, Position = green, Velocity = green, Heave = green, Position Accuracy (m) = c. 0.04. Check of POSPac ethernet log running. Check of GAMS calibration running.
Other sonars	In K-Sync administration computer Disabling of disturbing echo sounder signals from other instruments
Acquisition software	On multibeam acquisition PC. Check of PDS2000 software startup Project setup: UTM Zone 22 WGS 84 map projection, active grid 5 m resolution, coastline G100V DXF. Check of vessel configuration and offsets. Offsets only on MBES sonar required. Check of settings for logging and backup (PDS, Snippets, active grid, s7k) Check of Acquisition program in PDS2000. Start up, running line, check of Messages. Check of resulting files in folders on computer and NAS backup server

Patch test	Patch test at sea solving: A) Time delay and pitch bias combined a. Repeated line x4, same direction and inverse direction, 6 knots and 12 knots b. Perpendicular to a slope and a seabed feature B) Roll bias a. Repeated line x2, inverse direction, any speed b. Optionally across-track profile c. Flat, smooth seafloor C) Heading bias a. Offset lines, same direction, same speed, 6 knots b. Crossing the same seabed feature in both swaths
GAMS calibration	Calibration at sea of GNSS antenna positioning, and consequently online during cruise. Check GAMS Solution in software. Number of satellites in view >5. Maneuvering of vessel through moderately aggressive turns: figures of 8 and changes of speed. Check GAMS status to be Online. Save configuration

All checks and calibrations were fulfilled before the start of cruise.

3.4. Project geodesy and vertical reference

Data were recorded and processed in WGS84 UTM Zone 22 N (EPSG:32622).

Definition of WGS84 UTM Zone 22 N in OGC WKT:

```
PROJCS["WGS 84 / UTM zone 22N",
    GEOGCS["WGS 84",
        DATUM["WGS_1984",
            SPHEROID["WGS 84",6378137,298.257223563,
                AUTHORITY["EPSG","7030"]],
            AUTHORITY["EPSG","6326"]],
        PRIMEM["Greenwich",0,
            AUTHORITY["EPSG","8901"]],
        UNIT["degree",0.0174532925199433,
            AUTHORITY["EPSG","9122"]],
        AUTHORITY["EPSG","4326"]],
    PROJECTION["Transverse_Mercator"],
    PARAMETER["latitude_of_origin",0],
    PARAMETER["central_meridian",-51],
    PARAMETER["scale_factor",0.9996],
    PARAMETER["false_easting",500000],
    PARAMETER["false_northing",0],
    UNIT["metre",1,
        AUTHORITY["EPSG","9001"]],
    AXIS["Easting",EAST],
    AXIS["Northing",NORTH],
    AUTHORITY["EPSG","32622"]]
```

Spheroid	WGS84
Datum	WGS84
Semi major axis (a)	6,378,137.000 m
Semi minor axis (b)	6,356,752.314 m
Inverse flattening (1/f)	298.257223563
Projection	UTM
Zone(s)	22 N
Longitude of origin	129° W
Latitude of origin	0° N
False Northing	0
False Easting	500,000 m
Scale factor on CM	0.9996
Unit of measurement	Meters

In *Tusass Survey Requirements* it is required that *Swath bathymetry with all soundings and subsequent contours reduced to lowest astronomical tide (LAT) by prediction*.

For the current survey, measurements in three dimensions were received from the GNSS antennas, the multi beam sonar, and the inertial motion unit with GNSS positional corrections XYZ from the Trimble CenterPoint RTX online survey with a positional quality below 0.05 m.

The height information recorded through the current survey is relative to the Ellipsoid Heights, and depths have been reduced to Ellipsoid Elevations utilizing automatic recordings of local tidal changes in the Z direction from the GNSS instrument onboard.

Elevations have been further converted to Mean Sea Level Orthometric Heights for Greenland regionally, using calculations to the Greenland geoid GGEOID2016 produced by the Agency for

Data Supply and Infrastructure. By doing so the depths are referenced to Greenland Vertical Reference 2016, GVR2016. The geoid grid implements the transformation between GRS80 ellipsoid heights and heights in the GVR2016 system with coordinates referenced to GR96.

The horizontal grid is referenced to GR96 defined by the Agency for Data Supply (SDFI) and Infrastructure and the Nordic Geodetic Commission (NKG).

Download and more information on the GGEOID2016 geoid for Greenland can be found at the website of SDFI and NKG, and the GitHub page of NKG. (https://github.com/NordicGeodesy/NordicTransformations).

The measured swath bathymetry soundings and derived contours are not reduced further from the Greenland geoid to Lowest Astronomical Tide, LAT, or Chart Datum, during survey or in the subsequent processes.

Real-time water level data for the tide station of Nuuk (station 820) is not available from Danish Meteorological Institute, DTU Space, or the University of Hawaii Sea Level Center website with the station published by DTU Space (https://uhslc.soest.hawaii.edu/stations/?stn=820).

A national LAT model is under development by DTU Space for the SDFI, however not finalized yet by end of 2022 (pers. comm., SDFI employee).

For future expansion of bathymetric measurements to other regions and towns, and the subsequent cable installations and directional drillings from land to seabed, it is advised to consider local variances in the datums for Greenland, particularly between the Technical Base Maps of towns and villages and the used MSL, the current national geoid GGEOID2016, and the local LATs, as well as the documentation and data behind these datums.

It is advised to consult the national authorities and their scientific advisors on this subject: The Danish Agency for Data Supply (SDFI) and Infrastructure and the Danish Geodata Agency (GST), and their scientific advisors at Danish Meteorological Institute (DMI) and Denmarks Technical University, Department of Space Research and Technology (DTU Space).

4. Survey results

The survey involved remote sensing measurements with 44 kHz multi beam sonar and c. 100 kHz sub-bottom profiler, with no additional ground truthing observations such as grab, coring or imagery. Geological and morphological analyses are thus based on results from these acoustical methods. General depths quickly find depths of 100 m or deeper and consequently smaller details such as boulders are difficult to distinguish from the frequencies and beam properties utilized. Recordings from sub-bottom profiler have not been processed, because no burial of cable is planned. The data can be processed and interpreted upon request.

4.1. General description of segment

The surveyed segment is situated in the archipelago West Greenland, W of Nuuk. The sea bottom can be divided into coherent regions based on bathymetry, morphology, and geology.

The northernmost part near Nuuk is in a bay area with a homogenous subsea plain of possibly sediments (Chart 001, Nuuk Ring KP0-2, Nuuk Skærgård KP 0-4), then the route travers a narrow and shallow strait between the islands of Taartunnguaq and Ikaarissat made of Archaic bedrock (gneiss) before it runs through a subsea valley in the Ivinnguit fault, again with a relatively plain surface besides a depression (Chart 002-003). Later the route enters an area of undulating Archaic, which provides a challenging environment for navigation and cable installation to avoid numerous rocks, an open part of the route and finding the best route for installation (Chart 003).

Going SE, the route follows a deep valley, at deepest c. 280m, with good possibilities for cable installation – although a bend is needed at KP28 (Chart 003-004). The bottom seems soft with sediments, while the sides are of hard bedrock.

The deeper valley ends at KP 30, and it is again a challenging narrow subsea channel between the subsea bedrocks supporting the islands Qernertulissuaq, Angisorsuaq, and Qassisallit, and the smaller

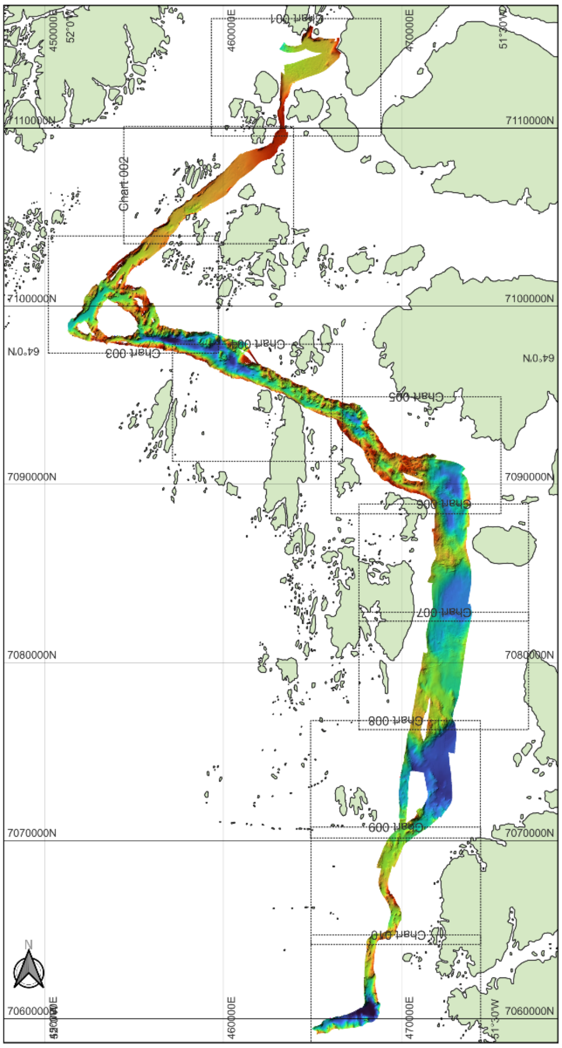


Figure 6: Bathymetric overview of the surveyed route.

island SE hereof. Near KP 35 the route is entering the navigational route to Nuuk (Chart 005). The subsea channel between bedrock outcrops continues until KP 43.

After a c. 90-degree bend to the S, the survey corridor broadens to cover the deep strait of Narsakkoortariaa (Narsaq Løb), which seabed include deep sediment basins and ripples of gravel waveform sediment deposits possibly produced by currents on the seafloor. The deep basin is 4 km x 1.5 km and ends at a subsea ridge with the similar ripples of 2-10 m height (Chart 006), and S hereof another basin of c. 7 km length, and then a bedrock ridge with a steep slope at KP 56-57 to the deepest basin of the survey (5 km length, c. 270 m depth, Chart 007-008).

Subsequently, the route enters the narrow and more shallow passage near Meqquitsoq (Skinderhvalen) and Saattut surrounded by small islands and numerous rocks that dries up during low tide. The route is difficult to navigate and with only a little space for cable installation. The survey ended near the territorial base line at KP 78.

4.2. Nuuk Ring from Start HDD to End HDD

Chart: Nuuk Bathy Segment 1 Chart 1

The near-coast waters shallower than c. 0-30 m meters have not been measured but require an inshore survey with a different logistical and sonar setup.

Nuuk Ring is a short segment running from a peninsula down a gradient slope at the mouth of the industrial harbor into the bay in front of Nuuk harbor around protruding rock outcrops to the north near the islands to the southernmost tip of the Qinngorput area up a steep slope.

Morphologically, the geology along the coast is of undulant bedrock (gneiss or similar) and the relatively flat sea floor near KP 01 and KP 02 seems to be of sediment, probably gravel with depths of c. 110-130 m.

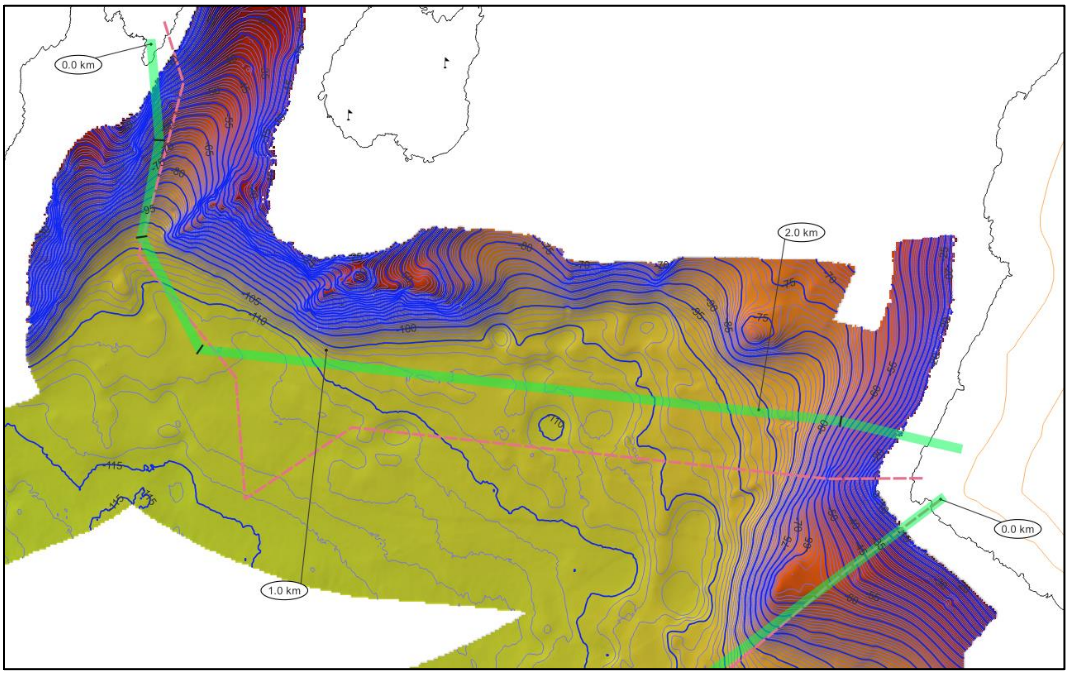


Figure 7: The Nuuk Ring route from Nuuk harbor to Qinngorput running through the harbor channel, along the deeper bay area around protruding rocks and to the steep slope.

4.3. Nuuk Skærgård from Start HDD to KP 06

Chart: Nuuk Bathy Segment 1 Chart 01

The route starts down a steep but even slope. The route of the proposed route differs slightly from the planned. From information by Tusass, it is assumed that the route will be drilled from KP 00 to depth contour c. 100-120.

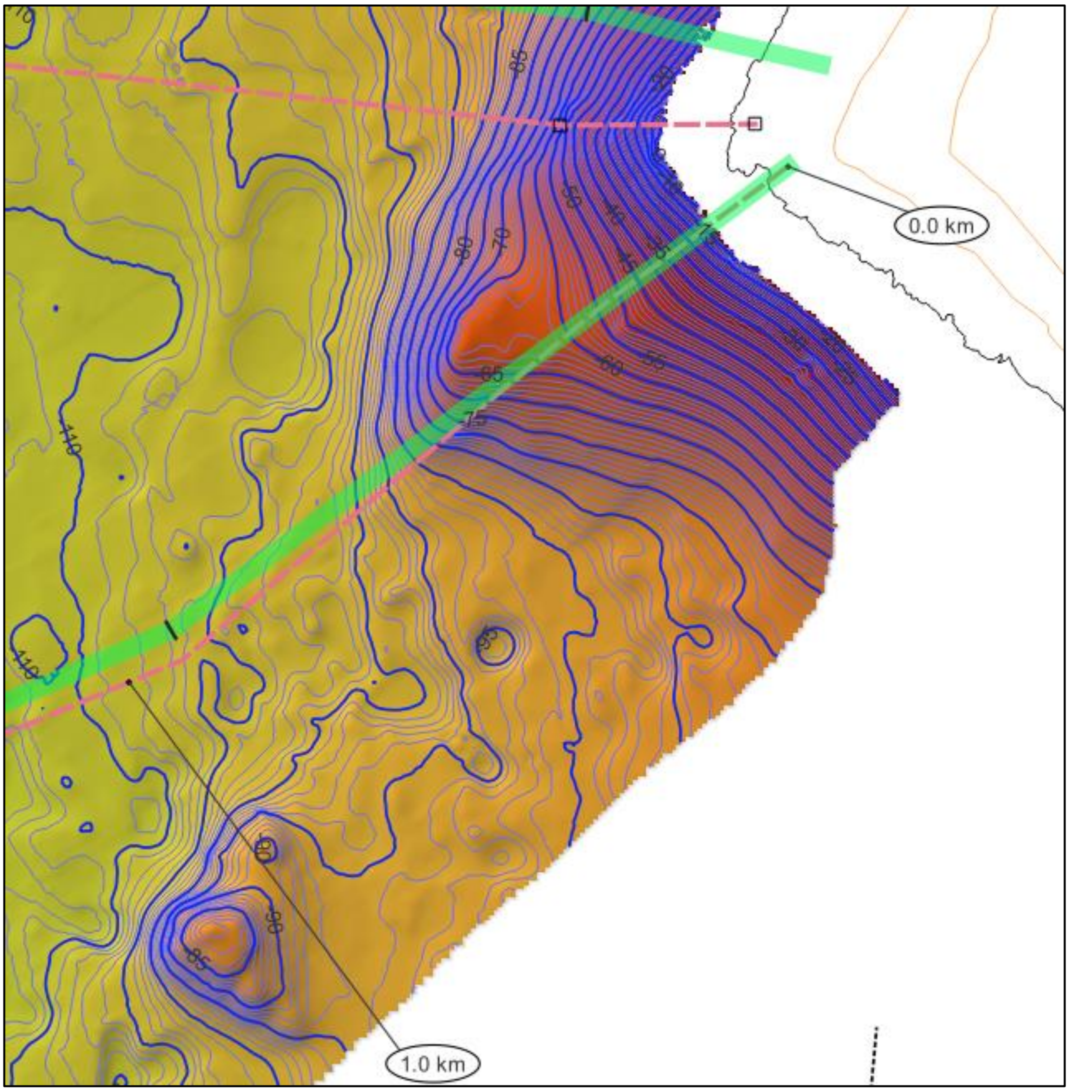


Figure 8: Details of the start of the route. Green line: proposed route, Red dotted line: planned route.

At c. 95 m depth, the route is at the relatively even floor of the bay. From KP 02 the seafloor is getting more rippling, likely due to underlaying bedrock forms mixed with sediments. After KP 03 the route bents towards SW going up through a channel between islands Taartunnguaq and Ikaarissat.

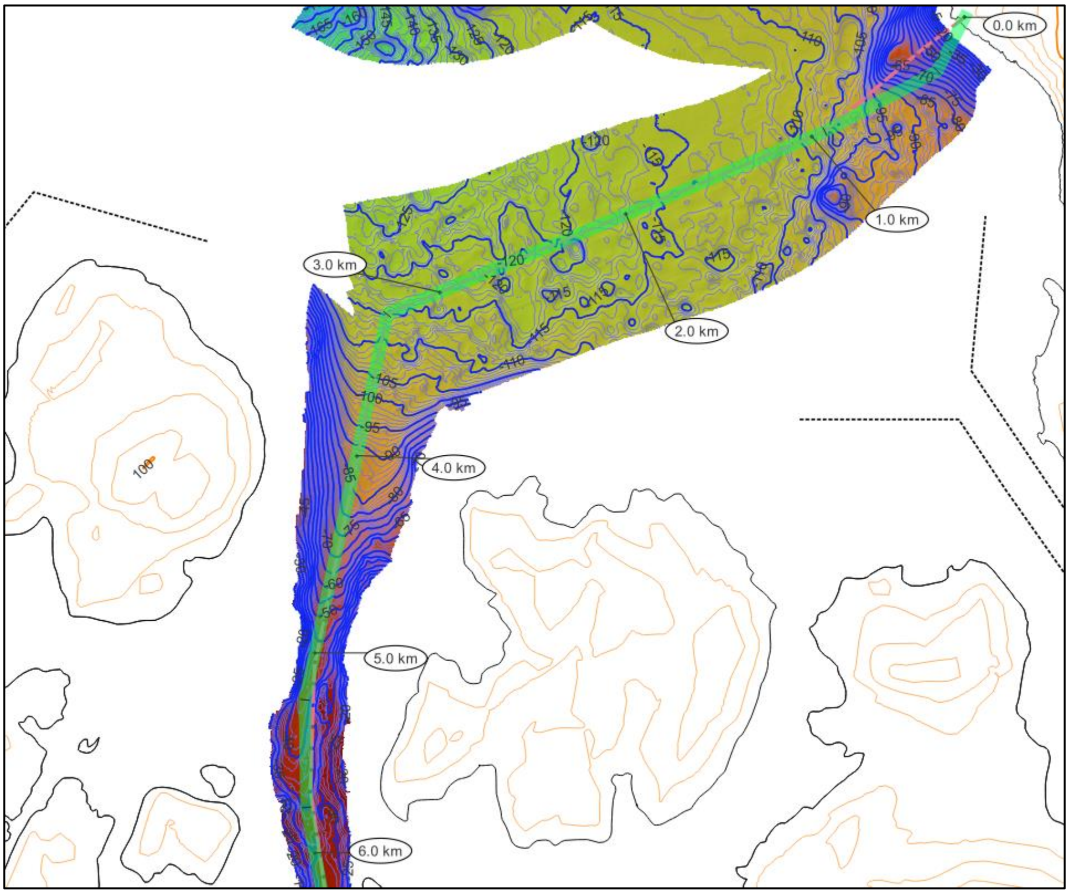


Figure 9: Overview of the section from Start HDD to KP 06 over the bay and through the channel

The route runs through the narrow channel between the islands Qeqertarsuaq and Taarunnguaq. The channel is surveyed in the width possible for safe navigation.

The channel is navigable using the correct navigation chart (Kort 1310) and a precise GPS navigation system, however with little space for operations.

If following the proposed route, the shallowest point should be c. 60 m at KP 06.

The route through the narrow channel is relatively evenly sloped, however slightly bending between rocky outcrops, leaving only around c. 80 m width in the stretch between KP 05 and KP 06.

At KP 06 the route is crossing a low rocky outcrop. An alternative route slightly to the East would involve an extra Alter Course.

The channel ends halfway between KP 06 and KP 07.

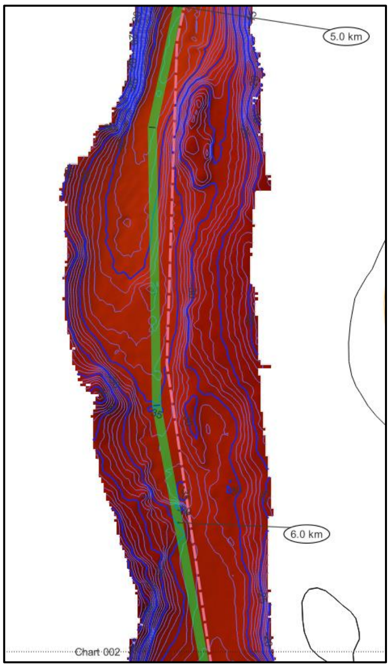


Figure 10: Detailed section of the narrow channel

4.4. Nuuk Skærgård KP 06 to KP 16

Chart: Nuuk Bathy Segment 1 Chart 02

The section starts between KP 06 and KP 07, when out of the narrow channel between the islands. The route runs between the numerous small islands in the archipelago near Nuuk, from Taartunnguaq and SW passing Angisunnguaq and nearby islands towards NW of the TRITON rock.

The strait is at the narrowest c. 300 m wide, and not surveyed to full 1000 m width due to safe navigation. Near KP 06 there is a basin of c. 60 m depth and from the nearest Alter Course to the SW, the subsea terrain gently slopes from c. 60 m to 100 m depth passing KP 08 and 09 to the next A/C. From there it follows a subsea valley of c. 700-800 m width of relatively gentle seafloor, probably a mix of bedrock and sediments.

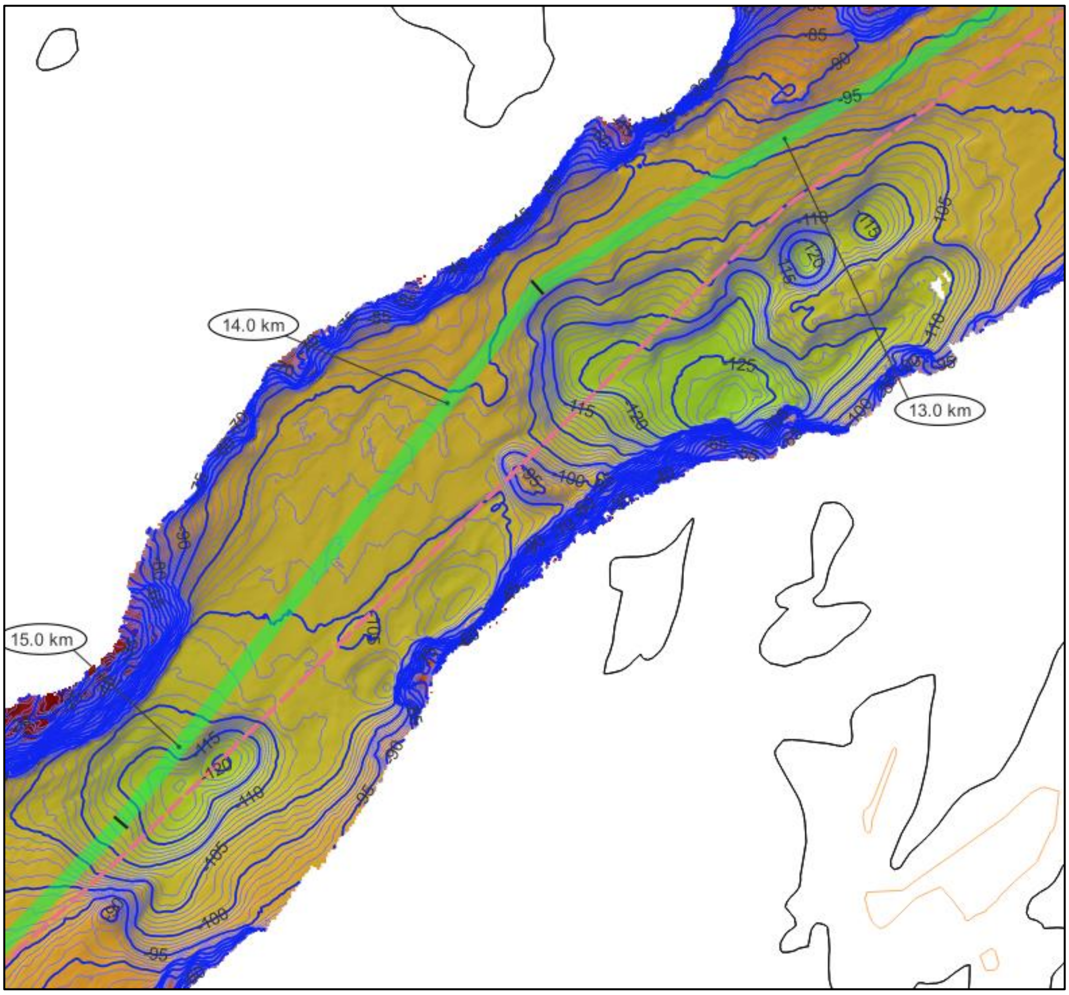


Figure 11: Depressions near KP 13-14 and KP 14

Near KP 13 and 14 there is a deep depression in the subsea terrain, close to a protruding and very steep rocky outcrop from the islands of Illutalissuaq. Within a 85 m horizontal distance, the depths goes from c. 70 to c. 145. To avoid the depression, a route to the NW is chosen, following a ledge near a steep wall of rock to the NW. Near KP 15 there is another depression, however of less steep slopes.

4.5. Nuuk Skærgård KP 16 to KP 24

Chart: Nuuk Bathy Segment 1 Chart 02 and 03

From KP 16 the subsea channel is getting narrower towards SW with more protruding rocky outcrops and narrower sedimentary sea floor. At KP 17 the proposed route has been moved slightly to SE from the planned route to avoid a singular standing rocky outcrop. At KP 18 the seafloor widens to become narrower at KP 19.

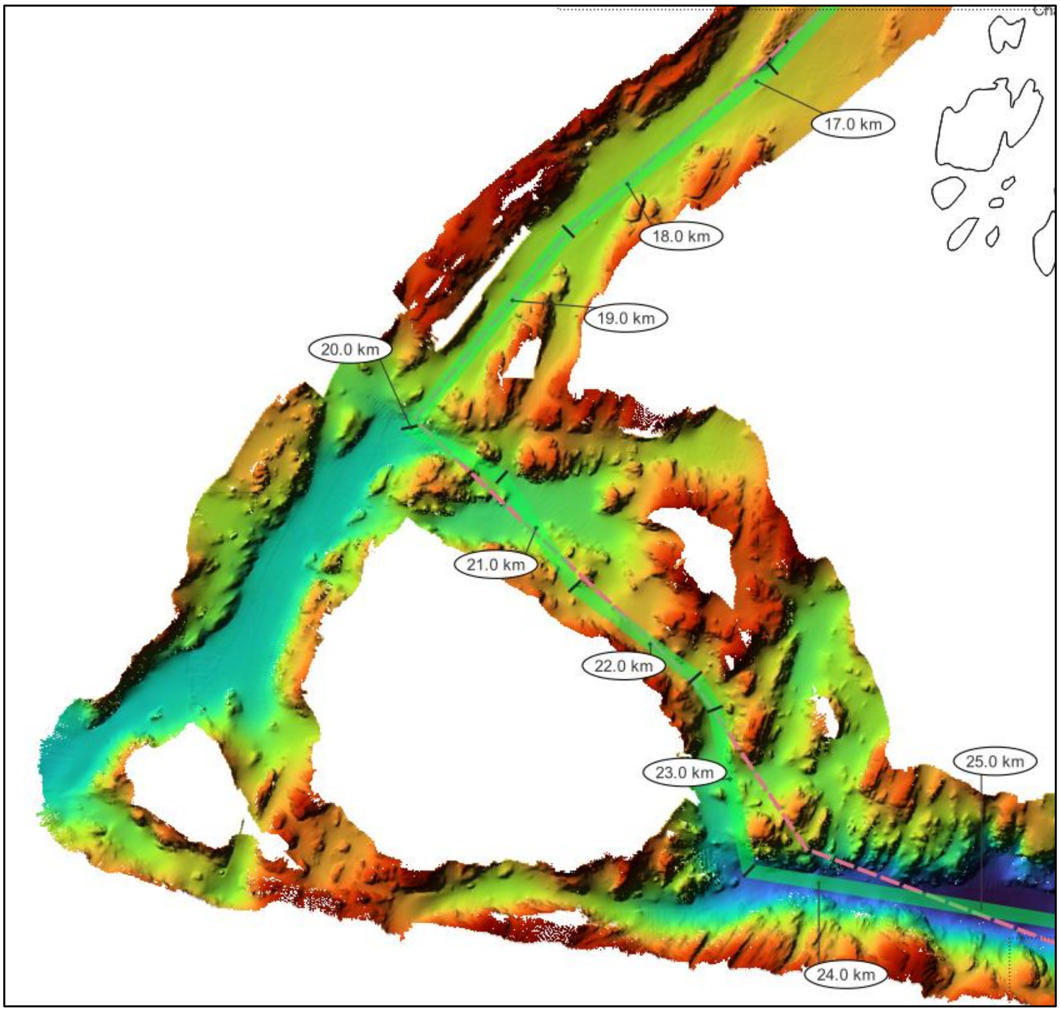


Figure 12: Overview of the section, through the very narrow and changing stretch between KP 20 and KP 24. The alternative route scanned to the south is visible in the bathymetric model.

Just before KP 20 the strait deepens fast by c. 40 meters within c. 200-250 m, and the sides are likely to be rocky.

The position of the planned Anchor Point should be moved c. 55-60 m to the SW and bend c. 85˚ to avoid protruding rocks just E of KP 20.

During the survey, alternative routes were scanned to the S of KP 20, where there is a deeper basin, and W of KP 24. At first, the route seemed promising, but a shallow and rough stretch with multiple rocky outcrops and a course slope over c. 875 m didn't provide a relevant alternative.

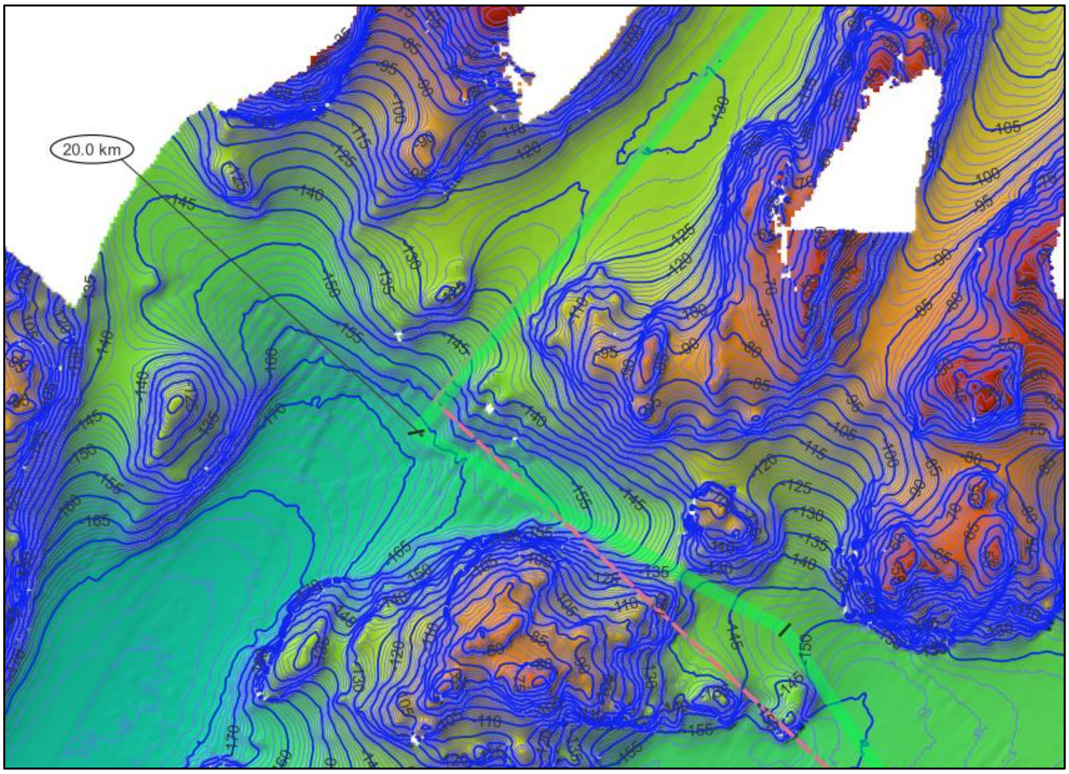


Figure 13: KP 20 of the planned Anchor Point and the c. 85 degree bend, down the slope from NE to SW, and then from NW to SE towards KP 21 through a narrow stretch.

From the almost 90-degree bend at KP 20 the route travels up again to a narrow (c. 30 m wide) pass between two rocks, and thus diverges from the planned route to avoid rock areas, also when arrived at the flatter area.

The next part from KP 21 to c. KP 22 has slightly more space but needs to bend to run between rocks at c. 110 m depth. A part of the route travers a slope of rock protruding from SW.

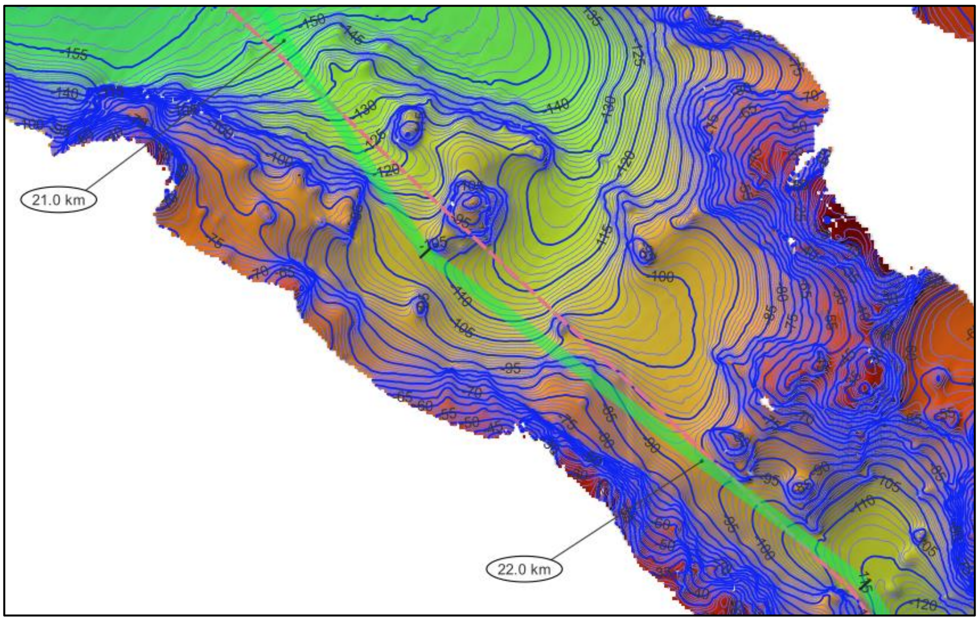


Figure 14: Area between KP 20 and 21 running between protruding rocks.

Near KP 23 the route again needs to run tight along rocky outcrops on particularly the E side of the route just E of an unmapped shallows with numerous rocks and N of an areas likewise numerous rocks according to the navigational chart. To the south is the island Qisuttuut (Ravneøer).

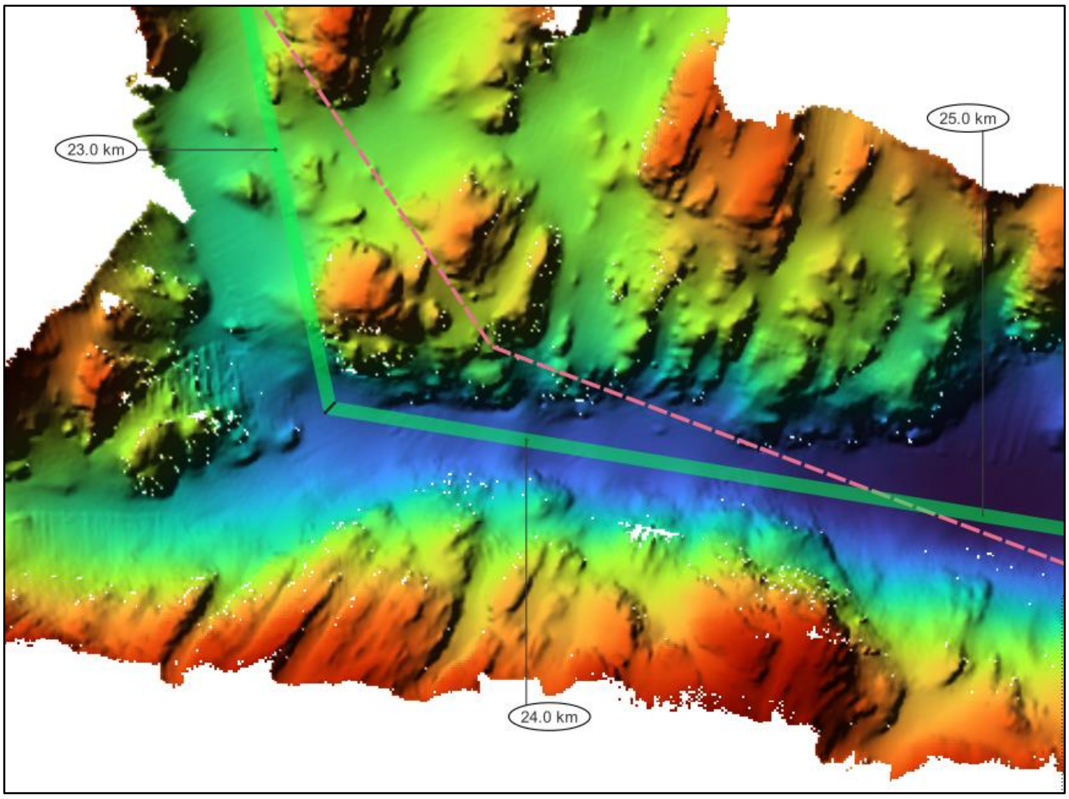


Figure 15: The corner bend between KP 23 and KP 24 with the north-south-going line in between rocky areas

Halfway between KP 23 and KP24 the route bends to a W-E direction in a deep, even valley of c. 200-400 m width and probably sediments between rocky outcrops. From KP 25, the valley widens and of softer features.

4.6. Nuuk Skærgård KP 25 to KP 35

Chart: Nuuk Bathy Segment 1 Chart 03 and 04

From KP 24 to KP30, the route follows a deep valley with sediments and a more space between protruding rock outcrops, one of the larger is just north of KP 28, where the route bends to avoid this.

From KP 30 the valley gets shallower and more rock outcrops protrude, which requires navigation of the route between these.

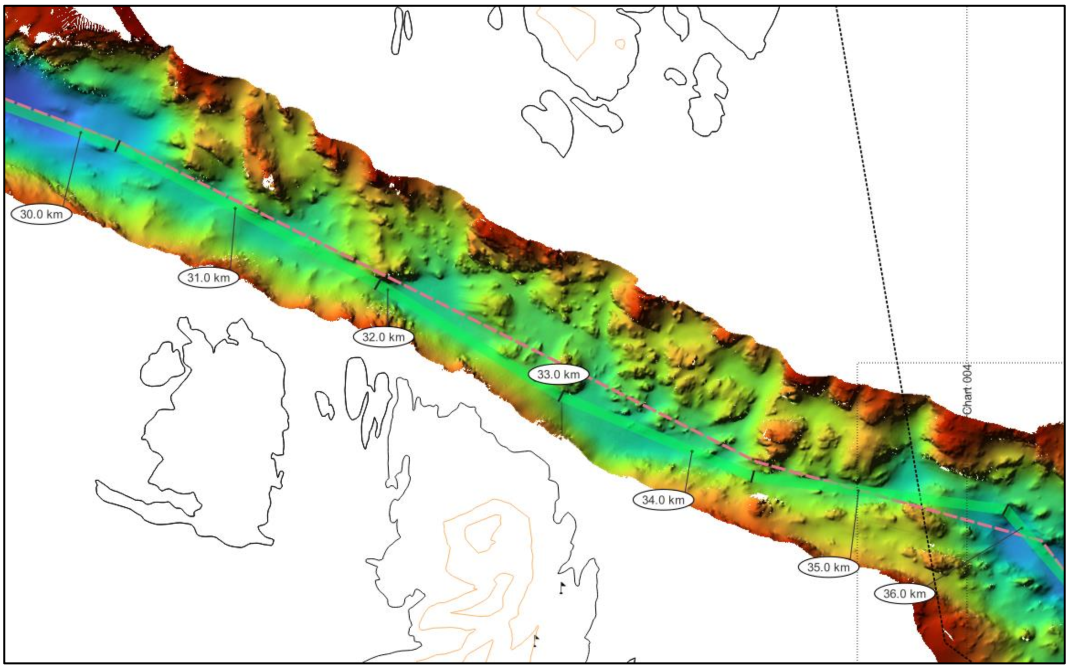


Figure 16: The shallowing of the valley with a more narrow strait and closer proximity to the coast

The route is only bending a little to avoid rocks, but after KP 34 a larger degree bend is necessary to find a passage.

4.7. Nuuk Skærgård KP 35 to 42

Chart: Nuuk Bathy Segment 1 Chart 04 and 05

The undulating terrain below sea surface continues from KP 34 to KP42. Between KP 36 and KP 38 it is wider but still with protruding rocks and not a smooth surface. Near KP38 and to KP 39 the submerged valley is very narrow (c. 100m) and surrounded by steep, shallow rock areas, changing c. 80 m vertically within 130 m.

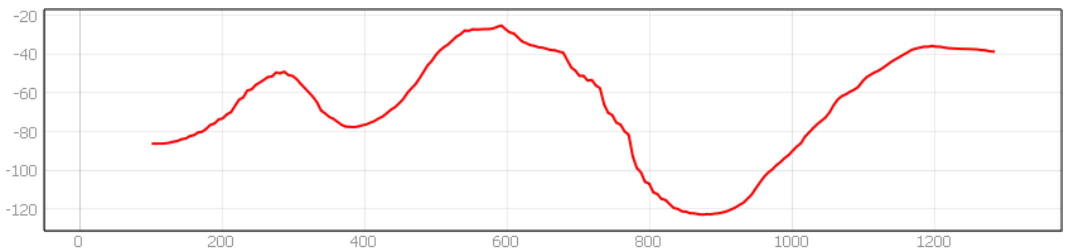


Figure 17: Cross section near KP 39. The proposed valley of cable installation is the deepest

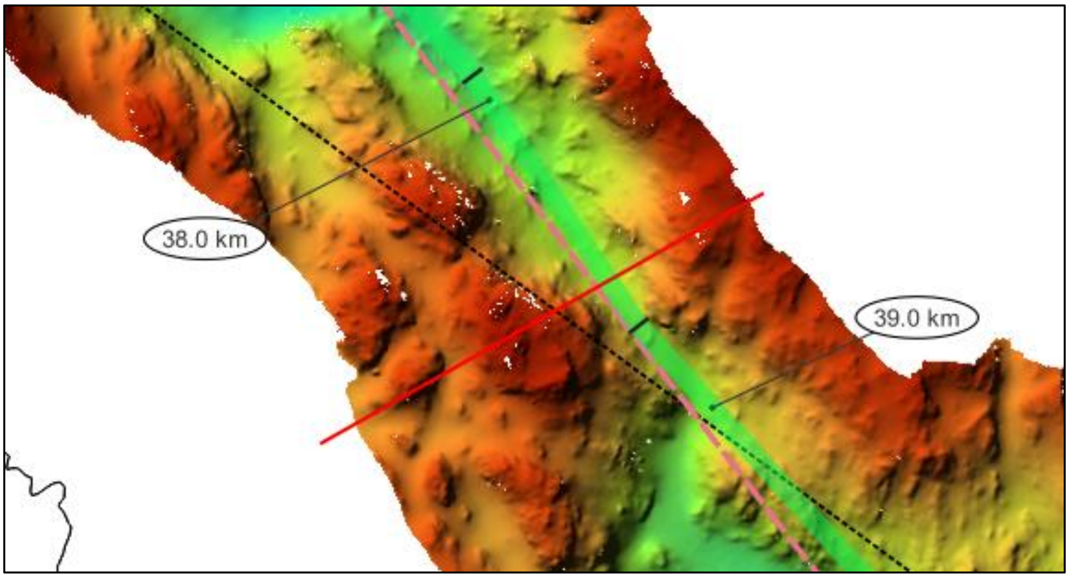


Figure 18: The narrow channel between KP 38 and 39 with the cross section marked with a full red line

From KP 39 the valley widens and deepens, and two options open for routing. However, as there is a wish for as few bends as possible, the deep valley is not followed entirely but a route least changes in depth are found passing KP 40 and north of a rocky outcrop.

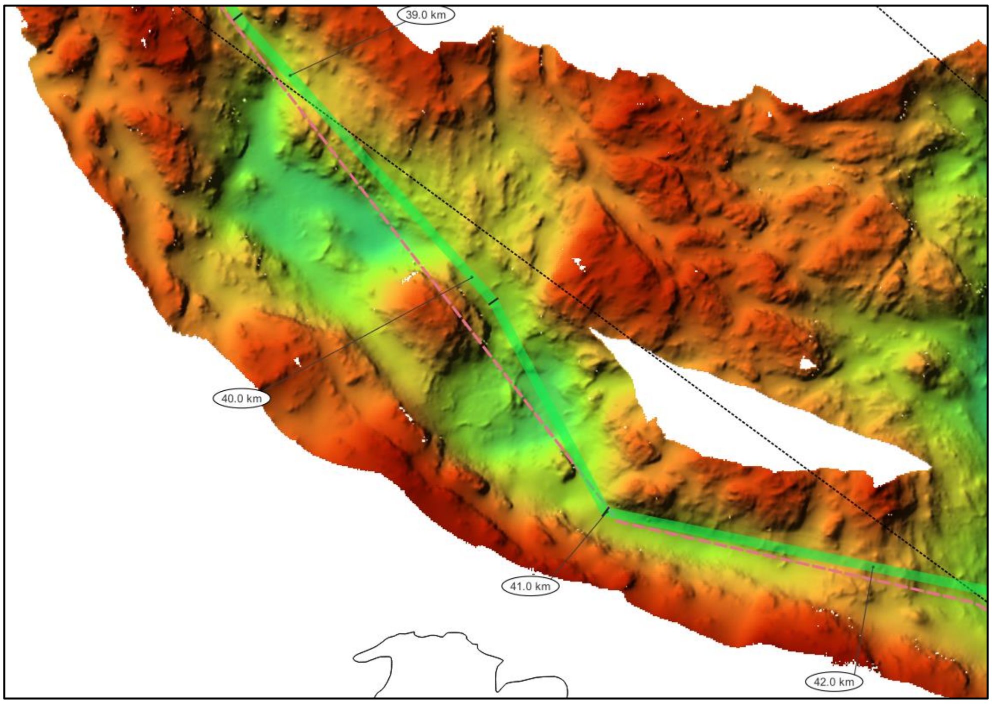


Figure 19: The valley between KP 39 and 42

4.8. Nuuk Skærgård KP 42 to 46

Chart: Nuuk Bathy Segment 1 Chart 05 and 06

From KP 42 the route is downhill towards a broad deep area. The geology changes immensely with the bedrock archipelago to the W and softer sediments to the E and S.

The part covers a large basin with sediments, surrounded by the archipelago and bedrock slopes.

Many gravel or sand ridges are located on the bedrock slopes or outcrops. The ridges are aligned in an E-W direction perpendicular to the proposed cable route. The amplitude of the ridges are c. 2-5 meters, Figure 20, and located at 100-200 m depths.

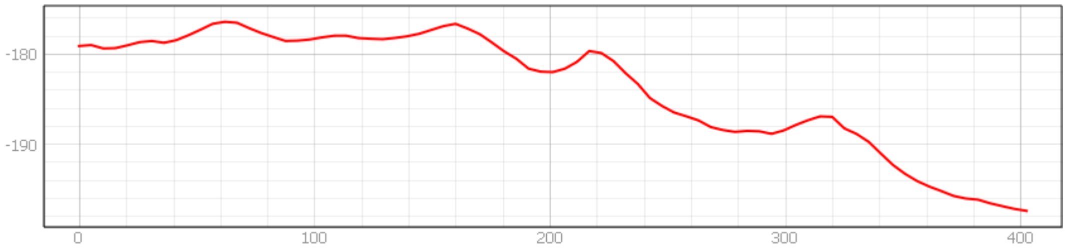


Figure 20: Cross section of ridges in Chart 5 and 6 with distinguishable sand or gravel ridges

These features suggest massive transport of sediments probably by tidal waves or currents between the fjords and the ocean. The nearby Ameralik Fjord is connected to the Greenland Icesheet via a large sedimentary delta and rivers, transporting large volumes of sediments.

The suggested route tries to find the route least affected by the gravel or sand ridges. However, it is not possible to entirely avoid this at KP 43 if no further bends must be introduced.

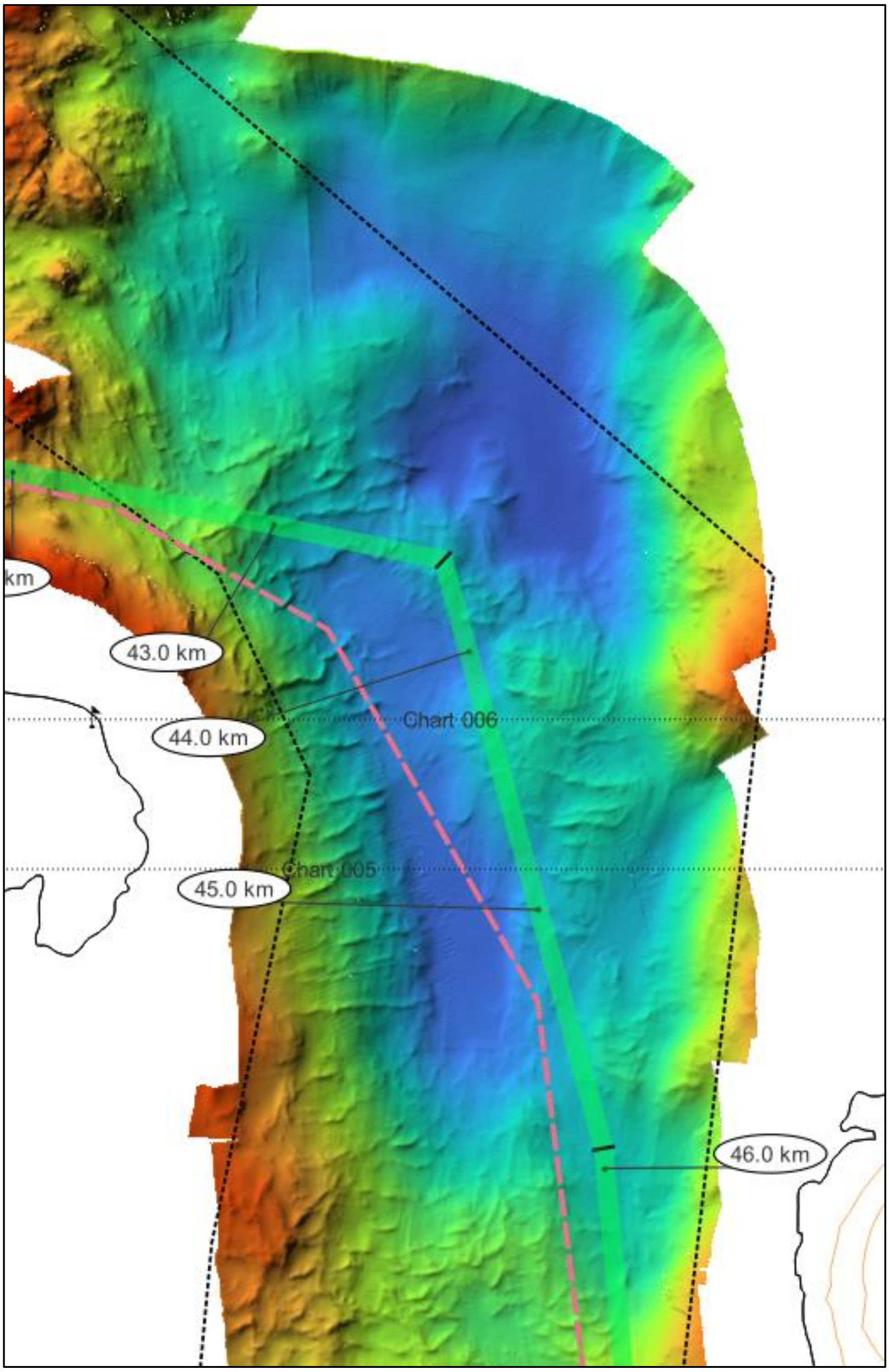


Figure 21: Change of geology from bedrock to sediments with wave formations

4.9. Nuuk KP 46 to 57

Chart: Nuuk Bathy Segment 1 Chart 06 and 07

In direction S from KP 46 there is a ridge over c. 1,5 km width from the island Qeqertarsuaq to the islands Qilaangaarsuit and Kittoqqat over the strait Narsakkoortariaa (Narssaq Løb). The ridge has similar waveform sedimentary ridges perpendicular to the strait but with longitudinal streams of sediments to the previous section. Reading the morphology, they sit on top of bedrock with a sediment cover softening the bedrock shapes.

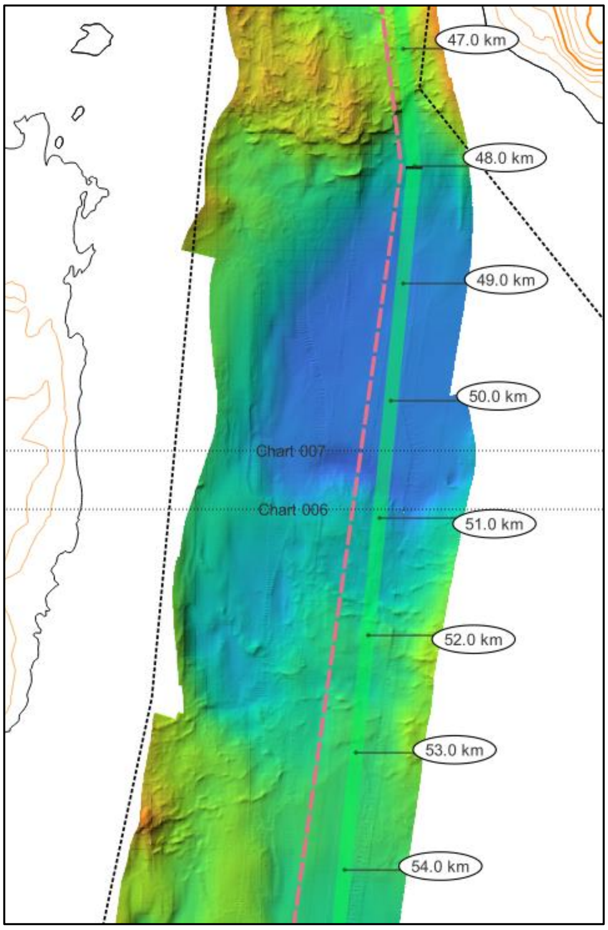
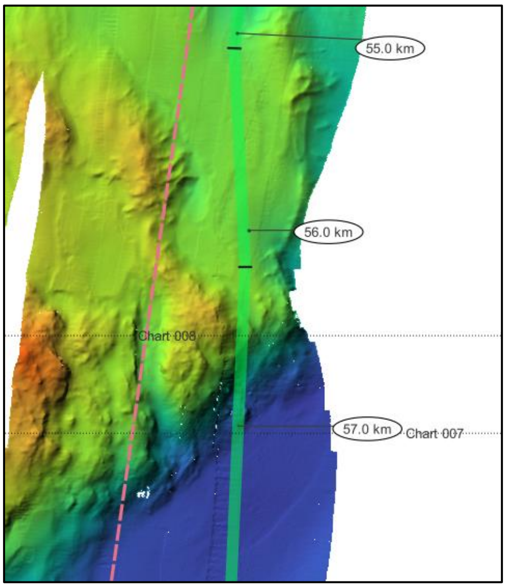


Figure 22: North-South going strait of Narsakkoortariaa with ridge, deeper basin and sediment wave ridges

From KP 48 to KP 51 there is a deep basin with a smooth surface indicating sediments. Further longitudinal sediment formations and a deepening near a bedrock formation to the S around the edge of the basin also indicate strong sedimentary transport processes in the N-S direction.

From KP 51 to KP 53 bedrock with the wavy sediment forms are met again, followed by a part until KP 56 with a smooth and little deeper surface. At KP 55 the route bends to avoid a rocky outcrop.

Between KP 56 and KP57, there is a sharp descent of c. 100 m vertically within c. 450 m horizontally into the deepest basin of the survey area. The optimal route down the slope is identified, and it is recommended to cover an additional area E of KP54 to KP58 to search for a smoother route avoiding a rocky area W of the mentioned KP's.



An extension of the survey to the W of the planned route did reveal a relevant alternative crossing the shallower rocky area but met other obstacles further to the south.

The survey coverage width was extended to 2400 m, almost 2.5 times the requirements. Due to severe weather in the near-offshore region, it was not possible within the time frame to cover further areas to the E.

For now, the proposed route follows a slope of less ruggedness as the planned route.

4.10. Nuuk Skærgård from KP 57 to 63

Chart: Nuuk Bathy Segment 1 Chart 08

After the steep descent between KP 56 and KP 57, there is a long stretch of smooth surface, probably of sediments in a deep basin of 255-265 m depth. At KP 60 and 61 there are some rocky outcrops, which can however be avoided easily. From KP 62 and onwards, the space between the rocky outcrops narrows significantly as a shallower (still c. 65 m depth) party of bedrock is passed, and the subsea landscape is becoming again more undulated.

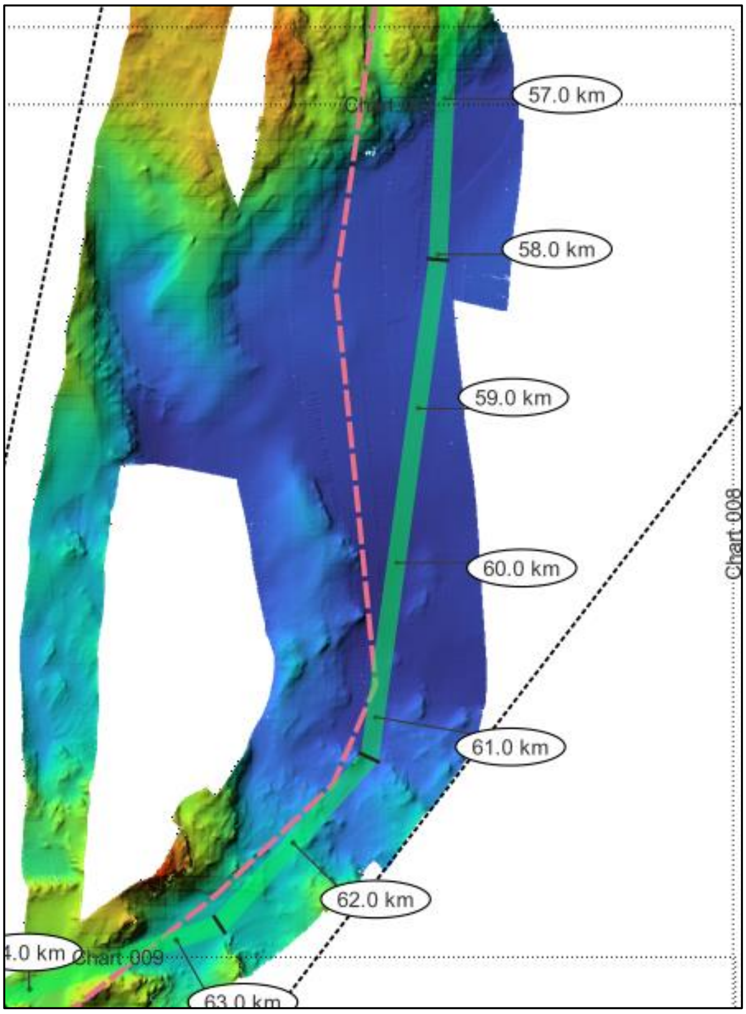


Figure 23: A coherent bassin of c. 255-265 m depth with sediments and fewer bedrock features

4.11. Nuuk Skærgård KP 63 to 74

Chart: Nuuk Bathy Segment 1 Chart 09 and 10

This section is close to the prominent land feature Meqquitsoq (Skinderhvalen) marking a geological outpost between the protected coastal waters, a complicated and undulated seabed morphology, and the open Atlantic Ocean. To local mariners, the area is known for strong winds and waves and swells from the ocean, and mixed wave behavior due to the change from ocean bathymetry to shallow, undulant waters. Nearby an oscillation of 40˚ on magnetic compasses is recorded (Anon., 2021).

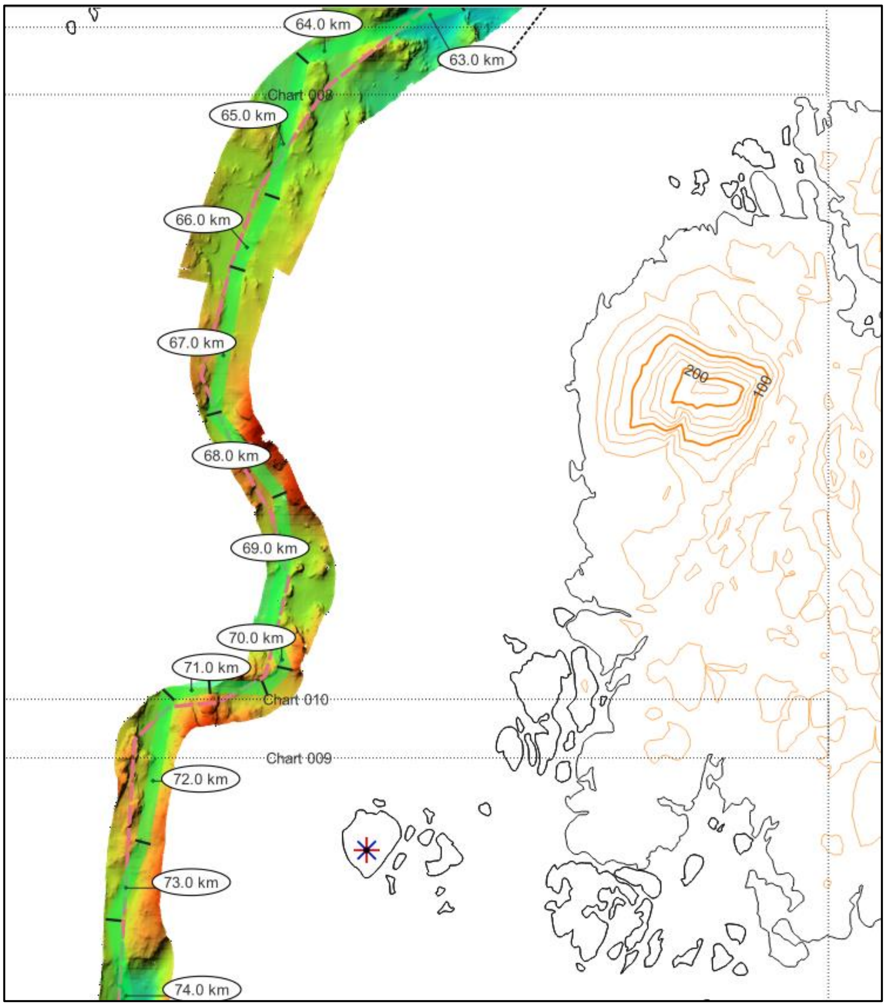


Figure 24: Shallow areas and narrow subsea channels W of Meqquitsoq (Skinderhvalen)

The stretch is characterized by rocky outcrops and narrow channels in between. The area is difficult to navigate due to harsh weather and shallow grounds. Near KP 68 and KP 73 there are rocks of only 6 m depth LAT or less, so the possibilities of finding alternative routes are very limited.

The full 1000 m coverage asked for has not been possible to meet with the current configuration and platform used for the survey. It would be difficult to expand the survey coverage much. If needed, then it is suggested to investigate part W of KP 69-70 (at 147 and 57 m depth on the navigational chart) for an alternative to the route between the to KP's.

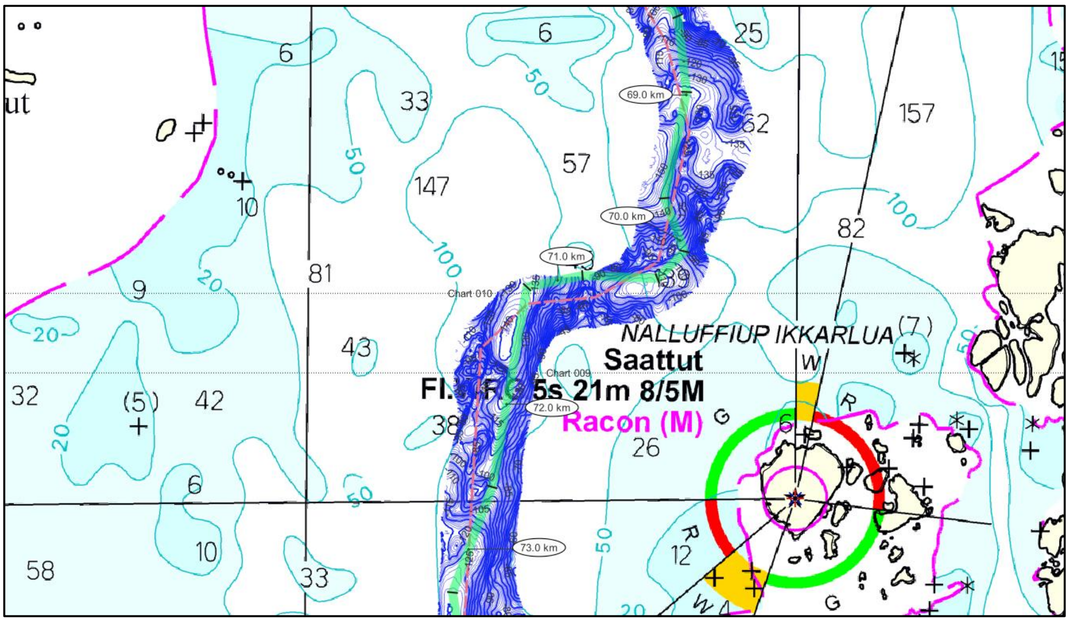


Figure 25: Part of the navigational chart displaying the shallow grounds and difficult navigation possibilities of the water near Saattut off Meqquitsoq. Navigational chart, copyright to Geodatastyrelsen

4.12. Nuuk Skærgård KP 74 to KP 78

Chart: Nuuk Bathy Segment 1 Chart 10

It was not possible to fulfill the entire survey to the W in the Atlantic Ocean due to severe weather, and the stretch is only covered by two lines stopping shortly after KP 78.

However, they reveal a very deep basin of c. 280m depth W of Sankta Maria Skær (a named rock). The route bends in the center of the basin midway between KP 75 and 76 and runs further along the basin moving into a valley depressing passing KP 77-78. The bassin is expected to have softer sediments in the bottom and is 500-1000 m wide.

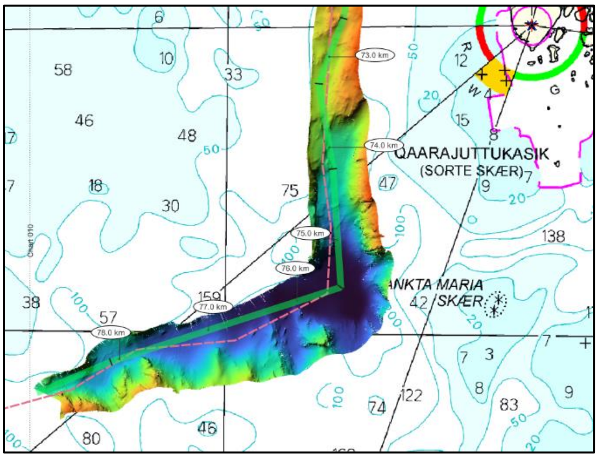


Figure 26: The deep basin and corner of the route near the Sankta Maria Skær rock SW of Saattut and Meqquitsoq. Navigational chart, copyright to Geodatastyrelsen

Although the planned route was not covered further than KP 78 with c. 22 km missing to the planned endpoint, the navigational chart Chart 1310 reveals that the valley is continuing to the WSW between shallower areas. A particular point of interest would be the narrow saddle or pass of 71 m depth.

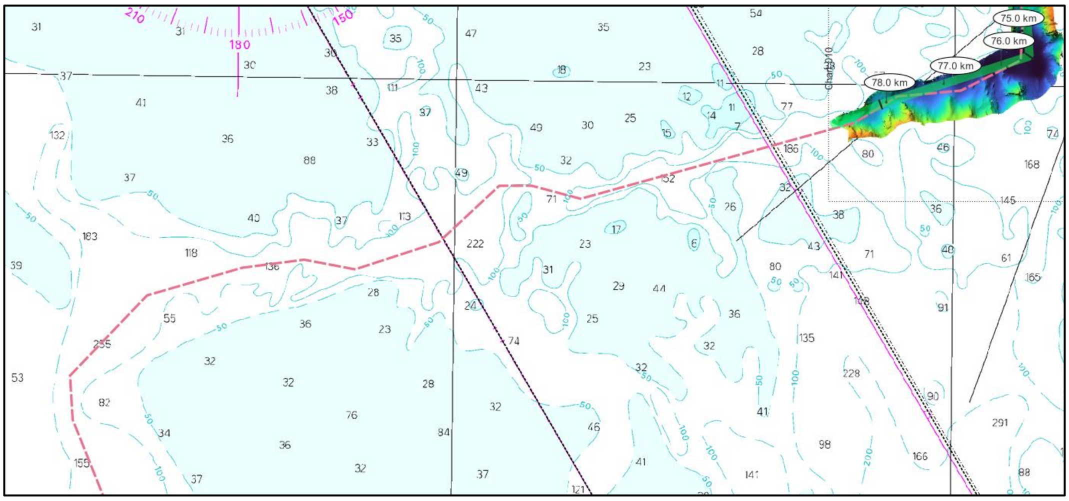


Figure 27: Continuation of the subsea valley possibly suitable for cable installation, however unmapped during the survey. Navigational chart, copyright to Geodatastyrelsen

The sources to the navigational chart is for the area scarce and of early origin, before multi beam systems were used and possibly also before the use of electronic survey systems, so positions and recordings are not of recent standards. However, the recordings provide an impression of the seabed morphology, and show that the planned route is possible throug the narrow valley and over the 71m pass. After the 71m pass the route should have a stronger bend to avoid side features of the shallower ground left of 71m.

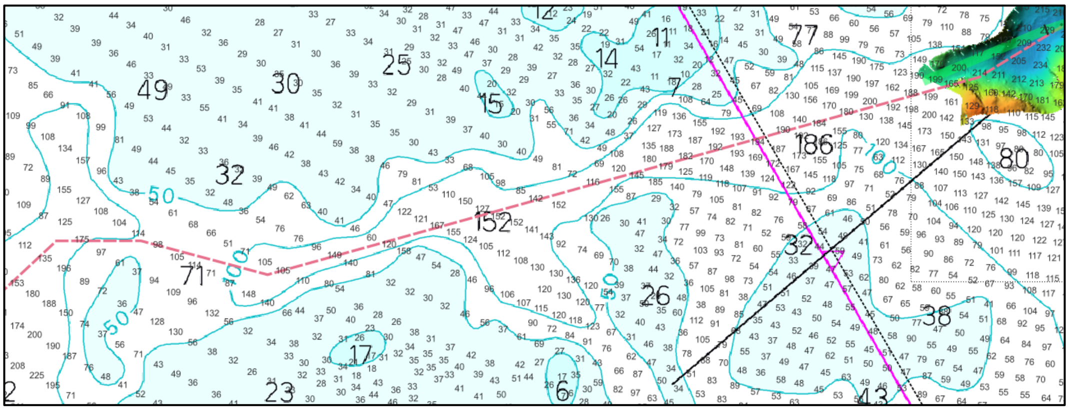


Figure 28: Readings from Danish Geodata Agency Hydrographic Office, survey D20261, undated. Copyright Geodatastyrelsen J. nr. KMS-739-00231

ST-336

Skipsteknisk

61.4 m Fishery Research Vessel for Arctic operation, Grønland Naturinstitut

Tarajoq

ST-design ®
- freedom to create

www.skipsteknisk.no

ST-336

61.4 m Fishery Research Vessel for Arctic operation, Grønland Naturinstitut

Tarajoq

GENERAL

This vessel, designated ST-336, is designed by Skipsteknisk AS. The vessel is outfitted and prepared mainly for the following duties:

- Fishery research operations - bottom trawling
- Fishery research operations pelagic trawling
- Acoustic research operations
- Environmental research and sampling operation

Main dimensions and capacities

Length over all	61.40 m
Length between p.p	53.40 m
Breadth moulded	16.00 m
Depth to trawl deck	8.80 m
Depth to 1st. deck	11.40 m
Depth to 2nd. deck	14.00 m

Tank capacities

- Fuel oil: 475 m^3
- Potable water: 105 m^3
- Misc.tanks: 400 m^3

Accommodation

- Marine crew 10 persons
- Deck operation crew 8 persons
- Scientists 12 persons
- Scientists offices on main deck
- Scientists worklabs on main deck
- Scientists wetlabs and technical facilities on main deck
- Stores room for scientific equipment and fishing equipment to be arranged in cargo room below main deck

Speed

- Service speed: 14 knots

Anti-rolling system

The vessel is arranged with antiroll stabilizer systems

Class

DNV +1A, ICE(1B), E0, TMON, SILENT(F), SPS "Stern trawler"

Main propulsion system

- Main engine for marine propulsion - abt. 2900 kW
- Diesel electric propulsion driven for various scientific operations 850 kW - Azimuth
- 1 x CPP propeller. Propeller diameter approx. 3800mm
- 1 x Gearbox with PTO/PTI/PTH
- 1 x 1700 kW shaft alternator

Power generating plant

- 1x 1900 kW 1800 rpm
- 1x 750 kW 1800 rpm
- 1x Emergency generator of 137 kW

Side and azimuth thrusters

- One combined tunnel / azimuth thruster of 850 kW in bow

Winches, cranes, handling equipment

Fishery and scientific winches, according to MAKERS LIST
Electric drive system:

- 2 x Trawl winches, abt. 44 tons
- 2 x Gilson winches, 15 tons
- 6 x Sweepline winches, 14.7 tons
- 2 x Windlass/Anchor winches
- 1 x Capstan
- 1 x Auxiliary winch, 7.8 tons
- 1 x Cod end winch, 11.2 tons
- 2 x Retriever winches, 1.6 tons
- 2 x Backstrop winches, 2.0 tons
- 2 x Outhaul winches
- 1 x Net drum, 31.4 tons
- 1 x Net sounding winch, 3.4 tons
- 1 x CTD winch, 4.0 tons
- 1 x Multipurpose winch, 11.9 tons
- 1 x Hydrografic winch, 1.0 tons
- 1 x Oceangraphic winch, 3.0 tons
- 2 x Chain stopper
- 1 x Drop keel winch, 7.0 tons
- 1 x El.aux. winch, 2.0 tons

Deck cranes, davits and frames, make acc. to Makers List

- 1 x Midship crane 6 tons / 15 m
- 1 x Fore crane 2 tons / 12 m
- 1 x CTD davit
- 1 x Gantry LARS

Laboratories

- Wet lab / fish lab with connecting freezer
- Dry lab
- Chemical lab
- Water sampling lab
- IT central / room
- Meeting rooms
- Observation office on top of wheelhouse

Observatory - Skylounge

Planetary observatory arranged on top of wheelhouse for continuous observation of atmospheric conditions as well as ice- and other arctic observations

Scientific equipment/sonars

Echo sounders and sonars according to MAKERS LIST

- CTD Rosette water sampling system
- Meteorological station
- Data Acquisition system
- Scientific Computer System Network
- 1 Echosounder for Deep Water
- 1 Echosounder for Medium Depth
- 1 Sonar for short/medium range
- 1 Sound Velocity Profiler with working depth of 1000 meters
- 1 Surface Sound Velocity Sensor
- 1 Acoustic Doppler Current Profiler (ADCP)
- Ocean Surveyor
- 1 Omni directional (long range) sonar for biomass. range: 4000+ m
- 1 High Precision Acoustic Positioning Subsystem type HiPAP 50

Drop keel

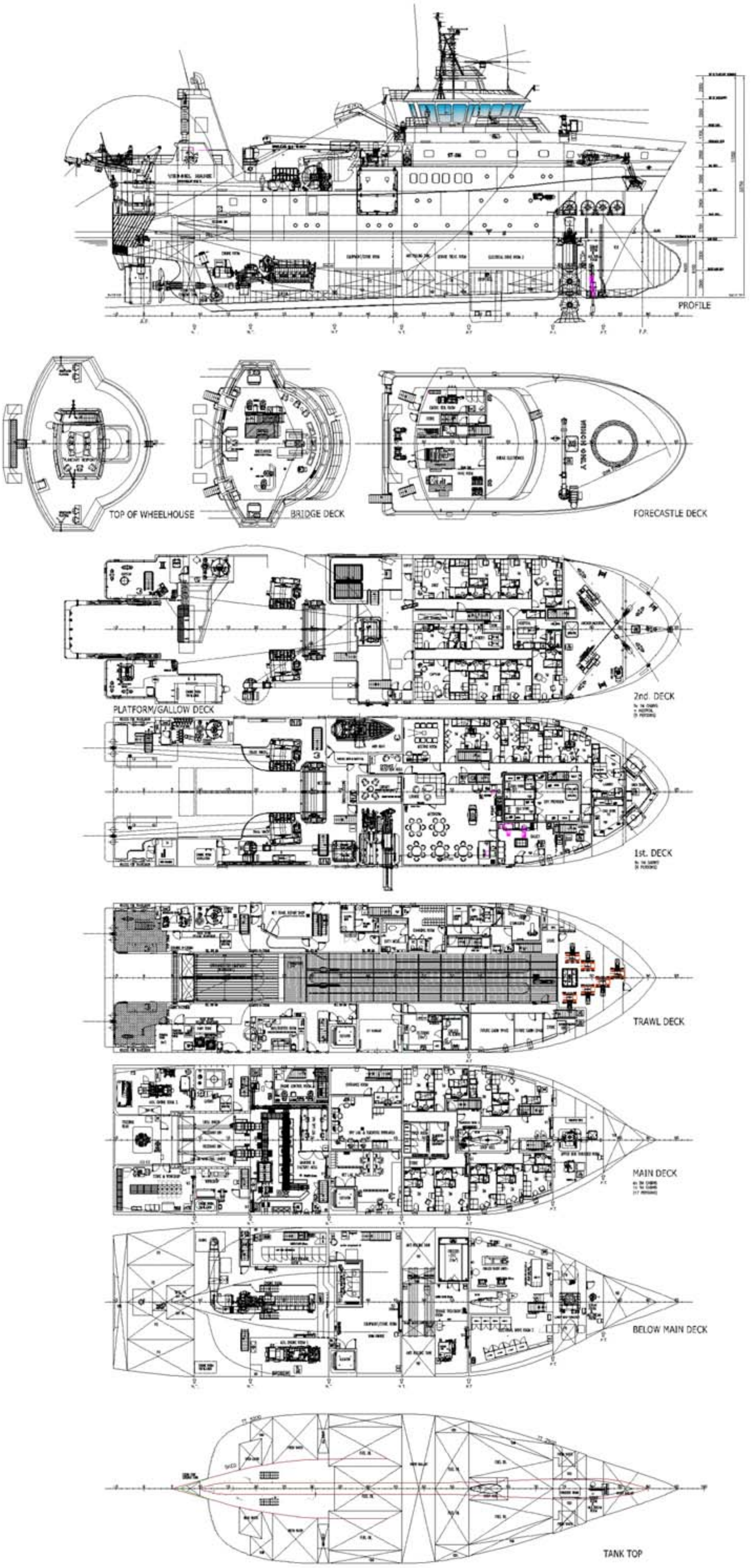
Vessel is arranged for sliding keel where bottom equipment for various scientific sounders shall be installed.

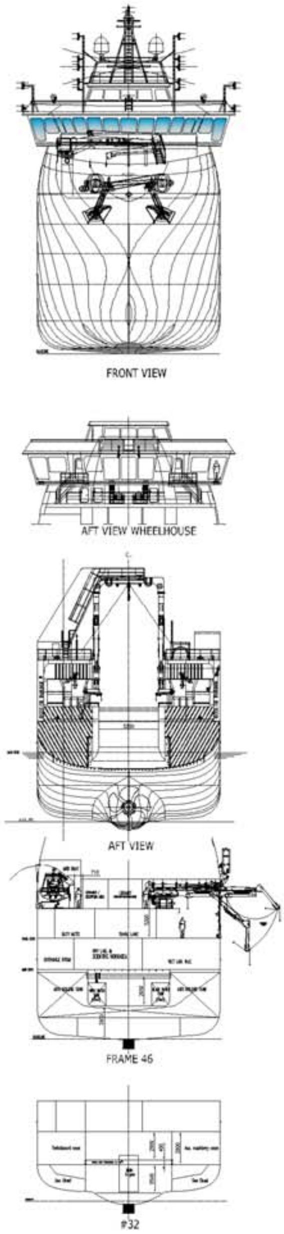
Safety equipment

- Safety equipment according to regulations for the specified authorities, class and number of crew
- 1 MOB boat

Skipsteknisk AS

ST-design.





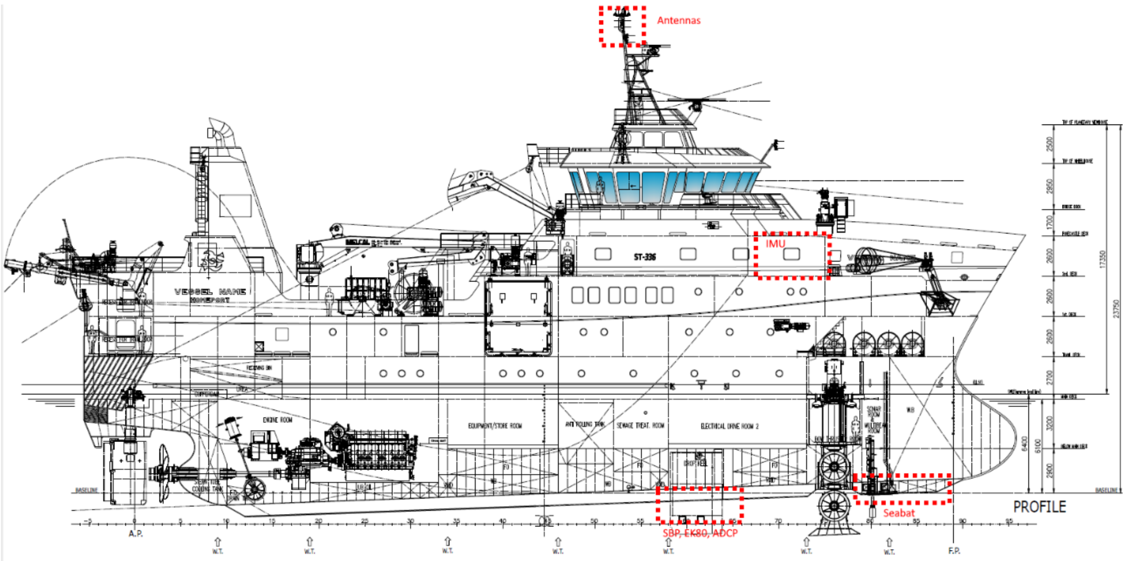
Tarajoq

Skipsteknisk

SKIPSTEKNISK AS Klaus Nilsens gt. 4, P.O.Box 36 Sentrum, NO-6001 Aalesund, Norway
PHONE +47 70 10 33 44 | FAX +47 70 10 33 48 | office@skipsteknisk.no | www.skipsteknisk.no

Survey equipment

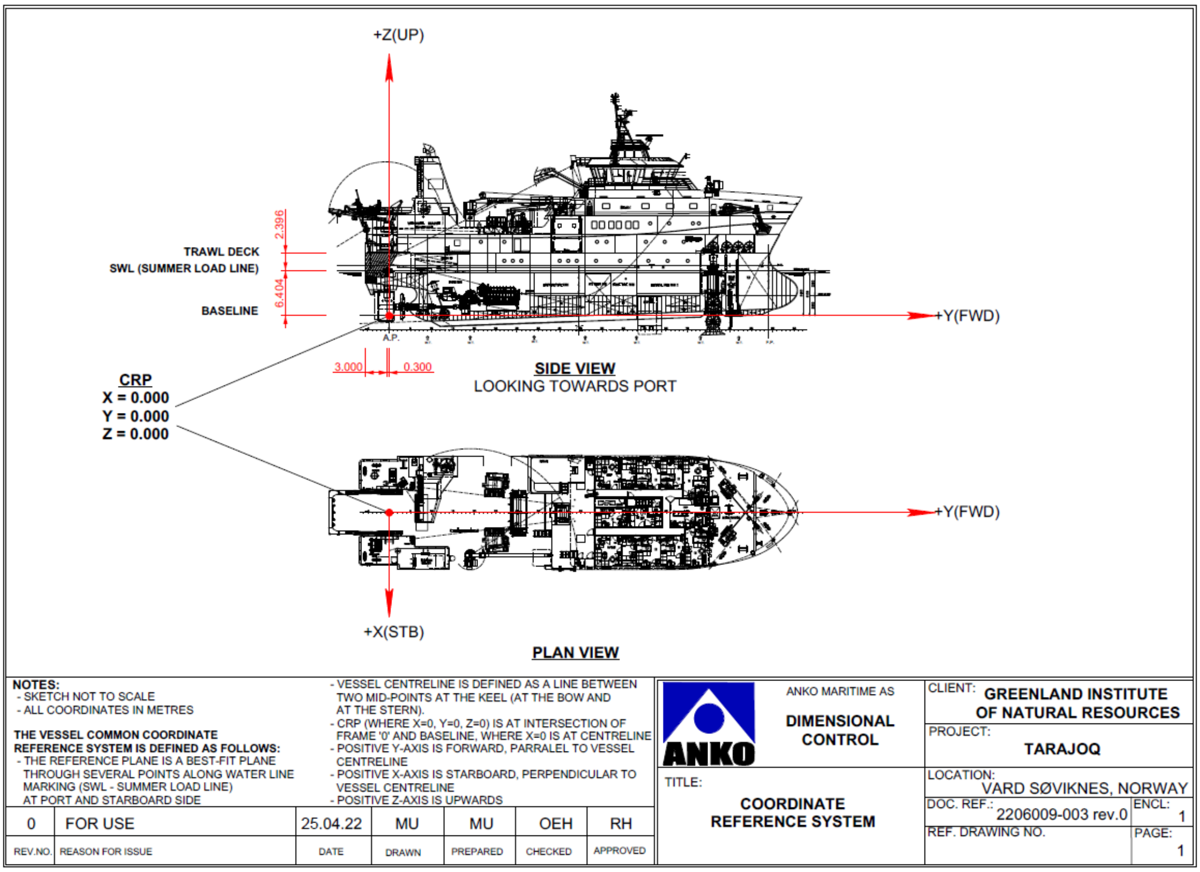
Location of most important instruments



Overview of positions of most important objects in the survey

Appendix 2

Vessel coordinate reference system



(during dimensional control survey, report can be received upon request)

2

Appendix 2

Applanix POS MV OceanMaster Positioning system

Rack mounted computing system. Stationary mounted IMU and GNSS antennas.

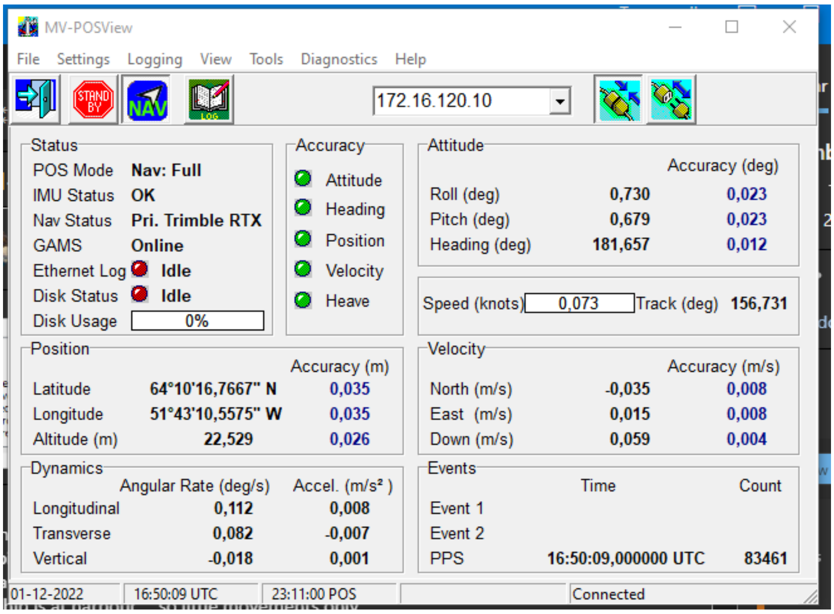
Manages GNSS position data, correction from base station data providers, IMU motion data, GNSS Azimuth Measurement System (GAMS) heading. Logging to files, and distribution via ethernet of data to SeabatUI, PDS2000 and Innomar SES-2000 (time tag, status, position, attitude, velocity, track, speed, dynamics, performance metrics, raw IMU, and raw GNSS data).

Post-processing of data in POSPac MMS8 as backup to Trimble CenterPoint RTX online corrections.

POS MV OCEANMASTER ACCURACY[1]

	DGPS	Fugro Marinestar®	IARTK	POSPac MMS PPP	POSPac MMS IAPPK	Accuracy Following 60 s GNSS Outage
Position	0.5 - 2 m[2]	Horizontal: 10 cm 95% Vertical: 15 cm 95%	Horizontal: +/- (8 mm + 1 ppm x baseline length)[3] Vertical: +/- (15 mm + 1 ppm x baseline length)[3]	Horizontal: < 0.1 m Vertical: < 0.2 m	Horizontal: +/- (8 mm + 1 ppm x baseline length)[3] Vertical: +/- (15 mm + 1 ppm x baseline length)[3]	~ 6 m (DGPS) ~ 3 m (RTK) ~ 2 m (PPDGNSS) ~ 1 m (IAPPK)
Roll & Pitch[4]	0.02°	0.01°	0.01°	< 0.01°	0.008°	0.03°
Heading[4]	0.01° with 4 m baseline 0.02° with 2 m baseline	0.01° with 4 m baseline 0.02° with 2 m baseline	0.01° with 4 m baseline 0.02° with 2 m baseline	0.01° with 4 m baseline 0.02° with 2 m baseline	0.01° with 4 m baseline 0.02° with 2 m baseline	1° per hour degradation (negligible for outages <60 s)
Heave TrueHeave™	5 cm or 5%[5] 2 cm or 2%[6]	-5 cm or 5%[5] 2 cm or 2%[6]	5 cm or 5%[5] 2 cm or 2%[6]	-	-	5 cm or 5%[5] 2 cm or 2%[6]

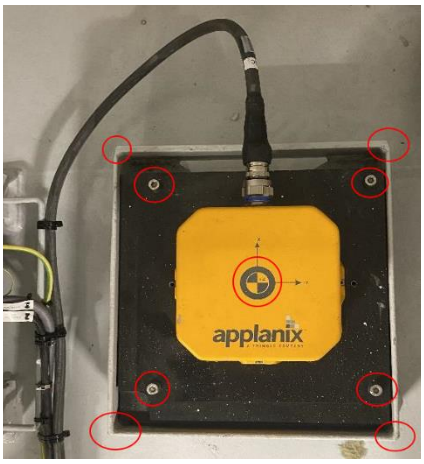
MV-POSView software, with corrections from Trimble CenterPoint RTX

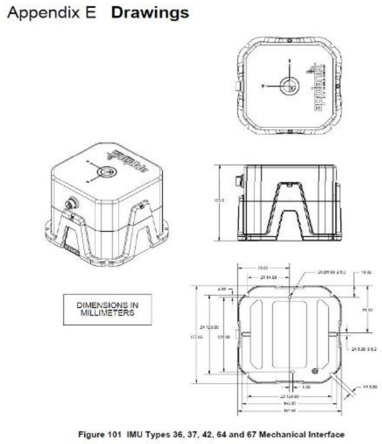


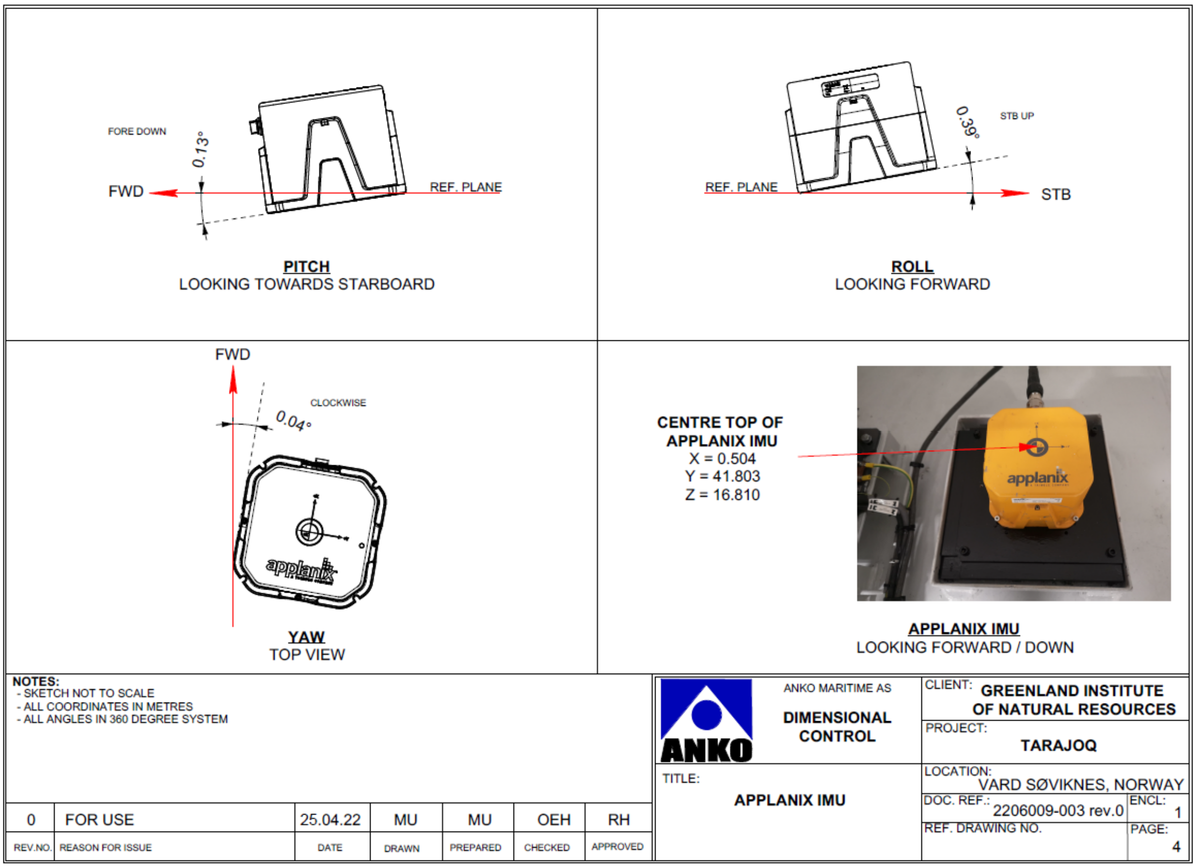
3

Appendix 2

Applanix OceanMaster Internal Motion Unit (SN 11262, top hat SN 5520)

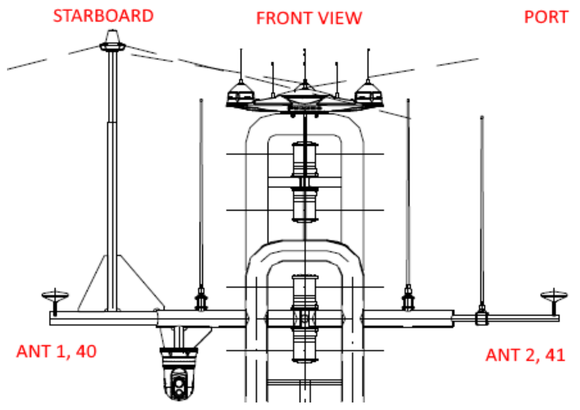


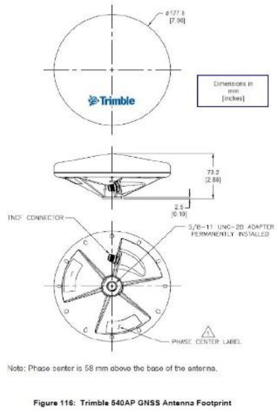


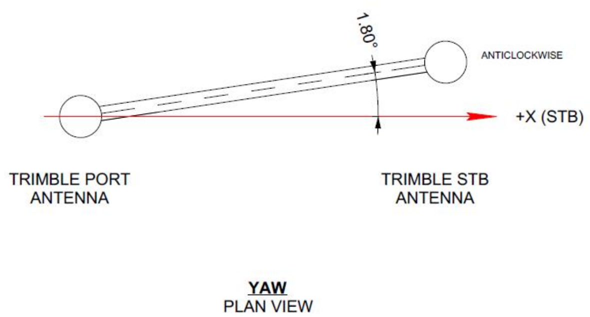


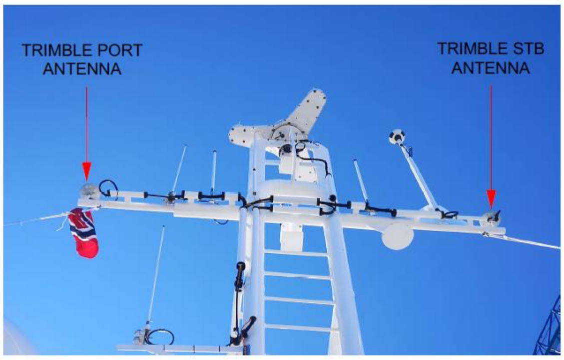
Appendix 2

Trimble 540AP GNSS antenna, ANT1 40 starboard side, ANT1 41 port side









TRIMBLE ANTENNAE
LOOKING FORWARD / UP

Item	+X (STB)	+Y (FWD)	+Z (UP)	Description
Trimble Antenna Port (id. 41)	-1.730	31.551	29.380	Centre at ARP
Trimble Antenna Port (id. 41)	-1.730	31.551	29.438	Phase centre
Trimble Antenna Stb (id. 40)	1.730	31.660	29.402	Centre at ARP
Trimble Antenna Stb (id. 40)	1.730	31.660	29.460	Phase centre

5

Sonar systems

Teledyne RESON Seabat 7160 multi beam sonar Tx, Rx

Sonar Head Assembly

The SeaBat 7160 Sonar Head Assembly is based on linear transmit and receive arrays, arranged in a Mill's Cross configuration. The complete transducer array is either mounted in the optional mounting frame or configured as a permanent hull mount.

The materials used are suitable for long-term immersion in sea water and are designed to withstand high-speed transits to and from survey areas and typical offshore sea conditions. Both arrays are sealed, self-contained units and contain minimal electronics encased in a protective coating. The receiver array contains wideband ceramic elements covering the frequency range of operation.

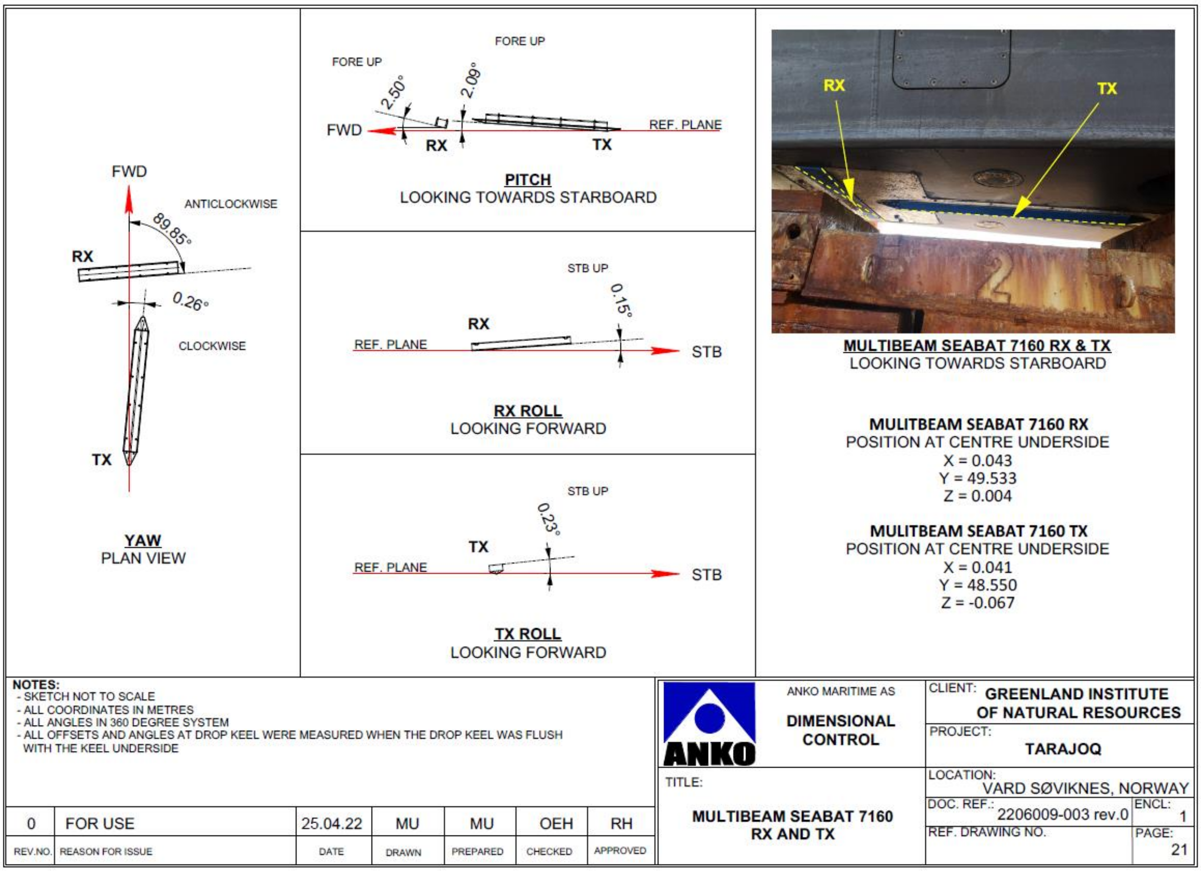
Figure 2: Sonar Head Assembly

Specification	Value
Dimensions	127mm x 1100mm x 82mm
Weight	Air: 34kg Seawater: 14.6kg
Temperature	Operation: -5° to +40°C Storage: -30° to +55°C
Depth Rating	60m

Table 3: EM7196 Hydrophone Array

Specification	Value
Dimensions	150mm x 1350mm x 100mm
Weight	Air: 42kg Seawater: 17.5kg
Temperature	Operation: -5° to 40° C Storage: -30° to 55° C
Depth Rating	60m

Table 4: TC2148 Projector Array



6

Appendix 2

Teledyne RESON Seabat Transceiver and Processing units

Transceiver Unit

The Transceiver Unit produces the transmit signal and routes it to the transmitter arrays on command from the Sonar Processor Unit. It also receives and digitizes the sonar returns from the receiver arrays and routes them to the Sonar Processor Unit.

All Transmitter and Receiver electronics are mounted in a single, 19" rack-mountable, enclosed chassis. The chassis contains power regulation, transmitter, receiver, and control circuitry in rack mounts and is suitable for mounting in machinery spaces.

Figure 3: Transceiver Unit

Specification	Value
Power	48VDC from Sonar Processor
Dimensions	265mm x 483mm x 469mm
Weight	15kg
Temperature	Operation: -5° to 40° C Storage: -30° to 55° C

Table 5: Transceiver

Sonar Processor

The Sonar Processor is a high-performance unit that manages data flow and signal processing using state-of-the-art FPGA processing architecture. This highly integrated design offers reliability, maintainability, and high performance in a small size.

The Sonar Processor offers a highly flexible platform that supports a number of disparate functions, including highly accurate time stamping, storage of interfaced sensors, and optional beam data storage on a large, external RAID array, in addition to more standard functions such as user displays and control interface. It is housed inside a 19", 5U high rack-mounted chassis and receives data from the Transceiver Unit.

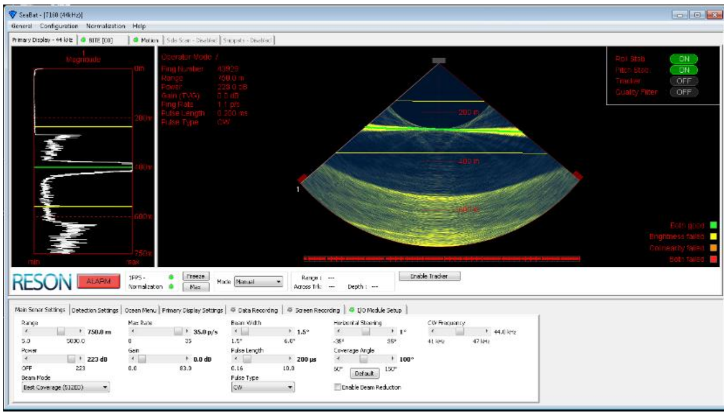
The Sonar Processor performs the following functions:

- Receives digitized sonar data from the transceiver
- Receives operational settings either directly through the user interface, or remotely from an external system.
- Provides beam forming and initial processing of acoustical data.
- Controls, formats and outputs data to external systems
- Provides an interface for a sound velocity sensor
- Optionally runs survey data acquisition software

Figure 4: Sonar Processor

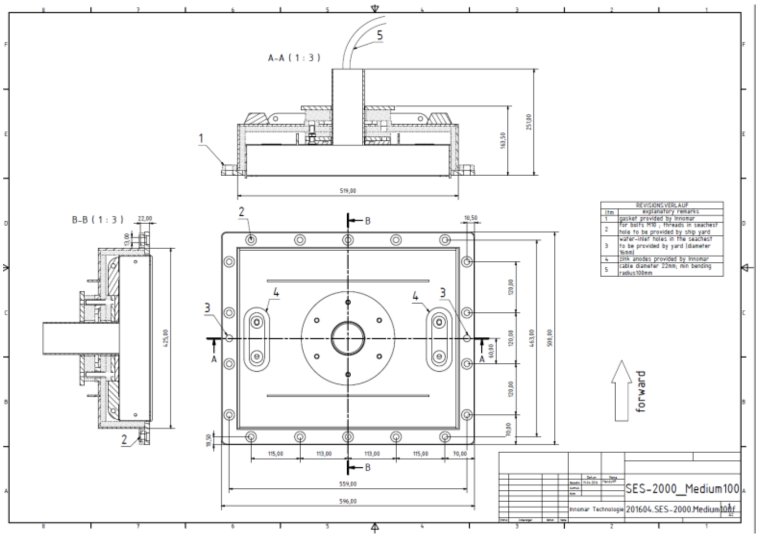
Specification	Value
Dimensions	Height: 221.5 mm ±0.7mm Width: 478.0 mm ± 0.7mm (with mounting ears) Depth: 556.8 mm ±0.7mm (with handles)
Weight	20kg
Temperature	Operating: -15° to +45° C Storage: -30° to +70° C

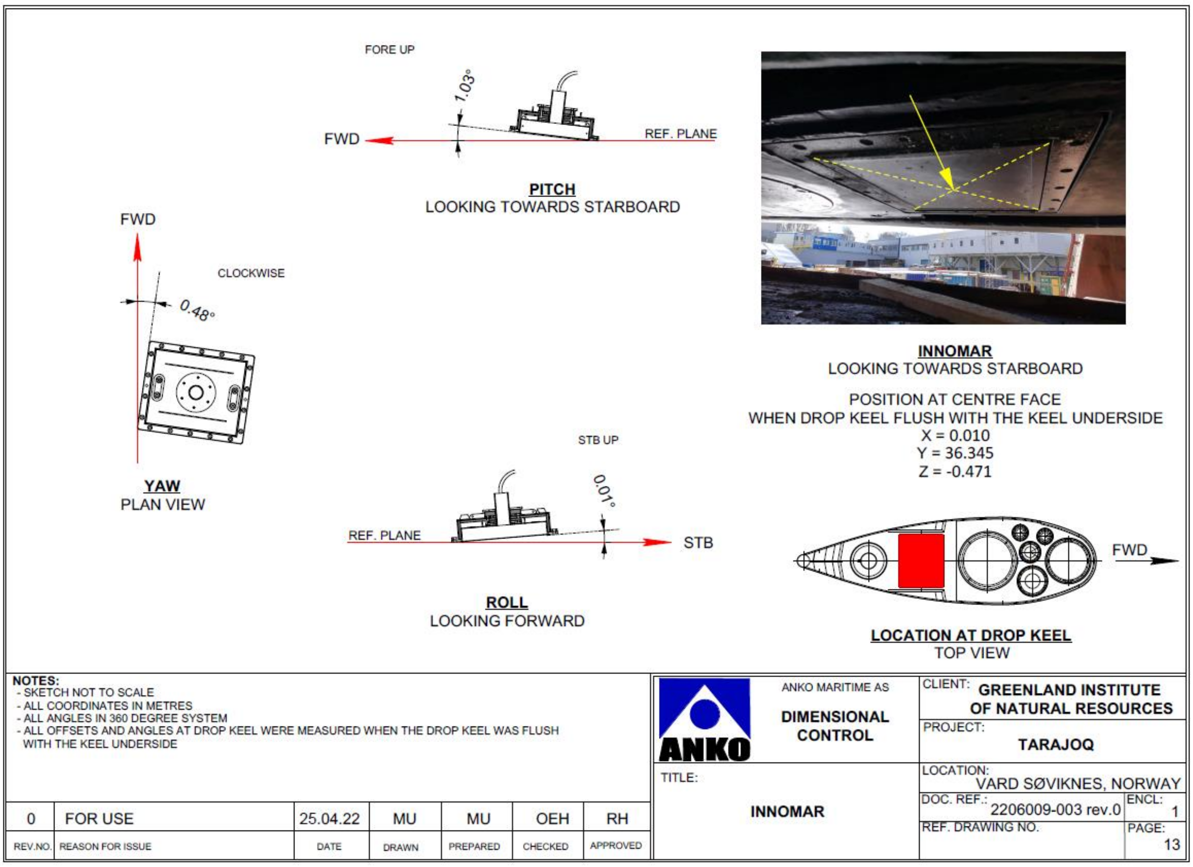
Table 6: Sonar Processor



Appendix 2

Innomar SES-2000 Medium-100 Sub bottom Profiler





8

Appendix 2

Sound Velocity Profiling

Teledyne SVP-70 online Sound Velocity Probe, hull mounted

SVP-70 Sound Velocity Probe

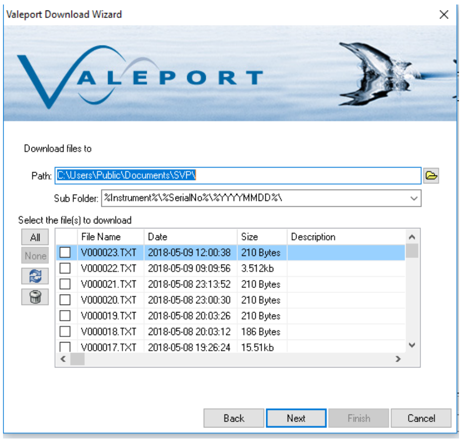
To ensure proper beam steering, the sonar requires the input of the local sound velocity at the transducers. The Sound Velocity Probe (SVP) is used to continuously report this value to the Sonar Processor Unit. The unit described below may be purchased from RESON as an option, or a SVP of similar specifications may be supplied.

Specification	Value
Sound Velocity	Range: 1350 - 1800 meters per second Resolution: 0.01 m/sec Accuracy: ±0.25 m/sec Sampling rate: 20Hz (programmable)
Depth Rating	6,000m (operational)
Ultrasonic Transmitter	Frequency: 2 MHz (nominal)
Cable Length	25m (standard)
Connector	Birns MCBH9MTT* (Titanium)
Data Interface	True RS-232 and True RS-422 (MCBH9M) Baud rate 2400-115200 Standard setup RS-232 configured as 9600,n,1
Operating Temperature	-20 to +55°C
Power Consumption	150mA at 12 V
Operating Power	9 - 55VDC
Housing	Titanium
Weight	Approx. 1 kg (excluding cable)
Dimensions	Tube Diameter: 44mm Length: 165mm (excluding connector) End-cap height: 69mm (maximum)

Table 8: SVP-70

Figure 13: SVP-70

Valeport miniSVP Sound Velocity Probe, for over the side profiling of water column, DataLog X2 software



Appendix 2

Sensors

Fitted with Valeport's digital time of flight sound velocity sensor, a PRT temperature sensor, and piezo-resistive pressure transducer.

Sound Velocity

Range	1375 - 1900m/s
Resolution	0.001m/s
Accuracy	±0.02m/s

Temperature

Range	-5°C - +35°C
Resolution	0.001°C
Accuracy	±0.01°C

Pressure

Range	5, 10, 30, 50, 100, 300 or 600 Bar
Resolution	0.001% range
Accuracy	±0.05% range

Data Acquisition

Features a selection of pre-programmed sampling regimes, covering many standard applications. Data may be sampled from 1 to 16Hz, making it suitable for rapid profiling or for continuous measurement at a fixed point.

Sampling Modes

Continuous	Regular output from all sensors at 1, 2, 4, 8 or 16Hz
Profile	Logs data as the device falls (or rises) by a defined amount through the water column.

Communications

Will operate autonomously, with setup and data extraction performed by direct communications with PC. Operates in real time, with a choice of communication protocols fitted as standard and selected by pin choice on the output connector.

RS232	Up to 200m cable, direct to serial port
RS485	Up to 1000m cable
Baud Rate	38400, 57600 or 115200
Protocol	8 data bits, 1 stop bit, No parity, No flow control
Bluetooth	Bluetooth logger and communication set available for cable free data recovery. Bluetooth module is limited to a depth rating of 500m.

Memory

Fitted with a solid state non-volatile Flash memory, capable of storing over 10 million lines of data (equivalent to 10,000 profiles to 500m, at 1m profile resolution).

Electrical

Internal	1 x C cell, 1.5V alkaline or 3.6V lithium
External	9 – 28V DC
Power	<250mW
Battery Life	approximately 30 hours operation (alkaline) approximately 90 hours operation (lithium)
Connector	SubConn MCBH10F

Physical

Materials	Acetal or Titanium housing (as ordered) Polycarbonate & Composite sensor components. Stainless steel (316) deployment cage
Depth Rating	500m (Acetal) 6000m (Titanium)
Note:	Maximum deployment depth may be limited by pressure transducer range
Instrument Size	Main Housing: 48mmØ Sensor Body: 54mmØ Length: 435mm (including connector)
Deployment Cage	110mmØ x 450mm long
Weight	0.8kg (Acetal) | 1.6kg (Titanium)
Shipping	51 x 42 x 27cm | 10kg

Software

The system is supplied with DataLog X2 software, for instrument setup, data extraction and display. DataLog X2 is licence free.

Ordering

0660001-XX	miniSVP Sound Velocity Profiler in Acetal Supplied with: • Deployment cage • Switch plug • 3m comms lead • DataLog X2 software • Manual and transit case
0660001BT-XX	miniSVP Sound Velocity Profiler in Acetal Supplied with: • Deployment cage • Switch plug • Bluetooth logger/communication set • DataLog X2 software • Manual and transit case
Note:	**XX** denotes pressure transducer range Select from 5, 10, 30 or 50bar
0660002-XX	miniSVP Sound Velocity Profiler in Titanium Supplied with: • Deployment cage • Switch plug • 3m comms lead • DataLog X2 software

Appendix 2

The configuration settings

Table 1 Offsets with IMU as reference origin and Applanix sign convention.

REFERENCE FRAME: APPL. +X FWD, +Y STBD, +Z DOWN REFERENCE ORIGIN: IMU REF POINT		LINEAR OFFSETS Alongship	 Athwartship	 Vertical	ANGULAR OFFSETS Roll	 Pitch	 Yaw
TARGET	SOURCE	+ FWD (X)	+ STBD (Y)	+ DOWN (Z)	+ PORT UP	+ BOW UP	+ COMPASS
Vessel Reference Point Baseline at Rudderstock	Calculated	-41.803	-0.504	16.81			
Center of Gravity	Calculated	-16.468	-0.504	9.331			
POS MV IMU Ref. Point	By definition	0	0	0	-0.39	-0.13	0.04
RESON 7160 TX Array	Calculated	6.747	-0.463	16.877	-0.23	2.09	0.26
RESON 7160 RX Array	Calculated	7.73	-0.461	16.806	-0.15	2.5	-0.15
GNSS Antenna PORT (ID 41)	Calculated	-10.252	-2.234	-12.628			
GNSS Antenna STBD (ID 40)	Calculated	-10.143	1.226	-12.65			

Table 2 Offsets with IMU as reference origin and Reson sign convention.

REFERENCE FRAME: RESON+X STBD, +Y BOW, +Z UP REFERENCE ORIGIN: IMU REF POINT		LINEAR OFFSETS Alongship	 Athwartship	 Vertical	ANGULAR OFFSETS Roll	 Pitch	 Yaw
TARGET	SOURCE	+ FWD (Y)	+ STBD (X)	+ UP (Z)	+ PORT UP	+ BOW UP	+ COMPASS
Vessel Reference Point Baseline at Rudderstock	Calculated	-41.803	-0.504	-16.81			
Center of Gravity	Calculated	-16.468	-0.504	-9.331			
POS MV IMU Ref. Point	By definition	0	0	0	-0.39	-0.13	0.04
RESON 7160 TX Array	Calculated	6.747	-0.463	-16.877	-0.23	2.09	0.26
RESON 7160 RX Array	Calculated	7.73	-0.461	-16.806	-0.15	2.5	-0.15
RESON 7160 TX Array relative to RX	Calculated	-0.983	-0.002	-0.071			
GNSS Antenna PORT (ID 41)	Calculated	-10.252	-2.234	12.628			
GNSS Antenna STBD (ID 40)	Calculated	-10.143	1.226	12.65			

List of key personnel employed and their responsibilities

Name	Title	Responsibilities On Board	Responsibilities On Shore
Helle Siegstad	Head of Department of Fish and Crustaceans	General responsibility of On Board cruise management	General project manager, logistics, economy, general planning
Aqqaluk Sørensen	Geophysicist, Department of Environment and Minerals	Configuration of instruments, calibrations, data acquisition and instrument operation, navigation directives to vessel operator, SVP probing.	Detailed survey planning. Instruments, calibrations, calculations. Geophysical and bathymetric data processing. QA/QC. Interpretation and reporting
Karl Zinglersen	GIS manager, Department of Environment and Minerals	Data acquisition and instrument operation, navigation directives to vessel operator, daily logs	Project and survey planning, reporting, data QA/QC, communication to client
Mala Broberg	Program coordinator, Greenland Climate Research Center	Data acquisition and instrument operation, navigation directives to vessel operator.	None
Jukka Wagnholt	Consultant, self-employed	Data acquisition and instrument operation, navigation directives to vessel operator. Technician on instruments	Documentation of data network
Jakup Mikkelsen	Captain, Tarajoq	Chief captain on R/V Tarajoq	Navigation reporting
Klaus T Nedergaard	Vessel manager	None	Planning of vessels' manning, maintainence and schedule

# DAILY PROJECT REPORT		PINNGORTITALERIFFIK GRØNLANDS NATURINSTITUT GREENLAND INSTITUTE OF NATURAL RESOURCES	
REPORT NO.:	001	DATE:	2022-11-30
VESSEL:	R/V Tarajoq	VHF CALL SIGNAL:	OYLD
VESSEL TELEPHONE:	+45 32421294	VESSEL E-MAIL:	Tarajoq.bridge@natur.gl
PROJECT NAME:	Tusass Connect Nuuk		
PROJECT NO.:	61014 /	PARTY CHIEF:	Karl Zinglersen
PROJECT MANAGER:	Helle Siegstad	PARTY CHIEF email.:	kazi@natur.gl
RECEIVERS OF DAILY REPORTS:			
Name:	Company:	Email:	Note:
Mads H. Petersen	Tusass	mhp@tusass.gl	Project manager, Tusass
Ture Jönsson	(Tusass)	tj@smeds.dk	Advisor to project
Steen Hansen	Tusass	sha@tusass.gl	Head of Department
Niklas Carlsson	Baltic Offshore	niklas@balticoffshore.se	Advisor to project
Helle Siegstad	GINR	hesi@natur.gl	Head of Department
POSITION AND OVERVIEW:			
Geographical position of the survey vessel at the time of the report and include an overview chart showing completed and non-completed sections.			
Position (Lat./Lon):	NA	NA	
Section:	NA	Area name:	Nuuk harbor
Overview chart insert:			
NA			

LAST SAVED: 02-01-2023 15:21:00 (local time)

PROGRESS AND EVENTS

SUMMARY OF WORK:

Summary of the work performed during the preceding 24 hours

Vessel in Nuuk harbor in morning. Setting up of: MBES operator computer to sonar room rack, network connectivity to sonar LAN network with assistance from Vodanet, Adder screens to operator computer w DVI to mini-display port, POSView network setup, POS Trimble RTX configuration with assistance from Applanix, Valeport SVP Datalog software configuration.
Afternoon: departure from Nuuk 15:10 local time. Patch test survey on slope and flat seabed close to Nuuk. Three times up and down slope, two times each way on flat area, two times across a distinctive feature. Run of SVP.
At harbor 18:45
Backup and finishing until 20:00

SUMMARY OF PLANNED WORK:

Summary of planned work for the next 24 hours

Wednesday will include processing of patch test data, setup of survey plan, setup K-Sync, Innomar SBP, extension of screens on Adder system. Plan for the next day's start of survey.

WEATHER AND SEA STATE:

LAST 24 HRS:	Not recorded
FORECAST 24 HRS:	Not recorded

SIGNIFICANT EVENTS THE LAST 24 HOURS:

Notes on: samplings, start and finish of sections, technical breakdowns or other issues, safety issues, navigation events, activities from fishery, shipping or other offshore activities.

15:00	Departure from Nuuk for patch test and sea trials
19:00	Arrival to harbor
20:00	End of day's work

LAST SAVED: 02-01-2023 15:21:00 (local time)

TIME STATISTICS			
Time spent on effective work during each 24 hour period and cumulative total.(ship time, not man hours)			
Activity	**Last 24 hours**	**Cummulative**	**Comments/notes**
Mobilization/demob.	7	7	Configurations
In transit			
WDT standby			
Ship downtime	1	1	Opening of HY hangar door
Other (comments)			
Sampling work			
Surveying work	4	4	Patch test
Total time (24h)	**12**	**12**	**Not full 24h**
TIME ON DAY RATE			
Mobilization/demob.	0	0	
In transit / survey	0	0	
Weather Down Time	0	0	
Ship downtime	0	0	
Other (comments)	0	0	
Sampling work	0	0	
Surveying work	0	0	
Total time (24h)	**0**	**0**	
TOTAL SURVEY TIME	**12**	**12**	

LENGTH STATISTICS (km)			
Survey track	0	0	
Proposed cable route	0	0	

SUMMARY OF SECTION
SEABED MORPHOLOGY AND SURFACE GEOLOGY
Steep slope with outcrop at c. 50 m, flat seabed at c. 300 m
SEABED SUBSURFACE GEOLOGY
Not applicable
OTHER OBSERVATIONS
Not applicable

LAST SAVED: 02-01-2023 15:21:00 (local time)

<table>
<tr><td colspan="4">COMMENTS & ENDORSEMENT</td></tr>
<tr><td colspan="4">COMMENTS</td></tr>
<tr><td colspan="4">Deviations, additions, alterations from survey party chief</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td colspan="4">REPRESENTATIVES’ COMMENTS</td></tr>
<tr><td colspan="4">Comments from the clients representative</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td colspan="4">SIGNATURES</td></tr>
<tr><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td colspan="2">Karl Zinglersen</td><td colspan="2">Niklas Carlsson</td></tr>
<tr><td colspan="2">Party chief</td><td colspan="2">Client representative</td></tr>
<tr><td>Date:</td><td></td><td>Date:</td><td></td></tr>
</table>

LAST SAVED: 02-01-2023 15:21:00 (local time)

DAILY PROJECT REPORT		PINNGORTITALERIFFIK GRØNLANDS NATURINSTITUT GREENLAND INSTITUTE OF NATURAL RESOURCES	
REPORT NO.:	002	DATE:	2022-12-01
VESSEL:	R/V Tarajoq	VHF CALL SIGNAL:	OYLD
VESSEL TELEPHONE:	+45 32421294	VESSEL E-MAIL:	Tarajoq.bridge@natur.gl
PROJECT NAME:	Tusass Connect Nuuk		
PROJECT NO.:	61014 /	PARTY CHIEF:	Karl Zinglersen
PROJECT MANAGER:	Helle Siegstad	PARTY CHIEF email.:	kazi@natur.gl
RECEIVERS OF DAILY REPORTS:			
Name:	Company:	Email:	Note:
Mads H. Petersen	Tusass	mhp@tusass.gl	Project manager, Tusass
Ture Jönsson	(Tusass)	tj@smeds.dk	Advisor to project
Steen Hansen	Tusass	sha@tusass.gl	Head of Department
Niklas Carlsson	Baltic Offshore	niklas@balticoffshore.se	Advisor to project
Helle Siegstad	GINR	hesi@natur.gl	Head of Department
POSITION AND OVERVIEW:			
Geographical position of the survey vessel at the time of the report and include an overview chart showing completed and non-completed sections.			
Position (Lat./Lon):	NA	NA	
Section:	NA	Area name:	Nuuk harbor, off Nuuk
Overview chart insert:			
Patch test area off Nuuk and work in Nuuk office of recorded data			

LAST SAVED: 02-01-2023 15:22:00 (local time)

PROGRESS AND EVENTS	
SUMMARY OF WORK:	
Summary of the work performed during the preceding 24 hours	
Summary of the work performed during the preceding 24 hours, Data processing of patch test data from the day before. Experienced a gross error on upslope/downslope measurements. Approximately 13 seconds delay resulting in several meters offset. The error was identified as a time delay between instruments, and Teledyne Marine was consulted. Check of configuration in PDS and changing Clock synchronization from POSMV to Seabat. Conducted new patch test survey on the slope off Nuuk, starting at 15:00 local time.	
SUMMARY OF PLANNED WORK:	
Summary of planned work for the next 24 hours	
Summary of planned work for the next 24 hours. Processing and reporting of new patch test. Planning of new ETD considering last mobilization efforts needed, and reporting to client and vessel crew of new ETD.	
WEATHER AND SEA STATE:	
LAST 24 HRS:	Not recorded
FORECAST 24 HRS:	Not recorded
SIGNIFICANT EVENTS THE LAST 24 HOURS:	
Notes on: samplings, start and finish of sections, technical breakdowns or other issues, safety issues, navigation events, activities from fishery, shipping or other offshore activities.	
8:00	Start of data processing and analysis of patch test
15:00	Start of new patch test survey off Nuuk
20:00	Leaving vessel after return to Nuuk harbor, backup procedures etc.

LAST SAVED: 02-01-2023 15:22:00 (local time)

TIME STATISTICS			
Time spent on effective work during each 24 hour period and cumulative total.(ship time, not man hours)			
Activity	**Last 24 hours**	**Cummulative**	**Comments/notes**
Mobilization/demob.	12	24	
In transit	0	0	
WDT standby	0	0	
Ship downtime	0	0	
Other (comments)	0	0	
Sampling work	0	0	
Surveying work	0	0	
Total time (24h)	**12**	**24**	**Not full 24h**
TIME ON DAY RATE			
Mobilization/demob.	0	0	
In transit / survey	0	0	
Weather Down Time	0	0	
Ship downtime	0	0	
Other (comments)	0	0	
Sampling work	0	0	
Surveying work	0	0	
Total time (24h)	**0**	**0**	
TOTAL SURVEY TIME	**12**	**24**	

LENGTH STATISTICS (km)			
Survey track	0	0	
Proposed cable route	0	0	

SUMMARY OF SECTION
SEABED MORPHOLOGY AND SURFACE GEOLOGY
SEABED SUBSURFACE GEOLOGY
OTHER OBSERVATIONS

LAST SAVED: 02-01-2023 15:22:00 (local time)

COMMENTS & ENDORSEMENT			
COMMENTS			
Deviations, additions, alterations from survey party chief			
REPRESENTATIVES' COMMENTS			
Comments from the clients representative			
SIGNATURES			
Karl Zinglersen		Niklas Carlsson	
Party chief		Client representative	
Date:		Date:	

LAST SAVED: 02-01-2023 15:22:00 (local time)

# DAILY PROJECT REPORT		PINNGORTITALERIFFIK GRØNLANDS NATURINSTITUT GREENLAND INSTITUTE OF NATURAL RESOURCES	
REPORT NO.:	03	DATE:	2022-12-02
VESSEL:	R/V Tarajoq	VHF CALL SIGNAL:	OYLD
VESSEL TELEPHONE:	+45 32421294	VESSEL E-MAIL:	Tarajoq.bridge@natur.gl
PROJECT NAME:	Tusass Connect Nuuk		
PROJECT NO.:	61014 /	PARTY CHIEF:	Karl Zinglersen
PROJECT MANAGER:	Helle Siegstad	PARTY CHIEF email.:	kazi@natur.gl
RECEIVERS OF DAILY REPORTS:			
Name:	Company:	Email:	Note:
Mads H. Petersen	Tusass	mhp@tusass.gl	Project manager, Tusass
Ture Jönsson	(Tusass)	tj@smeds.dk	Advisor to project
Steen Hansen	Tusass	sha@tusass.gl	Head of Department
Niklas Carlsson	Baltic Offshore	niklas@balticoffshore.se	Advisor to project
Helle Siegstad	GINR	hesi@natur.gl	Head of Department
POSITION AND OVERVIEW:			
Geographical position of the survey vessel at the time of the report and include an overview chart showing completed and non-completed sections.			
Position (Lat./Lon):			
Section:		Area name:	Nuuk harbor
Overview chart insert:			
Work in office at Greenland Institute of Natural Resources			

LAST SAVED: 02-01-2023 15:22:00 (local time)

PROGRESS AND EVENTS

SUMMARY OF WORK:

Summary of the work performed during the preceding 24 hours

Analysing data from patch tests at 30th november and 1st December. Contact with multi beam system provider Teledyne Marine RESON in Denmark. The two patch tests revealed an offset of c. 89 m along track when covering a steep slope from Malenebugt to Godthåbsfjord basin. The matters was discussed with the provider and analysed separately. AQQS discovered that there must be mistakes in the coordinate system configuration of POSView and PDS on board. Together with our US partner Multibeam Advisory Committee (MAC) servicing the US Academic Fleet

SUMMARY OF PLANNED WORK:

Summary of planned work for the next 24 hours

Update settings to new coordinate system
New test off Nuuk
Start of survey if successful

WEATHER AND SEA STATE:

LAST 24 HRS:	Severe storm came at 13:00 local time
FORECAST 24 HRS:	Storm will end c. 14:00, Dec 3, 2022

SIGNIFICANT EVENTS THE LAST 24 HOURS:

Notes on: samplings, start and finish of sections, technical breakdowns or other issues, safety issues, navigation events, activities from fishery, shipping or other offshore activities.

08:00	Start of office work
13:00	Severe weather started
14:00	Break
15:00	Visit at vessel for configuration
16:00	End of day

LAST SAVED: 02-01-2023 15:22:00 (local time)

TIME STATISTICS			
Time spent on effective work during each 24 hour period and cumulative total.(ship time, not man hours)			
Activity	**Last 24 hours**	**Cummulative**	**Comments/notes**
Mobilization/demob.	8	32	Vessel RF calculations
In transit	0	0	
WDT standby	16	16	
Ship downtime	0	0	
Other (comments)	0	0	
Sampling work	0	0	
Surveying work	0	0	
Total time (24h)	**24**	**48**	
TIME ON DAY RATE			
Mobilization/demob.	0	0	
In transit / survey	0	0	
Weather Down Time	0	0	
Ship downtime	0	0	
Other (comments)	0	0	
Sampling work	0	0	
Surveying work	0	0	
Total time (24h)	**0**	**0**	
TOTAL SURVEY TIME	**24**	**48**	

LENGTH STATISTICS (km)			
Survey track			
Proposed cable route			

SUMMARY OF SECTION
SEABED MORPHOLOGY AND SURFACE GEOLOGY
NA
SEABED SUBSURFACE GEOLOGY
NA
OTHER OBSERVATIONS
NA

LAST SAVED: 02-01-2023 15:22:00 (local time)

COMMENTS & ENDORSEMENT			
COMMENTS			
Deviations, additions, alterations from survey party chief			
REPRESENTATIVES' COMMENTS			
Comments from the clients representative			
SIGNATURES			
Karl Zinglersen		Niklas Carlsson	
Party chief		Client representative	
Date:		Date:	

LAST SAVED: 02-01-2023 15:22:00 (local time)

# DAILY PROJECT REPORT		PINNGORTITALERIFFIK GRØNLANDS NATURINSTITUT GREENLAND INSTITUTE OF NATURAL RESOURCES	
REPORT NO.:	04	DATE:	2022-12-03
VESSEL:	R/V Tarajoq	VHF CALL SIGNAL:	OYLD
VESSEL TELEPHONE:	+45 32421294	VESSEL E-MAIL:	Tarajoq.bridge@natur.gl
PROJECT NAME:	Tusass Connect Nuuk		
PROJECT NO.:	61014 /	PARTY CHIEF:	Karl Zinglersen
PROJECT MANAGER:	Helle Siegstad	PARTY CHIEF email.:	kazi@natur.gl
RECEIVERS OF DAILY REPORTS:			
Name:	Company:	Email:	Note:
Mads H. Petersen	Tusass	mhp@tusass.gl	Project manager, Tusass
Ture Jönsson	(Tusass)	tj@smeds.dk	Advisor to project
Steen Hansen	Tusass	sha@tusass.gl	Head of Department
Niklas Carlsson	Baltic Offshore	niklas@balticoffshore.se	Advisor to project
Helle Siegstad	GINR	hesi@natur.gl	Head of Department
POSITION AND OVERVIEW:			
Geographical position of the survey vessel at the time of the report and include an overview chart showing completed and non-completed sections.			
Position (Lat./Lon):	None recorded	None recorded	
Section:	Entire	Area name:	Nuuk skærgård
Overview chart insert:			

Nuuk patch test area. Nuuk Ring route. Nuuk along Skærgårdsruten northern part to AC46.

LAST SAVED: 02-01-2023 15:23:00 (local time)

PROGRESS AND EVENTS

SUMMARY OF WORK:

Summary of the work performed during the preceding 24 hours

Start up on harbor. Inserting of newly calculated coordinate system values. Start from Nuuk at around 9:30/10:00 local time. Four runs on patch test slope, 6 and 12 knots. Result showed no offset and very good resolution. Further analysis displayed that we should take care of sharper turns, which produce offsets, apparently.
Start of Nuuk Ring route from oil harbor (WP 0535) to Qinngorput (WP0451). Then along the coast near Qinngorput, then back to Nuuk harbor south of the route and then north of route.
Cummulative swath of c. 700 m. Needs to be expanded with one or two lines more.
Start on Nuuk Skærgårsdsrute from WP0534 along center line to AC03, return for SVP between AC02 and AC03, continue to WP0534, turn and towards AC03.
Then continue along the centerline.
Swells/waves at AC10-AC14. Small gap at AC13
PDS did not log without warning in a large stretch between AC25-AC26. The gap was filled after the incident was identified.
Due to large waves/swells producing swells under the keel, survey towards south west stopped at AC45, returning at 2022-12-04 5:40 UTC on the eastern side of the main route.

SUMMARY OF PLANNED WORK:

Summary of planned work for the next 24 hours

Continue to end of line, but there are reports of severe weather, and the region near AC40 is in an area of regular swells and unprotected.

WEATHER AND SEA STATE:

LAST 24 HRS:	
FORECAST 24 HRS:	

SIGNIFICANT EVENTS THE LAST 24 HOURS:

Notes on: samplings, start and finish of sections, technical breakdowns or other issues, safety issues, navigation events, activities from fishery, shipping or other offshore activities.

08:00 local	All on board, configurations
13:30 UTC	Departure from Nuuk
14:00 UTC	Start of new patch test and calibrations
17:30 UTC	Start of Nuuk Ring route
19:00 UTC	End of Nuuk Ring route, Start of Nuuk Skærgård route
19:30 UTC	Sound velocity profile
20:00 UTC	Start of logging
21:00	Waves and problems with air bubbles
01:00	Problem with PDS logging, covered afterwards
02:30	Sound velocity profile
03:00	Avoiding fishing equipment

LAST SAVED: 02-01-2023 15:23:00 (local time)

TIME STATISTICS			
Time spent on effective work during each 24 hour period and cumulative total.(ship time, not man hours)			
Activity	**Last 24 hours**	**Cummulative**	**Comments/notes**
Mobilization/demob.	4	36	Patch test
In transit	0	0	
WDT standby	8	24	
Ship downtime	0	0	
Other (comments)	0	0	
Sampling work	0	0	
Surveying work	0	0	
Total time (24h)	**12**	**60**	
TIME ON DAY RATE			
Mobilization/demob.	0	0	
In transit / survey	1	1	
Weather Down Time	0	0	
Ship downtime	0	0	
Other (comments)	0	0	
Sampling work	1	1	
Surveying work	10	10	
Total time (24h)	**12**	**12**	
TOTAL SURVEY TIME	**24**	**82**	

LENGTH STATISTICS (km)			
Survey track	Not recorded		
Proposed cable route	Not recorded		

SUMMARY OF SECTION
SEABED MORPHOLOGY AND SURFACE GEOLOGY
Nuuk Ring: Rocky shores near landing points WP0537 and WP0530. Otherwise flat or soft morphology of sediments. Malenebugten (AC01-03): soft morphology of sediments Nuuk Skærgård center line route (AC03-xx) soft morphology of sediments, rocky outcrops dispersed particularly near AC15/AC16, where two deeper grounds are separated. It is needed to find a route south or north of the largest outcrop.
SEABED SUBSURFACE GEOLOGY
OTHER OBSERVATIONS

LAST SAVED: 02-01-2023 15:23:00 (local time)

COMMENTS & ENDORSEMENT			
COMMENTS			
Deviations, additions, alterations from survey party chief			
REPRESENTATIVES' COMMENTS			
Comments from the clients representative			
SIGNATURES			
Karl Zinglersen		Niklas Carlsson	
Party chief		Client representative	
Date:		Date:	

LAST SAVED: 02-01-2023 15:23:00 (local time)

DAILY PROJECT REPORT		PINNGORTITALERIFFIK GRØNLANDS NATURINSTITUT GREENLAND INSTITUTE OF NATURAL RESOURCES	
REPORT NO.:	05	DATE:	2022-12-04
VESSEL:	R/V Tarajoq	VHF CALL SIGNAL:	OYLD
VESSEL TELEPHONE:	+45 32421294	VESSEL E-MAIL:	Tarajoq.bridge@natur.gl
PROJECT NAME:	Tusass Connect Nuuk		
PROJECT NO.:	61014 /	PARTY CHIEF:	Karl Zinglersen
PROJECT MANAGER:	Helle Siegstad	PARTY CHIEF email.:	kazi@natur.gl
RECEIVERS OF DAILY REPORTS:			
Name:	Company:	Email:	Note:
Mads H. Petersen	Tusass	mhp@tusass.gl	Project manager, Tusass
Ture Jönsson	(Tusass)	tj@smeds.dk	Advisor to project
Steen Hansen	Tusass	sha@tusass.gl	Head of Department
Niklas Carlsson	Baltic Offshore	niklas@balticoffshore.se	Advisor to project
Helle Siegstad	GINR	hesi@natur.gl	Head of Department
POSITION AND OVERVIEW:			
Geographical position of the survey vessel at the time of the report and include an overview chart showing completed and non-completed sections.			
Position (Lat./Lon):	Not recorded		
Section:	Nuuk Skærgård	Area name:	
Overview chart insert:			
Nuuk Skærgård route between AC26 and Anchor (AC14) No overview chart recorded			

LAST SAVED: 02-01-2023 15:23:00 (local time)

PROGRESS AND EVENTS

SUMMARY OF WORK:

Summary of the work performed during the preceding 24 hours

Ending first line of Nuuk skærgård, ended at c. AC45 due to severe swells and waves, which gave air bobbles under the sonar. Returned along Eastern/Northern part of the main route.
Took SVP near AC20. Area between AC25 and AC26 was not mapped due to signal or software failure. Was covered afterwards.
Returned North through Nuuk Skærgård between AC45 and Anchor, East of the main track, turned on Anchor and returned South along the West side of the main track. SVP at AC19. Continued South.
Meeting at 10:00 local time: Niklas, Karl, and Aqqaluk. Went through the intermediate bathymetry 5m grid model from start of survey to c. 2022-12-04 8:00. New areas were identified along the track for covering possible alternative routes. The weather forecast for the coming 24-48 hours is severe for the outer regions at around AC30, and not possible to cover in this survey. It was decided to try come as much South and offshore as possible and reasonable. The mapping work and general management of the survey including alternative measures was orally approved by Niklas. Niklas was presented with the daily reports until date, with no comments from his side, and they are considered as endorsed.

Already at AC26 the waves were too large for reasonable mapping and air bubbles disturbed the signal.
Return North on the East side of the track also covering the alternative routes, starting at AC25 at around 15:00 local time.

SUMMARY OF PLANNED WORK:

Summary of planned work for the next 24 hours

Covering the alternative routes, and broadening the swath coverage north of AC26, and not covering areas near and south of AC26 due to weather.
Approaching Nuuk at around 2022-12-05 12:00.
Further backup procedures and preparation of intermediate models

WEATHER AND SEA STATE:

LAST 24 HRS:	
FORECAST 24 HRS:	Severe weather, particularly offshore

SIGNIFICANT EVENTS THE LAST 24 HOURS:

Notes on: samplings, start and finish of sections, technical breakdowns or other issues, safety issues, navigation events, activities from fishery, shipping or other offshore activities.

05:45 UTC	Severe weather with waves, giving air bubbles under keel.
11:30	SVP
16:30	SVP
20:15	SVP
01:15	Heavy waves giving air bubbles under keel
01:25	Survey northbound
03:00	SVP
03:00	Survey continuing Southbound

LAST SAVED: 02-01-2023 15:23:00 (local time)

TIME STATISTICS			
Time spent on effective work during each 24 hour period and cumulative total.(ship time, not man hours)			
Activity	**Last 24 hours**	**Cummulative**	**Comments/notes**
Mobilization/demob.	0	36	
In transit	0	0	
WDT standby	0	24	
Ship downtime	0	0	
Other (comments)	0	0	
Sampling work	0	0	
Surveying work	0	0	
Total time (24h)	**0**	**60**	
TIME ON DAY RATE			
Mobilization/demob.	0	0	
In transit / survey	0	1	
Weather Down Time	0	0	
Ship downtime	0	0	
Other (comments)	0	0	
Sampling work	4	5	
Surveying work	20	30	
Total time (24h)	**24**	**36**	
TOTAL SURVEY TIME	**24**	**96**	

LENGTH STATISTICS (km)			
Survey track	None recorded		
Proposed cable route	None recorded		

SUMMARY OF SECTION
SEABED MORPHOLOGY AND SURFACE GEOLOGY
None recorded
SEABED SUBSURFACE GEOLOGY
None recorded
OTHER OBSERVATIONS
None recorded

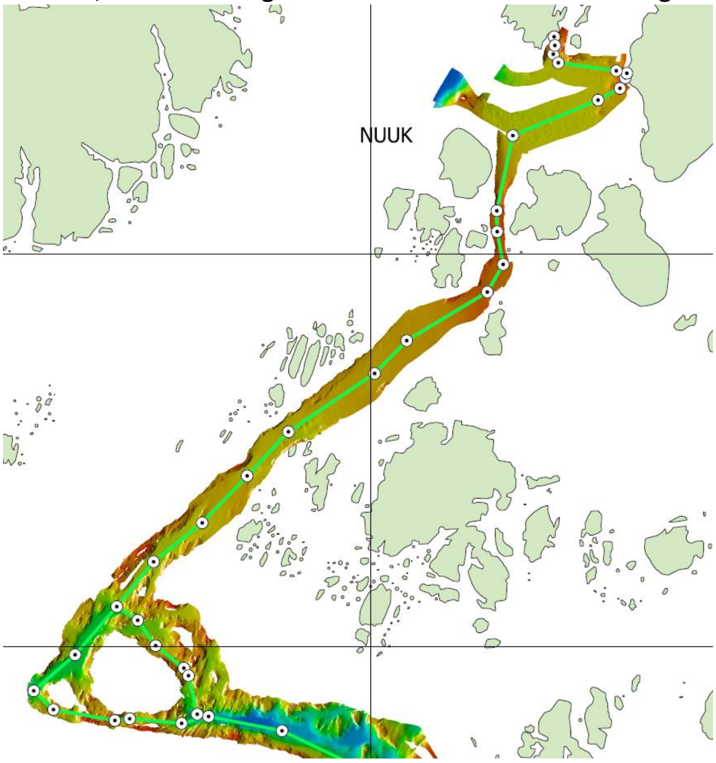
LAST SAVED: 02-01-2023 15:23:00 (local time)

COMMENTS & ENDORSEMENT			
COMMENTS			
Deviations, additions, alterations from survey party chief			
Route between AC 25 and AC 26 not mapped during first run due to software malfunction. Covered in second run. Route from AC 45 and towards West and the ocean is not covered due to severe weather with swells and waves.			
REPRESENTATIVES' COMMENTS			
Comments from the clients representative			
SIGNATURES			
Karl Zinglersen		Niklas Carlsson	
Party chief		Client representative	
Date:		Date:	

LAST SAVED: 02-01-2023 15:23:00 (local time)

DAILY PROJECT REPORT		PINNGORTITALERIFFIK GRØNLANDS NATURINSTITUT GREENLAND INSTITUTE OF NATURAL RESOURCES	
REPORT NO.:	06	DATE:	2022-12-05
VESSEL:	R/V Tarajoq	VHF CALL SIGNAL:	OYLD
VESSEL TELEPHONE:	+45 32421294	VESSEL E-MAIL:	Tarajoq.bridge@natur.gl
PROJECT NAME:	Tusass Connect Nuuk		
PROJECT NO.:	61014 /	PARTY CHIEF:	Karl Zinglersen
PROJECT MANAGER:	Helle Siegstad	PARTY CHIEF email.:	kazi@natur.gl
RECEIVERS OF DAILY REPORTS:			
Name:	Company:	Email:	Note:
Mads H. Petersen	Tusass	mhp@tusass.gl	Project manager, Tusass
Ture Jönsson	(Tusass)	tj@smeds.dk	Advisor to project
Steen Hansen	Tusass	sha@tusass.gl	Head of Department
Niklas Carlsson	Baltic Offshore	niklas@balticoffshore.se	Advisor to project
Helle Siegstad	GINR	hesi@natur.gl	Head of Department
POSITION AND OVERVIEW:			
Geographical position of the survey vessel at the time of the report and include an overview chart showing completed and non-completed sections.			
Position (Lat./Lon):	Not recorded		
Section:		Area name:	Nuuk skærgård
Overview chart insert:			

Northern part of Nuuk Skærgård. Survey of alternative routes near AC22 and AC20, as well as Anchor / AC14. Through the narrow strait to Malenebugten.



LAST SAVED: 02-01-2023 15:23:00 (local time)

PROGRESS AND EVENTS	
SUMMARY OF WORK:	
Summary of the work performed during the preceding 24 hours	
During night 2022-12-04 to 22-12-05 covering the alternative routes near AC18 to AC23 moving North. Early 2022-12-05 covering alternative routes near AC13-16 and broadening the coverage between AC13 to AC06. SVP around AC08. Three times through the narrow strait towards Malenebugten, broadening the coverage to Qinngorput and further to Nuuk. Patch test by the end of the cruise. Six hours waiting for a harbor slot without luck. Transport with dinghy from anchorage to harbor. Six hours after anchoring subsequently.	
SUMMARY OF PLANNED WORK:	
Summary of planned work for the next 24 hours	
Start of data processing and reporting in office.	
WEATHER AND SEA STATE:	
LAST 24 HRS:	
FORECAST 24 HRS:	
SIGNIFICANT EVENTS THE LAST 24 HOURS:	
Notes on: samplings, start and finish of sections, technical breakdowns or other issues, safety issues, navigation events, activities from fishery, shipping or other offshore activities.	
05:17 UTC	Northbound survey
07:30 UTC	Southbound survey
09:15	Direction East towards Nuuk
11:25	Narrow channel finished
11:45	Entering Malene Bugt region
13:11	SVP
14:00	Finishing survey near Nuuk
14:15	Starting calibrations of yaw
15:00	Ending calibrations of yaw
15:00	Waiting for harbor slot
21:00 UTC	Dinghy to set survey crew and Tusass representative to harbor

LAST SAVED: 02-01-2023 15:23:00 (local time)

TIME STATISTICS			
Time spent on effective work during each 24 hour period and cumulative total.(ship time, not man hours)			
Activity	**Last 24 hours**	**Cummulative**	**Comments/notes**
Mobilization/demob.	0	36	
In transit	0	0	
WDT standby	0	24	
Ship downtime	0	0	
Other (comments)	6	6	Anchoring after survey
Sampling work	0	0	
Surveying work	0	0	
Total time (24h)	**6**	**66**	
TIME ON DAY RATE			
Mobilization/demob.	1	1	Yaw calibration check
In transit / survey	0	1	
Weather Down Time	0	0	
Ship downtime	0	0	
Other (comments)	6	6	Waiting for harbor slot
Sampling work	1	6	
Surveying work	10	40	
Total time (24h)	**18**	**54**	
TOTAL SURVEY TIME	**24**	**120**	

LENGTH STATISTICS (km)			
Survey track	Not recorded		
Proposed cable route	Not recorded		

SUMMARY OF SECTION
SEABED MORPHOLOGY AND SURFACE GEOLOGY
Not recorded
SEABED SUBSURFACE GEOLOGY
Not recorded
OTHER OBSERVATIONS
Not recorded

LAST SAVED: 02-01-2023 15:23:00 (local time)

COMMENTS & ENDORSEMENT			
COMMENTS			
Deviations, additions, alterations from survey party chief			
REPRESENTATIVES' COMMENTS			
Comments from the clients representative			
SIGNATURES			
Karl Zinglersen		Niklas Carlsson	
Party chief		Client representative	
Date:		Date:	

LAST SAVED: 02-01-2023 15:23:00 (local time)

Summary of equipment breakdown or repairs

During mobilization and survey no breakdown was reported or repairs needed.

Note:

From the results from tests 30th of November and 1st of December near Nuuk it was required to re-establish the vessel reference coordinate system including change of reference frame and instrument positioning information in positioning and sonar aquisition software using information from the dimensional control survey carried out by ANKO earlier in 2022. The dimensional control survey by ANKO was conducted instead of the original dimensional control survey, which involved serious issues.

The revised calculations of the vessel reference coordinate system and instrument positioning and new patch test on 3rd of December provided a strong solution of offsets, meaning that the corrections for roll, pitch and yaw were minimal.

Bibliography

Anon., 2012. Seamless digital 1:500 000 scale geological map of Greenland, Geological Survey of Denmark and Greenland (GEUS), https://data.geus.dk/MetaVis/Klik.jsp?id=2378&lang=en&lang=en

Anon., 2021. Den grønlandske Lods. Sejladsanvisninger Vestgrønland. Ajourført til SKR 1-2/2021, Geodatastyrelsen. https://gst.dk/media/7013/181109_dgl_vestgronland_dk_skr_1_2_2021.pdf

Anon., 2021: Report. Tarajoq. Dimensional Survey Report. Surveyed at VARD Søviknes in Søvik, Norway. Anko Maritime AS. Client: Greenland Institute of Natural Resources. Document reference: 2206009-003.

Dowdeswell, J. A., Canals, M., Jakobsson, M., Todd, B. J., Dowdeswell, E. K., & Hogan, K. A., (eds) 2016. Atlas of Submarine Glacial landforms: Modern, Quaternary and Ancient. Geological Society, London, Memoirs, 46, http://doi.org/10.1144/M46.

Ghetta, M. et al., 2022, Data Plotly, D3 plots for QGIS. Plugin to QGIS3, release 3.9.2. https://github.com/ghtmtt/DataPlotly

Goudie, A., 2014. Alphabetical glossary of geomorphology. International Association of Geomorphologists, GLOSSARY_OF_GEOMORPHOLOGY1.pdf

Freire, F.F., 2016. High Arctic submarine glaciogenic landscapes. Doctoral Thesis in Marine Geology at Stockholm University, Sweden 2016. Meddelanden från Stockholm Universitets Institutionen för geologiska vetenskaper No. 360. ISBN: 978-91-7649-367-0, diva2:907168, http://su.diva-portal.org/smash/get/diva2:907168/FULLTEXT03.pdf

Jakobsson, M., L Mayer, C Bringensparr, C Castro, R Mohammad, P Johnson, T Ketter, D Accettella, D Amblas, L An, J E Arndt, M Canals, J Casamor, N Chauché, B Coakley, S Danielson, M Demarte, M-L Dickson, B Dorschel, J Dowdeswell, S Dreutter, A Fremand, D Gallant, J Hall, L Hehemann, H Hodnesdal, J Hong, R Ivaldi, E Kane, I Klaucke, D Krawczyk, Y Kristoffersen, B Kuipers, R Millan, G Masetti, M Morlighem, R Noormets, M Prescott, M Rebesco, E Rignot, I Semiletov, A Tate, P Travaglini, I Velicogna, P Weatherall, W Weinrebe, J Willis, M Wood, Y Zarayskaya, T Zhang, M Zimmermann, and K Zinglersen (2020): The International Bathymetric Chart of the Arctic Ocean Version 4.0, Nature Scientific Data (Paper #SDATA-20-00261A)

QGIS Development Team, 2022. QGIS v. 3.28. QGIS Development Team (2022). QGIS Geographic Information System. Open Source Geospatial Foundation Project. http://qgis.org

Pipeline Crossing Report

Marine pipeline crossings

No desktop investigations or assessments or field-based surveys of marine pipelines or cables were required prior to the initiation of the survey or conducted during the survey, nor an In Shore survey required.

During the marine multi beam sonar survey, no pipelines or cables were observed. In the deeper parts of the survey corridor, it would not be possible to detect pipelines or cables due to the footprint of the sonar beams.

The corridor of the telecommunication subsea cable Greenland Connect owned by Tusass A/S runs north of the survey area, with no known crossing of the current planned and accomplished survey corridor. (https://www.tusass.gl/en/infrastructure/submarine-cable/)

Terrestrial pipeline crossings

No desktop investigations or assessments or field-based On Shore surveys of terrestrial pipelines or cables were required prior to the initiation of the survey or conducted during the survey.

However, as a service to the client, it can be stated that multiple types of cables, pipelines or other structures exist within the borders of villages and towns in Greenland: Telecommunication cables, power cables, sewage systems, and energy pipelines, and connected manholes, wells, and erected structures.

It is strongly advised to communicate with the infrastructure owners and/or service providers concerning existing and planned structures:

a) Telecommunication: Tusass A/S
b) Power cables: Nukissiorfiit
c) Sewage systems: Kommuneqarfik Sermersooq or the relevant municipal authority, and Asiaq Greenland Survey for charts and data.
d) Energy pipelines: Polar Oil A/S

The desktop study below draws from publicly available sources on pipelines and cables in the vicinity of the landing points of the Nuuk Ring and Skærgården lines.

With respect to the Planning Act for Greenland, the infrastructure companies and authorities are required to publish this information on the Planning Portal of the national website NunaGIS, www.nunagis.gl for the support of physical planning by the municipalities of Greenland and other stakeholders.

Technical base map of towns and villages

For planning and installation of cables and structures on land and near the coast of towns and villages, it is advised to retrieve the technical base maps of Greenland from Asiaq Greenland Survey, or the drafting office of Tusass A/S.

Telecommunication cables and structures

On the website of Tusass A/S, www.tusass.gl, no information on the location of cables or related structures, or plans hereof, is available. No information on cables is available on NunaGIS either.

It is advised to contact the relevant department of Tusass A/S for further information.

Power cables

On the website of Nukissiorfiit, www.nukissiorfiit.gl, the national utility company for supply of electricity, drinking water and heating, there is geographical information available on transmission and distribution systems, only in Danish.

The information is displayed here: http://maps.nukissiorfiit.gl/ledningskort

The information can be retrieved here: https://portal.nukissiorfiit.gl/portal/apps/sites/#/opendata and as ArcGIS REST services here: https://portal.nukissiorfiit.gl/arcgisserver/rest/services/Opendata/.

Relevant layers (of January 3, 2023) would be OpenData_Gadelys_3182, OpenData_HSP_3182, OpenData_LSP_3182, OpenData_MSP_3182, OpenData_Vand_3182, OpenData_Varme_3182.

Data is in UTM Zone 22N GR96 (EPSG:3182) the Greenland geoid realization of UTM Zone 22 WGS.

For Nuuk Ring, the START HDD (WP0535) near Nuuk Harbor of the planned cable will not affect structures displayed by the Nukissiorfiit utility mapping portal of January 3, 2023.

For Nuuk Ring and Skærgården the landing points near Qinngorput, likewise no structures or cables mapped by Nukissiorfiit would be affected.

There could be other power cables on the landing sites not mapped by Nukissiorfiit.

Energy pipelines

Polar Oil A/S is the national supplier of oil products for shipping, heating, electricity or other purposes. Their rounded tanks are visible in the towns and villages, often near harbors, and included in the technical base maps.

The supply pipelines for oil products are supposedly updated in the technical base map, if located above ground and thus visible for chartered surveyors or by aerial photogrammetry.

Internal (geographical) information from Polar Oil A/S on their utilities is not publicly available.

It is advised to consult the local municipality or Polar Oil for digital copies of the most recent infrastructure before planning the location of landing points.

The existing technical base map from Asiaq Greenland Survey displays that the planned route of Nuuk Ring, START HDD (WP0535), interferes with the location of a pipeline and other structure likely to be operated by Polar Oil.

<u>It is advised to change the starting point START HDD of Nuuk Ring accordingly</u>.

An alternative position for Beach Man Hole is proposed.

The regulations of energy pipelines and structures might involve certain zones around the infrastructure.

<u>It is advised to consult the local authority</u>, Kommuneqarfik Sermersooq.

Sewage system

The municipality of Kommuneqarfik Sermersooq administrates sewer outlet pipes in the vicinity of the planned landing points of Nuuk Ring and Nuuk Skærgård cables. Cables and pipes from other infrastructure companies were not included.

It is advised to obtain the most current material and maps from the municipal authority Kommuneqarfik Sermersooq or the Asiaq Greenland Survey before installation of new cables or establishment of coastal facilities.

No sewer pipes or outlets were observed during the survey, as they are supposed to be located on shallower grounds close to the coastline.

At END HDD of Nuuk Ring and planned START HDD Nuuk Skærgård, a sewer main pipe and outlet is displayed in the sewer charts, Figure 2, and is very close or intersecting with the planned routes.

<u>The positions of the planned start and end HDD on land and connecting drilling of cable route should be changed accordingly</u>.

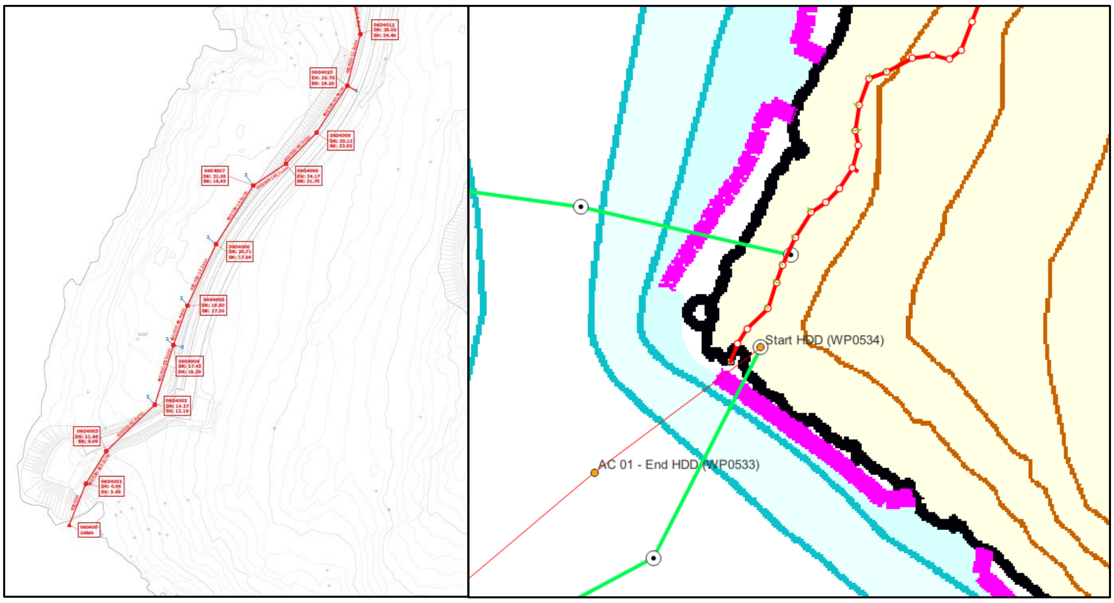


Figure 1: Charts of sewer lines and manholes from Kommuneqarfik Sermersooq municipality, and planned route

Similarly in Nuuk harbor near Start HDD of Nuuk Ring, however of a longer distance, Figure 2.

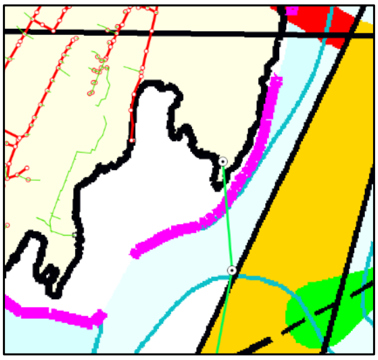


Figure 2: Sewer pipe lines on land and near shore. Source: Kommuneqarfik Sermersooq municipality

Proposal of revised positions of Beach Manholes

GINR has not received information from Tusass on requirements for Beach Man Holes (BHM) considering height above MSL, location in network, distances to other structures or pipes, and similar. It is out of scope of the current marine survey to propose changes to the land based part of the infrastructure.

However, based on a preliminary desktop study using publicly available geographical information from the relevant organizations in Greenland, it is possible to propose relocation of the planned Beach Manholes (BHM) on land.

A. It is advised to move the BHM in Nuuk to the W of the pipeline of Polar Oil A/S used for bunkering of ships, Figure 3.

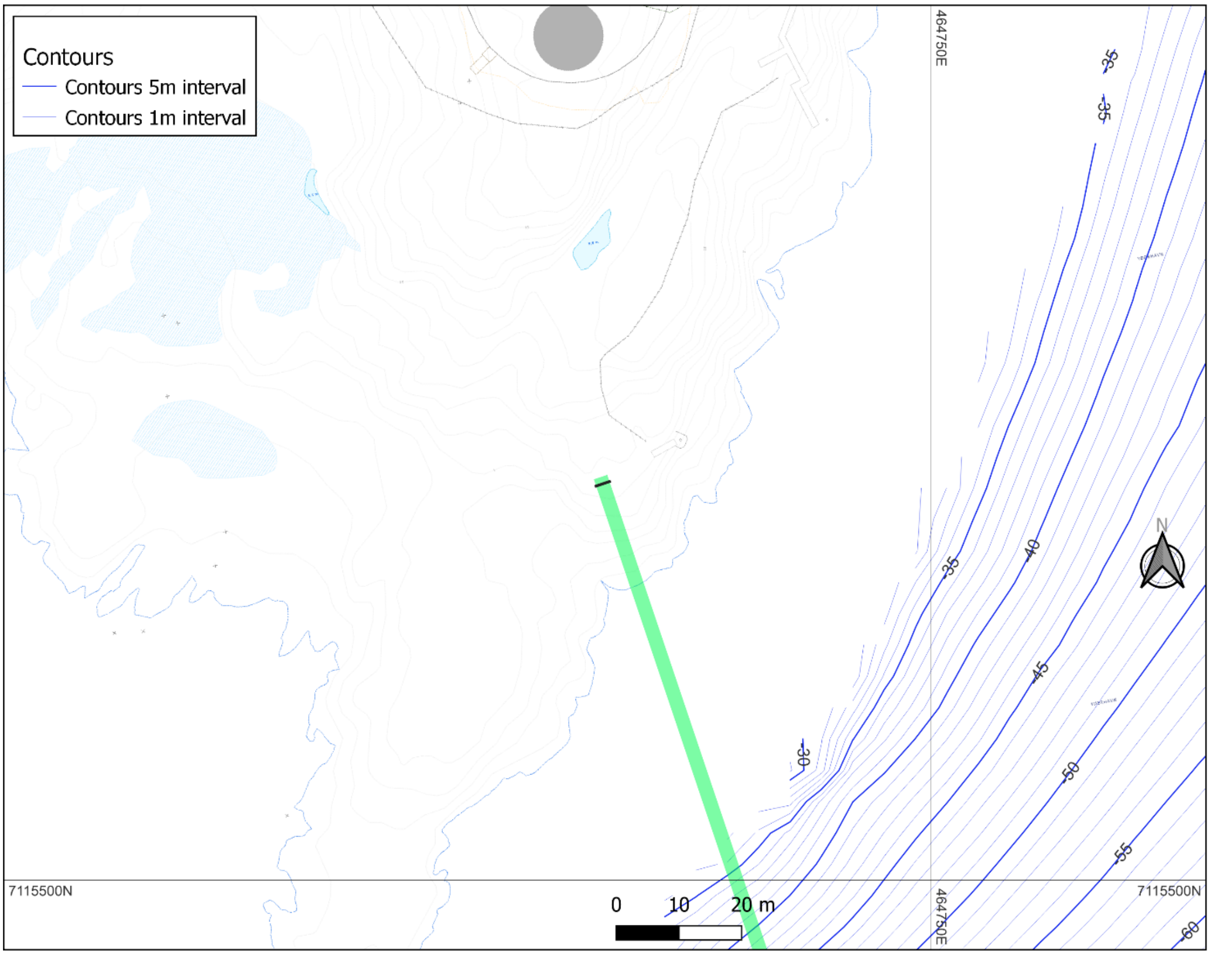


Figure 3: Nuuk Ring START HDD, proposal. Background map: Technical Base Map from Asiaq Greenland Survey, including location of oil pipeline (dotted grey line) and tanks NE of proposed landing. The planned start was further overlapping the pipeline.

B. For the landing points in Qinngorput – END HDD of both Nuuk Ring, it is proposed to move the END HDD of Nuuk Ring to the SW, as the branch pipes of the sewer system indicates that the municipality is planning construction sites for housing near the END HDD of Nuuk Ring, which should be moved, Figure 4.

C. For the landing point for Nuuk Skærgård, it is closely intersecting with the sewer outlet. It is advised to move the location to a place near the END HDD of Nuuk Ring, Figure 4.

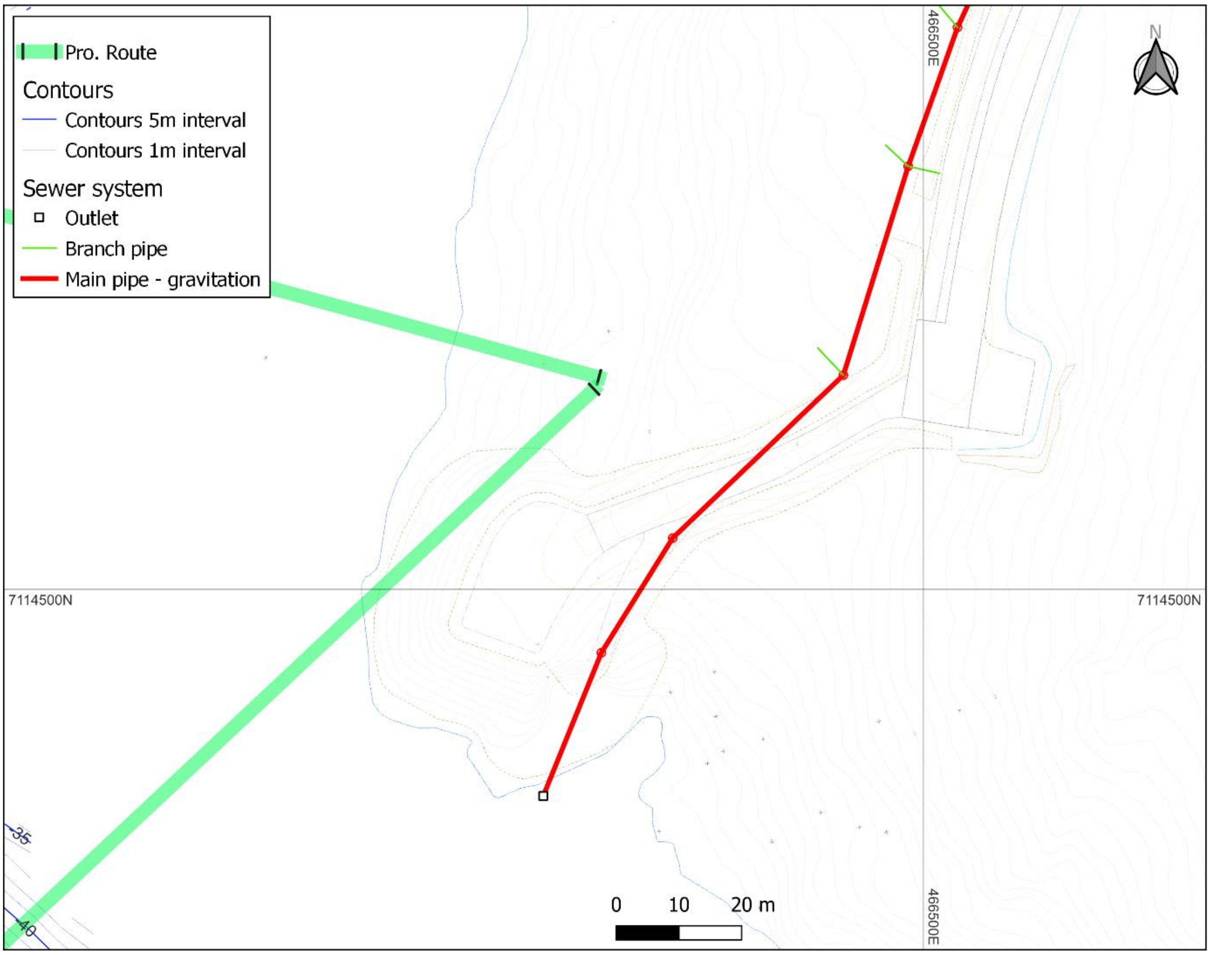


Figure 4: Landing point near Qinngorput. Technical Base Map from Asiaq Greenland Survey displays a road and built up ground, and the sewer chart displays a main pipe, an marine outlet and a number of branch pipes.