DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2009/67

Fehmarn Belt Fixed Link
Coastal profiles

Survey and Data Report

Steen Lomholt, Merete Binderup, Sabah M. Mustafa
& Niels Nørgaard-Pedersen

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
MINISTRY OF CLIMATE AND ENERGY

GEUS

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Client: DHI Water • Environment • Health

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Introduction

This project was conducted under a contract with DHI Water · Environment · Health. It is part of a larger project for investigating the area where a fixed link between Denmark and Germany is to be constructed. The fixed link will connect Denmark (Rødbyhavn) with Germany (Puttgarden at Fehmarn Island), Fig. 1.

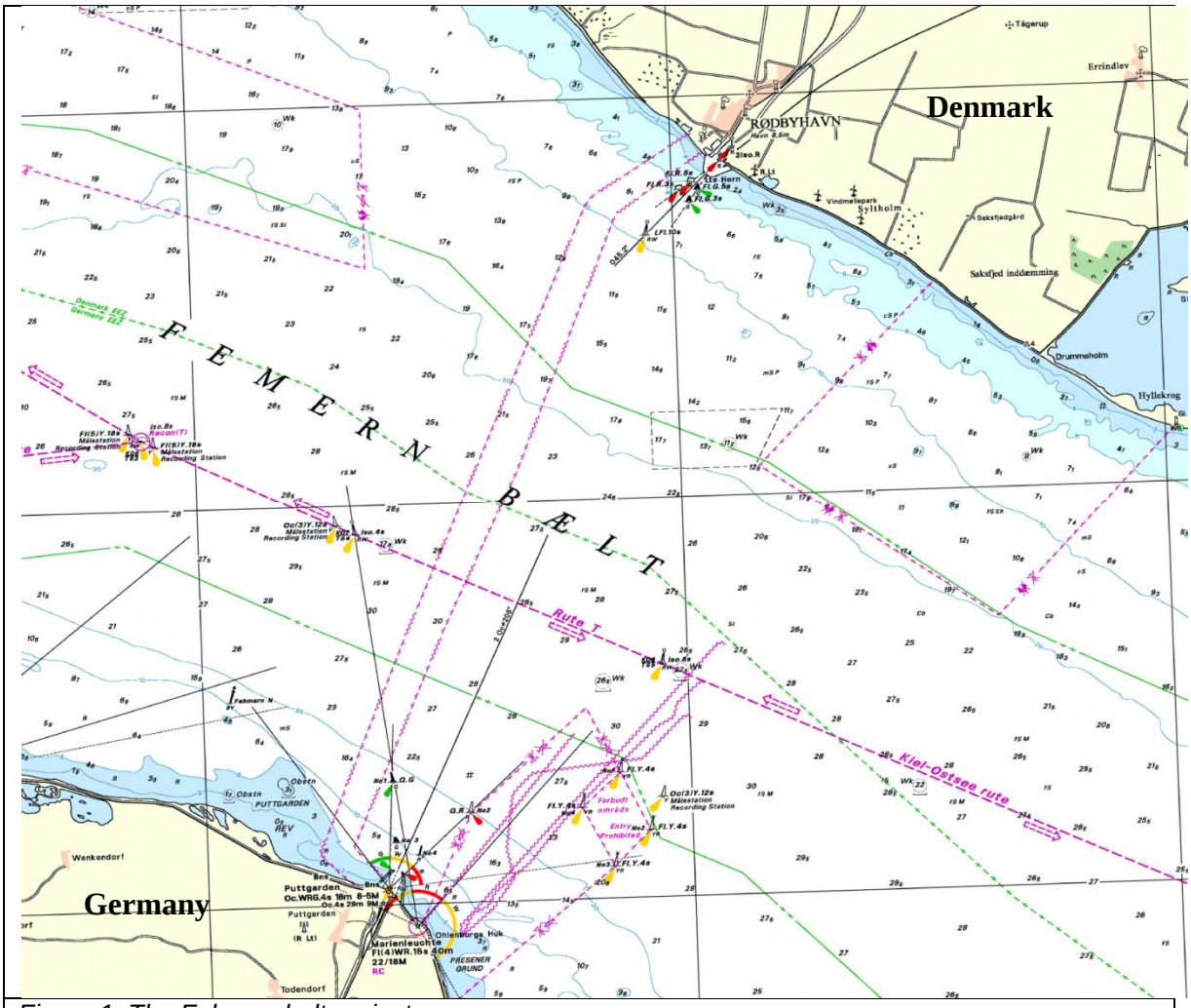


Figure 1. The Fehmarnbelt project area.

GEUS has been contracted to perform several geological and geophysical investigations in the Fehmarnbelt project. This report will present the results of coastal profile measurements (x,y,z).

The report includes the survey procedure and the results. All results are included in the DVD that accompanies this report.

Field work

Two main coastal zone regions have been investigated in the project, the Danish side (offshore Rødby harbour) and the German side (offshore Puttgarden harbour). A total of 445 profiles have been surveyed, 220 on the Danish side and 225 on the German, respectively. The required survey areas are approximately 6 km of coastline from 6 m depth contour up to shoreline (Figs. 2 A and B). The field work operation for this part of the project started at the 20th of May 2009 and lasted until the 12th of August 2009.

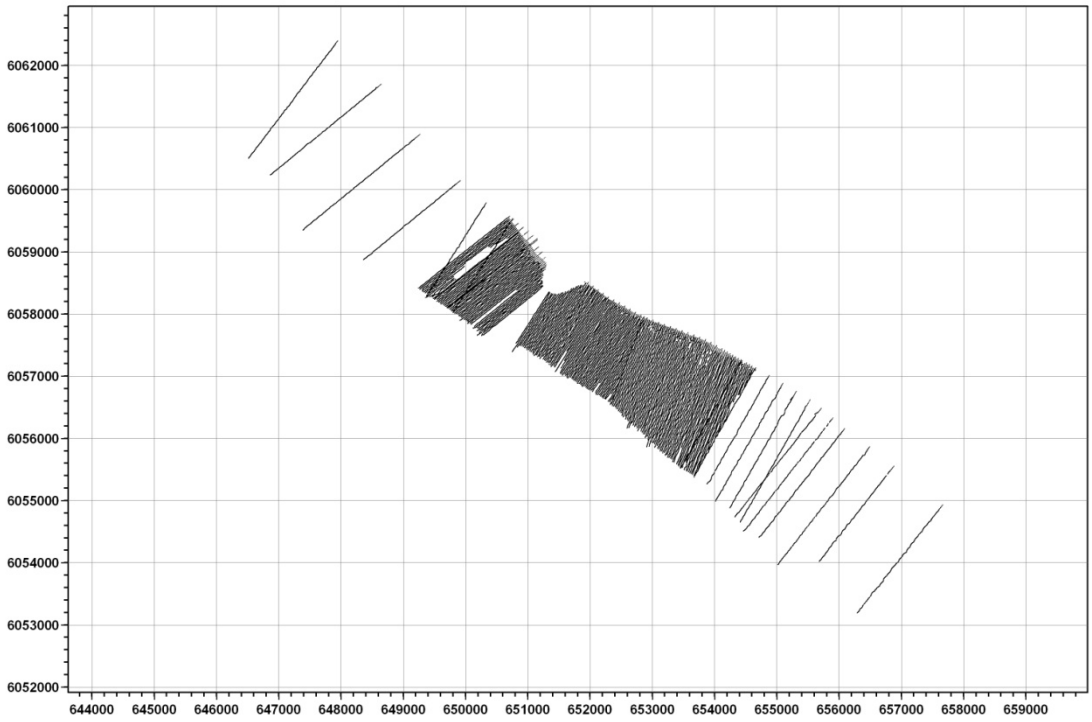


Figure 2 A. Coastal profiles near Rødbyhavn. Grid coordinates UTM zone 32N: Vertical axis (Northing (m)) and horizontal axis (Easting (m)).

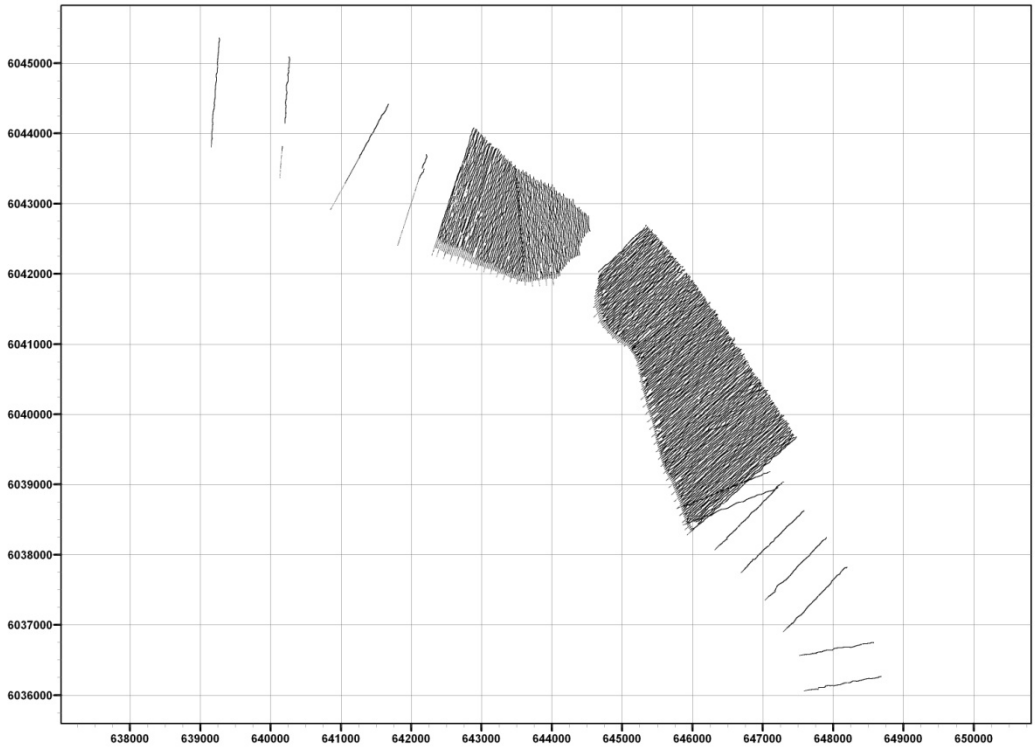


Figure 2 B. Coastal profiles near Puttgarden. Grid coordinates UTM zone 32N: Vertical axis (Northing (m)) and horizontal axis (Easting (m)).

Coastal profile measurements

The small GEUS survey vessel ”GEUS II” was used as platform for offshore coastal profiling. The echosounder data is combined with a leveling survey in the inner shore and onshore part of the profiles.

Levelling

By means of the predetermined co-ordinates for start points (SOL) onshore as well as the end-positions of the profile lines, the orientation of profiles was calculated prior to the levelling and echo soundings.

Equipment

The levelling is carried out using an electronically theodolite instrument, a Leica TC600 total station, with permanently built-in programs (App. I). The theodolite is levelled by use of a circular spirit level and is fine-tuned by use of a built-in electronic level. Hereafter, the

instrument is ready for use. The memory of the instrument is able to store as much as 2000 measuring blocks or 4000 sets of co-ordinates. Following the levelling, the stored data are transmitted to a computer. The accuracy of the positions in the distance measurement is 3 mm + (3*(the distance in m)/1000) mm. The theodolite was verified and controlled at Leica prior to the field investigations.

Methods

The theodolite is placed centrally in the profile line, at a predefined point. Hereafter, the profile line is laid out, by means of the pre-computed orientation and measuring with RTK GPS system.

The levelling by means of theodolite is performed from the largest accessible water depth, at least 1.3 m, to secure overlap to the echo sounded lines which extend to typically 60-100 cm water depth, depending on the configuration of the coastal profile. The inner limit is controlled by the nature of the backshore/hinterland.

All measuring points are stored continuously in a data logger. In the profile lines, the points are measured at intervals of 5 - 20 m. The distance between succeeding measuring points is less at characteristic changes in the topography.

During profile measurements (levelling), special attention is paid to recording distinctive breaks in the topography on land, beach and near-shore waters.

Echo sounding

Prior to the sounding survey, 431 navigation routes were laid out. The "start on line" -points (SOL) were identical to the predetermined co-ordinates used in the levelling from land. All data were stored in the navigation programme Hypack on the computer used for the survey navigation.

Efforts were made to ensure that the overlap between the echo sounding and the levelling was as large as possible. Where the coastal profile is steep, it is only possible to establish an overlap of a few meters, but where the coastal profile is even and shallow far offshore from the shoreline, a more substantial overlap could be established.

Methods and equipment

The points SOL and EOL co-ordinates were stored in the navigation program Hypack, which was used in the survey. Echo sounding data were compiled from “GEUS II”, a smaller boat of the type “Cadet” with shallow draught and an outboard echo sounder (Fig. 3).

Figure 3. Fehmarn Belt 2009, GEUS II, Rødby Harbour.

The small survey vessel was selected to enable an overlap between the marine bathymetric survey and levelling data measured form land.

Data were collected by means of a dual frequency echosounder Navisound Reson (200 kHz) (see App. II). A RTK GPS was used during the survey. All data were acquired in WGS84 and data were stored in the survey computer. Any remarks, e.g. relating to corrections, were written in a notebook PC and afterwards used during the subsequent data processing.

Data acquisition was not carried out at wind speeds larger than 8 m/sec and/or waves higher than ½ m. When surveying, it was possible to navigate with a maximum displacement of 10 m from the predetermined route except for those places where stones, fishing nets, boats lying at anchor or the like hindered sailing. The actual positions were continuously recorded (3 times per second), matching one point per 60 cm.

Compensation for waves was not carried out during the survey, but wave influence was compensated, during the subsequent data processing as described later.

Navigation

All sampling was positioned by RTK DGPS system. The system is installed by Dansurvey and further information about the RTK GPS can be found in Appendix III.

Data processing

A four step procedure has been used to produce the final coastal profile data. The costal profile is combined of levelling data, where these are present, and bathymetric data acquired with use of the 'Hypack Max' acquisition and processing software program. The first step in the processing of profile data is de-spiking of bathymetric data. This is done in the Hypack program as illustrated in Fig. 4.

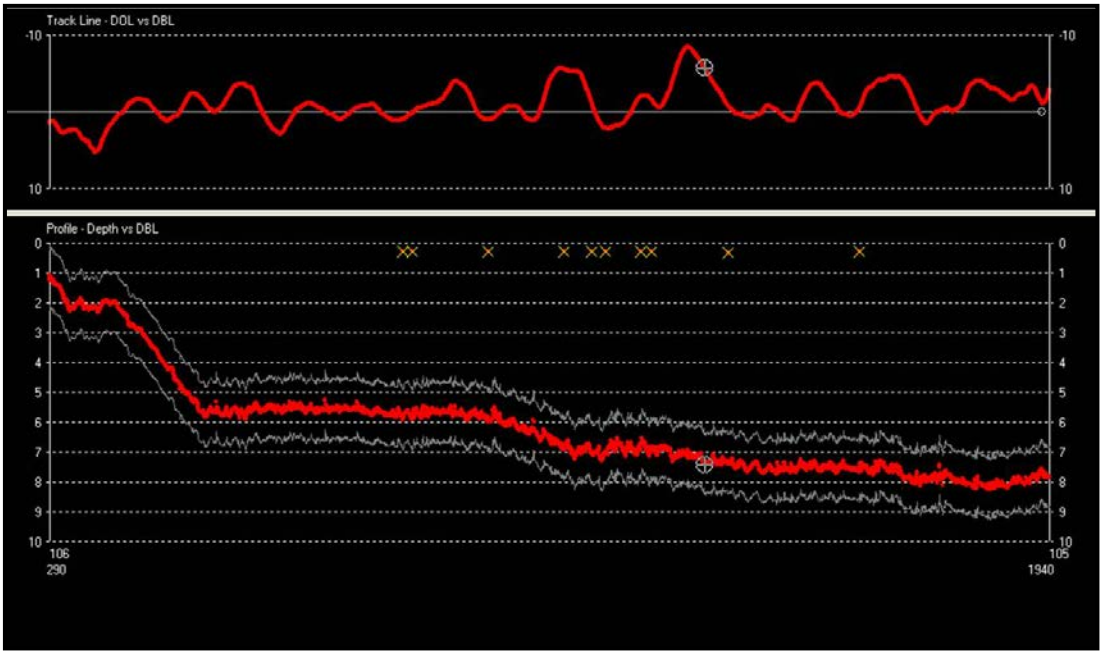


Figure 4. Screen print of echo sounding profile no. 420 on the Danish side of the Fehmarn Belt east of Rødby Harbour. Spikes are automatically marked by yellow crosses and removed.

Spikes are caused mainly by air bubbles or eelgrass, or similar items in the water column, and only minor uncertainties in data are introduced during this process. No motion sensor has been applied for the bathymetric survey. To remove motion-influenced effects on data, a second step in data processing is introduced. A heave compensation of data, based on measured z value of RTK of the antenna on the boat, and the expected z value. This RTK heave removal process is based on a calculation of difference in z value, Δz, in measured z value at each measurement and a mean RTK z level calculated for each profile, assuming that the RTK High is equal during the survey of a profile. A smaller uncertainty of maximum 1 -2 cm is introduced by neglecting tide difference between start and end of line. Examples on this processing can be seen as a comparison between measured raw data profile and RTK adjusted profiles in Figs. 5-8.

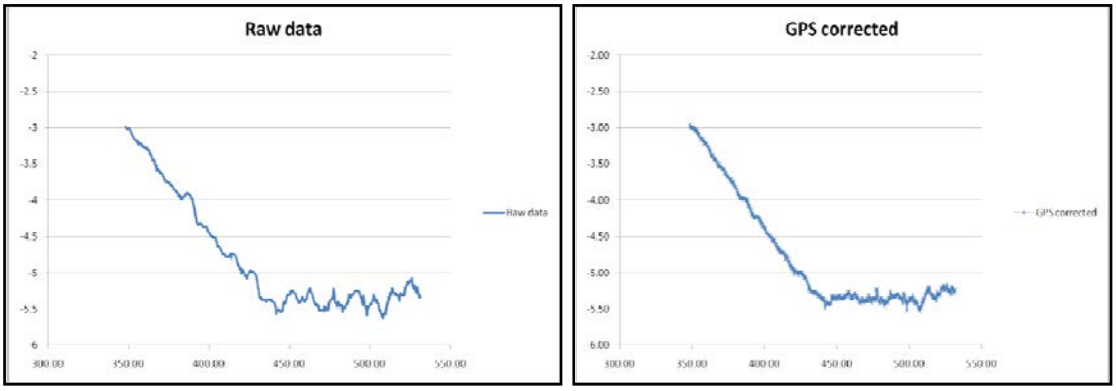


Figure 5. Original raw data profile DK 420 on left side diagram and GPS processed echosounding data on right side diagram.

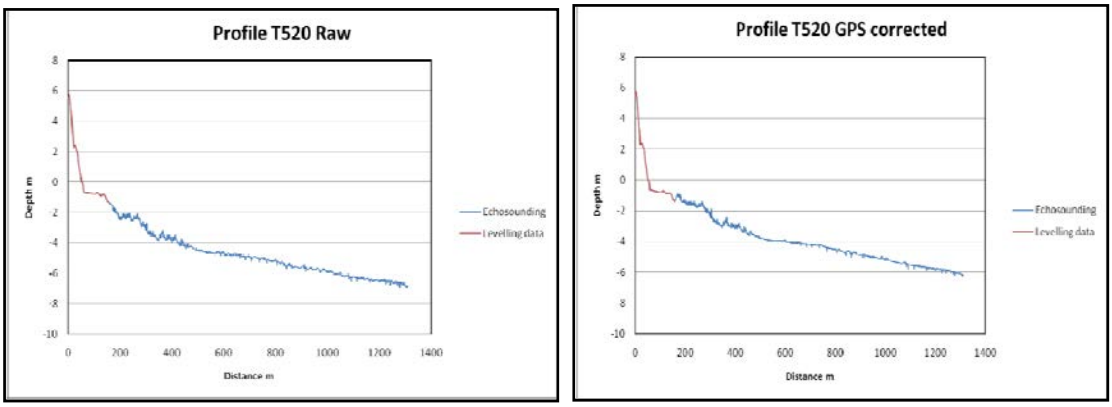


Figure 6. Original raw data profile T520 on left side diagram and GPS processed data (including levelling data) on the right side diagram.

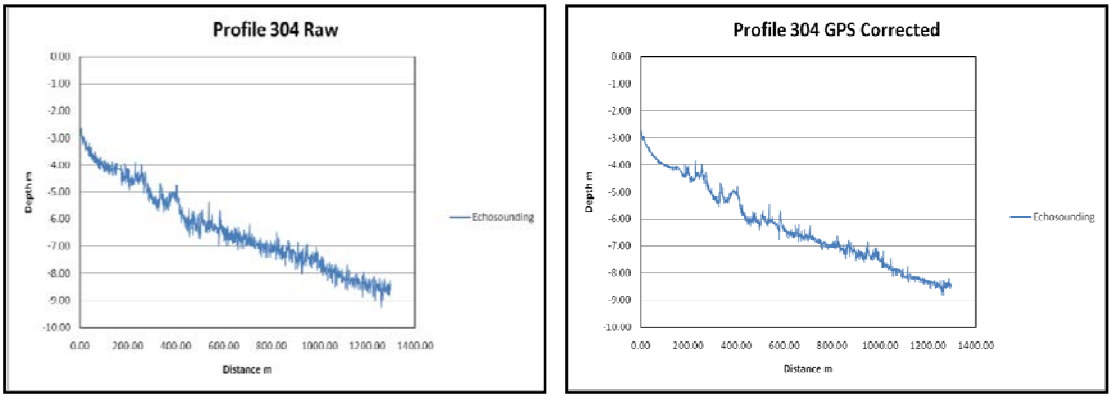


Figure 7. Original raw data profile DK 304 on left side diagram and GPS processed echosounding data on right side diagram.

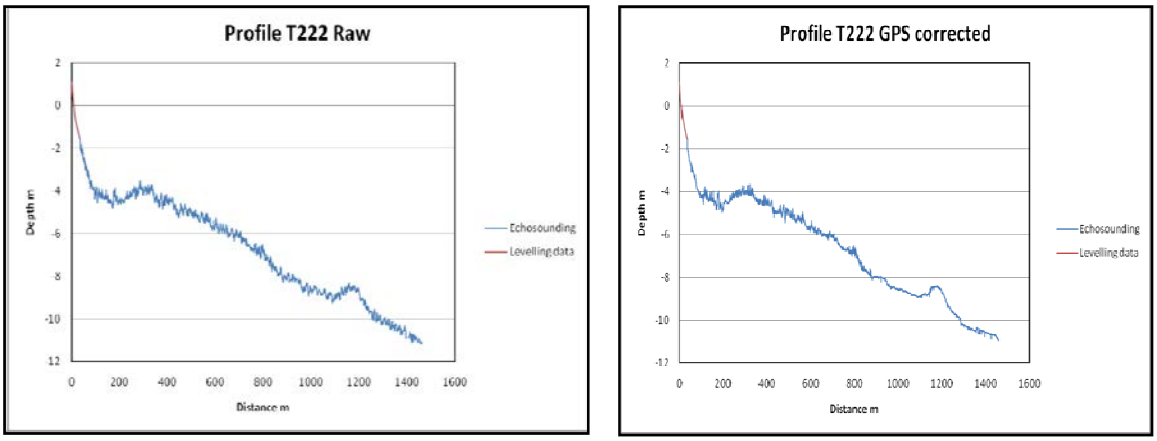


Figure 8. Original raw data profile T222 on left side diagram and GPS processed data (including levelling data) on right side diagram.

As it can be seen in Figs. 5 to 8, the RTK GPS correction to a large degree eliminate the wave and swell movement, but especially in the more shallow part of the profiles (T520 and T222), an uneven seabed signature is still left after this adjustment. This could be due to seabed vegetation or residual seabed type, with stones and cobbles, as documented in many of the seabed samples collected during the sediment sampling project in the area. Final data has been corrected to seabed level, combining the low and high frequency echo sounders, to eliminate possibly interference from seaweed or other vegetation.

Finally, a data smoothing has been introduced to remove more long waved influence from waves and swells. This has been done using the Moving Average method:

$$y_k = \frac{1}{n} \sum_{j=k-n}^{k-1} y_j$$

This process also smoothes out minor “jumps” in data introduced by roll and pitch movement during the data acquisition. The smoothing is individual for each profile. Most of the profiles have been smoothed between 7 and 32 succeeding data points, corresponding to 2 - 10 m along the profile. The effect of smoothing can be seen in Figs. 9-12 on the same four profiles as listed in Figs. 5-8.

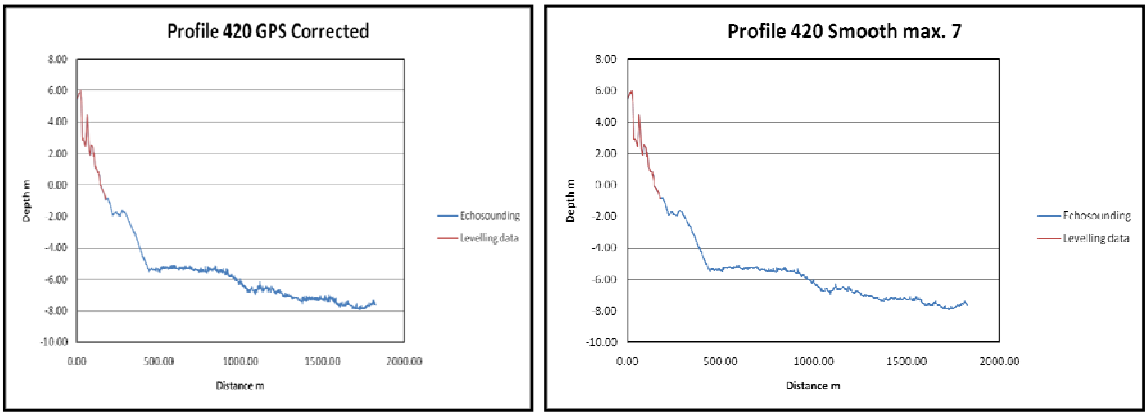


Figure 9. GPS corrected data profile DK 420 on left side diagram and smoothed (max. 7 succeding datapoints) processed data on the right side diagram. Levelling data is included.

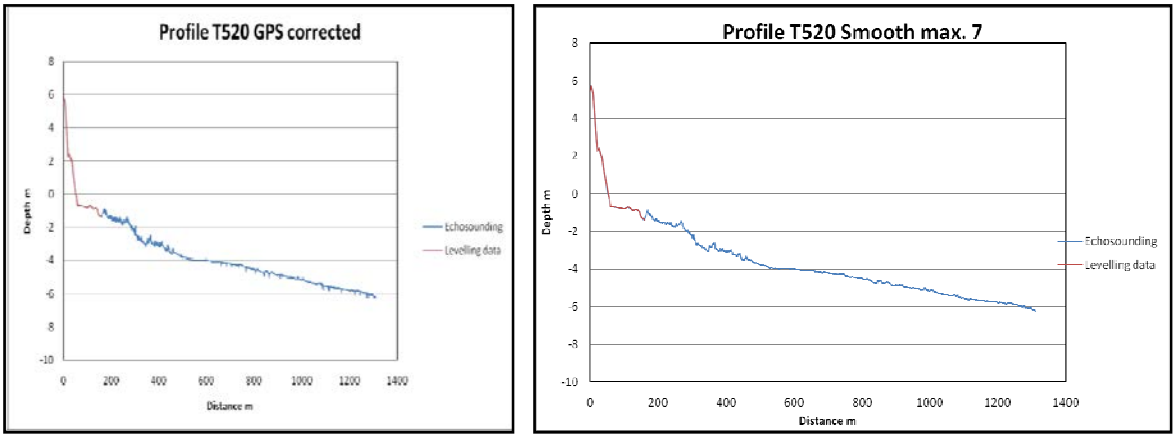


Figure 10. GPS corrected data profile T 520 on left side diagram and smoothed (max 7 succeding datapoints) processed data on right side diagram. Levelling data is included.

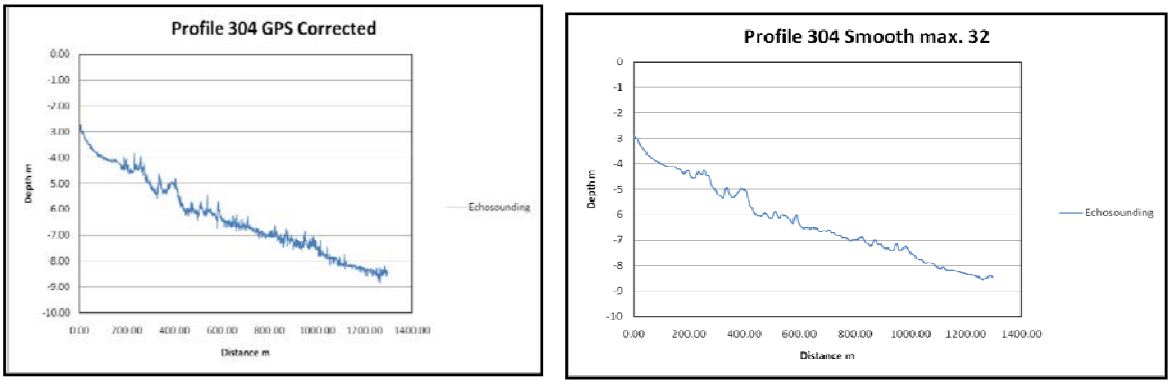


Figure 11. GPS corrected data profile DK 304 on left side diagram and smoothed (max. 32 succeding datapoints) processed data on right side diagram. Levelling data is included.

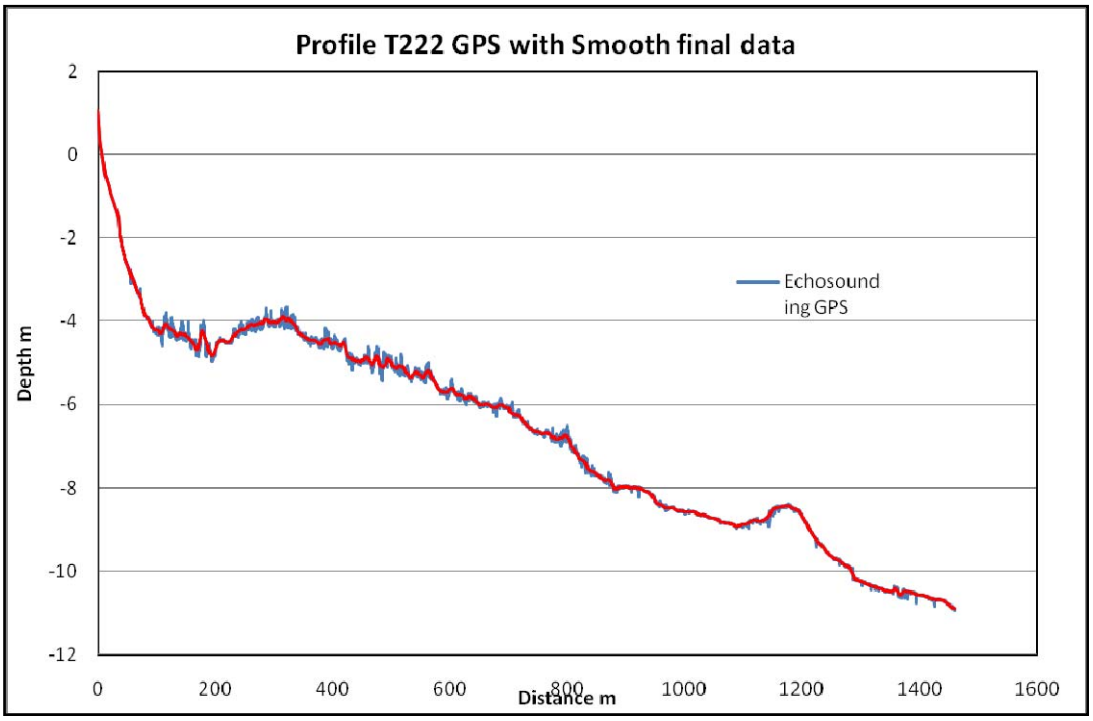


Figure 12. GPS corrected data profile T 222 (blue) with smoothed profile data (max. 32 succeding datapoints) shown in red. Levelling data is included.

The final step is the construction of coastal profile data. Leveling and echo sounding data are combined to a complete coastal profile as seen in Fig. 13.

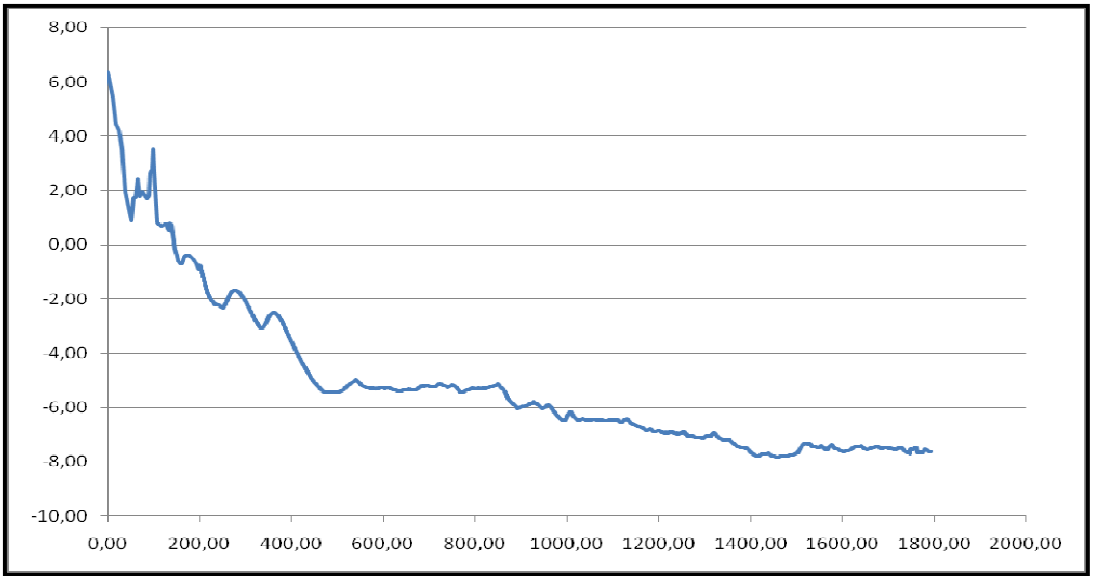


Figure 13. Coastal profile of line DK 424 after correction and smoothing.

Evaluation of data uncertainty

As mentioned in the previous section, the uncertainty of the GPS RTK data correction is in the range of a few cm. Estimates of the uncertainty caused by the smoothing process is discussed below. As seen in Fig. 14, where the smoothing of profile T222 is 32 succeeding data points, the final profile do not deviate much from the raw data profile. This profile can be regarded as one of the most affected profiles by weather conditions. The difference between raw data and final data is at maximum between ±20-30 cm. Another example showing profile DK 420 raw and smoothed data can be seen in Fig. 15. It can be seen that the maximum difference between raw data and final data is approximately ±10 cm.

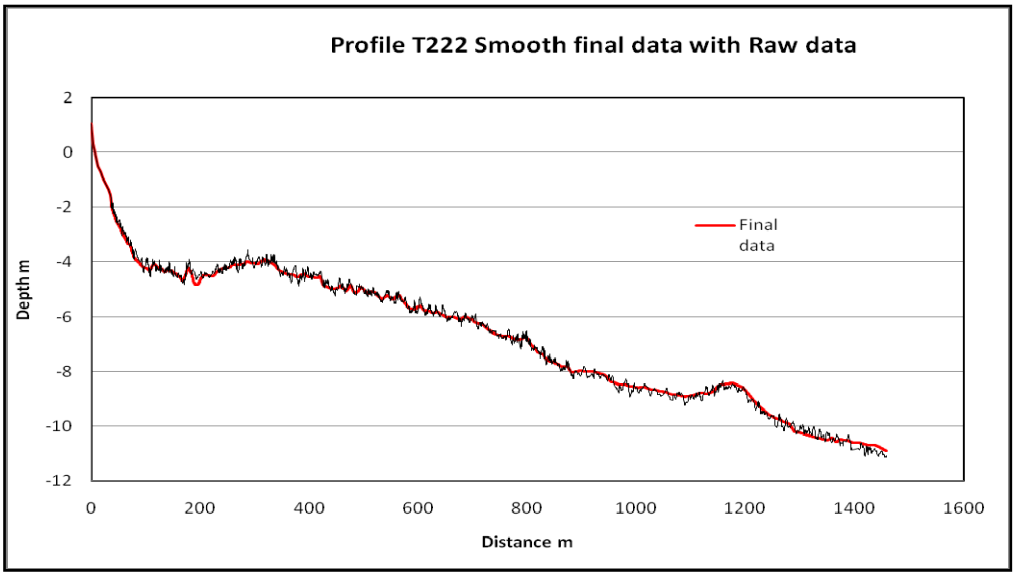


Figure 14. Comparison of the raw data profile (black) of line T222 with the final smoothed data profile (red).

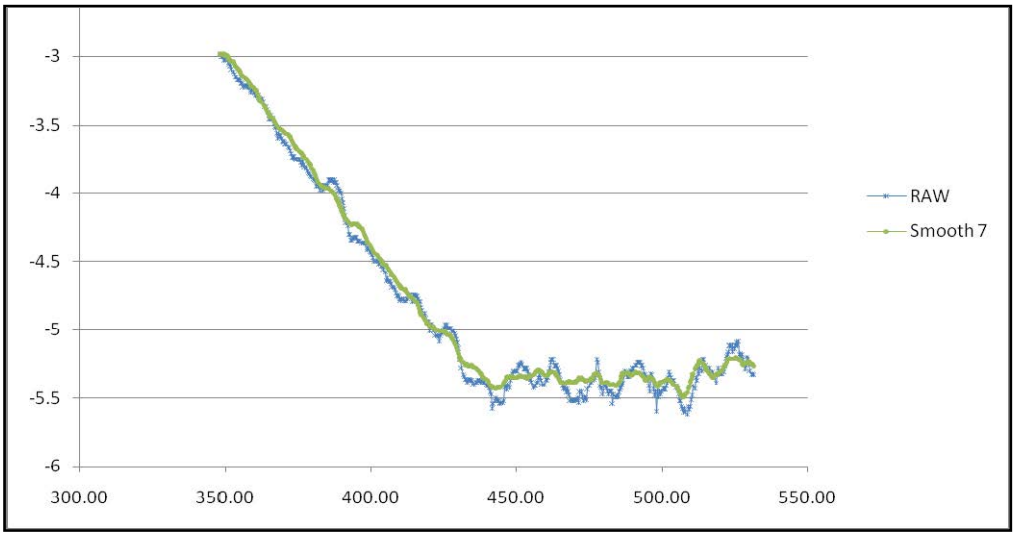


Figure 15. Profile T420 final data compared to raw data (only part of the profile is presented).

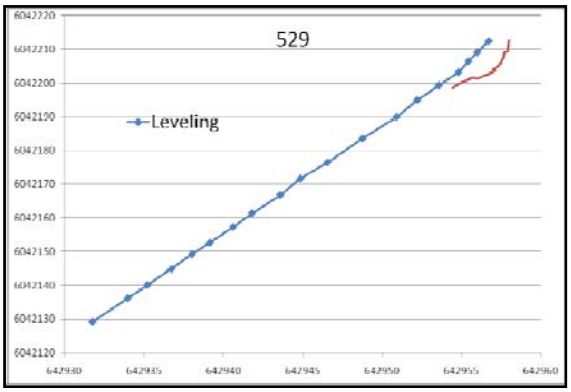
It is possibly to compare Leveling with Echo sounding data in flat shallow areas, where an overlap between the two acquisition methods are possibly. The only area is the western part on the German side of the Fehmarnbelt. Four profiles with overlap have been selected, as illustrated in Fig. 16. It is regarded, that the Leveling data are correct and the Echo sounding data fluctuate around the Leveling measurements. The two data set are not 100% compared, because the Leveling is measured in a single point, representing a few cm^2, while the echo sounder has a footprint at the seabed at 50 to 100 cm^2, in areas of water depths between 1 and 2 m.

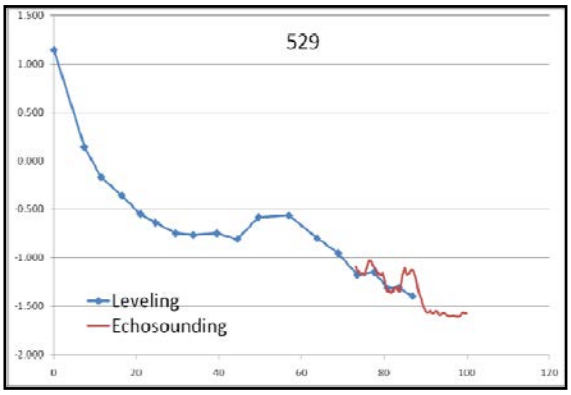
Profile 529 (Fig. 16): The Leveling data points and the Echo sounding data are slightly offset. The deviation in depth measurements is generally less than 10 cm between the two data sets, especially in the areas with least distance between Leveling and Echo sounding data points (< 3m). In the shore-near part of the overlap zone, the depth difference is up to 20 cm, and the lateral distance is up to 10 m.

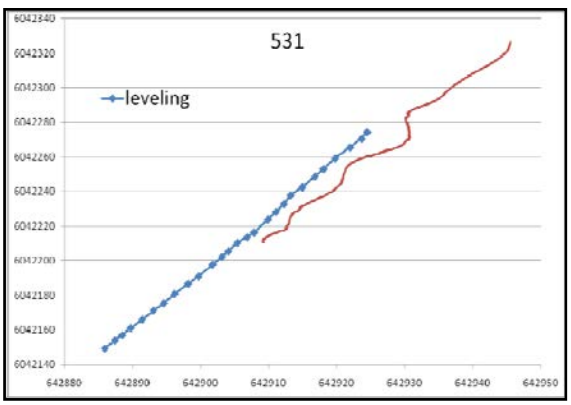
Profile 531 (Fig. 16): The lateral distance between leveling data points and the Echo sounding data is between 5 and 10 m. The deviation in depth measurements is less than 10 cm along the line.

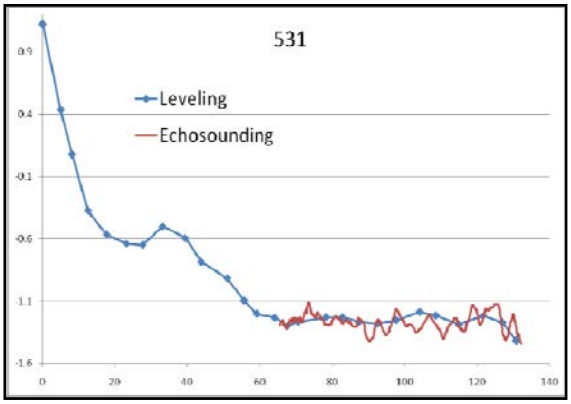
Profile 533 (Fig. 16): The lateral distance between Leveling data points and the Echo sounding varies between 0 and 4 m. The deviation in depth measurement is less than 10 cm along the whole line, and in the shore-near part depth measurements nearly coincide.

Profile 535 (Fig. 16): The lateral distance between Leveling points and the Echo sounding is very low in the outermost part of the overlap zone and less than 10 m on the rest. The deviation in depth measurements is less than 10 cm along the whole line.









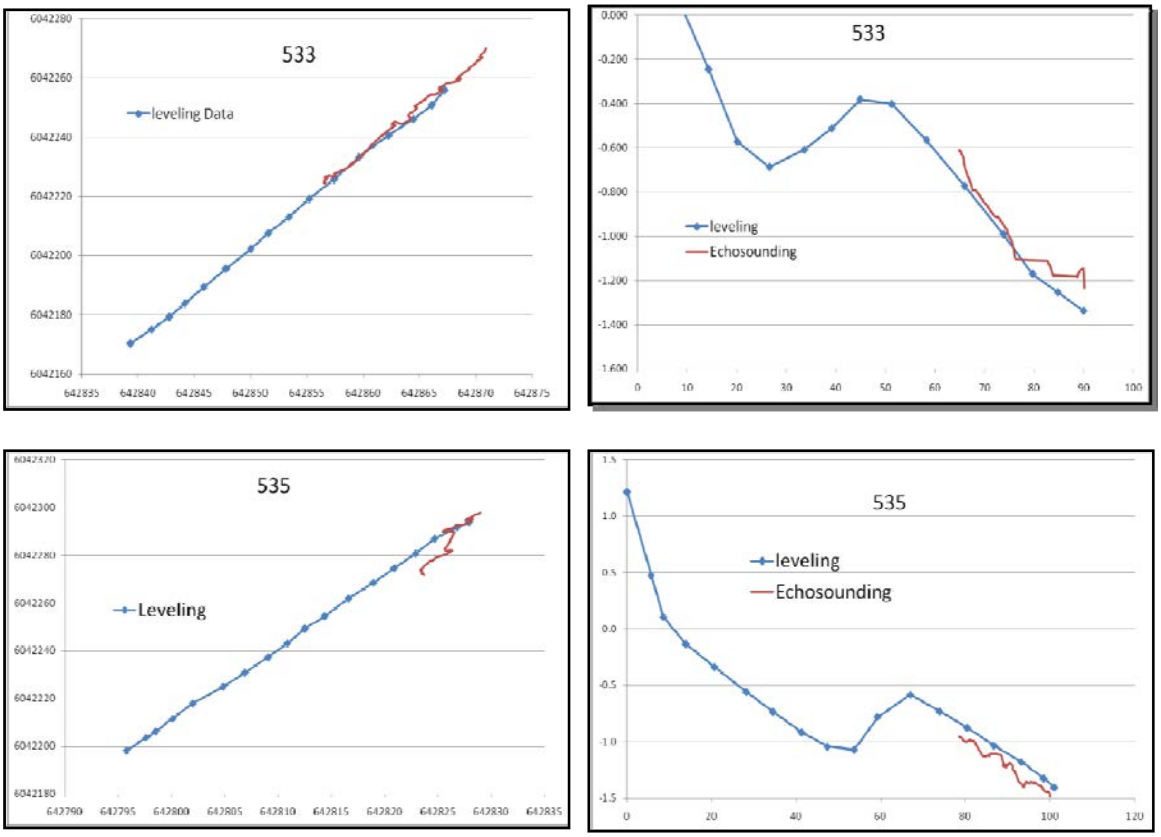


Figure 16. Profiles 529,531,533 and 535 showing examples of overlap between sailed echo sounding data (red) and leveling data points (blue). Navigation track plot is shown on the left side diagram and depth measurements on the right side.

As mentioned previously, it is not possibly to directly compare the two dataset because of difference in representation of depth measurements between the two methods, footprint of Echo sounder versus point measurements from a staff measurement.
If the Leveling measurements can be regarded as it represents the general level in the area, the two methods deviate ± 10 cm in these specific profiles.

Final adjustment of data

A comparison with existing Multibeam data acquired by Femern Bælt, have been used as a final QC of data.
Depending on what kind of difference appears between the two survey data set, single beam data have been recalculated and revised if justified.
A difference map between the Multibeam and single beam data has been extracted from data based on a difference between multibeam data with a 2m size and single beam data with the same grid size (Figure 17 and 18).

As seen from the two plots, some regular colored zones parallel to the multibeam sailing routes or zones possibly where outer beams of the survey appear and are present. This is interpreted as a systematic velocity phenomenon, introduced by the multibeam data. The zones are characterized with difference in depth beyond ± 0.20 m.

The statistics can be seen on the left side of the two plots.

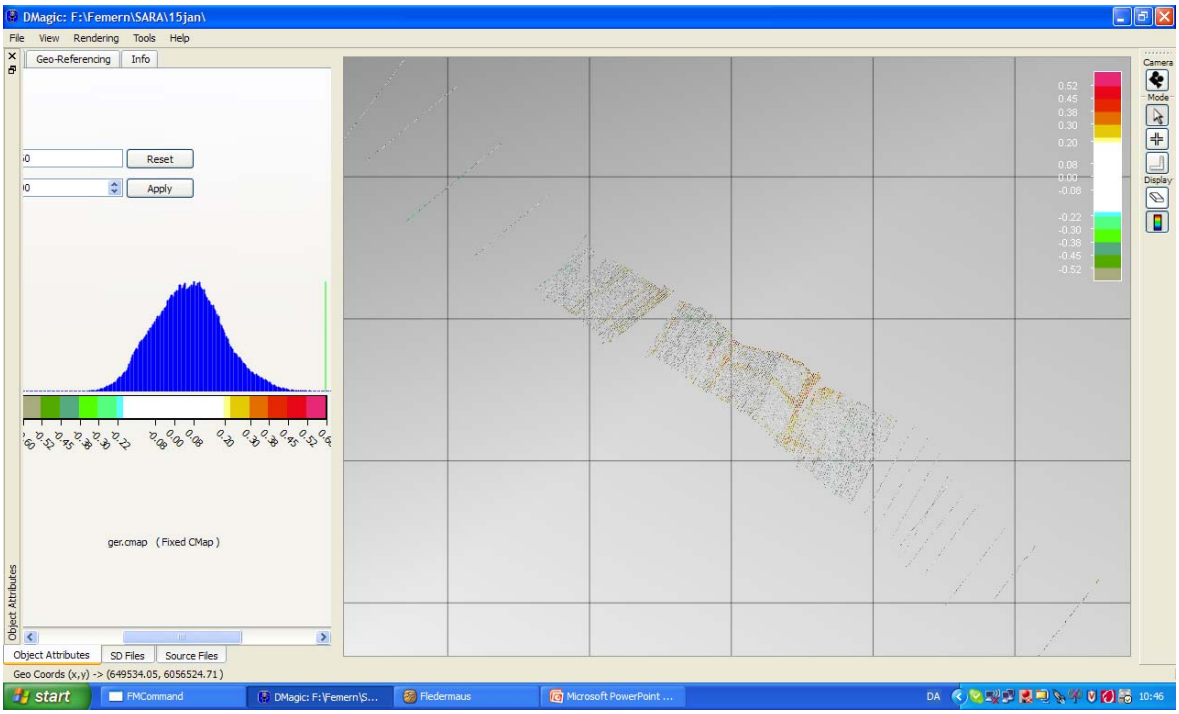


Figure 17. Plot of difference in depths between Multibeam and single beam data in the Danish coastal zone near Rødby in Femern Belt.

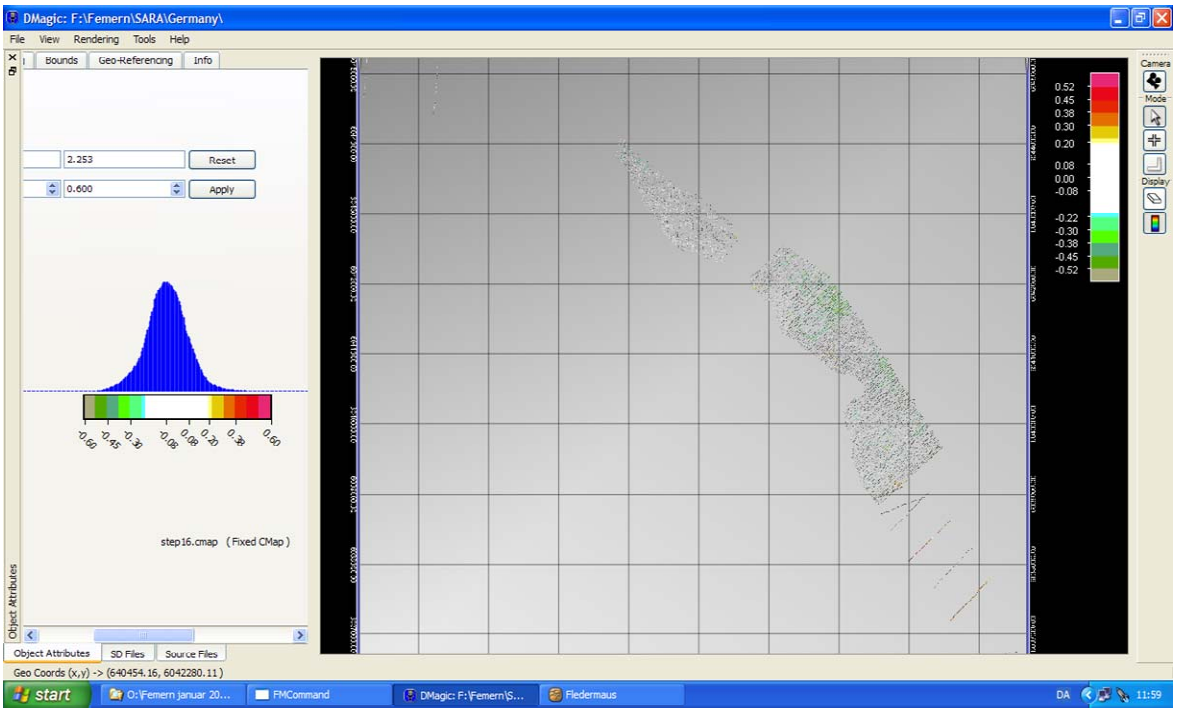


Figure 18. Plot of difference in depths between Multibeam and single beam data in the German coastal zone near Puttgarden in the Femern Belt.

In some areas single lines has been adjusted from data with overlap between land and marine data. An example is shown in figure 19-20, where single dataset has been

adjusted (Red color on figure 19). Group of data have been (Green area) analyzed on selected lines and corrections have been used for the whole group of date

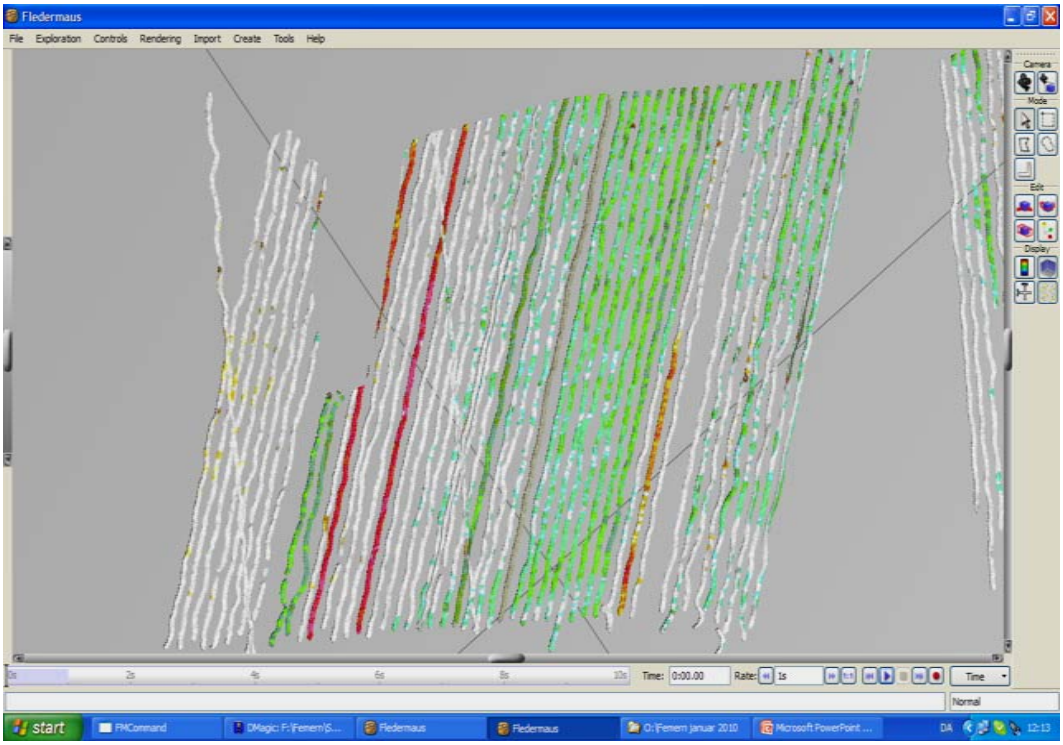


Figure 19. Plot of difference in depths between Multibeam and single beam data in the coastal zone to the northwest of the Rødby harbor before adjustments. Same Color code as figure 17.

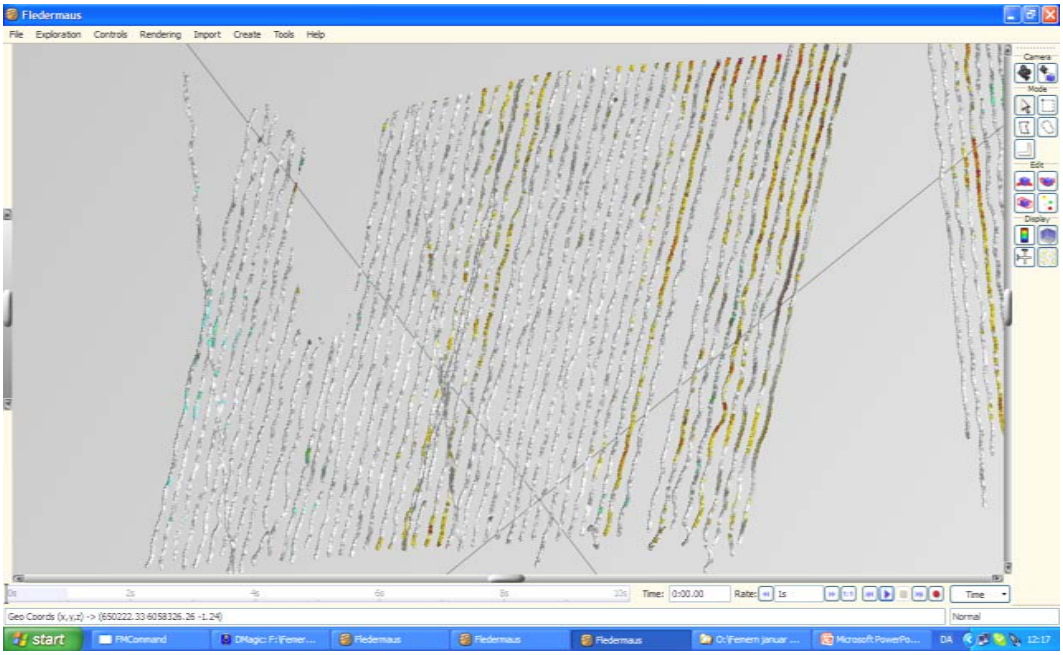


Figure 20. Plot of difference in depths between Multibeam and single beam data in the coastal zone to the northwest of the Rødby harbor after adjustments. Same Color code as figure 17.

Examples on depth adjustments based on overlap of are shown in figure 21 and 22.

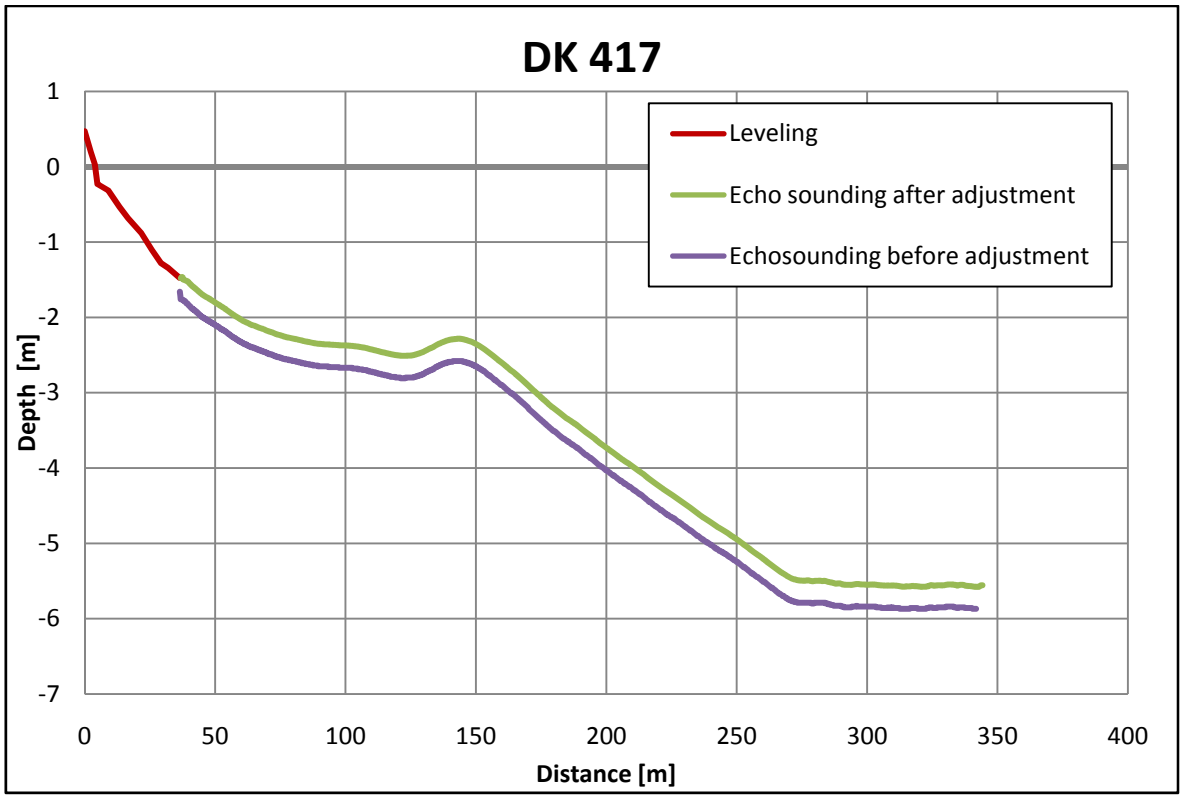


Figure 21. Profile DK 417 narrow part of the profile with echo sounding data before and after adjustment of data.

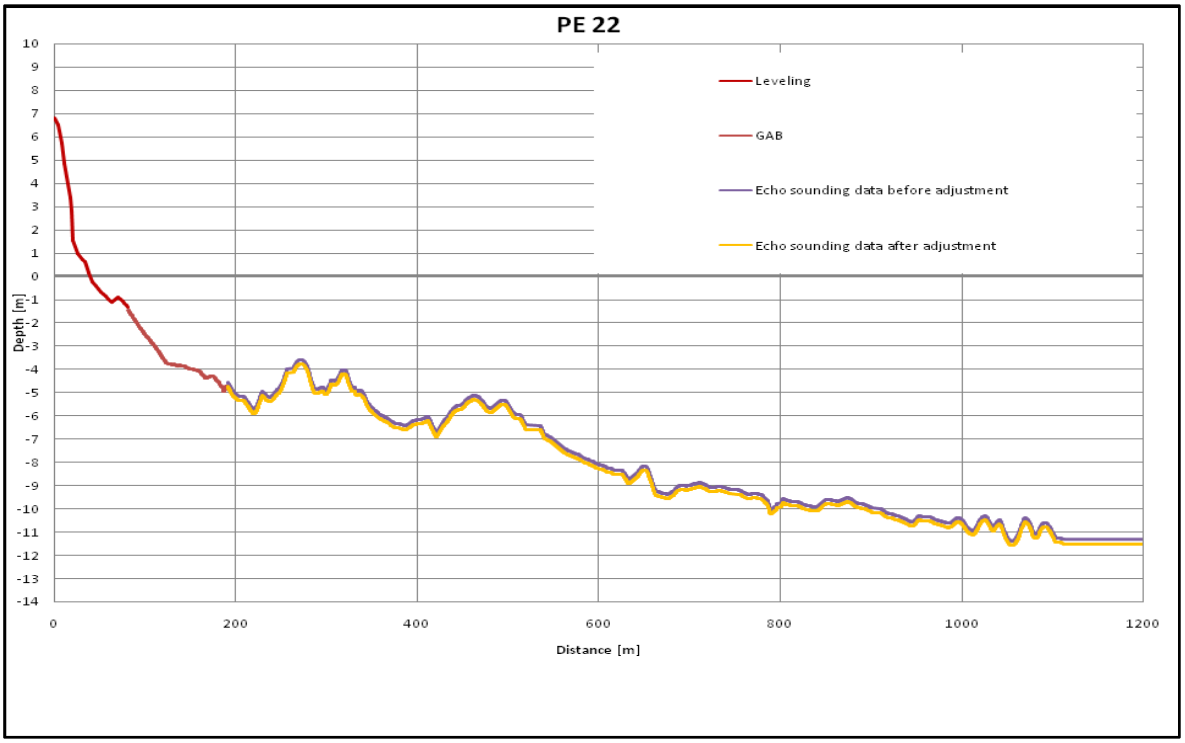


Figure 22. Profile PE 22 with echo sounding data before and after adjustment of data.

Last controls of data have been applied by profiles drawn perpendicular on the single beam data, with multibeam data as background. Five profiles have been drawn on data on

the Danish side (Figure 23-27) and six on the German side (Figure 28-33). Profiles are inserted on the figures. The single beam echo sounder data can be seen as vertical colored stripes on the profiles. And it can be seen that difference in seabed levels between the multibeam data and single beam is ± 0.2 m in most of the cross-sections. Only few data diverge from this general trend.

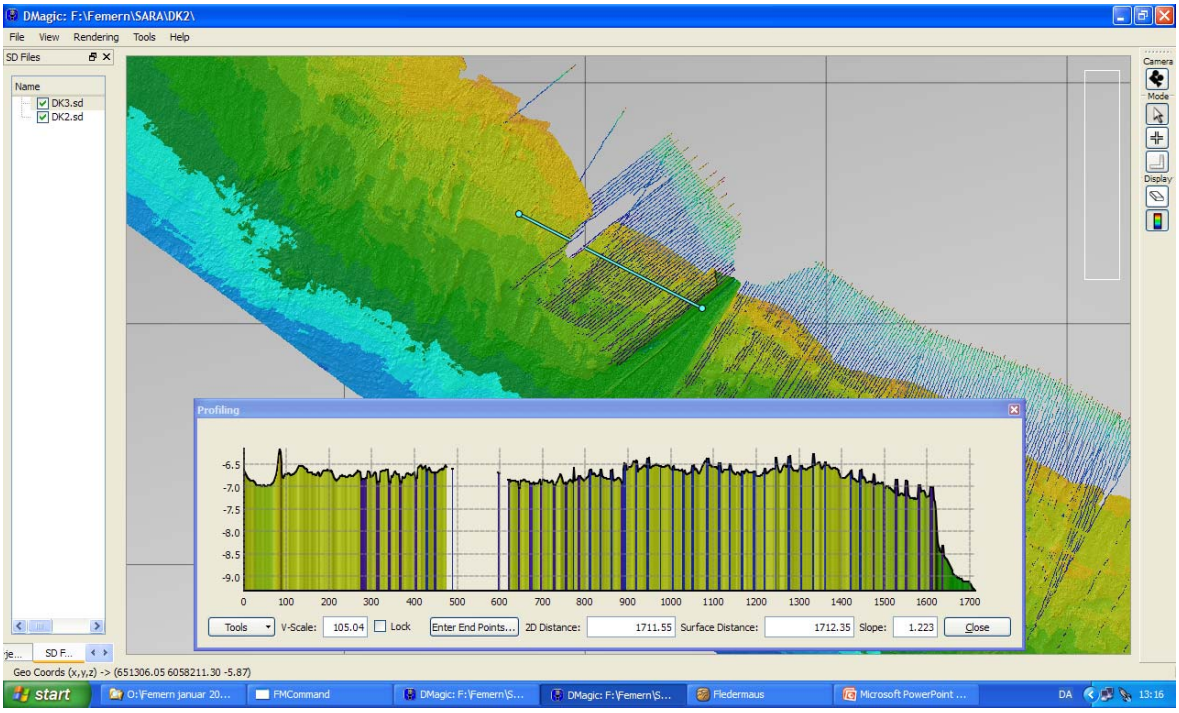


Figure 23. Cross section 1 on single beam profiles with multibeam data as background. Danish side.

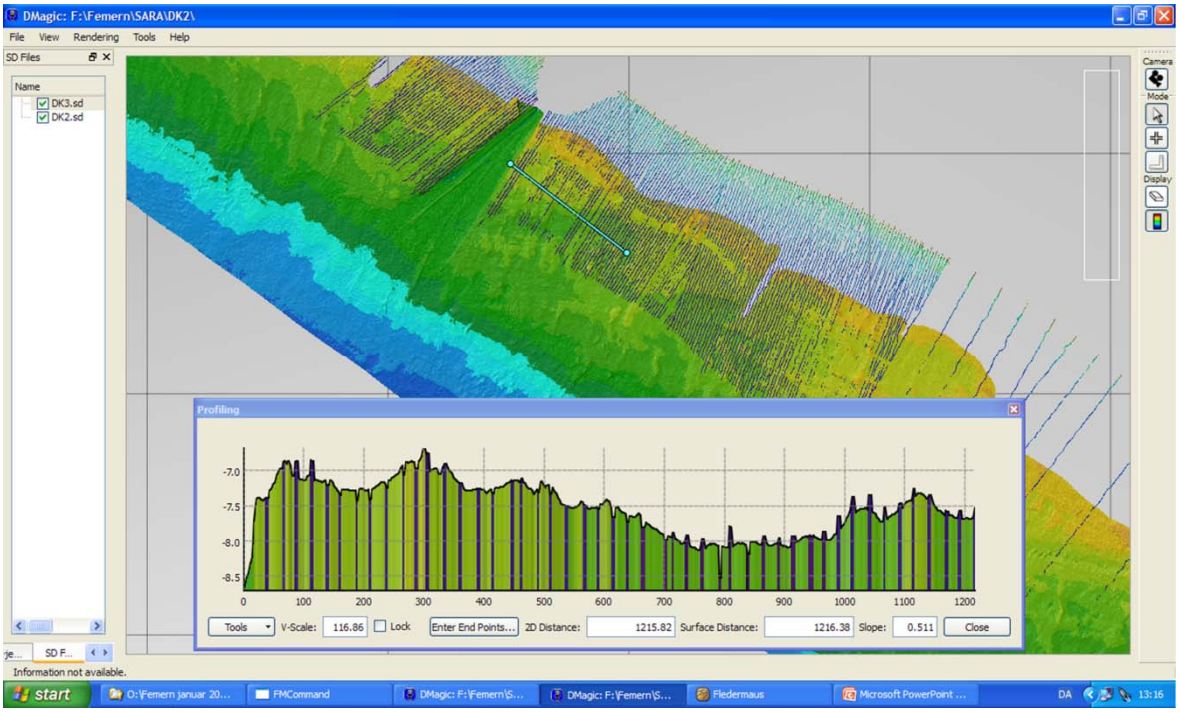


Figure 24. Cross section 2 on single beam profiles with multibeam data as background. Danish side.

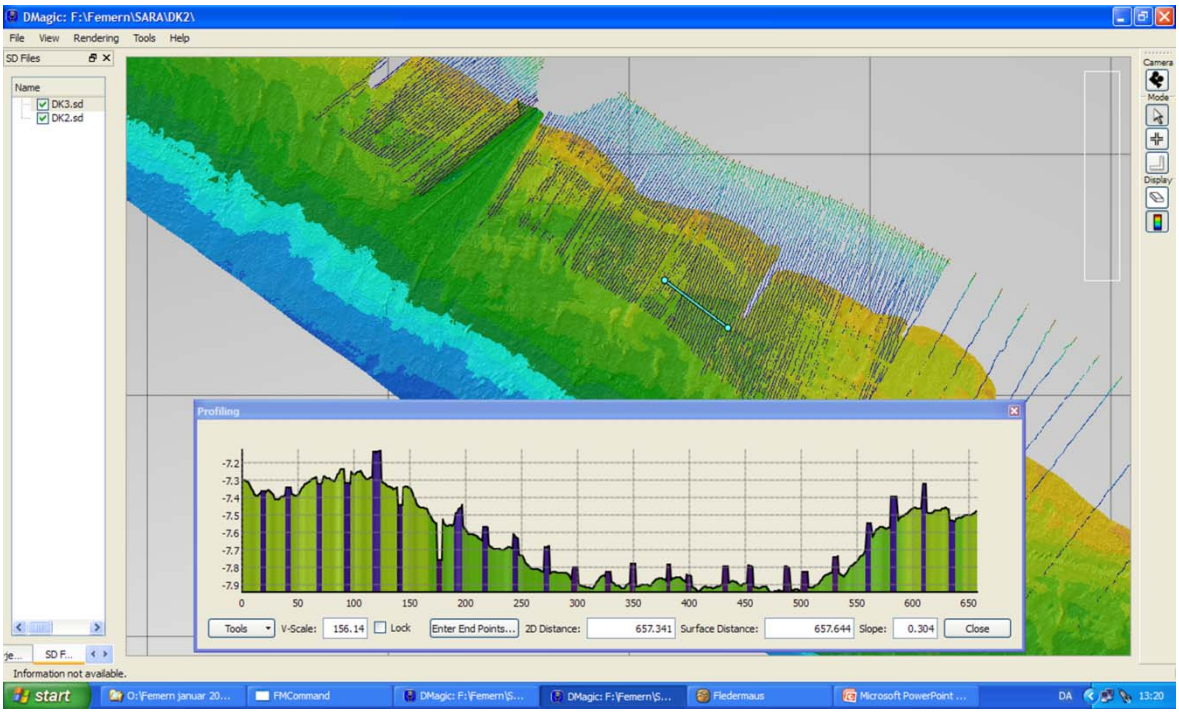


Figure 25. Cross section 3 on single beam profiles with multibeam data as background. Danish side.

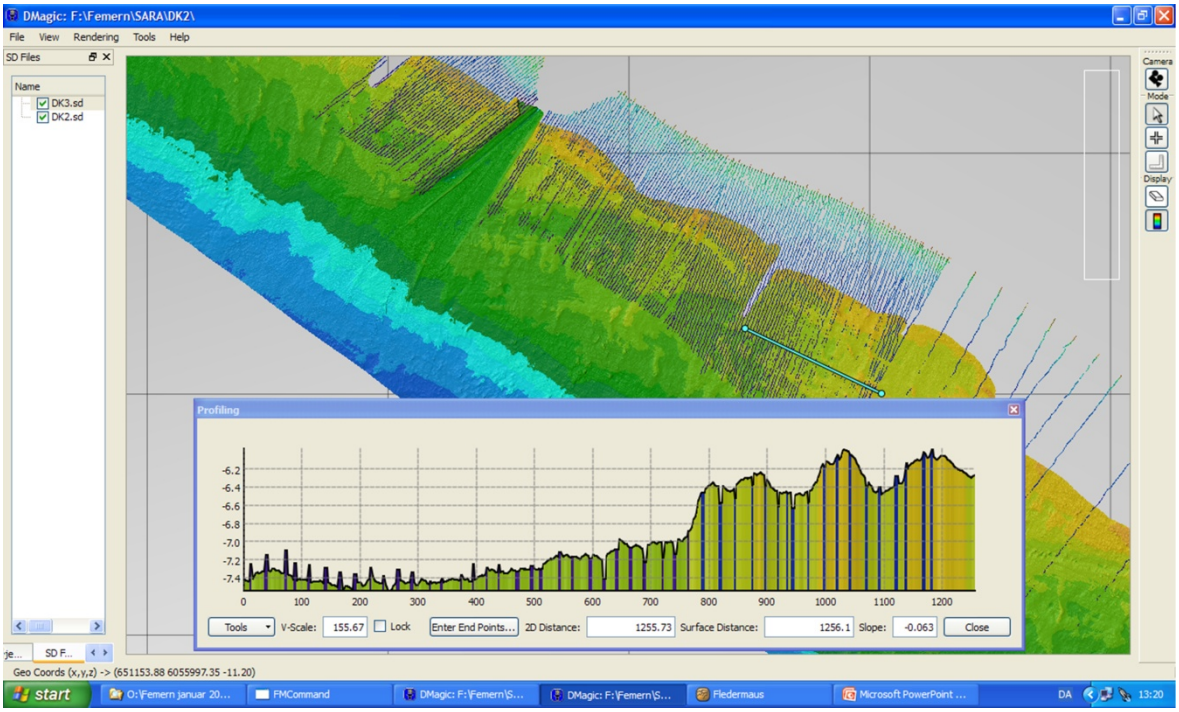


Figure 26. Cross section 4 on single beam profiles with multibeam data as background. Danish side.

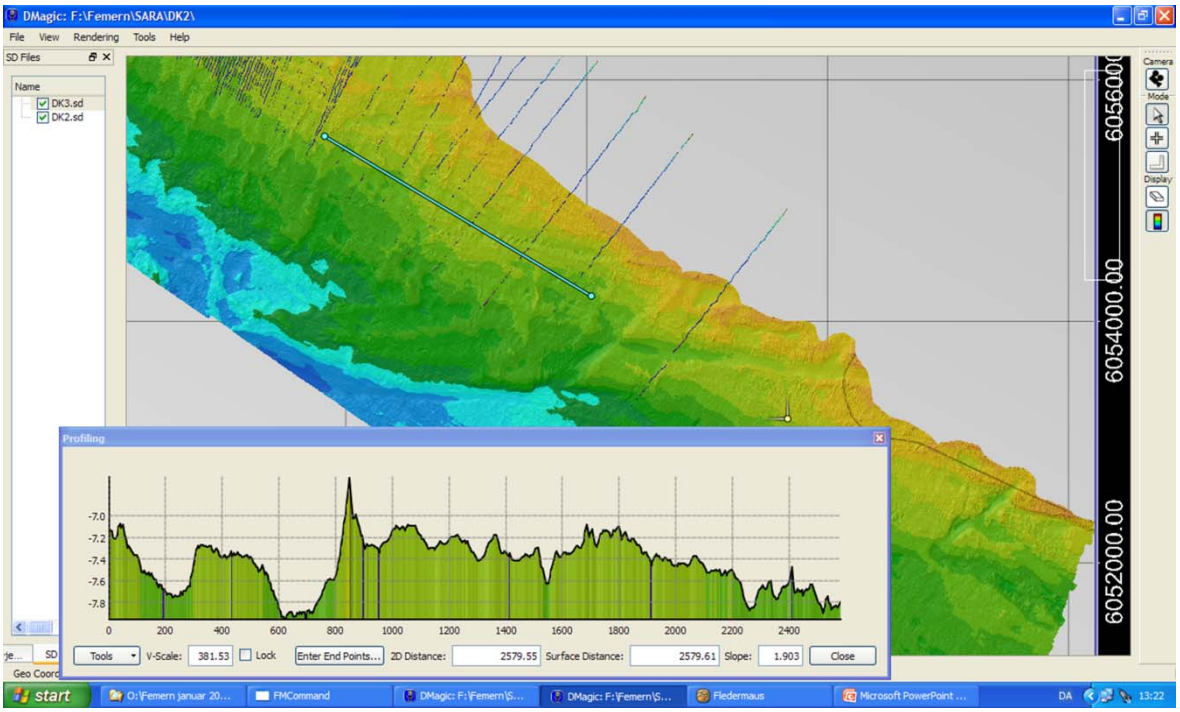


Figure 27. Cross section 5 on single beam profiles with multibeam data as background. Danish side.

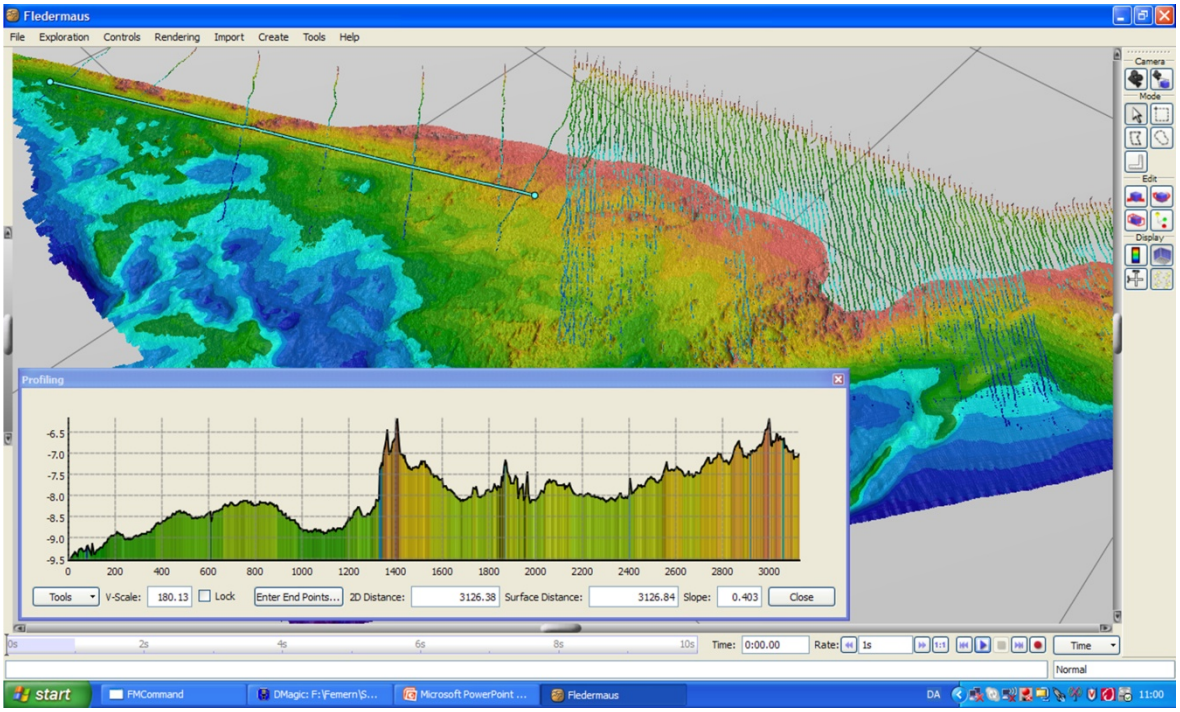


Figure 28. Cross section 6 on single beam profiles with multibeam data as background. German side.

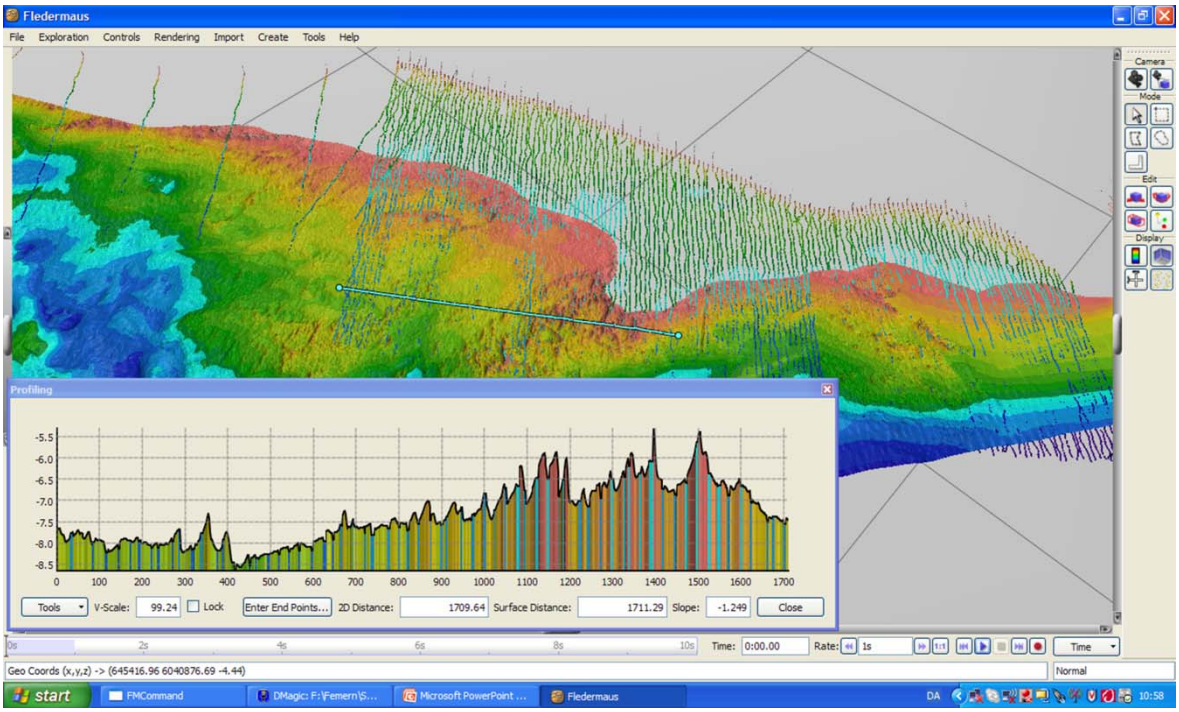


Figure 29. Cross section 7 on single beam profiles with multibeam data as background. German side.

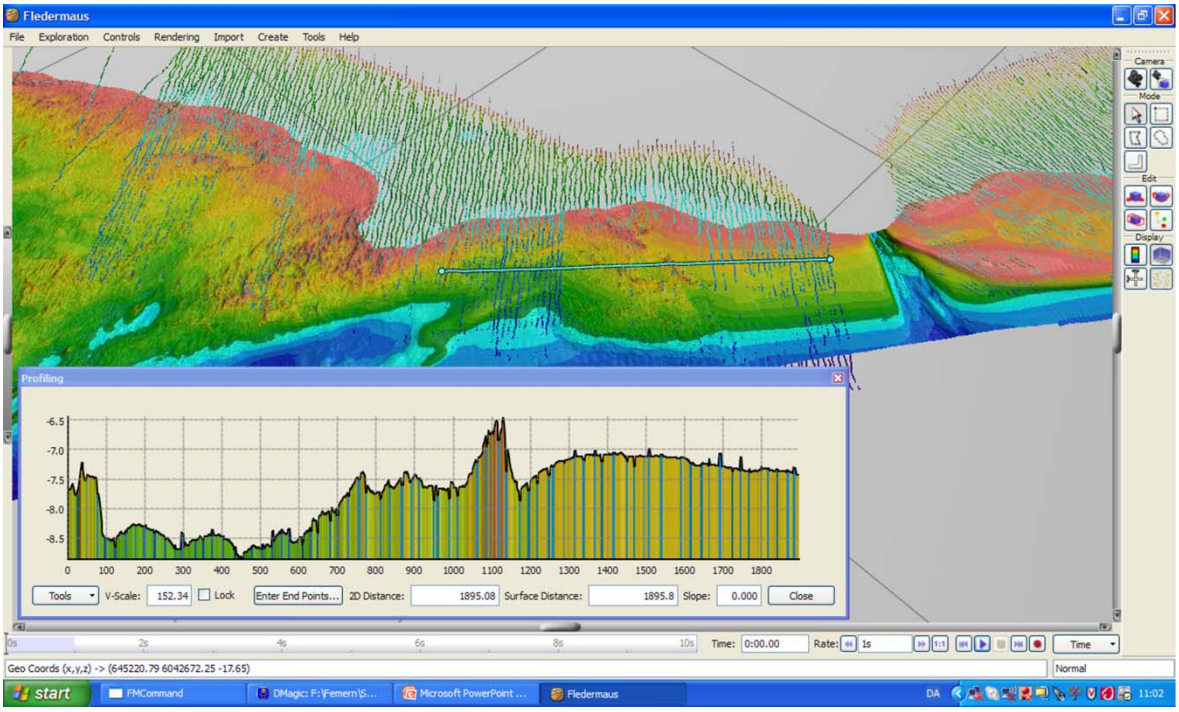


Figure 30. Cross section 8 on single beam profiles with multibeam data as background. German side.

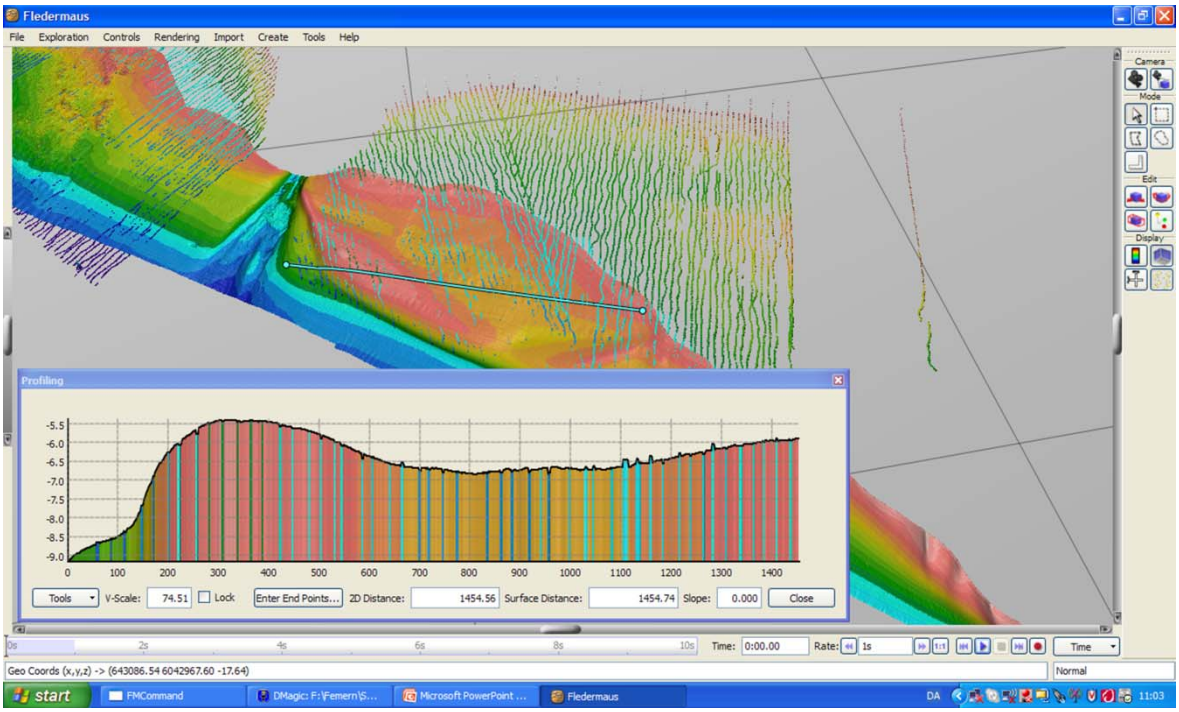


Figure 31. Cross section 9 on single beam profiles with multibeam data as background. German side.

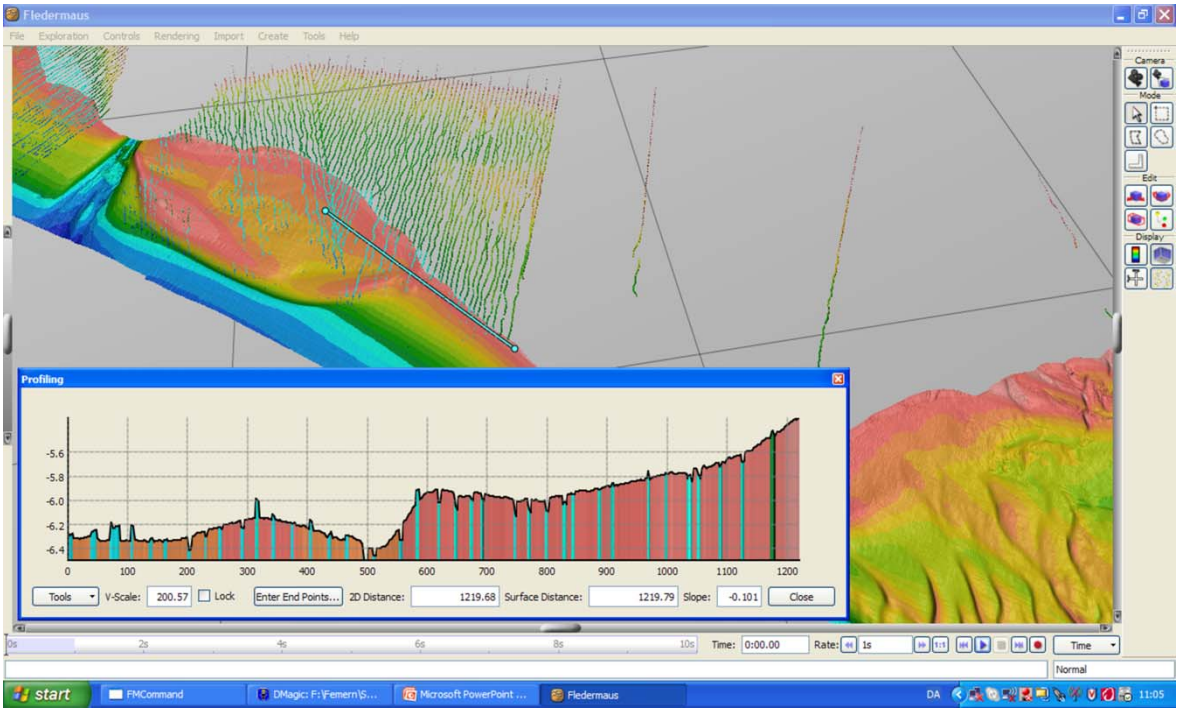


Figure 32. Cross section 10 on single beam profiles with multibeam data as background. German side.

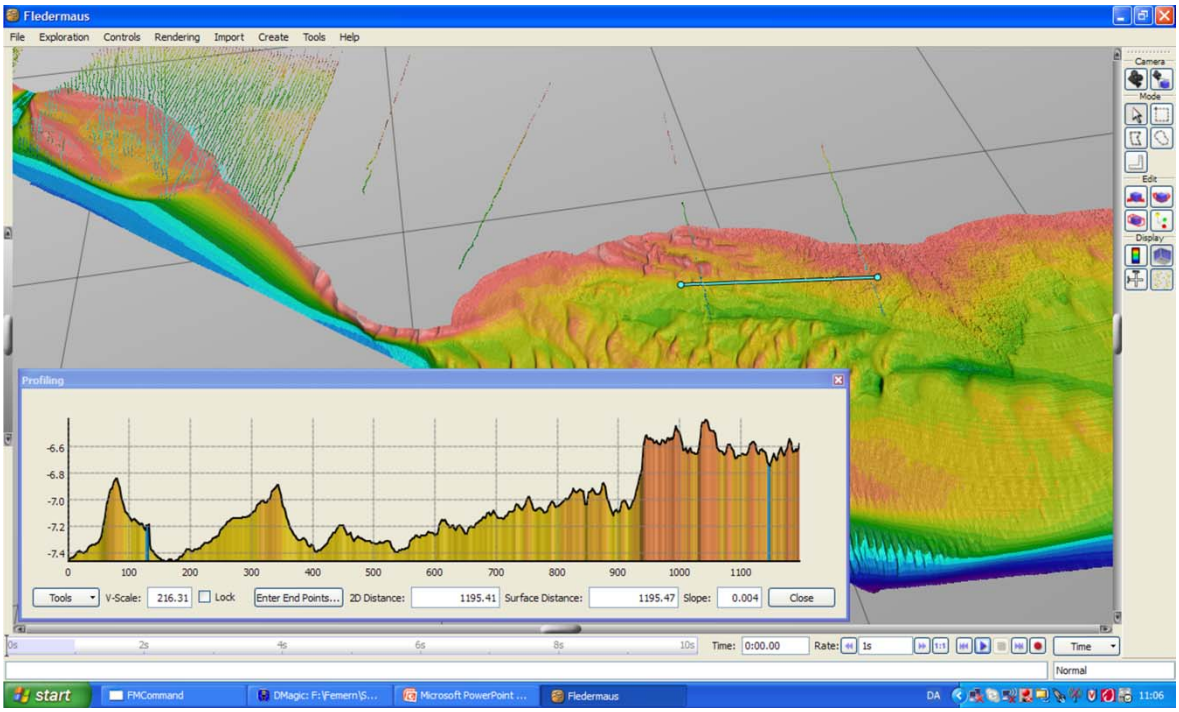


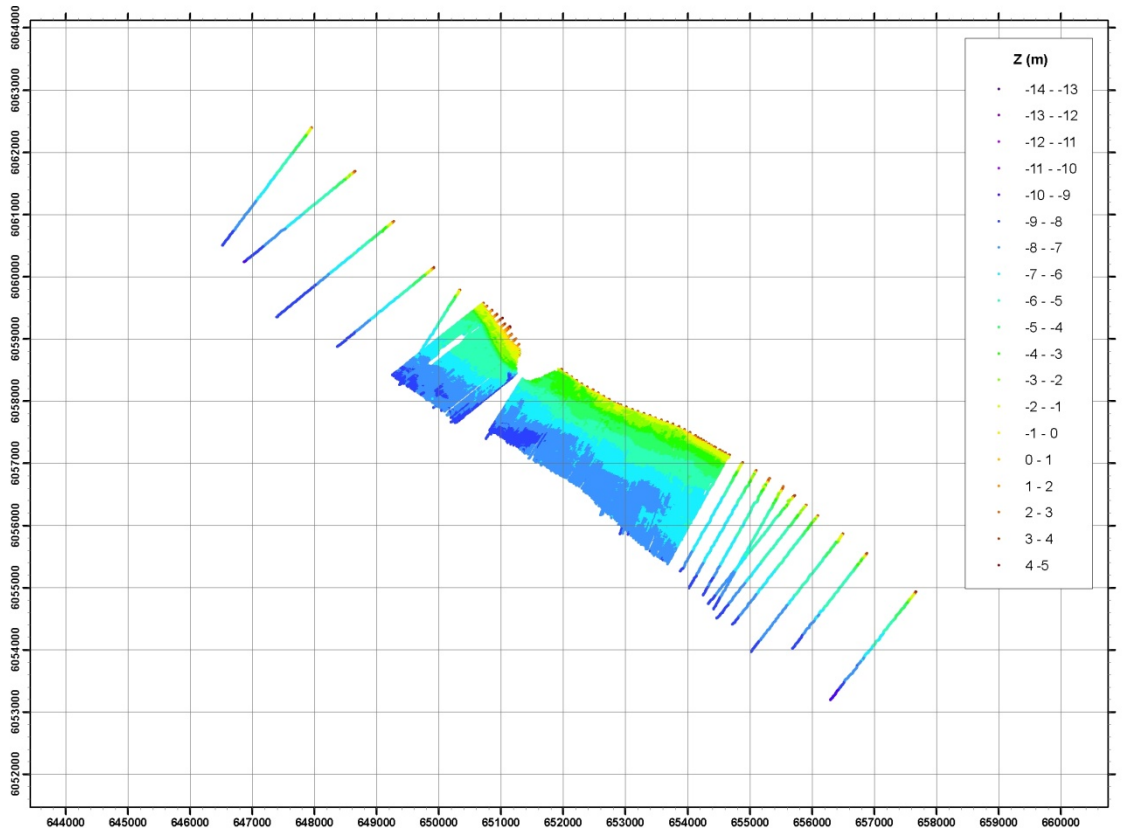
Figure 33. Cross section 11 on single beam profiles with multibeam data as background. German side.

Data and profile depth plots

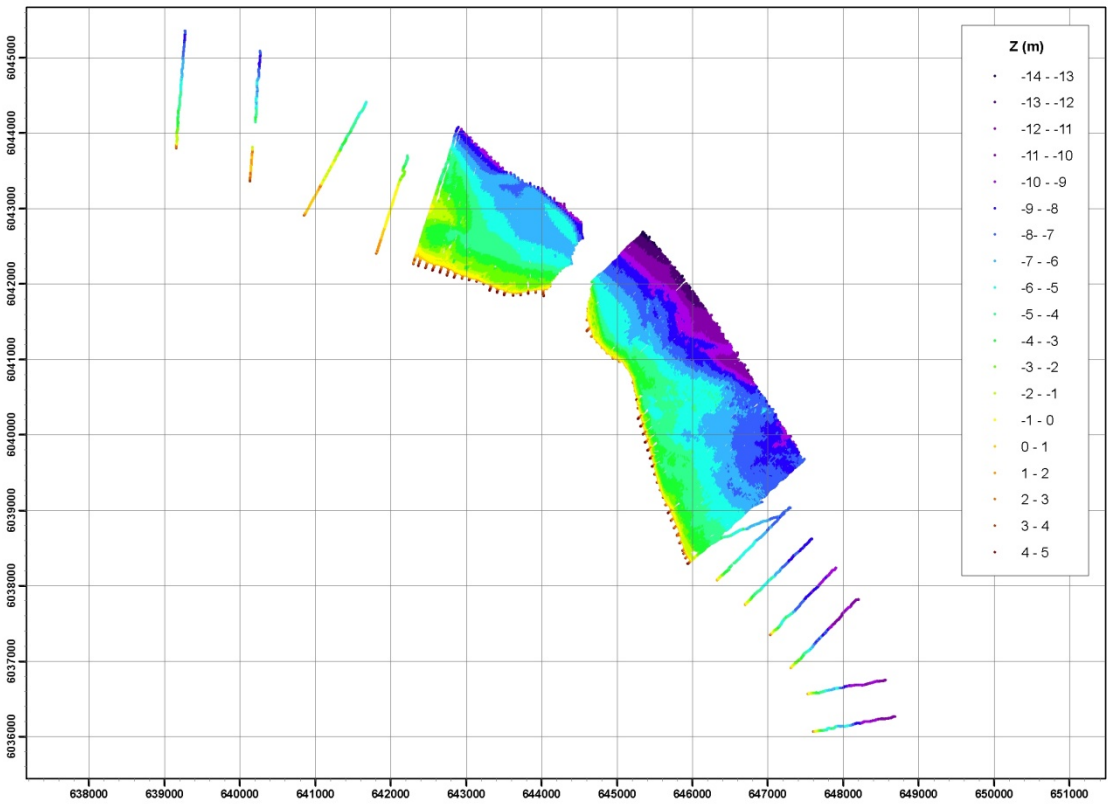
All corrected and smoothed profile data are attached this report in a DVD and maps showing depth colour-coded lines are shown in figures 34 A-D. Line numbers of individual lines are indicated in figures 35 A-D.

Figure 34 A-D (on following three pages). Depth colour-coded profile lines in the Rødbyhavn survey area (A) and Puttgarden survey area (B). Close-up line plots of the Rødbyhavn coastal area (D) and Puttgarden coastal area (D).

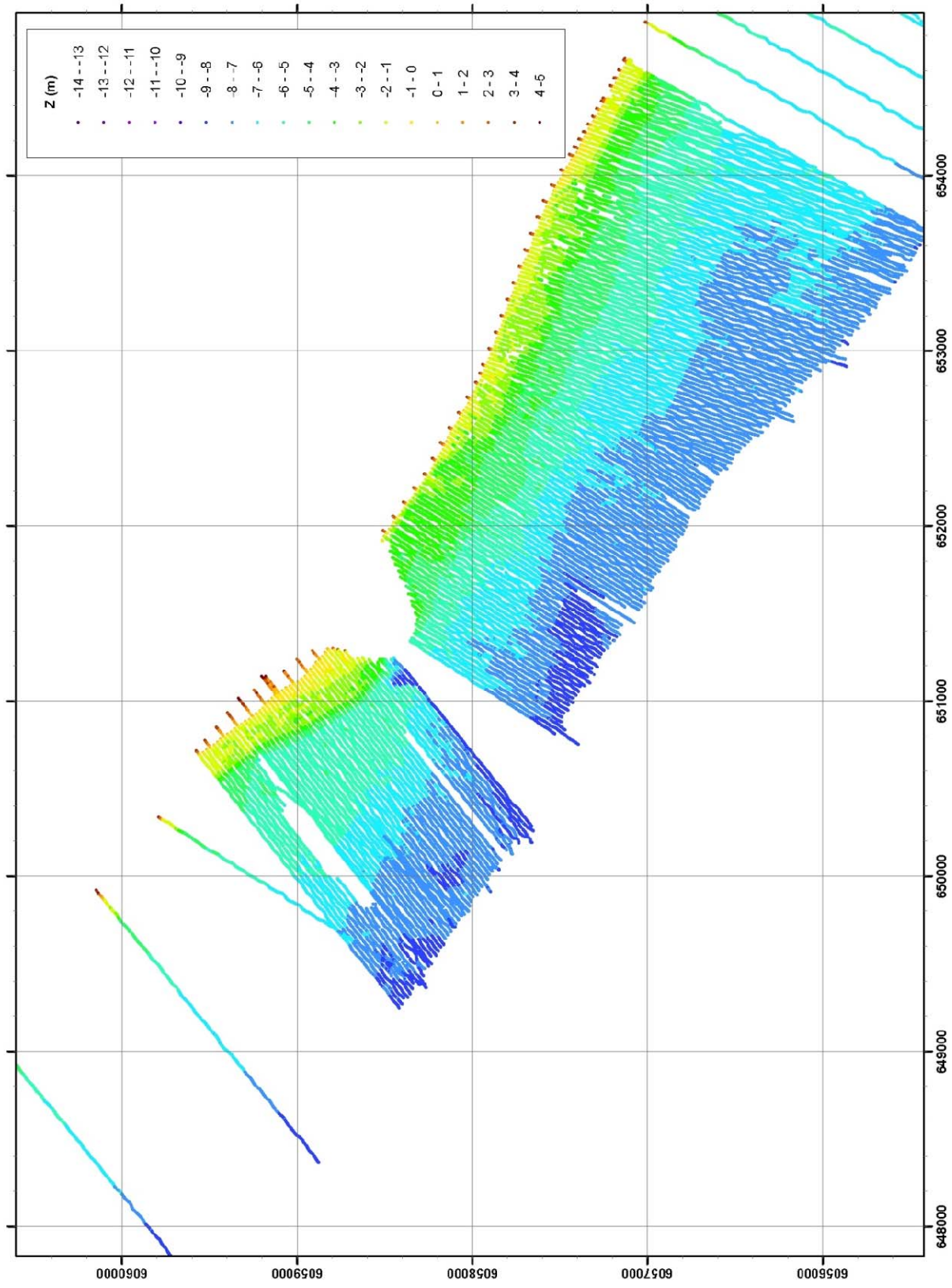
34 A. Rødbyhavn



34 B. Puttgarden



34 C. Rødbyhavn (zoom)



34 D. Puttgarden (zoom)

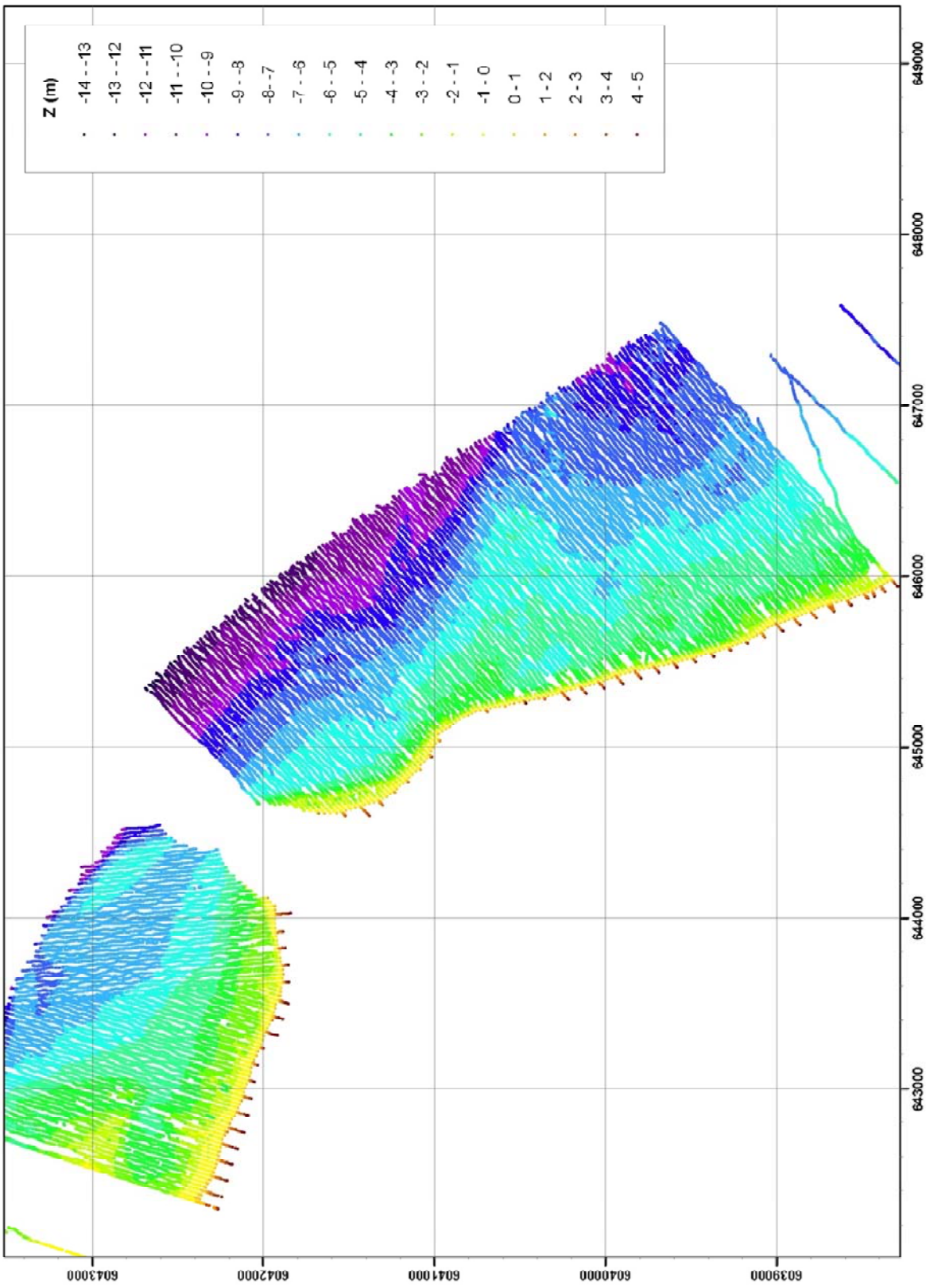
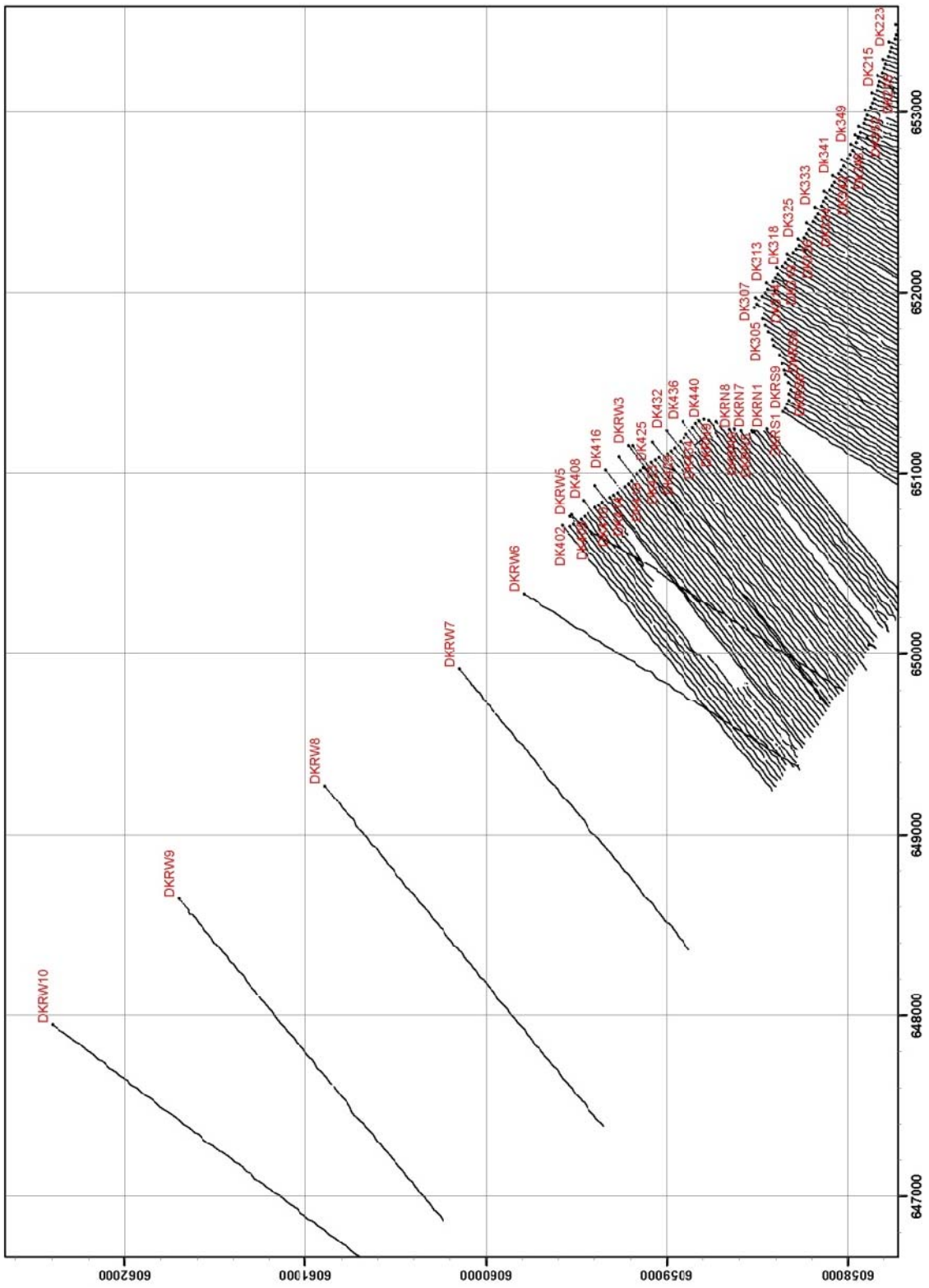
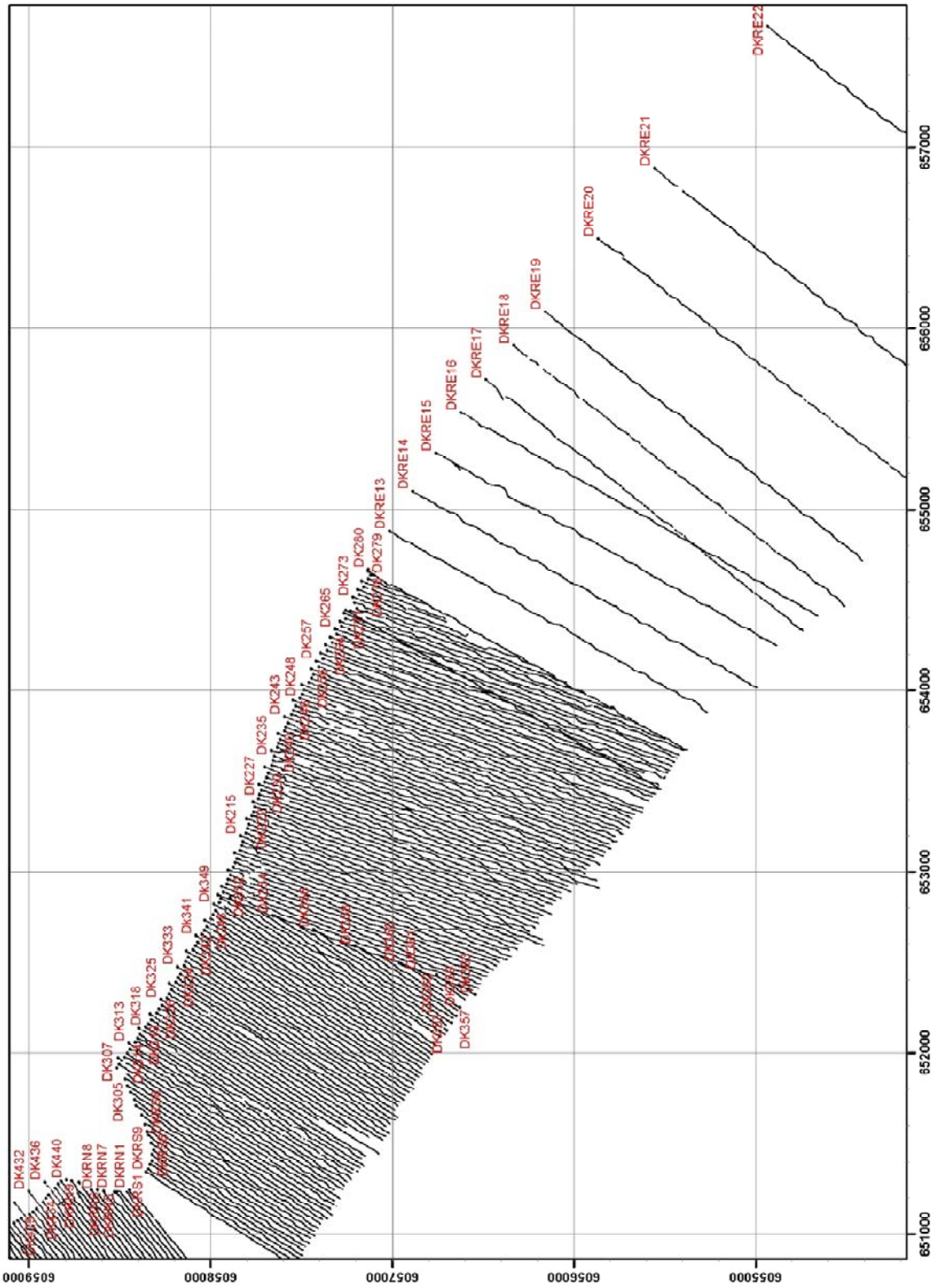


Figure 35 A-D (on following four pages). Profile lines with line numbers indicated. (A) Rødby NW, (B) Rødby SE, (C) Puttgarden NW, and (D) Puttgarden SE.

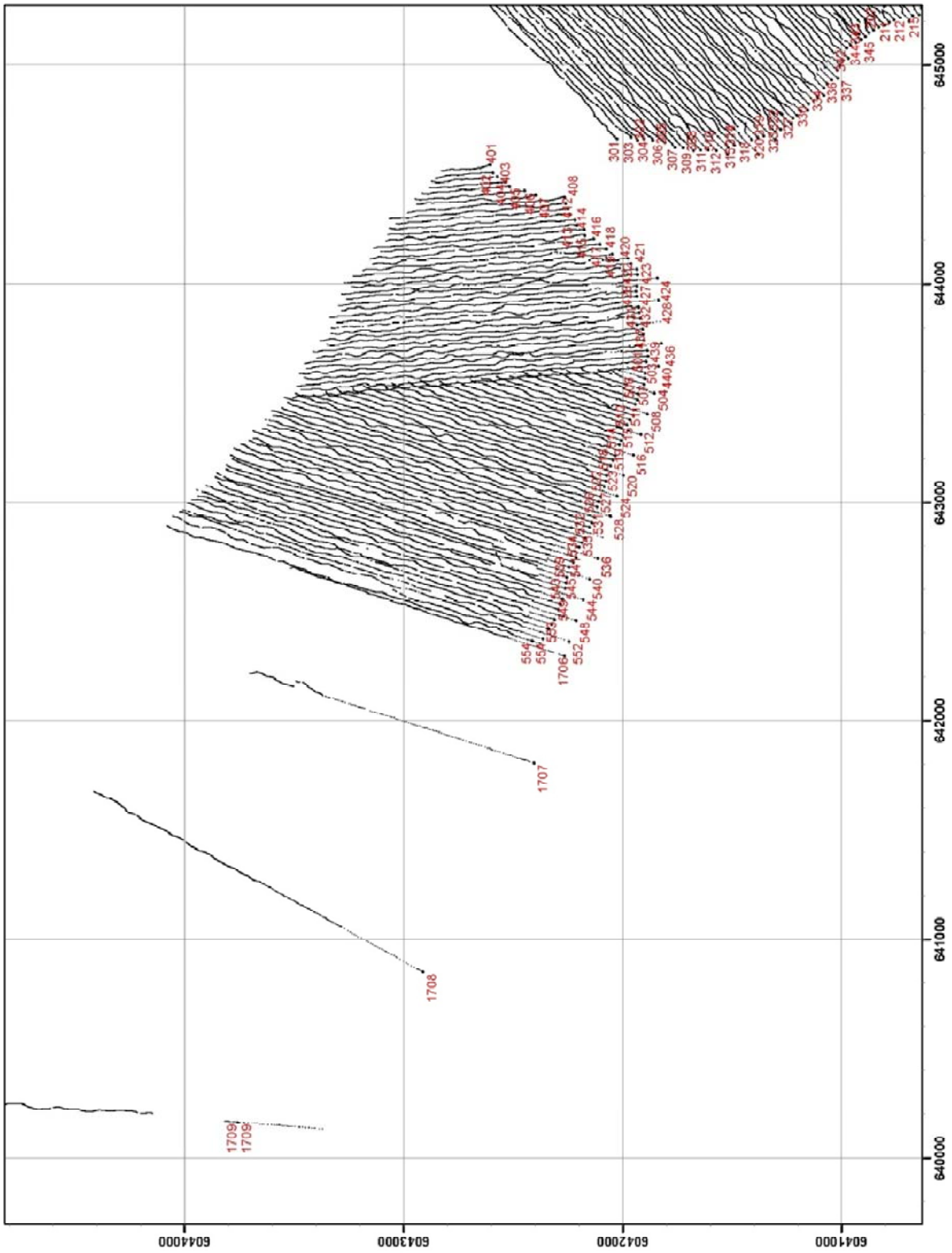
35 A. Rødbyhavn NW



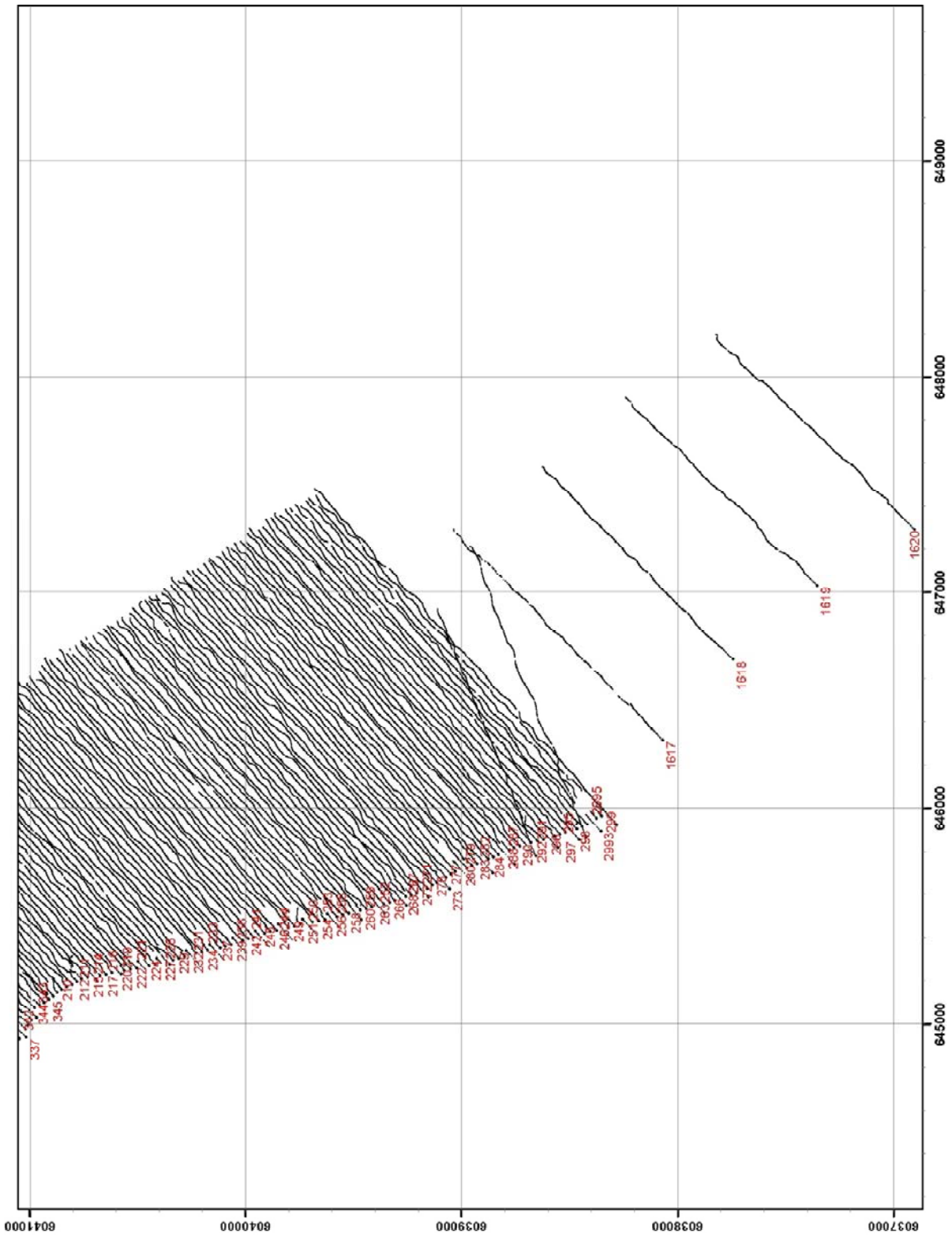
35 B. Rødbyhavn SE



35 C. Puttgarden NW



35 D. Puttgarden SE



Appendices

- **Appendix I.**

  Leica GPS1200

- **Appendix II.**

  Navisound 200 (Reson)

- **Appendix III.**

  RTK GPS (Dansurvey)

Leica GPS1200+ Series

High performance GNSS System

GNSS
future proof

- when it has to be **right**

Leica Geosystems

Leica GPS1200+
The only future proof GNSS

When it says future proof GNSS, it means maximum productivity and reliability. More satellites, more GNSS signals. Today and tomorrow! With Leica GPS1200+ you can be certain that you're ready for the future. Invest today in future proof GNSS technology and be sure that your equipment can track all satellites today and tomorrow. GPS1200+ is the only future proof GNSS System.

Best GNSS and RTK technology
Fast satellite acquisition, high accuracy measurements, tracking to low elevations, the world's first phase multipath mitigation technology, jamming resistant, high up-date rate, low latency, and fast, reliable, long-range RTK.

GNSS/TPS: standardized interface
Keyboard and touch screen, intuitive interface, powerful data management, on-board routines and programs: all easy to use and identical for GNSS and TPS.

SmartRover – extremely light weight
SmartRover weighs just 2.7 kg for a complete cable free all on the pole RTK GNSS rover. Work the complete day in comfort and enjoy full compatibility with SmartStation and SmartPole.

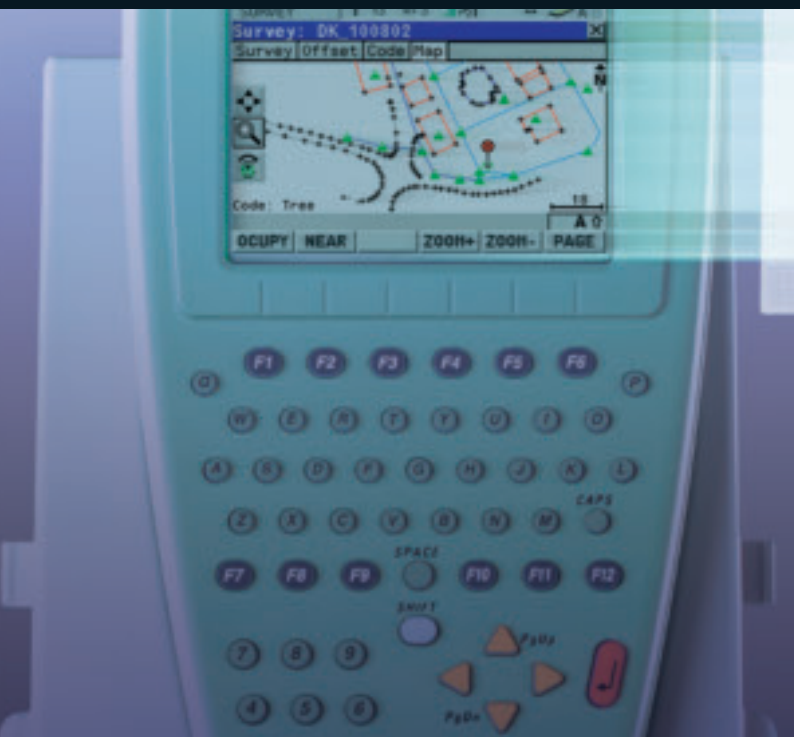
Fully waterproof, incredibly robust
GPS1200+ receivers are designed to work anywhere under the roughest conditions imaginable. They float, withstand falls, jolts and vibrations, operate in rain, dust, sand and snow, at temperatures from –40°C to + 65°C.

Totally versatile
GPS1200+ can be used as a reference or rover in any mode from static to RTK. Small, light, and supporting all formats and communication devices, it can be used on a pole, in a minipack, on a tripod, or even on a construction machine, survey boat or aircraft.

For all applications
You can use GPS1200+ for everything: control, topo, engineering, cadastre, stake out, monitoring, seismic – whatever you want.

FUNCTION integrated

Combine GNSS and TPS. Use them in the same way.
Change easily from one to the other.
Work faster, more accurately and more efficiently.
Enjoy all the freedom, flexibility and power of System 1200.



Leica SmartStation

TPS1200+ with integrated GNSS. All TPS1200+ can be ugraded to Smart Station.

Leica GPS1200+

Unites top GNSS technology with powerful data management. Perfect for all GNSS applications.

Leica System 1200

GNSS and TPS
Working together
For all applications
Today and in the future

Designed and built to the most stringent standards with the latest measurement technologies, Leica System 1200 instruments are extremely efficient and reliable, and stand up to the severest environments.

A highly intuitive user interface, a multitude of functions and features, powerful data management, and user-programming capabilities are common to both System 1200 GNSS and TPS instruments.

Operators can switch instantly between GNSS and TPS and use whichever is the most convenient and suitable; extra training is not required.

The new high-tech GNSS and TPS instrument of the System 1200 series with identical operation enable you to do every type of job, faster, more accurately and more efficiently than ever before.

And most important, you reduce your costs and increase your profits.

Leica TPS1200+

Top performance, high accuracy total stations do everything you want and much more.

Leica SmartPole

Save time with SmartPoles' setup On-the-fly and easily swap between GNSS and TPS when needed.

Leica SmartWorx

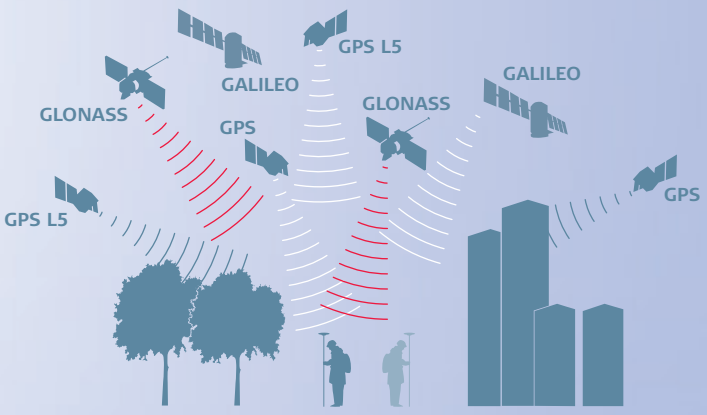
SmartWorx TPS/GNSS application software is both easy-to-use and extremely powerful.

Leica Geo Office

Everything you need in a single package for TPS and GNSS: import, visualization, conversions, quality control, processing, adjustment, reporting, export etc.

Leica GPS1200+

Fast, accurate, rugged and reliable



SmartTrack+

GNSS technology
GPS1200+ means newest GNSS technology. The third generation of SmartTrack+ measurement engine tracks all existing satellite signals and those planned for the future. This includes GPS L5, Galileo, GAGAN, WAAS, EGNOS, MSAS and Compass signals. More satellites means higher productivity, accuracy and reliability. SmartTrack+ acquires satellites within seconds and is ideal in urban canyons and obstructed areas where other receivers often fail. Uniquely, older GPS1200 receivers can be upgraded with the new SmartTrack+ measurement engine.

SmartCheck+
Continuously checking provides the highest possible reliability. A unique, built-in integrity monitoring system checks all results immediately. SmartCheck+ processes all available GNSS measurements simultaneously for centimeter-accuracy, 20 Hz RTK at 40 km and more. Initialize within seconds and survey in obstructed areas with a GX1230+ (GPS only) sensor or increase productivity with a GX1230+ GNSS/ATX1230+ GNSS (support all available GNSS systems).

SmartRTK
With Leica Geosystems SmartRTK and RTCM 3.1 correction data, performance and peace-of-mind is guaranteed. Never again you will need to worry about loosing consistency and traceability because of a moving virtually computed reference station. SmartRTK uses fixed reference station monuments that surveyors can trust. SmartRTK does not only give benefits with RTCM 3.1, the new atmospheric decorrelator technology provides precise positioning in all Networks regardless of the correction data.

SmartRTK

Exceptionally rugged
Don't worry about how your crews handle GPS1200+. It's built to MIL specs to withstand the roughest use. With its strong, precision-machined magnesium housing, GPS1200+ stands up to drops and falls and the jolts and vibrations of machines.

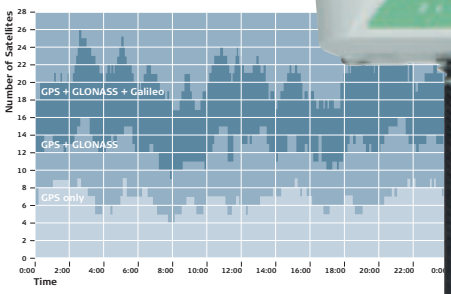
Immune to bad weather
Designed for temperatures from –40° C to +65° C (storage +80° C), GPS1200+ shrugs off arctic cold and blistering heat.
Fully waterproof – withstands immersion to 1 m – sand and dustproof, it operates perfectly in any conditions from tropical rainfall to desert sandstorms.
GPS1200+ just keeps on working.

High contrast touch screen
The high quality 1/4 VGA (11 lines by 32 characters) with optional colour option (RX1250) touch screen guarantees perfect clarity and contrast. Whether in fading light or bright sunshine, you can always read the display perfectly. Operate using the touch screen or the QWERTY keyboard, which-ever you prefer.

With or without controller
Connect the controller to the receiver when you need to input information and make full use of the on-board functions and programs.

RTK/DGPS communication
Radio modems, GSM, GPRS and CDMA modules fit in waterproof housings attached to the receiver. Attach either one or two devices for RTK/DGPS reference and rover applications.

With *Bluetooth*® Wireless-Technology built in to the RX1250 controller complete cable free operation and connectivity to compatible wireless products is available.



GNSS Modernization

When is the right time to invest in a new hybrid GNSS receiver? The answer is when the investment brings significant productivity gains. GLONASS has already proven such gains. GPS L5 and Galileo will bring even more advantages, such as allowing instantaneous ambiguity resolution and longer baseline ranges. An investment in GPS1200+ effectively increases the value of your equipment - a receiver guaranteed to track all satellite signals of today and tomorrow will remain competitive well into the future.

GPS1200+ receivers: GX1230+ GNSS/ ATX1230+ GNSS

- Triple frequency
- GPS/ GLONASS/ Galileo/ Compass[1]
- 120 Channels
- L1/L2/L5 GPS
- L1/L2 GLONASS
- E1/ E5a/ E5b /Alt-BOC Galileo
- 4 SBAS
- Full Real Time RTK
- Use as rover or reference

GX1230+/ GX1220+

- Dual frequency, GPS only geodetic receiver
- Easily upgradeable to GNSS receiver
- 16 L1 + 16 L2 GPS
- 4 SBAS
- Real-Time RTK (or DGPS option)
- GPS L5 and Galileo ready

SmartStation with SmartAntenna

SmartStation is a TPS1200+ with a ATX1230+ GNSS SmartAntenna. All GNSS and TPS operations are controlled from the TPS keyboard, all data are in the same database, all information is shown on the TPS screen. Touch the GPS key, let RTK determine the position to centimeter accuracy, then survey and stake out with the total station. You can do anything with SmartStation. You can also use SmartAntenna independently on a pole with a RX1250 controller.

- **Light, modular equipment**
  Use it the way that suits you best.
- **All on the pole**
  Light weight with excellent balance. Ideal for stakeout on construction sites and other demanding conditions.
- **Pole and minipack**
  Minimum weight in your hand when surveying for hours on end.
- **On a tripod or pillar**
  For geodetic control and reference stations.
- **All in the minipack**
  For 30 cm DGPS, GIS and seismic surveys.

Keyboard illumination

Switch on the display and keyboard illumination when working at night. All the keys light up.

Use GPS1200+ for everything

- For RTK, DGPS, and static data logging
- As a rover or reference
- On a pole, tripod, pillar, or in a minipack
- On construction machines, survey boats, or planes
- For every type of application

Seamless dataflow

WORKING TOGETHER

FUNCTION integrated

LEICA SYSTEM 1200

Choice of RTK pole

Carbon fiber or aluminum pole with adjustable, ergonomic handgrip.

Leica Geo Office

Software support package for GNSS and TPS with tools and components for import, visualization, conversions, quality control, processing, adjustment, reporting, export etc.

CompactFlash cards

Same CompactFlash cards for GNSS and TPS.

Plug-in Li-Ion batteries

For reliable, long-lasting power, GPS1200+ uses the best, high-capacity batteries available. Work for up to 17 hours with just two plug-in, Lithium-ion batteries.

TPS1200+ Total Stations

GNSS and TPS use the same CompactFlash cards, formats and data management. Transfer cards from one to the other and continue working in the same way.

[1] The Compass signal is not finalized, although, test signals have been tracked with GPS1200+ receivers in a test environment. As changes in the signal structure may still occur, Leica Geosystems cannot guarantee full Compass compatibility.

Leica GPS1200+

Extremely powerful
Yet very easy to use

GPS1200+ is loaded with a multitude of features and functions to meet the many different needs of users all over the world, yet it is remarkably easy to use.

GPS1200+'s graphical operating concept is self-explanatory and guides you straight to what you need.

You can use the default settings or, if you prefer, you can set GPS1200+ to operate, display and output data in exactly the way you require.

When you use GPS1200+, you'll find that everything is very easy to understand.

Even better, you'll notice that GPS1200+ and TPS1200+ are fully compatible with the same CompactFlash cards, data management, displays and keyboards.

Depending on the jobs you do, you can switch easily from GNSS to TPS and continue working in exactly the same way.

Operate GPS1200+ using the QWERTY keyboard or the large graphic touch screen, whichever you prefer.

Graphic view mode

Graphic views show your work. Zoom in for details and out for the entire survey. Use the touch screen or keyboard to access data related to points and objects.

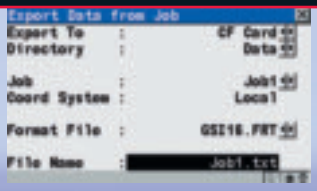
With graphical views you can check quickly in the field for completeness and correctness.

Coding and plan of your work

Define points, lines and areas to build up a plan in the display as you survey. You see immediately what you've done. Attach the codes, attributes and information needed for input into your office or mapping software.

System 1200 has all types of tools and is incredibly versatile.

Data export in any format



Data can be exported directly from GPS1200+ or via Leica Geo Office in various standard formats or in your own userdefined formats for direct input into any type of processing, office, CAD or mapping software.

System 1200 interfaces easily to third-party software packages.

Status icons
Indicate the current measurement and operation modes, recording and battery status, instrument settings etc.

Definable function keys
Allocate commands, functions, displays etc. to these keys for immediate access.

Configurable user menu
Set up your own user menu for the way you and your crews operate. Show what you need and hide the rest.

QWERTY keyboard
The standard QWERTY layout of the controller keyboard facilitates fast, easy input of alphanumeric data and information.

Program menu
Direct access to all loaded application programs such as survey, stakeout, COGO etc. and optional application programs.

Large graphic display
1/4 VGA high-resolution LCD with optional colour display (RX1250), easy to read in any light. Display and keyboard light up for work in the dark.

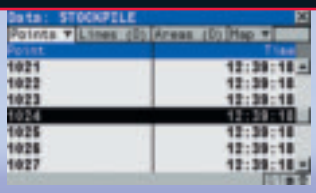
Touch screen
The controller's touch screen provides immediate access without using the keyboard. You can view data and information related to points and objects and call up all types of functions directly via the screen. Use the touch screen and/or the keyboard whichever you prefer.

User definable displays

With GPS1200+ you can define different display masks so that the system shows exactly what you and your crews want to see when surveying in the field. Set the displays according to the jobs you do and the information required.

GPS1200+ adapts perfectly to your needs.

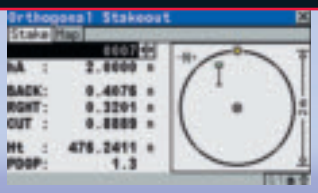
Data management



The powerful database manages data, files, jobs, quality checks etc. You can view, edit, delete, and search with or without filters. Coordinates of points measured more than once are averaged provided that they lie within specified tolerances.

Surveying is much easier and more reliable with System 1200.

Application programs



GPS1200+ is supplied with many useful programs such as Survey, Stakeout, COGO. Other programs such as RoadRunner, Reference Line and DTM Stakeout are optional. You can also write your own programs for special applications in Geo C++.

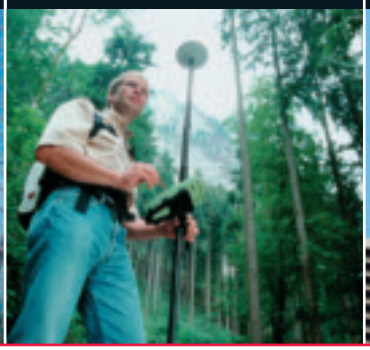
Most programs run on both GNSS and TPS.

WORKING TOGETHER
FUNCTION integrated
LEICA SYSTEM 1200

Leica GPS1200+
Superb measurement and RTK performance

SmartTrack+

SmartCheck



Reference stations

World leading GNSS technology

Low noise, reliable, high accuracy code and phase measurements are the basis of all satellite surveying work. The better the raw data and the more satellites being tracked, the better the performance and the results. GPS1200+'s completely new SmartTrack+ measurement engine and triple frequency antenna are matched with 120 channels perfectly to each other for the best possible receiver performance:

- Acquisition within seconds
- Excellent signal strength
- Tracking to low elevations
- Suppresses phase and code multipath
- Jamming resistant
- Top quality GNSS measurements
- Perfect tracking in dynamic environments
- Totally reliable

Fast, self-checking +40km RTK

The SmartCheck+ algorithms process all available signals and deliver fast, accurate RTK. Centimeter accuracy positions are available continuously at rates of up to 20 Hz. Integrity monitoring runs in the background resolving the ambiguities and verifying the coordinates. Reliability is phenomenal – 99.99% for baselines up to 40 km – and the range is outstanding.

Whatever the work, whether the receiver is on a pole or vehicle, you'll find GPS1200+ RTK to be the perfect tool:

- Initializes within seconds
- Measures amongst trees and obstructions
- Position updates every 0.05 second (20 Hz)
- Latency less than 0.03 second
- Consistent cm-accuracy
- Total reliability

GPS1200+ at CORS sites

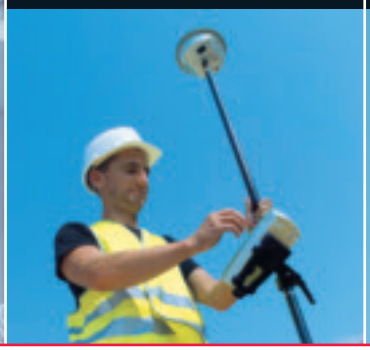
Organizations in many countries are establishing GNSS reference stations. GPS1200+ with a SmartTrack+ antenna or IGS/Dorne & Margolin choke-ring antenna is ideal for a Continuously Operating Reference Station (CORS). It logs data, streams data, outputs RTK and DGPS for transmission to RTK and GIS rovers, and is perfect for use with GNSS SPIDER, Leica's reference station software.

As GPS1200+ accepts all formats (Leica, CMR, RTCM) and outputs all standard messages (NMEA), GPS1200+ RTK rovers work perfectly with all reference station services all over the world.

- With single reference stations
- With networks of stations
- With MAX and i-MAX
- With area corrections (FKP) and virtual reference stations (VRS)

Everything you need for all applications

SmartRover



SmartRover – extremely light weight

SmartRover weighs just 2.7 kg for a complete cable free all on the pole RTK GNSS rover. Work the complete day in comfort and enjoy full compatibility with SmartStation and SmartPole.

SmartRover is fully compatible with SmartStation and SmartPole through the interchangeable SmartAntenna. Using *Bluetooth*® Wireless-Technology, the new light weight RX1250 colour display controller communicates with the SmartAntenna to provide RTK positioning to centimeter accuracy. SmartRover delivers many benefits:

- Weighs just 2.7 kg
- Interchange SmartAntenna between SmartStation, SmartPole and SmartRover
- Cable free all on the pole set-up is ideal for construction applications

SmartStation

GNSS & TPS perfectly combined

TPS1200+ total station with GNSS SmartAntenna combined in one easy-to-use instrument. Ideal for measuring to points that cannot be occupied by an RTK rover. Eliminates need for control points, traverses and resections when using a total station. Set up SmartStation and let RTK fix the position to centimeter accuracy, then survey and stake out with the TPS. Once SmartStation is positioned, use the SmartAntenna on a pole with controller and sensor as an RTK rover.

- Use TPS and GNSS together
- Fix the position with RTK, then survey with TPS
- Survey easier and faster
- Do any type of job
- Increase productivity and profits

SmartPole

Instantly switch between GNSS & TPS

Every survey site is different. Some sites are best suited to TPS and others to GNSS. With SmartPole both TPS and GNSS are available simultaneously. When GNSS is restricted by overhead obstructions use TPS; when no TPS line-of-sight is available use GNSS. No longer is it necessary to identify control points in the office and search for control in the field.

SmartPole is fully compatible with System 1200. The same light-weight GNSS SmartAntenna can be used together with a TPS1200+ as a SmartStation, together with a RX1250 controller as a SmartRover or together with the unique light-weight 360° reflector and RX1250 controller as a SmartPole.

- Higher accuracy & consistency of GNSS control
- Save time in planning and executing the survey
- Maximum flexibility and hence productivity

WORKING TOGETHER

FUNCTION integrated

LEICA SYSTEM 1200

Leica GPS1200+
Technical specifications and system features

GPS1200+ receivers	GX1230+ GNSS/ ATX1230+ GNSS	GX1220+ GNSS	GX1230+	GX1220+	GX1210+
GNSS technology	SmartTrack+	SmartTrack+	SmartTrack	SmartTrack	SmartTrack
Type	Triple frequency	Triple frequency	Dual frequency	Dual frequency	Single frequency
Channels	120 channels L1/L2/L5 GPS L1/L2 GLONASS E1/E5a/ E5b/ Alt-BOC Galileo Compass[1] 4 SBAS	120 channels L1/L2/L5 GPS L1/L2 GLONASS E1/E5a/ E5b/ Alt-BOC Galileo Compass[1] 4 SBAS (with DGPS option)	16 L1 + 16 L2 GPS 4 SBAS	16 L1 + 16 L2 GPS 4 SBAS (with DGPS option)	16 L1 GPS 4 SBAS (with DGPS option)
Upgrade to GX1230+ GNSS	-	Yes	Yes	Yes	Yes
RTK	SmartCheck+	No	SmartCheck	No	No
Status indicators	3 LED indicators for GX1200+: power, tracking, memory				

GPS1200+ receivers	GX1230+ (GNSS)/ GX1220+ (GNSS)	GX1210+	ATX1230+ GNSS
Ports	1 power port, 3 serial ports, 1 controller port, 1 antenna port		1 power/controller port, *Bluetooth*® Wireless-Technology port
Supply voltage, Consumption	Nominal 12 VDC 4.6 W receiver + controller + antenna		Nominal 12 VDC 1.8 W
Event input and PPS	Optional: 1 PPS output port 2 event input ports	Optional: 1 PPS output port 2 event input ports	
Standard antenna **Built-in groundplane**	SmartTrack+ AX1203+ GNSS Built-in groundplane	SmartTrack AX1201 Built-in groundplane	SmartTrack+ ATX1230+ GNSS Built-in groundplane

The following apply to all receivers except where stated.

Power supply	Two Li-Ion 4.4 Ah/7.4 V plug into receiver. One Li-Ion 2.2 Ah/7.4 V plugs into ATX1230+ GNSS and RX1250.
Plug-in Li-Ion batteries Same for GNSS and TPS	Power receiver + controller + SmartTrack antenna for about 17 hours (for data logging).
	Power receiver + controller + SmartTrack antenna + low power radio modem or phone for about 11 hours (for RTK/DGPS). Power SmartAntenna + RX1250 controller for about 6 hours (for RTK/DGPS)
External power	External power input 10.5 V to 28 V.
Weights	Receiver 1.20 kg. Controller 0.48 kg (RX1210) and 0.75 kg (RX1250). SmartTrack antenna 0.44 kg. SmartAntenna 1.12 kg. Plug-in Li-Ion battery 0.11 kg (2.2 Ah) and 0.2 kg (4.4 Ah)
	Carbon fiber pole with SmartTrack antenna and RX1210 controller: 1.80 kg.
	All on pole: carbon fiber pole with SmartAntenna, RX1250 controller and plug-in batteries: 2.74 kg.

Temperature ISO9022 MIL-STD-810F	Operation:	Receiver	−40° C to +65° C
		Antennas	−40° C to +70° C
		Controllers	−30° C to +65° C
		Controller RX1250c	−30° C to +50° C
	Storage:	Receiver	−40° C to +80° C
		Antennas	−55° C to +85° C
		Controllers	−40° C to +80° C
		Controller RX1250c	−40° C to +80° C
Humidity ISO9022, MIL-STD-810F	Receiver, antennas and controllers Up to 100 % humidity.		
Protection against water, dust and sand IP67, MIL-STD-810F	Receiver, antennas and controllers: Waterpoof to 1 m temporary submersion. Dust tight		
Shock/drop onto hard surface	Receiver: withstands 1 m drop onto hard surface. Antennas: withstand 1.5 m drop onto hard surface.		
Topple over on pole	Receiver, antennas and controllers: withstand fall if pole topples over.		
Vibrations ISO9022 MIL-STD-810F	Receiver, antennas and controllers: withstand vibrations on large construction machines. No loss of lock.		

[1] The Compass signal is not finalized, although, test signals have been tracked with GPS1200+ receivers in a test environment. As changes in the signal structure may still occur, Leica Geosystems cannot guarantee full Compass compatibility.

SmartTrack+ **Advanced GNSS measurement technology**	Time needed to acquire all satellites after switching on: typically about 50 seconds. Re-acquisition of satellites after loss of lock (e.g. passing through tunnel): typically within 1 second.
	Very high sensitivity: acquires more than 99 % of all possible observations above 10 degrees elevation. Very low noise. Robust tracking. Tracks weak signals to low elevations and in adverse conditions. Multipath mitigation. Jamming resistant.
	Measurement precision: Carrier phase on L1: 0.2 mm rms. On L2: 0.2 mm rms. Code (pseudorange) on L1 and L2: 20 mm rms.
SmartCheck+ **Advanced, long range RTK technology**	Initialization typically 8 seconds. Position update rate selectable up to 20 Hz. Latency < 0.03 secs. Range 40 km or more in favorable conditions. Self checking.
Accuracies	Kinematic Horizontal: 10 mm + 1 ppm Vertical: 20 mm + 1 ppm Static (ISO 17123-8) Horizontal: 5 mm + 0.5 ppm Vertical: 10 mm + 0.5 ppm
	Reliability: 99.99 % for baselines up to 40 km.
	Formats supported for transmission and reception: Leica proprietary (Leica, Leica 4G), CMR, CMR+, RTCM V2.1/2.2/2.3/3.0/3.1.
Reference station networks	RTK rover fully compatible with Leica's Spider i-MAX & MAX formats, VRS and Area Correction (FKP) reference station networks.
DGPS GX1230+ (GNSS), ATX1230+ GNSS, GX1220+ (GNSS) – standard GX1210+ – optional	DGPS, includes support of MSAS, WAAS, EGNOS and GAGAN. RTCM V2.1/2.2/2.3/3.0/3.1. formats supported for transmission and reception. Baseline rms: typically 25 cm rms with suitable reference station.
Position update rate and latency	Applies to RTK, DGPS and navigation positions. Update rate selectable from 0.05 sec (20 Hz) to 1 sec. Latency less than 0.03 secs.
NMEA output	NMEA 0183 V3.00 and Leica proprietary.
Post-processing with Leica Geo Office software **All GPS1200+ receivers**	Horizontal: 10 mm + 1 ppm, kinematic Vertical: 20 mm + 1 ppm, kinematic Horizontal: 5 mm + 0.5 ppm, static Vertical: 10 mm + 0.5 ppm, static For long lines with long observations Horizontal: 3 mm + 0.5 ppm, static Vertical: 6 mm + 0.5 ppm, static
Notes on performance and on accuracies	Figures quoted are for normal to favorable conditions. Performance and accuracies can vary depending on number of satellites, satellite geometry, observation time, ephemeris, ionosphere, multipath etc.

Controllers **RX1210/RX1250**	High contrast, 1/4 VGA display with colour option (RX1250) Touch screen, 11 lines x 32 characters. Windows CE 5.0 on RX1250. Full alphanumeric QWERTY keypad. Function keys and user definable keys. Illumination for screen and keys. Can also be used with TPS1200+ for alphanumeric input and extensive coding.
Operation with controller Same for GNSS and TPS	Via keypad and/or via touch screen. Graphical operating concept. Function keys and user definable keys. All information displayed.
Displayed information	All information displayed: status, tracking, data logging, database, RTK, DGPS, navigation, survey, stakeout, quality, timer, power, geographical, cartesian, grid coordinates etc.
Graphical display of survey Same for GNSS and TPS	Graphical display (plan) of survey. Zooming. Can access surveyed points directly via touch screen.
Stakeout display Same for GNSS and TPS	Graphical with zoom. Digital, polar and orthometric. Accuracy: 10 mm + 1 ppm at 20 Hz (0.05 sec) update rate. No degradation with high update rates.
Operation without controller GX1200+ only	Automatic on switching on. LED status indicators. For reference stations and static measurements.
Data logging Same cards used for GNSS and TPS	On CompactFlash cards: 256 MB and 1 GB Optional internal receiver memory: 256 MB.
Capacity	64 MB sufficient for (30 % less for GPS/GLONASS): About 500 hours L1 + L2 data logging at 15 sec rate. About 2 000 hours L1 + L2 data logging at 60 sec rate. About 90 000 RTK points with codes.
Data management Same for GNSS and TPS	User definable job management. Point identifiers, coordinates, codes, attributes etc.
	Search, filter and display routines. Multi point averaging. Five types of coding systems cover all requirements.
Coordinate systems Same for GNSS and TPS	Ellipsoids, projections, geoidal models, coordinate, transformations, transformation parameters, country specific coordinate systems. Fully support of RTCM 3.1 coordinate system transfer.
Application programs Same for GNSS and TPS	Standard: Full range of COGO functions. Hidden point.
	Optional: RoadRunner, Reference Line, DTM Stakeout, Reference Plane, Area Division and X-Section Survey, DXF Export, LandXML Export and Volume Calculations
Programmable Same for GNSS and TPS	User programmable in GeoC++. Users can write and upload programs for their own special requirements and applications.
Communication **Data links**	One or two of the following devices can be connected: Radio modem, GSM, GPRS, CDMA.
	Different frequencies and/or formats can be received and transmitted. Time slicing is supported.

Whether you want to survey a parcel of land or a construction site, a facade or indoors to create as-built plans or carry out high-precision measurements of bridge and tunnel constructions – Leica Geosystems' surveying instruments provide the right solution for all measuring tasks.

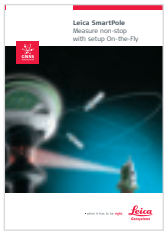
The System 1200 Series instruments as well as the software are designed to meet the daily challenges of modern surveying. They all have outstanding, easy to read and user-friendly interfaces. Their straightforward menu structures, their clearly outlined scope of functions and high technology perfectly mate GNSS and TPS applications in the field. Whether you use the advantages of both technologies combined or each separately – due to the exceptional flexibility of Leica Geosystems instruments, reliable and productive surveying is assured.

When it has to be right.

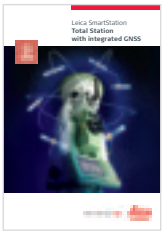
TQM
ISO 9001 / ISO 14001

Total Quality Management – our commitment to total customer satisfaction.

Ask your local Leica Geosystems dealer for more information about our TQM program.



Leica SmartPole
Product brochure



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Leica TPS1200+
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Leica System 1200 Software
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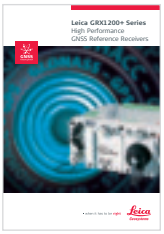

Leica GRX1200+
Product brochure

Leica Geosystems AG
Heerbrugg, Switzerland
www.leica-geosystems.com

- when it has to be **right**

Leica Geosystems

NaviSound 200 Series

PRODUCT SPECIFICATION

PORTABLE HYDROGRAPHIC SINGLE-BEAM ECHOSOUNDERS

- ***Portable, highly compact, lightweight unit***
- ***Broadband frequency agile***
- ***Multiple bottom digitizing with single frequency for sediment and vegetation surveys***
- ***Supports single or alternating channel operations***
- ***High-performance, easy-to-operate, and very reliable***

RESON's NaviSound 200 Series are highly portable, single-beam echosounders that offer a range of high-performance features. With a selection of models, the NaviSound 200 Series supports a wide range of hydrographic survey applications.

NaviSound 200 echosounders provide reliable depth measurements in a convenient, easy-to-operate unit. Advanced features include multiple bottom digitizing with a single frequency for sediment and vegetation surveys. Besides its compact size and low weight, the NaviSound 200 enclosure provides the highest possible water resistance.

An affordable side-looking sonar (SLS) option that records dual-sided imagery is also available for selected NaviSound 200 models.

Individual NaviSound 200 models are as follows:

- **NaviSound 215:** Enhanced single-beam echosounder that uses one receiver channel to operate two transducers in true real-time, alternating frequency operation
- **NaviSound 210:** Basic, one-channel, single-beam echosounder for hydrographic survey operations
- **NaviSound 205:** One-channel single-beam echosounder for light surveying

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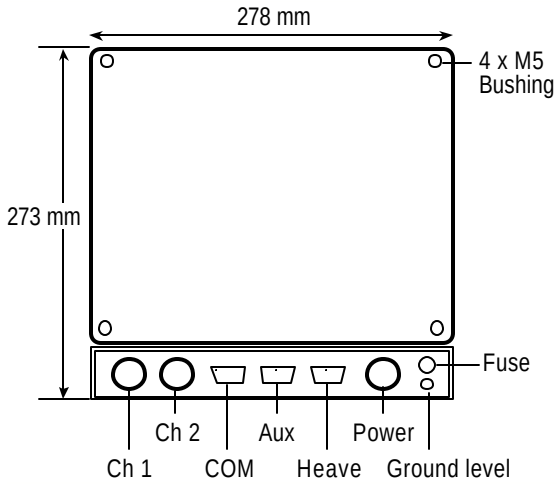
www.reson.com

NaviSound 200 Series System Specifications

TECHNICAL DETAILS

Frequencies:	User-selectable frequencies from 15-600 kHz. Standard 28-35 and 190-225 kHz
Impedance:	100 Ohm (others on request)
Max power:	300 W
Power control:	Manual or automatic
Pulse length:	Manual, 5 steps
Units:	Meters & feet
Resolution:	1 cm (210 & 215) 1 dm (205)
Accuracy:	1 cm at 210 kHz (1 sigma), 7 cm at 33 kHz (1 sigma) (assuming correct sound velocity, transducer draft)
TVC detection level:	20 Log (depth)
Additional feature:	Built-in barcheck utility
Sound velocity calibration:	1350 - 1600 m/sec in 1 m/sec step
Transducer draft comp:	0 - 99.99m
Graphics:	
Recording:	11 cm wide thermal paper recorder
Resolution:	800 pixels (gray shades)
Transfer speed:	20 lines/sec
Serial interfaces:	1: Communication 2: Heave input 3: Auxiliary input (DGPS) 4: Repeater output
Dimensions:	273 x 278 x 115 millimeters (11 x 11 x 4.5 inches)
Weight:	5.5 kg (12 lbs)
Supply voltage:	10 - 28 VDC (external AC converter available)
EMC radio noise:	CE approved

REAR VIEW



MODEL COMPARISON

NaviSound	205	210	215
Output resolution:	dm	cm	cm
Depth Range:	0.5-100m	0.2-600m	0.2-600m
Channels/Transducers:	1/1	1/1	1/2
Max. sounding rate (PRF):	5 Hz	20 Hz	20/10 Hz
Heave input:	-	✓	✓
NMEA output:	✓	✓	✓
DESOxx output protocol:	-	✓	✓
Supports SLS option	-	✓	✓
AC Converter Option	✓	✓	✓

Scope of delivery: NaviSound 200 Series User's Manual, DC power cable, RS-232C communication cable for PC, spare paper, transducer connector(s), and fuses & thermal head cleaning kit

RESON

Version: B42-PDF-0202

Client: **GEUS**
Lars Rödel

Femern campaign.
RTK: Reference stations.

Positioning Systems

Ref: Femern
Date:19-06-2009
Ver: final_ver1

Prepared by John Dahl
(jd@dansurvey.com)
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DK-3550 Slangerup
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TABLE OF CONTENTS

1. INTRODUCTION

EON operates one RTK reference station at Rødsand-2HR2. The RTK reference signal are broadcasted to all vessels via UHF, at frequency 449.100Mhz
This reference station is intended to be used initially throughout the area.

The base line is 10-28 km for the reference station at Rødbyhavn. The worst case accuracy is 5.5cm (XYZ, Equipment spec: 1.5cm+1.5ppm)

Starting with in-survey and geological investigations in 2006, this reference station has been used for the entire work.

The reference station coordinates has been verified by a chartered surveyor, using GPSnet-DK. Survey report can be requested.

For additional information, report malfunctioning etc.
Please contact Dansurvey.
Phone +45 45354585.
Mail jd@dansurvey.dk

2. GEODETIC PARAMETERS.

Geodetic Parameters: **UTM-EUREF-89. Zone 32N**
Vertical reference, DVR90

As there is no official transformation between WGS84 and EUREF89 at Rødsand 2, a 7 parameter transformation cannot be provided.
Presently work concerning a transformation between WGS84 and EUREF89 is in progress by officials. (KMS)

3. HEIGHT REDUCTION TO VERTICAL REFERENCE DVR-90.

The geoids model DVR-90 is an attempt to be MSL in 1990±10y. The model is accurate for the in-ways Danish water, and may not be absolute accurate to MSL at the Fermen area
In 2004, officials decided at all surveys, charts, C-maps and construction work shall use DVR-90 as vertical reference.

The height reduction to DVR90 can be carried out in one of three ways.

a.) The official geoids model, filename 'dvr90g2002.01'
This is a binary data file, which can only be handled by GPS manufactures and acquisition software,, which equipment are custom designed to import this file format.
b.) Fixed separation. A fixed separation can be calculated by use of the official program KMSTrans2007.
c.) Use interpolation model in sub-contractors acquisition software.

Link to Transformation software.:
http://www.kms.dk/English/Geodesy+and+Surveying/Transformation/

Download the program KMSTrans2008, and the responding geoids model dvr90g2202.01

4. PRIMARY POSITIONING SYSTEM. (ROVER)

The primary positioning system shall be RTK using GPS L1/L2. The GNSS receiver shall be capable of operating at long baselines
The accuracy archived all depends on the rover supplied by the subcontractor.

Please pay notice to the installation of the rover antenna. The GNSS antenna should have best possible free view to the horizontal above 12 degrees. Alternative there's a risk that the rover measurements gets unstable, running on multi path signals.¨

The elevation mask on the rover should be set to 12'. Our experiences indicates that - using not too low elevating mask when working on long baselines with different GNSS antennas.

The UHF antennas must be mounted in sufficient height to receive the reference at Rødbyhavn, (Line of sight) and further the antennas must have free horizontal view to avoid obstructions to block out the signal.

The UHF radio shall have 1-way connection only on the serial connection. This to insure the vessels rover can't cause the UHF radio to transmit, and by this interfere/jam the signals from the reference stations.

A positioning verification shall be carried out and demonstrated prior to the contractual work is initiated.
All systems and software used for navigation and transformation to DVR-90, shall be included in the verification.
(GNSS receiver, Acquisition software, Vessel reference unit, Vessel local reference measurement, etc.).

5. RØDBYHAVN RTK. REFERENCE, SPECIFICATION.

ID1: Reference Station: Rodbyhavn	
Station Name	**Station ID No: 1** Short ID: Rodbyhavn Long ID: Rodsand2
Reference Station co-ordinates. Geo_EUref 89 (WGS84) (WGS84)	Lat 54 39'18,81503 N Lon 11 20'57,32698 E Ellipsoid h = 90,314 m (Ant. APM to APC = 0.054+0.002m) Base-station h. 90.370 m (Entered value)
Reference Station co-ordinates. EUref 89 UTM Zone 32N	N 6058961.349 m. E 651550.376 m. DVR_90 h = 51.865 m. Geoide sep. 38.449 m (DVR90)
GNSS RTK receiver.	AD-Navigation model DC201B. L1/L2 GPS/GLONASS RTK receiver.
Measurements sent.	CMR format. (Reference coordinates = Antenna APC) GPS CA/L1,+P/L2, GLONASS L1 Update rate 5 hz. Time slot. 0.5 Period 0.25sec TX delay, 0.0s,
TX UHF radio specifications.	Telemetry: Satel 3AS Epic **Frequency 449.100 Mhz**, No addressing. TX power 10watt. Baud rate (Air) 19200. Omni directional antenna. (5db)
Rover telemetry: RX UHF Radio. (Recommended)	Telemetry: Satel 3AS Epic. Space diversity (Two antennas) **Frequency 449.100 Mhz**, . No addressing. Baudrate (RS232) 19200. Programmable. RS232 Connector DB9-F. RXd pin2.GND pin5. **Pin 3 (TX) must not be terminated due to risk of interference.**
Additional Information.	a.) DC-UPS, 30hours back up at 24volt. b.) Internet connection, fixed IP c.) GSM alarm & control. (SMS)

Figure 1: Rødbyhavn
GNSS antenna (LH) & UHF.

Coming up soon

6. PUMPESTATION: RTK. REFERENCE, SPECIFICATION.

ID2 Reference Station: Pumpestation	
Station Name	**Station ID No: 2** Short ID: PumpeStation Long ID: Rodsand2
Reference Station co-ordinates. Geo_EUref 89 (WGS84) (WGS84)	Lat 54 04.65043N Lon 11 28 18.00532 E Ellipsoid h = 45.5157m (Ant. APM to APC = 0.054m) Base-station h. 45.5697 m (Entered value)
Reference Station co-ordinates. EUref 89 UTM Zone 32N	N 6055086.8232 m. E 659591.4277 m. DVR_90 h = 7.154 m. Geoid sep. 38.3615 m (DVR90)
GNSS RTK receiver.	AD-Navigation model DC201B. L1/L2 GPS/GLONASS RTK receiver.
Measurements sent.	CMR format. (Reference coordinates = Antenna APC) GPS CA/L1,+P/L2, GLONASS L1 Update rate 2 hz. TX delay, 0.25s, 0.25 time slot. Period 0.5sec
TX UHF radio specifications.	Telemetry: Satel 3AS Epic **Frequency 449.100 Mhz**, No addressing. TX power 10watt. Baud rate (Air) 19200. Omni directional antenna. (3db)
Rover telemetry: RX UHF Radio. (Recommended)	Telemetry: Satel 3AS Epic. Space diversity (Two antennas) **Frequency 449.100 Mhz**, . No addressing. Baudrate (RS232) 19200. Programmable. RS232 Connector DB9-F. RXd pin2.GND pin5. **Pin 3 (TX) must not be terminated due to risk of interference.**
Additional Information.	a.) Internet connection, fixed IP b.) Not 24 hours accessible