NORDISKA KOMMISSIONEN FÖR GEODESI
Nordic Geodetic Commission Height Determination Working Group
Chairman
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Working group for Height Determination

Minutes of the meeting at the Landmælingar Islands, Akranes, Iceland, June 13-14, 2005.

Participants

Denmark:	Karsten Engsager Klaus Schmidt
Estonia:	Andres Rüdja
Finland:	Jaakko Mäkinen (Chairman of the SWG) Mikko Takalo (Chairman of the WGH)
Iceland:	Markus Rennen Thorarinn Sigurðsson Gudmundur Valson
Lithuania:	Arunas Buga
Norway:	Olav Vestøl
Sweden:	Per-Ola Eriksson (secretary of the meeting) Per-Anders Olsson Runar Svensson
Canada:	Jan Kouba (participated on 14th of June)

1. Opening of the WGH meeting

The Director Thorarinn Sigurðsson welcomed all participants to Iceland and to Landmælingar Islands. The chairman Mikko Takalo thanked Thorarinn for the opportunity to hold the WGH and SWG meetings in Akranes in connection to the

workshop on "The establishment of a New Vertical Reference for Iceland" the following days, and opened the meeting at 1:00 pm.

The chairman asked Per-Ola Eriksson to be the secretary of the WGH and the SWG meeting.

2. Approval of the agenda

The chairman emphasized that the issues concerning the results of the adjustment around the Baltic Sea, the land uplift model and the new height system of Sweden within the Technical session of the SWG were important issues for the meeting, and that those items must be allowed to take the time required. Mikko therefore proposed that the items concerning the SWG should be treated before the WGH items. This proposal was accepted and the agenda (appendix 1) was approved

3. Technical session of the SWG

3.1 New height system of Sweden

Runar Svensson described the new Swedish height system RH 2000. The final adjustment was finished in the spring 2005. The adjustment was done in geopotential numbers, and contains only levelling data with NAP fixed. The rms of unit weight app. 1 mm$\sqrt{}$km for the Swedish network. Transformation has been carried out from mean to zero tidal system, using formulas by Martin Ekman. Normal heights are calculated, according to the recommendations from UELN.

The land uplift model used is based on Olav Vestøls model, in combination with the geophysical model of Lambeck. The model is somewhat smoothed, and the version used in the adjustment is called RH 2000 LU.
In Sweden there is a problem with the second precise levelling, that does not fit to the land uplift. Klaus Schmidt informed that in Denmark has been found the similar problem with the second levelling of Denmark. Any reason and explanation has been found neither in Sweden nor in Denmark.

The results of the Swedish calculation shows that the loop misclosure of the Baltic Ring is about 10 – 15 mm. Jaakko Mäkinen informed that the agreement between RH 2000 and NH60 seems to be very good. There was earlier a bigger loop misclosure of the Baltic Ring.
The difference between DVR90 and RH 2000 at Pålsjö klint is now -22 mm. This also means that RH 2000 is at the same level as the German system. DVR90 compared to RH 70 was app.+50 mm.

Runar also told about the new height correction model SWEN 05LR, that will be released 2005 07 01. The model will correct for land uplift, permanent earth tide

and residuals. When using SWEN 05LR instead of NKG 04 the accuracy inproves from 38 mm to 15 mm.

3.2 Results of the adjustments around the Baltic Sea

Karsten Engsager reported on his work with the extension of the Olav Vestøl model ver 2. Karsten has used the grid-points all over the model, while in the Swedish solution only the LU observation points has been used, and interpolated in another way in the change-over to Lambecks model.
Olav informed that he has now developed ver 3, with an extension of the number of points. There will be even more improvements, since more levelling in critical areas will be performed. There will also be more mareographs taken in use. He also thinks that the accuracy of the GPS-stations will improve. Those improvements will primary affect the Norwegian part of the model.
Olav wants to see a common Nordic Height Datum. Could it be one of the WGH solutions, or should we send all the data to UELN and use their realisation of the European system? Mikko told that this should be an item later during the meeting.

Karsten reported on his investigations on the new geoid model NKG 04 concerning GPS-levelling. He has tested several connections across the Baltic Sea and the Gulf of Finland, and compared the levellings with the two geoid models NKG 96 and NKG 04, in order to find out if the new model is better than the old one. The result shows that some of the connections are better with the new model, while others do not seem to be improved. Some of them are even worse, so Karstens conclusion is that you cannot say that one model is better than the other.

This problem was discussed, and it was established that we need to have more GPS-points connected to the levellings in order to improve the geoid model. It turned out that each country already have a various number of points connected. Jaakko and Karsten want to see a Nordic database of such points. As a first step those existing points should be put together and be made available to all colleagues. Mikko urged all participants to try to connect as many additional points as possible in order to extend the database. One aim of this is to evaluate the geoid. Jaakko mentioned that there already is a project, EUVN_DA (Densification Action for the European Vertical Reference Network) going on within the frame of EUREF for densification of GPS/levelling- observations. The EUVN-DA points could form the starting set of the data collection. A simplified EUVN-DA form is now available.

3.3 Dynamic planet

In August there will be a IAG conference “Dynamic planet 2005” in Australia. A proposal has been sent from NKG to participate with a paper describing the Nordic Height Block. An acceptance to participate with a poster presentation has

been received. This means that a paper must be written. It was decided that Jaakko, Karsten and Mikael Lilje, or someone else from Sweden writes that paper.

3.4 Documentation and publication of the SWG work with the Baltic Ring

Mikko highlighted the question about documentation and publication of the SWG work with the Baltic Ring so far. There is a need for a good documentation of the work, and also for publication, in order to announce the efforts and the results achieved by the SWG. There will be some reports standing for themselves, and it could be good also to use those reports to publish the SWG work. Olav will write a report on his work with the land uplift model, and Jonas Ågren has written a detailed report on the Swedish adaptation of the LU model that will be published this autumn. Karsten will also write a report on his work, and there will be a special report on the Swedish work with the calculation of the new height system as well. All those reports can be compressed and merged into a common SWG report. It was decided that Mikko collects all the reports. He will also be the editor of the SWG report. It was also decided that the report should be finished before the next General Assembly, that will probably be sometime next autumn.

Jaakko pointed out that we must have permission from the nations included in the Baltic Ring to publish the national data in the planned report. It was decided that Mikko writes a letter to the countries involved to ask for such permissions.

3.5 Delivery af data to UELN

The delivery of data to UELN was discussed. The Danish data is already sent, and the question was whether each country should send their national data or if we should send the Nordic block as a whole. If each country sends the national data there is a risk that the Nordic block cannot be recreated, since the connections between the countries have been quite troublesome to establish, and it will probably be impossible for the UELN people to create the same solution that we have used. A complication if we send the whole block is that there will be some changes and additions in the data set from Finland and Norway.
Therefore it was decided that Sweden sends the Nordic block to the Nordic countries, and then each country approves their part. After that Sweden sends the whole block to UELN. The data that should be sent is the data that have been used for the realisation of the new Swedish height system, including corrections for land uplift using the RH 2000 LU model.

3.6 Closing the first day

The chairman closed the day`s meeting at 5:00 pm.

3.7 Opening the second day

The chairman reopened the second day's meeting at 9:00 am. In addition to the participants from the 13:th, Jan Kouba from Natural Resources of Canada attended the meeting.

3.8 Realisation for the national height systems and agreement between them

Jaakko informed about that the traditional NAP datum will probably be abandoned in the EUVN 2006 solution to be replaced with a global vertical datum, represented by a certain geopotential number **W0**, which represents the mean sea surface of the oceans, and could thus define a "world zero point or level" and be used worldwide.
In Finland it is not yet decided which datum to use. The working group on the new Finnish height system recommended to adopt the datum of whatever European system is valid in 2006 when the new system is created.

Olav believes that Norway will use the traditional NAP value, which is the same value used for the Swedish system RH 2000. In that case the Norwegian system will fit very well to the Swedish system.

The Danish zero point is constructed from the mean value of the sea level at the ten mareographs around the Danish coast. It turned out that the new Swedish system differs with 2 cm from the Danish system DVR90.

Jan Kouba pointed out that the choice of zero point is a political standpoint that is done in each country.

As long as we use the same kind of heights (normal heights) and the same tidal system (zero tidal) we can use a shift to convert from one system to another.

3.9 Closing of the SWG session and opening of the WGH session

The chairman closed the SWG session and opened the postponed WGH session.

4 National reports

4.1 Denmark

The national report from Denmark was not available at the meeting, but it was agreed to be delivered afterwards in order to be included in the minutes.

Klaus Scmidt informed about the problems with the total stations used in the Danish motorized trigonometric levelling (MTL). Earlier models of Topcon total station have been used for many years, and they have functioned very well. Two new Topcon models have now been bought, and those new instruments are not functioning satisfactory. The instruments give a difference of 2 cm/km between

forward and backward levelling. It seems that the error is depending on the length of the sections. Probably, there is an error in the software, but the manufacturer has not been able to give satisfied explanations to the problem.

4.2 Estonia

Andres Rüdja described the levelling programme going on in Estonia according to the principle of integrated geodetic networks. The fourth precise levelling network will consist of 15 loops with totally 3 000 km levelling lines, including connection of 11 mareographs and a large number of GPS - and gravimetric points. The new network will include the old one with addition of some new lines. The distance between benchmarks is 1.5 km, and the distance between GPS-levelling points is 5 km. The fieldwork started in 2003 with inventory of benchmarks and levelling in the Tallinn area and so far 320 km has been measured. The annual field season is from September to November, and according to the measurements performed so far, the mean error is estimated to 0.14 mm/√km. The digital levelling system DiNi12 is used for the levelling. A levelling database is built up, with all information about the measurements, and a benchmark database with information about all the benchmarks.

For 2005 inventory of old benchmarks and establishing of new ones is planned for 837 km in the southern parts of the country. About 50 % of the old points are preserved, but some of them do not meet the demands on good benchmarks. Levelling is planned for some 519 km in the western parts. The field work project is planned to be finished in 2009, and a new height system to be released in 2010.

4.3 Finland

Mikko Takalo reported on the activities in Finland. The levellings of the third precise levelling are now completed. Last year about 60 km of relevelling was done in addition to some 100 km levelling on Åland islands. Also three water crossings were carried out one in Åland islands and two in Kustavi using digital levelling technique with 4x enlarged scale of bar code rods. The length of crossings varied from 200 m to 400 m. Control measurement of limnographs and mareographs was performed to an extent of totally 57 km.

The National Land Survey of Finland carried out 390 km of precise levelling and 100 km of second order levelling. 290 km was measured to connect GPS points. There is a discussion with FGI to fit levelling points of NLS to the new height system of Finland in order to connect the NLS measurements.

Veikko Saaranen and Jaakko are working with the adjustment of the network, meaning land uplift model, adjustment of the Baltic ring and national adjustment for the new height system.

Test measurements are going on in order to develop new methods for water crossing, both with digital levels and trigonometric levelling. The results so far are very promising.

System and rod calibration of digital levels has been carried out, for equipment from Estonia, Lithuania, Latvia, Norway, Sweden, Denmark and Iceland beside the Finnish equipment. Totally 93 calibrations have been carried out. Comparison of system calibration comparators between Masala and Graz have also been carried out in spring 2005.

The plan for 2005 is to measure a 30 – 50 km joint line to Russia. The new height system will be launched in 2006 and in connection to that various reports dealing with the third levelling of Finland will be published.

4.4 Iceland

Markus Rennen informed about the activities in Iceland. The levelling network was originally one loop of 1 430 km, and the loop was closed in 2002. The misclosure of the loop was about 75 mm. During 2003 and 2004 the loop was divided into three smaller loops. The distance between benchmarks is 1 km, and the distance between GPS-points/gravity points connected to the levelling network is 8 km. There are also a few lines to the coast areas, where most of the population in Iceland is living. The levelling was completed last year, but so far no calculation has been done.

4.5 Lithuania

Arunas Buga described the activities concerning the establishment of the Lithuanian National Geodetic Vertical Network (NGVN). The network contains 1 900 km, built up in loops with a circumference of about 500 km. The measurements started in 1998, and the schedule is to finish in 2006. Mean distance between benchmarks is 1.5 km, at every 6 km there is a ground benchmark and at every 40 – 60 km there is a fundamental benchmark. The network is connected to the neighbouring countries. In 2004 280 km was levelled. Two levelling teams and one reconnaissance team are working in the field. Wild NA3003 is used for the measurements, and a systematic difference of +0.3 – 0.4 mm/km between forward and backward run was earlier noticed. After changing the measuring procedure to “Rote hose” the problems decreased. However there is still a difference between forward and backward run depending of the height difference of the section.

4.6 Norway

Olav Vestøl reported on the activities in Norway. Olav himself has put a lot of effort in the work on the land uplift model. The field production was relatively low in 2004, 242 km was levelled in the network. In addition to that 3 fjord

crossings have been measured. Control measurement was carried out for 3 tide gauges, and 32 GPS points were connected.

The plan for 2005 is to measure 430 km in the network, and hopefully the general levelling plan will be completed in 2006. This year there will also be more focus on calculation and introduction of a new height system.

4.7 Sweden

Per-Ola Eriksson reported on the activities in Sweden. The main focus last year was on the work with the establishment of the new national height system. In the network the updating programme proceeded. 130 new points were measured, which means 300 km levelling. Inventory was carried out for 770 points. This year inventory is planned for 2 500 points, and levelling of 50 new points. Some densification of the network was carried out in order to connect local networks with no possibilities to connect to RH 2000. 50 km was measured for that purpose.

Implementation of RH 2000 in the municipalities was another heavy task that started a few years ago, and accelerated last year. In that respect NLS helps the municipalities to connect the local networks to RH 2000, and then NLS recalculates the networks and helps them to analyse the results in order to get rid of deformations in the systems. Many municipalities seem to be interested to change from the local systems to RH 2000. So far this work is finished in 3 municipalities, and work is in progress with about 25 others. This will be a big issue in the coming years.

5 Presentations and other subjects

5.1 Results from closing the Øresund loop

Klaus Schmidt reported on his work with the calculations of the Øresund loop. The loop is built up by parts of the precise levelling networks in Denmark and Sweden. The networks have earlier been connected with several measurements across Øresund between Helsingør and Helsingborg, carried out with optical water crossings in 1896/1898 and 1980. A hydrostatic water crossing was carried out in 1939. The small loop created by those measurements had a closing error of -3 mm. A problem with those connections was that there was doubt about the stability of the benchmarks at Pålsjö on the Swedish side.

With the completion of the Øresund link a new connection could be established, and the possibility to close a loop around the Sound was created. In year 2000 the new connection was accomplished by motorised levelling as a joint enterprise by KMS in Denmark and NLS in Sweden, on a proposal from the Height Determination Group of NKG. The closing error of the new loop was -13 mm,

which is fully comparable with the quality of the precise levelling networks in Denmark and Sweden. Since the Øresund Link consists of a high bridge as well as a tunnel, gravity was measured along the whole Link and applied to the levelling. The effect was however almost insignificant. The conclusion is that the connections between the national height systems can be considered as reliable.

There is an exellent report written about the measurements and computations of the new Øresund loop.

5.2 Problems of Zeiss DiNi12

On the request from Sweden Mikko Takalo described some systematic effects of DiNi12. This effect is shown when forward and backward levelling is compared. Various sizes of those effects have been found in all countries using digital levels. In year 2000 Klaus Schmidt reported on the effect, and the reason was assumed to depend on movement of the rodbase or tripod, the way to set up and adjust the level or change of the ambient temperature.

In Finland tests were carried out in Metsähovi test field to find out if the effect is caused by movements of the rodbase or tripod, observer, level or tripod. The test showed that all factors except the compensator of the instrument could be excluded. Three Finnish instruments (DiNi12) had a systematic error in the interval from +0.6 mm/km to -0.6 mm/km.

In Sweden three instruments (Zeiss DiNi12) were used in 2004, and those instruments showed a systematic effect in the interval from -0.9 mm/km to -2.3 mm/km. The manufacturer claims that this is due to that the instruments are equipped with a turnable eyepiece and a device for blue toth that should cause unbalance in the instrument and obstruct the pendulum. Trimble in Jena has now confirmed that there is a residual error in the pendulums of the instruments, with individual magnitude for each instrument, and that the error can be eliminated if the “rote hose” observation method is used.

A quick question was asked around the table in order to find out what observation method was used in the different countries, and if there was any problems with the systematic effect. The result is shown in the table below.

Country	Type of instrument	Rote hose	Systematic effect
Norway	DiNi12	No / Random	No
Finland	DiNi12	No /Yes	Yes / No improvement
Estonia	DiNi12	Yes	No

Lithuania	Leica	No /Yes	Yes / No
Iceland	DiNi12	Yes	No
Denmark	DiNi12	?	No?
Sweden	DiNi12	No	Yes

The conclusion was that the "Rote hose" method probably can reduce the systematic effect from the residual error in the pendulum.

5.3 The third levelling of Finland – 27 years project

Mikko gave a resumé of the third levelling in Finland, from the preparations in 1974-1978 to the closing works 2004 – 2006. It was a very interesting overview, where different milestones in the project were pointed out. Different instruments, dataloggers and transportation equipment used during the project was shown. The new network consists of 9 050 km in 29 loops, compared to 8 200 km in 23 loops for the second levelling.

The measurements started 1978 05 11 at 3.15 pm in Helsinki and was finished 2004 10 15 in Kustavi. The observer of the very first section was Jaakko Mäkinen. The plan was originally to achieve the project in 10 years with 5 levelling teams, but it took 27 years with 3 teams. Through the years 10 observers and 800 other persons have been involved in the project. The new height system is called N2000, and there will be several publications describing the project.

6 Summary and future works of the WGH

The meeting was summarised.

- Data should be sent to UELN. After confirmation from each country Sweden sends the data including the land uplift model used in Sweden (RH 2000 LU). The format should be EUVN_DA-format.
- Mikko is responsible for collecting a common dataset of GPS-levelling points that should be available to each country.
- Mikko is the editor of the agreed publication of the work with the Baltic Ring. The publication should be available at the next General Meeting.
- There should be a unified handling of the determination of the tide gauges. The height difference between tide gauge benchmark and tide gauge zero should be determined and checked. The connections to the mareographs in Denmark should be included in the Nordic Block.

7. Next meeting

The next meeting of the WGH will be held the last week in March 2006 in Gävle. The date will be settled later.

8. Closing of the meeting

The chairman thanked all the participants for fruitful discussions and good contributions to the meeting. On behalf of all participants he thanked the hosts for a most successful and good organised arrangement. The chairman closed the meeting at 5.00 pm.

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Agenda for the Meeting of the NKG Working Group for Height Determination in Akranes, Iceland on 13th and 14th June, 2005

Monday 13th June, 2005.

12.00-13.00: Lunch

13.00-13.30: WGH meeting

- Opening of the meeting
- Approval of the agenda

13.30-17.30 Technical Session of SWG

New height system of Sweden RH2000: Technical description

Results of the adjustment around the Baltic Sea

Discussion and conclusions

Tuesday 14th June, 2005.

09.00 - 11.30: Technical Session of SWGs continues

Realisation for the national height systems and agreement between them

- Norway
- Finland
- Sweden

11.30 – 12.30: Lunch

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12.30 - 15.15: WGH meeting

National reports:

Denmark,
Estonia
Finland,
Iceland,
Latvia
Lithuania
Norway
Sweden

Presentations and other subjects

- Klaus Schmidt: "Results from closing the Øresund Loop"
- Per-Ola Eriksson and Mikko Takalo: "Problems of Zeiss DiNi12"
- Mikko Takalo: "The Third Levelling of Finland – 27 years project"

Summary and future works of the WGH

Next meetings

Closing of the meeting.