NORDISKA KOMMISSIONEN FÖR GEODESI
Nordic Geodetic Commission Height Determination Working Group
Chairman
Mikko Takalo
Finnish Geodetic Institute
P.O.Box 15 FIN-02431 Masala, Finland

Working group for Height Determination

Minutes of the meeting at the Estonian Land board, Maa-amet, Tallinn, Estonia, March 29-30, 2004.

Participants

Denmark: Karsten Engsager
Casper Jepsen
Klaus Schmidt

Estonia:
Harli Jürgenson
Tarmo Kall
Kalev Kangur
Natalja Morozova
Adolf Ostonen
Andres Rüdja
Ants Torim
Raivo Vallner

Finland: Jaakko Mäkinen (Chairman of the SWG)
Mikko Takalo (Chairman of the WGH)

Iceland: Markus Rennen

Latvia: Armand Celms
Jānis Kaminskis

Lithuania: Arunas Buga

Norway: Olav Vestøl

Sweden: Per-Ola Eriksson (secretary of the meeting)
Mikael Lilje
Per-Anders Olsson
Runar Svensson

NORDISKA KOMMISSIONEN FÖR GEODESI
Nordic Geodetic Commission Height Determination Working Group
Chairman
Mikko Takalo
Finnish Geodetic Institute
P.O.Box 15 FIN-02431 Masala, Finland

1. Opening of the meeting

Mikko Takalo opened the meeting and the Director General Kalev Kangur welcomed all participants to Estonia and Maa-amet. It was the first time a meeting of the NKG Height Determination Group was held in Estonia.

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

2. Approval of the agenda

Mikael Lilje stated that the issues concerning land uplift models and calculation of the Nordic Block within the Technical session of the SWG were the main issues for the meeting, and that those items must be allowed to take the time required. With that remark the agenda was agreed.

3. Minutes from the Hönefoss meeting

The minutes from the Hönefoss meeting were reviewed and accepted with no changes.

4. Technical session of the SWG

Jaakko Mäkinen asked Mikael to chair the session of the SWG.

Mikael checked off the list of actions that had been agreed upon in Hönefoss. The exchange of data between the countries has been completed, and a few misunderstandings regarding the designation of common points have been cleared out.

All the Nordic data is stored in the database at KMS.

Jaakko informed that all countries except Netherlands and Germany has accepted to deliver data. Jaakko was certain that there would be no problems with Holland and Germany. He has agreed with Johannes Ihde to change data next week during the EVRS-work shop in Frankfurt.

Jaakko asked the Nordic countries for the permission to deliver NKG data to UELN. The meeting decided that Jaakko could give Johannes Ihde uncorrected zero tidal data together with a land uplift model for all the Nordic countries. Jaakko informed that the agreement made with the UELN-countries so far is that FGI gets the data and not the NKG working group. The meeting decided that FGI should contact all countries concerned and ask them for permission to share the data between the Nordic countries. Jaakko thought that this would be no problem once the data is delivered to FGI.

NORDISKA KOMMISSIONEN FÖR GEODESI
Nordic Geodetic Commission Height Determination Working Group
Chairman
Mikko Takalo
Finnish Geodetic Institute
P.O.Box 15 FIN-02431 Masala, Finland

5 National reports

The national reports were mainly focused on the work within the SWG, but other related topics were also reported on.

5.1 Denmark

Karsten Engsager informed that KMS has made an adjustment with the Nordic Block data using the Finnish and Swedish digitisation of Lambecks land uplift map. The results are recorded in Appendix 1.

He asked if we should receive a single line from the UELN-countries or an area network. He was informed that we expect to have an area network from the UELN-countries. Karsten also introduced the name ”2nd Baltic Ring” for the adjustment.

Karsten had investigated the data from each country and was surprised that the mean error for Sweden was higher than expected (1.15). He assumed that the explanation was that the 2:nd and 3:rd order levellings was included in the Swedish network. The explanation is that the results from the relevelled loops are not included in the Swedish data. The Swedish network only includes the 1:st order levelling.

In the calculation he had divided the Norwegian data into 5 adjustment groups due to the long time span of the measurements. The result showed that the oldest observation group gave the lowest mean error (1.38), and that the group 1930-49 gave the highest mean error (2.20). Karsten assumed that the reason might be that where the eldest observations are found the uplift model is best fitting to the observations and that the uplift model is generally poor in Norway. These results are also recorded in Appendix 1.

Karsten was also concerned about the dense network of Sweden compared to the other networks. Runar Svensson showed later on that the density of the Swedish network does not influence the result.

Karsten will write a report on the calculations of the Nordic block.

5.2 Estonia

Ants Torim described the levelling programme going on in Estonia according to the principle of integrated geodetic networks. The old Estonian Height Network (EHN) is 50 – 60 years old. The new network will consist of 10 loops in the main land and 2 loops on the islands, totally 2 800 km levelling lines, including connection of mareographs, GPS - and gravimetric points. The new network will

include the old one with addition of some new lines. The fieldwork started in 2003 with inventory of benchmarks and 100 km of levelling in the Tallinn area. DiNi12 is used for the levelling. For 2004 inventory and establishing of new benchmarks is planned for 1 350 km, as well as levelling of some 200 km. Then the plan is to measure about 700 km per year from 2005 to 2008.

5.3 Finland

Jaakko described the work done in Finland regarding the calculation of the Nordic Block and the land uplift model. Lambeck map has been compared to values from Lambeck model and to tide gauge values. These two comparisons show the same pattern with the largest discrepancies around Oslo and along the western coast of Finland. Therefore Jaakko thinks that if the Lambeck map is fitted to the tide gauges it would be the best possible solution. Jaakko also compared Lambeck map to Bifrost and found the largest discrepancies to be 1.8 mm/year in the Gulf of Bothnia.

The Nordic Block has been adjusted with land uplift values from Bifrost and from the Lambeck map. The largest discrepancies between the two results turned out to be around 40 millimetres on the heights in epoch 2000 in a small part of western Norway.

5.4 Iceland

Markus Rennen informed about the activities in Iceland. The 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. Measuring of a line across the island that will divide the loop has been going on for the last few years, and will be completed this year. 55 km of levelling remains to complete this line. There is also a need to get levelling lines to the coast areas, where most of the population in Iceland is living.

5.5 Latvia

Armand Celms described the work with the precise levelling network in Latvia. The whole network will consist of 2 800 km and the measurements are planned to be finished in 2007. From 2000 to 2003 some 105 triangulation points have been measured and 52 pillars included in the national reference network.

Jaakko mentioned that the UELN database is missing levelling year but according to Jānis Kaminskis this information is sent to them. Janis will check with the UELN-data center.

5.6 Lithuania

Arunas Buga described the activities concerning the establishment of the Lithuanian National Geodetic Vertical Network (NGVN). The NGVN will

implement unified system of heights in the territory of Lithuania and guarantee reliable connection with other European height systems. The NGVN should be continuously updated for the purpose of heights and their accuracy determination. Institute of Geodesy, VGTU is involved in establishment of NGVN. First order of NGVN consists of 5 polygons of precise levelling lines. Most of the lines coincide with the existing levelling lines. 261 km of double run levelling was performed during 2003. Perimeter of the whole network (5 polygons (two of them already levelled, third one will be closed within a few months)) is some 1900 km. Digital levels Leica NA 3003 and bar code staffs Wild GPCL-3 are used. Closing error of the second polygon (after applying the staff calibration, temperature variations, refraction, tidal and normal corrections) was 12 mm.

5.7 Norway

Olav Vestøl reported that the field production of levelling has been very high the last few years. However the activities for this year is decreasing dramatically due to heavy budget cuts. The levelling production is planned to be about 230 km compared to almost 600 km per year the last few years. This means that the completion of the levelling project will be delayed by 2 years until 2007.

1 600 GPS-points has been connected to the levelling network so far.

"Cleaning" of the levelling database is going on. The database contains measurements from 1916 up till now.

Olav has looked into various land uplift models and noticed that Bifrost compared to Lambeck gives differences up to 4 cm in Norway. According to Jaakko that is due to the long time span of the measurements.

5.8 Sweden

Per-Ola Eriksson reported on the activities in Sweden. The relevelling programme was finished in 2003. The fieldwork is now concentrated to maintenance of the network. A plan for this work has been established. Related to the implementation of the new height system, densification of the network is planned to some extent in order to reach places with no possibility to connect to the new system.

Much effort has been spent on the disagreement between the 2:nd and 3:rd levelling, especially in hilly areas. There is a scale of some 140 ppm in the 2:nd levelling in such areas, somehow depending on the height difference, and it is especially problematic in the mountains of Härjedalen, where the heights differs with more than 12 cm at the Norwegian border. This is a well-known problem, and MTL measurements was done early to see if there was a systematic error in the ML technique, but the MTL measurements confirmed the ML levelling. This

is a serious problem when it comes to comparing the two levellings for land uplift purposes.

6 Discussion and conclusions

6.1 Land uplift model

The empirical models have shown a lot of progress over the last couple of years. Runar Svensson showed that SWEPOS and levelling data (Land Uplift values in SWEPOS stations by Martin Lidberg) shows a very good acceptance in Sweden with a few exceptions, probably due to influence of the faultiness in the 2:nd levelling.

Milne is releasing a new model shortly and Olav is working hard on a collocation model for the Nordic Area. The 2:nd levelling of Sweden has recently been sent to him, but he has yet not had the time to include it in his calculations. Due to fieldwork during the summer he expect to be able to finish the work in August.

Jaakko is working with the Åland-campaign, the oceanographic connection between Åland and Sweden as well as the crossing over the Gulf of Finland.

According to Casper Jepsen, NKG is about to release a new geoid.

6.2 Nordic Block

Denmark and Finland have done preliminary adjustments of the Nordic Block using Lambecks uplift map and the results differs with 6 centimetres from southern Denmark to Helsinki. Jaakko believes that his adjustment needs to be improved. Sweden has not yet been able to perform an adjustment of the Nordic Block.

Runar showed what happened in the Swedish network when he reduced the number of redundancy in several steps, from 707 in the complete network to 37, which is comparable with the 2:nd levelling. The standard error of unit weight changed from 1.136 in the first case to 1.144 in the last case. This shows that the worries about the density of the Swedish network causing an unwanted wrong balance in the Nordic Block, is unjustified.

It was preliminary decided to have a workshop on the 24th of May in Helsinki to discuss the adjustment of the Nordic Block and the complete Baltic Ring. It was estimated that the UELN data should have been delivered and investigated by then.

7 Closing the first day; Poster Session (Raivo Vallner). Opening of the second day

The chairman closed the day's proceedings at 5 p.m. First Deputy Director General Raivo Vallner provided a most successful poster session from 7 p.m. onwards. The chairman opened the session of the SWG on March 30 at 9 a.m.

8 Presentation of Maa-amet

The Director General Kalev Kangur presented shortly the activities and responsibilities of Maa-amet. The main task is land cadastre. Valuation of real estate is another task. Geodetic activities and mapping are mostly purchased from external producers. There are about 200 employees including a number of local offices. The turnover is 6 – 8 Million Euro.

9 Continuation of discussion and conclusions of the SWG

Mikko asked Mikael to chair the SWG session.

9.1 Nordic Block and the Baltic ring

Jaakko expects that UELN data will be delivered to FGI next week. Data from Germany will take some time since each state owns their data, and permission will be needed from each one of them. Data from Holland will also be delayed.

The agreement when data was required was that it should be delivered to FGI only. Hopefully it will be an easy task to get permission for FGI to deliver to the other Nordic countries. The Baltic countries gave their permission on request from the meeting.

It was agreed that the most urgent matter now is to try to speed up the process of the permission to have UELN-data delivered to FGI as well as to the other countries.

It was decided that Jaakko sends all the Nordic data to UELN together with a land uplift model (Lambecks map).

9.2 Land uplift model

Jaakko was more concerned about the loop misclosure around the Baltic Ring than the choice of land uplift model in each country, with respect to the harmonisation between the national systems.

The Danish and the Finnish preliminary adjustments of the Baltic Ring differs with 6 centimetres. Jaakko believed that his adjustment could be improved.

NORDISKA KOMMISSIONEN FÖR GEODESI
Nordic Geodetic Commission Height Determination Working Group
Chairman
Mikko Takalo
Finnish Geodetic Institute
P.O.Box 15 FIN-02431 Masala, Finland

10 Realisation of the national height systems and accordance between them

To summarise the thoughts about the realisation of the national height systems in the Nordic countries in order to harmonise them in the best way, the chairman asked each nation about their apprehension of the situation.

10.1 Sweden

Sweden had understood that the preliminary adjustment of the Baltic ring should give one datum point per country.

The Lambeck map should be used for the preliminary adjustment.

For the national adjustments each country can choose the best available model.

The epoch for the preliminary adjustment as well as the national adjustments should be 2000.

10.2 Norway

Norway had the same impression, but added that we should create a Zero tidal system, and we should calculate normal heights.

Olav stated that there should be another final calculation of the Nordic Block when the Norwegian network is complete. The measurements from the Baltic countries should also be included when they are finished.

10.3 Finland

Finland agreed to this apprehension, and added that they would most probably use an empirical land uplift model, but this should not influence the difference between Finland and Sweden too much.

11 Closing of the SWG session

After this summary the chairman closed the session at 11.30 a.m.

12 Opening of the WGH session

The chairman of the WGH, Mikko Takalo opened the WGH session at 12.30 p.m. Mikko asked the meeting to stand in a moment of silence in memory of Aimo Kiviniemi who has deceased.

The session contained some presentations on different issues.

NORDISKA KOMMISSIONEN FÖR GEODESI
Nordic Geodetic Commission Height Determination Working Group
Chairman
Mikko Takalo
Finnish Geodetic Institute
P.O.Box 15 FIN-02431 Masala, Finland

12.1 National report Denmark

Casper Jepsen described the activities going on in Denmark in the field of levelling besides the computation of the Nordic Block. The levelling season started 3 weeks ago. 2 teams are doing levelling for the municipalities and for the Danish new 3D 10 km net. One team is using the ML technique with DiNi12, and the other team is using the MTL technique.

Introduction of new height system, DVR90 goes on, the main goal for DK is that DVR90 is introduced and used all over DK on January the 1:st 2005. The maximum difference between the new and the old system is 15 cm in the southern parts of the country.

All national authorities have decided to change all their height data before that date, and all counties will do the same. The process for the municipalities goes on and the expectation is that they will also change by that date.

Maintenance of the precise levelling points is done with GPS. In 2004-2006 KMS will establish new points at the fundamental height points, called 4D and 5D net.

12.2 The implementation of RH 2000 in municipalities

Per-Anders Olsson talked about the introduction of the new national height system in Sweden, RH 2000, and the work going on at Lantmäteriet in order to convince the local users to leave the local systems and connect to the new one. The situation in Sweden is terrible since almost each municipality are using one or more local systems with bad connections to the national systems, which also means that most of the local networks are more or less deformed. Lantmäteriet has started a project in order to inform the municipalities about the situation, to create tools and procedures in order to help the users to analyse their local networks and then help them to connect and recalculate the networks into the new national system. So far some 10 municipalities have decided to connect their networks to RH 2000, and at least so far it seems that the bigger municipalities are more interested than the small ones. The activities in this field will be enlarged as soon as the national network is finally calculated.

12.3 Maintenance of RH 2000

Per-Ola Eriksson told about the maintenance of the third precise levelling. A plan is established on how to update the whole network due to age and expected exploitation in the area. The work is divided in several phases. All points are visited, and all information on the bench mark descriptions are updated. All the destroyed points are replaced with new ones, and new descriptions are established. In the cities local points are used if it is convenient, in order to get the local networks connected without extra levelling. The levelling to connect the new points to the network is normally done the year after the inventory. The

levelling is done so that the quality of the new point is equal to the older points. The work started in 1992 with two test areas, and continued until 1998. Then the relevelling programme replaced the systematic updating plan for a few years. In 2003 the maintenance was started again, and some 4 000 points were updated. The result was that about 180 new points were set out, and they will be levelled this year. At the same time the updating phase continues with some 3 000 points.

12.4 The closing of the Oresund loop

Klaus Schmidt reported on his calculations of the closing error of the Oresund loop. The result was 13 mm ± 13 mm. The length of the loop is 190 km. That was a quite good result keeping in mind that the loop includes the Oresund link with the bridge and the tunnel as well as the old optical crossings between Helsingborg-Helsingör. Klaus has also investigated different ways to treat the land uplift and gravity data (e.g. that on the bridge and in the tunnel you should take into account that gravity data is valid on ground level). Neither of them have any significant effect on the result. Klaus will write a full report on his investigations

12.5 The difference between the N60 and BK77 Height Systems

Harli Jurgenson reported on the investigations of the difference between the Finnish system N60 and the Estonian BK77. GPS-levelling has been performed using 28 points, 18 in Estonia and 10 in Finland. The method is based on the differences between the gravimetric and the geometric geoids. A gravimetric geoid was calculated specially for the present job, using also a very dense gravity data net from the North Estonia. Estonian levelling points were transformed first to epoch 1970 using Põltsamaa fundamental benchmark in the central part of the country as a reference point. It appears from the differences between the gravimetric and the geometric geoid that the difference between the two height systems is small, namely -2.9 cm ±1.4 cm when calculated from the means, or -2.6 cm ±1.1 cm when calculated using covariance analysis. It may be inferred that the N60 heights in Finland are higher than the BK77 heights in Estonia, i.e. they are referred to an equipotential surface that is lower by -2.9 cm ±1.4 cm. An analogous result is obtained from the sea surface topography. Transforming the heights, we can use formula:

BK77 = NH60 - 0.03 m + $10U_2$, where U_2 is absolute land uplift per year.

12.6 Long sighting using the digital level Zeiss DiNi12

Mikko Takalo reported on some test measurements with DiNi12 and an enlarged bar code scale in order to achieve long sight lines for water crossings or other purposes. With the original bar code DiNi12 can operate with sight lengths of maximum 100 m.

In the tests the scale was magnified 4 times in different ways. One method was to enlarge the scale with a direct paper copy. This was done for (No 1) a 2 m and (No 2) a 4 m rod. On (No 3) a 3 m rod, black tape was placed on the side of the rod frame. For (No 4) a 2 m rod, an Excel scale was produced and printed on plastic tape.

The field tests showed that for rod No 1 the sight length could be extended to 120 m. For rod No 2 the sight line could be increased in 50 m steps up to 450 m, and the repeatability was better than 0.5 mm. For rod No 3 the sight line could be increased in 50 m steps up to 400 m, with an accuracy of 0.6 mm. A "stair test" of rods No 3 and 4 with reference measurements at distances of 20, 40 and 72 m showed an error of less than 0.5 mm. A system calibration with rods No 3 and 4 shows that the corrections were very small, especially for rod No 4. The conclusion was that the bar code could be enlarged in order to obtain sight lengths up to 400 m also for precise levelling purposes.

13. Next meeting

The next regular meeting of the WGH will be held in the spring 2005 in Gävle. The date will be settled later.

On condition that the UELN-data have been delivered and processed in time, a small work shop will be arranged on the 24th of May in Masala to discuss the adjustment of the Nordic Block and the complete Baltic Ring.

14. Closing the WGH meeting

The chairman summarised the meeting and thanked all the participants for fruitful discussions and good contributions in the efforts to achieve the final adjustment of the Nordic levelling Block. On behalf of all the participants he thanked the hosts for a most successful and good organised arrangement. The chairman closed the meeting at 4.00 p m.

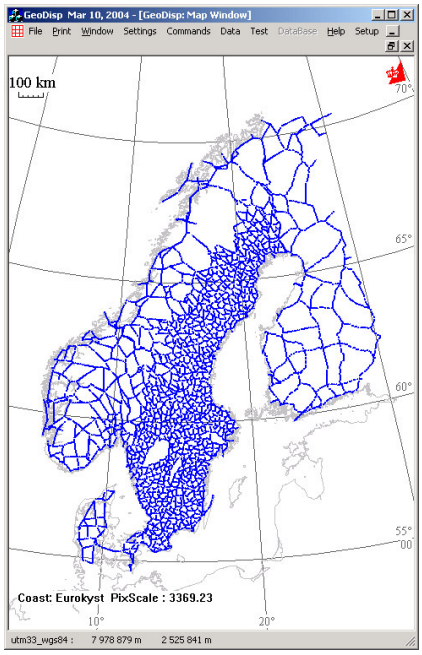
NORDISKA KOMMISSIONEN FÖR GEODESI
Nordic Geodetic Commission Height Determination Working Group
Chairman
Mikko Takalo
Finnish Geodetic Institute
P.O.Box 15 FIN-02431 Masala, Finland

Appendix 1

Results from the preliminary Danish adjustment of the Nordic Block

Mean error on the weigh unit (mew) of adjustment 0.99

Denmark	0.845 ne	0.01mm	mew 0.98
Sweden	1.15 ne	0.01 mm	mew 0.98
Finland	0.77 ne	0.01 mm	mew 0.98
Norway 1900-	1.38 ne	0.1 mm	mew 0.98
1930-	2.20 ne	0.1 mm	mew 1.01
1950-	1.80 ne	0.1 mm	mew 0.99
1970-	1.85 ne	0.01 mm	mew 0.96
1980-	1.60 ne	0.01 mm	mew 1.01



From the Danish results was extracted (calculated):

Ref.	me	mgpu	Dgpu	Helmert	D_H
UELN 125	15.65921 gpu			15.9544 m	
22*46*500503	19.12980 gpu	10.716	3.47059 gpu	19.4892 m	3.5348 m
H37N0080	63.89250 gpu	14.875	48.23329 gpu	65.0735 m	49.1191m
B37N0029	1.76503 gpu	24.596	-13.89418 gpu	1.7977 m	-14.1567 m
Y3N0021	40.77585 gpu	24.684	25.11664 gpu	41.4962 m	25.5418 m
SF 96129	10.57778 gpu	18.996	-5.08143 gpu	10.7681 m	-5.1863 m
SF 7HB	2.76098 gpu	22.800	-12.89823 gpu	2.8118 m	-13.1426 m