



NKG, Working Group: Positioning and Reference Frame  
21<sup>st</sup> – 22<sup>nd</sup> of October 2009, FGI, Masala, Finland

Draft version, November 13, 2009

Revised version, December 8, 2009

## Participants

Denmark: Per Knudsen, Shfaqat Abbas Khan

Estonia: Priit Pihlak

Finland: Hannu Koivula, Pasi Häkli, Markku Poutanen (Wed)

Latvia: Janis Zvirgzds, Aivars Ratkevics, Madara Caunite, Inese Janpaule

Norway: Torbjørn Nørbech, Oddvar Bråvold Tangen, Gunstein Dalane

Sweden: Lotti Jivall

## A (draft) agenda:

- 1) Welcome - Practical info
- 2) Status
- 3) Brief national reports (including report from the NKG LAC) including
  - Madara Caunite: Report on coordinate calculating in Latvia.
  - Pasi Häkli and Hannu Koivula: Transforming ITRF coordinates to national ETRS89 realization in the presence of postglacial rebound - evaluation of Nordic geodynamical model in finland.
  - Abbas Khan: GPS for Greenland uplift studies.
  - Markku Poutanen: European Combined Geodetic Network (ECGN). (this needs to be on wednesday since Markku is not available on thursday).
- 4) Week 40 campaign: - Status of the computations (Lotti Jivall)
- 5) Other activities - WGs, NGOS, projects - (all)
- 6) AOB - ESA project on Arctic Testbed (Per Knudsen)
- 7) Next meeting
- 8) End of meeting

## 1. Welcome and opening

Risto Kuittinen welcomed everybody to FGI and to the evening buffet. Also Hannu welcomed everybody and Per opened the meeting. Since there were new people in the meeting, everybody introduced themselves. The agenda was approved and Pasi was appointed to secretary tasks for the meeting.

## 2. Status (of the GPS campaign)

Minutes of the previous meeting were talked through. Agreed action for antenna/instrument change at the permanent GPS stations has not yet been solved and it was decided to repeat the action in the minutes due to the importance of the topic.

“Agreed action: The Positioning and Reference Frames WG and the Nordic Positioning Service Project will come up with procedures for changing the GPS antenna (and other equipment) on the permanent GPS stations.”

WG will continue to work with the topic.

WG also noticed that the work on the NKG2008 campaign has to be finished before the General Assembly in Norway 2010. Therefore some deadlines were set (see end of ch. 4).

Torbjørn was appointed to coordinate the transformation part of the campaign.

## 3. National reports

### Denmark (Per)

DTU has been busy in Greenland. The GNET continues in co-operation with Ohio State University and University of Luxemburg. There are permanent stations build or to be build: 23 (2007), 11 (2008), 11 (2009) and 9 national permanent sites on Greenland.

New reference frame will be computed for Faroe Islands. It will be based on ETRS89 and NKG2008 campaign.

There is a mean sea-level project going on. MSL is monitored with GPS stations and class 1 tide gauges.

### Estonia (Priit)

Estonian Land Board (Maa-amet) has 9 permanent stations, of which some has identified bad stations. There are probably some problems with multipath and possible antenna change is being discussed. Antenna was already replaced for KUIV and as a result approx. 20 mm jump is seen in time series. Priit showed also other time series from the permanent stations they have computed.

Maa-amet is also computing coordinates for the permanent stations of private companies.

### **Finland (Hannu)**

Hannu told about the GPS antenna test performed at Kyviskes baseline in Lithuania. GPS baselines were compared to those measured with Kern Mekometer ME5000 having a traceability chain to the definition of meter. The results show that the rms (wrt. the true values) of the results decreases in all the cases when individually calibrated antenna calibration values are used. Especially when the linear combination (L3) is used (QIF-strategy in Bernese) the rms decreased to  $\frac{1}{4}$  compared to ones when type calibrations were used.

### **Norway (Torbjørn)**

New structure of Statens Kartverk (SK) was taken into operation in the beginning of 2009 and it has worked well.

SK has aim to have a positioning service with 1 cm accuracy but they have noticed that current reference frame (ETRF93) is not accurate enough. Horizontal is ok (rms ~6-7 mm) but vertical is three times worse (rms ~17 mm) leading to min-max difference of  $\pm 5$  cm. There are plans of realizing RF in a new way. The backbone of new RF could be realized through the permanent GPS stations, planned approx. 130 stations in the future.

SK has processed NKG2008 campaign with Bernese (Oddvar) and GIPSY (Gunstein).

### **Sweden (Lotti)**

SWEPOS has now 188 stations, approximate inter-station distance being approx. 70 km. There are also some densification areas where network is denser.

Lantmäteriet (LM) has plans to update station equipments, mainly antennas for L5, etc. Original core network (20 stations) remain untouched, there plans are to build new monuments. LM will carry out tests for optimum mast/pillar structure for future monuments at the GNSS stations.

LM has done also some tests with using eccosorb under the reference antennas and is still aiming for station calibrations.

LM has continued to introduce SWEREF99 and RH2000 to municipalities. SWEREF99 already in wide use but only 25 municipalities approved RH2000 so far.

### **Latvia (Janis)**

LATPOS has now 20 permanent stations. Inter-station distance is approx. 40-70 km.

Next target is more precise geoid (2 cm geoid). This is done with GPS/levelling, the question is now how long does the observing time has to be? Is 8 hours enough for 1 cm? So far only 2 LATPOS permanent stations are levelled but plan is to level them all.

### **Other presentations:**

- The effect of GNSS base station selection (Madara)

NKG2008 data including all EPN/IGS stations within the area of NKG2008 campaign was used to study the effect of selection of fiducial stations. Madara showed two solutions with different station selection: one with fiducial stations within the whole NKG area and other with stations only near Latvia. These solutions were compared and results show clear network effect both in horizontal and vertical coordinates.

- The effect of absolute GNSS... (Inese)

Inese has used the same network as Madara in her study. Two solutions were computed: one with type calibrated (relative) and other with individually calibrated (Geo++, absolute) antenna tables. Results show up to 6 cm offsets when absolute (individual calibrated) and (type calibrated) relative results are compared.

- Transforming ITRF coordinates to National ETRS89 Realization in the Presence of Postglacial Rebound - Evaluation of NKG\_RF03vel Model (Pasi)

Pasi showed results from transformation comparison where a 100-point network was transformed from ITRF2000 to national ETRS89 realization, EUREF-FIN. Two different approaches were compared: first was done according to "memo" (recommended by EUREF) and second with NKG transformation (recommended by NKG Pos+RF WG). First one does not take into account intraplate deformations while second one does.

Vertical residuals of memo transformation show clearly the effect of land uplift (residuals up to ~7 cm). Horizontal residuals are from a few mm to 3 cm. NKG transformation shows a bias in vertical residuals (approx. 1-3 cm in Finland). This was shown to be caused by NKG\_RF03 coordinates that were used for determining the transformation parameters. When new transformation parameters were computed with IERS published coordinates, residuals decreased to below-cm level (rms).

The results raised a discussion on how should the NKG2008 campaign be constrained. The author concluded that the bias in the results is most likely due to network effect, i.e. while network is constrained with global transformation parameters to ITRF, a regional/local misalignment may

occur. However the topic raised a discussion, see more in chapter 4 – constraining the solution.

- Influence of Orbit Error on Detecting Vertical Crustal Motion due to Unloading of ice (Abbas)

Abbas has studied the melting of Jacobshavn glacier in Greenland. There is a huge loss of ice annually, and the phenomenon is likely to be accelerating. Results show that uplift rate may be misinterpreted if APCVs are not used in PPP processing (this is mainly due to changing satellite constellation in terms of renewal of GPS satellites). If DD observations are used uplift rates are quite similar with the predicted rates. With DD results however, it is essential to choose fiducial stations outside the area of influence. So far uplift rates are only from GPS and they are not yet compared to e.g. gravity related rates.

- ECGN (Markku)

Markku presented the status of ECGN. There is a need for combining the geodetic networks and a targeted accuracy of RF realization and maintenance is  $10^{-9}$  with long time stability. ECGN consists of three basic structures: stations, data banks and products (combination of data). Current status is ok for GNSS (e.g. EPN) but otherwise situation is not acceptable. A lot of data exists but main problem is lack of coordination.

ECGN WG will undergo some changes and therefore WG is now seeking for 3-4 new (young) researchers to join and this was also announced to the NKG pos+RF WG. Also new guidelines and recommendations are needed. The first call for participation (implementation of ECGN stations) will be updated. Markku announced also that there will be an NGOS meeting before the Presidium meeting in Masala 24.-25.11.2009 (noon-to-noon).

- NKG web pages (Markku)

Markku showed the new NKG web pages (still not yet published and partly under construction). The pages are lacking of input data. Markku asked all the chairmen of the NKG WGs to check the new pages (can be found at the moment in <http://217.152.180.26/nkg>, later in [nkg.fgi.fi](http://nkg.fgi.fi)). Input data (data, text, links, photos,...) and feedback were asked to send to Markku or Heli ([markku.poutanen \(at\) fgi.fi](mailto:markku.poutanen@fgi.fi) or [heli.suurmaki \(at\) fgi.fi](mailto:heli.suurmaki@fgi.fi)). Later WG chairmen will have access to the pages.

- FGI's transformation service (Markku)

Markku presented the new FGI's transformation service. It can be found from <http://coordtrans.fgi.fi>. It consists of a transformation tab

(coordinate transformations), data tab (e.g. geoid models for Finland available) and info tab (help, links and documents). Currently consists of only transformations for Finland.

## **4. Week 40 campaign: - Status and strategy of the computations**

### **Status of the processing**

Lotti briefed the WG of the current situation with the processing of the NKG2008 campaign (see details in attached PPT-presentation). The campaign has been processed with different softwares and methods: Bernese double difference (Priit: Baltic states + BB, Lotti: Denmark, Sweden, Finland + BB, Oddvar: Norway, Greenland, Faroe Islands, Iceland + BB), Bernese PPP (Abbas: Denmark, Greenland, and Faroe Islands) and GIPSY (Abbas: Denmark, Greenland, Iceland + BB, Torbjørn/Gunstein: Norway, Greenland, Faroe Islands, Iceland + BB). Martin will do the GAMIT solution for the full network (no solution yet).

Bernese solutions were evaluated with daily repeatability, elevation cut-off tests and fix-float test. The worst daily repeatabilities in Lottis solutions were 2.5 mm, 1.9 mm and 4.7 mm in North, East and up, respectively. One outlier was found. The elevation cut-off tests (3, 10 and 25 degrees) were also performed and solutions were compared. Cut-off test shows some discrepancies up to 3-4 cm in vertical component. 20 mm was considered as a threshold and discrepancies above this were/will be examined. In Oddvars solution some relative antenna solutions showed bad results while using absolute values results were ok. It was decided to study bad stations more thoroughly and perform for example multipath tests. In fix-float test no outliers (>10 mm) were found. The combined Bernese solution was minimally constrained to IGS05.

The different solutions of the BB stations were compared. Solutions are Bernese DD, Bernese PPP with IGS products, Bernese PPP with MIT products and GIPSY PPP with JPL products. The comparison show several cm discrepancies between the solutions. The topic was dicussed and it was concluded that Bernese DD solution probably gives better internal consistency than PPP solutions. The best Bernese solution was obtained with absolute antenna tables and with 3 degree cut-off angle (or maybe 10 degree absolute solution). However, below 10 degree cut-off angles probably more sophisticated troposphere models/mapping functions are needed than standard Niell. In GAMIT this is possible since GMF or VMF are available.

## Constraining the solution

Constraining the solutions produced a lot of discussion. Should the final campaign be constrained globally or regionally and by which method? And should the final solution be

- a) a new (globally constrained) reference frame or
- b) a densification of current ITRFyy?

Minimum constraints are generally accepted as the most efficient and correct method but it allows the coordinates of the fiducial stations to alter since constraining is done through minimum constraints on transformation parameters. The advantage of this method is that an optimum datum definition is obtained and possible inaccuracies in coordinates of fiducial stations do not influence on internal geometry of the network. However, is it the best method if an ITRF densification is the target? Traditionally removable constraints were used for densifications.

Maybe more important than method is selection of fiducial stations. Global constraints are likely to lead to option a) while regional (densification) leads probably to option b). It was noted that NKG2003 campaign coordinates differ from IERS published ITRF2000 coordinates and this influences on the usefulness of the published transformation. A part of the discrepancy is probably due to chosen constraining method along with the site selection leading to network effect, i.e. globally constraint/aligned solution may have discrepancies at local/regional level. A part of the bias comes from the extrapolation of the ITRF coordinates outside the temporal extent of the data used in the ITRF2000 solution by IERS. However, both cases need to be studied before the constraining method of NKG2008 campaign will be chosen.

Related to the topic it was also discussed about the purpose of the transformation. Who will use it (and how)? If it is meant to be used with GNSS campaigns with DD solutions, we probably need something close to option b) while PPP users may need option a). It was decided that Lotti will do a proposal on constraining the solution before the end of February 2010.

## Agreed actions with deadlines

- Nov 15, 2009: Lotti uploads comparison to ftp
  - each country/CC checks own stations (antennas, radomes, cut-off test, daily repeatability)
  - each country studies their own bad stations (multipath etc)
- Dec 31, 2009: GAMIT solution is ready (Martin)
- Dec 31, 2009, new intraplate model based on new Milne model is available; this fits better to GPS velocities. Martin/Lotti will provide the new model before the end of year.

- Jan 31, 2010: processing of BB ready (all proceeding centres). WG greed that we need all different solutions to confirm and choose the best solution. However for this purpose, it is not necessary to process all stations, BB is enough. At least two solutions with different softwares are needed for all stations.
- Feb 28, 2010: proposal of constraining of the solution is ready.
  - a new (globally constrained) reference frame or
  - a densification of current ITRFyy?
- April 30, 2010, PPP solution of Norway ready. Norway will do the GIPSY processing with absolute antenna tables (probably both relative and absolute solution). All stations will be processed with GIPSY (Torbjørn has an ambition ;-). Norway will possibly do also Bernese PPP solution? Lotti will prepare PCF-files, Abbas will put his unix files and scripts to ftp.
- Apr 30, 2010: first transformation ready (with old and new intra-plate models)
- May 18-19, 2010: Next meeting

## **5. Other activities – WGs, NGOS, projects**

Skipped due to tight time schedule.

## **6. AOB – ESA project on Arctic test bed (Per Knudsen)**

Per had invited prof. Ruizhi Chen (Head of the Dept. of Navigation and Positioning at the FGI) to join the meeting. Per and Ruizhi informed the WG on GNSS arctic test bed that is a possible ESA project.

## **7. Next meeting**

Next meeting will be held in Copenhagen in May 18-19, 2010.

## **8. End of meeting**

Per ended the meeting 11:35.





*Pasi, Hannu, Gunstein, Abbas, Markku, Torbjørn, Oddvar, Per, Lotti, Priit, Madara, Aivars, Janis, Inese*