NORDISKA KOMMISSIONEN FÖR GEODESI

Nordic Geodetic Commission, Working Group of Reference Frames
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NKG Working Group of Reference Frames

DRAFT Minutes for the meeting in Reykjavik, Iceland, March 10–11, 2020

Place: Icelandair Hotel Reykjavík Natura
Nautholsvegur 52, 102 Reykjavik, Iceland

Participants:

Denmark	Kristian Evers (on Skype)
Estonia	Jaanus Metsar, Karin Kollo (partly)
Finland	Pasi Häkli (chairman of the WG), Markku Poutanen
Iceland	Dalia Prizginiene, Gudmundur Valsson (partly), Thorarinn Sigurdsson (partly)
Latvia	Ksenija Kosenko, Ivars Liepins (partly)
Lithuania	Eimuntas Parseliunas (partly)
Norway	Hans-Sverre Smalø, Karoline Skaar, Michael Dähnn, Sveinung Himle
Sweden	Lotti Jivall, Martin Lidberg (partly)

Presentations:

The presentations are restrictedly available at the WG FTP server hosted by the SDFE. Possible number after the presentation refer to naming at the server. Part of the presentations are also publicly available at the NKG webpage (https://www.nordicgeodeticcommission.com/).

Session 1: Scientific/technical presentations

(The two announced presentations by Kristian Evers were postponed to a later occasion as he was not physically present at the meeting and we anticipated problems with the Skype-connection.)

- **Pasi Häkli, Simo Marila, Sonja Lahtinen, Hannu Koivula: E2 service - Update**

Early 2000's the Finnish government decided not to open a governmental positioning service. Instead, commercial services run by private companies are widely used in Finland. Control point measurements are guided by the Recommendations for the Public Administration (JHS) number 184 (http://www.jhs-suositukset.fi/suomi/jhs184) and this

instructs also how active benchmarks (positioning services) can be included to the official control point hierarchy. Following the guidelines, reference stations of commercial positioning services can be included as part of the second order network of the national EUREF-FIN reference frame. This is called E2 service. Currently, about 200 stations have the official E2 status. FGI processes the official E2 coordinates for the stations from minimum 5 weeks of data (avoiding winter period) using the NKG AC FGI-solution as the backbone. The coordinates are first determined in ITRF2014 and then transformed to E2 coordinates with the NKG transformation. FGI also monitors the coordinates on a regular basis (every day). Station time series in ITRF2014 and EUREF-FIN are produced. Despite the monitoring, the service providers are obliged to inform the FGI on all equipment changes. Approved E2 coordinates along with some additional information are maintained here: https://www.maanmittauslaitos.fi/tutkimus/asiantuntijapalvelut/e2-laskentapalvelu. (See presentation 1-3)

Session 2: WGRF status and planning

The outcomes and thoughts from the workshop on Monday were discussed. The workshop was found very interesting and much useful information was presented. Some important statements from the panel discussion:

- The basis is good observations and knowledge of error sources, calibration, modelling e.t.c
- We need the entire field of geodesy to cope with the future for the benefit of the users
- The process from idea to application takes time (about 10 years) and there are no shortcuts
- Start to talk about the integrity of geo-data

We think that the workshop could have been extended to a full day to allow time for wrap-up and start defining a road-map. Short breaks between the 45 min presentations would also have been good.

Concerning future activities for our WG, Hans-Sverre proposed to work with the evaluation of rapid coordinate time series and quality checks from Anubis, with the aim to develop automatic routines for warnings based on the daily (rapid) processing. This was discussed further in session 5.

Pasi mentioned the plans for a BIFROST 2020 that was proposed by the WG for Geodynamics. This new solution would be extended both in time and coverage (e.g. a lot of new stations in Germany) compared to earlier BIFROST solutions. The plan is to process both with Gamit and Gipsy. It would be good to coordinate this with NKG AC and have a Bernese solution as well. In NKG AC we plan to perform the next reprocessing at the same time as EPN (where we also will contribute with our NKG_EPN solution) and this will first start when we have all necessary products from IGS Repro3 (earliest 2021). With the Bernese we need to fix the orbits and cannot easily update the frame and orbits afterwards when new orbits get available as with Gamit. NKG AC need to produce a combined coordinate and velocity solution, as our main interest is the reference frame, but BIFROST has so far mainly been focused only on the velocities.

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This is also related to how we can combine or at least compare results from Bernese, Gamit and GIPSY in the best way.

Concerning DRF and positioning services we note that the combined coordinate and velocity solutions as well as the NKG transformation are very important. Transformations is a key issue in connection to the use of geodata combined with positioning services.

Our role in the coming joint project on DRF in positioning services with WGFP is to provide the coordinate and velocity solution.

Session 3 (jointly with WGFP): National reports

National reports jointly with WGFP. Only headlines mentioned here, see presentations for more details.

- **Denmark** (see presentation 3-1)
  - A national strategy underway
  - DANGO (A project set to enhance the use of the Galileo High Accuracy Service)
  - Realtime GNSS data for smart city projects and green solutions
  - TAPAS (Testbed in Aarhus for Precision positioning and Autonomous Systems)
  - New GNSS stations, antenna changes and new ETRS89 coordinates
  - Harmonizing the GNSS IT infrastructure in SDFE
  - PROJ 7.0.0: e.g. New System 34 transformations
  - WEBPROJ
  - GR96 transformations
  - GNET: e.g. reestablishment of KELY station
- **Estonia** (see presentation 3-2)
  - ESTPOS
  - Multi-year solution for ESTPOS
  - Connections to EH2000
  - Gravity network
  - Maintenance of geodetic marks
  - Metrology of geodetic instruments
- **Finland** (see presentation 3-3)
  - FINPOS
  - Precise levelling in Finland
  - GPS/levelling

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- Horizontal intraplate velocities of the NKG_RF17vel model
- NKG transformation
- Renewal of control point registry
- Arctic-PNT, SAMK-ISTLAB, SAR-HSU

- **Iceland** (see presentation 3-4)
  - IceCORS - The Icelandic CORS system
  - Long-term goals and measures for the next years
  - Web Applications: Cocodat- I, Post – processing Services (IceCORS – PPS), SBPPS (Short Baseline Post – Processing Services), Virtual RINEX
- **Latvia** (see presentation 3-5)
  - Benchmark inspection
  - LatPos modernization
  - LATREF stations
  - Restoration of Struve geodetic arc's point Nessaule-kalns
  - New levelling line in Riga
  - Pilotproject: geomagnetic measurements for declination model
  - Absolute gravimetric measurements
- **Lithuania** (see presentation 3-6)
  - Juridical issues
  - CORS Network LitPOS
  - Zero and First-order GPS network re-measurements in 2018-2019
  - Vertical network
  - Gravity survey
- **Norway** (see presentation 3-7)
  - New Director General
  - Organization changes
  - Expansion in streaming of rawdata
  - Users of the positioning services
  - Contract with Bane NOR – railroad authorities
  - Performed user analysis 2019
  - Ny-Ålesund geodetic observatory: VLBI, SLR
  - High priority tasks in 2020

- **Sweden** (see presentation 3-8)
  - Lantmäteriet's responsibility
  - Department of Geodetic infrastructure
  - Review and update of SWEREF 99
  - PCO/PCV from SWEPOS Station calibration
  - SWEREF 99 AND RH 2000
  - SWEPOS – modernisation and station densification
  - Project adaption for new infrastructure
  - SWEPOS activities
  - Ongoing projects: Network RTK Positioning for automated driving (NPAD), Prepare ships
  - Doctoral disputation: Martin Håkansson
  - New Swedish gravity frame RG 2000
  - Ongoing VLBI Reanalysis
  - New versions of our transformation software Gtrans
  - National Boundary Sweden-Norway

Session 4 (jointly with WGFP): Joint activities WGRF and WGFP

- **Lotti Jivall: NKG GNSS Analysis Centre (NKG AC)**

NKG GNSS AC was formed as project in NKG in 2012 and started to produce operational weekly solutions in 2014 and from 2017 all eight Nordic and Baltic countries contribute with national solutions as local analysis centers (LAC). There are two independent combination centers (CC) and the solutions and results are stored and exchanged at an ftp-server hosted by SDFE. The EPN NKG solution (one of 16 AC of EPN) is used as a backbone to connect the national sub-networks. Today the NKG solutions consists of about 300 stations, including 100 EPN stations. NKG AC has performed one re-processing (1997-2017) and plan to do the next one in coordination with the coming EPN reprocessing, that earliest will start next year. NKG AC has contributed to the EPN densification project with the result from the reprocessing and now on a regular basis with operational solutions. Last year several changes were made to the operational processing, most important is the implementation of RINEX3 and Galileo. The consistency between the LACs is ensured by benchmark tests and the last one, which was performed in connection to the change of processing strategy, showed a very good agreement between LACs both before and after the change. Besides the operational work NKG AC will for the coming period mainly focus on making a first cumulative solution, based on the NKG Repro1 and the operational solutions. Minor activities in the field of extended regional solutions and exchange of experiences on

monitoring station positions and quality parameters (based on daily files) are also planned. (See presentation 4-1)

- **Pasi Häkli: NKG transformations**

Main driving force behind the NKG transformation project is to account for plate tectonic motions and motions caused by Glacial Isostatic Adjustment (GIA). Due to resultant deformations, traditional static reference frames become eventually too distorted. Therefore deformations must be accounted for, with e.g. regular updates of static reference frame or semi-dynamic or dynamic reference frame. Most Nordic-Baltic ETRS89 realizations were established in the 1990's leading to ~20 years of deformations compared to present-day coordinates. These deformations are too large to be neglected in accurate georeferencing applications and in the maintenance of national ETRS89 realizations.

Two main motivations for the NKG transformation project are:

1. To ensure, improve and update the accurate transformations (incl. deformation model) from global ITRFs to the national ETRS89 realizations in the Nordic/Baltic area,

2. Establish an accurate and homogeneous common reference frame in the Nordic-Baltic-Arctic region

The first version of the NKG transformation was developed in 2006 and major update on the approach was released in 2016 (called NKG2008 transformation based on the NKG2008 GPS campaign). NKG2008 transformation utilizes transformation recommended by EUREF, amended with intraplate corrections and national transformation parameters. Together with the NKG2008 transformation, a common NKG reference frame aligned to ETRF2000(2000.0), designated as NKG_ETRF00, was released. Its main purpose is to act as a transformation hub to national ETRS89 realizations but also as a common frame for specific purposes, e.g. for geoid validation at Nordic-Baltic level using GPS-levelling points in a common frame. The NKG2008 transformation corrects intraplate deformations with NKG_RF03vel_ETRF2000 model.

NKG(2008) transformation supports all ITRF realizations and epochs and enable (sub-)cm level transformation accuracies. The approach includes several steps but it can be simplified by summation of parameters and corrections. To make the NKG2008 transformation available to users, it was implemented to PROJ starting from version 5.

NKG transformation will be updated soon. The methodology remains the same but input coordinates and intraplate model are updated. ITRF coordinates (as input for parameter estimation) are now based on time series and national ETRS89 coordinates revised. The updated transformation utilizes new intraplate model that is based e.g. on longer GNSS time series and improved GIA models. As a consequence new national transformation parameters will be estimated. Also the new transformation will be implemented in PROJ. (See presentation 4-2)

- **Anna Jensen: Status for real-time positioning**

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The trends in different positioning services were presented. The services were divided into three groups; global, national and local. The coming Galileo high accuracy service (global) is delayed until 2021/22. Other commercial global services are usually based on PPP and gives coordinates in ITRF. Some of the services are integrated with national or local services to get higher accuracy when possible. There are many public/governmentally operated national services which could be used for free, e.g. SAPOS. At the same time there are also many commercial services which operate in many countries forming regional services. There are also local services for large infrastructure projects, e.g. for Fehmarn Belt and there also many single-station RTK systems used e.g. in connection to Drones. Corrections are usually distributed using the RTCM format, but the new format of Sapcorda is also coming up. (See presentation 4-3)

- **Martin Lidberg: Challenges in geodetic reference frames – with future precise ship navigation as an example**

The Baltic Sea Chart Datum 2000 (BSCD 2000) is used for the depth information. With national services working in ETRS89 and NKG geoid models this works fine but when navigating in the open sea and using PPP services the land uplift and epoch need to be taken into account! How is this best done? (See presentation 4-4)

- **Input from the DRF-project**

Pasi presented the 15 milestones if the DRF-project. (See presentation 4-5)

- **How to proceed with joint activities**

We noted that that transformations play an important role for Interactivities between PPP and network-RTK services. Dalia informed that GNSMART has a module that can transform with a transformation grid, which she has tested for the transformation between ISN2016 (epoch 2016) and ITRF2014 current epoch.

It was decided that we should propose a joint activity for WGFP and WGRF with the following scope:

Setting up a network-RTK service running in a dynamic reference frame (DRF), providing geodata either in a national frame or in ITRF current epoch. Different concepts should be considered:

1. NRTK service running in DRF, output to users in national coordinates (and geodata in national system)

2. NRTK service running in DRF, output to users in DRF

a. Geodata provided in ITRF current epoch

b. Geodata provided in the national system

TAPAS or Finland were mentioned as possible platforms for the test.

A group will be formed consisting in the first place of Iceland, Finland and Denmark. Pasi and Anna will write a proposal for the activity.

Wednesday March 11

Session 5: Project NKG GNSS AC

- **Report from the EPN Analysis Centre workshop in Warsaw in October 2019**

Lotti reported from the workshop, where she, Tina Kempe and Martin Lidberg participated. As NKG AC acts as a densification of EPN and we also use the NKG EPN solution as the backbone, it means that we need to follow the changes made by EPN. The background for the switch of CODE products (MGEX -> rapid) was explained (related to antenna model problems when combining GPS/GLO with Galileo). For the same reason new real receiver-calibrations for Galileo will not be implemented in EPN until we switch to IGS20/ITRF2020. The EPN Analysis centre coordinator (EPN ACC/WUT) has performed some tests on global solutions in EPN. It shows systematic effects (translation and scale), varying from day to day, to the official regional solutions. The fit between the two solution types (global/regional) is very good, so the internal geometry is not affected. The height differences are highly correlated to the loading effects. The EPN reference frame coordinator Juliette Legrand will investigate the effect on estimated velocities. EPN started to briefly discuss the next reprocessing, which will be based on the IGS Repro3, which products are expected earliest early next year, but there might also be an iteration. An analysis centre meeting devoted to EPN Repro3 is planned for 2021. (See presentation 5-1)

- **Status and achievements in NKG GNSS AC since last WG meeting**

Lotti presented the status of NKG GNSS AC in more detail (compared to session 4) with focus on the results from the Benchmark testing and the effect on coordinated from the implemented changes. The following changes was introduced since last WGRF meeting in Copenhagen a year ago:

- GPS-week 2055: RINEX3 and Galileo
- GPS-week 20??: New atx- and sta-files from EPN (_recalib)
- GPS-week 2078: Final MGEX => rapid CODE
- GPS-week 2089: ORBGEN: increased number of parameters

The benchmark test revealed that the consistency between the LACs were good both before and after the changes. The benchmark test with the old setup showed some larger coordinate differences for some LACs, as different fiducial sites had been used, but the internal geometry was on sub-mm level with both the old and the new setup. The daily repeatability was slightly better with the new setup for the test week 2055. The rms in the combination between LACs was on the same level both before and after the inclusion of Galileo in week 2055, but the coordinates were affected up to 5 mm (up) dependent on which antenna/radome type was used on the stations. Five stations did also have horizontal differences > 1 mm between the GPS+GLO and GPS+GLO+GAL-solutions. The differences are similar with what was found in EPN. The change of orbits introduced small systematic differences in the coordinates (tilt) which varied from day to day. All the changes and benchmark testing have

delayed our operational solutions and we have had several months delay but are hopefully soon coming back to normal operation again. (See presentation 5-2)

- **New realization of IGS14/ITRF2014**

Lotti reported briefly about an updated version of the IGS14 frame, which was sent via IGS-ACS-mail 1360. Paul Rebischung has computed a new updated version of the IGS14 frame, IGb14, which is based on 5 more years of data and updates for discontinuities, that can be used until the new ITRF2020 based frame is adopted (in ~2 years at least).

IGb14 was obtained from a long-term stacking of daily IGS combined repro2/operational solutions from 1994/01/02 to 2020/02/15. IGb14 is aligned in origin, scale and orientation to IGS14 via a subset of 233 selected stations. The switch from IGS14 to IGb14 should therefore not introduce discontinuities in the IGS operational product series.

Feedback to Paul are welcome until April 12. If no objection received, an IGSMAIL will be sent to announce the switch, which then would start with products of GPS week 2106.

Lotti will inform NKG GNSS AC when this email comes.

- **Short reports from each LAC**

LM: Four new stations (two will be co-located with Geodetic SAR), have been added to the network which now consists of 88 stations. All the changes in processing setup have been implemented and weekly solutions since week 1934 have been submitted to EPN densification project, since week 2060 routinely in connection to the submitting to SDFE-ftp. Lantmäteriet is additionally working on the upgrade of SWEREF 99, which will be based on a campaign in autumn 2019. Solutions from NKG GNSS AC will be used to overcome the differences in models, equipment and stations compared to the original defining campaign and NKG_RF17vel to convert between epochs. (See presentation 5-2)

FGI: The network has increased from 20 to 47 stations. Simo Marila is taking care of the operational processing while Sonja is on maternity leave. Introduced all requested changes. Contributes to EPN densification by automatically submitting solutions in connection to submitting to SDFE-ftp. Pasi did some combinations with CATRERF as long as Sonja was still working, but had no time to continue after the summer (has been busy with the transformation project). Sonja will probably be back after the summer. (See presentation 5-3-3)

LAT: LAT has submitted all weekly solutions from the weeks 1795-2055 to EPN densification and after that on a routine basis. Four (roof top stations) stations (BAUS, PREI, SIGU and TALS) have been rebuilt with an extension + 50 cm (to BAU1, PRL1, SGD1 and TAL1) and three new LATREF stations (ALKS, DLKS and VAIN, all ground monuments) are added to the network. All stations except IRBE have now GPS+GLO+GAL. The old ETRS89 realization LKS-92 will be replaced with a new frame based on LATREF and LATPOS. A preliminary solution based on about half a year of data has been processed with the mean epoch 2020.0. (See presentation 5-3-5)

ISS: The network consists of 16 national stations, three observing also Galileo. Six of the stations will be offered to EPN as new EPN stations: AKUR, ISAF, HEID, RMOL, SKHA, GUSK, in addition to the present two EPN stations: HOFN and REYK. (See presentation 5-3-4)

SK: SK has managed to implement the NKG setup on Linux and is now running three BPEs in parallel:

- Daily surveillance/monitoring based on rapid products – on Linux
- Weekly processing for coordinate determination – on Windows
- NKG processing – still operational on Windows but works also on Linux, preparatory scripts e.t.c. around the Bernese need to be developed.

Additionally GNSS processing is carried out also with other programs, Michael Dähnn uses GIPSY and Halfdan Kierulf uses Gamit. To facilitate the work with the programs scripts are under development to extract station information from the equipment database in the different formats needed by the programs.

Michael offers also GIPSY processing for the NKG GNSS AC to be used as a verification, at least of the Norwegian network.

EST: All requested changes have been implemented and weekly solutions are regularly uploaded to the EPN densification project. No new stations added but some 10 private stations have been excluded as there are now enough stations in the own ESTPOS network (29 stations).

LIT: No representative at the session.

- **Planning the development until next WG meeting** (see presentation 5-2)

PRC-files to SDFE-ftp

We decided to submit also our PRC-files to the structure at the SDFE-ftp, but first the PRC-files need to be cleaned from all warning/error messages in part 0 (RINEX-inconsistences). Jaanus volunteered to write a perl-scrip for this and Lotti will provide him with instructions of what to exclude.

Time series plots from combined operational solutions

Lotti proposed that we should also make time series plots from the combined operational solutions available on the SDFE-ftp. We have now plots only from the reprocessing. Residuals from a mean of a stable system (e.g. ETRF2014 ep 2000.0) are proposed, so we get rid of the plate tectonics and the land uplift and in that way can identify local movements. A program/script is needed. Pasi will check if he has something useful when he gets the time.

Cumulative solution based on NKG Repro1 + operational solutions

We decided to start to produce a first cumulative solution, as the main activity this year, besides the always ongoing operational processing. Pasi will start testing using CATREF this spring. The first step will be to convert the old solutions from NKG Repro1 from

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IGS08.atx to IGS14.atx. Jaanus will help with scripts and experiences. The real work with CATREF will however first start in the autumn when also Sonja will be back. We decided that the cumulative solution shall be based on solutions up to epoch 2020.5, i.e. ending GPS-week 2111 = 2020-06-27. National pre-analysis of data to define breaks and bad periods, just as we did for the Repro, is useful and good if a longer time period of data is added to the previous cumulative solution, like now when we will add 3.5 years. In the future, when we maybe have a more regular update of cumulative solutions several time a year, we probably have to think of other routines. The following time schedule was agreed:

1. All operational LAC-solutions up to week 2111 should be available at the SDFE-ftp-server by 2020-08-20.

2. The LAC solutions up to week 2111 should be combined and stacked coordinate files for input to TSview should be available at the SDFE-ftp by 2020-09-20.

3. The pre-analysis by each LAC (eq-files) should be available at the SDFE-ftp by 2020-11-01.

Global solution or extended regional solution

EPN ACC (Analysis center coordinator)/WUT has made some more testing since last year on global solutions, but there are still discussions within the EUREF GB on whether EPN should develop in this direction or if global solutions from IGS could be used instead. We will follow the development in EPN. Instead, we decided to evaluate the extended regional solutions that ISS is already processing. Dalia will compare the extended regional solutions to the standard ISS solutions for NKG GNSS AC. Later on, by the end of the year, Lotti will test to use the extended solutions also in the combination.

Next Re-processing

No actions until the next WG meeting, except to complete the EPN historical database with missing RINEX files if there still are any. It is mainly old data before a station became operational in EPN that is missing.

Rapid solutions

Not so important to start an activity on this now in NKG GNSS AC. We note that many of the LACs already have rapid processing (1-2 days delay after observations) on their full national network.

Routines for monitoring station positions and quality of data

Hans-Sverre proposed in earlier discussions to have some joint activity on the evaluation of rapid coordinate time series and quality checks from Anubis, with the aim to develop automatic routines for warnings based on the daily (rapid) processing. The Norwegian team has worked with Anubis for quality check of 1 second observation files and found some useful quality parameters, like no of cycle slips per day and the number of GPS observations per day, that e.g. could indicate forest growing. As a first step to exchange experiences we decided to have Skype meeting in April. Hans-Sverre will search for a suitable date and time and arrange the Skype meeting. There might be other persons outside our group that are interested to participate but this can be arranged through the contact persons in our group and a joint Skype connection.

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Troposphere

We have produced troposphere solutions as a by-product to our operational and repro solutions since the start of NKG GNSS AC. These solutions could be interesting to the meteorological or climate community. Lotti will ask Rosa Pacione if there is an interest in our solutions as they are (without combination). The efforts from our side need to be limited as we have many other requests with higher priority for us.

Session 6: Project NKG transformations

- **New land uplift model NKG_RF17vel**

Pasi presented the status of the new NKG_RF17vel model. The model is now based on self-made least-squares collocation routines and Pasi presented some basics used in the modelling, as well as handling of input data and tests related to covariance analysis. Several models were developed iteratively during the process and extensive comparisons to Gravsoft, R. Steffen's and O. Vestøl's results prove good consistency on the velocity domain despite of slightly different methodologies. One of the main outcomes was to develop an algorithm to de-localize (smooth) the solution to represent GIA effect. After extensive testing, the final version of the velocity model was released in December 16, 2019. The model agrees with the NKG Repro1 velocities at 0.1 mm/yr level (horizontal, rms). The model velocities are already used in the updated NKG transformation. The uncertainty model and documentation are still to be done. (See presentation 6-1)

Discussion:

The NKG_RF17vel is (as the previous model) just describing the internal velocities within the European plate, the question is if we should, for the DRF-project, also provide a model in ITRF2014 that includes the plate tectonic movements as well. Martin Lidberg thinks this is not necessary, but otherwise there were no clear opinions.

The next step is to model the uncertainties of the velocity model, where one option is to follow the example of the NKG2016LU_abs-model.

Pasi plans to document the model in a peer-reviewed paper. Until then the model is presented in a powerpoint presentation available at SDFE-ftp and NKG webpage.

The next NKG velocity model will probably be based on either the next BIFROST 2020 or the next NKG AC Repro and for the vertical the coming NKG202xLU_abs.

Ivars asked how often we can expect new velocity models. From legal aspects it is not optimal to change model so often. Looking back what we did so far, an estimation is that we will not produce models more often than every 5 years.

Martin mentioned that we in the future can be prepared that the future IERS ITRF solutions might be composed differently from today when somebody else will take over after Zuheir Altamimi. Today we have three versions of ITRF2014; the IERS version and German version, which both use a secular model (linear velocities) and a version from JPL with an instantaneous frame.

- **Updated NKG transformation**

Pasi presented the activities since the last WGRF meeting in 2019 that can be summarized:

- Waiting for the NKG_RF17vel model to be finalized
- Final velocities released in 2019-12-16
- Routines verified with Swedish colleagues
- Next set of data (residuals etc) provided to each country 2020-01-13, feedback asked by 2020-01-27
- Some fine tuning and results according to the received feedback
- Final results presented here?

Pasi presented the transformation results (residuals) country-by-country for discussion and verification purposes. (See presentation 6-2)

Discussion:

Martin noted that the Danish national ETRS 89 frame is now based on a campaign from the autumn 2015, which has been transformed with a 7-parameter Helmert-transformation to the old defining REFDK campaign stations. This means that the internal geometry of the network is in epoch 2015.829 and not 1994.704. The fit will be better when using the epoch 2015.829 instead of the epoch 1994.704 and then the parameters in the Helmert-fit will additionally absorb the land uplift between the two epochs. Pasi will test and evaluate the different alternatives together with the Danish colleagues and the rest of the transformation team.

Data licensing for the transformations and for the model, see next item (PROJ).

Should NKG or each country submit to the PROJ repository, see next item (PROJ).

Documentation as a part of NKG_RF17vel or separately? Not decided yet.

- **PROJ**

Kristian Evers made a Skype presentation of PROJ, also including a short summary from each country.

PROJ passed the “incubation period” at OSGeo (test of sustainability) on Nov 25th 2019.

New version PROJ 7.0.0 was released in March 2020. Main new features are:

- New grid format: Geodetic TIFF Grid, GTG
- Grids can be (partially) fetched on-the-fly from the internet via https://cdn.proj.org/
- Reorganized and simplified grid repositories
- projsync grid download utility added

There were discussion on which PROJ versions (5, 6 and 7) to support with new NKG transformation. They use different grid formats and have different properties and features. We agreed to go for the newest version 7 because based on PROJ development strategy no new grids to version 6 or older cannot be added to repository anymore (however necessary grids and parameter files can be produced and used locally).

Copy right and the use of CC-BY: CC-BY does not mean that the holder (NKG) has to be credited each time the transformation is used. This means that we will predict no big issues related to licensing of NKG products.

Discussion whether the new transformations should just replace the old transformations in PROJ or if the old transformations still should be available. Pasi wanted the old one to still be available and then the question is how to label them.

Kristian got the task to make with a plan for the implementation of the NKG_RF17vel and the NKG transformations in PROJ. (See presentation 6-3)

Any other business

- **NKG web pages (http://www.nordicgeodeticcommission.com/)**

National reports and scientific presentations could be put on the web, but maybe not status reports. Some people found it very useful to have everything available on the same place (e.g. Kristian and Hans-Sverre). We shall also remember that for internal use in the group, we do have the SDFE-ftp. The problem with some presentations could be that they were not intended for public presentation, and things like GDPR were maybe not considered. A suggestion is just to upload presentations of some types from a certain event when we know that they will be published. Another suggestion is to put the status reports behind a login for nkg-users.

What about the minutes of the meetings?

It was decided that Pasi will leave the status reports out and upload the rest to the NKG web.

- **NKG Summer school 2020**

Statens Kartverk invites to the next NKG Summer School 2020 to be held in Hønefoss. Topic of the summer school is “Space Geodesy in Support of the Future Autonomous Society”.

- **Next meeting**

The Latvian Geospatial Information Agency invites the WGRF meeting to be held in Riga in March 2021.