NORDISKA KOMMISSIONEN FÖR GEODESI

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

Minutes of the working group meeting in Helsinki on 24–25 March 2026

Place: Helsinki + online (marked with *)

Participants:

DEN: Kristian Evers, Mette Weber*, Thomas Knudsen*

EST: Jaanus Metsar, Andres Rüdja*, Gert Jõgiste*

FIN: Pasi Häkli, Markku Poutanen, Marko Ollikainen

ISL: -

LAT: Ksenija Kosenko, Aigars Keiselis

LIT: Jokūbas Ogintas

NOR: Tobias Arnell, Michael Dähnn, Sveinung Himle*

SWE: Tina Kempe, Lotti Jivall, Holger Steffen*, Rebekka Steffen*, Tong Ning*, Tobias Nilsson*, Christiana Lilje*, Per-Anders Olsson*

Minutes written by Michael.

The slides of the presentations will be available at the KDS FTP server.

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Action items

Summarization of action items identified at the NKG WGRF meeting:

Item	Responsible	Description
1	All LACs	Each LAC should contact Ambrus Kenyeres for coordinating the upload of EPN densification solutions, including making solutions available to Joaquin Zurutusa (if not done before).
2	All LACs	Each LAC should send a letter to Astronomical Institute of the University of Bern (AIUB) to underline the importance of solving the critical security issue related to QT version 4.8.7 in Bernese, which reached end of life in 2015. A common letter will be prepared, which can be used by each LAC.
3	All LACs	Decision is needed, if NKG GNSS AC solutions should be delivered on quarterly basis. To be discussed in the coming NKG AC online meeting (preliminarily in April-May).
4	ALL LACs and NKL combination centre	Bernese solution for BIFROST project should be delivered until the end of August
5	All LACs	LACs should start with TSview pre-analysis for rejecting outliers, identifying breaks/discontinuities and exclusion of bad data periods of NKG Repro2 solution.
6	Tobias	Invitation to NKG GNSS AC online meeting in April/May for further discussion and planning of activities
7	Michael, Lotti, Kristian, Ksenija	Prepare short description and reasoning about the proposed new topics for the next NKG period (2026-2030) to be presented in the next NKG presidium meeting. Deadline May 1
8	ALL	Other new topics for the next NKG period (2026-2030) can be proposed until May 1
9	Pasi	Prepare and circulate draft of the updated visions and goals, as well as milestones and keywords. Deadline mid-May
10	ALL	Nominate candidates for the NKG award until 15th May 2026.
11	Pasi	Start preparations for the NKG202X transformations, e.g. collecting national ETRS89 coordinates etc. Pasi will coordinate

		the task, to be started based on the proposed schedule after the GA.
12	Sveinung, Kristian	It was announced at WGRF meeting in Gävle that transformation correction grid approach should be added to transformo. Deadline: by the end of 2026.

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Session 1: Presentations

Tina Kempe, Lantmäteriet's Geodetic Strategy 2026-2035: The purpose of Lantmäteriet's geodetic strategy for the period 2026-2035 is to secure the geodetic infrastructure for the future while also taking into account current trends. The focus will be related to SWEPOS positioning service, national reference frames, geoid determination and gravity measurement, establishing a robust geodetic infrastructure and contributing to the global geodetic supply chain. Strategic directions are given also for other key areas like research, advisory services and cooperation, international cooperation and artificial intelligence and machine learning.

Jaanus Metsar, Using the GridCheck method to check the accuracy of the ESTPOS network: The aim is to check the accuracy of network RTK solutions, especially from commercial network operators. For this purpose, a grid with 15 km density was established for Estonia. Virtual Reference Stations are determined for each grid point by simulating a rover with RTKLIB, which gets the Network RTK corrections from ESTPOS. The VRS solution is saved and finally converted into RINEX files. Position solutions are determined based on these RINEX files for each grid point with Bernese and compared to the "true" grid point positions. Preliminary results were shown, which indicates for some areas that probably the coordinates of some ESTPOS GNSS reference stations are not correct. They want to further develop this approach, that it can be applied continuously for ESTPOS and commercial positioning service providers.

Pasi Häkli, Status of EUREF study group on ETRS89: The EUREF study group is looking for alternatives to ETRS89. The study group has reviewed strategies how reference frames are defined by other countries, established a list of needs regarding Terrestrial Reference Systems, prepared a questionnaire to authorities responsible of the national reference frame and listed scenarios of ETRS89 alternatives with pros and cons. In the end a white paper with recommendations should be published. Any decisions will be approved by an EUREF resolution at the EUREF symposiums.

Session 2: NKG GNSS AC

GNSS analysis development

Michael Dähnn, Operational GNSS timeseries analysis of NKG GNSS AC solutions: Automatised methodology is presented how daily NKG GNSS AC solutions given in SINEX format can be prepared and used for timeseries analysis with Hector. In addition, prototype for a web application is shown, which can visualize NKG GNSS AC timeseries solutions. The question arose, if such web solution is of interest for NKG WGRF and especially NKG GNSS AC. Positive feedback is received that such web solution can be useful for sharing timeseries solutions between ACs and can contribute to improved collaboration due to the web-based access.

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NKG operational processing and re-processing

Tobias Arnell, Short follow-up on topics from last meeting:

- NKG FTP server is not a viable option for EPN densification project therefore each NKG AC should contact Ambrus Kenyeres (ambrus.kenyeres@sgo-penc.hu) for coordinating upload of solutions to the EPN densification project (including making solutions available to Joaquin Zurutusa), if not already done. The provided SINEX files can be either NEQ or COV format as long as the same format is used consistently throughout the entire series (OP and REPRO).
- Bernese 5.4 software depends on Qt 4.8.7, which reached end of life in 2015. This creates installation, maintenance, usability, and security challenges. Not all LACs observe an installation issue, which is probably related to use of different operating systems. At the last NKG presidium it was recommended, that each LAC should send a letter to Astronomical Institute of the University of Bern (AIUB) to underline the importance of solving this security issue. A common letter will be prepared by Pasi, Ivars (the secretary of the Presidium), Tobias and Kristian, which can be used by each LAC.

Tobias Arnell, NKG: Status LAC OP and Repro2

- Submission deadline for daily and weekly SNX files of operational solution was changed after last year's WG meeting from 2 weeks to 4 weeks after CODE products become available. In case of delays, LACs should inform the combination centre (Lotti, LM). But some LACs still deliver solutions in large batches covering periods of 5-20 weeks. Therefore, it was proposed to deliver four submissions per year (on quarterly basis) to fixed dates to make the combination process more predictable and ensure LAC deliveries in time, which can be difficult e.g. in holiday periods. The WG agreed on this proposal but the details will be discussed in the coming online NKG AC meeting.
- It is essential that each LAC remains vigilant regarding outliers, especially large outliers related to ambiguity resolution. The outliers can affect not only individual stations, but also wider parts of the network solution. Affected stations should be excluded for the affected day, and the processing should be rerun without the problematic station or stations. Otherwise, the LAC's daily solution may be rejected in combined solution. Therefore, it should be avoided to submit solutions with large outliers.
- All LACs have delivered NKG Repro2 solutions, except for Norway. Most of the submitted solutions are in good order, although a few minor corrections are still required.
- LGIA has carried out parallel session processing with Bernese which could improve the performance significantly. Seven sessions in parallel seems to be optimal if many CPUs are available.

Lotti Jivall, NKL combinations for operational and Repro2

Solution of 8 national networks and the NKG_EPN solution are with more than 400 stations input for the combinations. Daily and weekly positioning solutions are combined, whereas tropospheric solutions are not combined. The presentation described the combination procedure used by Lantmäteriet. The final combination results are uploaded to the NKG FTP server. Combinations have been done until week 2405, whereas only solutions up to week 2386 are uploaded to the NKG FTP server. Some corrections have to be done for the other weeks before they will be uploaded.

Holger Steffen, From BIFROST2025 to new NKG models

The land uplift model NKG2016LU_ABS model was released for more than 10 years ago. Since then, more data are available and in addition we have access to levelling and GNSS data from Germany and Poland. The area is also extended in 2025 with UK and Faroe Islands. The whole chain of land uplift modelling approach is also refined. These are the main reasons, why the BIFROST2025 project was initiated for generation of new NKG models. In the following information and discussions points are summarized related to the BIFROST2025 project:

- GAMIT solution is more or less complete
- GipsyX solution is complete beside Germany, UK and Poland
- Bernese solution is missing Norway, Germany, UK and Poland
- Different strategies are available for outlier detection. In general, the reason for outlier detection should be explained. For example, that outliers are rejected due to meta data issues, building subsidence or local deformation processes.
- Different software packages are available for velocity calculation (TSVIEW, MIDAS, CATREF, Hector). The proposal is to use first GAMIT results to test the different timeseries software.
- There will be only one set of input data for the NKG202XLU. That means for GIA model, levelling data and 3D velocity estimates. Levelling data are in place. Either GAMIT or GipsyX solution is used for the velocity field. The Bernese solution is still important for the uncertainty estimates. Tide gauge and GRACE data will not be used.
- What signals should the new NKG202XLU (AND NKG_RF2Xvel) model include?
    - The velocities should be corrected for time-dependent elastic deformation. The model will be provided by Valentina Barletta (DTU Space). For the modelling it is required to know the start and end time of the observation time period for each calculated station velocity.

  - Ideally the non-tidal loading should be applied on GNSS observation level (RINEX files), but this would require reprocessing of GNSS solutions. Maaria Nordman et al. will deliver an uncertainty estimate.
  - Local deformation outliers will be removed and smoothed, but this will be discussed in the corresponding scientific publication.
- Draft schedule is presented, where the Bernese processing should be finished end of August. The schedule foresees a possible final delivery of the new land uplift model (2D+1D) in March 2027. WGRF will produce the horizontal part but the work is coordinated within the BIFROST activity.
- NKG-FTP server is recommended to use for collecting the BIFROST results. This should be carried out by using existing FTP users to minimize the workload.

Tobias Arnell/Lotti Jivall, Plans for finalisation of NKG Repro2 /Bernese BIFROST

- TSview should be used for pre-analysis by each LAC for rejecting outliers, identifying breaks/discontinuities and exclusion of bad data periods.
- The time schedule for the Bernese BIFROST delivery can be tough until the end of August. A challenge is that the LAC SK is not available, which delays the start of the combination. A solution could be that the combination is already started backwards for periods where all LAC solutions are available. The LACs should start already with the pre-analysis with TSview to speed up the process.
- More details will be discussed in the online meeting in late April – early May. Tobias will send invitations.

Session 3: National Reports

Only main points listed here, see details in the presentations (available at the NKG webpage)

Denmark

- New realization of Greenland reference 1996 (GR96), which is also available in EPSG/PROJ
- Starting investigations if ETRS89-DNK is degraded, at least RTK users report difficulties for some Danish CORS stations
- Organizational changes are carried out due to major budget cuts, which leads also to that planned CORS stations and InSAR reflectors will not be established
- Looking into alternatives for Bernese, whereby GINAN software provided by Geoscience Australia seems to be a promising tool

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Estonia

- Organizational changes are carried out
- Service-based management are introduced since September 2025
- ESTPOS is updated with new stations and by relocating stations, which are affected by Russia's jamming activities
- Introduction of paid service for ESTPOS
- Providing an interference detection website for ESTPOS stations
- Preliminary results presented for a quality check of ESTPOS network by using a grid-based approach
- Public survey is carried out for getting user feedback about geodetic point database
- Re-measurement of national 1st and 2nd order geodetic points
- Inventory of national densification network points

Finland

- FinnRef will connect terrestrial vertical and gravity reference frames. For this purpose, FinnRef stations are connected to N2000 height system via precise levelling and with centering measurements (local tie) from benchmarks to the GNSS antennas. In addition, absolute gravity measurements are continuously carried out.
- All tide gauges are levelled every three years, latest was done in 2025
- Optimization tool in QGIS for redesign and optimization of the 1st order levelling networks is established via TarGeOp project
- NKG2020 transformation is added into EPSG
- Metsähovi:
  - GNSS, gravimetric and DORIS measurements have continued normally
  - VGOS system is progressing
  - Finalizing the commissioning of the SLR telescope and system
  - Local tie measurements will be repeated in 2026

Iceland

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Latvia

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- Introduction of Latvian coordinate system LKS-2020, which is also available in EPSG
- LATREF consists of 5 long-term and stable base stations, which connects global and national reference frames and define national coordinate system
- LatPos service is free of charge and uses Leica GNSS spider software for Network RTK solution
- Main user groups of LATPOS are agriculture, surveying and construction and number of users increase with about 350 new users each year
- Plan to establish new GNSS reference stations and relocate some of them in LatPos
- Future plans are to improve ionospheric monitoring, jamming and spoofing detection and RTCM/NMEA monitoring
- Test measurements are carried to InSAR corner reflectors
- LAT LAC has finished Repro2, BIFROST and EPN Repro 3 calculations
- LATREF stations ALKS and DLKS are included in EUREF Permanent Network

Lithuania

- administrative changes → governed under Ministry
- CORS network LitPOS consists of 44 stations, which are equipped with Trimble NETR9 and TRM59900.00 choke ring antennas
- Done with Repro 2, operational calculations are up to date
- Vertical Network: ongoing levelling of the 1st order network for the second time
- Marine gravity surveys in the Baltic Sea

Norway

- Levelling activities has declined over several years, but regained a slight momentum in 2025
- New vertical reference frame is launched (NN2000:2025) and also registered as EPSG code
- Long-term strategy established to migrate new national EPSG codes for ETRS89 and vertical reference frame
- Investigations are carried out related to the potential of GNSS reflectometry for water level determination
- Increased focus on Svalbard in relation to generate a new reference frame, a new transformation and funding activities for establishing co-located tide gauges and GNSS stations

Sweden

- around 500 active SWEPOS stations
- working with replacement of antennas on SWEPOS fundamental stations and finishing installation of snow-melting systems
- GNSS station in-situ calibration are carried out to detect site dependent effects
- SAR target infrastructure established with the main purpose to develop and maintain geodetic infrastructure
- Contribution with VLBI solutions to IVS reprocessing (1979-now) for the next ITRF-update (ITRF2020_u2025)

Session 4: NKG transformations

Pasi Häkli, Status of the NKG transformations

Based on the discussion in the WGRF meeting in 2025, the NKG2020 transformation was added to the EPSG dataset. The solution is based on the new coordinate operation that combines Helmert transformation and deformation corrections: Position Vector (geocen) & Geocen translations NEU velocities (gtg). It was decided to exclude older NKG2008 transformations and Latvian NKG2020 transformation parameters for old national reference frame LKS-92. PROJ adopted the new EPSG codes in the version 9.7.0 (Sep 15, 2025).

Kristian Evers, Transformo - What's new?

Transformo webpage is operational under https://transformo.xyz . Information is available on the webpage about program installation, use of the program, architecture and use cases. Transformo is a Python program, which is available on GitHub. The configuration input is managed via a YAML file, which includes information about source data, target data, used operators and presenters. A use case was presented for determination of transformation parameters for Nordic and Baltic ETRS89 realizations.

Pasi Häkli, Ksenija Kosenko, Ivars Liepins: NKG2020 transformation: Latvian update

In Latvia two national ETRS89 realizations exists: the old LKS-92 and the new LKS-2020. Latvians has established a transformation between LKS-92 and LKS-2020. The general methodology for NKG2020 transformation was presented, which was used in 2021 to determine transformation parameters to LKS-92. Different options were tested for the NKG2020 transformation parameter determination for LKS-2020. Conclusion is to use the same approach as for the other NKG countries. NKG2020 transformation parameters were determined for

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LKS-2020 by Pasi and LGIA. Both transformation solutions show similar results. NKG2020 transformation to LKS-2020 is available in EPSG and PROJ. It was decided not to include the old transformation to LKS-92 to EPSG.

Discussion on NKG202X transformation

- A lot of steps related to GNSS velocity determination, GIA, and land uplift model has to be done before we can start with NKG202X transformation. Based on the schedules of other related steps, the work can start after NKG General Assembly when also NKG Repro2 is finalized.
- The methodology for the transformation was partly decided in the WGRF meeting in Gävle (2025). The national transformation methodology can be finally decided during the testing and iteration phase in the first part of 2027, whereby first should be tested if the Helmert transformation is enough or if in addition the correction grid approach should also be used.
- Transformo will be the official maintained tool for estimating the NKG202X transformation parameters. Scilab implementation by Pasi will also be used as a comparison. Also, Tobias Nilsson has own transformation tools and is interested to contribute to the NKG202X transformation. Also Ksenija will join the parameter estimation.
- All countries will be included in testing and iteration of the NKG202X transformations.
- Pasi presented a draft for time schedule of NKG202X transformation. The time schedule was accepted. Based on the draft schedule, the activities of the NKG202X transformation will start after the NKG General Assembly and planned to be finalized by the end of June 2027. Pasi will coordinate the activity.

Session 5: Next NKG period

- The NKG presidium will proceed with the four NKG working groups and their activities. In addition, a task force will be established for NGOS (VLBI/SLR observatories in the NKG region) and related to Education & Outreach.
- Persons can be nominated for the NKG Awards (NKG Award and NKG Young Scientist Award) until 15th May 2026. The call is open at the NKG webpage (https://www.nordicgeodeticcommission.com/) under the General Assembly. The first NKG Young Award was given to Timo Saari in 2025.
- Current vision and goals for the NKG WGRF group were presented. Only minor changes were considered necessary for the next period 2026-2030: addition to make NKG GNSS AC solutions accessible and available for public users.
- Status of milestone of current period (2022-2026) was presented. Most of the milestones are either in progress or done. An exception is the development of cumulative NKG solutions towards regularly updated solutions, which is not started and will continue after the NKG Repro 2. It is proposed to continue with the former milestones for the next 4 years period,

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except that the NKG GNSS reprocessing activities are already carried out. It was also decided to proceed with the work of sharing software tools via GitHub.

- Following new WGRF topics were suggested for next NKG period (named persons after the topics will prepare a short description and reasoning for the proposed topic, deadline May 1):
  - Analysis and visualization of NKG GNSS AC results (Michael)
  - Station-dependent effects (Lotti)
  - Station classification, whereby the NKG document from Andreas Engfeld (2006) could be used as the basis. Also EPN classification of stations can be checked. (Lotti)
  - Study group for GINAN. GINAN is an open-source positioning software package from Geoscience Australia. Denmark has already carried out promising benchmark test against Bernese solution. Could GINAN be used as alternative to Bernese (which struggles with security issues)? (Kristian)
  - Use of artificial intelligence for velocity determination (Ksenija)
- Also other topics with short description and reasoning can be proposed until May 1.
- The proposals of new topics should be presented at the last Presidium meeting before the NKG General Assembly (planned in late May/early June). Pasi will prepare updated visions and goals, as well as milestones and keywords based on the input and circulate the draft in mid-May. After a revision, Pasi will present/provide the proposed topics for the Presidium.
- Pasi Häkli will not proceed as the chairperson for the NKG WGRF group, therefore candidates are needed for the election at the NKG General Assembly. The election procedure of the NKG WG chairperson was presented. Ksenija Kosenko announced that she will be a candidate for the WG for the next period 2026-2030.

Session 6: Business matter

- The NKG General Assembly will be from 14.-17. September 2026 in Lithuania.
- EUREF Symposium will be in Paris from 23.-25. June 2026.
- Next WGRF meeting will be held in Norway, preliminarily during weeks 15-17 in 2027. Lithuania has offered to host the WGRF meeting in 2028.