



NORDISKA KOMMISSIONEN FÖR GEODESI

Nordic Geodetic Commission, Working Group of Reference Frames
Chairman
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National Land Survey of Finland
Vuorimiehentie 5
FI-02150 Espoo
Finland

NKG Working Group of Reference Frames

Minutes of the working group meeting in Gävle on 27-28 March, 2025

Place: Gävle + online (marked with *)

Participants:

DEN: Kristian Evers, Mette Weber
EST: Jaanus Metsar*, Tarmo Kall*, Andres Rüdja*
FIN: Pasi Häkli, Simo Marila, Ulla Kallio*
ISL: Dalia Prizginiene*
LAT: Aigars Keiselis
LIT: Jokūbas Ogintas*
NOR: Karoline Skaar, Tobias Arnell, Michael Dähnn*, Sveinung Himle*
SWE: Tina Kempe, Christina Lilje, Holger Steffen, Tobias Nilsson, Lotti Jivall, Rebekka Steffen, Jonas Ågren, Per-Anders Olsson, Martin Lidberg, Chrishan Puwakpitiya Gedara*, Tong Ning*

Session 1: National reports

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

Denmark:

- SDFI has changed name to Klimadatastyrelsen (Agency for Climate Data)
- There is a new CORS station in Hanstholm (HANK)
- New requirements for private GNSS positioning services approved for cadastral applications have been published
- There are six new GNSS stations in Greenland. A new GR96 realisation is planned this year.

Estonia:

- The coordinates of the ESTPOS CORS network have been updated.
- The ESTPOS network is used for GNSS interference monitoring.
- The network consists of 40 stations, 13 of them are new.
- The Estonian part of NKG Repro2 has been finished, and the operational NKG processing is on track.
- The Estonian Land Board has changed name to Maa-ja Ruumiamet (Land and Spatial Development Board)
- Will provide the ESTPOS RTK service free of charge 1 April-30 September. The ESTPOS RINEX & Virtual RINEX service, including the Computation and Transformation service will be free of charge 17 January-31 December.



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Finland:

- Precise levelling and centering measurements of the FinnRef stations ongoing. Levelling of 40 of 47 stations finished, most of the stations will be ready by 2026.
- 20 FinnRef stations equipped with pillars for absolute gravity measurements. Each station will be measured every three years.
- Several FinnRef stations are equipped with SAR reflectors.
- Some large-scale interference has been observed at some FINPOS stations in the south-east since summer 2024
- Major updates were submitted to EPSG.
- The Nummela Standard Baseline was remeasured in 2024. The uncertainties are below 0.1 mm.
- There is an ongoing project (TarGeOp) investigating what to do with the levelling lines along the railroads, since these are no longer accessible.
- Metsähovi: The commissioning of the new VGOS telescope is ongoing. On-sky tests of the SLR telescope are expected in the third quarter this year. There are plans to do local tie measurements this year. Three new technical experts will be hired.

Iceland:

- The National Land Survey of Iceland has merged with two other institutes to form Natural Science Institute of Iceland (NSII).
- There was a successful tender for aerial images in 2024. The flights will start in September.
- In the CORS network IceCORS six receivers have been replaced in order to also receive Galileo signals. Eleven receivers and antennas will be replaced in the coming years. There is also a new station: KALT.
- There are a lot of earthquakes and lava flow in the Reykjanes area. There are eruptions every 8-12 weeks and deformations of several meters. Because of this, a single base RTK service has been established in the area, using 4 base stations. There are plans to update the coordinates of two reference stations in the area.
- The Icelandic part of reprocessing for NKG Repro2 is complete.

Latvia:

- There is a new Latvian coordinate system: LKS-2020.
- The LatPos CORS network now consists of 28 stations. One has been relocated in the last year; one new station is planned.
- Observations of geomagnetic parameters have been made in the eastern part of Latvia.
- InSAR reflector tests are ongoing.
- Measurements of the second order gravimetric network and geopotential measurements are being made mostly in the eastern part of Latvia as well.
- The year 2022 has been processed for the Latvian part of NKG Repro2, the rest will follow this year. The operational NKG solutions have been made up to week 2357.

Lithuania:

- In the Lithuanian CORS network there are 44 stations: 35 in Lithuania and the rest abroad. Four new stations were added 2021-2023, and one was removed.



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- The data up to 2014 have been processed for the Lithuanian part of NKG Repro2, the rest will follow this year. The operational NKG solutions have been made up to week 2351.
- Levelling of the height network is being done.
- There was a marine gravity survey in the Lithuanian part of the Baltic Sea in 2024, using the marine gravimeter from Lantmäteriet. The survey covered about 5000 km.

Norway:

- A web-based coordinate transformation service was launched last month.
- At Ny-Ålesund, a laser system will be installed in the SLR telescope this year. The aim is to have the SLR operational 2026.
- Airborne gravity surveys have been performed over Svalbard and over western Norway.
- A white paper on the two-frame approach has been written.

Sweden:

- The NKG EPN-Repro3 solution has been calculated.
- There are plans to contribute to the EPN ultra-rapid product, based on the Near Real-time processing of the SWEPOS network.
- Data from 28 EPN stations are sent to EPOS, and since September 2024 also data from about 40 EPN-D stations.
- The coordinates of the SWEPOS stations have been adapted to IGS20.
- An antenna heating system for melting snow in the winter has been tested. The system seems to work well.
- The antennas at almost all fundamental SWEPOS stations have been replaced in the last years.
- Work is being done on the consolidation points. Especially, there is an effort to improve the connection to the height network.
- A new geodesy strategy is being written. It will be finished at the end of this year.

Session 2: NKG GNSS AC

GNSS processing development:

- Tobias N. presented his latest results on global alignment. He had combined five years of the EPN-NKG Repro3 solution with the CODE IGS Repro3 solution. The results show that global alignment works well and makes it possible to apply a global datum to a regional GNSS solution. It might be interesting to apply global alignment for NKG Repro2.
- Michael presented a new SINEX-based time series format. There are tools in the Midgard geodesy library to read and write this format. A time series analysis tool (Analyx) has also been developed, currently for internal use but some parts could be shared. A web-based visualization of the NKG AC solutions based on this tool was also presented. This shows time series, trends, etc. for the station coordinates. It might be possible to make this externally available (with some security restrictions).



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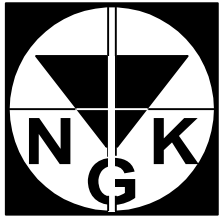
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NKG operational processing:

- Most countries are on track with the operational processing. Denmark still has some issues with the new version of the Bernese software.
- There is a lack of useful IGB20 stations in the NKG area. For example, in Finland the METG was included in IGB20 instead of the more appropriate MET3. To increase the number of stations, ITRF2020-u2023 stations can also be used, since it is the same frame.
- There was a discussion on how to provide solutions to the EPN densification project, if it is better to upload or open up the NKG ftp server from which our data can be downloaded. Furthermore, it was discussed what solutions to provide (daily NEQ, daily COV, or weekly COV). Tobias Arnell will contact the responsible persons for the EPN densification project and ask what they prefer.
- There are some security concerns for the Bernese software, since it uses the old outdated QT4 library. This makes it difficult to install on modern operating systems. Tobias Arnell will draft a letter to the Bernese team, expressing our concerns.
- Some LACs, especially Norway, still experience issues with the ambiguity resolution in the Bernese software version 5.4.
- Lotti made a presentation about the NKL combination. The daily and weekly SNX-files from the LAC are combined using the ADDNEQ program in the Bernese software. Lately, there have been some problems with the TOIL station, possibly due to jamming. Some LACs are not submitting their contributions on time, which leads to delay in the combination and of the feedback to the LACs from the combination.
- Tobias A. proposed to change the submission time of the daily and weekly SNX-files from two to four weeks after CODE products availability. The WG agreed on this but at the same time would like to make this rule stricter in order to make subsequent combinations possible. In case of possible delays, LACs should inform the combination center (Lotti, LM).

NKG re-processing:

- Most LACs are on track with Repro2, some are even finished. However, Norway and Denmark have not started yet.
- The daily LAC solutions will be combined with ADDNEQ. Time-series analysis will be performed with TSview to identify outliers and jumps. Then the daily solutions will be combined in a multiyear cumulative solution using CATREF, and the uncertainties will be estimated using HECTOR. Ideally, all this should be done by week 11, 2026, however, this may be challenging. If needed, the LACs may need to prioritize Repro2 over the operational analysis. Further on, we recommended to process the more recent years first, enabling combination to start before the finalizing all the LAC reprocessing. It was suggested to make a Gant chart for Repro2 to visualize dependencies and time consumption. In order to meet the Repro2 goal, all daily LAC solutions should be processed by the end of January 2026. More detailed planning of the following steps will be done later in the autumn. See also other dependencies with the schedules of the NKG_RF2Xvel/NKG2026LU models and NKG202X transformation (section 3).
- Holger gave a presentation about the status of BIFROST. The BIFROST processing is done using Bernese (GPS-only solution from Repro2), GAMIT, and GipsyX. The



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GAMIT processing is 50% done. In addition to stations from the NKG area, the solutions will also include data from Poland and Germany. It is also under consideration to include data from the Faroe Islands and the UK.

- Tong reported that the GipsyX processing for BIFROST is running according to the schedule, it will hopefully be done in the fall this year. A potential issue is that JPS currently does not provide orbit and clock products before 2002. Hopefully, the earlier years will be available soon so that the years 2000-2001 can also be processed.
- There was a discussion about where to save the results from the BIFROST processing.

Session 3: NKG transformations

NKG deformation model:

- Pasi presented his latest work on the NKG_RF17vel model. There were some improvements made to the scripts and some bug fixes, however, these did not result in any significant differences. The uncertainties of the velocity estimates were calculated using the method of Vestøl et al. (2019), which gives more realistic uncertainties than what is obtained directly from the least-squares collocation. He also tested the one-step approach of Vestøl et al. (2019). This gave some differences compared to the current approach and may be a better approach to apply for future velocity models. Several comparisons with other velocity models were also made, and in general good agreement was found. A paper about the velocity model is being written.
- There was a discussion about the future NKG velocity model NKG RF2Xvel. This will be based on the velocities estimated from BIFROST and NKG Repro2, and the velocity field from NKG2025GIA as a background model. The reference frame of the model will probably be ETRF2020. Holger suggested also including the non-linear effect caused by the elastic response to present day ice-melting in the model. The goal is to have the model ready by NKG GA 2026 (or a few months before to allow for some testing). The modelling will be coordinated and planned with the NKG2026LU group later in the fall.

NKG transformations:

- Kristian presented the Transformo software. This is a software being developed for deriving transformations. Currently only a three parameter Helmert transformation is implemented, but other transformations will be added. For example, there are plans to include the code Pasi used for the NKG transformations. The software is available on Github: <https://github.com/kbevers/transformo/>.
- There was a discussion on the next NKG transformations. This will be based on the ITRF2020 coordinates of the NKG stations estimated in the NKG Repro2 cumulative solution and the corresponding national ETRS89 coordinates. For this, all countries should provide up-to-date national ETRS89 coordinates of their reference stations. The transformation method will be similar to that of the current NKG transformations, i.e. do the transformations via ETRF2020, epoch 2000.0, estimating a Helmert transformation for each country and possibly also a correction grid. The goal is to be finished by NKG GA 2026; however, this is dependent on Repro2 and BIFROST.



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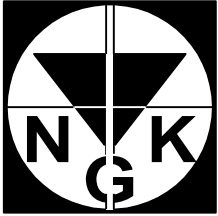
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Session 4: Geodetic Registries

- Pasi made a presentation on registration of the EUREF-FIN reference frame and the Finnish transformations in EPSG. The major update was done partly by changing the datum of the existing EPSG codes, and partly by adding new codes. For example, all recent Finnish geoid models were added. The transformations are now also available in PROJ. After the updates, both EPSG and PROJ cover all Finnish nationwide CRSs and transformations.
- Martin gave an update on the ISO Geodetic Registry and the work done to implement SWEREF 99 there. It has not yet been implemented, since there are difficulties implementing the transformation to ITRF2014. There are different ways to do this which are being considered.
- There was a discussion about registration of the NKG transformations in EPSG. Current ISO 19111 data model requires CRS of each (intermediate) step to be registered whereas the step including ETRFyy(2000.0) coordinates has no meaning and should not be registered. The solution proposed by IOGP is to define a new coordinate operation that would combine Helmert transformation and point motion by grid. Currently, the solution is possible only for Estonia, Finland, Latvia, Lithuania and Sweden that have registered their national ETRS89 realizations. To include Denmark and Norway, their national ETRS89 realizations need to be registered in EPSG. Furthermore, the correction grid used for the Norwegian transformation is not implemented in EPSG but could be added. The WG agreed with the IOGP proposal and Pasi will collect the necessary information for the registration and contact IOGP.

Session 5: Meeting news

- Karoline gave a report on the Joint EUREF and EURO-SDR Workshop "Georeferencing in the digital era", which was held in Tromsø in October 2024. Precise positioning is becoming available for a wider community, many of which are non-specialists. These do not have a good knowledge on reference frames, EPSG codes, the accuracy of WGS84, etc. A problem is also that important metadata may get lost. This will require improved metadata management, better user friendliness, more standardization, and training and education of the users. The discussion on these topics will continue in the next meeting, which will be held in Gardermoen in Oslo, May 27-28, 2025.
- Martin reported on the EUREF study group on ETRS89. The task of this group is to investigate various issues with ETRS89 and suggest possible alternatives. The problem is that there is a 7 cm difference between the recent ETRS89 realizations (ETRF2014 and ETRF2020) and ETRF2000 (which is used as the basis of many national reference frames). Furthermore, the reference epoch of ETRS89 is now over 35 years back in time.
- Rebekka gave a presentation about the UN-GGCE Workshop which was held in Bonn 17-21 February 2025. The goal of the UN-GGCE is to communicate the importance of



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geodesy to decision makers, provide guidance on Geospatial Reference Systems, etc. The workshop dealt with topics like funding of geodetic infrastructure, risk analysis, Land-sea, and the need for collaboration (here NKG was pointed out as a good example).

Session 6: Business matters

- Next meeting will be held in Finland, in March 2026.