Time & location:
Tuesday, February 12, 2019, 1300 – 1800
Wednesday, February 13, 2019, 0830 – 1200
FÖMI headquarters, Budapest, district XIV, Bosnyák tér (square) 5

MINUTES
Last update: February, 13, 2019

1. **Opening & Welcome (Kenyeres)**
   The GB chair AK opens the meeting and thanks the participants for coming to Budapest. In particular he welcomes the invited guest Heiner Denker (Institut für Erdmessung (IfE), Leibniz Universität Hannover), one of the key persons of European gravity and geoid computation.

2. **Approval of minutes of 78th GB meeting in Helsinki (Söhne)**
   Since there are no comments to the final version, the secretary will forward it to Manuela Vasconcelos for publication on the EUREF web page.

3. **Review of Action Items from previous GB meetings (Söhne)**
   After a short discussion, the GB decides to close the action item 78_5 on publishing old campaign reports by scanning. The GB does not see the need to scan the existing reports on old campaign reports since they are published in the series of the BKG and BEK. The planned campaign web page should contain the references to the printed reports only.
   The EUREF session at EGU is discussed. Since there were 20 abstracts received, one oral slot with 7 talks is available on Monday morning 8:30 to 10:15, followed by the poster session. MP reads what the session convenors AK, MP and WS selected for oral presentations.
   The EPN contribution to the IGS Technical Report 2018 was uploaded in time. RD reports that many contributions are delayed, in particular from the US, probably due to the shutdown.

4. **Height & Gravity**

   a. **Towards EVRF2019 (Sacher)**
      Prior to the meeting, on January 24, MS distributed the preliminary report on EVRF2019 to the GB members. Email feedback came from EB. MS explicates in detail the figures within the report about the selection of datum points, on mean and zero tides, uplift and correction models. She explains special cases for France and Britain as well as the exceptions made within table 3 for Belgium and France. AK asks for the datum points, e.g., that there were none from Scandinavian countries or from the Netherlands.
      The questionnaire, given at the end of the preliminary report, is discussed. It should be distributed to all contributors together with a letter signed by the EUREF chair. AC recommends to re-order the three options with the preferred one on top, which is agreed by the GB. EB recommends to add some questions to the questionnaire on the use of the EVRS implementation in the respective countries receiving the questionnaire.. The GB agrees. MS is not in favour, she has concerns these additional questions will delay the answer. LH is asking for the meaning of the columns MS is presenting, in particular the zero tide column. Who needs it? ML replies that it is important for Sweden for example. RD asks whether the questionnaire with additional questions may delay the introduction of the new EVRS2019. The GB decides to not split the questionnaire.
      Action Item to MS and MP: update the draft questionnaire of the report with the suggestions made by the GB concerning re-ordering the options and additional question on the usage and distribute it together with a letter signed by the EUREF chair.

   b. **Optimal application of height and gravity data – Resolution No. 2 / 2018 (Kenyeres, Denker)**

HD gives a detailed presentation about the European gravimetric geoid. First attempts at the Leibniz University Hannover started around 1982. There are several releases starting with EGG97. Some countries still have gaps in the data delivered to the data base, e.g. Romania, Ireland. In a second block HD explains the use of optical clocks. The clocks are highly sensitive to the gravity potential. Currently gravimetric observations are used as an input for corrections but in future optical clocks could be used for gravity measurements. The required frequency stability is in the order of 10**18, corresponding to 1 cm. Stability is needed for at least 1000 to 3600 seconds. Also the length of the connection line is limited. HD uses two examples in the environment of INRIM and LSM to explain the influence of erroneous local gravity measurements, which can cause errors of up to 10 cm. He shows differences of the evaluation of EGG2015 by GNSS/levelling using the EVRF2019 (preliminary version provided by MS) and EVRF2007. The problem with Great Britain remains, although the error/bias is only half the size as before[1], whereas there are now new problems or signatures visible in France where a west-east-jump in the centre replaces the tilt. The statistics (rms, min, max) for the new EVRF2019 are slightly larger than for the old realization. With examples from USA and Canada HD shows large discrepancies between GNSS/geoid versus geometric levelling in the order of several dm. Some countries, e.g. GB/UK, Canada and USA are defining geoid based vertical datums. AK raises the questions how to derive "something" easy to handle for the user. Which role can EUREF play? HD asks MS if the introduction or inclusion of GNSS in the adjustment of the levelling would be possible. MS answers that it would be possible, including the introduction of a variance/co-variance matrix. MP proposes to set up some guidelines but the GB believes that it is too early for this. ML asks for the future of the data base. Some of the data available at IfE cannot be shared. AC suggests the topic of geoid computation for a future symposium's tutorial. AK raises the general question on height modernization in Europe. The resolution 02_2018 on a working group should be followed and concluded during the Tallinn symposium.

Action Item to the GB: following the resolution 2_2018 start forming a working group on height modernization and gravity.

5. **EPN**

   a. **Central Bureau**

      i. **EPN CB Report (Legrand)**
      On behalf of CB, JL presents the status of the Central Bureau (EPN CB). 12 new stations have been added compared to last year, giving 333 stations in total. A new file is added to the EPN CB web page, which lists the frequencies per station, on a daily basis. Some new sub-directories for the long (9) character station names are introduced, e.g. for log, new, and old. JL gives three examples for duplicate short (4) characters in the moment, due to the largely increased number of stations within the EPN densification. RD asks for the long station names in the products, in particular in the SINEX files. Presently the new long station names cannot be included in the SINEX files. The IERS is responsible for the standards defining the SINEX-files but did not yet approach a solution sufficient for all techniques. RP confirms there are identical 4 characters station names even in Italy (i.e., where the long 9 character naming would not fit as well). Independently of these cases the EPN CB proposes to use the site log files with 9 characters in the future for the EPN users. RD proposes to

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[1] After the meeting, MS "found out, that the national ODN heights have the same tilt to the geoid as the derived EVRF2019 heights."

differentiate between Rx2 files and short site log names on the one hand and Rx3 files and long site log names on the other hand. JL says that would be rather difficult to maintain at the EPN CB. The GB is not favour of creating site logs for Rnx2 and Rnx3. It prefers to maintain site logs with short and long names for a while and finally switch to site logs with long names only.

JL reports on the request from several station managers to submit Rx3 files only. GFZ has been indicating to stop Rx2 upload. It seems that the upload of Rx2 files has been drastically reduced within the IGS. The EPN guidelines say that the submission of Rx2 files is mandatory. The GB agrees that upload of Rx3-only should be accepted as a third option. The question is who is doing the Rx3 to Rx2 conversion, the user or the data centre. WS mentions possible inconsistencies at the regional data centres in case of such conversion. The GB is in favour to leave this to the user. There is software available to perform this step (e.g. RTKLIB, gfz3rnx, BNC). CV raises the question whether the conversion software provided by GFZ is for scientific use only or also for commercial purposes.

Action Item for CB (EPN CB): write a EUREF mail indicating that, in the future, EPN guidelines may change and that some station provider may stop Rx2 file upload, that only Rx3 files will be available for these stations and that the conversion of Rx3 to Rx2, if necessary, should be done by the user.

JL shortly reviews the M3G tool which is used at the EPN CB for some time now. There are some open points to solve, e.g. the site log update. Prior to the meeting, EB had raised the open issues concerning the site log submission and upload. Especially the missing option of uploading a site log as plain file instead of using the M3G tool is discussed. JL confirms that this option, i.e. uploading plain site log files, will be introduced as one of the list of open points.

Last point in the report are re-calibrated antennas. The EPN CB received new individual chamber calibrations (including multi-GNSS signals) for two antennas which already had individual robot calibrations. These individual robot calibrations were used in operational EPN processing, but at other stations. To take advantage of the new signals available in the new chamber calibrations and to be consistent with the operational EPN analyses, there is a need to include, in the EPN calibration file, both individual calibrations (robot and chamber) for the same antenna but with different validity periods. The ANTEX format allows this by using the VALID FROM/UNTIL sections which are already successfully used for satellites. But testing by CB and TL showed that some software packages do not handle these section correctly for ground stations. Therefore, the old individual robot calibrations have been temporarily removed from the EPN calibration file and a EUREF mail (EUREF mail 9670) has been sent out to clarify the situation. But the problem may occur in the future more often and has to be solved.

ii. **EPN data centres (Söhne)**

During his last workshop, the IGS on its IC & DC splinter meeting decided to go for gzip (*.gz) instead of compress (*.Z) compression. WS shortly reviews the discussion within the IGS IC&DC WG on changing compression from compress to gzip. The UNIX compression seems to be not or not fully supported in the near future whereas gzip is widely available. Start should be June 1 (or June 2 to start with a full GPS week). In the first stage, this change touches the station provider and the EPN data centres but later

on each analysis centre or user. One question is whether historic data should be changed or keep untouched. The pros (no break in download series) and cons (discontinuity of SUMs) have been discussed in the IGS. WS emphasizes that EUREF should follow the same strategy as the IGS to avoid problems.

RP asks whether the local date centres were also affected by this change. RD recommends to distribute Nacho Romero's original email on the proposed change to all data centres and also to the analysis centres to get enough feedback before the symposium. EB asks if all station managers were aware of this issue. CV adds the problem with the firmware of the reference station receivers, because some of them may not support the gzip compression. If they were not able to change, a conversion has to be introduced within the EPN data centres.

Action Item to WS: forward Nacho Romero's email on the change of compression to the EPN local data centres and analysis centres.

b. **Analysis Centre Coordinator – Report (Liwosz)**

TL gives an update on the activities of the ACC since the last meeting covering two main topics. To the operational combination with GPS and GLONASS a new combination with Galileo has been added. A few more contributions with Galileo are available bringing the number to eight. The stations having individual calibrations for G&R&E show larger discrepancies in East and North and some systematics in Up, while computing the differences between the eight AC combination with Galileo and the operational solution of 16 ACs. Differences between mixed (16 ACs where eight have Galileo) and operational show almost the same pattern. The station LEON shows the largest differences in Up, AUBG in East. Two more ACs providing solutions with Galileo are expected soon. So one question is how long the parallel running, for processing as well as for combination, should continue. CV asks if this is not a decision of the Analysis Centres. RP agrees that the ACs must be informed about the combination results. She proposes to stop the double work until more ACs are uploading. There are enough products for further investigations available. However, waiting for the planned AC workshop in fall is too long. CV proposes to ask the ACs right now. RP proposes to send feedback to the contributing ACs and encourage them to switch to the Galileo solution. RD repeats his concerns he made at the IGS workshop to include Galileo into those products relevant for reference frame realization due to the missing ground antenna calibrations for Galileo. CV reports from a contact he had with Geo++. The status is that the post-processing implementation of the antenna calibration procedure is ready since the beginning of the year. The results are promising. All frequencies and signals for all GNSS are implemented. Geo++ is currently working on a larger sample size for verification and comparisons. The goal is to have a fair number of antenna types ready before the next IGS AC workshop in Potsdam (15.-17.4.2019). Geo++ is asking for a priority list of antennas that are important to be calibrated for the EPN. JL asked for time to properly test the impact of Galileo on the multi-year position and velocity combination.

Action Item to TL: write an email to the missing EPN ACs to encourage them to include Galileo and another one to the already contributing ACs to switch to the Galileo-only solution as the operational solution if they are convinced.

Action Item to CB: provide a priority list of antennas important for the EPN to be calibrated.

On the second day TL continues with the second part of his report on the investigations of the EPN with global solution. Horizontal differences show a pattern which is not constant for individual days. In the height there is some kind

of constant shift but with changing directions for individual days. After applying a Helmert transformation with 3 translation parameters the differences become very small. Applying a 6- or 7-parameter transformation the differences almost disappear. RMS values after the 7-parameter transformation are 0.11/0.11/0.45 mm (NEU). The differences in positions look different, i.e. slightly increased, after no net rotation transformation of EPN operational solution into IGS14, in particular in height. TL also shows the difference time series of the Up component for the IGS stations compared to loading time series, provided by the international mass loading service; they look quite similar.

The GB discusses the conclusions to be drawn from this exercise. A more stable solution could be one result. Signals possibly lost in the regional solution may be restored. EB points to the comparisons done by the IGS, in person of Tom Herring, which sometimes look quite bad for EPN stations. TL replies that he removed approx. 10 stations from his exercise where different antenna models (individual vs. type mean, were used. JD asks for the main goal of the global combination, as it currently seems targeting both, 1) the reduction of the impact caused by the selection of fiducial sites in European scope, and 2) the elimination of the impact caused by regional signals (which could be however modelled at some level) such as the non-tidal (atmospheric and hydrological) loading, in particular if not applied together with the Vienna Mapping Function, and probably significantly contributing to visible systematic differences between global vs European solutions. The GB recommends that the ACC should get in contact with Tom Herring to share and discuss his results with respect to his combination.

Action Item for TL: inform the ACs about the content of his investigations on EPN with adding globally distributed stations. In preparation to the AC workshop, ask the ACs to consider going for a global EPN solution.

Final decision on this may be drawn at the AC workshop. EB raises the general question if the EPN as the European densification should give answers to global questions. More pros and cons have to be compiled, e.g. how many global stations would be needed.

c. **Troposphere Coordinator – Report (Pacione)**

RP starts her report with the topic of combining the contributions including Galileo. With increasing number of ACs analysing Galileo observations the number of stations where Galileo could be combined increases. Stations without Galileo may also be affected but the differences are very small. She emphasizes that some ACs are using different set of stations for the so-called 3GNSS solution. CV confirms this for BEK since it has been stated on the AC workshop in Brussels 2017 that each AC testing Galileo can enlarge its network to provide more Galileo stations. RP also mentions to submit an abstract to the Galileo Colloquium in September as a joined contribution of the ACC and the troposphere coordinator. The GB is in favour.

Action Item to TL and RP: prepare an abstract for the Galileo scientific colloquium in Zurich, Switzerland in September 2019 on the investigations and results of the inclusion of Galileo observations in the EPN processing (the abstract deadline is March, 31).

In the second part of her report RP talks about the operational combination. She is ready to upload the solutions in both formats, the old one and the new one in SINEX TRO 2.0 format, with long file names and 9 char station names included. RP is in favour of starting with GPSweek 2034.

Action Item for RP and WS: RP to upload the combination result in both formats to BKG starting with GPSweek 2034, WS to prepare the BKG Data Centre for this.

The third issue is on the investigation on linear horizontal gradients. Different

mapping functions are used in the software packages (BSW and GAMIT use Chen-Herring, GIPSY(X) is using Bar-Sever) which significantly impact the size of horizontal gradients and thus should not be directly combined or compared (see AMT paper Kačmařík et al. 2018). JD adds that the differences between Bar-Sever and Chen-Herring indicate extreme cases while using the tilting mapping function is in between.

In addition RP reports that she received an e-mail from the IVS troposphere coordinator asking for an endorsement letter from EUREF (and IGS) about an upgrade of the IVS troposphere product that are now at a critical stage. The number of IVS ACs contributing to the product is very small and sometimes even below the required minimum to get a reliable combined product.

Action Item for RP: prepare the endorsement letter and send it to the IVS troposphere coordinator.

    d. Reference Frame Coordinator

        i. Usage of PPP for reference frame realization in EUREF (Pacione, Dousa, Lidberg, Legrand, Bruyninx)

        The five colleagues picked up again the discussion on this action item from GB76 several weeks ago. RP notes that she has a complete reprocessing based on PPP available which could serve as the basis for investigations. JD recalls three impacts which could be investigated: systematic effects in reference frame given by the precise products, consistency between products and users, and the PPP ambiguity resolution. RD raises the general question about the potential users for such a product. ML mentions the EPOS case where there are two ACs producing a PPP solution with GAMIT and GIPSY with almost 1500 stations. JD recalls the initial moment – recent updates of the EPN AC guidelines where it was decided not to mix processing strategies of DD and PPP approach. The GB recommends to not follow this topic strongly but to still observe the PPP topic.

    e. EPN Real-Time

        i. RT QC monitoring (Dousa)

        JD presents some results of selected EUREF and IGS stations using the new RT QC monitoring tool developed at GOP. He shows the new features of the G-NUT software package with respect to real-time. GOP compared RINEX and RTCM QC results and found differences mainly in 1) data availability (missing epochs in RTCM, but also missing daily RINEX files), 2) availability of systems, observation signals and frequencies (due to receiver settings), and 3) quality of data (namely presence of more cycle-slips in RTCM). AC asks for the importance of broadcasting all available signals, in particular for Galileo, since bandwidth is an issue. JD notes that real-time stream setting might be optimized for positioning service, but it would be good if EPN real-time data support as many systems and signals for scientific purpose The RT QC service on the Pecny web pages will continue for some time but for the mid-term it needs some agreement e.g. with the EPN CB how to proceed in the future.

  6. EUREF

    a. Strategy and Implementation Plan – Resolution No. 5 / 2018 (Poutanen)

    MP distributed a new version of the strategy plan very closely before the meeting, so not all GB members were able to read it in time. The GB proposes to postpone the discussion and to organize a dedicated webex or skype meeting in March.

Action Item to all: read the distributed strategy plan and give feedback (until February, 27).
Action Item to MP: set up a webex or skype conference, preferably in March, at least well before the Tallinn symposium.

b. **EUREF representatives & GB membership (Kenyeres, Söhne – GB members only)**
Candidates for the EUREF chair and for the GB chair are identified and they are asked to give a short presentation at least at the next GB meeting in Tallinn on how their plans and ideas are.
Changes to the GB membership are discussed. MP proposes to change the GB membership in a similar way as the membership is regulated within the IAG or the IGS.
After some discussion there is no decision how to proceed with the election of new GB members. LH recommends to again read very carefully the ToR and to make a dedicated webex conference on this topic.
Action Item to all: organize a dedicated webex or skype meeting on the EUREF representatives and the GB membership, preferred in March.
Action Item to AK, MP and WS: write a EUREF mail to invite the community to propose persons for EUREF chair. WS to provide a first draft asap.
Action Item to AK, MP and JT: evaluate the incoming proposals, if any, and present, together with the already existing proposals, the candidates to the GB for voting.

7. **EUREF symposium 2019 (Kollo)**
KK explains the web page of the symposium which now includes the registration and abstract submission. The program should be made available two weeks before the symposium. The conveners are encouraged to consider the invited talks. GB members are encouraged to book hotels soon. The conveners ask KK to forward incoming abstracts not only all together after the final abstract deadline but when they are arriving.
Action Item to session conveners of EUREF2019: consider invited talks for your session.
Action Item to KK: forward incoming abstracts to the session conveners.

8. **Working Groups**

a. **WG on EPN Densification**

i. **Contribution of ESTPOS (Kollo)**
KK gives an overview on the ESTPOS positioning service, in particular on the potential contribution to the EPN densification. ESTPOS consists of 29 stations, approx. 23 of them to be proposed for the EPN densification (EPN densification project web-site:
http://www.epncb.oma.be/_densification/; information from ELB:
https://geoportaal.maaamet.ee/est/Andmed-ja-kaardid/Geodeetilised-andmed/Geodeetilised-vorgud/GNSS-pusijaamad-p571.html - only in Estonian;) 27 stations are Galileo-capable. Estonia made a reprocessing based on GPS-only, covering GPSweeks 1407 to 1933. From GPSweek 1934 on the operational solution with GPS and GLONASS is available. There is an issue with IGb08 and IGS14 before and after this week. The guidelines on the EPN densification may need a small update to cover the ESTPOS case. The GB recommends a report of Estonia for validation of the proposed contribution by the GB and for presentation on the symposium.
Action Item to KK: prepare and distribute a report on the EPN densification by ESTPOS containing processing procedures, results etc. well before the next GB meeting.

    b. WG on Deformation Models (Lidberg)
ML gives a short report on the progress of the WG. He reports on the work mainly done by Rebekka Steffen on deformation models. The work is based on the input of both WGs on Dense Velocities and on EPN Densification. Covariance functions fit better to the EPN Densification than to the Dense Velocities. Rebekka used a specific collocation method developed by JL in 2007. The conclusion is that the collocation method is working. The part that deals with the modelling of plate boundaries or faults is yet not included. Also, the vertical component is waiting to be included. There will be an oral presentation at EGU2019 and possibly also at the EUREF Symposium. JZ asks for the exclusion of outliers during the collocation. EB suggests to give some feedback to the working groups that deal with velocities.

9. AOB

    a. Security / IT issues, file distribution and exchange (all)
WS asks the GB members to include a pdf of their documents in addition to overcome problems of some GB members. A valid solution for a safe and permanent exchange of documents, reports etc. is still missing.
Action Item to WS: investigate solutions for the exchange and storing of documents.

    b. Next GB meeting(s) (all)
Next GB meeting will be in connection to the symposium in Tallinn, as a noon-to-noon meeting starting on Monday, May 20. Next spring meeting in 2020 could be in Munich.

    c. AC Workshop 2019 (all)
TL invites to Warsaw to host the AC workshop in connection to the autumn GB meeting. Date should be in October or November this year and shall be fixed before the next GB meeting.
Action Item to TL and WS: investigate possible dates in October or November for the AC workshop and inform the GB on the results if necessary.

    d. IUGG 2019 – abstract deadline February, 18 (all)
Following a general question of the secretary on a EUREF contribution to the IUGG General Assembly in July this year, AC initiates a proposal for an abstract which has been consolidated with, e.g. ZA and AK. Other GB members indicate that they submit or already submitted abstracts as well. The GB agrees to include all GB members as co-authors to ensure that everyone would be able or allowed to give a presentation. ML indicates that he could upload the abstract to the IUGG.
Action Item to all: ensure to upload the EUREF abstract to the IUGG in time.

10. Action Items (Söhne, Kenyeres)
AK and WS will compile the list of Action Items together with the minutes soon.

PARTICIPANTS

Z. Altamimi   excused
E. Brockmann (EB)
C. Bruyninx   excused
A. Caporali (AC)
R. Dach (RD)
J. Dousa (JD)
R. Fernandes   excused
A. Kenyeres (AK)
J. Legrand (JL)
M. Lidberg (ML)
T. Liwosz (TL)
R. Pacione (RP)
M. Poutanen (MP)
M. Sacher (MS)
W. Söhne (WS)
J. Torres   excused
C. Völksen (CV)

H. Denker (HD)
L. Huisman (LH)
K. Kollo (KK)
J. Zurutuza (JZ)