3 Reports of IERS components

3.1 Directing Board

The IERS Directing Board (DB) met twice in the course of the year 2017. Summaries of these meetings are given below.

Meeting No. 64

April 23, 2017, Technical University of Vienna, Gusshausstr. 27, Vienna, Austria

Introduction and approval of agenda

Brian Luzum welcomed the guests and the members of the IERS Directing Board. The agenda was accepted. Some additional points were added and discussed during the meeting.

Formalities

The minutes of IERS DB Meeting #63 were distributed together with the agenda of DB Meeting #64.

IERS Convention Centre: Update

Nick Stamatakos reported on recent modifications of the IERS Conventions 2010:

Updates completed

- IERS Conventions code affected by leap second change
- Mean pole wording in Chapter 7

Pending modifications (TBD)

- Update of: W0, mean pole definition and equations, Tables 8.2a and 8.2b, Chapter 9

Recent changes to IERS Conventions

- New IERS conventions web and ftp sites:
  http://iers-conventions.obspm.fr/
  http://maia.usno.navy.mil/conventions
  ftp://maia.usno.navy.mil/conventions

Users can sign up for notification of Conventions updates: http://iers-conventions.obspm.fr/mail-list.php.

Zuheir Altamimi announced to provide an update of Chapter 4 in about a month. Nick Stamatakos announced that the next major update is planned for 2019. Tom Herring raised the question whether mirroring the sites to IERS.org is planned.

New Action Item

#64.01 Check and coordinate a mirror of the IERS Conventions website at the IERS CB site

ITRF2014 validation and comparisons
Report from ITRS Centre

Zuheir Altamimi presented the following report:

Summary of the ITRS Centre activities

- New ITRF website is delayed to end of 2017
- ITRS Centre Operational entity for local survey: an IGN document will be prepared and given to the IERS CB
- Recognize the Operational entity by the IERS (change of the IERS ToR connected to the ITRS Centre, e.g. “Centre is collaborating with the Operational entity”?)

Detlef Angermann noted that the GGOS Bureau of Network and Observations is also working on the topic of local surveys.

ITRF2014 related activities

- ITRF2014 was published on January 21st, 2016 (see http://itrf.ign.fr/ITRF_solutions/2014/forfullinformation)
- PSD models are now successfully implemented by most TCs and other users
- A JGR open access article published in July 2016
- Article on Plate motion model accepted by Geophysical Journal International
- Update of Chapter 4 of the IERS Conventions: still to be done (see Action Item #62.04)

ITRF2014 related TN

- TN38: IERS Technical Note on the official ITRF2014 published
- TNxx: IERS Technical Note on the evaluation of the three solutions: ITRF, DTRF and JTRF
  - No real progress so far
  - To be published by the end of the year at the latest
    Daniela Thaller: What is the status of evaluation in the Technique Centres?
    Hugues Capdeville [IDS]: Plans to write an article on the evaluation, which can be published in the TN as well.
    Chopo Ma: No news from IVS.
    Erricos Pavlis [ILRS]: Some contributions are expected by the end of June.

Richard Gross will submit a summary of JTRF2014 by the end of June the earliest. Rolf Dach will discuss the subject within the IGS. Detlef Angermann will contribute a summary of DTRF solution and a summary of the comparisons.

EOPs: 14C04: an interpolation issue

- EOP08C04 and EOP14C04: doubled noise (?)

Z. Altamimi: Proposal: provide the 14C04 at two epochs: noon & midnight or publishing two separate series.
S. Lambert noted that the series at noon are dominated by GNSS.
R. Gross: JPL publishes one series at noon and one at midnight, separately.
R. Dach proposes an hourly solution and suggests to put this topic on the agenda for the upcoming GGOS UAW.

VLBI & SLR Scale Issue

DGFI and IGN agreed to analyze their respective SLR & VLBI cumulative solutions, using SLR-VLBI co-location sites only (no GNSS).

Discussion

Tom Herring raised the question about adding Flicker noise to the scale. Zuheir Altamimi proposed to add GNSS co-location sites.

Report from ITRS Combination Centre at DGFI-TUM

This report was presented by Detlef Angermann.

Scale analysis of VLBI and SLR solutions:

- Results are sensitive to single particular stations, e.g., Yarragadee. No significant scale offset and rate between IGN and DGFI single technique solutions for VLBI and SLR.
- Different methods for scale investigations:
  a. Direct transformation
    - Only few transformation stations, dependency on local tie fits!
    - Large variation of estimated scale differences; smaller offset for DGFI

  b. Indirect transformation using GNSS as reference
    - Difference between SLR and VLBI: DGFI 0.1 to 0.7 mm, IGN -3.3 to -1.3 mm
    - Set up scale for VLBI or SLR in DTRF2014 – 3 Tests: Transformation via a set of good and globally well distributed

  - VLBI only, SLR only, GNSS only

Summary:

- The results of the direct transformation between VLBI and SLR are affected by a poor distribution of transformation stations and local tie misfits. It is thus critical if the results rely on this method only. High dependency from single stations, e.g. Yarragadee.
- The transformation of VLBI and SLR via GNSS provides much more stable results:
  - Range of estimated scale offsets via GNSS (epoch: 2000.0): DGFI-TUM: 0.1 to 0.7 mm, IGN: -3.3 to -1.3 mm
- The observed scale rate differences might explain some part of the scale offset at 2010.0 obtained by IGN.

Comments:

Axel Nothnagel asked for the physical reasons of the scale discrepancies. Zuheir Altamimi proposed to use appropriate local-tie weighting; Detlef Angermann will do the tests with the DTRF2014.

Reconstruction of IGN tests:

- Large scale offset not reconstructed

Report from ITRS Combination Centre at JPL

The report from ITRS CC at JPL was given by Richard Gross.

Correlation in ground deformation

- Account for regional correlations in ground deformation

Joint TRF/EOP/CRF Determination

- Kalman filter to determine CRF from VLBI-only data developed

JTRF2014

- Article submitted to JGR-Solid Earth
- Starting to write an article for IERS TN
- Development capability to provide monthly updates to JTRF 2014

Helmert transformation parameters (at 2005.0) (Kalman filter vs. linear propagation of ITRF2014)

- 10 years signal for scale parameter

Geocentre

- Velocity fields (numbers = correlation coefficients): horizontal: JTRF2014, vertical: ITRF2014

Earth orientation parameters

- Seasonal signal due to comparison to linear parameterization

Zuheir Altamimi mentioned that the operational IGS series are still aligned to 2008.

New Action Items

#64.02 Propose revised wording for ToR to acknowledge operational entities in general
#64.03 Provide input to Technical Note on ITRF/DTRF/JTRF including validation

Reports from Technique Centres

IDS

This report was presented by Hugues Capdeville.

DORIS constellation

- Current Missions: 6 DORIS missions in flight with DGXX(S) Receiver (7 channels)
- Future Missions: 10 missions planned between 2018 and 2023

Network

- 45 co-locations out of 57 DORIS sites
- 9 beacons are currently out of order (5 for over a year)
- Reliable service: annual mean of 89% of active sites in 2016
- Recent events: New station at Wettzell observatory; local tie survey at Papeete, Tahiti; RF compatibility tests at Papenoo, Tahiti; restarting at Socorro Island, MX
- Future events: New stations in San Juan, AR, Guam, US, and Easter Island, Chile, Rothera, Antarctic, Ny-Ålesund, Norway, Kathrine, AS, Changchun, CN and Papenoo, Tahiti

Analysis update

- 6 active ACs (using 5 different software packages for orbit determination)
- Processing routine: IDS Combination Centre is finalizing the extension of combined series until 2016 day 360
- Work in progress:
  - Implementation of DORIS RINEX data processing since the launch of Jason-3, Sentinel-3A (DORIS data is only delivered in RINEX-like format)

  - Work on the open points following ITRF reprocessing: DORIS scale increase in 2012 (understood and can be removed); Increase of DORIS residuals from Jan. 2013 for all missions
  - Jason-2 and Jason-3 USOs are sensitive to the SAA (a solution was proposed to minimize the SAA effect)
  - Switch to ITRF2014 for IDS operational products soon

Comparison on the DTRF2014, ITRF2014 and JTRF2014 solution using DORIS

- Evaluation of TRF solutions by IDS CC
- Evaluation of TRF solutions in POD by CNES/CLS IDS AC (positive: ITRF2014 fits better)
- Article in progress on this subject, which can also be used as reference for the IERS TN on ITRF2014 evaluation.

DPOD2014: DORIS extension of the ITRF for Precise Orbit Determination Switch to ITRF2014 for IDS operational products

- Version 1 available (SINEX and text format)
- Updated twice a year
- Switch to ITRF2014 when ACs use DPOD2014

IDS news

- Next IDS AWG meeting in London (UCL), May 22–24, 2017
- IDS website upgraded
- New version of the web service: time series visualization tool
- New products from the Combination Centre: DPOD (Cumulative solution)

IGS Rolf Dach presented the IGS report.

- Transition to ITRF2014 has been done on 29 January as announced (no unforeseen occurrences)
- In combination protocol: JPL does not contribute because of reprocessing, other ACs took the chance to make model changes and to review the station lists
- Ongoing process: transition to RINEX3, 30% of stations provide RINEX3 data or both formats
- IGS workshop in Paris, 3–7 July 2017

- Internal structure: new chair of the antenna unit (R. Schmid stopped working, now: A. Villiger)

Since the beginning of 2017, a new working group on monitoring and assessment of GNSS products has been established as a joint effort with ICG. It is a neutral entity, not belonging to any system administration (U. Hugentobler chair, T. Springer coordinator of operational concerns).
ORBEX: orbits exchange in SINEX-like format (also altitude information?)
In frame of MGEX: exchange orbits planned

ILRS Erricos Pavlis presented this report.

Recent ILRS Developments

- ILRS GB is in the process of selecting two associates to be appointed as "At-Large" members (according to the newly adopted ToR)
- "Quality Control Board" (QCB): meeting monthly by telecon; plans the next phase of the implementation of near-real-time QC analysis tools and procedures to help the stations' engineers resolve systematic errors affecting their systems

ILRS Network

New initiatives in Russia, NASA SGP, Ny Ålesund, Metsahovi, etc., but still large geographic gaps. Mix of new and legacy technologies (expanded use of the newer technologies to move from legacy to new technology status).

ILRS Network Development

- Activities in the Chinese Network: San Juan being repaired and upgraded, Wuhan being repaired and upgraded, Shanghai has a 10kHz system and a newly implemented Super-Conducting Nanowire Single Photon Detector (SNSPD), 1-meter aperture telescope under development at Wuhan
  - New SLR systems underway: Metsahovi (Core Site), Yebes (Core Site), Mt Abu and Ponmundi in India (2017)
- Several sites now working routinely at kHz rates:
  - Current: Herstmonceux, Sejong, Wettzell (SOS-W), Changchun, Beijing, Shanghai, Potsdam, Graz
  - Future: SGSLR (McDonald, Ny Ålesund, Hawaii, ...), others?
- Riyadh station is still not operational.

Missions

- ~100 satellites routinely tracked in 2017
- New satellites added; GNSS satellites routinely tracked
- Future missions: SWOT, HY-2C, ACES, NISAR, COSMIC-2, and ICESat-2

ILRS ASC – Analysis Activities

- ITRF2014 implementation completed (some ACs still need to join)
- Pilot Project on station systematics over next 2 months
- New products related to near real-time system evaluation (in development stage)
- Next PP will deliver low-degree gravity coefficients (weekly product) and introduce LARES for ITRF support
- ILRS special issue in the Journal of Geodesy progressing
- Significant scale differences found comparing the ILRSA scale w.r.t. three TRF Models (DTRF2014, ITRF2014, JTRF2014)

ITRF2014/SLRF2014 Implementation Schedule

- All ACs will have completed the implementation by end of May 2017
- SLRF2008 and SLRF2014 series of products will run in parallel up to the middle of June 2017
- After mid-June 2017 a single “pos+eop” and “orbits” product will be generated and released, with ITRF2014/SLRF2014 being the underlying TRF

IERS 2010 Conventions Update

- CMP: Chapter 7, Section 7.1.4

IERS CMP Comparison

- Large X- and Y-Pole variations for different versions

Future Meeting Schedule

- October 01–05, 2017, Riga (Latvia): ILRS Technical Workshop on Laser Ranging
- Next ASC meeting: Sunday, October 01, 2017, Riga (Latvia)
- 21st International Workshop on Laser Ranging: November 04–09, 2018 in Canberra (Australia)

IVS Tom Herring presented this report prepared by Rüdiger Haas.

IVS Transition to ITRF2014

- Two IVS Analysis Centres have started submitting SINEX files with ITRF2014 as a priori (several more are ready to do so in the near future)
- IVS Combination Centre has started to submit ivs2017a which uses ITRF2014 as a priori (waiting for more ACs to make the switch)

Importance of HF-EOP

- Study by Tim Springer: full year 2016 with two identical 24 h multi-GNSS processing runs; using 60 multi-GNSS tracking stations; using all available GPS, GLONASS, Galileo satellites (two runs with different sub-daily ERP models: 1. IERS conventional model (ortho_erp.f), 2. Gipson "hfeop_withlibra" model based on VLBI analysis)
- Amplitude spectra of the difference in the Right Ascension of the Ascending Node at the day boundary (dRAAN0h): similar effects visible for radial, along-, and cross-track differences, direct X, Y, and Z differences, inclination, semi-major axis, and cross-track overlaps.
- Results confirm a previous study in 2011
- Now also shown for GLONASS and Galileo $\rightarrow$ real improvement due to the VLBI-based model by Gipson

Intensives for EOP

USNO uses intensives from USNO, GSFC and GSI in its EOP series:

- All sessions are standard 1-hour S/X Intensives

NASA/GSFC has done simulations comparing:

- a) KOKEE-WETTZELL S/X Intensives with
- b) KOKEE12M-WETTZ13N VGOS (broadband) sessions
- VGOS sessions get ~4 times as many observations
- Formal errors ~1/2 those of S/X observations
- VGOS sessions less sensitive to atmospheric turbulence

Next step: schedule some KOKEE12M-WETTZ13N sessions at the same time as standard S/X sessions.

Improving “Intensives”

Simulation study by Chalmers University of Technology (Kareinen et al., Earth Planets Space 2017). Goal: finding optimum additional stations locations to improve INT → “cheap” way to effectively improve INTs

VLBA “Intensives”

Over the last few years USNO has started to schedule “Intensives” using the VLBA:

- Schedules made using software “SCHED”
- Duration: originally 45 minutes, in February 2017 switched to 90 minutes.
- Dynamically scheduled: do not occur at the same time every day, $\pm$ 4 hours of 6:30 UT
- Usually use Mauna Kea – Pie Town if this is available
- NASA/GSFC has just started working with USNO to import these data and make it available to IVS
- “Pilot project” starts with data from January 2017
- Need to make “master file” which uses: actual starting time, actual duration, actual stations
- Need to make schedule file that can be used by IVS (VEX file used for correlation; additional information needed)
- Expect to have some results by the end of the summer

VGOS (broadband) sessions

Began “regular” broadband sessions in January 2015 on trial basis: baseline GGAO12M–Westford, 1 h sessions 2015-Jan-20, worked up to 24 h sessions 2015-Dec-08
Beginning in 2016 added additional stations as they became available: 2016-Feb-12: KOKEE12M, 2016-Jul-07: RAEGYEB (Yebes13M), WETTZ13S; 2016-Sep-20: ISHIOKA
Process continues in 2017: two 24 h sessions per month.

Analysis of broadband sessions

Current processing chain uses new VLBI vgosDB database format:

- vgosDBmake: knits correlator output into vgosDB
- vgosDBcalc: adds in a priori and partial information
- vgosDBproclog: adds in met and cable cal data from log file

- nuSolve: Analysis vgosDB data

Same processing chain can be used for both VGOS (broadband) and S/X observing.

VGOS network development

- 3-station broadband network in North America
- Westford18 m – Goddard 12 m – Kokee Park 12 m
- Wettzell: WETTZ13S (13.2 m)
- Ishioka (13.2 m)
- Yebes: RAEGYEB (13.2m)
- Onsala: ONSA13SW, ONSA13NE (13.2 m)
- Several other VGOS projects (Ny-Ålesund, Shanghai, RAEGE, HartRAO, Metsähovi, ...)

VGOS Twin telescopes in Wettzell (TTW), Onsala (OTT) and Ny-Ålesund (NTT)

Upcoming IVS-meetings

- 9th IVS Technical Operations Workshop, 30 April – 4 May 2017, Haystack Observatory, MIT
- 23rd Working Meeting of the European VLBI group for Geodesy and Astrometry, EVGA2017, 14–19 May 2017, Chalmers University of Technology, Gothenburg

Preparation for CONT17

15 consecutive days: 28 Nov. 0 UT – 12 Dec. 24 UT, using three different networks: two legacy S/X networks of about 13 stations each (one legacy network will include the ten VLBA stations) and one network consisting of VGOS broadband stations.
Preparations ongoing, including simulations, optimal assignment of stations, assignment of correlator resources, etc.
Detlef Angermann asked about scale comparisons.

EOP Products

Report from Earth Orientation Centre

Axel Nothnagel asked about implementing more rigorous combination procedures, i.e. a combination on normal equations including the EOPs and the TRF for generating the IERS EOP series, as already discussed at the previous IERS Retreat (is part of the evaluation process).

Sébastien Lambert replied that Paris Observatory is working on software that uses normal equations from the 4 Techniques. This could lead to a

C04 combination in a more advanced way according to the requests of the IERS Retreat.

Zuheir Altamimi stated that there are not enough co-locations on a weekly basis, which are the limiting factors. Is a project on more rigorous combination of the EOP series needed?

Report from Rapid Service/ Prediction Centre

Christine Hackman reported:

Mission

- Provide rapid-turnaround EOPs for real-time users: Weekly (IERS Bulletin A), Daily (estimates and predictions), Sub-daily (estimates and predictions)

Products 2016

- finals.daily (PM, UT1–UTC). Increased UT1 RMS (observed between 18 Mar and 04 Oct 2016) was from UTGPS

RS/PC ITRF2014 Transition

- Transition implemented since March 23, 2017
- PM, UT1–UTC aligned to ITRF2014 series
- Celestial pole offsets aligned to IVS combined 24-h VLBI series

2008→2014 transition discontinuities

- 2008–2014 transition: RMS 20, 54 μas for PMx, y; RMS 21 μs for UT1–UTC
- 05 C04-to-08 C04 transition: RMS 76, 70 μas for PMx, y; RMS 7 μs for UT1–UTC

New Action Items

#64.04 Study procedures for a rigorous combination to derive EOP series (esp. C04)
#64.05 Provide two C04 series (at noon and at midnight epochs); add note to the users that the midnight series is interpolated

Switch to ITRF2014 for operational products: Status and experience

What is missing?
Open question.

What can be learned?
C. Hackman noted that the schedule for IERS Rapid Service/Prediction Centre will be in near real-time in future: more discussion on how to do the transition (multi-stage process).

Scale comparisons?
See topic “ITRF2014 validation and comparisons” above

Prepare roadmap and guidelines for further ITRF products
ITRF process

Brian Luzum presented thoughts about the future ITRF process.

Aim: better planning of resources, availability of persons, etc.

Goals:

- Create a defined process to be followed for future ITRF generation
- Provide documentation for external users

Fast, good, cheap $\rightarrow$ pick two principle

Brian Luzum presented a possible timeline comprising ITRF transitions at the TCs and validation, as well. Feedback is requested on the timeline, amount of time, steps and wrap-up until December. Detlef Angermann asked whether a validation is foreseen before introducing the ITRF.

Unanswered questions:

- Are fundamental assumptions correct? E.g., is “Pick two” reasonable?
- What is the optimal time from beginning to end? Beginning = ITRS Centre recommending new ITRF, End = adoption of new ITRF
- How do we determine optimal time?

Next steps:

E-mail dialog regarding:

- Missing steps
- Missing dependencies
- Reordering tasks
- Length of time for tasks

Brian Luzum will give an update on the process including the feedback given at the meeting in December.

Zuheir Altamimi noted that there are unforeseeable delays between the call for participation and the contributions from the Technique Centres. It needs about 6–12 months from TC submissions to a new ITRF.

Criteria for choosing a new ITRF: minimum 3 years, maximum 5 years (additional data, models, etc).

New Action Item #64.06 Discuss proposed ITRF process. How to optimize the procedure at the TCs for reprocessing?

UAW 2017 Richard Gross announced that the Unified Analysis Workshop will be hosted by IGN and will take place from noon July 10 to noon July 12.

Topics:

- Technique biases and systematic errors
  - VLBI: Loading effects
  - SLR: Loading effects; range biases
  - GNSS: Antenna patterns
  - DORIS: Antenna patterns; South Atlantic Anomaly
- Model improvements
  - Mean pole: Definition, modeling, and prediction
- Reference systems and frames
  - Deficiencies of current systems and frames: Examples
  - Joint TRF/EOP/CRF determination: What is needed?
  - Towards more frequent TRF updates: What is needed?
- Standards, Conventions, and Formats
  - Metadata: Implementation
  - SINEX format extensions: Radio source positions?
  - SINEX format extensions: Loading parameters?

UAW participants: ~50 participants are invited representing GGOS, IERS, IGS, IVS, IDS, ILRS and IGFS.

IERS Technical Notes on ITRF2014: Status and way forward TN on ITRF2014 solutions: This TN was discussed in topic “ITRF2014 validation and comparisons” above.

TN on input and evaluation by the Technique Services: This TN was discussed in topic “ITRF2014 validation and comparisons” above.

TN on C04 series aligned to ITRF2014 (replace TN planned for 08 C04): S. Lambert explained that this was not started yet.

IERS Workshop celebrating 30th Anniversary in 2018 Z. Altamimi announced that REFAG2018 will be jointly with the 42nd COSPAR Scientific Assembly and organized by Geoff Blewitt at Caltech in Pasadena, USA, 14–22 July 2018. Another possibility would be the IAU General Assembly in August 2018 in Vienna.

New Action Item #64.07 Ask Geoff Blewitt about the possibility to organize an IERS anniversary event in conjunction with REFAG2018.

Status of ICRS/ICRF and IAU Working Group Bryan Dorland gave an ICRF3 status update:

ICRF3 Background

- ICRF3 Working Group formed to define next ICRF; target date is 2018 IAU adoption

Goals

- Competitive in precision with Gaia (~70 μas, 1-σ, RA & Dec)
- Uniform precision for all sources $\rightarrow$ VCS positions must be improved
- Extend to higher frequency (S/X $\rightarrow$ S/X, K and X/Ka band)
- Possible multi-wavelength catalog
- Improve southern coverage
- Maximize high-quality optical-radio tie sources
- Complete ICRF3 by 2018 (Gaia comparison)

Multi-wavelength? $\rightarrow$ TBD

ICRF3 Status

S/X: Continued contributions from IVS scheduled observations (e.g., R1, R4, CRF)
S/X: VLBA Cal Survey-II (VCS-II) to re-observe VCS sources published

- 2400 VCS sources re-observed in S/X (2062 previously detected and 324 previously undetected)
- Average position uncertainty of 0.24 and 0.41 mas in RA and Dec, respectively, a factor of ~5x improvement
- “Second Epoch VLBA Calibrator Survey Observations - VCS-II,” Gordon et al. 2016, AJ, 151, 154

K-band densification

- Dedicated Southern Hemisphere and VLBA observations to increase precision and density of sources
- 788 sources (expect >1000 ultimately), ~50 μas precision

X/Ka data continues to be collected and processed.

- 18 VLBA sessions in 2017 to re-observe poorly observed ICRF2 and VCS-II targets

100 μas zonal declination errors being investigated for all bands: S/X, K, X/Ka
Images available for S/X and K-bands

Gaia Status

ESA Gaia astrometry mission (launched 2013, science data collection since 2014, nominal mission end = 2019, may be extended to 2021, 2023)

Data products:

- Data Release 1 (DR1) – September 2016
- DR2+ ~April 2018, approximately yearly thereafter

Tying reference frames: ongoing work to look at Gaia optical-to-ICRF radio reference frames; frame tie < 1 mas achieved. Precision ~5–10 μas per rotation angle.
Accuracy dominated by systematics currently bounded at ~0.5 mas level.

USNO-related work

(X/Kz = X/S)

- USNO now publicly releasing Mauna Kea – Pie Town VLBA intensives for use by the general community
- USNO to begin processing backlog in VLBI imaging database this year
- K-band observations supported via USNO VLBA time allocation
- Additional X/Ka observations supported via USNO VLBA time allocation
- UCAC5 Catalog
- UPC: URAT Parallax Catalog
- UBAD, URAT bright star catalogs
- Mid IR AGN Catalog – spans the gap between visible and radio sources
- Ongoing validation work between ICRF3, Gaia and other sources
- Dedicated optical-radio link work commencing in 2018 at CTIO

Summary and future work

- Final observations for ICRF3 underway
  - K-band observations completed, will be considered as part of reference frame
- On-track for 2018 adoption
- Gaia DR1 received and ingested
- VLBA now supporting increased Celestial Reference Frame and Geodesy
- Research
- Additional work being done now
  - Radio imaging database
  - Radio-optical link
  - IR reference frame

New Action Item #64.08 IERS Conventions need to be updated with ICRF3

GGOS Detlef Angermann reported on the GGOS CB meeting of April 22, 2017.

- H. Kutterer sent a designation letter to H. Schuh. Process started to select a new chair, EC meeting on Friday with further information. H. Kutterer will continue until a new chair is selected.
- Bureau of Network and Observation: Meeting on Wednesday evening;
- Bureau of Products and Standards: Meeting on Tuesday; two representatives from IERS (Analysis Coordinator, Convention Centre), but need to be decided who will succeed G. Petit (either N. Stamatakos or Ch. Bizouard)
- GGOS focus areas:
  - Unified height system
  - Geohazards
  - Sea-level change

Proposal for a 4th focus area on atmosphere $\rightarrow$ decided to be established within GGOS. GGOS Days are planned in conjunction with COSPAR meeting in South Korea in September 2018 (3-3.5 days).

New Action Item #64.09 Clarify representative of IERS Conventions Centre to GGOS Bureau of Products and Standards

Reports from the Working Groups

IERS Working Group on SINEX Format

Daniela Thaller reported that a more user friendly SINEX description as a web interface for each block was set up, which is easier to maintain and to update, and more user friendly to implement or to check. Until now, it is available only internally at the IERS CB; possibilities to access from outside will be evaluated.

Zuheir Altamimi asked to approve a PSD block and a discontinuity part.

IERS Working Group on Time Series Format

Laurent Soudarin presented the report of this WG.

Work plan

Applied method:

- expression of requirements
- establishment of a list of existing formats
- review of the formats
- propositions for the exchange format based on conclusion of the existing
- identification of still open issues to be addressed next

Status

WG meeting at AGU 2012

- Start of the list of requirements (time scale, reference system, coordinate system, metadata)

WG meeting at EGU 2013

- Start of a list of existing formats at IAG services and GPS time series providers. Several issues concerning the time series were discussed (epoch, time tag, accuracy, correlations, ...).

WG meeting at EGU 2015

- Review of some existing formats. Metadata and data have been examined 2015–2016.
- List of the necessary elements for the time series exchange format (metadata content, data table, mandatory and optional inputs) as well as the units, the coordinate system, the date and time system

Main conclusion

Three groups of metadata:

- File information

- Site information
- Product information

Data

Users prefer to plot NEU position variations, but XYZ coordinates are necessary to express positions in a different reference frame or to obtain NEU and then delta NEU on a different ellipsoid.
→ Two blocks: XYZ (+sigma ...) and ISO date and time (accurate data), dNdEdU(+sigma ...) and Modified Julian Days (understandable by humans; easy to plot)

Format proposition:
1) SINEX-based format
2) YAML format

Draft proposal for the station position time series exchange format. The two formal proposals have to be discussed.

Annual Reports Daniela Thaller reported that the AR 2015 was published recently and that the AR 2016 needs to be drafted.

Next DB meeting (#65) The next DB meeting (half-day afternoon meeting) will take place on Saturday, December 09, 2017 before the AGU in New Orleans.

New Action Item #64.10 Prepare next DB meeting #65 in New Orleans.

Meeting No. 65

December 9, 2017, Hilton New Orleans Riverside Hotel, 2 Poydra Street, New Orleans, USA

Introduction and approval of agenda Brian Luzum welcomed the guests and the members of the IERS Directing Board. The agenda was accepted.

Changes in IERS personnel Brian Luzum presented an overview of the following changes:

- Guanli Wang replaces Chopo Ma as IVS representative to the IERS DB
- Richard Gross replaces Bernd Richter as GGOS representative to the IERS DB
- Rüdiger Haas replaces Chopo Ma as the IERS representative to the IVS Directing Board
- Still open: IERS representative to the WDS (replacing Bernd Richter); the next conference “International Data Week” will be

held in Botswana, November 5–8, 2018. Any suggestions and/or volunteers for the IERS representative to the WDS should be sent to the CB.

New Action Item #65.01 Suggestions for the IERS representative to the WDS

Associate Members The current list of IERS Associate Members was distributed by the IERS Central Bureau in advance. Any changes/additions should be sent to the CB before December 31st, 2017.

ITU request "Future of the UTC time scale" Brian Luzum reported on the ITU request:

- The IERS needs to prepare an answer on the ITU request "Future of the UTC time scale" (ITU-R 236-2/7).
- A Working Group should be established to prepare the answers.
- Groups that need to be represented: Technique Services, Earth Orientation Centre, Rapid Service/Prediction Centre
- Work of the group needs to be coordinated with BIPM (Patrizia Tavella), IUGG, IAU.
- H. Schuh: similar request as 10–15 years ago; a very good document with pros and cons had been generated at that time; to be checked whether this document is publicly available (via IAU?).

New Action Items #65.01 Establish Working Group to prepare answer to ITU request on "Future of the UTC time scale", chaired by Brian Luzum

#65.02 Prepare IERS answer to ITU request

UAW 2017 Summary Richard Gross presented the topics discussed at the UAW, including the recommendations achieved for each session:

- The sessions were dedicated to systematic errors and biases in all four space-geodetic techniques, site survey/co-locations, reference systems/frames, conventional mean pole, standards/Conventions/Formats, Interoperability of portals and metadata.
- A detailed report of the UAW is available from ggos.org: http://176.28.21.212/en/meetings/2017/unified-analysis-workshop/general/ [See also Chapter 4 in this Report]
- Achieved outcomes are (as of Dec. 2017):
  - A new linear mean pole model is available.
  - Differences in different formulations of relativistic effects are understood.

  - Working Group on sub-daily EOP variations is established (chaired by John Gipson).

- H. Schuh: The Working Group on sub-daily EOP variations should be organizationally part of either GGOS or IERS → R. Gross will clarify this issue with John Gipson.

New Action Item #65.03 Clarify whether WG on sub-daily EOP variations will be part of IERS (or GGOS)

ITRF2014 and beyond

Report from ITRS Centre Zuheir Altamimi presented the report of the ITRS Centre.

Summary of the ITRS Centre activities:

- Work on new ITRF website is still in progress.
- ITRS Centre operational entity for local surveys will focus on establishing a database for local survey observations (work is in progress with priority to archive local tie vectors).
- Modification of IERS ToR to recognize the operational entity of the ITRS Centre (follow up Action Item #64.02).

Discussion:

- The operational entity at the ITRS Centre is responsible only for Data Management, but not exclusively for local surveys, as many other institutions are carrying out local surveys at their geodetic sites, too.
- Conduct email voting on modification of IERS ToR.

Presentation for ITRF Error Budget Workshop, organized by Tom Johnson, to be held on Thursday, Dec. 14, 2017:

- Comparison of DGFI- and JPL-internal technique solutions with ITRF to evaluate scale
- Scale discrepancy of ~1.4 ppb between SLR and VLBI
- Statement: DTRF and JTRF solutions are keeping the technique-specific scales of SLR and VLBI (therefore a good agreement with SLR and VLBI solutions); ITRF explicitly allows for scale parameters by the techniques, therefore, combined scale is an average of SLR and VLBI scale
- DTRF scale w.r.t. ITRF at 2010.0: 4.2 mm (VLBI), 0.6 mm (GNSS), 4.3 mm (SLR)

- JTRF scale w.r.t. ITRF at 2010.0: 4.2 mm (VLBI), 2.5 mm (GNSS), 3.9 mm (SLR)

Report from ITRS Combination Centre at DGFI-TUM

This report was given by Mathis Bloßfeld.

Summary of the ITRS-CC activities:

- Comparisons between three TRF solutions carried out; discrepancies at the cm-level detected after 2 years of propagation only

Presentation for ITRF Error Budget Workshop, organized by Tom Johnson, to be held on Thursday, Dec. 14, 2017:

- A detailed list of contributions to the current ITRF error budget was compiled; errors can be grouped into:
  - Limitations of input data (this is partly resolvable by an ITRF roadmap as suggested by B. Luzum, and by a transparent communication among the Services)
  - Limitations of current ITRF solutions, mainly related to network and co-locations (hard to solve as network improvements are required)
  - Limitations of the absolute ITRF accuracy and the statistical information (partly resolvable, but requires clear communication)

Report from ITRS Combination Centre at JPL

Richard Gross provided an overview of the work by summarizing science talks at AGU:

- JPL works towards more frequent updates of the TRF: bi-monthly updates based on solutions provided by Technique Services as operational products.
- Consistency between EOPs and TRF could be ensured with more frequent updates.
- Actual time series of geocentre motion (CM-CN) could be provided based on the assimilation of new data.
- Ongoing work related to joint TRF-EOP-CRF determination based on Kalman filter method.

New Action Item

#65.04 Email voting on modification of IERS ToR

Roadmap for next ITRF generation

Brian Luzum recalled the idea of preparing a roadmap for the next ITRF before starting with the generation of the ITRF (as already presented at IERS DB Meeting No. 64).

Mathis Bloßfeld presented the thoughts of the ITRS CC at DGFI-TUM:

- Currently missing: feedback loops, responsibilities, product specifications, future steps.
- It needs to be defined, who is responsible for the CfP, and who should approve the CfP.
- Test scenarios and evaluation criteria needs to be defined thoroughly (GGFC should also be involved in testing).
- A feedback loop based on the internal and external validations needs to be incorporated (e.g. by higher frequency of UAWs).
- ITRF publication and documentation should be authored by all IERS CCs and Technique Centres.

Discussion:

- Duration for reprocessing (Step 4) needs to be at minimum 1 year.
- Duration for initial TRF combination (Step 5) needs to be at minimum 9 months.
- Details for Call for Participation (Step 1) needs to be defined in advance: IERS internal discussion before fixing details of CfP; CfP will be sent out by ITRS Centre to IERS DB, Technique Centres and Analysis Coordinators.
- Ch. Hackmann / N. Stamatakos: Step 9 (adoption of new EOP series) should be split into two parts, i.e., adoptions at the Earth Orientation Centre and adoption at the Rapid Service/Prediction Centre.
- H. Schuh suggested to include an external (independent) review process and evaluation.
- R. Gross emphasized that external verification is highly important.
- Z. Altamimi mentioned that he will distribute soon a list of proposed models for the next ITRF and ask the TCs for their input.
- The roadmap should be finalized at next IERS DB meeting in April 2018; any comments and suggestions should be sent to B. Luzum; he will update the documents.

New Action Item #65.05 Send comments on ITRF roadmap to Brian Luzum

EOP Products Christian Bizouard presented the recent activities at the Earth Orientation Centre:

- C04 series is now consistent with ITRF2014 solution.
- Combination procedure has been updated: nutation offsets dX/dY are directly combined; new weighting method; modelling of bias or trends by piece-wise linear functions; reanalysis since 1984
- Problem: C04 is provided with 30 days latency, but IVS Quarterly solution cannot be considered for recent epochs → are there improvements possible?
- Publication in Journal of Geodesy is accepted: Bizouard C., Lambert S.B., Becker O., Richard J.Y., The IERS EOP14 C04 Solution for Earth Orientation Parameters Consistent with ITRF2014
- Interpolation issue: 14C04 at noon epochs (as answer to Action Item #64.05) is available at ftp://hpiers.obspm.fr/iers/eop/eopc04/eopc04.dX_dY.12h.84-now and ftp://hpiers.obspm.fr/iers/eop/eopc04/eopc04.dPsi_dEps.12h.84-now

Christine Hackman presented the recent activities at the Rapid Service/Prediction Centre:

- New email addresses are in place: @navy.mil
- Contact email for IERS RS/PC: navobsy_eop@navy.mil (not ser7@maia.usno.navy.mil anymore)
- UT was improved when taking out UTGPS → to be revised in 2018
- Improvements of predictions for PM and UT1 via AAM/OAM

Ch. Bizouard presented the idea of Leonid Petrov to incorporate his NERS (Network Earth Rotation Service) as an official IERS component:

- Delivery of the EOP products to the customers is the weakest point: printed version until 1990s; ftp servers since 1990s.
- Modern requirements are different: NTP protocol; seamless client/server interaction; internet services; “internet of things” / interaction of internet services.
- NTP client for UTC available (function and command line interface) → is a similar tool possible that provides UT1 or the Earth Rotation matrix?

- NERS implemented EOP dissemination in a modern form, including short-term EOP forecast.
- NERS project is supported by NASA and Paris Observatory.
- Suggestion by L. Petrov and Ch. Bizouard: accept NERS as an official IERS product (in addition to other products) or extend pilot phase.

Discussion:

- The delivery of the IERS products in general (not only EOPs) should be improved and modernized.
- Ch. Hackman: The Rapid Service/Prediction Centre UT is already distributed via NTP by the National Institute of Standards and Technology (NIST).
- H. Schuh: The ideas of NERS should be included into the official IERS products instead of establishing parallel structures.
- B. Luzum suggests to prepare a graphical overview at which time which value of the EOPs is the official IERS product.
- General agreement within DB:
  - There should be only one official IERS product to avoid confusions.
  - Accessability and availability of official IERS products need to be ensured for long time; this is questionable with project-funded developments as NERS is.
  - The methods for IERS product distribution should be revisited and modernized where needed.
  - A working group should investigate the actual product distribution within IERS (not only EOPs) and propose possible improvements to the IERS DB.
  - The WG should be chaired by the IERS Analysis Coordinator.
  - Members of the WG should be all Product Centres (EOC, RS/PC, ICRS Centre, ITRS Centre), the ITRS CCs, the CB.

New Action Item #65.03 Establish an IERS WG to investigate possible improvements related to the distribution of the IERS products, chaired by T. Herring

Reports from the Technique Centres

IDS Report Hugues Capdeville presented the IDS report:

- New 3-technique site San Juan (Argentina).

- New 4-technique site Ny-Alesund (Norway) by relocation of the beacon.
- IDS combined series is extended to 2017-183.
- DORIS scale increase in 2012 is understood and can be removed (HY2A with new position of the CoM need to be used).
- DPOD2014 is available since October 31st (in SINEX and text format).
- IDS Workshop to be held in Ponta Delgada (Azores), September 24–29, 2018.
- IDS Retreat planned in 2018 to define the activities for the next 5–10 years.

IGS Report This report was given by Rolf Dach.

- Workshop held in Paris in early July 2017.
- Next Workshop will be held in Wuhan (China), October 29 – November 2, 2018.
- An IGS Associate Member Meeting will be held tomorrow during AGU week.
- Transition with RINEX-3 naming is almost closed; for products it is still under discussion.
- Real-time GNSS: Open data policy will be continued by IGS.
- Galileo: new 4-satellite launch planned for 2018; at least a few ACs will include Galileo in their official products.
- Metadata for Galileo satellites and partly QZSS satellites are available.

ILRS Report The presenter of this report was Erricos Pavlis.

- ILRS Governing Board was enlarged with 2 “At-large Members”: A. Sokolov, Z. Zhongping.
- New ILRS Network Application form is available.
- New data Quality Control Board (QCB) is established to address laser ranging data quality issues.
- LARES-2 is approved by ASI; the satellite will have improved laser reflector design.
- ITRF2014 (SLRF2014) was adopted as the ILRS TRF for operational products starting June 15, 2017.

- A complete re-analysis using ITRF2014 is planned.
- A new model for Centre-of-Mass corrections will be developed in 2018.
- Pilot project on systematic biases is running and hopefully improving the scale contribution by SLR.
- Special Issue of Journal of Geodesy (JOGSILR) is waiting for submissions; deadline February 28, 2018.
- A Technical Workshop was held in Riga (Latvia) on October 2–5, 2017: https://cddis.nasa.gov/2017_Technical_Workshop/Program/index.html
- Next Workshop will be held in Canberra (Australia) on November 4–9, 2018.

IVS Report John Gipson reported for IVS:

- The TWIN telescopes at Onsala were inaugurated during the EVGA meeting in May 2017.
- VGOS sessions are scheduled evey 2 weeks, with 5 operational telescopes included (3 in US, 2 in Europe).
- CONT'17 is running at the moment; 3 independent network configurations are scheduled in parallel: Legacy network, VLBA+others, VGOS network.
- WG dealing with aberration is working in close cooperation with ICRF-3 generation.
- Next IVS General Meeting will be held in Ny-Alesund (Norway) on June 4–8, 2018.
- Ludwig Combrinck (from Hartebeesthoek) resigned from all IVS activities.

IERS Technical Notes related to ITRF2014 Zuheir Altamimi and Mathis Bloßfeld gave an overview of the status.

- IERS TN No. 38 (Analysis and results of ITRF2014) is published.
- IERS TN No. 39 (IGN best practice for surveying instrument reference points at ITRF co-location sites) is published.
- IERS TN on the evaluation of the three solutions ITRF, DTRF and JTRF (follow up Action Item #64.03):
  - There seems to be no real progress so far; no input available yet.

  - Scientific papers are (partly) available → can be summarized for the TN.
  - DGFI-TUM is preparing two contributions (DTRF2014 solution; Validation of DTRF2014 w.r.t. other ITRS realizations).
  - Discussion of "external" contributions / validations: e.g. GIA vs. up velocities; annual signals vs. geophysical signals → Can GGFC contribute on this topic?

Action Item #64.03 with new date: Provide input for the IERS TN on evaluation of ITRF2014, DTRF2014, JTRF2014

IERS Workshop Celebrating 30th Anniversary In earlier DB meetings, a session during REFAG2018 (integrated in COSPAR GA) was seen as a good choice. However, nobody is volunteering to organize such kind of event.

IAU Report Richard Gross summarized some news from IAU:

- IAU General Assembly to be held in Vienna (Austria), on August 20–31, 2018.
  - 2 Sessions of interest for IERS: Reference Systems and Frames; Gaia.
  - Division Days are Friday, August 24 and Monday, August 27.
- IAU Commission A2 (Rotation of the Earth) has its Centennial Anniversary on July 28, 2019.
  - A workshop is planned to be held in Brussels (Belgium) on October 7–11, 2019.
  - Workshop proposal is due by December 15; otherwise the event will be held independent of IAU, e.g. in conjunction with Journées.
- New President of IAU Commission A2 will be Florian Seitz, starting after IAU GA 2018; new Vice-President needs to be elected.

Status of ICRS/ICRF and IAU Working Group Bryan Dorland reported about the current status:

- ICRF-3 Working Group is on track for an adoption by IAU during its General Assembly 2018
- ICRF-3 will be a multi-wavelength reference frame: S/X, K, X/Ka
- 2nd Gaia data release is foreseen for April 2018
- Frame tie between IVS / ICRF and Gaia should be better than 1mas (from first assessments); but still ongoing work on the link optical-to-radio reference frames

- 50% of VLBA network is supporting ICRF-3

Updates on IERS Conventions Nick Stamatakos presented the recent updates:

- W0 has been modified in Table 1.1 to correspond to value adopted in the IAG 2015 resolution No. 1.
- Substantial updates in Chapters 6 and 7 to reflect UAW recommendations regarding the filtered (former mean) pole.
- Next major revision to IERS Conventions estimated to be 2021.
- Starting selection process for obtaining experts for each chapter, including editor-in-chief, chapter experts, assistant experts (more details to follow); an official call for experts will be issued soon.
- IERS Conventions Software version control has been established.

UN-GGIM Subcommittee on Geodesy Zuheir Altamimi outlined the developments:

- A follow-up of the UN General Assembly Resolution 69/266 in February 2015, “A global Geodetic Reference Frame for Sustainable Development”.
- The former working group now became “UN-GGIM Subcommittee on Geodesy”, with a first meeting held in Mexico on November 26, 2017 (chaired by Gary Johnston; co-chaired by Alexej Trifonov).
- The 5 major fields for realizing the UN resolution are:
  - Geodetic infrastructure
  - Policies, standards, conventions
  - Education, training, capacity building
  - Appropriate governance
  - Outreach and communication
- At the moment, the implementation plan is developed (to be ready by June 2018); IAG and all of its components will be solicited to provide input to the document.

Annual Reports Daniela Thaller reported that the Annual Report 2016 is almost ready.

Next DB meeting (#66) The next DB meeting (half-day morning meeting) will take place on Sunday, April 8, 2018 before the EGU in Vienna.

New Action Item #65.06 Prepare IERS DB meeting No. 66.

Daniela Thaller, Sabine Bachmann, Wolfgang R. Dick