

## 3 Reports of IERS components

### 3.1 Directing Board

The IERS Directing Board (DB) met twice in the course of the year 2018. Summaries of these meetings are given below.

|                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
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| <b>Meeting No. 66</b>                                           | April 08, 2018, Technical University of Vienna, Gusshausstr. 27, Vienna, Austria                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>Introduction and approval of agenda</b>                      | Brian Luzum welcomed the guests and the members of the IERS Directing Board. The agenda was accepted. No additional comments were made.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>Report within IERS</b>                                       | A standardized template for report contributions (e.g. Annual Report) is provided by the Central Bureau.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>IERS Technical Notes on ITRF2014: Status and way forward</b> | <p>Technical Note 2: Input and evaluation by the Technique Centers</p> <ul style="list-style-type: none"> <li>• No contributions received by the CB until now</li> <li>• Services:               <p>DGFI is working on two contributions: one on DTRF and one on evaluation – both are intended to be finished by end of May)</p> <p>IVS: no contribution so far (A. Nothnagel will talk to John Gipson)</p> <p>IDS: need more time (before summer)</p> <p>IGS: reference frame chair and ACs showed no interest</p> </li> <li>• The publication is foreseen for summer 2018.</li> </ul> <p>Technical Note 3: C04 series aligned to ITRF2014</p> <ul style="list-style-type: none"> <li>• The publication is not yet ready. A Technical Note exists, but has to be improved. The Technical Note is expected to be ready in one month.</li> </ul> |
| <b>New Action Item</b>                                          | #66.01 Remind Technique Centers to contribute to Technical Note 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Reports from the Technique Centers</b><br><i>IDS Report</i>  | <p>The report from IDS was given by Hugues Capdeville.</p> <ul style="list-style-type: none"> <li>• DORIS constellation status:               <p>currently six DORIS missions in flight with DGXX(S) receiver, five future missions planned starting on April 2018 by the SENTINEL-3B mission; 46 co-locations out of 58 DORIS sites; nine beacons are currently out of order (reliable service of the network despite coverage gaps in Pacific and Russia)</p> </li> </ul>                                                                                                                                                                                                                                                                                                                                                                      |

- Analysis update:  
Processing routine: 6 DORIS Analysis Centers provide SINEX solution; an IDS combined series is available online until the end of the third quarter of 2017. DPOD2014 v3: delivery is expected by June 2018 (observations from 1993.0 to 2018.0). Work in progress: implementation of DORIS RINEX data processing; DORIS scale issue (DORIS scale increase in 2012 can be removed); minimize the SAA effect on Jason-2 and Jason-3 USOs Next work: implementation and validation of the new standards/models recommended by IDS/IERS; DORIS orbit comparison campaign
- IDS reprocessing preparation for the next ITRF:  
DORIS specific issues: systematic errors and others; adopt and evaluate the new standards/models recommended by IERS, IDS position for the next ITRF: doing the evaluation and elaboration of the combination will take between nine to twelve months → reprocessing could start in the second half of 2019 for an ITRF2020.
- IDS News:  
Next IDS AWG meeting in Toulouse: 11–12 June  
2018 IDS Retreat 13–14 June near Toulouse  
Next IDS workshop in Ponta Delgada 24–29 September 2018  
New Network display tool will be available soon.

**IGS Report** The report from IGS was presented by Rolf Dach.

- Analysis:  
The database switched to RINEX 3: the ACs are working on the implementation of the new format. The discussion on output is still ongoing and is the upcoming task for the ACs for implementation. There will be no time for a reprocessing for the upcoming ITRF. T. Herring indicated that a radiation force model is needed. IGS will not be able to start a reprocessing before the end of 2019.
- Constellation:  
New satellites QSat, Galileo: four satellites launched, four more will be launched in summer (24 satellites by the end of the year); Beidou: new signals (not defined in RINEX yet, ICD is not published yet)
- Format:  
New Beidou 3 format, with two parallel identifiers for the same satellite (problem to be solved in RINEX); first Beidou 3 data should be available by the end of the year in network data (no receiver calibrations yet)

- **Personality:**  
IGS Central Bureau changes: Steve Fisher quit, Allison Craddock was asked to fill the position – as Ruth Neillan retired – by the end of the year. Gary Johnston will step down from the Governing Board.
- **Next meeting:**  
IGS workshop in Wuhan in the last week of October/first week of November (directly before ILRS workshop)

C. Hackman asked about the new secretary position and when Allison would become IGS Central Bureau Director. R. Dach said that this will be discussed in the afternoon within the IGS meeting.

- First papers on orbits of Beidou 3 satellites have been published in Chinese.
- UNAVCO established a new program: NCEO, supporting full GNSS, supports IGS coordinator role.

### ***ILRS Report***

The report from ILRS was given by Cincia Luceri.

- **ILRS network:**  
still larger geographic gaps; about 13 (out of 38) stations are responsible for 76% of the observed passes on all satellites; new way to rate the stations in terms of observation quality and quantity
- **Missions and campaigns:**  
Routinely tracked nearly 100 satellites in 2017  
New satellites: Galileo, QZS, TechnoSat, S-Net and Geo-IK-2.  
Future missions: additional Beidou/Compass, Galileo, etc., PN constellation (China), Sentinel-3B, GRACE-FO, HY-2c, SWOT, NISAR, COSMIC-2, IceSAT
- **Status and activities:**  
Quality Control Board (QCB) addressing laser ranging data quality issues via monthly telecons; update to site log format complete; examining new strategies to “rate” station performance; new concept in retroreflector designs (e.g. LARES-2)
- **Analysis activities:**  
preparations for reprocessing for upcoming ITRF are ongoing; currently the ILRS is working on a complete reanalysis from 1983; new operational approach to handle error sources in the current modeling standards will be discussed within the upcoming meeting.  
A pilot project (PP) on station systematics is close to the operational phase (June 2018); next PP will deliver low-degree gravity

coefficients as a weekly product; Journal of Geodesy Special Issue on Laser Ranging (deadline is May 31, 2018)

- ITRFXX Plans:  
implement linear mean pole model; develop and implement diurnal-subdiurnal tidal EOP models based on Desai-Sibois (2016) approach; adopt post EGM2008 static gravity field; highest-fidelity time-variable gravity (TVG) model; handling station Range Biases; use updated CoM offsets; handling of Time Biases.  
A loading model will not be included in the reanalysis product for the next ITRF. As far as ILRS is concerned, the new model could be ITRF2019.  
Metadata to implement instrument-monument thermal effect models: Z. Altamimi: collect data on the sites, but not necessarily for the next ITRF
- Recent and future meetings:  
ILRS Technical Workshop was held in Riga on October 2017; the 21st International Workshop on Laser Ranging (IWLR) will be held on November 4–9, 2018 in Canberra, Australia.  
The 22nd IWLR will be held in Kunming, PR China.

Z. Altamimi: impact of range bias on scale and also center of mass: total impact? C. Luceri: CoM correction 1:1 to range bias, range bias with CoM correction as we have now, if the model is changed, review range bias.

**IVS Report** The report from ILRS was presented by Rüdiger Haas.

- 50 years of geodetic VLBI (1968 to 2018); jubilee experiment VGOS session VT8095
- VGOS:  
observing plan: several 24h experiments scheduled for 2018 using the VGOS antennas; in 2019 weekly and/or daily VGOS sessions  
Plan forward: timeline for milestones (see presentation)
- Recent and upcoming VLBI activities:  
correlation of CONT17 almost finished: three networks (2 legacy S/X, 1 VGOS)  
Managing station clock offsets for correlation (e.g. ensure consistent UT1 values)  
VEX2 roll-out: requires finishing specifications and parser  
ICRF3 to be adopted at IAU General Assembly in August  
GM2018 in Longyearbyen, Svalbard, Norway in June 2018  
EVGA2019 in Gran Canaria in March 2019
- Letter from North Korea received, but not answered.

Z. Altamimi suggested for the improvements of sessions to repeat sessions with the most number of stations for the ITRF with more than 20 stations. A. Nothnagel pointed out that there are six sessions per year with close to 20 stations. Request on increasing these sessions. D. Thaller proposed that for the reprocessing for the upcoming ITRF a guidelines for sessions to be reprocessed would be helpful.

**Current activities at the ITRS  
Combination Centers  
*Report from ITRS Center***

The report from ITRS Center was given by Zuheir Altamimi.

- ISO standard on ITRS  
Initiated originally by C. Boucher; a complete document finished, now available, and has been submitted to the ISO Project Team (PT) for comments and approval. Waiting for comments from the ISO PT.
- ITRS Technical Notes  
Three past Technical Notes published by the IERS Center (TN37, TN38, and TN39); Technical Note on the evaluation of the three solutions (ITRF2014, DTRF2014, and JTRF2014): no contributions so far.  
ITRS Center did substantial evaluation on the DTRF and JTRF strategy. Conclusion: persistent scale discrepancy of  $\sim 1.4$  ppb between SLR and VLBI
- Periodic signals  
Aim: evaluate and understand technique differences at co-location sites; concentrate on annual & semi-annual signals; combine them at co-location sites, provide them in a coherent Reference Frame (CM or CF/CN), and provide a coherent annual geocenter motion model compatible with ITRF2014  
Estimated differences of the annual geocenter motion reach up to 4 mm depending on the approach and technique.

***Report from ITRS  
Combination Centre at  
DGFI-TUM***

The report was presented by Detlef Angermann.

- Comparison of ITRS realizations: ITRF2014, DTRF2014, JTRF2014  
Precise Orbit Determination (POD) of SLR satellites (see Rudenko et al. 2018)  
DGFI-TUM performed investigations on SLR and VLBI scale (publication under review)
- Consistent estimation of CRF, TRF and EOP  
A consistent realization of CRF, TRF and EOP by combining VLBI, SLR and GNSS data (2005–2015) has been performed: see poster EGU2018–8843 and publication of Kwak et al. (2018)

- Contributions to ITRF error budget workshop in New Orleans  
Presentation of M. Bloßfeld in New Orleans (Dec. 2017)
  - Current limitations of the ITRF:
    - \* Limitations of input data
    - \* Limitations of current ITRF solutions
    - \* Other limiting factors (e.g., networks, co-locations, geophysical models)
  - Future ITRF concepts
    - \* Estimation of Epoch Reference Frames (ERFs)
    - \* Improved handling of non-linear station motions
    - \* Refined geophysical modeling of non-tidal loading corrections
    - \* Consistent estimation of CRF, TRF and EOPs
    - \* Inclusion of new parameters (e.g. low degree Stokes coefficients)
- Contributions to discussion on roadmap for next ITRF  
CfP for next ITRF:
  - ITRS Center consulted ITRS CCs and TCs concerning handling of technique systematic errors and needed model updates
  - Interaction between different components to prepare the CfP for next ITRF solution
  - Role of the IERS DB concerning the CfP?
- Test of ITRS CC solutions by TCs
  - Who defines test scenarios and criteria?
  - Who is responsible for the tests?
  - What are the consequences of the test outcome?
- ITRF validation (external)
  - External validation of ITRF (who, responsibilities, how, consequences,...)?
  - External validation after release of the ITRF?
- DGFI-TUM contributions to IERS TN “ITRF Comparisons”  
2 DGFI-TUM contributions: DTRF2014 solution (Bloßfeld et al.) and DGFI-TUM comparisons of latest ITRS realizations (Angermann et al.)
- Latest DGFI-TUM publications on ITRF-related issues

T. Herring noted that survey ties do not match well in DTRF but better for ITRF.

**Report from ITRS  
Combination Centre at JPL**

The report was given by Richard Gross.

**Activities:**

- Correlations in ground deformation (Chin et al.)
  - Account for regional correlations in ground deformation, caused by large-scale loading processes by including statistics of regional deformation in stochastic model of process. Extending software to allow a full process noise matrix, not just diagonal
- Joint TRF/EOP/CRF Determination (Soja et al.)
  - Kalman filter to determine CRF from VLBI-only data developed, variability of radio source positions modeled as random walk
- JTRF2014 Analysis (Abbondanza et al.)
  - Continuing to write article for IERS Technical Note; continuing to develop capability to update JTRF2014 monthly; time variable structure of VLBI-SLR scale difference

**VLBI-SLR scale differences:**

- Motivation
  - Analysis of the scale difference between VLBI and SLR within the framework of KALman filter for terrestrial REFerence Frame.
  - Dedicated study entirely focused on the combination of VLBI and SLR only Space-Geodetic inputs (X, EOPs) along with local ties at VLBI-SLR co-located sites.
  - As a result of the sequential nature of the algorithm, KALREF outputs a time series of the quasi-instantaneous Helmert scale parameters mapping VLBI's to SLR's scale.
  - We provide and discuss the time-variable structure of the quasi-instantaneous scale difference between the two observing systems.
- Key facts about the VLBI-to-SLR Scale Differences
  - Evidence of a persistently negative scale bias throughout the 6 configurations examined.
  - According to the sign convention, a negative VLBI-to-SLR scale difference indicates that the baselines between VLBI stations must be contracted in order to match SLR's.
  - This is equivalent to state that VLBI baselines are on average larger than SLR's.

- Biases and Drifts in the process noise-free configurations appear to be consistent with the results of Altamimi et al., who, on an equivalent data set, found an SLR-to-VLBI bias at 2010.0 of 1.02 ppb (6.5 mm) and a drift of 0.01 ppb/yr (0.06 mm/yr).

#### Roadmap for next ITRF generation

Z. Altamimi gave the following overview:

- Consultation on the roadmap for the next ITRF solution (2019 or 2020) was sent to the technique ACCs and GGFC (Jan. 2018).
- An inventory (list) was compiled including all effects and model updates to be considered.
- Feedback so far:
  - IVS:** General agreement, except: HF-EOP model to be recommended by the WG, Loading model (Atmospheric?) will be applied. Include the “removable” model corrections in SINEX. High priority to updating software to apply gravitational deformation.
  - ILRS:** Mostly agree on ITRS proposal. Different opinions on some topics, mainly the gravity field model(s). HF EOP: awaiting for a “consensus” model. ILRS will not include a loading model and no model for 3D thermal effects.
  - IDS:** Mostly agree on ITRS proposal. HF EOP: awaiting for a “consensus” model; waiting for IERS recommendation to apply or not a non-tidal loading model; no opinion on 3D thermal effects; a number of DORIS-specific effects will be addressed.
  - IGS:** response from Michael Moore: mostly agree on ITRS proposal. Adopt post EGM2008 model: Not all ACs are convinced this has a significant impact on GNSS; HF EOP: awaiting for a “consensus” model; most ACs not in favor of applying a loading model; 3D thermal effects: little impact on GNSS.
  - GGFC:** response from J.-P. Boy: GGFC is ready to provide the atmospheric, oceanic & hydrology loading in both CF & CM reference frame, and the corresponding geocenter time series.

Discussion of feedback to ITRF questionnaire and planning for ITRF2019/2020. Still open questions:

- IVS: only atmospheric loading model (removable model corrections?) → ITRF2020
- ILRS: will not include loading model → ITRF2019 or 2020
- IDS: → ITRF2020
- IGS: post EGM2008 model → ITRF2020



### Summary and conclusion

- The data to be submitted need to be ready by Jan/Feb 2021. It takes about 6 months to generate a combined contributions from the Technique Centers.

### Comments and discussion

- A. Nothnagel: NT-AL: how to describe the parameter: deltaX,Y,Z or dNEH in SINEX. This is a question for the SINEX WG.
- R. Dach: one additional parameter as scale of the model
- A. Nothnagel: thermal expansion of DORIS ground constructions; Source positions: unstable sources
- Z. Altamimi will circulate a call for participation by the end of the year.
- D. Angermann: the timeline of ITRF should be included in the CfP.

**New Action Item** #66.02 ITRF2020: circulate a call for participation.

**IERS Conventions** This report was given by N. Stamatakos.

### Overview of IERS Conventions Centre (CC) Activities

- Chapters 6 and 7 were updated to be consistent with the overall direction of the UAW Conventional “mean” pole session summary and recommendations resolution held in July 2017.
- Next major revision to IERS Conventions estimated to be 2021 to 2022 time frame.
- Intention of IERS CC to publish electronic version of IERS Conventions 2021, and then, soon afterward, to publish a paper copy.
- It was announced at the last IERS DB meeting (December 2017): IERS CC has agreed upon a selection process for obtaining chapter experts, assistant experts, and editors to greatly assist IERS CC staff in updating the Conventions for version 2021. (More details to follow.)
- An email announcement – Call to Participate in the IERS Conventions – was sent via IERS Message No. 349 in early February 7, 2018. Additional emails sent to a few other parties who might be interested.

### Rationale for Call to Participate in IERS Conventions

- IERS CC staff does not have all of the needed expertise or resources to create an IERS Conventions 2021/2022.

- Responsibilities and selection criteria for each role are:
  1. One Editor-in-Chief for each chapter
  2. One to three Chapter Experts for each chapter
  3. One Software Editor
- The details as well as the final selection criteria scoring can be found on <http://iers-conventions.obspm.fr/announcements/call-for-contributors.php> or <http://maia.usno.navy.mil/conventions/announcements/call-for-contributors.php>

### Discussion

- Z. Altamimi asked the IERS CC to provide and update of the chapters that the TC need to have consistent models for the next ITRF20XX preparation.
- T. Herring noted that a reference should be given to which specific Convention Update one's referring.
- T. Herring proposed to provide implementations of conventional tests to evaluate the specific versions of the users.
- T. Herring noted that ocean tide models (current: FES2004) need better clarification of the data files.
- Z. Altamimi asked to update Chapter 4 to include the ITRF2014.

### IERS CC activities

A volunteer participation should be kept and it should eliminate the necessity to provide a sponsoring letter from the institution, because this may cause the opposite intension and the institution itself is not willing to sign a paper. The letter could be included as an optional extra. The intentions are the following: 1) to know who is working on the Conventions, 2) to plan ahead, and 3) to create a sort of enforcement mechanism.

### EOP Products *Report from Earth Orientation Centre*

Ch. Bizouard provided the following overview:

- Need for UT1 intensives 14 C04 (no systematic changes, but outliers because of missing UT1 intensive data).
- A flaw in UT1 values till January 2018 is visible.
- 14 C04 over the interval 1994–2017: The UT1 intensive sessions have not been taken into account, only IVS Combined values contributed. Anomalous residuals in SLR LAGEOS orbits disappear with the use of 08 C04 values (for which UT1 intensives contributed). Since January 2018 there are operational C04 accounts for UT1 intensives (IAA and BKG).

Necessity to correct prior values of the 14 C04 series since the start of “UT1 intensives” (1993), but C04 series are supposed to update only the last 30 days.

- Technical Note to appear soon

### Decision

Omit the 30-days rule, add a version number and document changes in a readMe file. Indicate changes in the file header and the release date in the file name.

Older versions should be stored in subdirectories. If there are changes more than 30 days in the past, archive the current version and include the version information in the file header.

A. Nothnagel notes that it is not a C04 anymore and proposes one change to include all intensive sessions.

IERS CB: send out a message announcing the changes and the agreement.

IVS: ACs providing intensive SINEX files.

### ***Report from IERS Rapid Service / Prediction Centre Update***

This report was given by C. Hackman.

IERS RS/PC product changes 29 Mar 2018:

- Products now aligned to 2014 C04 (was ITRF 2014)
- Implements IERS 2010 Conventions dX/dY CPO paradigm

Transitioning to new email system handling RS/PC, Bulletin A operations:

- Bulletin A delivery, bounce-backs
- User questions/issues/requests
- Will be from mail.mil domain
- Transition expected Fall 2018
- Will notify users via IERS Message, Bull. A, other means

Z. Altamimi proposed to generate an updated solutions for specific weeks (e.g. reprocessed IGS combination).

### ***Decisions***

C04 series: omit the 30-days rule, add a version number and document changes in a readMe file. Indicate changes in the file header and the release date in the file name.

### ***New Action Item***

#66.03 Send out a message announcing the changes on C04 series and the agreements.

**Working Group on “IERS  
Product Distribution”**

T. Herring noted: ftp is getting a bad name and web services in http(s) are more convenient currently. A working group on how to make products available in future has to be established. The TCs should be part of the working group. N. Stamatakis and the IERS CB are also willing to participate in the WG.

**Working group to handle ITU  
request “Future of the UTC  
time scale”**

B. Luzum reported and discussed the following:

- He had no contact to the other WG members so far. One decision is that the organizations should involve Christian Bizouard, Christine Hackman, IDS, IVS, IGS, and ILRS.
- Organizations have to be able to answer the questions, which impact can be expected if the UTC definition changes (ITU request).
- The question arises, which of the two representatives will be the person to send the official response (in 2021, one year ahead of the official response in 2022).

**IAU Report: Preparations for  
GA in Vienna, August 2018**

R. Gross reported:

- Two Sessions: (1) Reference Systems and Frames and (2) Gaia
- Centennial anniversary of IAU and IAU Commission A2 celebration on July 28, 2019
- Proposed IAU Symposium for October 7–11, 2019 in Belgium
- IAU Commission A2: 12 persons as organizing committee (president, vice-president, ex-officio members + regularly elected members)

**Status of ICRS/ICRF and  
IAU Working Group**

B. Dorland presented the following report:

**ICRF Status Update****ICRF3 Status**

- ICRF3 on schedule for approval at IAU in 2018
- Multi-wavelength reference frame
- Refereed ICRF3 paper to be submitted by 1 June 2018
- Heavy use of VLBA to support ICRF3 and follow on
- VLBA-St. Croix station knocked off-line by Hurricane Maria on 19 Sept 2017
- USNO beginning to work through imaging backlog for Radio Reference Frame Image Database

### ICRF3 Technical Update

- S/X: Continued contributions from IVS scheduled observations (e.g., R1, R4, CRF)
- S/X: VLBA Cal Survey-II (VSC-II) to re-observe VCS sources published: sky distribution of the 2400 sources in the VCS-II campaign
- K-band: 825 sources from combined data sets; full sky coverage completed
- X/Ka data continues to be taken and processed (XKa (32 GHz): 678 sources)
- 100  $\mu$ as 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
- Data products:  
Data Release 1 (DR1) – Sept 2016  
DR2+ – April 2018
- Tying reference frames: Ongoing work to look at Gaia optical-to-ICRF radio reference frames; Precision  $\sim 5\text{--}10$   $\mu$ as per rotation angle.
- Independent confirmation of VLBI and ICRF at the sub-mas level

### USNO IERS ICRS Center-Related Work

- USNO is allocating 50% of the VLBA time to support reference frame and geodesy (e.g., ICRF3, CONT17)
- USNO is now processing backlog in VLBI imaging database this year (Radio Reference Frame Imaging Database – RRFID)
- Completing URAT-Southern Hemisphere bright star survey in June 2018 – fill in current Gaia bright star gap
- USNO, University of Hawaii collaborating on Northern Hemisphere K-band (IR) survey using UKIRT telescope
- USNO, Paris Observatory actively coordinating on ICRS Center issues

### Summary and Future Work

- ICRF3 nearing completion

- On-track for 2018 IAU adoption
- Awaiting Gaia DR2 release
- Additional work being done

### Overview on ICRF3

#### Background

- IAU Working Group formed in 2012 to generate ICRF3 for presentation at IAU 2018 General Assembly
- Excerpt from ICRF3 charter (see presentation)
- 2012–2015 focus on acquiring proper new VLBI data; 2015–2018 focus on building the frame

#### Data sets

- ICRF3 incorporates data up to 31/12/2017 in S/X (8 GHz), K (24 GHz), and X/Ka (32GHz) band

#### Overview of the work achieved

- Three rounds of ICRF3 prototype solutions produced; 9 solutions (using 6 different software) produced each time; alternate solutions varying the modeling/analysis configuration (assess the level of systematic errors)
- Comparisons between different solutions (also with Gaia DR1); final solutions to be produced shortly

#### Modeling/analysis configuration

- Adhere to IERS conventions: VMF1 mapping function for troposphere; GPS ionospheric maps from CCDis for K band data; orientation of celestial reference frame defined using no net rotation (NNR) constraints on the ICRF2 defining sources; orientation of terrestrial reference frame defined using NNR constraints on ITRF2014
- Parameters estimated: (local) clocks, troposphere, EOPs; (global) source positions, station positions and velocities

#### Variations in modeling/configuration

- Goal is to assess the level of systematic errors
- Various configurations varying cutoff elevation angle, troposphere modeling, station positions, special handling sources
- Impact of new (since ICRF2) southern-hemisphere stations in Australia and New Zealand

- ICRF2–ICRF3 transfer sources (alignment of the two frames) (Ongoing)
- Galactic aberration (not modeled, fixed to a priori value, estimated) (Ongoing)

#### Results (vs ICRF2)

- ICRF3 vs ICRF2 (3414 sources)
- ICRF3 vs Gaia DR1 (2191 sources)

#### Main features of ICRF3

- Incorporates 12 million VLBI observations (about twice as much compared to ICRF2); Includes an additional 30% of sources vs ICRF2; Much more uniform distribution of position errors than ICRF2; Multi- frequency frame (S/X, K and X/Ka band)

#### Remaining work to be done

- Finish tests regarding Galactic aberration and make a decision on whether to include it in the modeling
- Finalize the list of special handling sources and the list of ICRF2–ICRF3 transfer sources
- Produce the final ICRF3 solution, incorporating data up to 31/12/2017
- Estimate realistic errors (inflation factor and noise floor)
- Compare ICRF3 with the Gaia Data Release 2 (DR2) when available (25 April 2018)
- Select the list of ICRF3 defining sources

#### Communication and release plan

- Prepare a journal paper: the aim is to submit it in June and have it accepted before the IAU General Assembly
- ICRF3 to be presented at two upcoming conferences (IVS General Meeting and COSPAR 2018 Assembly)
- ICRF3 to be presented for adoption at IAU General Assembly 2018 (IAU resolution submitted on 15 February 2018)
- Press release to be made by the time of the IAU General Assembly
- ICRF3 to be released when paper accepted or by the time of IAU General Assembly.

The working group triennial report 2015–2018 is available.

### Discussion on Adoption of ICRF3

A. Nothnagel: There was no involvement of the IVS in the whole ICRF3 process (and nor IERS involvement). Why IERS is asked for endorsement now?

#### Decision:

- Collect comments on the question of the endorsement, eventually electronic vote set up by the IERS CB (by the end of April or May, but before the IAU)
- IERS DB comments to be sent to the ICRF3 Working group
- Probably a follow-on WG will be established when the WG ends in August 2018

**New Action Item** #66.04 Collect comments on the question of the endorsement, eventually electronic vote.

### GGOS report on EGV Panel

This presentation was given by D. Angermann.

Background on Essential Geodetic Variables (EGVs)

- It was agreed during GGOS Days 2017 that GGOS should work on the definition of EGVs.
- Example of EGVs: position of reference objects (e.g., ground stations, radio sources), EOPs, ground- and space-based gravity observations, ...)
- The EGVs could then serve as a basis for a gap analysis to identify requirements concerning observation requirements, networks and products.

Definition of EGVs

- A Panel on the definition of EGVs should be established within the Bureau of Products and Standards (BPS).
- BPS distributed a letter on the establishment of such a Panel on EGVs to the IAG Services and GGOS Science Panel members on Feb. 5th, 2018.
- The Panel should be re-named in “Committee on EGVs” and it should comprise the GGOS Science Panel members, the IAG Commissions, the Inter-Commission Committee on Theory, and the 4 GGOS Focus Areas, Representatives of the IAG Services, the GGOS Chair, Director GGOS BPS.



Meeting of GGOS BPS on Wednesday, April 11, 2018.

### Discussion

The question came up on the IERS representative: as T. Herring is already nominated for IGS, the IERS is being asked to nominate two other representatives.

The IERS CB will send out an email to the DB asking for representatives for the Committee on EGVs.

**New Action Item** #66.05 Send out email to DB asking for representatives for the Committee on EGVs.

### Reports from the Working Groups *IERS Working Group on Site Co-location*

R. Haas reported for S. Bergstrand.

- Conclusions: Systematic technique errors dominate error sources in discrepancies between ties and solution → differences between analytic solutions and local ties are thus primarily indicators of systematic errors of the techniques on the site (annual site surveys not necessary). See also IERS TN 39.
- Recommendations from the UAW: optimize a local network setup for a bundle adjustment based on instrument specification; development of an in situ GNSS antenna calibration method is a high priority.
- VLBI: gravitational deformation: measure as many VLBI antennas as possible to determine their gravitational deformation (A. Nothnagel will provide recommendations). Gravitational deformation of VLBI antennas needs to be taken into account when reducing VLBI observations.

**SINEX format** D. Thaller report: There has been no progress; one topic is loading deformations in SINEX and the question is how to handle long station names in IGS.

**Time Series Format** L. Soudarin reported: no progress in the last time, WG is on stand-by for the two last years, 75% of the work is done, requirements are defined, and two different format have been proposed. The next step is to share the formats within the WG and to evaluate them. L. Soudarin is looking for someone to take over the WG (within the WG).

**Annual Reports** D. Thaller reported that the printed versions have been sent out last week for the AR 2016. The call for the AR 2017 will be sent out after the DB meeting.

**Next DB meeting (#67)** The next DB meeting (half-day meeting) will take place on Saturday, December 8, 2018, before the AGU in Washington.

C. Hackman proposed to ask the DB members and invitees beforehand, whether they have some news to provide and to shorten the agenda appropriately.

**New Action Item** #66.06 Prepare IERS DB meeting No. 67

**Miscellaneous** IDS: new elections in September/October 2018.

**Meeting No. 67** December 8, 2018, Hotel Washington Marriott at Metro Center, 775 12th Street NW, Washington, USA

**Introduction and approval of agenda** Brian Luzum welcomed the guests and the members of the IERS Directing Board. Agenda was accepted as is; no additional comments.

**Changes in IERS Directing Board**

New DB members:

- ILRS representative: Jean-Marie Torre
- Analysis Coordinator (starting with 1 January 2019): Robert Heinkelmann
- Representative of the Conventions Centre (starting with 1 January 2019): Nick Stamatakis

Other changes:

- IERS Representative to the World Data System: Christine Hackman
- IERS Representative to the IAU Comm. A2 OC: Daniela Thaller

**Notes**

The changes in the IERS DB have been announced – no concerns.

Z. Altamimi raised concern regarding IERS nominations to IAG EC – only 2 names; should we have 3? Time to submit names has probably passed.

**Associate Members** The list of Associate Members was reviewed, 4 corrections were proposed.

**IERS Analysis Coordinator: Nomination and election** No changes for election at this time; review ToR during interim and discuss in Vienna in April 2019.

**Current activities at the ITRS  
Combination Centres  
Report from ITRS  
Combination Centre at JPL**

Richard Gross reported on the following activities:

- Correlations in ground deformation (Chin et al.)  
Account for regional correlations in ground deformation caused by large-scale loading processes by including statistics of regional deformation in stochastic model of process. Extending software to allow a full process noise matrix, not just diagonal (Chin et al., GRACE/GRACE-FO STM, GFZ Potsdam, 09–11 October 2018).
- Joint TRF/EOP/CRF determination (Soja et al.)  
SRIF filter to jointly determine TRF/CRF from SLR & VLBI data. Process noise applied to both station positions and radio source coordinates (Soja et al., Wednesday December 12, 13:40–18:00).
- JTRF2014 analysis (Abbondanza et al.)  
Submitted article for IERS TN, Evaluation of JTRF2014 EOPs, Comparison to ITRF2014 & DTRF2014 EOPs, COMB2016, and geophysical models (Abbondanza et al., Thursday, 10:35–10:50).

**Report from ITRS  
Combination Centre at  
DGFI-TUM**

Mathis Bloßfeld presented this report.

**IERS Technical Note on ITRF2014 – TN2**

DGFI-TUM submitted in November two contributions to the IERS CB:

- DTRF2014: DGFI-TUM realization of the International Terrestrial Reference System (ITRS).
- Comparison of the latest ITRS realizations: ITRF2014, JTRF2014 and DTRF2014.
- Three additional contributions from different persons planned + two requested contributions.

**ITRF roadmap**

- Iteration of roadmap with Brian Luzum during the summer.

**ITRF2020 Call for Participation**

Important points for DGFI-TUM in the CfP are:

- ITRS CCs should be free to apply NT-L corrections officially provided by GGFC.
- GGFC models (NT-ATML, NT-OVNL, NT-CWCL) should be consistent to each other.
- IAG services should provide a preliminary list of discontinuities for the CCs.

**LT issue**

G. Johnson stated in his presentation that an improved alignment of measured local ties (LTs) to the current ITRF is necessary. Better transformations from the local horizontal system to the ITRF are required.

LTs with equal vector components (equal length) are not forwarded/reported to the ITRS Center! Is this really true? Identical measured LTs at different epochs will strongly improve the TRF stability!

### ***Report from ITRS Center***

The report was presented by Zuheir Altamimi.

#### **ISO Standard on ITRS**

Complete document is now at the stage of DIS (Draft International Standard), which will be submitted by January 2019. Final Standard publication is expected by April 2020.

#### **Update of Chapter 4 of the IERS Convention**

Terrestrial reference systems and frames to include ITRF2014 information (post-seismic deformation and transformation parameters to past ITRFs). First version circulated among members of ITRS Center for comments. Update in progress will be ready by January 2019.

#### **Activities of UN-GGIM Subcommittee on Geodesy**

Proposal under discussion: adoption of the International Terrestrial Reference System (ITRS) and its numerical realization, the International Terrestrial Reference Frame (ITRF) by the UN-GGIM Committee of Experts as the standard reference for geospatial and scientific positioning applications. France (Z. Altamimi) is chairing the Infrastructure WG.

#### **IERS Technical Notes on ITRF**

3 past Technical Notes published by the ITRS Center:

- TN37: Analysis and results of ITRF2008.
- TN38: Analysis and results of ITRF2014.
- TN39: IGN best practice for surveying instrument reference points at ITRF co-location sites.

TN40: IERS Technical Note on the evaluation of the three solutions: ITRF, DTRF and JTRF:

- Was hoping to be published by the end of the 2017.
- ITRS Center evaluation/contribution is also ready.
- Still waiting for input until a deadline: End of March 2019.

#### **Specific investigations**

Seasonal signals, geocenter motion: evaluate and understand technique differences at co-location sites to provide a coherent annual geocenter motion model compatible with ITRF2014.

Results:

- Large discrepancies of Up annual signals in CM-SLR caused by the co-motion constraints.

- Different estimates of annual geocenter motion for SLR using an uneven network, 8 stations or via multi-technique.

Investigate SLR to VLBI scale offset using new TEST solutions from VLBI (GSFC) and SLR (ASI).

Results:

- Scale offset of the ASI SLR Preliminary solution (with range biases applied following the new bias table) w.r.t. ITRF2014: 0.47ppb. Offset between ASI SLR Preliminary solution and the ILRS solution in ITRF2014: ~1.1 ppb.
  - GSFC VLBI Test solution: ATML does not capture all periodic displacements.

### Roadmap for ITRF2020?

Call for Participation (first draft ready).

### **Error assessment by IERS Analysis Coordinator**

The report was presented by Tom Herring.

#### **Two aspects:**

- Releasing products with realistic standard deviations associated with them: problematic due to correlated noise representation (current values in SINEX files e.g. not even close to realistic). For IVS and ILRS combined SINEX files, variance factors of 50 are needed to generate realistic short period noise estimates. We should be supplying the “best” estimates we can.
- Comparison of VLBI and SLR colocations again looking at scale differences:
  - Colocation sites for time series and scale comparison.
  - 25 VLBI/SLR sites within 10 km of each other. 17 pairs of these have VLBI and SLR velocities standard deviations < 1 mm/yr (3 of these are 1 VLBI with 2 SLR stations).
  - Only 6 pairs have survey ties between the VLBI and SLR sites in the ITRF2014 site-tie files.

Results:

#### *Height differences*

- Mean height difference excluding TIGO/CONZ is 3.9 mm which is equivalent to 0.6 ppb (about half the ITRF2014 value).
- TIGO/CONZ is outlier most likely due to complexity of earthquake processes.

#### *Scale between SLR and VLBI*

Values with  $\sigma < 5$  mm. Mean  $\sigma \sim 2.5$  mm:

- VLBI Mean 0.5 mm RMS 2.8 mm # 2603.
- SLR Mean -3.6 mm RMS 3.0 mm # 969.

There is a drift in the IGS scale for ITRF2014 which was not present for ITRF2008.

#### Where next?

- IERS services to provide realistic variances in their SINEX files?
- Generation and distribution of the “consensus” position time series and EOP estimates in simple ASCII files (for general community) and SINEX (for experts).
- Note the number of interesting phenomena that have been found in GPS time series to that non-expert users can access these results and do their own analyses (although not without some issues about how results are generated).

#### Roadmap for next ITRF generation (ITRF2020)

##### *Presentation by IERS Chair*

The current draft needs to be sent out. Only Zuheir Altamimi expressed an interest in receiving it.

##### *Presentation by ITRS Centre*

The report was presented by Zuheir Altamimi.

#### Recall of the Background/History

- Consultation was sent to the technique ACCs and GGFC on January 24, 2018.
- An inventory (list) of all effects and model updates to be considered by all and individual techniques in the reprocessing effort.
- Questions:
  - Review the list of effects and models.
  - Indicate the time needed for Software update.
  - Indicate the time needed to accomplish the reprocessing of the full history of observations?

#### Current status per Technique Center

- IVS  
General agreement, except HF-EOP model to be recommended by the WG and Atmospheric Loading model (ATML) will be applied. The contribution of the ATML corrections to the right-hand side of the normal equation must be provided in the SINEX, i.e.  $A^T P \cdot (oY_{ATML})$ .

High priority to updating software to apply gravitational deformation.

No major obstacle for reprocessing time line.

- ILRS

Mostly agree on ITRS proposal. Different opinions on some topics, mainly the gravity field model(s). High-frequency EOP: awaiting for a “consensus” model. Will not include a loading model. No model for 3D thermal effects.

No major obstacle for reprocessing time line.

- IDS

Mostly agree on ITRS proposal. High-frequency EOP: awaiting for a “consensus” model. A number of DORIS-specific effects will be addressed.

Reprocessing time line: ITRF2020 is more realistic.

- IGS

Mostly agree on ITRS proposal. Adopt post EGM2008 model: not all ACs are convinced this has a significant impact on GNSS. High-frequency EOP: awaiting for a “consensus” model. Most ACs not in favor of applying a loading model.

Reprocessing time line: 15–17th April 2019 Dedicated AC workshop (after EGU) and start of reprocessing probably June 2019.

### Call for Participation

- Draft circulated among IERS DB Thursday, December 06, 2018.
- List of suitable model updates in the annex of the CfP.
- Comments are welcome until January 10, 2019.
- Final CfP to be sent out by January 10, 2019.

### ITRF2020 Inputs by TCs: specific model updates are strongly requested

- IVS: modeling the gravitational deformation for as many antennas as possible, possibly refine the thermal expansion modeling.
- ILRS: SLR range biases to be estimated/applied.
- IGS: up to date GNSS force models to be used.
- IDS: Improve analysis strategy, DORIS-specific model updates.

### In preparation for ITRF2020, the ITRS Center will:

- Request specific solutions for testing purposes, e.g.
  - SLR range biases estimated.
  - New High-frequency EOP model applied.
  - Others TBD.

**Schedule and time-line**

|                        |                                                                                          |
|------------------------|------------------------------------------------------------------------------------------|
| January 10, 2019       | Dissemination of the Call for Participation                                              |
| February 10, 2021      | Deadline for solution submissions by Technique Centers. Earlier submissions are welcome. |
| April 2021             | First and early results to be shared and discussed with the TCs.                         |
| Until end of May, 2021 | Inter-comparisons of the ITRF CCs solutions.                                             |
| ~June, 2021            | Preliminary ITRF2020 solution available for evaluation by TCs.                           |
| Sep–Oct, 2021          | Final ITRF2020 solution released by the ITRS Center.                                     |

***ITRS CC DGFI-TUM***

The report was presented by Mathis Bloßfeld

**Important points for DGFI-TUM in the CfP:**

- ITRS CCs should be free to apply NT-L corrections officially provided by GGFC.
- GGFC models (NT-ATML, NT-OVNL, NT-CWCL) should be consistent with each other.
- IAG services should provide a preliminary list of discontinuities for the CCs.

***New Action Item***

#67.01 Send out final Call for Participation for ITRF2020.

**IERS Technical Notes related to ITRF2014**

Zuheir Altamimi will send e-mail to CB and DGFI regarding deadline; should there be doi numbers associated with Technical Notes?

***New Action Item***

#67.02 Send out e-mail to CB and DGFI regarding deadline for TN on ITRF2014.

**IERS Conventions**

This report was given by N. Stamatakos.

**Overview of Changes to IERS Conventions Chapters Since IERS DB meeting in Vienna, April 2018**

- No major changes have been made since the last IERS DB meeting in Vienna, April 2018.



- A few changes to the Glossary Section are being implemented regarding definitions of Secular and Mean Pole.
- Those changes will be published soon.
- No major software changes have been implemented.

#### **New Proposed Version Control of Text and Software**

- “Conventions Updates” has been replaced by “Conventions Versions”: each version number lists what was changed, starting version was 1.0.0.
- When clicking on version number (e.g., v1.1.0), a tar ball is downloaded containing all the conventions Chapters and software related to that version.

#### **Status of IERS Conventions Centre re-write staff tentative selections**

- At previous IERS Directing Board (IERS DB) meeting, it was agreed by those participating in the IERS DB meeting that all selections for the IERS Conventions major revision staff should be reviewed by the IERS DB.
- E-mail was sent to all IERS DB members (twice) asking for their review. The list members of the IERS DB was found at <https://www.iers.org/DB>.
- Many members have given their approval/review; no members have had objections as of the writing of this presentation.
- Erricos Pavlis has suggested Sergei Kopeikin, PhD for providing assistance to Chapters 2 and 10.
  - Any additional suggestions by the IERS DB for positions that are vacant are most welcome.
- IERS CC will assume that the review is complete if no objections are raised by the end of the IERS DB meeting on Dec. 8, 2018 (agreement with the selections made and including Sergei Kopeikin to help with the re-write).

#### **Changes in staff positions at the IERS CC**

On January 1, 2019 Mr. Nick Stamatakis will become the Current representative to the IERS Directing Board (as agreed). It had been the tradition that the current representative switch between the French co-chair and the USNO co-chair once every 3 years (French co-chair started on 01 January 2016).

**Sample of Questions Regarding IERS Conventions from Users**

- Jim Williams on 23-SEPT-2018 asked about Section 9.1.2: Johannes Boehm answered on behalf of IERS CC.
- Kaifa Kuang had questions about the validity of FES2004 ocean tide model pertaining to the “Sn0” terms: Florent Lyard answered on behalf of the IERS CC.

**EOP Products**  
**Report from Earth Orientation**  
**Centre**

The report was presented by N. Stamatakos on behalf of C. Bizouard.

**Main changes/novelties since April 2018**

- IDS retreat held at Château de Mons (Caussens), 13–14 June leads us to update the “status” of DORIS pole coordinates series at Earth Orientation Center.
- The DORIS pole coordinates have been tremendously improved.
- On <http://iers.obspm.fr/eop-pc> IDS & INASAN operational solutions are provided for comparison and analysis.
- IDS Combined solution is now included in C04 combination.

**Earth rotation news**

1. The Chandler wobble amplitude decreased down to 40 mas with a tremendous phase change since 2012: situation is similar to the period 1925–1930.
2. The Earth rotation has strongly accelerated since 2016.

**Status of 14 C04 Update April 2018**

- Updates listed at: <http://hpiers.obspm.fr/iers/eop/eopc04/update/C04.txt>.
- Last update: April 16, 2018 according to the decision of IERS DB 66 (April 8, 2018 in Vienna): 14 C04 solution for UT1 has been modified by including the contribution of UT1 Intensives back to 1996 (see note of January 2018). Old version updated until 2018/04/16 is put in the sub-directory /eopc04.2017.
- Update essentially under-weighted R1 and R4 24-hour VLBI relative to intensives. A correction was applied to fix that issue in August 2018.

**Report from Rapid Service /**  
**Prediction Centre**

C. Hackman presented the following report.

**2017 Daily Product Accuracy**

- 2017 (est/1-d pred): PM ( $\mu$ as): 73/304; UT1 ( $\mu$ s): 63/88
- 2014 best; 2016 had UT1 probs (UTGPS)

- 2017 changes: UTGPS de-weighted 29.03.2017; Aligned to ITRF2014
- 2017 outcomes: UT1 better than '16; PM worse than '16; Still chasing 2014
- 2017 factors: Compared to C04; aligned to ITRF; two  $\sim 650 \mu as$  residuals included in PM-X, PM-Y

#### **Optimization/modernization of combination/prediction algorithm**

- Current algorithm has known problems.
- 2018: preliminary research on optimizing estimation scheme.
- Code-optimization effort is now a funded research program (Financial Years 2019–2023)
  - Examining normal-equation-based optimal estimation strategies (e.g., Kalman filter) for solving the combination solution.
  - May examine using some kind of VLBA/IVS solution (Mk-Wz) for coverage when Ishioka plans to go down.
  - Hiring of contract support underway; expected to begin early Calendar Year 2019.

#### **IERS RS/PC product changes 29 Mar 2018**

- Products now aligned to 2014 C04 (was ITRF 2014).
- Implements IERS 2010 Conventions dX/dY CPO paradigm.

#### **Transitioning to new email system handling RS/PC, Bulletin A operations**

- Bulletin A delivery, bounce-backs.
- User questions/issues/requests.
- Will be from mail.mil domain.
- Transition expected Fall 2018.
- Will notify users via IERS Message, Bulletin A, other means.

#### **Working Group on “IERS Product Distribution”**

Tom Herring presented the report.

- Working group still to be formed. WG should probably be made up of Analysis Coordinators of each service component and data centers.
- Highest priority: FTP access to products will almost certainly go away due to security issues with FTP. CDDIS has already stopped

for product uploads (curl replacement); Mac no longer includes FTP in OS distributions.

- HTTPS is likely replacement which would keep similar functionality as now (use curl or wget to access). Users will need to be informed and educated.
- Implementation of web services: similar to above but products delivery can more tailored to users requirements.
- WG should address both of these issues.
- Additional item: encourage IERS services to make more results available for ease of use by community. Specifically, position time series and even EOPs of some services (see for example, University of Nevada, JPL, UNAVCO, MIT for GPS position time series as ASCII files that users can analyze.) Less code needed than for SINEX files.

**New Action Item** #67.03 Notify users about then new e-mail system via IERS Message.

**Reports from Technique  
Centers  
IDS Report**

The report was presented by Hugues Capdeville.

**DORIS Constellation Status**

- Current Missions: Sentinel-3B and -3A, Jason-3 and -2, SARAL, HY-2A, Cryosat2.
- Future Missions: Sentinel-3C and -3D, HY-2C and -2D, Jason-CS1+CSB, SWOT (, MOBILE).

**Current DORIS tracking network**

- 3 generations of beacons have been developed; third-generation beacon implemented everywhere since 2010 (improve measurements accuracy). Today, about 25% of the network has Starec C antennas.
- Planned network maintenance (2019): restarting at Santa-Cruz, Ecuador; reconnaissance in Iceland with the view to relocate the station; relocation at Easter Island, Chile; 4th generation beacon deployment from mid-2019.
- 4th generation beacon: up-to-date electronic components: to be operational up to 2033; deployment will start in mid-2019.
- New stations in Guam (MILAC, Mangilao) and San Juan (SJUC, Argentina). Relocated station Rothera, Antarctica and Ny-Ålesund, Svalbard. Restarted stations in Rio Grande, Argentina and Mahé, Seychelles. Station Badary, Russia shut down for indefinite period.

**Analysis Update*****Routine Processing***

- Six DORIS Analysis Centers (ESA, GOP, GSC, IGN, INA, GRG) routinely process data.
- The processing of the 3rd quarter of 2018 is underway by the IDS Combination Center.
- IDS Combination through the end of 2nd quarter 2018 is available:  
[https://cddis.gsfc.nasa.gov/pub/doris/products/sinex\\_series/idswd](https://cddis.gsfc.nasa.gov/pub/doris/products/sinex_series/idswd)  
[https://doris.ensg.eu/pub/doris/products/sinex\\_series/idswd](https://doris.ensg.eu/pub/doris/products/sinex_series/idswd)
- DPOD2014 v3 is available. (DORIS extension to ITRF2014 for Precise Orbit Determination). <https://cddis.gsfc.nasa.gov/pub/doris/products/dpod/> <https://doris.ensg.eu/pub/doris/products/dpod/>  
 See also: Moreaux, G., Willis, P., Lemoine, F.G., Zelensky, N.P., Couhert, A., Ait Lakbir, H., Ferrage, P., 2018. “DPOD2014: a new DORIS extension of ITRF2014 for Precise Orbit Determination”, Adv. Space Res., 63(1), 118–138, doi:10.1016/j.asr.2018.08.043.

***Work in progress***

- Implement DORIS/RINEX data processing by all ACs.
- Introduce Jason-3 and Sentinel-3A in the IDS combined solution for All ACs.
- Verify that all ACs can reprocess 2012 data to eliminate scale anomaly.
- Mitigate the SAA effect on Jason-2 and Jason-3 USOs.

***Continuing work***

- Implement and validate the new standards/models recommended by the IDS/IERS.

***How DORIS can Contribute to Future Realizations of the ITRF Origin***

See also: Couhert, A., Mercier, F., Moyard, J., Biancale, R., 2018. “Systematic error mitigation in DORIS- derived geocenter motion”, J. Geophysical Research: Solid Earth, 123(11), 10,142–10,161, doi: 10.1029/2018JB015453.)

- “Cookbook” for obtaining independent DORIS-based geocenter time series: Sun-synchronous satellites should be disregarded ( $\beta' \approx 365$  days) and vertical site displacement should be estimated.

**IDS News**

IDS Meetings in 2018:

- IDS AWG June 11–12, 2018, Toulouse, France.
- IDS Retreat June 13–14, 2018, Château de Mons, France.
- IDS Workshop September 24–29, 2018, Ponta Delgada, Portugal.

#### IDS Working Groups:

- WG “Near-real time data”, Chair: Denise Dettmering (DGFI/TUM).  
Delivery of NRT for use in Ionosphere models.
- IDS GB is evaluating formation of another WG on the Geocenter where non-IDS participation would be encouraged.

IDS Newsletter published ~2 times per year.

#### IDS Elections:

- Two positions to be renewed within the Governing Board for the term 2019–2022: Analysis Coordinator (1 candidate team) and Member-at-large (4 candidates). 2019: start of 4-yr term.

**IGS Report** Rolf Dach presented the report.

#### Recent IGS workshop in Wuhan:

- Location made it a challenging environment for splinter meetings.
- Returning to two-year IGS Workshop schedule.

#### Future workshop

- Boulder, CO, USA in 2020.

#### Recent activities

- Working on incorporating Galileo (calibration, etc.).
- GFZ will make multi-GNSS product generation.
- IGS elections: new vice-chair position.

**ILRS Report** Erricos Pavlis presented the report.

#### ILRS Status and Activities

- Governing Board Elections for the 18 elected members completed; Prof. Toshimichi Otsubo of Hitotsubashi University, Tokyo, Japan elected as the new GB Chair.
- Infrastructure: updated formats for Data (CRD) and Tracking Predictions (CPF), web-based station site log archive and maintenance; Harmonized data screening & QC between EDC and NASA OCs.

- Routine submission of all full-rate data to OCs and DCs from 32 out of the currently active stations (39).
- Stations asked to provide additional resolution in their epoch recording precision of their data ( $< 1$  ns).
- Implementing new strategies to “rate” station performance underscoring value to the users and science products; list of satellites on ILRS tracking roster continues to grow ( $>100$ ).
- ILRS sets tracking priorities to balance requests and maximize the utility of the network.
- Increased scrutiny in selecting new missions to track.
- Discussions with the IGS and the ICG on tracking GNSS s/c.
- Issues: Network gaps in Latin America, Africa, and Oceania, and mix of new and old technologies are the primary issues of concern now.

#### **ILRS Network Status**

- BKG AGGO in setup in La Plata Observatory (Argentina).
- New stations underway:
  - Russia: Ensenada (Mexico), Java (Indonesia), and Gran Canaria (Spain).
  - NASA/NASA affiliated: McDonald, Haleakala (USA), and Ny-Ålesund (Norway).
  - Others: Metsahovi (Finland), Mt. Abu and Ponmudi (India), and Yebes (Spain).
- Upgrades underway at some stations.
- First co-locations in Russian and NASA SLR laser systems established at Hartebeesthoek, South Africa; two Russian SLR at Mendeleevo.

#### **ILRS Network Productivity (All targets)**

- About 16 (out of 39) stations are responsible for ~80% of the observed passes on all satellites (wide divergence in station performance).

#### **Mission News & Support**

- Network routinely tracked 100+ satellites in 2018.
- New, approved missions in 2018: S-NET, Sentinel-3B, GRACE-FO, Tiangong-2, Beidou-3M, PAZ, ICESat- 2, Astrocast Precursor, GNSS.

- Future missions: Additional GNSS: BeiDou/Compass, Galileo, etc.; LightSail-2, COSMIC-2, HY-2C, SWOT, NISAR.

### **ILRS ASC – Analysis Activities**

- Preparations for contributing to the development of ITRF2020.
- New operational approach in handling error sources was adopted at the last ASC meeting: estimation of systematic errors simultaneously with all other parameters (eliminate biases in station positions/velocities); correction of identified serious shortcomings in the current model for the target signature (“CoM correction” can affect the SLR-VLBI scale difference at the 0.25 ppb level); Adoption of new CoM model (early results to be presented at the 2019 EGU).
- SSEM PP resulted in significant change in the SLR scale (much closer to VLBI network scale now).
- SSEM Pilot Project on station systematics completed the next phase (awaiting final submission from DGFI (end of 2018) to complete the combination product).
- Result will be used as basis for the development of the ILRS product for ITRF2020 contribution.
- Time Biases estimation/handling added: Time biases now modelled based on T2L2 results; Additional time biases from T2L2 results for 2017 expected soon.
- RB & TB values &  $\sigma$  applied to each station included in SINEX file for next contribution to ITRF
- New QC products related to near real-time system evaluation (available online) and presented at the recent 21st IWLR in Canberra, Australia.
- Next PP will deliver low-degree gravity coefficients as a weekly product and introduce LARES as a 5th target for ITRF product support (by EGU 2019).

### **Special Issue of the Journal of Geodesy**

- 10 articles accepted, 8 additional articles still under review.

### **Recent & Future Meetings Schedule**

- 21<sup>st</sup> International Workshop on Laser Ranging (IWLR) November 4–9, 2018 in Canberra, Australia.
- ASC meeting on Sunday, Nov. 3, 2018.



- Technical Workshop in late 2019, candidate sites Stuttgart, Germany and Arequipa, Peru (no decision yet).
- 22<sup>nd</sup> International Workshop on Laser Ranging will be held in Kunming, PRC, in 2020 (date TBD).

**IVS Report** John Gipson presented the report.

#### **CONT17**

- 2 legacy and 1 VGOS network
- Data correlated and released
- Analysis ongoing
- Indications that legacy-1 with VLBA + IVS gave superior results

⇒ in 2019 RDV sessions with VLBA in parallel to R1

#### **VGOS development**

- In 2018: VT-sessions every 2nd week.
- Up to 7 station network.
- Data correlated at Haystack.
- VT-sessions will continue with this setup at least to April 2019.
- VGOS correlation cookbook pre-released.
- VGOS-correlation workshop in May 2019 at Haystack.

#### **IVS DB elections**

- Elections November 2018. New members:
  - Hayo Hase (BKG, La Plata)
  - James Anderson (GFZ Potsdam)
  - Chet Ruszczyk (MIT/Haystack)
  - Laura la Porta (Bonn correlator)

#### **Office for Outreach and Communication (OOC)**

- Call for Proposals: discussed at DB meeting in Longyearbyen in June 2018.
- Call distributed on July 9 with deadline for August 31.
- Successful proposal: MIT Haystack Observatory with Lead: Nancy W. Kotary.
- Implications: Extension of Directing Board. Change of IVS Terms of Reference to include the OOC.

- Tasks: attractive Web presence, outreach activities to other organizations, flyers and info material for colleagues, political decision makers and general public.

### VLBI meetings

#### *Past meetings:*

- 10<sup>th</sup> IVS GM June 2018 in Longyearbyen, Svalbard, Norway.

#### *Future meetings:*

- 24<sup>th</sup> EVGA March 2019 in Las Palmas, Gran Canaria, Spain.
- TOW May 2019 in Haystack, USA.
- 11<sup>th</sup> IVS GM March 2020 in Annapolis, USA.

**IAU Report** Richard Gross presented the report.

Two resolutions – resolution B1 on ITRF and resolution B2 on ICRF – adopted at IAU General Assembly which took place on August 20–31, 2018 in Vienna, Austria.

IAU members voted to recommend renaming the Hubble law as the Hubble-Lemaître law. A new IAU representative to IERS needs to be named.

Commission 19/A2 centennial will be celebrated at Journées 2019 (07–09 October 2019) in Paris, France.

**ICRS/ICRF report** Brian Dorland presented the report.

### ICRF3 Status

- ICRF3 released in 2018.
- Endorsed by IERS DB.
- Approved by IAU for adoption. Date of adoption: January 1, 2019.
- Key accomplishments:
  - Multi-wavelength (S/X, K, X/Ka).
  - Majority of sources much more accurate (factors of 3x+ improvement).
  - Approximately 30% more sources.
  - Available now via IERS ICRS Centre website.

### Post-adoption plans

- Maintain ICRF3 with additional observations.
- Begin planning/discussion regarding integration of radio reference frame (ICRF3-based) with optical reference frame (Gaia-based).
- Comments

- Communication issues arose over the last six months between ICRF and possible “endorsing organizations” such as the IERS.
- These organizations might want to consider appointing official liaisons to the ICRF3 WG follow-on to represent the organization’s equities in the maintenance and development of the reference frame.

### Possible IAU Symposium

- USNO and Paris Observatory (jointly, the IERS ICRS Centre) are planning on proposing a 2020 symposium to the IAU with the title: “Active Galactic Nuclei and the Celestial Reference Frame (AGNCRF)”.
- Motivation: Bring together AGN researchers with CRF researchers to communicate/coordinate/collaborate on AGN observations and research, benefitting both disciplines.
- Venue: Observatoire de Meudon (outside of Paris).
- Request: IERS DB/Chair endorsement (part of IAU proposal package).

An IERS representative to the next WG is needed; requesting letter of support for proposed IAU symposium.

**GGOS report** Richard Gross presented the report.

### Personal changes

- Coordinating Office
  - Director of Coordinating Office Matthias Madzak resigned on October 31, 2018. Acting Director of Coordinating Office is Martin Sehnal.
  - Host of Coordinating Office is the Bundesamt für Eich- und Vermessungswesen (BEV), which is in process of finding permanent replacement.
- GGOS Focus Area on Sea Level
  - Lead of Focus Area Tilo Schöne resigned effective September 30, 2018.
  - Currently discussing options for continuation. Continue current focus, liaise with sea level community and redirect focus.

### GGOS Affiliate

- National or regional organization that coordinates space-geodetic activities there.

- Established to increase participation in GGOS, particularly from under-represented areas like Africa, Asia, South and Central America.
- A component of GGOS with one representative each to Consortium and collectively two representatives to Coordinating Board.
- First GGOS Affiliate is the GGOS Working Group of Japan (established in 2013): provides a forum for multi-technique, space-geodetic discussions within Japan.
- Encourage others to become GGOS Affiliates.

### **Essential Geodetic Variables**

- Observed variables are crucial to characterizing geodetic properties of Earth and key to sustainable geodetic observations (positions of reference objects (ground stations, radio sources), EOPs, Gravity measurements (ground-based, space-based))
- Assign requirements to each EGV like accuracy, spatial and temporal resolution, latency, stability, ...
- Derive requirements on EGV-dependent products (TRF, CRF, ...) and on infrastructure (observing systems)
- Can be used to update GGOS2020 book following a bottom-up approach to deriving requirements
- Established Committee within GGOS BPS to create list of EGVs, assign requirements to them, etc. The Committee includes representatives of IAG Services, Commissions, Intercommission Committees, GGOS Focus Areas.

### **DOIs for Geodetic Data**

- Digital Object Identifiers (DOIs) for publications widely used by publishers and a unique identifier of publication. The DOI system is managed by International DOI Foundation (IDF).
- DOIs for data sets benefits users and benefits data providers.
- Registration agency manages DOI to URL mapping and develops registration server to share among data providers.
- Granularity of DOI assignment: one data set = one DOI, even if data set is updated. Example: IVS contribution to ITRF2014 (data set does not change). Example: IGS Final combined EOPs (data set changes, but not file name).
- Establish Working Group with representatives of the Services and data centers, and establish procedures for assigning DOIs to geodetic data sets.

**Meetings**

GGOS Days 2018 at GSI Headquarters from October 02 to 05, 2018 in Tsukuba, Japan.

***Other Meetings:***

- European Geosciences Union in Vienna, Austria; April 08–13, 2018.
- Japan Geoscience Union in Chiba, Japan; May 20–24, 2018.
- ISC WDS International Program Office – NICT in Koganei, Tokyo, Japan; October 01, 2018.
- American Geophysical Union in Washington, DC; December 10–14, 2018.

***Future Meetings:***

- European Geosciences Union in Vienna, Austria; April 07–12, 2019.
- International Union of Geodesy and Geophysics in Montreal, Canada; July 08–18, 2019.
- GGOS Days / SIRGAS in Rio de Janeiro, Brazil; November 11–14, 2019.
- American Geophysical Union in San Francisco, CA; December 09–13, 2019.

***Unified Analysis Workshop 2019:***

- Venue (tentative): GFZ Potsdam August 13–15, 2019.
- Program (tentative): Topics specific to each technique, e.g. systematic errors and biases in each technique, and Topics common to all techniques, e.g. Reference systems and frames (including preparation for ITRF2020), site surveys, co-location of techniques (including with gravity, unified height system), standards, conventions and formats, Digital Object Identifiers (DOIs) for geodetic data sets.
- Attendance by invitation, 5–6 representatives from each Service.

**Annual Reports**

B. Luzum reported: The last contribution to the Annual Report 2017 will be submitted by 9 December. All other 20 contributions have been submitted, edited and formatted; most of them are finally ready. The Annual Report 2017 will be published online not later than on 17 December.

*Daniela Thaller, Sabine Bachmann, Wolfgang R. Dick*