3 Reports of IERS components

3.1 Directing Board

The IERS Directing Board (DB) met twice in the course of the year 2019. Summaries of these meetings are given below.

Meeting No. 68

April 07, 2019, 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. There were no additional comments.

IERS Technical Notes on ITRF2014

Technical Note 2: ITRF-CCs, Input and evaluation by the Technique Services and others; agreement on editors of IERS Technical Note No. 40: on the evaluation of the three solutions: ITRF, DTRF and JTRF

- 4 contributions so far received at ITRS CC
- A final deadline: End of March 2019 is now passed.
- Proposal: Publication with received contributions after the EGU

Technical Note 3: C04 series aligned to ITRF2014 (replaces TN planned for 08 C04 series)

- No news. Paper on 14C04 was published in the Journal of Geodesy.

Decisions

Z. Altamimi will send the contributions that he received to the IERS CB.
A joint editing by IERS CB and Z. Altamimi was agreed.
Include a ist all the authors that contributed to the TN.
DGFI: send contributions to Z. Altamimi.
Update in two months.

New Action Items

#68.01 Provide (hidden) directory to collect the contributions to the Technical Notes.
#68.02 Provide LaTex template for IERS Technical Notes.
#68.03 Update the metadata reference on the website.
#68.04 Update the text file of C04 on the ftp server.

Current activities at the ITRS Combination Centers

Report from ITRS Combination Centre at JPL

The report from IDS was given by Richard Gross.

SREF development (Chin et al.)

- Status
  - Time variable, square-root information filter with full process noise matrix
  - Optionally estimates radio source positions for joint TRF/EOP/CRF determination
  - TRF and joint TRF/EOP/CRF test solutions being analyzed
- Plans
  - Reproduce JTRF2014 with SREF
  - Include EOP dynamics, postseismic displacement model
  - Will use SREF to determine JTRF2020

Joint TRF/EOP/CRF determination (Soja et al.)

- Using SREF to jointly determine TRF/EOP/CRF
  - Geodesy Division Outstanding Early Career Scientist Award Lecture by B. Soja: Chasing Consistency: Joint Determination of Terrestrial and Celestial Reference Frames (Session G2.6, Tuesday April 9, 15:30–15:45, Room D2)

JTRF2014 analysis (Abbondanza et al.)

- Submitted article to Comptes Rendus Geoscience
  - A Sequential Estimation Approach to Terrestrial Reference Frame Determination by Abbondanza, C., T. M. Chin, R. S. Gross, M. B. Heflin, J. W. Parker, B. S. Soja, and X. Wu
  - Invited for special issue on Space-Time Reference Frames
  - Reviews JPL's approach to determining TRFs, comparing it to other approaches

Report from ITRS Combination Centre at DGFI-TUM

The report from IDS was given by D. Angermann.

Publications on the ITRS realizations 2014

- IERS Technical Note on ITRF2014 – TN2:
  - DGFI-TUM submitted in November two contributions to the IERS CB: (1) DTRF2014: DGFI-TUM realization of the International Terrestrial Reference System (ITRS) and (2) Comparison of the latest ITRS realizations: ITRF2014, JTRF2014 and DTRF2014
- Contributions to TN2 already submitted:
  - JPL already submitted a paper on the JTRF2014 solution

  - Moreaux G. et al: A comparison of the DTRF2014, ITRF2014, and JTRF2014 solutions using DORIS
  - Rodriguez J.: comparison of ITRF2014 and DTRF2014 based on SLR
- Paper on DTRF2014 (Seitz et al., 2019?): DTRF2014: The new ITRS realization of DGFI-TUM considering non-tidal station loading
  - Is close to be submitted to JoG
  - New computation strategy: consideration of non-tidal loading models
  - Extended solution:
  - DTRF2014 solution (SINEX)
    * non-tidal loading corrections per station (time series)
    * time series of translations
    * station position residual time series
    * allows for a reconstruction of the real station positions

→ All publications on the realizations and their validation should be published soon to make it possible to discuss and if necessary further study important outcomes before ITRS2020 realization.

Effect of non-tidal loading on ITRS realizations

- Atmospheric and hydrological loading model corrections already applied for DTRF2014 (model data provided by Tonie van Dam)
  - Applied on NEQ level
  - Effect of NT-L loading corrections on TRF solutions analyzed for DTRF2014 and for IVS contribution of DGFI-TUM IVS AC:
    * Improvement of standard deviations
    * Improvement of WRMS of station position and datum parameter time series
    * Improvement of the accuracy of the estimated positions and velocities in case of short observation time spans
    * Large effect on datum parameter time series: annual signals disappear.
- Improvements due to NT-load:
  - Standard deviations (ITPI decreases)
  - WRMS of station position and datum parameter time series
  - Accuracy of position and velocity in case of short observation time spans
  - Datum parameter time series: annual signals disappear

  - Additional investigations on the gravitational effect on the SLR satellites lead also to a slight improvement of SLR solution

→ It is recommended to consider NT-loading on observation level for future ITRF solutions

Tidal frequencies in LOD and ∆UT1 series

- Difference time series w.r.t. IERS 14 C04:
  - GNSS and SLR also show periodic signals w.r.t. IERS 08 C04, but Ampl < 9 μs
  - DTRF2014 LOD: Ampl = 3 μs

→ The systematics are relevant w.r.t. the combination of the EOP (all IERS EOP products) and w.r.t. the consistent realization of CRF, TRF and EOP. This should be clarified in preparation of ITRF2020!

Local tie re-measurements

- Started to be discussed during the last IERS Directing Board meeting
  - Local ties with equal vector components (equal length) are not forwarded/reported to the ITRS Centre?
  - Identically measured Local ties at different epochs also strongly improve the TRF stability!
  - Could we get significantly more Local tie measurements for ITRF2020?

DOGS software development

- Software unification and extension
  - A new format was developed for observation equations, normal equations and solutions, which allows for:
    * a higher temporal resolution of parameters
    * the entrainment of metadata from input SINEX file → DOGS-CS → SINEX file of the combined solution

→ full SINEX file can be directly written from DOGS-CS without any additional files

Discussion

- Tidal frequencies in LOD and dUT1 → problem in C04 series? No systematics in JPL solution
- ITRF2020: consistency of models; local tie issue AI: ZA: CfP via IERS Message addressing also local ties at co-location sites (stations should send updated local tie measurements)
- DOGS software development

Report from ITRS Center The report was given by Zuheir Altamimi.

Status ISO Standard on ITRS

- After the release of the draft document at the stage of DIS (Draft International Standard), and vote by ISO member countries:
  - P-members in favour: 25 (5 with comments)
  - P-members voting against: 0
  - P-members abstaining: 11
- The DIS ballot stage started on March 26 & will end June 18, 2019.
  - All certification organizations are invited to vote and/or formulate comments on the Draft Document.

Update of Chapter 4 of the IERS Conventions

- Update of Chapter 4: Terrestrial reference systems and frames
  - Include ITRF2014 information
    - Post-Seismic Deformation
    - Transformation parameters ITRF2014 $\rightarrow$ Past ITRFs
  - First version submitted to the CC on Feb 08, 2019
  - Review by D. McCarthy received on Feb 21
  - Revised version submitted Feb 28, 2019
  - Published at the IERS Conventions website: April 1

Activities of UN-GGIM Subcommittee on Geodesy

- Proposal under discussion: Adoption of the ITRS and its numerical realization, the 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:
    - Review the membership & add other experts
    - Review the list of actions following the recommendations of the GA resolution & roadmap
    - Will ask the UN-GGIM Committee of Experts to provide feedback on GGRF recommendations
    - Articulate the Infrastructure needs in terms of attributes of a governance mechanism
    - Will solicit the Techniques to establish a list of urgent needs for Core sites
- TN40: IERS Technical Note on the evaluation of the three solutions: ITRF, DTRF and JTRF $\rightarrow$ see (TOP 2).

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

Revisit the scale offset between SLR & VLBI

Roadmap for ITRF2020?

- Call for Participation posted at the ITRF Website

Specific investigations in preparation for ITRF2020:

- seasonal signal & geocenter motion; investigate VLBI and SLR test solution

Discussion

- Re-establish a Working Group on Geocenter motion (as WG IERS and IAG Comm. 1)? No objections from the IERS DB.
- Input test solution GSFC VLBI (session-wise) vs ASI SLR (weekly)

Decisions Re-establish Working Group on Geocenter motion in conjunction with IAG Commission 1 (after new IAG structure has been established)

New Action Items #68.05 Send out a CfP via IERS Message addressing local ties at co-location sites (stations should send updated local tie measurements). #68.06 Send out message to ask for contributions/volunteers to chair the WG on Geocenter motion (after re-organization).

Reports from the Technique Centers

IDS Report

The report from IDS was given by Hugues Capdeville.

DORIS constellation status (current and future missions)

- current missions (Sentinal-3A and 3B, Jason-2 and 3, SARAL, HY-2A, Cryosat2)
- 7 future missions (Sentinel-3C and 3D, HY-2C and 2D, Jason-CSA and CSB, SWOT

Network operational status

- 60 permanent stations of which: 9 beacons are out of order and 3 are decommissioned, 48 co-locations out of 59 DORIS sites.

Tie vectors available at: ftp://ftp.ids-doris.org/pub/ids/stations/DORIS_ext_ties.txt

Network evolution

- 2 stations pending replacement: Yuzhno-Sakhalinsk, Russia; Port-Moresby, Papua New Guinea; 3 ongoing projects (in order of progress): Changchun (China); Easter (Chile); Katherine (Australia)

IDS reprocessing for next ITRF

- Adopt and evaluate the new standards/models recommended by IERS
  - Implement new linear mean pole model
  - Implement HF (diurnal-subdiurnal) tidal EOP model recommended by IERS after evaluation by the IERS working group lead by J. Gipson
  - Adopt Time-Variable Gravity (TVG) model based on GRACE data + GOCE data + SLR data coherent with new mean pole convention (C(2,1) / S(2,1) coefficients) new EIGEN-GRGS.RL04.MEAN-FIELD is available for download: https://grace.obs-mip.fr/variable-models-grace-lageos/mean-fields/release-04/
  - Ocean tide model: FES2014-c soon available on AVISO website
  - Others models/standards from IERS?
- Implement RINEX DORIS processing (crucial topic to take into account the DORIS data of the latest satellites Jason-3, Sentinel-3A and Sentinel-3B
  - Necessary to use the same format for the same satellite
- Modelling improvement
- Attempt to mitigate the non-conservative force model error on satellites (draconitic signals): use quaternions when available, SRP coefficients and macromodels
- South Atlantic Anomaly compensation $\rightarrow$ mitigate the SAA effect on DORIS USOs for Spot-5 and Jason series
- Scale, elevation cut off and data downweighting
  - For all IDS ACs: adopt the same elevation cut-off and downweighting law for low elevation data?
- Preparation of individual ACs

  - Analysis Coordinators will send to ACs a roadmap to follow in preparation for the next ITRF reprocessing. From April to the next AWG scheduled end Sept. 2019, ACs will work on the 5 topics presented above. During the first day of the AWG: presentation and discussion on the tests done by ACs and the CC. During the second day: final definition of the IDS processing configuration. After this AWG: ACs could start the IDS reprocessing for the ITRF.

- IDS reprocessing
  - We could divide the IDS reprocessing in 4 periods: [1992-2001], +sp5 +env +ja1 [2002-2008], +ja2 [2008-2015], +ja3 +s3a +s3b [2016-2020]
  - ACs could start their reprocessing end 2019 for the first period [1992-2001]
  - IDS Combination Center could start its combination of the first period at the beginning of the year 2020.
  - IDS ACs could continue at the beginning of year 2020 their reprocessing with the second period and provide their solution to IDS CC, ...
  - IDS CC propose to deliver to IERS the final SINEX (until 2020) in February–March 2020.

IDS News

- Passing of Richard Biancale: a tribute to Richard in IDS Newsletter #6
- IDS Newsletter #6 (February 2019)
- IDS Meetings in 2019: IDS AWG April, 2019 at DGFI, Munich; next IDS AWG 30 Sept. – 1 Oct., 2019 at CNES, Paris (TBC)
- IDS Elections: Two positions renewed within the Governing Board for the term, 2019–2022: Analysis Coordinator: New tandem: Hugues Capdeville (CLS, France) & Petr Stepanek (GOP, Czech Republic); Member-at-large: Claudio Abbondanza (NASA, US) succeeds to Marek Ziebart (UCL, UK)

Discussion:

- Gravity field model (#4) vs. ILRS field gravity model #6: discuss within IDS rather to use the same model as the ILRS does or/and to specify the differences between the two versions.

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

Governing Board

- New vice-chair Felix Perosanz from CNES (who will become chair afterwards), Gary Johnston elected for two more years as chair.

Three complete constellations

- 24 active satellites, Beidou: 3 satellites in space, only one year the data receivable
- Multi-GNSS data files available

IGS AC workshop in 2 weeks in Potsdam with the following topics:

- orbit modelling
- taken for lower satellites for DORIS and SLR (tbd)
- Inclusion of Galileo in re-processing and/or legacy products: not decided yet, but progress is on the way (deficiencies with E5 antenna calibration).
- Antenna calibration: the IGS WG is co-operating with Bonn for chamber calibrations; also geo++ made a presentation on robot calibration.

Galileo

- Fully calibrated satellites and receivers, which will allow to contribute to the scale.

Next IGS workshop will be held in Boulder, USA, on August 12–16, 2020.
Start reprocessing for ITRF2020 this summer.

Discussion

- Ask John Gipson when the high-frequency pole model will be available (agreed that no empirical model) $\rightarrow$ decide on the model.

Questions:

- Nick Stamatakos: Does the model need to go through the IERS Conventions Center?
  Answer: Decide after decision on the model.

ILRS Report The report from ILRS was given by Erricos Pavlis.

ILRS status and activities

- Governing Board Elections for the 18 elected members were completed; and two additional members will be appointed by the new GB: Ulrich Schreiber and Krzysztof Sośnica
- Infrastructure
  - Testing new formats for Data (CRD) and Tracking Predictions (CPF)
  - Web-based station site log archive and maintenance operational
  - Harmonized data screening & QC between EDC and NASA Operations Centers (OCs) is ongoing
- Routine submission of all full-rate data to OCs and DCs from 32 out of the currently active stations (39). We continue to press the rest to confirm ASAP.
- Etalon Campaign Project: dedicated tracking campaign for Etalon 1 & 2 in progress (February 15 to May 15):

  https://ilrs.cddis.eosdis.nasa.gov/science/awg/awgActivities/trackingEtalon1_and_2_Feb2019.html

- Increased scrutiny in selecting new missions to track
- Discussions with the IGS and the ICG on tracking GNSS s/c: meeting with stakeholders on Monday afternoon 3:00-5:30 (TUW)
- Issues:
  - Network gaps in Latin America, Africa, and Oceania, and mix of new and old technologies are the primary issues of concern now
- Site log update lapses cause trouble with analysis/products; delinquent sites/agencies are reminded often

ILRS Network Status

- BKG AGGO setup at La Plata Observatory (Argentina)
- New stations underway:
  - Russia: Ensenada (Mexico), Java (Indonesia), Gran Canaria (Spain)
  - NASA/NASA affiliated: McDonald, Haleakala (USA), and Ny-Ålesund (NMA, Norway)
  - Others: Metsahovi (Finland), Mt. Abu and Ponmundi (India), and Yebes (Spain)

- Upgrades underway at some stations
- First co-locations of Russia and NASA SLR laser systems established at Hartebeesthoek (South Africa); Two Russian SLR at Mendeleevo

Mission News & Support

- Network routinely tracked 100+ satellites in 2018
- New, approved missions included: 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, GY-2C, SWOT, NISAR

ILRS ASC – Analysis Activities

- Preparations for contributing to the development of ITRF2020 are on schedule.
- New operational approach in handling error sources was adopted at the last ASC meeting (Canberra, November 2018):
  - Allowance for estimation of systematic errors simultaneously with all other parameters to eliminate biases in station positions/velocities (in progress)
  - Correction of identified serious shortcomings in the current model for the target signature (also known as “CoM correction”) for all types of ground systems (implemented)
  - Correction of such errors alone can affect the SLR-VLBI scale difference at the 0.25 ppb level.
  - Adopted the new CoM model which was recently released (November 2018) by NSGF, (implemented)
  - SSEM Pilot Project on station systematics completed the next phase and we are awaiting the final submission from all ACs to complete the combination product and the tabular form of the new model
  - The result will be used as the basis for the development of the ILRS product that will be contributed to ITRF2020.
  - We have added estimation/handling of Time Biases:
    * Time biases are now modeled based on T2L2 results.
    * Additional time biases from T2L2 until the end of 2017 were added.

  - We will include applied RB & TB in SINEX file for next contribution to ITRF with their constraint information in each SINEX combined product.
    * The SINEX will contain the RB & TB values & σ applied to each station and the applied CoM offsets for that weekly product.
  - Next PP will deliver low-degree gravity coefficients as a weekly product and introduce LARES as a 5th target for ITRF product support (by end of 2019).

Status of Special Issue of the Journal of Geodesy

- 12 articles accepted and 12 additional articles currently under review

Recent & Future Meetings Schedule

- The 21st International Workshop on Laser Ranging (IWLR) was hosted by SERC in Canberra, Australia from November 4 to 9, 2018. The ASC meeting was held on Sunday, Nov. 3, 2018. Website of 21st IWLR: http://www.iwlr2018.serc.org.au. Abstracts, Presentations and Papers are available from the CDDIS-based site: https://cddis.nasa.gov/lw21.
- A Technical Workshop will take place in Stuttgart, Germany: 21–25 October 2019, “Laser ranging: To improve economy, performance, and adoption for new applications”.
- The 22nd International Workshop on Laser Ranging will be held in Kunming, PRC (date TBD in 2020).

Discussion

- ITRF2020 preparation will start by end of the year 2019 (high-frequency model needs to be available; after finishing the Etalon project).

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

Past and upcoming meetings

- Past meetings: March 2019: 3rd IVS VLBI training school and 24th EVGA working meeting in Las Palmas, Gran Canaria
- May 2019: TOW at Haystack (including a workshop on VGOS correlation)
- March 2020: 11th IVS GM in Annapolis, USA

IVS was celebrating its 20th anniversary at EVGA 2019.

IVS DB elections

- New members since elections in Nov. 2018: Network Representative: Hayo Hase (BKG, La Plata), Analysis and Data Center Representative: James Anderson (GFZ Potsdam), Technology Development Representative: Chet Ruszczyk (MIT/Haystack), Correlator Representative: Laura la Porta (MPIfR Bonn correlator)
- At Large Member: Evgeny Nosov (IAA, St. Petersburg), Aletha de Witt (HartRAO), and Jingling Li (Shanghai Observatory)

CONT17

- Two legacy and one VGOS network.
- Data are correlated and released.
- Analysis results have been presented on EVGA2016.
- A Journal of Geodesy special issue on CONT17 is planned.
- Generally, the baseline length repeatability has been found to be better for VGOS than for the legacy network (see presentation for details).

VGOS development

- VGOS Test (VT) 24 h sessions every 2nd week:
  - Network with up to 7 stations: Wf-Gs-K2-Ws-Yj-Oe/Ow-Is
  - Data correlated at Haystack (e-transfer + disk shipping)
  - Regular production of VGOS-databases since January 2019
  - VT-sessions will continue with this setup at least until April 2019.
  - VGOS-correlation workshop in May 2019 at Haystack
- EU-VGOS 4 h sessions
  - Three European sites (Yj-Ws-Oe/Ow)
  - Study of polarization conversion (HH+VV) $\rightarrow$ (RCP+LCP)
  - Study of impact of radio source structure
- Japanese VGOS tests (1 GHz wide frequency bands)
- Upcoming VGOS partner stations
  - Hobart, Katherine, Yarragadee (all Australia), broadband upgrade
  - McDonald (Texas, USA), under construction
  - Ny-Ålesund twins (Svalbard, Norway), waiting for broadband receivers
  - Metsähovi (Finland), waiting for broadband receiver

  - Shanghai siblings (China), first fringes
  - Zelenchukskaya, Badary, Svetloe (all Russia), need broadband upgrade

IVS preparations for TRF2020

- Using ICRF3, including galactic aberration
- Using new pole tide model
- New high-frequency EOP model: work is not finalized (annual signal?)
- Important topics to work on:
  - Local-ties at VGOS-legacy co-location stations
  - Thermal and gravitational deformation of telescopes (see presentation for details)

Questions

- Christine Hackman asked about the broadband receivers. Rüdiger Haas explained that these are digital backends.
- Detlef Angermann proposed that other Services should also introduce such a school as the IVS school. Daniela Thaller mentioned that there is a South American SIRGAS training course.
- Robert Heinkelmann asked about local ties. Gravitational deformation will not be available for all stations (some do not exist any longer).

New Action Item #68.07 Send request to John Gipson asking on the availability of the high-frequency EOP model.

Roadmap for next ITRF generation (ITRF2020)

Presentation by IERS Chair

Brian Luzum presented the “Process for Transitions to new ITRF”

- Includes a testing phase of up to 3 months for the ITRS Combination Centers and Technique Centers and a documentation describing with the new ITRF.
- IERS DB finally adopts the new ITRF.
- External evaluation of all combined TRFs foreseen (2 years after IERS DB adoption) to identify areas of concern and areas for improvement.
- Review areas of concern at UAW (within 2 years of IERS DB adoption): UAW provides recommendations as appropriate and IERS addresses recommendations and takes action to resolve concerns.

Presentation by ITRS Centre

Zuheir Altamimi presented the “Roadmap for ITRF2020”:

Recall of the Background/History

- Consultation was sent to the technique ACCs and GGFC on January 24, 2018 => ITRF2020.
- An inventory (list) of all effects and model updates to be considered by all and individual techniques in the reprocessing effort.

Current status per Technique Center

- IVS: high-frequency EOP model to be recommended by the WG; Atmospheric Loading model (ATML) will be applied
- ILRS: Gravity field model, compatible with linear pole model; high-frequency EOP: waiting for a “consensus” model; Will not include a loading model; Reprocessing may start end 2019, beginning 2020
- IDS: high-frequency EOP: waiting for a “consensus” model; A number of DORIS-specific effects will be addressed; Start of processing: beginning of 2020, but maybe earlier
- IGS: Adopt post EGM2008 model: Not all ACs are convinced this has a significant impact on GNSS; high-frequency EOP: waiting for a “consensus” model; Most ACs not in favor of applying a loading model; Start reprocessing probably June 2019

ITRF2020: Call for Participation

- Draft circulated among IERS DB Thursday, Dec 06, 2018 with a list of suitable model updates in the annex
- Comments were welcome until January 10, 2019, but no comments received
- The CfP is now final & posted at the ITRF website: http://itrf.ign.fr/doc_ITRF/CFP-ITRF2020.pdf

ITRF2020 Inputs by TCs: specific model updates are strongly requested

- All techniques waiting for the consensus high-frequency EOP model
- 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: SRP & SAA

Schedule and time-line

Date	*Action*
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

Discussion

- Richard Gross explained that the JTRF2020 will be one combination solution and one experimental solution for combination at the observation level.
- Robert Heinkelmann asked about the consistency with ICRF. This needs to be evaluated by the IVS first. Therefore, radio sources will not be part of ITRF2020.
- The Word document by Brian Luzum related to the transition process should be put to the internal area of IERS DB members.

Decisions Radio sources will not be part of the ITRF2020

New Action Items #68.08 Contact John Gipson concerning the NT-AL and providing it in SINEX files.
#68.09 Distribute CfP via IERS Message and put on website (ITRF and IERS-CB).
#68.10 Put word document on ITRF transition process to internal area for IERS DB members

IERS Conventions This report was given by N. Stamatakos.

Status report on the update process

Overview of Changes to IERS Conventions

- Major update to Chapter 4 to be consistent with ITRF2014 (cf. report of ITRS Center above)

- Emails to be sent to IERS Chapter Editors-in-Chief and Technical Experts (CETEs): Review ITRF2020 Call for Participation and become familiar with needed / requested items. Identify sections of their associated chapters which could move to a reference section or to Additional Supporting Material section on the Conventions web site.

Access to the Conventions Update v1.3.0

- One method to access the latest update of the Conventions is to use the new Quick Links feature which includes a link to the most "Updated" Conventions (see presentation for details).
- Another method to access the latest update of the Conventions is Conventions Versions link

IERS CC Configuration Management Training / Discussion on using GitLab

- Configuration management for IERS CC is a major challenge. Many organizations use GitLab or other configuration management tools
- All involved in meeting and telecon download latest canonical version before meeting / telecon starts (Slack instant messaging and email can be backup for those rare times when someone cannot access the repository because of internet or other problems.)
- Planned training seminar for GitLab / discussion tentative date and location: on afternoon of 9 October 2019. Location is probably Paris Observatory (in conjunction with Journées 2019).

Preliminary schedule of IERS Conventions Major re-write: final editing by September 2022 (see table on next page)

Actions / Milestones	*Response requested by*
Chapter Editors and Technical Experts (CETEs) provided Call for Participation in ITRF2020. Conventions Centre asked CETEs to be prepared for the actions in the Call for Participation.	Early 2019
CETEs asked to identify sections that could be shortened.	August 2019
CETEs to be asked to identify sections that might need technical updates.	September 2019
CETEs to be asked to review UAW workshop 2019 direction and plan accordingly.	End of October 2019
1/2 day workshop on GIT (Conventions config management) training at end of Journées 2019.	Early October 2019
Ask for status from CETEs each quarter after April 2019. Slack instant messaging will be proposed to increase communication among CETEs and Conventions Centre.	Each quarter and when needed
Various communications TBD ...	Between end of October 2019 and mid 2021
ITRF 2020 released.	Sept, Oct 2021
CETEs should have rewrites submitted to IERS CC staff. (May slide if ITRF 2020 release is delayed).	June 2022
Allow 3 months of final editing and approvals to be obtained for final draft of re-write.	Sept 2022

Discussion on models agreed for the next ITRF

- Robert Heinkelmann asked about a strategy to fill gaps with people willing to contribute to the Conventions. Nick Stamatakos will ask people directly or propose possible people.
- Zuheir Altamimi asked about the need for updating the geopotential/gravity field chapter.
- Central Bureau: There is an inconsistency with Love number.
- Daniela Thaller mentioned that the ITRF reprocessing clearly name the Conventions and the version number. Therefore, there is a need to put all updates into one version to be used for ITRF2020 analysis.
- Zuheir Altamimi asked about other models that need to be considered for next ITRF2020.
- List important model updates on the website. List all models for the next ITRF release so Technique Centers can refer to the updated model through the website.
- Detlef Angermann pointed out that Chapter 1 is on general definitions and numerical standards and that someone from gravity group needs to be found → Contact IGFS to nominate someone to review that section.
- Zuheir Altamimi noted that if new numbers are introduced in Chapter 1, one needs to be sure that they have no impact on other chapters.

Decisions Clearly name the conventions and the version number and put all updates into one version to be used for ITRF2020 analysis.

List important model updates on the website. List all models for the next ITRF release so Technique Centers can refer to the updated model through the website.

New Action Item #68.11 Contact IGFS to ask for nominations to review Chapter 1.

GGOS report R. Gross provided the following report:

Coordinating Office

- Host of Coordinating Office: Bundesamt für Eich- und Vermessungswesen (BEV)
- Director of Coordinating Office Matthias Madzak resigned effective 31 October 2018; New Director of Coordinating Office is Helmut

Titz effective 17 December 2018, Martin Sehnal will continue to assist.

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 and liaise with sea level community, or
  - Redirect focus as incubator for International Altimetry Service

GGOS Affiliates

- 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
- Is a component of GGOS with representation on Consortium and Coordinating Board. Each GGOS Affiliate has 1 representative to Consortium and collectively they have 2 representatives to Coordinating Board
- First GGOS Affiliate is GGOS Japan, which was established in 2013; Chair: Toshi Otsubo of Hitotsubashi University, Japan. It provides a forum for multi-technique, space-geodetic discussions within Japan, and strives to improve quality of observations & encourage collaboration in Japan
- Encourage others to become GGOS Affiliates
- Held discussions to encourage new GGOS Affiliates

Essential Geodetic Variables

- Observed variables are crucial to characterizing geodetic properties of Earth and are key to sustainable geodetic observations, EOPs
- 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

- Established Committee within GGOS BPS to create list of EGVs, assign requirements to them, etc. including representatives of the IAG Services, Commissions, Intercommission Committees, GGOS Focus Areas
- IERS Rep is Tom Herring, but he is no longer IERS AC. A replacement and eventually a second IERS Rep is needed.

DOIs for geodetic Data

- Digital Object Identifiers (DOIs) for publications are widely used by publishers and provide a unique identifier of publication. DOI system managed by International DOI Foundation (IDF)
- DOIs for data sets provide benefits to users and benefits to data providers
- Establish a Working Group with representatives of Services, and data centers. Establish procedures for assigning DOIs to geodetic data sets. Helmut Titz agreed to chair the WG asking for representatives from data centers.

GGOS Representation

- Group on Earth Observations (GEO):
  - IAG is Participating Organization & member of Program Board
  - Program Board manages GEO Work Program, IAG/GGOS participates in Sub-Groups on Sendai & Sustainable Earth Observation
  - GEO Week 2018: 29 October 2018 to 02 November 2018; Kyoto, Japan (IAG/GGOS delegation: R. Gross)
- Committee on Earth Observation Satellites:
  - GGOS is an Associate Member.
  - 32 nd CEOS Plenary takes place 16–18 October 2018; Brussels, Belgium. GGOS delegation: R. Gross who gave a presentation on geodetic observations and importance of TRF to Earth observations.

GGOS at Conferences

- European Geosciences Union, Vienna, Austria; 07–12 April 2019 with GGOS Session
- No Bureau meetings this year; instead, they will be held in conjunction with the IUGG
- PLATO Working Group Meeting at Technical University Vienna; Room SEM 124; 08 April 2019; 13:30–15:00. Chairs: Daniela Thaller and Benjamin Männel

- American Geophysical Union in San Francisco, CA; 09–13 December 2019 with a GGOS Session

IUGG 2019

- Venue : Palais des Congrès, Montréal, Canada 08–18 July 2019
- GGOS Symposium G06
- GGOS Coordinating Board meeting on transition from old GGOS CB to new GGOS CB: Tuesday, 16 July 2019; 12:00–13:30 (to be confirmed)
- GGOS Bureau meetings not yet scheduled

UAW2019

- Venue Institut de physique du globe de Paris (IPGP), Paris 02–04 October 2019 (by invitation only)
- Program (tentative)
  - Topics specific to each technique: systematic errors and biases in each technique and status of next generation observing systems
  - Topics common to all techniques: Reference systems and frames (including preparation for ITRF2020), Model improvements, Site surveys, Co-location of techniques (including with gravity, unified height system), Standards, conventions and formats, DOIs for geodetic data sets, Essential Geodetic Variables

Journées 2019

- Venue , Paris 7–9 October 2019

GGOS Days 2019

- Venue: to be held in parallel with SIRGAS2019 Symposium, but 1 day will be joint with SIRGAS2019 in Rio de Janiero, Brazil; 11–14 November 2019

EOP Products
Report from Earth Orientation Centre

Ch. Bizouard provided the following overview:

Main changes/novelties since December 2018

- March 2019: Update of the interactive tool “Geophysical Analysis” now including atmospheric – ECMWF, oceanic – MPIOP, land water, sea level excitations derived at GFZ
- Filtered mean pole: updated the first day of each month
- Towards an operational multi-technique EOP series GNSS+VLBI from GINS/DYNAMO treatments (COMB OPA).

Earth rotation monitoring

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

Inconsistencies were found when EOP series were aligned to ITRF2014.

X-pole differs from GNSS series by about 40–50 micro-as since about December 2017. The reason is still unclear, but needs to be figured out.

Report from IERS Rapid Service / Prediction Centre Update

This report was given by C. Hackman.

Preliminary estimates of 2018 accuracy

- Summary: Better than 2017? Agree same w/C04, JPL except in UT1: more like JPL
- PM, estimated: 2018: 57 μas, 2017: 74 μas
- PM, 1-d pred: 2018: 274 μas, 2017: 304 μas
- UT1, estimated: 2018: 50-76 μs, 2017: 63 μs
- UT1, 1-d pred: 2018: 70-89 μs, 2017: 88 μs
- 29 Mar 2018 Δs: re-alignment to C04, CPO $\rightarrow$ dX/dY paradigm, UTGPS deweighted

Status update on various items

- Combination/prediction algorithm improvements: contract about to start!
- Still in progress:
  - R&D on UTGPS repairs
  - Completion of RS/PC email migration: waiting on another departments technical development; ser7@maia.usno.navy.mil not blocked by major spam blockers; Bulletin A inquiries: please use usn.ncr.navobsydc.mbx.eopcp@mail.mil; Transition to new network (USNO DC, NOFS).
- Ongoing research: prediction improvements thru use of OAM/AAM data

IERS RS/PC staff presentations, activities

- Presentations since DB Meeting # 67

- EGU GA 2019 Poster Session G3.1 (Thu 11 Apr 2019): N. Stamatakos, D. McCarthy, D. Salstein, Investigating Possible Combinations of Atmospheric, Ocean, and other Geophysical Angular Momentum Data to Improve Operational Earth Orientation Information
- 24th EVGA Meeting (17–19 Mar 2019; Gran Canaria, ES) oral presentation O303: M. Davis, M.S. Carter, C. Dieck, The IERS Rapid Service / Prediction Center UT1–UTC Combined Solution: Present and Future Contributions
- Unified Analysis Workshop (2–4 Oct 2019; Paris, FR): Stamatakos to represent IERS, deliver RS/PC presentation
- Journées 2019 (7–9 Oct 2019; Paris, FR): Stamatakos, Davis to attend, conduct IERS Conventions workshop after European VLBI Group for Geodesy and Astrometry

The IERS RS/PC team (besides C. Hackman):

- Mr. Nick Stamatakos, RS/PC Production Director & Lead Project Scientist
- Ms. Merri Sue Carter
- Mr. Nathan Shumate
- Ms. Maria Davis

Notes
Nick Stamatakos mentioned that the transition of website from http to https was made (redirection should be happen automatically). An IERS Message should be sent out when the transition takes place.

Working Group on IERS Product Distribution

R. Heinkelmann presented the draft charter of the new IERS Working Group on “Possible improvements related to the distribution of the IERS products” (accordingly to IERS DB decision #65.03)

Draft Charter

- Proposed goals
- Questions to be addressed:
  - What is the current situation of data distribution and is the current situation satisfying the user needs?
  - Who are the users of the IERS products?
  - What are the requirements / preferences of the users in terms of data distribution?
  - Has the actual user need / requirement in terms of distribution been assessed?

  - What are the potential proposals for improvements?

- Proposed structure of the group: tbd
- Working plan including schedule / deadline: tbd

Candidate for a chairperson

- Chair (suggested as of 2017-12-09): IERS AC: Heinkelmann, R.

Initial list of members

- Members (suggested as of 2017-12-09): CB: Thaller, D.; Earth Orientation Center: Bizouard, C.; ICRS Center: Souchay, J.; ITRS Center: Altamimi, Z.; ITRS CC DGFI: Seitz, M.; ITRS CC IGN: Altamimi, Z.; ITRS CC JPL: Gross, R.; Rapid Service / Prediction Center: Hackman, C.

Term

- Two years with a possible one-time re-appointment

Charter of the WG has to be defined.

Discussion

- Christian Bizouard proposed to ask Leonid Petrov if he is willing to join the WG.
- Zuheir Altamimi proposed to add the Technique Centers since they are using the data.
- Detlef Angermann pointed out that an interaction with GGOS BPS will be necessary and proposed to add the GGOS BPS to the member list.

EOP comparison UT1–UTC

R. Heinkelmann presented the report.

Current conventional products

- Realization of ITRS: ITRF2014
- Realization of ICRS: ICRF3
- Realization of GCRS $\leftrightarrow$ ITRS transformation: IERS EOP 14 C04

Problem statement

- The products are of high quality but determined independently of each other. For ITRF20xx, DORIS, GNSS, SLR, VLBI and local ties are used, but CPO and CRF are not explicitly considered. Analysis approach 1, includes data up to 20xx
- ICRFi: VLBI, no other techniques involved, analysis approach 2, includes data up to yyyy EOP xx C04

- dX, dY, and UT1 are treated independently of x, y
- IVS combined solution considers non-tidal atmospheric loading, ITRF2014 not

Assessment approach by VLBI

- VLBI solution using IVS data between 1984-Jan-24 and 2018-Apr-1 (in common with ICRF3)
- 5992 sessions with about 13.25 x 10^6 observations
- NNR w.r.t. 303 defining sources (ICRF3) / NNR + NNT w.r.t. 31 stations (ITRF2014)
- EOP are determined together with the global coordinates!

Results and Conclusions (TRF and CRF)

- We realized a consistent set of TRF, CRF, and EOP from a single VLBI solution.
- The GFZ-TRF (VLBI) shows a scale bias w.r.t. ITRF2014 (VLBI + SLR) of about 7 mm.
- The choice of terrestrial datum stations is important and at the same time it becomes increasingly difficult as more and more VLBI stations are affected by seismic events.
- Conclusion: precise co- and post-seismic deformation modeling becomes important.
- Presumption: with the upcoming new generation VGOS ground stations, it will be a big challenge to maintain the VLBI terrestrial frame stability.
- The GFZ-CRF shows small rotations, deformations and a declination bias w.r.t. ICRF3 but within the GGOS goals.
- The VLBI-determined EOP disagree with the IERS EOP 14 C04 on a level exceeding the GGOS goals.
- The EOP prior to about 1992–1993 are much less precise and show large variations. At this time, the VLBA (and other stations) joined the IVS.
- Conclusion: For detail Earth rotation studies that require high-precision EOP, VLBI prior to 1992 could be omitted.
- Hydrostatic mass loading deformation introduces quasi-annual signals in the pole coordinates.

Final conclusions

- With our VLBI-only approach, we cannot fully assess the consistency between TRF, CRF and EOP.
- For the EOP and for VLBI it is important to work with consistent TRF and CRF.
- If highest consistency is aimed for, the TRF, CRF and EOP need to be determined in a single solution involving the four space geodetic techniques (and local ties).

New Action Items

#68.12 Send out IERS Message when transition to https website has been done (2–3 weeks).
#68.13 Ask Leonid Petrov, the Techniques, and the GGOS BPS to participate in WG on IERS Product Distribution.

ICRS/ICRF report
Status of ICRF-3 and next steps for the IERS

R. Gross presented the report.

ICRF3 adopted by IAU on 1 Jan 2019

- Key accomplishments:
  - Multi-wavelength (S/X, K, X/Ka)
  - Majority of sources much more accurate (>3x improvement)
  - Approximately 30% more sources
  - Available now via IERS ICRS Centre website

Plans

- ICRF3 is now in “maintenance” phase
  - Focus is on improving current positions, source quality
  - Looking at position shifts between frequencies
- ICRF3 team is working with Gaia team towards defining an integrated radio/optical reference frame
  - Likely to be proposed as a working group to IAU
- USNO, Paris Observatory are collaborating on AGN monitoring program (FRAMEx) for reference frame sources

Discussion

- Daniela Thaller asked if there are any ideas to have a better link to the IERS this time. Reply: No ideas so far.

IAU Report

R. Gross reported:

100 anniversary of IAU

- During Journées 2019 an IAU centennial session is planned with presentations of the history of IAU Comm. 19 and the Earth rotation over the last 100 years.
- A proposal was sent to have an Earth rotation session at the last Symposium in August, but the IAU did not support it either.
- Plans to publish a history of the commission in a journal article; Zinovy Malkin is writing the part on polar motion.

Other reports

WG on Site Survey and Co-location

R. Haas presented the following report:

Terms of Reference

- Ultimate objective: improving the accuracy of tie vectors as well as the consistency of space geodetic solutions.
- Provide authoritative source of surveying methodology advice, promote technical discussion, a forum for the evaluation of existing and new procedures and analysis strategies.
- Support new survey activities with advice and advocate for re-survey where necessary.

Background

- Local ties between different techniques differ from results from geodetic analysis at a level of several millimeters.
- Standard surveying equipment better by a factor of 10
- Industrial grade instruments better by factor 100 $\rightarrow$ Systematic errors in space geodetic techniques

What has been done in the WG?

- Focus has been directed towards deformation studies of VLBI reflectors
- These studies have been able to separate the internal deformation parameters of the VLBI telescopes, aliasing as several millimeters movements of the telescope in previous and current analysis (undetected in “classic” local tie measurements).
- More telescopes need to be measured – of particular urgency are those telescopes about to be decommissioned.
- Maintenance issue for the telescope operators and the geodetic society as a whole, and a requirement to fulfill the GGOS/VGOS objectives. If this task is not fully embraced by the geodetic community, I fear the GGOS objectives will inevitably fail.

Focus on VLBI

- Structural deformation of reflector alters the internal raypath (non-issue in astronomy)
- Not detected with local tie measurements
- Application of photogrammetric methods (snapshots, equally accurate, non-loading)
- Effects detected at several mm

UAW 2017 Recommendations

- VLBI: 2) Gravitational deformation of VLBI antennas. It is recommended that as many VLBI antennae as possible be measured to determine their gravitational deformation.
- Site survey
  1. Optimize a local network setup combination [...] based on instrument specification.
  2. Development of an in situ GNSS antenna calibration method is a high priority; and especially important to commission at GNSS sites with long history.
  3. In a choice [...] sites without local ties should be prioritized.
  4. For IDS, IGS, ILRS, and IVS specifically (i.e. comment directed to the services):
     (a) Examine ITRF2014 tie and space geodesy discrepancies available at http://itrf.ensg.ign.fr/ITRF_solutions/2014/ to look for indications of systematic errors.
     (b) Choose sites with poor consistency between local ties and space geodetic solutions to identify and address problems.

What is the intention of the space geodetic community in this aspect?

- Equipment maintenance to provide best possible data for analysis
- Measurement teams are not deployed at space geodetic sites
- Travel needed for surveying teams
- Measurement data analysis required ⇒ Station operators need to pay ... (!)

Discussion

- Christine Hackman asked about the costs of drone measurements. Those costs are unclear, but Zuheir Altamimi said that a local survey is about 50,000 Euros.

- Zuheir Altamimi proposed to draft a list of co-location sites with highest priority and to support institutions doing local surveys.
- Mike Pearlman notes that the WG in GGOS supports deformation issues in VLBI. He asked if the WG does what IERS expects.
- Zuheir Altamimi responds that local ties of stations are more valuable than the work of the WG. The WG is giving advice to the stations how to do the local survey. This might not be the right frame to solve the discrepancies between terrestrial local-ties and measured coordinate differences by the space techniques.
- Rüdiger Haas notes that the WG is giving advice on doing local survey, but the local surveyors are not following these advice.
- Erricos Pavlis asked if someone is keeping track of the surveys that have been done.
- Zuheir Altamimi proposed to set up a website and asking the sites to make the surveys/reports available.

New Action Item #68.14 How to proceed with the Working Group on Site Survey?

Annual Report 2018 The call for the Annual Report 2018 was sent out 3 weeks ago. The Central Bureau started to print the previous Annual Report 2017.

Next DB meeting (#69) Zuheir Altamimi asked to move the meeting to Sunday morning starting at 8 a.m. for a half-day meeting, because the IAG Executive Committee meeting is normally the whole day on Saturday before AGU.

Decision:
The next DB meeting (half-day meeting) will take place on Sunday, December 8, 2019, before the AGU in San Francisco.

Decisions Organize IERS DB Meeting on Sunday morning.

New Action Item #68.16 Prepare IERS DB meeting No. 69

Meeting No. 69

December 8, 2019, Park Central Hotel, 50 Third Street, San Francisco, California, USA

Introduction and approval of agenda Brian Luzum welcomed the guests and the members of the IERS Directing Board. The agenda was accepted. There were no additional comments.

Changes in IERS personnel since last DB meeting

- IAG / IUGG representative since 7 Dec. 2019: Tom Herring (Thanks to Axel Nothnagel, IAG rep. 2015–2019)
- Richard Gross will continue as GGOS representative to the IERS DB (representative since 2017)
- Detlef Angermann will continue as IERS representative to IAG Commission 1 (Reference Frames) Steering Committee (representative since 2016)
- New IERS representative to IAG Commission 3 (Earth Rotation and Geodynamics) Steering Committee since 8 Aug. 2019: Robert Heinkelmann (Thanks to Brian Luzum, representative 2011–2019)

Deceased IERS officers:

- George A. Wilkins (1929 – Dec. 2018), UK (IAU Representative to the DB, 1 Jan. 1988 – Aug. 1988; Chair of the DB, 1 Jan. 1988 – Aug. 1988)
- Richard Biancale (1952 – Feb. 2019), France (Primary scientist of the CRC at Groupe de Recherches de Géodésie Spatiale (GRGS), 1 Jan. 2001 – 31 Dec. 2008; Chair of the Working Group on Combination at the Observation Level, Oct. 2009 – Apr. 2016)
- William G. Melbourne (1930 – Sep. 2019), USA (Head of the GPS Coordinating Centre, 1990? – 31 Dec. 2000; GPS Coordinating Centre Representative to the DB, 1989? – 31 Dec. 2000)

Associate Members

The updated list of the IERS Associate Members was sent out in advance.

New Action Item

#69.01 Ask all IERS components to update.

IERS Technical Notes on ITRF2014

TN 40: IERS Technical Note on the evaluation of the three solutions: ITRF, DTRF and JTRF

- Nearly ready
- 4 contributions by the ITRS Centre and the ITRS Combination Centres
- 3 contributions by the IERS Technique Centres (IDS, ILRS, IVS)

Decisions

- TN 40 to be published at the beginning of 2020.

TN xx: C04 series aligned to ITRF2014 (replaces TN planned for 08 C04 series)

- No news. Paper on 14C04 was published in the Journal of Geodesy.

Decisions: TN 40 to be published at the beginning of 2020.

New Action Items #69.02 Publish TN on ITRF, DTRF and JTRF.
#69.03 Report on TN related to C04

Current activities at the ITRS Combination Centres

Report from ITRS Combination Centre at JPL

Richard Gross reported on the following activities:

SREF development (Chin et al.)

- Status
  - Time variable, square-root information filter with full process noise matrix
  - Optionally estimates radio source positions for joint TRF / EOP / CRF determination
  - TRF and joint TRF/EOP/CRF test solutions being analyzed
- Plans
  - Reproduce JTRF2014 with SREF
  - Include EOP dynamics, postseismic displacement model
  - Will use SREF to determine JTRF2020

JTRF2014 analysis (Abbondanza et al.)

- Article accepted by Advances in Space Research (A Sequential Estimation Approach to Terrestrial Reference Frame Determination, by Abbondanza, C., T. M. Chin, R. S. Gross, M. B. Heflin, J. W. Parker, B. S. Soja, and X. Wu)
- Reviews JPL's approach to determining TRFs, comparing it to other approaches

Vector spherical harmonics (Soja et al.)

- Used to intercompare CRFs
  - Allows higher order differences between frames (warping) to be evaluated
- Used here to intercompare TRFs

Report from ITRS Combination Centre at DGFI-TUM

Mathis Bloßfeld presented this report.

Non-tidal loading corrections in DTRF2014 and DTRF2020

- NT-L loading corrections at NEQ level are performed accordingly to OBS level.

- In DTRF2014, NT atmospheric (NCEP) and hydrological loading (GLDAS) was considered (provided by GGFC).
- In DTRF2020, also NT oceanic loading should be considered (TUGO-m + ERA5?).
- NT-L correction: effect on station positions (DTRF2014)
  - Change of station position and velocities depends on observation interval.
  - In particular GNSS station coordinates are changed (many short obs. intervals).
  - From additionally applied OCN loading, stations at the coast (colocation with tide gauges for referencing sea level rise) will benefit!
  - In particular GNSS station heights benefit from NT-L corrections (lowest scatter).
  - Horizontal components do not benefit. Model deficiencies? Level of application?
- NT-L correction: effect on datum parameters (DTRF2014)
  - The characteristic annual signal vanishes when NT-L corrections are applied.
- NT-L correction: VLBI analysis at DGFI-TUM
  - NT-L corrections are performed on NEQ and OBS level.
  - NT atmospheric, hydrological and oceanic loading corrections are applied (single components and combined loading signal)
  - In case of VLBI station networks, in particular the correction for the hydrological component of NT-L leads to a strong reduction of the annual signal!
- NT-L correction on the NEQ level: summary
  - Is in accordance with the definition of the ITRF as a conventional reference frame (IERS conventions) $\rightarrow$ corrections are applied by a reduction of the original observations.
  - NT-L corrections are fully geophysical (compared to sine/cosine signals).
  - Station heights and datum parameters benefit clearly.
  - But: horizontal station positions do not benefit (also for GNSS with a low scatter of time series and many well distributed stations).
  - Improved in ITRS realization 2020
    - Full effect on orbit (OBS level) will be applied.

        * Full effect on station positions (NEQ level) will be applied.
        * Level of application for station position corrections and temporal resolution of corrections?
    - For future ITRS realizations, the application of NT-L corrections at OBS level should be investigated!

Consistency of applied loading models

- Both, non-tidal atmosphere and ocean circulation products require high temporal resolution (at least 3 h) → problems with application at NEQ level?
- Gravity coefficients and loading should be always derived from identical mass distributions.
- Consistency of NT-L models (example: ILRS)
    - TV Gravity field and NT loading products must be consistent (as e.g., the products from GFZ).
    - They can be combined with all modern ocean and atmospheric tidal loading models.
    - ILRS will use the given AOD models?
    - IDS will apply other AOD products?
- GGFC must be informed about decisions!
- Finally, consistent NT loading models for station corrections must be used!

Scale of ITRS realizations 2020: many model changes related to the scale

- Many model changes will have an impact on the ITRS scale realization.
- For many models the impact of the scale is not well investigated yet.
- ITRS scale realization in 2020 will be a challenge (no consistency with ITRS realizations of 2014).
- A careful step-by-step analysis of the individual contributions is necessary to understand the scale of the ITRS realizations in 2020!

Summary

- NT-L corrections on the NEQ level
    - Station heights, origin and scale benefit.
    - NT-L corrections should be applied with all three components.

  - Investigations on how to improve the impact on horizontal station components (model deficiencies, inconsistencies, level of application) is still necessary.
- NT-L models should be consistent for ITRS 2020 realizations
- ITRS 2020 scale realization
  - Many model changes in the individual technique-analyses will have an impact on the scale.
  - ITRS scale realization will become challenging.
  - Investigations of the IERS Technique Services on the impact of the different model changes are very important and will help to validate the new ITRF scale.

Discussion

Jean-Paul Boy added that the GGFC will release a fully new and consistent model based in ERA-5. The latter's latency is thought to be reduced. A consistent hydrology model is also available. Loading and time-variable gravity will be provided. Models from GFZ including predictions are also suitable. A comparison with GFZ models is planned.

Report from ITRS Center The report was presented by Zuheir Altamimi.

Status ISO Standard on ITRS

- The final document is now under publication
- Translation of the standard in French
- Final publication is expected soon, or January 2020
- Former Resolutions/Agreements on ITRS & ITRF:
  - IUGG2007: adopted the ITRS as the preferred Geocentric Terrestrial Reference System (GTRS) for scientific and technical applications
  - CGPM2011: recommends that the ITRS, as defined by the IUGG and realized by IERS, be adopted as the unique international reference system for terrestrial reference frames for all metrological applications
  - ICG: recommendation to align GNSS-specific reference frames (WGS84, PZ-90, GTRF, CGCS2000, JGS) to the ITRF
  - IUGG2019: recommend to the user community that the ITRF be the standard for positioning, satellite navigation and Earth Science applications, ...
  - UN-GGIM-2019: adoption of the ITRS and the ITRF as the standard for scientific, geospatial and operational geodetic applications

Activities of UN-GGIM Subcommittee on Geodesy

- Participation in the UN-GGIM 9th Session
- Adoption of the ITRS and its numerical realization, the ITRF by the UN-GGIM Committee of Experts as the standard reference for scientific geospatial and operational geodesy applications
- Towards the creation of a Global Geodetic Center of Excellence (GGCE):
  - Mission & modalities still to be defined/articulated
  - Consultations are ongoing
  - 1st draft will be presented at the UN-GGIM HLF in Windsor, UK, April 2020
- Questionnaire on Geodetic Infrastructure
  - Sent to the IAG Services, including the IERS
  - IERS: Need to agree who should respond?
  - The Central Bureau, with contributions from IERS DB and Components

IERS Technical Note 40: evaluation & inter-comparisons of the three solutions: ITRF, DTRF and JTRF 2014

- Under publication: 7 contributions
- Many thanks to IERS Central Bureau: Wolfgang Dick, Sonja Geist and Sandra Schneider-Leck
- Editors: ITRS Center & IERS CB: Zuheir Altamimi and Wolfgang Dick

Towards ITRF2020

- The CfP was adopted and finalized
- Roadmap and schedule discussed and agreed in past DB meetings
- The ball is in the Technique courts now and hope they will respect the initial time line with no delays
- The ITRS Center is willing to evaluate any test solutions at any time
- UAW2019-RF-Recommendations
  - The IGS is urged to preserve the alignment of its operational products (orbit, clocks, ERP) to the ITRF2014 until the ITRF2020 is published

  - The IVS is urged to provide the ATML corrections (if applied) to the right-hand side of the normal equation in the SINEX files
  - The ILRS is urged to provide the Range Biases estimates with covariance in their weekly SINEX files
  - The IDS is encouraged to mitigate IDS-specific systematic errors that impact the TRF parameters (origin & scale)
  - The GGFC is invited to provide a unified loading model including all contributions (Atmosphere, Hydrology & Ocean) for all ITRF2020 sites

ITRF2020: Schedule & 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

IAG Commission 1 and IERS joint Working Groups

- Colocations & Local ties $\rightarrow$ Renamed to “Methodology for surveying geodetic instrument reference points”
  - Chair: Ryan Hippenstiel (NGS/NOAA)
- Geocenter Motion: “Toward reconciling Geocenter Motion estimates”
  - Chair: Kristel Chanard (IPGP-IGN)
- Consistent realization of TRF, CRF and EOP
  - Chair: R. Heinkelmann (GFZ)
- The three WGs were approved by the IAG EC.
- Need to be approved by the IERS DB.

New Action Items

#69.04 Provide test data set
#69.05 Provide station list, especially VLBI and SLR
#69.06 Put list of resolutions/agreements on ITRS & ITRF on IERS website
#69.07 Coordinate IERS's answers to Questionnaire on Geodetic Infrastructure

Reports from the Technique Centers

IDS Report

The report was presented by Guilhem Moreaux. DORIS constellation status (current and future missions)

- 6 current missions (Sentinal-3A and 3B, Jason-3, SARAL, HY-2A, Cryosat2)
- 7 future missions (Sentinel-3C and 3D, HY-2C and 2D, Jason-CSA and CSB, SWOT
- 1 proposed mission (MOBILE, proposed to ESA, for gravimetry and geodesy)

Current DORIS Network

- 47 co-located sites out of 58 DORIS stations
- Rate of operating stations over the past year 80%
- Currently out of order: Badary, Krasnoyarsk, Betio, Santa-Cruz, Crozet, Tristan, Ny-Alesund

Network Evolution

- Recent Network Events
  - Jun. 2019: start of the deployment of the 4th generation DORIS beacon at St-John's, Canada.
  - Jul. 2019: 4th generation beacon installation at Ponta-Delgada, Azores, Portugal.
  - Sep. 2019: re-installation at Santa-Cruz, Galapagos, Ecuador after 10-yr outage.
  - Nov. 2019: 4th generation beacon installation at St-Helena, South Atlantic, UK.
- Short Term (2020)
  - La Réunion, France: antenna relocating and 4th generation beacon installation.
  - Crozet, France: 4th generation beacon installation.
  - Male, Maldives: antenna relocating and 4th generation beacon installation.
  - Reykjavik, Iceland: relocating at Höfn (co-location with IGS station "HOFN").

  - Changchun, CN: new station installation in place of Yuzhno-Sakhalinsk – TBC.
  - Easter Island, Chile: relocating (hosting migration).
- Longer Term
  - Dionysos, Greece: relocating before site closure.
  - Katherine, AS: new station installation in place of Port-Moresby (3 techniques site).
  - Papenoo, Tahiti, FR: new 4 techniques site (TBC).

POD Results: The POE-F DORIS-only orbital radial performance approaches the GPS-based orbits, especially for satellites with smaller Surface/Mass ratio.

DORIS Scale: The IDS contribution to the ITRF2014 shows a scale increase early 2012. The IDS identified the reasons for these patterns:

- Wrong CoM-CoP vector for HY-2A.
- Dependency on the validity standards from the data provider.

As demonstrated by the latest GRG multi-satellite solution, we can now achieve a stable scale from 1993.0 to 2018.0.

IDS reprocessing for next ITRF

- Time Span
  - 1993.0-2021.0
- DORIS Constellation
  - Cryosat-2, Envisat, HY-2A, Jason-1/2/3, Saral, Sentinel-3A/B, SPOT-2/3/4/5, TOPEX
- DORIS Data Format (DORIS 2.2 / RINEX)
  - IDS recommends to the ACs to have one format per mission.
- Satellite Modelling
  Attempt to mitigate the non-conservative force model error on satellites (draconitic signals):
  - Use quaternions (for bus and solar panels) when available.
  - Revisit SRP coefficients and macromodels.
- SAA Mitigation Strategies
  - Jason-1: recommendation of the data correction model already used for ITRF2014.
  - Jason-2: TBD.
  - Jason-3: TBD.
  - SPOT-5: recommendation of the data correction model already used for ITRF2014.

- DORIS Antennas
  - Alcatel, STAREC-B/C + associated phase laws.
- Data Elevation
  - IDS encourage the ACs to adopt an elevation cut-off below 10°
  - IDS strongly recommends to downweightlow elevation data.
- New standards/models recommended by IERS and IDS
  - New linear mean pole model.
  - Desai & Sibois HF (diurnal-subdiurnal) tidal EOP model recommended by IERS
  - Time-Variable Gravity (TVG) model (based on GRACE data + GOCE data + SLR data coherent with new mean pole convention (C(2,1) / S(2,1) coefficients)
  - Oceanic tidal model (ex: FES2014-b)
  - "Dealiasing products" (atmospheric, ocean -ex: AOD1B-RL06).
- Site Observation Time
  - No more minimum duration (2.5 yrs for ITRF2014).
- Time Schedule (TBC)
  - 2020, April 30th: AC delivery of 1993.0–2002.3 (Until start of Envisat – First DORIS 2G receiver).
  - 2020, June 30th: AC delivery of 2002.3–2011.8 (Until start of HY-2A).
  - 2020, Sept. 30th: AC delivery of 2011.8–2020.0.
  - 2021, Feb; 10th: First delivery of the IDS combined solution to the IERS (1993.0–2020.0).
  - 2021, Feb. 14th: AC delivery of 2020.
  - 2021, Mar. 15th: Complete delivery to the IERS of the IDS combined solution.

IDS Combination Center

- Position and velocity cumulative solution (ids19d04)
  - Based on new IDS combined solution.
  - From1993.0 to 2019.0.
  - Aligned to ITRF2014.
  - Includes193 DORIS stations at 84 sites.
  - Available in both SINEX and text formats at CDDIS & IGN ftp sites.
- DPOD2014 version 4.0

  - Based on ids19d04.
  - Includes 205 DORIS stations at 89 sites.
  - Available in both SINEX and text formats at CDDIS & IGN ftp sites. → Update of the SINEX Master file available at IDS CB ftp site.
- DORIS discontinuities
  - Review of the station position and velocity discontinuity → Less unknown breaks.
  - Not used in the DPOD2014 version 4.
- Coordinate Time Series Plots
  - New version of the plots delivered to CDDIS and IGN.
  - Indicate date(s) and origin(s) of the discontinuities (geophysical, technical, unknown) for a better understanding by the users.

IDS News

- IDS Meetings
  - In 2019
    - IDS AWG, April 4th, at DGFI, Munich.
    - IDS AWG, Sept. 30th–Oct. 1st, at CNES, Paris.
  - In 2020
    - IDS AWG, Spring, place TBD.
    - IDS Workshop, Oct. 19–21, at Venice.
- IDS Newsletter
  - Newsletter #7 will be issued in December 2019.
  - All issues are available at https://ids-doris.org/ids/reports-mails/newsletter.html
- IDS Life
  - DORIS will turn 30 in 2020.
  - DGFI-TUM is the 4th Associated Analysis Center.
  - Jason-2/3: DORIS RINEX and DIODE orbit may be soon available in NRT (Followed a request from the IDS NRT DORIS Data WG chaired by D. Dettmering).
  - Creation of an IDS Working Group on Geocenter.
  - Elaboration of first IDS strategic plan.
- IDS Strategic Plan
  - Output of the first IDS retreat
  - Nearly 20 recommendations
    - To grow the community.

    - To improve the technology, the infrastructure and the processings.
    - To extend DORIS applications.

- First Realizations:
  - Organization of a “DORIS day” prior to EGU 2020 to promote the use of the IDS products.
  - Free access to DORIS POD software to lower the barrier to entry: GINS from CNES/GRGS and GEODYN from NASA may be soon available.

IGS Report The report was presented by Tom Herring.

- Administrative:
  - The current chair Gary Johnston will hand over the business to his vice-chair Felix Perosanz, likely during the workshop in August.
- Workshops:
  - The next IGS workshop is scheduled for August 10 to 14, 2020 in Boulder, Co. It will be organized by UNAVCO and UCAR. The theme is “Science from Earth to Space”
  - The program was developed by F. Blume (UNAVCO) and will be discussed at the IGS GB meeting this afternoon.
- Regarding the processing:
  - Putting the MGEX products in the context of the legacy product chains we can state:
    - GPS has the best quality
    - Galileo comes (closely) behind GPS
    - GLONASS is the third
    - BeiDou is far away
    - QZSS is in a quite good shape but as a regional system of a lower interest for global solutions.
  - Galileo starts to enter the legacy product chains:
    - The repro for ITRF2020 will contain Galileo from a number of ACs (not only the MGEX-ACs made this announcement); will enter the final products after the repro
    - First AC started to add Galileo to the rapid and ultra-rapid products (not relevant for the reference frame)
    - The critical point is the receiver antenna correction model (see below)
- Repro for ITRF2020:
  - After the last IERS DB meeting in May 2019 several milestones have been passed.

  - In the week after the EGU, a IGS AC workshop was carried out at GFZ facilities from April 15 to17.
    * Arturo Villiger (chair Antenna WG) has shown based on chamber calibrations that together with the satellite antenna calibrations (provided for Galileo from GSA) can be used to provide scale information from GNSS for the ITRF generation.
    * At the workshop Geo++ has shown for the first time a multi-GNSS calibration including the Galileo frequencies. Because of this opportunity, the schedule was revised in a way that these calibrations can be considered as well for the repro.
    * Apart from this discussion on the antenna calibrations, it was decided to include Galileo (in addition to GPS and GLONASS in the previous repro); recommendations for the satellite orbit modelling have been established (expecting an improvement wrt. to the previous repro); and numerous other models have been agreed.
  - According to the new schedule, a preliminary table of antenna corrections was established for a test solution over two years. This test campaign has been processed during the summer by four of the ACs and confirmed the general suitability of these corrections. For some selected antennas further updates have been carried out based on this experience.

- By the 10th September a telecon of all ACs was organized to discuss the results from the test campaign. The use of the new ANTEX corrections was agreed. The ACs have further agreed to process the year 2014 following the standards of the repro for ITRF2020 and check the consistency of these submissions. This is planned for an AC splinter meeting during the AGU.
- It is planned that the solutions are available until summer 2020 for combination.
- Final remark:
  - All updates of the antenna models have been accomplished by updates of the IGS realization of the ITRF14 (big work by Paul Rebischung)

ILRS Report The report was presented by Erricos Pavlis.

ILRS Network Activities

- Station closings:

  - MLRS, McDonald, TX: lightening strike; to be replaced by SGSLR (ca. 2021)

- Upgraded stations:
  - Simosato (Japan): kHz operations since late 2018
  - Wuhan (China): submitting data (validated, operational)
  - San Fernando, Spain (validated, operational)
  - Tanegashima, Japan (irregular data submission)
  - San Juan (Argentina): kHz operations planned for 2020
  - BKG AGGO (Argentina): setup at La Plata Observatory; (TIGO relocation)
- Quarantined stations:
  - Zelenchukskya, Russia
  - Tahiti, French Polynesia
  - NRL/Stafford, Virginia
  - Geochang, Korea (new station; no data yet)
  - Stuttgart, Germany (new station; no data yet)

Mission News & Support

- Missions Standing Committee
  - New chair (Stephen Merkowitz) and co-chair (Toshi Otsubo)
- Tracked 110+ satellites in 2019
- Formulated new GNSS tracking strategy
- Completed 3-month Etalon campaign
- Updated mission support request guidelines, e.g. advance notice of six months (minimum)
- Future missions requesting ILRS support:
  - Astrocast Precursor (2 cubesats/engineering testing)
- Additional GNSS: BeiDou/Compass, Galileo, etc.
  - COSMIC-2, HY-2C, SWOT, NISAR

ILRS Status and Activities

- Infrastructure
  - Testing new formats for Data (CRD) and Tracking Predictions (CPF)
  - Web-based station site log archive and maintenance operational

  - Harmonized data screening & QC between EDC and NASA OCs (Implemented)
- Implemented new strategies to “rate” station performance underscoring value to the users and science products (online tool)
- ILRS sets tracking priorities to balance requests and maximize the utility of the network
- Routine submission of all full-rate data to OCs and DCs from most of the currently active stations (40)
  - We continue to press the rest to conform ASAP
- Etalon Campaign Project: dedicated tracking campaign for Etalon 1 & 2 (February 15 to May 15, 2019)
- Published ILRS workshop planning guidelines
- Developed draft MOU between ILRS/GGOS and ROSCOSMOS
- Increased scrutiny in selecting new missions to track
- Adopted plan for tracking GNSS s/c:
  - Each constellation selects 4 satellites for higher priority tracking (3 segments of tracking requested per pass)
- Issues:
  - Network gaps in Latin America, Africa, and Oceania, and mix of new and old technologies are the primary issues of concern now
  - Site log update lapses cause trouble with analysis/products; delinquent sites/agencies are reminded often!
  - Lack of standardization in system hardware and operations
  - Marginal operation at many stations, making little or no contribution to the ILRS data products
  - Addressing data quality issues; still some systematics
  - Continued increase in number of target satellites as new missions use SLR for orbit determination and other applications (110+ satellites)

ILRS ASC – Analysis Activities

- Preparations for contributing to the development of ITRF2020 are on schedule
- New operational approach in handling error sources adopted at the ASC meeting in Canberra, November 2018 implemented:
  - Allowance for estimation of systematic errors simultaneously with all other parameters to eliminate biases in station positions/velocities (in progress);

  - Correction of identified serious shortcomings in the current model for the target signature (also known as “CoM correction”) for all types of ground systems (implemented);
  - Correction of such errors alone can affect the SLR-VLBI scale difference at the ~0.25 ppb level.
  - Adopted the new CoM model which was recently released (November 2018 & September 2019) by NSGF (implemented).

- SSEM Pilot Project on station systematics completed the next phase and we received the final submission from ALL (7) ACs to complete the combination product and the tabular form of the new model (TBD);
- The result will be used as the basis for the development of the ILRS product that will be contributed to ITRF2020;
- We have added estimation/handling of Time Biases:
  - Time biases are now modeled based on T2L2 results
  - Additional time biases from T2L2 until the end of 2017 added
  - Review of T2L2 bias from NASA OC in progress
- We will include applied R_B & T_B in SINEX file for next contribution to ITRF with their constraint information in each SINEX combined product
  - The SINEX will contain the R_B & T_B values & σ applied to each station and the applied CoM offsets for that weekly product
- Next PP will deliver low-degree gravity coefficients as a weekly product and introduce LARES as a 5th target for ITRF product support (in early 2020)

Publications

- Special Issue of the Journal of Geodesy, Vol. 93, #11, Twenty articles and the preface, 287 pages
- ILRS 2016–2018 Report in Preparation

Recent & Future Meetings Schedule

- An ILRS Technical Workshop took place in Stuttgart, Germany: 21–25 October 2019, “Laser ranging: To improve economy, performance, and adoption for new applications”
  - The ITWLR Website: http://cddis.nasa.gov/2019_Technical_Workshop
  - We held the first ILRS one-day school on laser ranging with large participation and success; expanding to 2 days seems most appropriate in the future; replies from a survey under evaluation

- An ILRS ASC meeting will take place on the Saturday, May 2, prior to EGU 2020; information and details in early January 2020
- The 22nd International Workshop on Laser Ranging (IWLR) will be held in Kunming, PRC: November 2 – 6, 2020
  - We will probably hold the ASC meeting on Nov. 1, 2020 (TBD)
  - A meeting website will be released soon, early in 2020

IVS Report The report was presented by Johannes Böhm.

The Past and upcoming VLBI meetings

- Past meeting: May 2019: TOW at Haystack, including workshop on VGOS correlation/postprocessing
- March 2020: 11th IVS GM at Annapolis; IVS stakeholder meeting directly before the IVS GM

Legacy S/X

- Continued observing program for the alignment of ICRF3 and Gaia
- R1-2020: every 2nd R1-session with 14+ station network to improve EOP determination (i.e. mimic CONT performance)
- Journal of Geodesy special issue on CONT17 in progress, 16 papers submitted

VGOS

- IVS VGOS test sessions in 2019 with up to 8–9 stations
  - EU: Ws (Wettzell, DE) – Yb (Yebes, ES) – Oe (Onsala, SE), Ow (Onsala, SE),
  - US: Gs (Goddard) – Wf (Westford) – K2 (Kokee) – Mg (MacDonald)
  - JP: Is (Ishioka)
  - Every 2 weeks, 24 h long sessions, correlated at Haystack
  - VG databases available at data centers since January 2019
- EU VGOS sessions with 4 stations
  - Ws (Wettzell, DE) – Yb (Yebes, ES) – Oe (Onsala, SE), Ow (Onsala, SE)
  - Every 2nd week, 4–6 h long sessions, correlated at Bonn
  - Focus: source structure, polarization
- VGOS intensive tests performed: K2 (Kokee) – Ws (Wettzell)
  - Correlation by several correlators for quality control

  - To be operational in 2020
- In December 2019 VGOS intensive series Oe (Onsala) – Is (Ishioka) will start
- ”VGOS operational series” (VO) will run bi-weekly with 8+ stations
- EU-VGOS series continue as well
- VGOS mixed-mode sessions planned for 2020

VGOS development

- Upcoming VGOS partner stations
- US: MacDonald (Texas, USA), quasi operational
- AU: Hobart, Katherine, Yarragadee, broadband upgrade
- EU: Ny-Ålesund twins (Svalbard, Norway), waiting for broadband receivers; Metsähovi (Finland), waiting for broadband receiver; Santa Maria (Azores), broadband upgrade
- CN: Shanghai siblings, first fringes
- RU: Zelenchukskaya, Badary, Svetloe(all Russia), need broadband upgrade
- Thailand
- Tahiti
- 2 additional Chinese “telescopes abroad”

IVS preparations for ITRF2020

- Using ICRF3, including galactic aberration
- Using new pole tide model
- Using new high-frequency EOP model
- Important topics:
  - Local-ties at VGOS-legacy co-location stations
    * Several short-baseline interferometry sessions, e.g. Kokee, Wettzell, Onsala, to tie legacy and VGOS stations
  - Thermal and gravitational deformation of telescopes

Roadmap for next ITRF generation (ITRF2020)

Zuheir Altamimi reminded about the roadmap for the generation of ITRF2020:

- The time line was agreed, there should be no delays.
- Test solutions are highly welcome.

- Seasonal signals will be in the center-of-mass frame of SLR.

Discussion

- The IERS CB will establish an FTP area to submit solutions.
- Scale issues: The Galileo-based scale by IGS need to be evaluated.

New Action Item #69.08 Establish an FTP area to submit solutions for ITRF2020.

GGOS/IERS Unified Analysis Workshop 2019

69 participants attended this workshop.

Sessions

- Opening Session: Welcome
- DORIS Systematic Errors and Biases
- GNSS Systematic Errors and Biases
- VLBI Systematic Errors and Biases
- SLR Systematic Errors and Biases
- Gravity Models for Precise Orbit Determination
- Global Space Geodesy Infrastructure
- Standards, Conventions, and Formats
- Digital Object Identifiers for Geodetic Data Sets
- Global Unified Height System
- Reference Systems and Frames
- Site Survey and Co-location
- Closing Session: Summary of sessions and discussion of recommendations

DORIS Systematic Errors & Biases

- Recommendations
  - South Atlantic Anomaly
    - Determine optimal strategy for reprocessing by holding test campaigns
      - During 2007 for Jason-1 and SPOT-5
      - During 2017–2018 for Jason-2 and Jason-3
- Scale
  - Use corrected values of antenna phase center offset (PCO)
  - Downweight low-elevation data

- Non-conservative force modeling
  - Mitigate 117-day signal in DORIS data and products by
    - Using quaternions for Jason satellites
    - Adjusting 1Cr/arc
  - Use more recent albedo and infrared models
- Notes: Imperfect thermosphere models remain a limiting factor in determining orbits of DORIS satellites at those altitudes

GNSS Systematic Errors & Biases

- Recommendations
  - Troposphere products
  - Provide results, especially from reprocessing, because of their importance

VLBI Systematic Errors & Biases

- Recommendations
  - Gravitational deformation of antennas: All VLBI antennas should have surveys done in order to determine the effect of gravitational deformation

Global Space Geodesy Infrastructure

- Recommendations
  - Inter-Service communication
    - Establish regular communication channels among the different techniques, to ensure that issues impacting each other are discussed in a timely manner
  - Sustaining space geodesy enterprise
    - Great opportunity to participate in analysis and interpretation of geodetic data
    - Encourage students and young scientists to become involved

Standards, Conventions, & Formats

- Recommendations
  - Inconsistency of tide systems
    - IAG resolve inconsistency concerning treatment of permanent tide
  - Inconsistency of numerical standards
    - Clearly document the numerical standards used for all geodetic products
    - Develop a new Geodetic Reference System (GRS20XX), based on best estimates of ellipsoidal parameters
  - Simplifying IERS Conventions

    - Encourage contributors to follow guiding principles for simplifying Conventions
  - Nutation models
    - Update amplitudes of leading terms of IAU2000
    - Test shortened series for certain operational purposes
    - Correct existing inconsistencies in precession-nutation models
    - Test available FCN models. Consider whether IERS should recommend an FCN model
    - Prioritize tasks of IAU/IAG JWG on Improving Earth Rotation Theories and Models, in order to obtain results in two years
  - High-frequency EOP models
    - Adopt Desai & Sibois / Egbert TPX08 model

Reference Systems and Frames

- Recommendations
  - IGS
    - Urge IGS to preserve alignment of products to ITRF2014 until ITRF2020 is published
  - IVS
    - Urge IVS to provide atmospheric loading corrections to right-hand side of normal equations in SINEX files
  - ILRS
    - Urge ILRS to provide range bias estimates with covariance in weekly SINEX files
  - IDS
    - Encourage IDS to mitigate DORIS-specific systematic errors that impact frame parameters (origin, scale)
  - GGFC
    - Invite GGFC to provide a unified loading model that includes all contributions (atmosphere, hydrology, and ocean) for all ITRF2020 sites

Site Survey and Co-location

- Recommendations
  - IERS Working Group
    - Continue IERS Working Group on Site Survey and Co-location
    - Set objectives
    - Clarify reporting expectations
    - Engage IAG Services in activities of the Working Group
    - Hold annual meetings

    - Disseminate knowledge of antenna deformation measurements
    - Issue guidelines
    - Liaise with the tide gauge community
    - Distribute publications related to the activities of the Working Group
  - Deflection of vertical
    - Understand deflection-of-vertical contribution to local tie measurements
  - Prioritize site surveys
    - Survey sites that have never been done before re-surveying those that have

(For a more detailed report, see Section 4 of the IERS Annual Report 2019.)

GGOS report Changes to GGOS Structure

- Chair
  - Basara Miyahara, GSI, Japan
    - Appointed by IAG Executive Committee following search conducted by GGOS
  - Also known as GGOS President (adopted by IAG EC)
    - The President of GGOS is the Chair of the GGOS Coordinating Board
    - The President of GGOS is also known as the Chair of GGOS
- Vice Chair
  - Laura Sánchez, DGFI-TUM, Germany
    - Selected by GGOS Chair (Basara Miyahara)
    - Approved by GGOS Coordinating Board
- Consortium
  - Representatives of Services, Commissions, ICCs, Affiliates
  - 36 members in total
  - BIPM no longer represented since it is no longer considered to be an IAG Service
- Coordinating Board
  - Consortium elects
    - 4 Service representatives, 2 Commission and ICC representatives, 1–2 Affiliate representative(s)
    - Representatives elected to CB must be members of the Consortium

    - Except for Affiliate representative(s) which must be member(s) of Affiliate(s)
  - Coordinating Board elects
    - 3 members-at-large to increase diversity (geographic, gender, discipline)

- Executive Committee
  - Chair appoints
    - 2 voting members of CB to be CB representatives to Executive Committee
    - 1 represents the Services
    - 1 represents the Commissions
  - Subject to approval by Coordinating Board

- Focus Area on Geohazards
  - Application of geodetic techniques to improve tsunami warning
  - John LaBrecque intends to resign as lead, search for new lead ongoing

- Focus Area on Sea Level
  - Application of geodetic techniques to mitigate or adapt to sea level change hazards
  - Tilo Schöne resigned as lead effective 01 October 2018, search for new lead and/or topic of Focus Area not successful
  - Has been dissolved

- Representatives to other organizations
  - International Earth Rotation and Reference Systems Service
    - Richard Gross (JPL, USA)
  - IAG Inter-Commission Committee on Theory
    - Michael Schmidt (DGFI-TUM, Germany)
  - IAG Inter-Commission Committee on Climate Research
    - Mayra Oyola (JPL, USA)
  - IAG Inter-Commission Committee on Marine Geodesy
    - Marie Francoise Lalancette-Lequentree (SHOM, Brest, France)
    - Yusuke Yokota (University of Tokyo, Japan)
  - Committee on Earth Observation Satellites (CEOS)
    - GGOS is an Associate Member of CEOS
    - Allison Craddock and Richard Gross are the GGOS representatives to CEOS
  - All representatives approved by GGOS Coordinating Board
  - Group on Earth Observations (GEO)

        * IAG is a Participating Organization in GEO and a member of its Program Board
        * Allison Craddock and Richard Gross are the IAG representatives to GEO

- Bureau of Products and Standards
  - Working Group on ITRS Standards for ISO TC 211
    * Will not continue because work has been completed
  - Working Group on the Establishment of the GGRF
    * Will not continue because work has been completed
  - Working Group "Towards a consistent set of parameters for the definition of a new GRS"
    * Will be established with Urs Marti as Chair
- Coordinating Office
  - Director
    * Martin Sehnal replaces Helmut Titz as Director
  - Working Group on DOIs for Geodetic Data Sets
    * Newly formed
    * Chaired by Kirsten Elger, GFZ, Germany
    * From one to four representatives from GGOS, IERS, IGS, IVS, IDS, ILRS, IGFS and four other representatives
    * 22 members in total
    * Meeting at AGU: Monday, December 9, 2019

Past Meetings

- Unified Analysis Workshop
  - Jointly organized by GGOS and IERS; 2–4 October 2019; IPGP, Paris, France
- GGOS Days 2019
  - Held in conjunction with SIRGAS Symposium; 12–14 November 2019; IBGE, Rio de Janeiro, Brazil
- American Geophysical Union
  - GGOS session merged with real-time GNSS session
    * Title: Real-Time High-Accuracy GNSS Positioning: Error Modeling, Applications, and Incubation of New Initiatives
    * Orals: G13A; Monday, December 9, 2019
    * Posters: G23B; Tuesday, December 10, 2019

Future Meetings

- European Geosciences Union, 2020
  - GGOS session: The Global Geodetic Observing System: Improving Infrastructure for Future Science
- GGOS Days 2020: 5–9 October 2020; TU Munich (tentative)

IERS Conventions
Status report on the update process

The report was presented by Nick Stamatakos.

Review of Changes to IERS Conventions Centre

- A letter sent to the IERS and signed by the Commanding Officer of USNO indicated that the servers maia.usno.navy.mil was undergoing modernization and would be offline beginning 24 October 2019.
  - The Conventions web site and ftp sites were hosted at the maia server.
  - Expected completion of work and return to servers is estimated 30 April 2020.
- The site http://iers-conventions.obspm.fr remains available for all users to use for conventions related issues.
- USNO is looking at options / suggestions for where to also host the Conventions in the interim between the shutoff date and the new date.
  - Version tar-balls may be soon available at http://www.usno.navy.mil. However, it is not feasible to host the entire conventions at this site.

Status of IERS Conventions Centre re-write staff and Chapter numbering

- Michael Efroimsky has generously volunteered to be the Editor-in-Chief of Chapter 10. If there are no objections, then the co-chairs will officially make him the Editor in Chief.
- We need more volunteers for some positions.
- There is a change in the IERS Conventions 2010 and IERS Conventions 2022 Chapter numbering.

IERS Conventions Template and Conventions Rewrite Guidelines

- Proposed Conventions template finished by Maria Davis of IERS Conventions staff.
  - Template is under review but we hope to have an official template for users very soon.
  - A copy of the proposed template is available upon request.
- Proposed Rewrite Guide and Rewrite Example has been approved by IERS Conventions co-chairs on 4 December 2019.
  - Will be emailed to all participants of IERS Conventions rewrite staff in mid December.
  - The rewrite guide and Rewrite Example can be provided upon request to the IERS DB.

  - Rewrite Example is a simplified, slimmed down, easier-to-follow version of the latest Chapter 5 from IERS Conventions 2010; it is *not* intended to be a rewrite of Chapter 5 for the IERS Conventions 2022.
  - The number of pages in the Rewrite example was about $\frac{1}{2}$ of what it is today.

IERS Conventions Centre Configuration Management Training / Discussions

- Conventions Rewrite Guidelines communication will be via SLACK or other arrangements.
  - Planned training in Oct 2019 was postponed due to lack of travel funding.
  - GitLab training / discussion is being rescheduled to do via netmeeting or internet meeting.
- Conventions rewrite guidelines and communication will be via SLACK instant messaging, phone calls, or netmeetings.
  - If there are questions or concerns with the guidelines, we will certainly discuss issues and concerns with all involved.
- IERS Chapter 5 example re-write details were presented at UAW in Oct 2019.

New Action Items

#69.09 Provide tar-ball, put this also to IERS website
#69.10 Provide LaTeX template for TN
#69.11 Store LaTeX source code of new conventions at IERS CB

EOP Products

Report from Earth Orientation Centre

This report was not presented.

Report from IERS Rapid Service / Prediction Centre

This report was presented by Christine Hackman.

24 October 2019 changes to IERS RS/PC product distribution

- The ftp servers/websites on which USNO distributes IERS products (RS/PC, Conventions) were shut down per US Navy direction 24 Oct 2019
- We advised users (per the above direction) that the estimated return-to-service date was 30 April 2020
- Impacted users are/were advised to fill out a requirements form at https://www.usno.navy.mil, or to contact USNO PAO Mr. Geoff Chester at Geoff.chester@navy.mil; +1 (202) 762 1438
- Nick Stamatakos + team have been hard at work developing new distribution channels and handling user requests/comments

- IERS RS/PC products currently available at:
  - CDDIS: daily EOPs, Bulletin A (ftp://cddis.gsfc.nasa.gov/pub/products/iers)
  - IERS: daily EOPs, Bulletin A (ftp://ftp.iers.org/products/eop/rapid/)
  - Possible: Navy open website
- Future:
  - Official return to stock date: 30 April 2020
  - Advise building margin into that date when planning
  - We will advise when completion date/URLs/etc. finalized
  - Huge thank you to the IERS RS/PC team, CDDIS and IERS CB for assistance in product distribution

IERS RS/PC staff presentations, activities

- Presentations since DB Meeting # 67
- EGU GA 2019 Poster Session G3.1 (Thu 11 Apr 2019): N. Stamatakos, D. McCarthy, D. Salstein, Investigating Possible Combinations of Atmospheric, Ocean, and other Geophysical Angular Momentum Data to Improve Operational Earth Orientation Information
- 24th EVGA Meeting (17–19 Mar 2019; Gran Canaria, ES) oral presentation O303: M. Davis, M.S. Carter, C. Dieck, The IERS Rapid Service / Prediction Center UT1–UTC Combined Solution: Present and Future Contributions
- Unified Analysis Workshop (2–4 Oct 2019; Paris, FR): Stamatakos to represent IERS, deliver RS/PC presentation
- Journées 2019 (7–9 Oct 2019; Paris, FR): Stamatakos, Davis to attend, conduct IERS Conventions workshop after European VLBI Group for Geodesy and Astrometry

The IERS RS/PC team (besides Christine Hackman):

- Mr. Nick Stamatakos, RS/PC Production Director & Lead Project Scientist
- Ms. Merri Sue Carter
- Mr. Nathan Shumate
- Ms. Maria Davis
- Their hard work is gratefully acknowledged.

New Action Items

#69.12 Remove selection of Bulletin A from subscription form at IERS website
#69.13 Reconsider the need of email version of Bulletin A

ICRS/ICRF report
Status of ICRF-3 and next steps for the IERS

The report was presented by Bryan Dorland.

ICRF3 Status/Update

- ICRF3 adopted by IAU on 1 January 2019
- Key accomplishments:
  - Multi-wavelength (S/X, K, X/Ka)
  - Majority of sources much more accurate (3x improvement)
  - Approximately 30% more sources
  - Available now via IERS ICRS Centre website
- Plans:
  - ICRF3 is now in “maintenance” phase
    - Focus is on improving current positions, source quality
    - Looking at positions shifts between frequencies
  - ICRF3 team is working with Gaia team towards defining an integrated radio/optical reference frame
    - Likely to be proposed as a working group to IAU
  - USNO, Paris Observatory are collaborating on AGN monitoring program (FRAMEx) for reference frame sources

S/X-band Status

- S/X ICRF3 maintenance work being led by NASA/GSFC + USNO (David Gordon (GSFC), Alan Fey (USNO), Lucas Hunt (USNO))
- USNO VLBA time allocation used for X/S observations of under-observed and weak sources in 3 proposals
  - Made to improve ICRF3 and for ICRF3 maintenance
  - Most target sources too weak to be observed in regular IVS sessions
- Observations:
  - 20 UF001 sessions – 2017
  - 24 UG002 sessions – 2018
  - 24 UG003 sessions – 2019–2020
    - 14 analyzed to date

K-band Status

- K-band work being led by HartRAO & JPL with USNO VLBA time allocation

- VLBA dual polarization (RCP/LCP) at 4 Gbps operational
- Demonstrated 4 Gbps imaging
- Improving ion calibration from GNSS data
- HartRAO-Hobart observations continue
- HartRAO improving pointing
- Preparing for Italy-South Africa baselines to improve Declinations
- Work in progress to add 50-meter LMT to VLBA sessions
- See DeWitt et al., K-band Roadmap, Journées 2019, https://syrte.obspm.fr/astro/journees2019/journees_pdf/SessionIII_1/DE%20WITT_Aletha.pdf

X/Ka-band Status

- X/Ka work being led by JPL
- Observations continue with NASA's DSN at 2Gbps
- ESA's Malargüe Argentina station upgraded:
  - 256 Mbps to 896 Mbps single band to dual band X/Ka
  - GNSS ion calibrations no longer needed for this station
- JAXA is close to completing its 54-meter antenna at Misasa (near Usuda).
- First Ka fringes with JAXA expected 1st half 2020.
- Baseline from Japan to Australia expected to improve Declinations.
- Jacobs et al., Journées, 2019 give more details: https://syrte.obspm.fr/astro/journees2019/journees_pdf/SessionIII_1/JACOBS_Christopher.pdf

Optical Reference Frame Status

- Current visible standard: Gaia DR2 (2018)
  - Approx. 1.6 Gsources, mG = ~4.5–20.7
  - 1 mas accuracy for bright to mid-range sources
  - Tied directly to AGN (mid-IR AGN)
  - Next full release: DR3, 2nd half of 2021
- USNO producing bright star catalog m_v5 to supplement Gaia
  - Combination of URAT (SH) + UBAD (NH)
  - April 2020 timeframe
- Future: LSST to produce optical astrometry to mg~27

  - 2020-2030 timeframe
  - Southern ~60% of sky only
- NIR (J, H, and K bands)
  - VISTA survey (southern hemisphere)
  - UKIRT survey (northern hemisphere)
    - Expected completion ~2021–22

ICRF-related Research Work

- USNO and Paris Observatory are collaborating on the Fundamental Reference Frame AGN Monitoring Experiment (FRAMEx)
  - Utilize observing assets around the world to observe and monitor reference frame objects to best characterize astrometry and photometry, identify excellent reference frame sources, and better constrain underlying astrophysics
  - Initial observing is utilizing VLBA, USNO telescopes, SWIFT, VLA

Other items

- October 2019, Paris Observatory hosted the 2019 Journées meeting
  - 118 participants from around the world; discussions covered TRF, CRF and EOPs
  - Next meeting will be in St. Petersburg in 2020 and will focus on time
- USNO websites taken offline for major upgrades; expected back online in mid-2020
  - IVS Analysis Center, IVS Source Structure Center, IERS ICRS Center, IAU Double Star Center
- Paris Observatory continues to fully support IERS ICRS needs
- Paris Observatory, USNO and Paris Institute for Astrophysics is hosting a workshop on AGN/Reference Frames in June 2020 at Paris Observatory

Other reports

IERS WG on Site Survey and Co-location and relationship with GGOS BNO

The report was presented by Mike Pearlman.

Mike Pearlman gave an overview of the work of the GGOS Bureau of Networks and Observations (BNO) and its relations to the IERS Working Group on Site Survey and Co-location. This WG provides a large body of valuable work that is a significant contribution to GGOS.

Proposed change in IERS World Data System membership type

The report was presented by Christine Hackman.

- C. Hackman became IERS ISC World Data System (WDS) representative Fall 2018. (Formerly B. Richter)
- IERS WDS membership had expired
- Renewal as Regular Member required complex IT certification procedure, entry into which cost 1000 euro, and which needed to be renewed every three years
- Becoming Network Member skips above complex procedure, is free. IVS, IGS are network members.
- Per November 2019 DB polling C. Hackman will apply for Network Membership.
- If you have significant WDS involvement, please let C. Hackman know.

Annual Report 2018

The AR 2017 was printed and distributed in spring. For the AR 2018, 16 contributions have been received and edited, the last 4 contributions are in preparation.

New Action Items

#69.14 Finalize IERS AR 2018.

Next DB meeting (#70)

The next DB meeting (half-day meeting) will take place on Sunday, May 3, 2020, before the EGU in Vienna.

New Action Items

#69.15 Prepare IERS DB meeting #70.

Daniela Thaller, Sabine Bachmann, Wolfgang R. Dick