Joint Working Group on the Consistent realization of TRF, CRF, and EOP

IAG Sub-Commission 1.4 joint with IAU Commission A2 and IERS

Terms of Reference

Considering the **IUGG Res. 3 (2011)**[1] urging, the **IAG Res. 2 (2019)**[2] recommending that "*highest consistency between the ICRF, the International Terrestrial Reference Frame (ITRF), and the Earth Orientation Parameters (EOP) […] should be a primary goal in all future realizations*" and the **IAG Res. 5 (2019)**[2] resolving that *"[…] the EOP, and related theories, equations, and ancillary models governing their time evolution, must be consistent with the reference frames and the resolutions, conventional models, products, and standards adopted by the IAG and its components,[…]"*.

Noting that many applications, e.g. in geodesy, astronomy, or navigation, rely on the consistency between terrestrial (TRF) and celestial (CRF) reference frames and EOP. The EOP connect the CRF and TRF in terms of their orientation and rotation differences. For Earth system science based on EOP the consistency is a crucial characteristic. The EOP can be considered as physically meaningful only if determined consistently with the reference frames. The quality requirements for the applications including societal contributions were addressed through the IAG GGOS[3] as 1 mm accuracy and 0.1 mm yr^{-1} stability, i.e. about 33 μas and 3.3 μas yr^{-1} in terms of EOP expressed as angle / rotation seen on the Earth surface from the geocenter. Today's reference frames and EOP do not meet the quality requirements.

Noting that currently, TRF and CRF are determined independently of each other. The releases of the terrestrial and celestial frames do not happen at the same time. Individual Working Groups (CRF) or Combination Centers (TRF) compute the frames through reprocessing / combination efforts every five to ten years. In this way, the frames are computed based on different input data and on different analysis models in case of updates of the conventional models. Following independent approaches, the consistency of a new release of one of the frames can only be ensured to the last release of the respective other frame. If the frames are not fully consistent, the EOP based on these frames cannot be consistent.

Currently, DORIS, GNSS, SLR and VLBI observations are combined with local tie vectors at co-location sites for the TRF computation, whereas the CRF is directly connected to the TRF through VLBI alone. This situation does not change when applying alternative data analysis procedures. Nevertheless, as VLBI networks are relatively sparse in comparison to multi-technique networks, it has been shown that the terrestrial part of Earth orientation (polar motion) significantly improves through the combination with satellite-based data. The celestial part of Earth orientation, dUT1 (UT1~ERA) and CPO, determined by VLBI observations only – and possibly by LLR data –, can in turn improve due to correlations between the EOP within the data analysis. CRF realizations in other wavelengths are currently aligned to the X/S VLBI CRF and thus, do not contribute to the orientation of ICRF3. Nevertheless, they present an independent option for validation. Apart from the rotation and spin, catalogues based on Gaia (optical) data releases can provide independent insight into deformations and other technique-dependent systematic errors and thus present another independent option for validation of the VLBI-based CRF.

Noting that for geodetic and astrometric data analyses and other purposes, the reference frames and the EOP are customarily applied in prediction mode. Accordingly, values have to be given beyond the data time span considered for the reference frame realization. As long as no

[1] http://www.iugg.org/resolutions/IUGG%20Resolutions%20-%20XXV%20GA%20-%20Melbourne%20(English).pdf
[2] https://iag.dgfi.tum.de/fileadmin/IAG-docs/IAG_Resolutions_2019.pdf
[3] H.-P. Plag & M. Pearlman (2009) Global Geodetic Observing System, Springer, 10.1007/978-3-642-02687-4

significant non-linearity occurs, the global coordinates and reference point displacements serve very well for the prediction of the position into the future. The predicted EOP require consistency to the frames and to the reprocessed EOP at the same time. It is impossible to fulfill both requirements, when new reference frame releases become available.

Objectives
Addressing the abovementioned issues, the joint working group will

- compute multi-technique CRF-TRF solutions together with EOP in one step, which will serve as a basis to
- quantify the consistency of the current conventional reference frames and EOP as well as to
- assess the consistency of reprocessed and predicted EOP.

The joint working group will further

- investigate the impact of different analysis options, model choices and combination strategies on the consistency between TRF, CRF, and EOP,
- study the differences between multi-technique and VLBI-only solutions,
- study the possible contributions to EOP and frame determination by the LLR technique,
- study the differences between EOP derived by VLBI solutions at different radio wavelengths in cooperation with the IAU Division A WG Multi-waveband Realisations of International Celestial Reference System,
- study the differences between EOP derived by VLBI solutions improved through Gaia (optical) data in cooperation with the proposed IAU Division A WG on VLBI – Gaia topics,
- study the effects on the results, when different data time spans are considered,
- compare the practically achievable consistency with the quality requirements deployed by IAG GGOS; and
- derive conclusions about future observing systems or analysis procedures in case the quality requirements cannot be met with the current infrastructure and approaches.