

3.3 Analysis Coordinator

1. Introduction In this report we outline the activities of the Analysis Coordinator during 2012. The main activities were continued planning for the IERS Retreat to be held in May 2013, activities in the Sub-Commission 1.1 Coordination of Space Geodetic Techniques, and discussions of the future of leap seconds.

2. Planning for the 2013 IERS Retreat The theme of the retreat will be to focus on maintaining the IERS's core role of the generation of regular, high accuracy products. The aims of the retreat are to establish directions for IERS over next decade that will ensure this core role is met. Initial planning had been to hold the retreat in Vienna in association with the EGU meeting in April. For a variety of logistical reasons this was not possible and now the retreat is planned to held in conjunction with the IERS Workshop on Local Surveys and Co-locations at University Paris-Diderot, Amphitheatre Alan Turing Paris, France, May 21–22, 2013 with the retreat being held May 23–May 25 at the same venue.

2.1 Retreat organization Retreat will be held over two days during which 7 topics and a summary and recommendations session will be covered. There will be 4 sessions per day with 2 session in the morning and 2 sessions in the afternoon. Each session will 1.5 hours. The sessions will start with a 30-minute presentation that will address the issues associated with each topic. The remaining hour of the session will be discussions and the development of recommendations that will be presented at the board meeting immediately following the retreat. Each session will be organized by two people, one of whom will make the presentation and the other will take notes during the discussions. Both organizers will write the final report and present the recommendations from their session. As the plan for the retreat develops in more detail, some of the lengths of the sessions may be altered to allow more discussion of the most critical topics.

The target of the workshop is to determine what can be done, determine if it is necessary and, if necessary, how do we proceed. The overall theme has to be maintaining the quality and regularity of the IERS' products and to ensure that the service continues to meet the needs of all of its users. The path forward will be developed in detail outside of the retreat. Most likely a set of working groups will be established that will determine how to implement the recommendations of the retreat. These working groups are likely to meet over the next year.

2.2 Sessions

1. *Move towards “real-time” products* (products that support low latency (1-sec) applications of geodetic data; eVLBI incorporation). The theme to be addressed here is the need for low latency high accuracy EOP for the real-time GNSS applications being developed. A current trend in these applications is the use of precise point positioning methods, as opposed to differential positioning, and these PPP methods need to define the terrestrial reference frame through the orbits and clocks on the GNSS satellites. Currently this is a challenging task and this session will examine how to best deploy IERS resources to achieve these aims.

Chaired by Harald Schuh and Jens Wickert

2. *Rigorous combined products* (e.g., services are generating EOP and terrestrial RF simultaneously; IERS is simply averaging EOP values). This topic is considered critical to the future of the IERS and will occupy two sessions because of its great impact potentially on the service. Of importance here is the consideration of inclusion of both the terrestrial (ITRF) and celestial reference frames (ICRF). The discussion here will focus on how to assess the need for rigorous combination, how best to achieve such combinations, and how to determine whether we need to proceed with such techniques. It is possible that different methodologies would be used for different levels of service. The rapid service for example due to speed requirements might retain the current types of combinations while the Bulletin B products might be generated through a rigorous combination. The impact of this type of combination on the ICRF and nutation must be considered. The implementation of a rigorous combination approach also has major impact on the services contributing to the IERS and the path forward will need to establish the impact on the services as well. It will also need to be established how we blend pre-spaced geodesy measurements with the conventional astronomical ones. This session will be allotted two time slots.

Chaired by Zuheir Altamimi and Manuela Seitz

3. *Long-term stability and parameterization of the reference frame*. This session will address how to parameterize the ITRF. With the GGOS aims of defining an ITRF accurate to 1 mm and 0.1 mm per year, serious consideration has to be given to precisely how to define such a system when there are unknown non-secular components to the motions of all of the ITRF sites. The session will outline the steps that need to be taken in understanding how to incorporate such phenomena as earthquake co-seismic and post-seismic deformations, anthropogenic and natural loading phenomena, and other deviations from secular motion. Also to be addressed is how

to approach the appropriate parameterization of variations in the ICRF. Consideration of source structure variation and source evolution needs to be addressed. The impact on the services will need to be assessed.

Chaired by Daniela Thaller and Xavier Collilieux

4. *Next Generation of models and Center-of-Mass products.* How to establish need (improvements needed in diurnal/semi-diurnal EOP, tidal loading)? This session will address the types of model updates that should be included in the IERS conventions, and how to determine the need for these updates. The inclusion of new IERS products such as a center of mass product will also be discussed. Models and new products should also consider the celestial component of the reference systems as well.

Chaired by Richard Gross and Tonie van Dam

5. *EOP prediction improvements.* This session will address the need for EOP prediction accuracy and how best to achieve these accuracies and determine the timescales over which predictions need to be made. The users of these prediction products will also need to be determined and their requirements established.

Chaired by Brian Luzum and Christian Bizouard

6. *Unification of product formats.* This session will cover two broad areas. One will be the unification of the IERS product formats to allow easy comparison and combination. The other area will be establishing modern standards for product formats such as the metadata content and how to express that.

Chaired by Thomas Herring and Laurent Soudarin.

7. *Establish mechanisms that allow changing contributions.* The aim of this session is to provide a mechanism for evolving the IERS as time goes on and needs change. During the last retreat, over a decade ago, new components of the IERS were established. Since then these components have stayed in place and there is no formal mechanism for changing the components of the IERS. This session will look at how best to establish such procedures so that the IERS can evolve more quickly between retreats.

Chaired by Bernd Richter and Chopo Ma

8. *Summary and Recommendations.* The final session will summarize the retreat and develop a set of synthesized recommendations to be passed on to the full board at the IERS board meeting immediately following the retreat. All members of the retreat will be involved in this discussion and the Chair of the IERS and the Director of its Central Bureau will lead it.

Plans are in place for the retreat to be held and next year's report will summarize the outcome of the retreat.

3. International Association of Geodesy (IAG) Activities

The IERS Analysis Coordinator has been involved in the IAG Sub-Commission SC 1.1 Coordination of Space Techniques. The space geodetic observation techniques, including Very Long Baseline Interferometry (VLBI), Satellite and Lunar Laser Ranging (SLR/LLR), Global Navigation Satellite Systems (GNSS) such as GPS, GLONASS, GALILEO, and COMPASS, and the DORIS system, as well as altimetry, InSAR, LIDAR, and the gravity missions, contribute significantly to the knowledge about and the understanding of the three major pillars of geodesy: the Earth's geometry (point coordinates and deformation), Earth orientation and rotation, and the gravity field as well as its time variations. These three fields interact in various ways and they all contribute to the description of processes in the Earth System. Each of the space geodetic techniques contributes in a different and unique way to these three pillars and, therefore, their contributions are critical to the Global Geodetic Observing System (GGOS).

Sub-Commission 1.1 coordinates efforts that are common to more than one space geodetic technique, such as models, standards and formats. It shall study combination methods and approaches concerning links between techniques co-located at fundamental sites, links between techniques co-located onboard satellites, common modeling and parameterization standards, and perform analyses from the combination of a single parameter type up to a rigorous combination on the normal equation (or variance-covariance matrices) as well as at the observation level. The list of interesting parameters includes site coordinates (e.g. time series of combined solutions), Earth orientation parameters, satellite orbits (combined orbits from SLR, GPS, DORIS, altimetry), atmospheric refraction (troposphere and ionosphere), gravity field coefficients, geocenter coordinates, and others. One important goal of SC 1.1 will be the development of a much better understanding of the interactions between the parameters describing geometry, Earth rotation, and the gravity field as well as developing methods to validate combination results, e.g., by comparing them with independent geophysical information.

To the extent possible SC 1.1 should also encourage research groups to develop new observation techniques connecting or complementing the existing set of measurements.

Sub-Commission 1.1 has the task to coordinate the activities in the field of the space geodetic techniques in close cooperation with GGOS, all of the IAG Services, and with COSPAR.

3.1 SC 1.1 Objectives

The principal objectives of the scientific work of Sub-Commission 1.1 in collaboration with GGOS are the following:

- Study systematic effects of and between space geodetic techniques.
- Develop common modeling standards and processing strategies.
- Comparison and combination of orbits derived from different space geodetic techniques.
- Explore and develop innovative combination aspects such as, e.g., GPS and VLBI measurements based on the same high-accuracy clock, VLBI observations to GNSS satellites, and the combination of atmospheric information (troposphere and ionosphere) of more than one technique.
- Establish methods to validate the combination results (e.g., with global geophysical fluids data).
- Explore, theoretically and practically, the interactions between the gravity field parameters, EOPs, and reference frames (site coordinates and velocities plus extended models), improve the consistency between these parameter groups, and assess, how a correct combination could be performed.
- Study combination aspects of new geodetic methods such as Synthetic Aperture Radar (InSAR), LIDAR and optical image analysis methods.

Additional objectives of Sub-Commission 1.1 are:

- Promotion of international scientific cooperation.
- Coordination of common efforts of the space geodetic techniques concerning standards and formats (together with the IERS and GGOS).
- Organization of workshops and sessions at meetings to promote research.
- Establish bridges and common activities between SC1.1 and the IAG Services.

3.2 Links to Services

Sub-Commission 1.1 will establish close links to the relevant services for reference frames, namely Global Geodetic Observing System (GGOS), International Earth Rotation and Reference Systems Service (IERS), International GPS Service (IGS), International Laser Ranging Service (ILRS), International VLBI Service for Geodesy and Astrometry (IVS), and International DORIS Service (IDS) and the International gravity services.

3.3 Working Groups

WG 1.1.1: Creation of common geodetic coordinate time series

Chair: Laurant Soudarin (Laurent.Soudarin@cls.fr)

This working group, formed in collaboration with the IERS, will explore methods for creating position time series for the different geodetic techniques so that they can be displayed in a common format and consistent reference frame. The working group will explore, in the format and interfaces for time series. A common tool that can be used to display and compare these results will also be developed. The working group will have a representative from each technique combination center, a representative from the ITRS Center, and from the GGOS portal. There should also be representatives from the geophysics/geodynamics and oceanography communities who are seen as the primary users of this product. The final product of this working group will be recommendations on how the geodetic community should proceed in developing common positional time series and making such results readily available to the broad scientific community.

WG 1.1.2: Investigate methods for merging geodetic imaging systems (InSAR, LIDAR and optical methods) into a geodetic reference system

Chair: Sebastian Le Prince

With the development of new methods for studying surface deformations, such as InSAR, LIDAR and optical methods, this working group will explore the methods that should be used to ensure that these deformation measurements are made in a well-defined geodetic reference frame. Issues to be addressed include how to establish the reference frame for these classes of measurements, how to ensure the long-term stability of the reference frame, and to make recommendations for changes in future systems that would allow more robust reference frame realization.

4. Discussions of the future of Leap Seconds

Brian Luzum has reported the conclusion of the conference on UT1 redefinition. His report has been included in the IERS April 2012 directing board meeting. Participants mainly came from the International Telecommunication Union and its relevant Study Groups and Working Parties and from other international organizations with interests in this subject. The presentations are available at <http://futureofutc.org/program/> .

Wolfgang Dick summarized the consequences of an UT1 redefinition for the IERS:

- The outcome of the official ITU-R vote in January 2012 is not certain. 70% of Yes-votes necessary of attending people on national base. If successful, there would be no more leap seconds after 2019.

3 Reports of IERS components

- XML format was suggested for the IERS products to make them more user friendly and more compatible with modern software applications.
- It could be possible to continue to publish pseudo-leap-seconds at IERS if the leap seconds were to be abolished. These pseudo-leap-seconds would show how far UTC had drifted from the conventional definition of UT1.
- UTC will continue to be linked to the rotation of the Earth since the difference UT1–UTC will be available at the level of microseconds from IERS.
- IERS needs to make its products better known and understood.

A press release should be prepared to inform the IERS community about the result of the vote. In the case that leap seconds are to be abolished, the IERS should establish an IERS leap second service. At this time the future of leap seconds is unresolved with the status quo of introducing leap seconds to keep UTC with ~0.5 seconds of UT1 will continue. Future international agreements will be needed if the leap seconds are to be eliminated and for UTC to become a continuous time series.

Thomas Herring