Director's Report on the Activity and Management of the International Bureau of Weights and Measures

Supplement: Time Department

(1 January 2014 – 31 December 2014)

March 2015

Bureau International des Poids et Mesures

BIPM Time Department
Director: E.F. Arias
(1 January 2014 to 31 December 2014)

1. International Atomic Time (TAI), Coordinated Universal Time (UTC) and Rapid UTC (UTCr)
(E.F. Arias, A. Harmegnies, Z. Jiang, H. Konaté, W. Lewandowski[1], G. Panfilo, G. Petit and L. Tisserand)

The reference time scales, International Atomic Time (TAI) and Coordinated Universal Time (UTC), are computed from data reported regularly to the BIPM by the various timing centres that maintain a local UTC; monthly results are published in *Circular T*. The UTC rapid solution (UTCr) is published every Wednesday at 18 h UTC at the latest. All information related to the publication of UTC and UTCr can be accessed at www.bipm.org/en/scientific/tai/ftp_server/introduction.html.

The *BIPM Annual Report on Time Activities for 2013*, volume 8, provides the definitive results for 2013 and is available on the BIPM website at www.bipm.org/en/bipm/tai/annual-report.html.

2. Algorithms for time scales (G. Panfilo, G. Petit, A. Harmegnies, L. Tisserand and F. Parisi[2])

The algorithm used to calculate the time scales by the Time Department is an iterative process that starts by producing a free atomic scale (*Échelle atomique libre,* EAL) from which TAI and UTC are derived. Research into time-scale algorithms is ongoing in the department, with the aim of improving the long-term stability of EAL and the accuracy of TAI.

The revision of the algorithm was completed at the start of 2014 with the official introduction of the new clock weighting algorithm in UTC. The new procedure is based on the concept of clock frequency predictability. The weight assigned to a clock reflects its predictability rather than its stability, as was the case in the previous procedure. The result is a more balanced distribution of weights between caesium clocks and hydrogen masers and enhances the influence of the hydrogen masers in the ensemble. An improvement in the short- and long-term stability of EAL is foreseen by applying the new weighting algorithm.

Work started on updating the method to evaluate the uncertainties of [UTC-$UTC(k)$] reported in Section 1 of *Circular T*. The current algorithm provides underestimated values for the pivot laboratory (currently PTB) which does not correspond to real physical values. This is due to the fact that some correlations are not taken into account.

2.1 EAL stability

Some 88 % of the clocks used in the calculation of time scales are either commercial atomic clocks with high performance caesium tubes or active hydrogen masers. A weighting procedure was developed to guarantee the long-term stability of EAL. To prevent domination of the scale by a small number of very stable clocks, a maximum relative weight is used each month which depends on the number of participating clocks. On average, about 10 % of the participating clocks were at the maximum weight during 2014; almost all of these were hydrogen masers. The total weight of hydrogen masers and caesium clocks is about 50 % while the number of these clocks in the ensemble is significantly different, about 300 caesium clocks and 100 hydrogen masers. This means that the time scale implicitly relies on the hydrogen masers in the short term and on caesium clocks in the

[1] Retired on 1 May 2014
[2] Department of Mathematics, University of Torino, Italy, on a six-month secondment from 1 November 2014

long term, which was an aim of the new weighting procedure. Both the short- and long-term stability of EAL are expected to improve by 20 %. The stability of EAL at the end of 2014, expressed in terms of an Allan deviation, is about three parts in 10^{16} for averaging times of one month. A long-interval estimation of the frequency stability of EAL after the introduction of the new weighting procedure indicates that it will decrease by up to 1.8 parts in 10^{16} over the next few years.

2.2 TAI accuracy

To characterize the accuracy of TAI, estimates are made of the relative departure, and its uncertainty, of the duration of the TAI scale interval from the SI second, as produced on the rotating geoid, by primary and secondary frequency standards. Since January 2014, individual measurements of the TAI frequency have been provided by eleven primary frequency standards, including nine caesium fountains (LNE-SYRTE FO1, LNE-SYRTE FO2, NIST F1, NIST F2, IT CSF2, SU CSFO, NPL CSF2, PTB CSF1 and PTB CSF2), and by a rubidium secondary frequency standard (LNE-SYRTE FO2Rb). Reports on the operation of the primary and secondary frequency standards are regularly published on the BIPM website and collated in the *BIPM Annual Report on Time Activities*.

Since January 2014, the global treatment of individual measurements has led to a relative departure of the duration of the TAI scale unit from the SI second on the geoid ranging from $+0.46 \times 10^{-15}$ to -0.99×10^{-15}, with a maximum standard uncertainty of 0.28×10^{-15}. No steering corrections have been applied since October 2012, demonstrating the positive impact of the new algorithms on the accuracy of TAI.

2.3 Independent atomic time scales: TT(BIPM)

TAI is computed in 'real-time' and is subject to operational constraints; as a result it does not provide an optimal realization of TT, the time coordinate of the geocentric reference system. The BIPM therefore computes an additional realization, TT(BIPM), in post-processing, which is based on a weighted average of the evaluation of the TAI frequency by the primary frequency standards. The Time Department provided an updated computation of TT(BIPM), known as TT(BIPM13), valid until December 2013, which had an estimated accuracy of about 2-3 parts in 10^{16} over recent years. Moreover, the Time Department provides a formula to extend TT(BIPM13) based on the most recent TAI computation. Such an extension is useful for pulsar analysis pending on the yearly updates of TT(BIPM). Studies to improve the computation of TT(BIPM) are ongoing, in order to keep it in line with improvements in the primary and secondary frequency standards.

2.4 Local representations of UTC in national laboratories as broadcast by the GNSS

The Time Department continues to calculate and publish the differences between the predictions of UTC(USNO) and UTC(SU) (as broadcast by GPS and GLONASS) and UTC in BIPM *Circular T*. As a consequence of the alert made by the BIPM on the offset of GLONASS time and the broadcast prediction of UTC(SU) with respect to UTC, work is under way with the VNIIFTRI, Russian Federation, and the GLONASS authorities on the absolute calibration of a BIPM receiver and the receiver at the AOS, Poland, that provides data for the offset evaluation.

3. Primary frequency standards and secondary representations of the second (E.F. Arias, G Panfilo, G. Petit and L. Robertsson)

Members of the BIPM Time Department actively participate in the work of the CCL-CCTF Frequency Standards Working Group (WGFS), and the Consultative Committee for Time and Frequency (CCTF) Working Group on

Primary and Secondary Frequency Standards (WGPSFS). These Working Groups seek to encourage comparisons, knowledge-sharing between laboratories, the creation of better documentation, the use of high-accuracy primary frequency standards (Cs fountains) and secondary frequency standards for TAI. In 2014, the WGPSFS reviewed four new Cs fountains that had been submitted by four different laboratories.

The WGFS maintains a list of recommended values of standard frequencies for applications including secondary representations of the second. The latest changes to the list, as recommended by the CCTF in September 2012 as secondary representations of the second have been endorsed by the CIPM in Recommendation 1(CI-2013). Work is under way to prepare the elements necessary for the revision of the list of recommended frequencies at the WGFS meeting in September 2015.

Secondary representations of the second reported in BIPM Circular T

Since January 2012 the LNE-SYRTE has reported frequency measurements of the Rb microwave transition obtained with a double Cs-Rb fountain (FO2Rb). Eight measurement reports of FO2Rb were submitted in 2014 and have been officially used for the accuracy of TAI. For the first time, FO2Rb measurements were used for the computation of TT(BIPM13) in January 2014.

4. **Time links used for UTC** (E.F. Arias, A. Harmegnies, Z. Jiang, H. Konaté, W. Lewandowski, G. Panfilo, G. Petit, L. Tisserand, A. Kanj[3] and W. Wenjun[4])

At the end of 2014, 73 time laboratories supplied data for the calculation of UTC at the BIPM. The laboratories are equipped with GNSS receivers and some of them also operate two-way satellite time and frequency transfer (TWSTFT) stations.

Data from three independent techniques are included in the process of comparison of laboratories' clocks based on tracking GPS and GLONASS satellites, and TWSTFT.

The GPS all-in-view method is widely used and takes advantage of the increasing quality of the International GNSS Service (IGS) products (clocks and IGS time). Clock comparisons are possible using C/A code measurements from GPS single-frequency receivers, or dual-frequency, multi-channel GPS geodetic-type receivers (P3). The older GPS single-channel single-frequency receivers are almost obsolete, having been replaced by either multi-channel single- or dual-frequency receivers.

The Time Department also regularly computes combined GPS/GLONASS links resulting in improved link uncertainty. About five GPS/GLONASS links are regularly computed for *Circular T*.

Fifteen TWSTFT links are officially submitted for use in the computation of UTC, representing 19 % of the time links. The combination of TWSTFT and PPP (so called TWPPP) is used whenever possible. This generally concerns about a dozen links for which the two techniques are available. This combination takes advantage of the small noise of the GPSPPP and of the accuracy of the TWSTFT links.

The GPS phase and code data provided by time laboratories which operate geodetic-type receivers is processed each month using the Precise Point Positioning (PPP) technique. The NRCan's PPP software is used for the time link calculation. The current version of the software is capable of processing both GPS and GLONASS data but only GPS results are used operationally. Comparisons with other PPP software have been carried out. Studies are continuing to improve long-term stability, using new processing techniques, in collaboration with software developers at NRCan, the *Observatoire Royal de Belgique* (ORB), the *Centre National d'Études Spatiales* (CNES) and also with other institutes. A novel PPP technique using integer phase ambiguities (IPPP) has been successfully developed within the framework of a post-doctoral project. It significantly improves the stability in the medium term (several hours) and long term (days).

[3] Post-doctoral research under a two-year BIPM-CNES contract starting on 1 January 2013
[4] Chinese Academy of Sciences, NTSC (Xi'an, China), on a one-year secondment starting 3 June 2014

GPS PPP alone or in combination with TWSTFT are in use for UTC clock comparisons in 55 % of the links, where the statistical uncertainty of time transfer is well below the nanosecond, the best value is 0.3 ns for 46 % of the time links.

Comparisons of the different possible links on a baseline linking two contributing laboratories are computed and published monthly on the Time Department's ftp server.

4.1 Global Positioning System (GPS) and Global Navigation Satellite System (GLONASS) code measurements

All GNSS time and frequency transfer data are corrected for satellite positions using IGS and European Space Agency (ESA) precise satellite ephemerides. The measurement data obtained by using single-frequency receivers are corrected for ionospheric delays using IGS maps of the total electron content of the ionosphere.

4.2 Phase and code measurements from geodetic-type receivers

Techniques that use dual-frequency, GNSS carrier-phase measurements in addition to the codes, are widely used by the geodetic community, and have been adapted to the needs of time and frequency transfer. This topic is studied within the framework of the IGS Working Group on Clock Products, which has a physicist from the Time Department as a member.

Data from world-wide geodetic-type receivers are collected for UTC computation, using procedures and software developed in collaboration with the ORB. These P3 time links are routinely computed and compared to other available techniques, notably two-way time transfer. The software producing iono-free has been implemented in some receivers, and these now automatically produce both formatted GPS and GLONASS P3 code results. These newly available data will be used in multi-GNSS system time links, but further studies on GLONASS inter-frequency biases have to be carried out first.

4.3. Two-way time transfer

Two meetings of the TWSTFT participating stations were held during 2014. The 22nd annual meeting of the CCTF WG on TWSTFT was held at the VNIIFTRI, Mendeleevo, Russian Federation, on 16-17 September 2014. The outcomes of these meetings that will have an impact on the Time Department's activities are: the organization of calibration trips between TW stations, where the BIPM is charged with the validation of the reports and introduction of the calibration parameters in the calculation of UTC, and the recommendation to elaborate a document with the guidelines for TWSTFT links. The BIPM has been invited to lead the group that is preparing the guidelines.

The TWSTFT technique is currently operational in twelve European, two North American and nine Asia-Pacific time laboratories. Fifteen TWSTFT links are routinely used in the computation of UTC; they are combined with GPS PPP solutions. The TWSTFT technique applied to clock comparisons in UTC is at its maximum potential with sessions scheduled every two hours.

Some of the TWSTFT links involved in the computation of UTC are used for particular experiments such as the Time Transfer by Laser Link (T2L2). The BIPM is interested in developing studies on this technique which could be used to validate less accurate time links and their calibrations.

The BIPM is also involved in the calibration of two-way time-transfer links by comparison with the corresponding GPS links. This is necessary to maintain the stability of the TWSTFT links in case of a loss of their direct calibration.

Campaigns with a travelling calibration station that were organized and funded by the participating laboratories in 2014, resulted in the calibration of seven TW UTC links. The parameters obtained have been implemented for UTC computation following validation of the results by the Time Department.

Results of the time links and link comparison using GNSS single-frequency, dual-frequency and TW observations are published monthly on the Time Department's ftp server (ftp://tai.bipm.org/TimeLink/LkC).

4.4 Calibration of delays of time-transfer equipment and time links

Calibration of time transfer equipment in the contributing laboratories is necessary to improve the uncertainty of [*UTC*-*UTC*(*k*)] and for the accuracy of UTC dissemination. As part of the process of maintaining UTC, the BIPM organizes and runs campaigns to measure the relative delays of GPS time equipment in participating time laboratories.

The method previously developed by the Time Department to perform absolute calibration of the Ashtech Z12-T hardware delays allows the use of this receiver in differential calibrations of the same type of receivers world-wide; calibration campaigns have continued since January 2001 and have been expanded to include other types of receivers (Septentrio PolaRx2-3-4, Dicom GTR50 and GTR51, Javad JPS E-GGD, PikTime TTS3 and TTS4). New types of receivers are being investigated in collaboration with the laboratories that use the equipment. In all cases, at least two receivers remain at the BIPM to serve as a local reference to which the travelling receivers are compared between calibration trips. Results of the differential calibration exercises are made available on a dedicated web page (www.bipm.org/jsp/en/TimeCalibrations.jsp), where past calibration results are also provided.

Based on a successful pilot experiment run by the Time Department in 2012-2013, a time transfer system consisting of two or three GNSS receivers, antennas and auxiliary equipment has been developed, together with a calibration procedure, with the aim of performing GPS time link calibrations that can be transferred to any other technique on the same baseline. The system and procedures have been validated, and the process, named METODE (MEasurement of TOtal DElay), has been used regularly in 2014 for direct calibration of GPS links, and for transferring the calibration to links between Asia and Europe.

Following a recommendation by the CCTF, the Time Department has issued the '*BIPM Guidelines for GNSS equipment calibration in UTC contributing laboratories*'. This document is intended for Regional Metrology Organizations (RMOs) and aims to establish a permanent cooperation for sharing the organization of campaigns to determine the relative delays of time transfer equipment in UTC contributing laboratories. The *Guidelines* are being continuously improved and this led to a revised edition of the *Guidelines* being produced in 2014 and the elaboration of standard processing and reporting procedures. Global processing of all measurements using METODE was carried out in 2013 and 2014, completing the measurement campaign being conducted by selected laboratories in APMP and EURAMET. Measurements are continuing in COOMET and SIM, and after the end of the BIPM campaign, regional calibration trips will be implemented in accordance with the *BIPM Guidelines*. By applying this new procedure time transfer accuracy is expected to improve by a factor of 2.

The BIPM Time Department is not directly involved in specific TWSTFT calibration trips, but is responsible for validating the calibration reports and implementing the results in the calculation of UTC. It also provides support whenever necessary to maintain a TW calibration by alignment with a calibrated GPS link (see section 4.3).

The CCTF WG on TWSTFT decided, in September 2014, to establish guidelines for TWSTFT link calibration, and appointed a task group to prepare a draft document, under the leadership of the Department. The first draft of the guidelines has been completed and is being revised before final approval by the WG.

4.5 Advanced time and frequency transfer

One of the Time Department's innovative activities in this field is related to the establishment of optical fibre links between certain laboratories which maintain local representations of UTC. A successful experiment was conducted using the BIPM GPS equipment in parallel with the optical fibre link regularly operated between two institutes that represent UTC in Poland. This experiment demonstrated excellent agreement (at the level of the GPS PPP uncertainty) between the GPS PPP link calculated with the BIPM equipment and the optical fibre link. The optical fibre link can be used to assess the calibration of a UTC link calculated with the current time transfer techniques as a result of the small (hundred picoseconds) and stable calibration uncertainty. This experiment enabled the validation of the new BIPM calibration system with u_B within 1 ns. It also allowed validation of the results of the newly developed IPPP processing technique. Several other fibre links between contributing laboratories are calculated on a regular basis and are anticipated to achieve a potential measurement uncertainty of about 100 ps in the future. In order to benefit from the quality of these links, the Time Department has initiated discussions with the laboratories that already implement time transfer via optical fibres with the aim of establishing standards for data transmission and to validate the compatibility of the different techniques.

In parallel, the Time Department continued its activities in the framework of the CCTF WG on Coordination of the Development of Advanced Time and Frequency Transfer Techniques (WGATFT), and followed the progress in the NMIs and other institutes in this field of activity.

5. **Key comparisons** (E.F. Arias, H. Konaté, Z. Jiang, W. Lewandowski, G. Panfilo, G. Petit, L. Tisserand, A. Harmegnies and L. Robertsson)

Key comparison in Time CCTF-K001.UTC

Results of the key comparison in time, CCTF-K001.UTC, involving the time laboratories participating in the CIPM MRA, are published monthly as BIPM *Circular T*.

Key comparison of stabilized lasers CCL-K11

Following a decision at the 98th meeting of the CIPM in 2009 the BIPM continues to support the CCL-K11 key comparison by participating in measurement campaigns and by providing general advice whenever solicited. This comparison is the internationally recognized traceability chain to the SI metre and is supervised by the CCL. In 2014, dialogue with the participants helped towards the development of the measurement campaigns and reporting.

6. **Rapid UTC** (A. Harmegnies, G. Panfilo, G. Petit and L. Tisserand)

Since January 2013 the Time Department has published a UTC rapid solution 'UTCr', that is, daily values of [*UTCr – UTC*(*k*)] evaluated on a weekly solution on one-month batches of data. About 44 laboratories traceable to UTC contribute to UTCr, together representing 60 % to 70 % of the clocks participating in UTC.

UTCr attained the expected quality, providing a weekly solution which is consistently better than ±3 ns peak to peak with the values published monthly in BIPM *Circular T*. The results (ftp://tai.bipm.org/UTCr) have been published every Wednesday, without interruption since the end of February 2012.

UTCr does not change the procedures for the monthly calculation of UTC, which remains the only key comparison on time. However, UTCr favourably impacts on the quality of the local representations UTC(k) in national laboratories, and on the steering of GNSS times to UTC via some UTC(k).

7. New proposed definition of UTC (F. Arias)

The BIPM has actively participated in discussions about a possible redefinition of UTC without leap seconds since 2000. This proposal favours systems that require precise time synchronization and does not allow a discontinuity in the time scale that they use as a reference.

BIPM delegates have had a critical role during this process at the International Telecommunication Union (ITU), and also in disseminating information and promoting decision making at the level of national representatives. In 2014 the work has focused on the preparation of the relevant documents for the World Radiocommunication Conference to be held in Geneva, Switzerland, from 2-27 November 2015 (WRC15), where a decision is to be taken on the redefinition of UTC without leap second adjustments.

8. Pulsars (G. Petit)

Collaboration continues with radioastronomy groups that observe pulsars and which analyse pulsar data to study the possibility of using millisecond pulsars as a means of sensing the very long-term stability of atomic time. The Time Department provides these groups with its post-processed realization of Terrestrial Time, TT(BIPM). Additionally it participates in a Working Group on pulsars and time scales established by the International Astronomical Union (IAU).

9. Space-time references (E.F. Arias and G. Petit)

Activities related to the realization of reference frames for astronomy and geodesy are ongoing in cooperation with the International Earth Rotation and Reference Systems Service (IERS). In these domains, improvements in accuracy will increase the need for a full relativistic treatment and it is essential to continue to participate in international working groups in this field.

Cooperation continues on the maintenance of the international celestial reference system within the framework of the activities of a working group created by the IAU in August 2012; the target is to report on the features of the next realization of the International Celestial Reference Frame (ICRF3) to the IAU General Assembly in 2015 and to provide the set of coordinates in ICRF3 in 2018.

As part of its participation in the Conventions Centre of the IERS, the BIPM maintains the web and ftp sites for the *IERS Conventions* (http://tai.bipm.org/iers/). The Conventions describe the latest realizations of the celestial and terrestrial reference frames, and the model for the transformation between them. They also describe conventional models for the gravitational field, the displacement of markers on the Earth's crust and for the propagation of electromagnetic signals. In addition, the *Conventions* now provide a complete set of associated conventional software. Since the completion of the latest reference edition, *IERS Conventions* (2010) in December 2010, work is continuing with the help of an Editorial Board to provide updates to the *Conventions* (2010) which are posted on the website (http://tai.bipm.org/iers/convupdt).

10. Comb activities (L. Robertsson)

The BIPM comb activities are limited to the maintenance of the BIPM frequency comb for internal use related to laser applications only and in other departments when needed.

11. Publications

External publications

1. Jiang Z., Total Delay and Total Uncertainty in UTC Time Link Calibration, *Proc. 45th PTTI Meeting*, 2014, 112-125.
2. Jiang Z., Lewandowski W., Evolution of the Uncertainty of [*UTC-UTC(k)*], *Proc. 45th PTTI Meeting*, 2014, 208-216.
3. Jiang Z., Accurate time link calibration for UTC time transfer - Status of the BIPM pilot study on the UTC time link calibration, *Proc. 28th European Frequency and Time Forum*, 2014.
4. Jiang Z., Tisserand L., Stability of the BIPM GNSS travelling calibrator, *Proc. 28th European Frequency and Time Forum*, 2014.
5. Jiang Z., Czubla A., Nawrocki J., Nogaś P., (2014) Calibration comparison between optical fiber and GPS time links, *Proc. ION/PTTI2014*.
6. Jiang Z., Lewandowski W., An Approach to the Uncertainty Estimation of [UTC-UTC(*k*)], *Proc. ION/PTTI2014*.
7. Konaté H., Arias E.F., The BIPM Time Department Database, *Proc. 45th PTTI Meeting*, 2014, 1-13.
8. Panfilo G., Harmegnies A., A new weighting procedure for UTC, *Metrologia*, 2014, **51**, 285-292.
9. Petit G., Arias E.F., Harmegnies A., Panfilo G., Tisserand L., UTCr: a rapid realization of UTC, *Metrologia*, 2014, **51**, 33-39.
10. Petit G., A timescale based on the world's fountain clocks, *Proc. PTTI meeting*, Bellevue, WA, December 2013.
11. Petit G., Kanj A., Harmegnies A., *et al*., GPS frequency transfer with IPPP, *Proc. 28th European Frequency and Time Forum*, 2014, 451-454,.
12. Petit G., Wolf P., Delva P., Atomic time, clocks and clock comparisons in relativistic space-time: a review, in *Frontiers of Relativistic Celestial Mechanics*, Volume 2, *Applications and Experiments*, Sergei M. Kopeikin Ed., De Gruyter, 2014, 266pp.

BIPM publications

13. *BIPM Annual Report on Time Activities for 2013*, 8, 121 pp., available only at http://www.bipm.org/en/publications/time_activities.html.
14. *Circular T* (monthly), 8 pp.
15. *Rapid UTC* (*UTCr*) (weekly), 1 pp.

12. Activities related to the work of Consultative Committees

E.F. Arias is Executive Secretary of the Consultative Committee for Time and Frequency (CCTF). She is the Secretary of the CCTF Working Group on TAI (WGTAI) and the CCTF Working Group on Strategic Planning (WGSP).

Z. Jiang is Secretary of the CCTF Working Group on TWSTFT (WGTWSTFT).

G. Panfilo is Secretary of the CCTF Working Group on the CIPM MRA (WGMRA) and the CCTF Working Group on Time Scale Algorithms (WG-ALGO).

G. Petit is Secretary of the CCTF Working Group on Primary and Secondary Frequency Standards (WGPSFS) and the Working Group on Global Navigation Satellite Systems (WGGNSS).

L. Robertsson is Executive Secretary of the Consultative Committee for Length (CCL), a member of the CCL Working Group on Strategic Planning (WG-S) and of the Discussion Group DG-11 (Lasers). He is the BIPM representative on the CCM Working Group on Gravimetry (WGG). He is also Secretary for the CCTF WG on

Coordination of the Development of Advanced Time and Frequency Transfer Techniques (WGATFT) and shares the secretariat of the CCL-CCTF Frequency Standards WG (WGFS) with E.F. Arias.

13. Activities related to external organizations

E.F. Arias is a member of the IAU and participates in its working group on the International Celestial Reference Frame (ICRF), she is vice-president of Commission 31 (Time) and co-chaired the working group on the redefinition of UTC. She is an associate member of the IERS, a member of its International Celestial Reference System Centre, and of the Conventions Centre. E.F. Arias is a member of the International VLBI Service (IVS). She is the BIPM representative to the Governing Board of the International GNSS Service (IGS). She is the BIPM representative to the UN sponsored International Committee on GNSS (ICG) and the chairperson of its Task Force on Time References. E.F. Arias is a member of the IAG Global Geodetic Observing System (GGOS) Steering Committee representing the BIPM. She is a member of the Argentine Council of Research (CONICET) and an associate astronomer at the LNE-SYRTE, Paris Observatory. She is a corresponding member of the *Bureau des longitudes* and the BIPM representative to the Working Party 7A of Study Group 7 of the International Telecommunication Union – Radiocommunication Sector (ITU-R).

G. Petit is co-director of the Conventions Centre of the IERS. He is an associate member of the IGS and member of the IGS Working Groups on Clock Products and on Bias Calibration. He is a member of the IAU Working Groups on Numerical Standards in Fundamental Astronomy and on Pulsar Time Scale.

G. Panfilo collaborates with the Joint Committee for Guides in Metrology (JCGM) Working Group 1 (WG1) on the Expression of Uncertainty in Measurement (GUM) to provide a section on uncertainty of time measurements for the new version of the GUM.

14. Travel (conferences, lectures and presentations, visits)

E.F. Arias to:

- Delft (The Netherlands), 17-18 March 2014, for a meeting of the EURAMET Time and Frequency Technical Committee;
- Paris (France), 9 April 2014, for a discussion on the IERS Conventions;
- Geneva (Switzerland), 6-14 May 2014, for the meeting of the ITU-R WP7A;
- Neuchâtel (Switzerland), 23-26 June 2014, to the 28th European Frequency and Time Forum and for the meetings of CCTF Working Groups;
- Neuchâtel (Switzerland), 27 June 2014, to the Workshop "frequency standards with trapped ions";
- Beijing (China), 18-23 August 2014, for the URSI General Assembly, and as convener of a session on UTC;
- Hendaye (France), 17 September 2014, to give a training course on Time Scales at the Chateau d'Abbadia (expenses paid by the Chateau d'Abbadia Foundation);
- Geneva (Switzerland), 30 September to 7 October 2014, for the meeting of the Working Party 7A at the ITU;
- Luxembourg, 14 October 2014, to the meeting of the IAU Working Group on the ICRF3;
- Boston (USA), 1-5 December 2014, for the 46th PTTI Meeting, as convener of a session and for the meeting of TW participating stations.

Z. Jiang to:

- Nanjing and Beijing (China), 21-28 May 2014, for the China Satellite Navigation Conference, organizing a session, for the Interoperability Workshop, for a meeting with BeiDou time experts;
- Neuchâtel (Switzerland) to the 28th European Frequency and Time Forum (giving presentations) and for the meetings of CCTF Working Groups,;
- Mendeleevo (Russian Federation), 15-16 September 2014, for the 22nd Meeting of the CCTF Working Group on TWSTFT;
- Boston (USA), 1-5 December 2014, for the 46th PTTI Meeting (giving presentations) and for the meeting of TW participating stations.

A Kanj to:

- Neuchâtel (Switzerland), 23-26 June 2014, to the 28th European Frequency and Time Forum and for the meetings of CCTF Working Groups (expenses paid by the CNES);
- Boston (USA), 1-5 December 2014 for the 46th PTTI Meeting and for the meeting of TW participating stations.

W. Lewandowski to:

- Krakow (Poland), 6-7 February 2014, for the "Industrial policy of the European Union. The Economic Weimar Triangle";
- Geneva (Switzerland), 6-14 May 2014, for the meeting of the ITU-R WP7A;
- Namur (Belgium), 19-20 May 2014, for the meeting of the ESA Programme Board on Satellite Navigation (PB-NAV);
- Nanjing and Beijing (China), 21-28 May 2014, for the China Satellite Navigation Conference, for the Interoperability Workshop, and for a meeting with BeiDou time experts.

G. Petit to:

- Toulouse (France), 16 January 2014, to visit the CNES time laboratory and for a Workshop "Precise positioning Using Carrier Phase Measurements" ;
- Paris (France), 9 April 2014, for a discussion on the IERS Conventions;
- Vienna (Austria), 27 April 2014, to participate in the IERS Directing Board;
- Paris (France), 13 June 2014, to participate in a PhD jury;
- Neuchâtel (Switzerland) 23-27 June 2014, to attend the EFTF 2014 meeting, to give an oral presentation, a CCTF WG meeting and a CCL-CCTF WG meeting;
- Besançon (France), 1-2 July 2014, to give two lectures at the European Frequency and Time Seminar;
- Luxembourg, 13-14 October 2014, to attend the REFAG 2014 workshop;
- Paris (France), 23 October 2014, to attend a CNES workshop on GRASP;
- Prague (Czech Republic), 12-14 November 2014, for the ninth meeting the International Committee on GNSS (ICG), with presentations.

G. Panfilo to:

- Rome (Italy), 8 October 2014, invited to give a presentation on the BIPM Time Department activities at the Sapienza – Università di Roma, Rome.

L. Robertsson to:

- Toulouse (France), 12 February 2014, for the "Journée peignes de fréquence optique";
- Neuchâtel (Switzerland), 23-26 June 2014, to the 28th European Frequency and Time Forum and for the meeting of four CCTF Working Groups;

- Neuchâtel (Switzerland), 27 June 2014, to the Workshop "frequency standards with trapped ions".

W. Wenjun to:

- Neuchâtel (Switzerland), 23-26 June 2014, to the 28th European Frequency and Time Forum (to give presentations) and for the meeting of four CCTF Working Groups (expenses paid by the Chinese Academy of Sciences);
- Mendeleevo (Russian Federation), 15-16 September 2014, for the 22nd Meeting of the CCTF Working Group on TWSTFT (expenses paid by the Chinese Academy of Sciences).

15. Visitors, secondees

- A. Kanj as a post-doctoral researcher under a BIPM-CNES contract for the optimization of GNSS time transfer, 1-15 February and 1 August - 31 December 2014;
- J. Faller (JILA, USA) for a BIPM seminar and discussions on gravity measurements associated with BIPM activities, 20 March 2014;
- P. Fisk (NMIA, Australia) for discussions on the activities of the CCTF WG on TAI, 28 March 2014;
- S. Junqueira (ONRJ, Brazil) and a team from the Observatory for discussions on time transfer at ONRJ, 23 April 2014;
- W. Wu (NTSC, Chinese Academy of Sciences) on a one-year secondment starting on 3 June 2014, for activities on time transfer and calibration;
- A. Bauch (PTB, Germany) for discussions on time transfer and calibrations, 12 June 2014;
- C. Lin (TL, Chinese Taipei) for a discussion on GNSS calibrations, 1 July 2014;
- G. Garcia (INMETRO, Brazil) for discussions on the Brazilian contribution to UTC, 26 September 2014;
- F. Parisi from the University of Torino (Italy) to study an independent time scale based on the Kalman Filter, 1 November 2014 – 6 February 2015.