

Report of Working Group D: Reference Frames, Timing and Applications

1. Introduction

The Co-Chairs welcomed all to the meeting. Unfortunately neither Matt Higgins nor Chris Rizos could attend ICG-8. The working group was co-chaired by Zuheir Altamimi of the International Association of Geodesy (IAG), Ruth Neilan of the International Global Navigation satellite Systems (GNSS) Service (IGS) and Mikael Lilje the International Federation of Surveyors (FIG). Zuheir acted as chair of the meeting and Mikael as secretary. Almost 30 persons were present at the beginning of the meeting on Monday, 11 November 2013. The meeting on Tuesday, 12 November 2013 mainly focused on discussing proposed recommendations and these were finalised at the meeting on Wednesday, 13 November 2013.

2. Review of Minutes from the Seventh Meeting of the ICG (ICG-7)

The minutes are available on the ICG website. No comments on the minutes were made at the meeting.

3. Task Force on Geodetic References

Discussions on progress with WG-D Recommendations:

Recommendation 11 on “Finalization and Publication of Templates on Geodetic and Timing References”;

- Galileo: Has produced an updated template. GTRF was updated to 2013 GTRF13v02. The new template will be uploaded on the ICG website.
- GPS: Unfortunately Barbara Wiley was not available but information given at the meeting was that an update is planned when ITRF2013 is released
- Glonass: An update template on PZ-90.11 will be given at the end of ICG-8
- Beidou: No representative at the meeting
- QZSS: No update at this stage.
- India: No representative at the meeting

Recommendation 12 on “Interoperability of geodetic references among the different GNSS systems”;

- GPS: Eleven stations are already in ITRF2008
- Glonass: Currently not possible to share information but will be in the future

Recommendation 13 on “International GNSS Service Multi-GNSS Global Experiment - IGS M-GEX”.

There are 92 multi-GNSS stations included in the MGEX. More information about MGEX can be found at <http://igs.org/mgex/>. First results from the project are about to be published. The project will be addressed at the IGS workshop in June-14. There is a published article in GPSWorld and there will also be presentation at the *4th International Colloquium on Scientific and Fundamental Aspects of the Galileo System* in Prague, Czech Republic in December by Oliver Montenbruck. This presentation will describe the project and the paper will be shared among the WG-D members after the presentation.

Recommendation 14 on “Interrelationship of GNSS geodetic references through the International Terrestrial Reference System (ITRS)”

This recommendation was set up for the awareness of ITRS to ICG. Therefore there is nothing to report on here.

Recommendation 15 on “Improving the GNSS contribution to the ITRF defining parameters: Satellite antenna calibration;

- **Galileo:** The antennas are calibrated on ground.
- **GPS:** No information was given at the meeting.
- **Glonass:** Antennas are calibrated but at this meeting the level of accuracy could not be given.
- **Beidou:** The antennas are calibrated on ground
- **QZSS:** For the antennas on Michibiki, the phase center is measured and the same procedure will be done for the coming satellites.
- **India:** No representative

John Labrecque discussed if it is meaningful to calibrate in space instead of on ground. The quality of the calibration is not as good and the procedure is much more complicated. This item will also be discussed at the WG-B meeting.

Adding retro-reflector to permit satellite laser ranging to the satellite

- **GPS:** GPS-III will include retro-reflectors
- **Galileo:** The first 27 satellites will carry
- **Glonass:** retro-reflectors are already installed with retro-reflectors and will continue doing so.
- **Beidou:** laser reflectors are on some satellites. At this meeting not clear on how many
- **QZSS:** Michibiki carries one retro-reflector and probably one more satellite will carry.
- **India:** No representative

Accelerometers to GNSS satellite

GPS: No information at this stage. There is a need to study this more to be sure that it will contribute in the end.

The meeting discussed about the situation on the clocks used on the satellites. It is suggested to add/use an ultra-stable clock to each GNSS satellite in order to improve the geocenter determination by GNSS. One suggestion was to add this information to the template for timing in the future. Zuheir has a PhD-student working on this subject and will be ready by mid-2014 to deliver more information on this to ICG.

Discussion on International GNSS Monitoring and Assessment

There was a joint meeting with WG A and WG B on Monday afternoon discussing mainly IGMA. The discussions resulted in a revision of a recommendation from last year from WG A.

Presentations on Recent Developments in Geodetic References;

The following presentations were made. They are all available on the ICG-8 webpage.

- Galileo Terrestrial Reference Frame (GTRF) – Werner Enderle, ESA
- GLONASS and National Reference Systems of the Russian Federation, including the user segment – Vladimir Vdovin, Russia.

Relevant Developments in International Standards Organization (ISO);

The project 19161 within ISO TC211 is called Geodetic References. The main idea is to have ITRS as an ISO standard. The leader of the work is Claude Boucher, France and there are a number of members in the group even though they are missing participation from Russia and India (among the providers). According to Zuheir, some documentation will be ready by end of year and will most probably be made available to ICG at that time. It was mentioned that those who would like to participate should contact their national representatives to ISO TC 211. The timetable for the project is not clear.

Discussion of the need for more comprehensive information about new GNSS satellites to improve orbit modeling;

Template needs to be prepared by IGS and will be sent to the providers in due time.

4. Task Force on Timing References

This agenda item was led by Felicitas Arias.

Recommendation 11 on “Finalization and Publication of Templates on Geodetic and Timing References”;

- **Galileo:** No update at this stage
- **EGNOS.** No information on when the template will be finalized
- **GPS:** No information was given at the meeting
- **Glonass:** A draft version was given a few years ago. The final version will be completed but the time frame is not set.
- **Beidou:** No update at this stage
- **QZSS:** No update at this stage
- **India:** No representative at the meeting
- **IGS time scale:** It was provided a few years ago.

Recommendation 16 on “Information on the works related to the proposed redefinition of UTC”

Felicitas Arias gave a presentation on the redefinition of UTC. ITU/BIPM organized a workshop in September 2013 with the title *future of the international time scale*. The background was that no decision was made in 2012 at the Radiocommunication Assembly on the redefinition of UTC. It was decided that the next step was to focus on the World Radiocommunication Conference in 2015 (WRA 15). Documents must be submitted not later than six months before the WRA for being considered at the Conference. The workshop in September provided unique opportunity to get all available information on time scales and dissemination systems and different views on the future of UTC. GPS, Galileo and Beidou acknowledge the benefits of a continuous UTC for the sake of security in operations, and support a redefinition of UTC without leap second. Glonass prefers to maintain the present UTC system based on difficulties in upgrading some specific equipment. There are more aspects to take into account and a final document is intended to be finished at ITU in March 2014. For more information about the meeting in September, please visit www.itu.int/ITU-R/go/itu-bipm-workshop-13.

Recommendation 17 on “Declaration on the computation of Rapid UTC (UTC_r)”

At the plenary session of ICG-8 Felicitas made a presentation on Rapid UTC (UTC_r) and explained that UTC_r started within BIPM as a project in January 2012 and was officially declared as a permanent product in July 2013. Currently 39 laboratories are participating and daily results are published every Wednesday at 18 h UTC.

Presentations on Recent Developments in Timing References;

The following presentations were made. They are all available on the ICG-8 webpage.

- Galileo IOV Timing Results - Jörg Hahn, EU/ESA
- BDT performance and time offset - Zhiwu Cai, China
- The modified standard for time, frequency and national time scale UTC(SU) of the Russian Federation – Vitaly Palchikov, Russia
- GLONASS Time and UTC(SU) – **Andrey** Druzhin et al, Russia
- Coordinated Universal Time and GLONASS – **Dmitry** Aronov et.al, Russia

5. Overarching ICG Activities

Actions arising from other ICG Working Groups;

As discussed at the meeting, and as discussed at a joint meeting during ICG-8, there has been focus on the work together with WG A and WGB on IGMA. Several meetings have taken place since last ICG. Werner Enderle noticed that we might have overlapping objectives with what is happening already within IGS. We need to have a clear understanding on what is the overlap regarding ongoing activities in IGS. A special focus should be put on comparing with the IGS project MGEX. Zuheir clarified that the recommendation will most probably endorse the IGS activities but the wording is not set and that no decision is made if a recommendation is needed. Felicitas added that we should also consider what is happening within BIPM in mind.

Other whole-of-ICG issues such as Joint Workshops, etc;

It is already planned a joint workshop and/or sessions on IGMA during the IGS workshop in June, 2014 in the USA. There is an overall lack of information on seminars on the ICG-website but the working group also notes the situation at the ICG secretariat with few persons being able to help on this.

6. Next Steps for the Working Group

Review of Work Plan and emphasis for the coming year

The work plan should be distributed to the working group members. There should be a space on the webpage where a participant can find more information about the various working groups etc.

Agreement on Draft Recommendations to Plenary of ICG-8

Recommendation 18; Assessment of the alignments of GNSS associated reference frames to the ITRF

Revision Recommendation 16A; Information on the works related to the proposed redefinition of UTC (revision of Recommendation 16 (2012))

Recommendation 19: Official provision of a rapid UTC (UTC_r) by the BIPM

Recommendation 20: BIPM publication of [UTC-GNSS times] and [UTC-UTC(k)_{GNSS}].

Recommendation 21: Suggestion on GNSS time offset monitoring and broadcast

These recommendations are enclosed to these minutes.

There will also be a revision on recommendation ICG-7 4.1 on IGMA that is a joint recommendation between WG-A, B and D.

A proposed recommendation on the *Dissemination by GNSS of the values of UT1-UTC predicted by the IERS* was not accepted by the Russian Delegation and it was decided that we will discuss this recommendation again at ICG-9.

7. Next Meeting

The next full meeting of Working Group D will be at ICG-9 that will be held November 10-14 2014 in Prague. Communication and meetings between co-chairs and other participants will occur between meetings on an opportunity basis.

APPENDIX A: Attendance List

Monday, 11 November 2013

Mr Zhiwu Cai	China
Ms. Jing Tang	China
Mr Werner Enderle	ESA
Mr Jérôme Delporte	EU
Mr Jörg Hahn	ESA
Mr Pieter De Smet	EU
Mr Ryuichi Ichikawa	Japan
Mr Testuro Imakiire	Japan
Mr Sean Daisuke Lyons	Japan
Mr Hiroaki Maeda	Japan
Mr Hiroaki Tateshita	Japan
Mr Noordin Ahmad	Malaysia
Mr Dmitry Aronov	Russia
Mr Andrey Druzhin	Russia
Mr Iskandar Gaiazov	Russia
Mr Alexander Grechkoseev	Russia
Mr Victor Kosenko	Russia
Ms Marina Molokanova	Russia
Mr Vitaly Palchikov	Russia
Mr Alexey Pokhaznikov	Russia
Mr Maxim Sanzharov	Russia
Mr Arkady Tyulyakov	Russia
Mr Vladimir Vdovin	Russia
Ms Maria Vinogradova	Russia
Mr Vasily Zvonar	Russia
Mr Jim Burton	US
Mr Stephen Esterhuizen	US
Mr Larry Hothem	US
Mr John Labracque	US
Mr Johannes Ihde	EUREF
Mr Mikael Lilje	FIG
Mr Zuheir Altamimi	IERS
Ms Ruth Neilan	IGS
Mr Włodzimierz Lewandowski	BIPM
Ms Felicitas Arias	BIPM
Mr Joseph Arcssee	Nigeria

Thursday, 12 November 2013

Mr Zhiwu Cai	China
Mr Werner Enderle	ESA
Mr Jérôme Delporte	EU
Mr Pieter De Smet	EU
Mr Ryuichi Ichikawa	Japan
Mr Testuro Imakiire	Japan
Mr Dmitry Aronov	Russia
Mr Andrey Druzhin	Russia
Mr Victor Kosenko	Russia
Ms Marina Molokanova	Russia
Mr Vitaly Palchikov	Russia
Mr Alexey Pokhaznikov	Russia
Mr Arkady Tyulyakov	Russia

Ms Maria Vinogradova	Russia
Mr Vasily Zvonar	Russia
Mr Larry Hothem	US
Mr Johannes Ihde	EUREF
Mr Mikael Lilje	FIG
Mr Zuheir Altamimi	IERS
Ms Ruth Neilan	IGS
Mr Wlodzimierz Lewandowski	BIPM
Ms Felicitas Arias	BIPM

APPENDIX B:**Recommendation for Committee Decision (WG-D#16-A)**

Date of Submission: 12 November 2012

Issue Title: Information on the works related to the proposed redefinition of UTC (revision of Recommendation 16 (2012))

Background/Brief Description of the Issue:

Considering that:

- the navigation systems have unique timing and geodetic references for operational necessity. Interoperability of the GNSS requires interrelationship of the timing and geodetic references to reduce ambiguities for users with regard to the interpretation of navigation and timing solutions.
- discussion on redefinition of UTC started in 2000 at the ITU-R, SG7 Science Services WP7A Time Signals and Frequency Standard Emissions,
- during 2000-2010 WP7A studied the issue, considered different options, organized an open meeting (Torino, 2003), and worked on a proposal for an amended ITU recommendation,
- in 2010 the Draft Revision of Recommendation ITU-R TF.460-6 (new proposed version) was submitted by ITU-R WP7A to ITU-R SG7; while considering this issue at SG7 no consensus on the Draft Revision of Recommendation ITU-R TF.460-6 was achieved,
- the SG7 sent the Draft Revision of Recommendation ITU-R TF.460-6 to the Radiocommunication Assembly 2012 (RA -12) for « final decision »,
- at RA-12 after several statements of Administrations and Sector members supporting different views the Chairman stated that there are almost even balance between those administrations that are in favour of the draft revision of the Recommendation, those that are opposing it, and a third group of administrations who indicated that as they had not participated actively at SG7 and WP7A meetings, more information is required to enable them to form an opinion,
- as a result RA-12 decided to address this issue in the RA-12 Report for World Radiocommunication Conference 2012 (WRC-12) to develop a new WRC-15 Agenda item.
- WRC-12 started a new study question on WRC-15 Agenda item 1.14 in accordance with Resolution 653 (WRC-12) and put back the Draft Revision of Recommendation ITU-R TF.460-6 to SG7-WP7A for a final decision at WRC-15,
- WRC-12 Resolution 653 on the feasibility of a continuous UTC involves the BIPM, CCTF, CGPM, IAU, IUGG, URSI, ICAO, IMO, WMO, ISO, and invites to consider the feasibility of achieving a continuous reference time-scale, whether by the modification of UTC or some other method, and take appropriate action, taking into account ITU-R studies,

Recommendation of Committee Action:

It is recommended that the ICG monitors the ongoing development of the proposed redefinition of UTC and that reports be presented until a decision is made at WRC-15.

Recommendation for Committee Decision (WG-D # 18)**Date of Submission: November 12, 2013****Issue Title: Assessment of the alignments of GNSS associated reference frames to the ITRF****Background/Brief Description of the Issue:**

Considering

- The alignment of CGS2012 for Beidou, JGS2010 for QZSS, PZ-90.11 for GLONASS and WGS84(G1674) for GPS, the GTRF13v02 for Galileo to the latest realization of the International Terrestrial Reference System in the form of ITRF2008,
- The IGS effort in conducting MGEX project and in making publicly available all data collected at MGEX sites, including broadcast orbits and clocks

Discussion/Analyses:

The users of different GNSS broadcast orbits contained in the corresponding navigation messages need consistent and precise point positioning results expressed in a reference frame that is pre-aligned to the ITRF.

Recommendation of Committee Action:

The ICG WG-D recommends that interested groups to determine multiple sets of coordinates for MGEX or/and other stations where multi-GNSS receivers are operated, using individual sets of GNSS broadcast ephemeris, evaluate their consistency and provide feedback to the IGS multi-GNSS experiment.

Recommendation for Committee Decision (WG-D#19)

Date of Submission: 12 November 2013

Issue Title: Official provision of a rapid UTC (UTC_r) by the BIPM

Background/Brief Description of the Issue:

In November 2012 the ICG recognized that a rapid computation of UTC at the BIPM was an important service benefiting interoperability of navigation systems.

Considering that:

- after a successful pilot experiment started in January 2012, UTC_r has attained the expected stability and accuracy,
- at the issue of the validation process, UTC_r become an official BIPM product in July 2013, and is regularly published on the BIPM website every Wednesday at 18 h UTC at latest,
- the weekly provision of the offsets between local realizations UTC(k) in national institutes with respect to UTC_r enhances the traceability of these local realizations to the ultimate reference UTC,
- the UTC(k) serving for synchronizing the GNSS times to UTC participate to the weekly UTC_r solution, and that predictions of these UTC(k) are broadcast by GNSS,
- users of GNSS get a better synchronization of GNSS times to UTC, through improved UTC and UTC(k) predictions.

Discussion/Analyses: N/A

Recommendation of Committee Action: WG-D recommends that GNSS Providers consider the use of UTC_r for

- getting a better synchronization of GNSS times to UTC,
 - improving the quality of the predictions of UTC(k) broadcast by GNSS,
- and further recommends studying the possibility of using UTC_r as a common time reference for interrelationship between GNSS times.

Recommendation for Committee Decision (WG-D#20)

Issue Title: BIPM publication of [*UTC – GNSS times*] and [*UTC – UTC (k)_{GNSS}*]

Background/Brief Description of the Issue:

Considering that

- Coordinated Universal Time UTC is the sole international reference time scale,
- That GNSS times are constraint to keep within specified offsets from UTC(k),
- That GNSS broadcast a prediction of UTC(k) namely *UTC (k)_{GNSS}*.

Noting that

- the BIPM has been publishing in its monthly *Circular T* for over 25 years daily values of [*UTC – GNSS times*] and more recently also of [*UTC – UTC (k)_{GNSS}*],
- This information is useful to users of GNSS services, but also to GNSS systems to assess the quality and interoperability of their systems.

Discussion/Analyses:

The monitoring of the values of [*UTC – GNSS times*] and [*UTC – UTC (k)_{GNSS}*] serves to a better coordination of the various GNSS and to provide a better time service to users.

The procedure for calculation of these values is provided in Section 5 of *BIPM Circular T*, available at <http://www.bipm.org/jsp/en/TimeFtp.jsp?TypePub=publication>.

Recommendation of Committee Action:

The ICG WG-D recommends that the BIPM continues the regular provision of the values of [*UTC – GNSS times*] and [*UTC – UTC (k)_{GNSS}*] and extends them to other GNSS, in particular Galileo and BeiDou.

Recommendation for Committee Decision#21**Date of Submission: 13 November 2013****Issue Title: On the monitoring of offsets between GNSS times****Background/Brief Description of the Issue:**

Offsets between GNSS times are important information for GNSS users. Monitoring of the offsets between GNSS times and provision of consistent broadcast information are essential to improve interoperability and combined navigation using multiple GNSS.

Discussion/Analyses:

Information of the differences between the GNSS times is the basis of interoperability and combined application of the various GNSS systems. Every GNSS system has its own time system and they are different. The time offsets between different GNSS could be measured continuously by GNSS timing receivers, could be obtained by direct time comparison link or computed from a common reference. The monitoring and broadcast of GNSS time offsets are technically possible and will benefit GNSS providers and users.

The time offset between GPS and Galileo (GGTO) is currently being monitored and is planned to be broadcast in their navigation messages. The time offset parameters of BDT relative to the other three GNSS times have been designed in BeiDou navigation messages and the relevant experiments of monitoring and prediction have been implemented.

In order to improve the monitoring of offsets between GNSS times, the different GNSS should work for reaching consistency in the procedures for monitoring and broadcasting the GNSS time offsets.

Recommendation of Committee Action:

1. GNSS Providers should consider monitoring of offsets between GNSS times and implement the broadcast of this information in the navigation messages.
2. GNSS Providers are encouraged to undertake studies on possible approaches for giving information on the offsets between GNSS times.
3. In order to improve consistency of offsets between GNSS times broadcast by the various systems, GNSS Providers should discuss on the adoption of the same or similar models.