

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

1. Introductions

The Co-Chairs welcomed all to the meeting. Almost 50 persons were present at the beginning of the meeting on Wednesday. About 30 persons attended the Thursday meeting. A list of participants can be found in Appendix A

2. Review of Minutes from Tokyo meeting

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

3. Report on ad-hoc meeting in Poland

The IGS 2012 workshop was held in Poland in July. The workshop was successful with many delegates and reports on important developments within IGS. Special focus was given to the Multi-GNSS experiment (MGEX) and the IGS real-time service. The presentations from the workshop are available on the IGS website (<http://igs.org>).

At the workshop, both ICG Working Group A and Working Group D met as well as the ICG Working Group A subgroup GNSS Monitoring and Assessment. This was the first meeting for the subgroup. Working Group D noticed at this meeting that some of the geodetic and the timing templates are missing but progress was being made to finalize and receive the missing ones. Follow up on this is done at ICG-7.

4. Representatives at this meeting from the Providers regarding geodetic reference system and timing

The appointed representatives from the different providers at this meeting regarding Geodetic Reference System and Timing can be found in the table below. Unfortunately, India was not present at this meeting.

	Beidou	Galileo	Glonass	GPS	QZSS
Geodetic	Yang Yuanxi	Altamimi	Vdovin	Wiley	Kishimoto
Timing	Han Chunhao	Delporte	Tyulyakov	Wiley/Hothem	Ichikawan

Note: Ed Powers, the official representative for GPS on Timing References, was not present but was represented by Wiley and Hothem from USA.

Note also that all presentations from this Working Group D Meeting are already available on the meeting website (www.icg2012.cn - click on "Download File"). They will also be made available on the ICG web site from UN OOSA in due course.

5. Task Force on Geodetic References

This agenda item was led by Zuheir Altamimi.

Discussion on progress with WG-D Recommendations:

All the providers were asked to give a summary on the status regarding the following recommendations.

- ICG Recommendation 4 and ICG Recommendation 10 on “*Retroreflectors for Laser Ranging to GNSS satellites*”

QZSS reported that retro-reflectors are on their satellites.

- ICG Recommendation 11 on “*Finalization and Publication of Templates on Geodetic and Timing References*”;
 - Galileo template on Geodetic Reference is available for ICG.
 - GPS template on Geodetic Reference is available for ICG. However, there is ongoing work on updating WGS84 and aligning it to ITRF2008. This will be accomplished soon and the template will be updated accordingly.
 - Glonass template on Geodetic Reference is not available yet. Russia informed that the work on the template is progressing and they are waiting for approval to release it. It can be expected before ICG-8. Russia also informed on the update regarding the reference frame for Glonass, see below.
 - Beidou template on Geodetic Reference was provided to ICG at the IGS workshop in Poland in July 2012. The Beidou reference system will be updated and this was also presented at this meeting, see below.
 - QZSS template on Geodetic Reference had been provided earlier.

ACTION: The available templates will be published as soon as possible on the ICG website.

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

Zuheir also informed all the delegates that input GNSS data for ITRF2013 will be adjusted by IGS during 2013 and urged all to have data ready by January 2013. China and USA will be supplying data for inclusion in next computation of ITRF in accordance with Recommendation 12. Japan informed that they could make data available once RINEX format covering QZSS data is officially approved.

- ICG Recommendation 13 on "International GNSS Service Multi-GNSS Global Experiment - IGS M-GEX".

Presentations made at the meeting concerning Geodetic References;

The following presentations were made. They are all available on the ICG-7 webpage.

- Compass Geodetic System (CGS) by Wei Ziqing, China
- Global Geocentric Coordinate System of the Russian Federation by V. Vdovin, Russia

Relevant Developments in International Standards Organization (ISO);

The presentation was prepared by Claude Boucher but presented by Zuheir.

A proposal to investigate standardization needs related to geodetic references has been submitted by France to the International Standardization Organization (ISO) early in 2012. This proposal was specifically sent to the ISO Technical Committee 211 on Geographical information/Geomatics. This proposal was approved in June by ISO TC 211 under the title of Project 19161.

Larry Hothem reported on the progress for the Geodetic Registry Network, another ISO standard initiative.

6. Task Force on Timing References

This agenda item was led by Włodzimierz Lewandowski in place of Felicitas Arias, who was unavailable for this meeting.

Discussion on progress with WG-D Recommendations:

- Recommendation 11 on “*Finalization and Publication of Templates on Geodetic and Timing References*”;
 - Russian Federation has drafted the Timing template on GLONASS and is awaiting approval to release it.
 - The Working Group has still no response from India.
 - The templates from all other GNSS are now submitted.
 - No responses as yet from any SBAS but EU reported that Timing Template for EGNOS has been drafted and is awaiting approval for release.

Presentations made at the meeting concerning Timing References:

- Performance Evaluation of Satellite Clocks of Beidou System by Lin Yuting, China;
- Generation of the National time scale UTC(SU), its transfer to Glonass and harmonization with UTC, Russia – I. Silvestrov
- System time scale Generation and Coordination to UTC(SU) – A. Tyulyakov, Russia

Report on developments with “*Rapid UTC*”

Włodzimierz went through parts of the presentation that he gave at the plenary sessions. The need to publish UTC more rapidly motivated the project Rapid UTC (UTC_r). A pilot project of UTC_r has started at the beginning of 2012. The methodology is still under development (a few ns is the goal between UTC and UTC_r). UTC is kept unchanged. UTC will benefit from UTC_r due to better anticipation and easier detection of problems (clocks and links). Lack of calibration of Glonass clocks leads to differences of about 150 ns between Glonass and UTC. Difference between GPS and UTC is typically some ns. Last CCTF in September 2012 has endorsed the UTC_r and a regular service should start in 2013.

Report on Leap Second deliberations at the ITU

The discussion on redefinition of UTC as a continuous time scale started in 2000 at the ITU-R, SG7 Science Services WP7A Time Signals and Frequency Standard Emissions. The SG7 sent the Draft Recommendation to the Radiocommunication Assembly 2012 (January) for « final decision ». However, WRC 2012 put back the recommendation to SG7-WP7A for a final decision at WRC 2015.

7. Next Steps for Working Group D

The following Draft Recommendations to Plenary of ICG-7 were discussed.

- Interrelationship of the GNSS geodetic references through the International Terrestrial Reference System (ITRS).

- Provision of Physical Information on GNSS Satellites for Improving Orbit Dynamic Modelling and Orbit Determination. After discussion it was decided that this recommendation will not be put forward this time. ACTION; To next ICG-8 Working group D to develop the MGEX template on satellite information and at ICG-8 make a recommendation on asking the various providers to fill in the template.
- Improving the GNSS contribution to the ITRF defining parameters. ACTION: Share any existing papers studying calibration of antennas. ACTION: Share any existing papers studying the usefulness of accelerometers on satellite. ACTION: Study other additional information on satellite “equipment” (?) that will improve the GNSS contribution to ITRF defining parameters.
- Recommendation on the on-going redefinition of UTC – to raise awareness about the issue.
- Declaration on the computation of Rapid (UTC).

The recommendations put forward to the Plenary can be found as attachments to these minutes.

8. Next Meeting

The next full meeting of Working Group D will be at ICG-8. Communication and meetings between co-chairs and other participants will occur between meetings on an opportunity basis.

APPENDIX A: Attendance List

Wednesday, 7 November 2012

Mr Chunhao Han	China
Mr Xiaolin Jia	China
Mr Wenhai Jiao	China
Mr Shuanggen Jin	China
Mr Donghang Li	China
Mr Tianke Xu	China
Mr Xianbing Wu	China
Mr Ziqing Wei	China
Mr Yuanxi Yang	China
Mr Werner Enderle	ESA
Mr Jérôme Delporte	EU
Mr Satoshi Horiuchi	Japan
Mr Ryuichi Ichikawa	Japan
Mr Motohisa Kishimoto	Japan
Mr Yoshimi Ohshimi	Japan
Mr Dmitry Aronov	Russia
Ms Anna Dorofeeva	Russia
Mr Roman Fatkulin	Russia
Mr Alexander Grechkoseev	Russia
Mr Alexey Ivanov	Russia
Ms Ekatarina Kapustina	Russia
Mr Andrey Kupriyanov	Russia
Ms Tatiana Migorodskaya	Russia
Mr Alexey Pokhaznikov	Russia
Mr Sergey Revnivykh	Russia
Mr Sergey Rybkin	Russia
Mr Igor Silvestrov	Russia
Mr Grigoriy G. Stupak	Russia
Mr Arkady Tyulyakov	Russia
Mr Vladimir Vdovin	Russia
Mr Larry Hothem	US
Mr Perry Nosker	US
Ms. Barbara Wiley	US
Mr Johannes Ihde	EUREF
Mr Matt Higgins	FIG
Mr Mikael Lilje	FIG
Mr Chris Rizos	IAG
Mr Zuheir Altamimi	IERS
Ms Ruth Neilan	IGS
Mr Wlodzimierz Lewandowski	BIPM
Mr Bernald Smith	FAI
Ms Elisabeth Fischer	IAIN
Ms Jina Maceachern	Canada
Mr Khalid Ishaq	Pakistan

Thursday, 8 November 2012

Mr Chunhao Han	China
Mr Xiaolin Jia	China
Mr Donghang Li	China
Mr Tianke Xu	China
Mr Xianbing Wu	China

Mr Ziqing Wei	China
Mr Yuanxi Yang	China
Mr Werner Enderle	ESA
Mr Jérôme Delporte	EU
Mr Satoshi Horiuchi	Japan
Mr Ryuichi Ichikawa	Japan
Mr Motohisa Kishimoto	Japan
Mr Yoshimi Ohshimi	Japan
Ms Anna Dorofeeva	Russia
Mr Roman Fatkulin	Russia
Mr Alexander Grechkoseev	Russia
Mr Arkady Tyulyakov	Russia
Mr Vladimir Vdovin	Russia
Mr Larry Hothem	US
Ms. Barbara Wiley	US
Mr Johannes Ihde	EUREF
Mr Matt Higgins	FIG
Mr Mikael Lilje	FIG
Mr Chris Rizos	IAG
Mr Zuheir Altamimi	IERS
Ms Ruth Neilan	IGS
Mr Wlodzimierz Lewandowski	BIPM
Mr Khalid Ishaq	Pakistan

APPENDIX B:**WG-D Recommendation 14 for Committee Decision**

Prepared by: Working Group D

Date of Submission: 08 November 2012

Issue Title: Interrelationship of the GNSS geodetic references through the International Terrestrial Reference System (ITRS)

Background/Brief Description of the Issue:

Considering

- that several global navigation satellite systems (GNSS) exist and that each is continuously expanding and improving,
- these 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.
- the existence of the International Terrestrial Reference System (ITRS),
- the adoption of the ITRS by the International Union of Geodesy and Geophysics (IUGG) and by the General Conference on Weights and Measures (CGPM) for geosciences and metrological applications,
- that the adoption of a theoretical reference system would lead to benefits for users regarding interrelationship of navigation and timing solutions and systems interoperability.

It is essential for multi-GNSS positioning users to be able to position precisely their locations in a unique terrestrial reference frame. Given the fact that each GNSS system has its own reference frame, e.g. WGS84 for GPS, PZ-90 for GLONASS, CGCS2000 for COMPASS, GTRF for Galileo, etc., it is desirable, from the user point of view, to relate or align these different frames to the International Terrestrial Reference Frame (ITRF), as a realization of the ITRS

Discussion/Analyses:

The individual GNSS reference frames are materialized through the provision/computation of the coordinates using data collected at the ground control stations.

All the current individual GNSS reference frames are aligned to the ITRF.

Recommendation of Committee Action:

The ICG WG-D recommends that the ITRS, as defined by the International Union of Geodesy and Geophysics (IUGG), adopted by the General Conference on Weights and Measures (CGPM) and realized by the International Earth Rotation and Reference Systems Service (IERS), be adopted by the ICG as the theoretical reference system for the alignment of GNSS terrestrial reference frames to the ITRF.

WG-D Recommendation 15 for Committee Decision

Prepared by: Working Group D

Date of Submission: 08 November 2012

Issue Title: Improving the GNSS contribution to the ITRF defining parameters

Background/Brief Description of the Issue:

Considering

- several global navigation satellite systems (GNSS) exist and that each is continuously expanding and improving,
- the existence of thousands of continuously observing GNSS stations,
- the importance of improving the ITRF defining parameters for earth science and positioning applications
- the importance of the GNSS contribution to the ITRF from the IGS,
- the nearly unique role of GNSS in accessing and densifying the ITRF,

But considering also

- that weaknesses affect the GNSS reference frame in origin and scale

Discussion/Analyses:

The GNSS reference frame exhibits weaknesses in origin and scale determination because of high correlations between (1) the reference frame Z-axis and satellite solar radiation pressure parameters and (2) the scale of the reference frame and the satellite antenna phase center offset.

Recommendation of Committee Action:

The ICG WG-D recommends that the GNSS Providers consider (1) calibrating satellite antenna phase center and variations before launch, (2) adding retro-reflectors to GNSS satellites and (3) studying the possibility and utility of adding an accelerometer to new satellites.

WG-D Recommendation 16 for Committee Decision

Prepared by: Working Group D

Date of Submission: 08 November 2012

Issue Title: Information on the works related to the proposed redefinition of UTC

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 Recommendation ITU-R TF.460-6 (new proposed version) was submitted by WP7A to SG7; discussion came to a « dead-end » with a 10-year opposition from one administration, plus two more administrations joining this position,
- the SG7 sent the Draft Recommendation to the Radiocommunication Assembly 2012 (January) for « final decision »,
- WRC 2012 put back the recommendation to SG7-WP7A for a final decision at WRC 2015;
- WRC 2012 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:

to inform the Providers and all ICG participants that the redefinition of UTC was not resolved at the WRC-2012 and the decision is deferred until WRC-2015. It is recommended that the ICG monitors the ongoing development of this issue.

WG-D Recommendation 17 for Committee Decision

Prepared by: Working Group D

Date of Submission: 08 November 2012

Issue Title: Declaration on the computation of Rapid UTC (UTCr)

Background/Brief Description of the Issue:

Considering:

- that 10 to 40 days delay as publication of UTC in BIPM Circular T is not adequate for some applications,
- that short term assessment of UTC(k) steering to UTC, is impacting contributing laboratories, and in particular GNSS times steering to UTC(k),
- better determination of GNSS times offsets is essential for interoperability of navigation systems,
- discussions at the ICG in 2010 and 2011,
- discussions with experts in commissions for developing strategies for GNSS times,
- need of a « rapid » product, to give access on a shorter delay to an approximation to UTC, before final validation by Circular T, similar to IERS, IGS rapid products ,
- that UTC contributing laboratories have been invited to participate on a voluntary basis to a pilot experiment (daily submission of daily data),
- positive responses of national time laboratories with adequate equipment,
- pilot experiment started on January 2012 computing every Wednesday rapid UTC and publishing it on BIPM website,
- report to the Consultative Committee for Time and Frequency in September 2012,
- pilot experiment will continue until final validation (few months)
- routine production of UTCr should start in 2013,
- UTC as calculated and published today will not be affected, however, it will benefit from UTCr,

Recommendation of Committee Action:

to recognize UTCr as an important service benefiting interoperability of navigation systems, and to thank the BIPM and contributing time laboratories for their efforts and commitment. It further recommends that GNSS providers consider studying the possibility of using UTCr as a common time reference for interrelationship between GNSSs.