

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

**4 – 6 December 2017, Kyoto, Japan**

Co-Chairs: Chris Rizos, Jerome Delporte, Suelynn Choy

Secretary: Mikael Lilje

### **1. INTRODUCTIONS**

On behalf of the co-chairs, Chris Rizos welcomed us all to the meeting. The names of the participants can be found in Appendix A. The meeting was split into two days where discussions devoted to Geodetic References were held on Monday Dec 4 and Timing References on Tuesday Dec 5. On Wednesday Dec 6 the meeting focused on discussing future recommendation, joint statement and work plan.

C. Rizos gave an introduction to the meeting regarding the purpose and focus of the working group. All presentations will be available on ICG website.

### **2. REVIEW OF MINUTES FROM ICG-11 MEETING**

The minutes from the working group meeting at ICG-11 in Sochi, Russia were reviewed. Round-table discussion of the representatives of Providers on the minutes concerning the templates and comments can be found in the meeting.

### **3. TASK FORCE ON GEODETIC REFERENCES**

#### **Discussion on progress with WG-D Recommendations:**

Recommendation #12 – Interoperability of geodetic reference among the different GNSS systems.

Recommendation #23 – Improving the accuracy of multi-GNSS orbits determination by the IGS.

These recommendations were discussed in particular. Especially regarding Recommendation #23 the working group noted the white paper by IGS to explain why satellite metadata is required. (<https://kb.igs.org/hc/en-us/articles/115000802772>).

#### **Presentations on Recent Developments in Geodetic References:**

- Coincidence Level among Terrestrial Reference Frames available through GNSS Broadcast Messages, by S Malys (USA);
- Realization of semi-dynamic reference frame using multi constellation of GNSS and IGS products in Japan, by H. Tsuji (Japan);
- Status of the Galileo Terrestrial Reference Frame (GTRF), by Werner Enderle (on behalf of the GGSP Consortium);

- Coordination and prioritization of laser ranging on retroreflector equipped GNSS satellites, by G Bawden (USA);
- The continuing evolution of Multi-GNSS Precise Positioning, by S Choy (FIG);
- A proposal on satellite data sharing for GNSS POD, by S Ikari (Japan).

### **Next Steps in Task Force Activities and Recommendations from Task Force on Geodetic References**

From the presentations and the discussions afterwards the Working Group D considered one new recommendation concerning the possibility of coordination between ICG and ILRS on laser tracking of GNSS satellites. The recommendation is to develop guidelines on how to select and prioritize GNSS satellite laser tracking to ensure the best utilization of the ILRS resources.

## **4. TASK FORCE ON TIMING REFERENCES**

### **Discussion on progress with WG-D Recommendations:**

A report on actions since ICG-11 was given by J. Delporte on behalf of G Petit; The 21<sup>st</sup> CCT meeting was held on 8-9 June 2017. Among the recommendations can be noted no 3 regarding the definition of time scales TAI and TT and the recognition of BIPM as provider of UTC. At this meeting, it was also presented the recent improvement on Rapid UTC (UTC<sub>r</sub>). The main reason is new computation procedures to solve problems observed in recent years. UTC<sub>r</sub>-UTC is now below 1 ns. It was also noted the efforts made in reducing time offsets between GLONASS time offset from UTC caused mainly in the calibration of equipment. Implementation of results used in Circular T since 1 March 2017. It was also noted that there was a timing session at the IGS Workshop, July 2017, Paris, France.

The meeting discussed the status on previous recommendations and noted:

- Recommendation #11; some templates (GPS; GLONASS and IGS) need updating; e.g. to be independent of leap second insertion.
- A modified version of Recommendation #21 to be considered at this ICG-12.

### **Presentations on Recent Developments in Timing References:**

- Galileo OS timing performances, by J Delporte (France);
- Galileo implementation status and performances, by J Hahn (ESA);
- National time scale UTC(SU) development and GNSS receiver's calibration in Russian Federation, by I Silvestrov (Russian Federation);
- New results of GNSS time differences (offsets) monitoring, by Y Haibo (China);
- The multi-mode time transfer based on GNSS, by S Zhao (China);
- EGNOS timing performances, by J Delporte (France);
- GLONASS timescale, the new edition of the GLOASS timescale template, by A Druzhin (Russian Federation);

- Update on Beidou time system and its performance evaluation, by Z Cai (China);
- Time and coordinate system for QZSS, by Yishibashi (Japan).

Discussion concerning a proposed recommendation:

- Need to modify the text in Recommendation #21.
- Encourage GNSS provider to conduct joint experiments and trials on the GNSS to GNSS time offsets, for instance in producing and broadcasting XGTO as generated by multi-GNSS calibrated receivers or other experimental techniques. Encourage GNSS Providers to steer their individual time sales as close as possible to UTC; this reduces these time offsets. GNSS Providers to evaluate the different possibilities also with an open discussion addressing BIPM, IGS and the timing community to avoid controversial choice and to work together pro-actively to the best solution. Coordination with WG-S to be reinforced on this topic.

### **Next Steps in Task Force Activities and Recommendations from Task Force on Timing References:**

Revision of Recommendation #21 (On the monitoring of offsets between GNSS times).  
See Appendix B.

### **Investigate time offset computation strategies**

## **5. NEXT STEPS FOR WORKING GROUP D**

The meeting went through the draft joint statement and agreed on the wording. The meeting also went through and updated the presentation to be presented at the second plenary session of ICG. The meeting also discussed two recommendations to be presented at ICG-12 (see Appendix B):

- Proposal of new Recommendation - Guidelines and Prioritizing Laser Ranging to GNSS satellites by the ILRS.
- Revision of Recommendation #21 - On the monitoring of offsets between GNSS times.

## **6. CLOSING OF THE MEETING**

The co-chairs of the meeting thanked all the participants to the WG-D meeting held at ICG-12, Kyoto, Japan. Next WG-D meeting will be held in conjunction with ICG-13 in China.

**APPENDIX 1: ATTENDANCE LIST****05 December 2017**

Mr Zhiwu Cai	China
Mr Shuo Ding	China
Mr Yuanxi Yang	China
Mr Haibo Yuan	China
Ms Shuhong Zhao	China
Mr Jerome Delporte	European Union
Mr Horimichi Tsuji	Japan
Mr Basara Miyahara	Japan
Mr Tetsuro Imakiire	Japan
Mr Igor Gusev	Russian Federation
Mr Oleg Denisenko	Russian Federation
M Sergey Donchenko	Russian Federation
Mr Igor Silvestrov	Russian Federation
Ms Anastasiia Zueva	Russian Federation
Mr Igor Norets	Russian Federation
Mr Gerald Bawden	United States of America
Mr Jim Burton	United States of America
Mr Larry Hothem	United States of America
Mr Robyn Anderson	United States of America
Mr Stephen Malys	United States of America
Mr John Dawson	Australia
Mr Markku Poutanen	EUREF
Me Suelynn Choy	FIG
Mr Mikael Lilje	FIG
Mr Chris Rizos	IAG

**06 December 2017**

Mr Zhiwu Cai	China
Mr Shuo Ding	China
Mr Yuanxi Yang	China
Mr Haibo Yuan	China
Ms Shuhong Zhao	China
Mr Jerome Delporte	European Union
Mr Horimichi Tsuji	Japan
Mr Basara Miyahara	Japan
Mr Tetsuro Imakiire	Japan
Mr Ryuichi Ichikawa	Japan
Mr Satoshi Zicari	Japan
Mr Toshimichi Otsubo	Japan
Mr Igor Gusev	Russian Federation
Mr Oleg Denisenko	Russian Federation
M Sergey Donchenko	Russian Federation
Mr Andrei Druzhin	Russian Federation
Ms Tatiana Primakina	Russian Federation
Mr Igor Silvestrov	Russian Federation
Mr Arkadii Tiuliakov	Russian Federation
Ms Anastasiia Zueva	Russian Federation
Mr Igor Norets	Russian Federation
Mr Gerald Bawden	United States of America
Mr Jim Burton	United States of America
Mr Larry Hothem	United States of America
Mr Robyn Anderson	United States of America
Mr Stephen Malys	United States of America
Mr John Dawson	Australia
Mr Markku Poutanen	EUREF
Me Suelynn Choy	FIG
Mr Mikael Lilje	FIG
Mr Chris Rizos	IAG

## **APPENDIX B: RECOMMENDATIONS**

### Recommendation for Committee Decision#21-B

**Prepared by:** WG-D

**Date of Submission:** 06 December 2017

**Issue Title:** On the monitoring of offsets between GNSS times (revision of Recommendation #21-A)

#### **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 being monitored and is currently broadcast in Galileo navigation message. GLONASS also broadcasts its offset to GPS time. 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.

4. In order to promote GNSS compatibility and interoperability, GNSS providers and time relevant organizations, including the BIPM, actively develop methods to monitor the offsets between GNSS times, share the monitoring data and relevant research results and actively collaborate with the relevant experts in WG D and S.

### **Recommendation for Committee Decision**

**Prepared by:**            **WG-D Reference Frames, Timing & Applications**

**Date of Submission:** **6 December 2017**

**Issue Title:**            **Guidelines on Selection and Prioritizing Laser Ranging to GNSS Satellites by the ILRS**

#### **Background/Brief Description of the Issue:**

The International Laser Ranging Service (ILRS) coordinates a global network of approximately 40 laser tracking stations.

Laser tracking provides a very accurate means of determining satellite orbits, including of the GNSS satellites fitted with laser retroreflectors.

The ILRS supports a variety of satellite missions, with the highest priority being for the ITRF and Earth remote sensing. Currently the ILRS tracks all GNSS satellites in an uncoordinated fashion.

#### **Discussion/Analyses:**

The ILRS is close to being overloaded and will be unable to track all future GNSS satellites. Satellite laser ranging is the best independent means of evaluating the precise GNSS satellite orbits derived by GNSS System Providers, and other researchers and third parties.

It is vital that this valuable service continues to be provided, so that GNSS orbits with centimeter-level accuracy can be assured with progressive refinements in orbit models and analyses.

The ILRS seeks advice on how to select and prioritize the GNSS satellites that should be tracked.

#### **Recommendation of Committee Action:**

That ICG work with the ILRS to develop guidelines on how to select and prioritize GNSS satellite laser tracking to ensure the best utilization of the ILRS resources.