

Update of actions since ICG-11

News of the BIPM and the 21st CCTF meeting

Templates of GNSS times

IGS Workshop

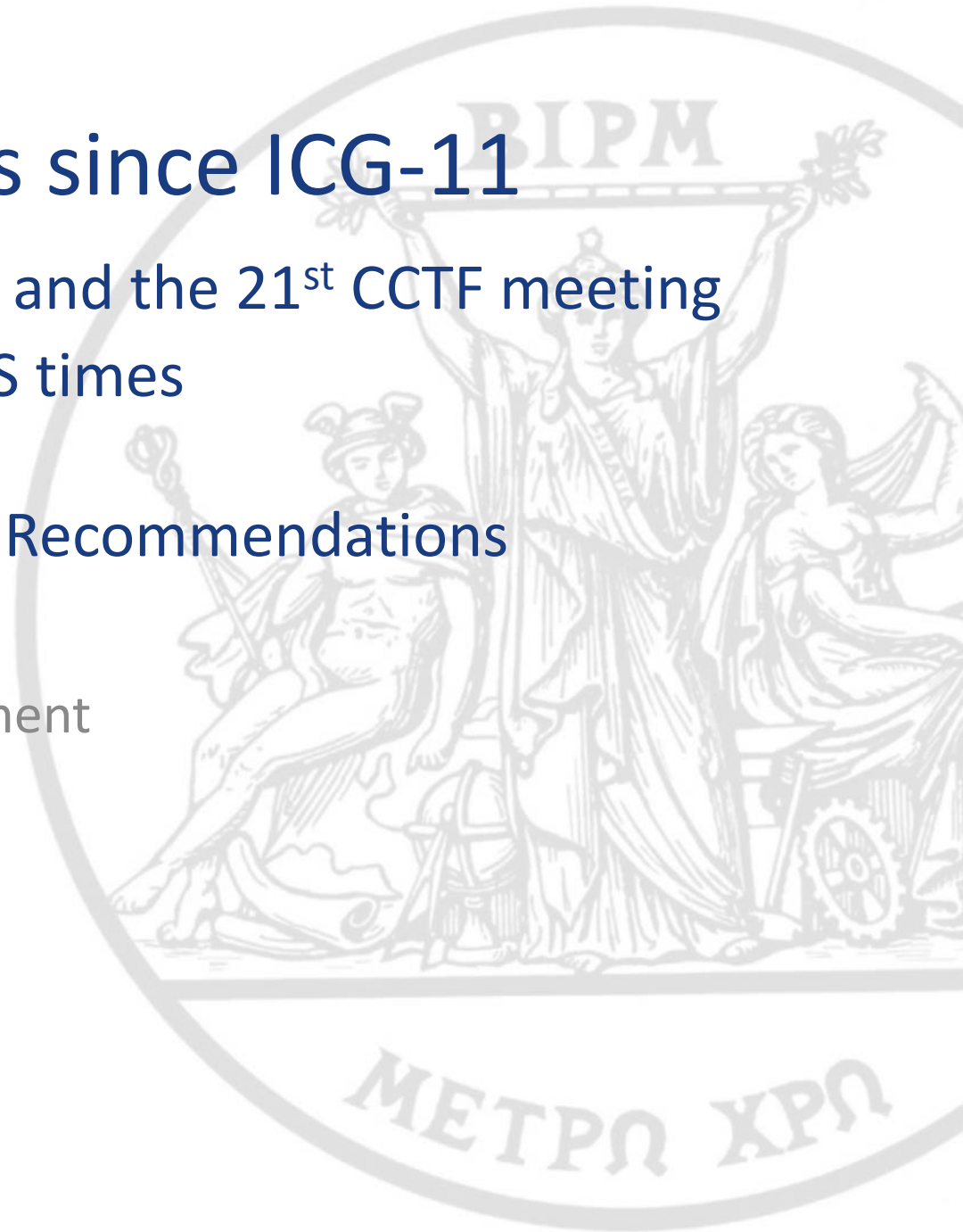
Status of past ICG Recommendations

G. Petit, BIPM Time Department

J. Delporte, CNES

12th ICG Meeting

3-7 December 2017



Part I: News of the BIPM and the 21st CCTF meeting

- ◆ 21st CCTF meeting on June 8-9 2017
- ◆ Recommendations
 1. for operating, comparing and reporting frequency standards as secondary representations of the second
 2. updates to the CIPM list of standard frequencies
 - 3. on the definition of time-scales**
 4. on the utilization and monitoring of redundant time transfer equipment
 5. on improving the uncertainty of TWSTFT for UTC Generation
- ◆ Felicitas Arias retired on 30 November 2017. Patrizia Tavella replaces her as Director of the Time Department.



Rec CCTF-3 (2017) Definitions of timescales TAI and UTC

- ◆ Remove ambiguity between TAI and TT that has been present since the IAU redefined TT in 2000.
- ◆ State that the BIPM produces UTC
- ◆ Promote working together on dissemination of UT1-UTC

decides

- 1- International Atomic Time (TAI) is a continuous time scale produced by the BIPM based on the best realizations of the SI second. TAI is a realization of Terrestrial Time (TT) with the same rate as that of TT, as defined by the IAU Resolution B1.9 (2000),
- 2- Coordinated Universal Time (UTC) is a time scale produced by the BIPM with the same rate as TAI, but differing from TAI only by an integral number of seconds,

and recommends that

- all relevant unions and organizations consider these definitions and work together to develop a common understanding on reference time scales, their realization and dissemination with a view to consider the present limitation on the maximum magnitude of UT1-UTC so as to meet the needs of the current and future user communities,
- all relevant unions and organizations work together to improve further the accuracy of the prediction of UT1-UTC and the method for its dissemination to satisfy the future requirements of the users.

ITU

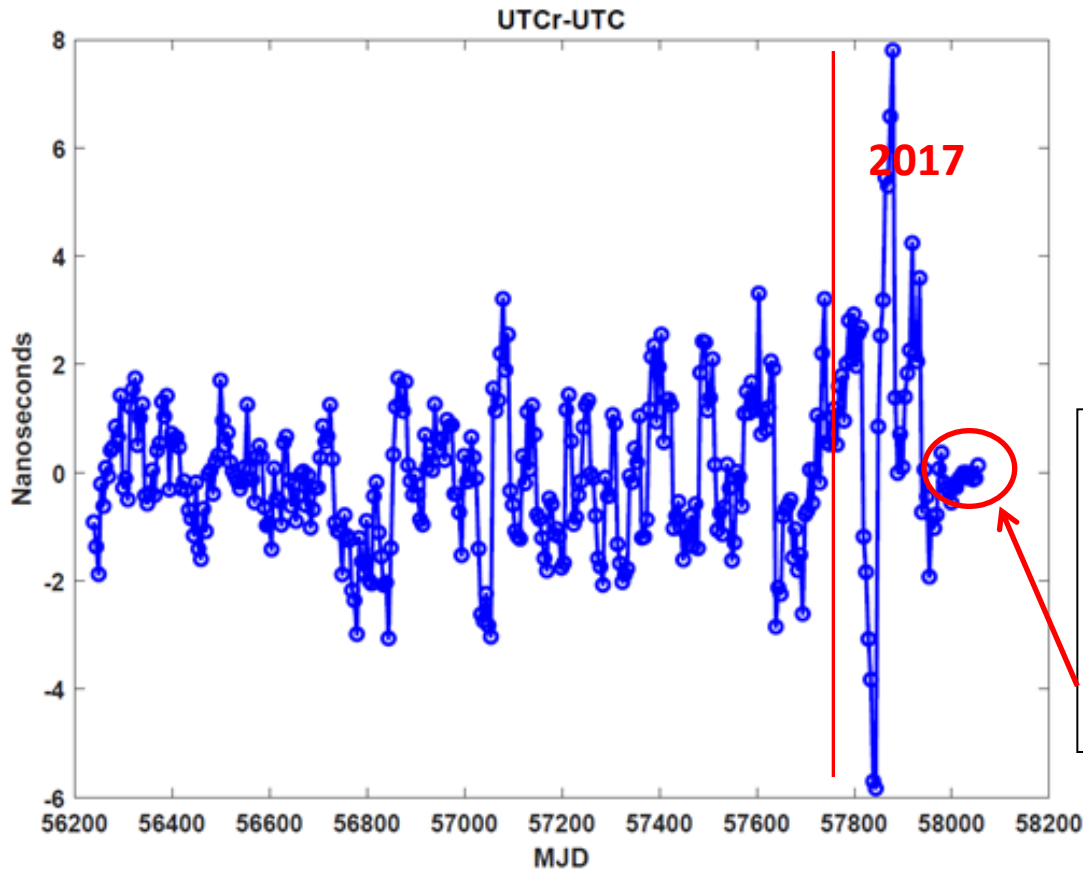
◆ WRC-15

- Recognized the roles of the BIPM and ITU concerning time scales definition and maintenance, and their dissemination;
- Invited the various organizations to cooperate for developing studies on the present and potential future reference time scales and submit contributions to WRC-23;
- Decided than until WRC-23 Rec. 460-6 will continue to apply.

◆ News in 2017

- Work started at WP-7A on the preparation of a « Preliminary draft report » report aiming at
 - ◆ providing a summary of the studies and activities related to the description, use and dissemination of UTC, and
 - ◆ describing the various aspects of current and potential future reference time scales, their impact and applications in radiocommunication and other fields.

Improvement in Rapid UTC (UTCr)



- Uninterrupted weekly publication since July 2013
- ~46-50 participants
- ~75% of the clocks in UTC

Summer 2017:
New computation procedure to solve problems observed in recent years
UTCr-UTC now below 1 ns

GLONASS time offset from UTC – actions report

- ◆ An independent laboratory (AOS, Poland) provides the data to compute the values of [UTC-GLONASS time] and [UTC-UTC(SU)_{GLO}];
- ◆ The hundreds-of-ns offset observed is historical, and originated partly in the calibration of the equipment;
- ◆ Coordinated actions between the BIPM, VNIIFTRI and AOS resulted in:

- ✓ Absolute calibration by VNIIFTRI of the BIPM receiver (June 2015);
- ✓ Measurements for the calibration of receivers at AOS relative to BIPM (Sept/Oct 2016)
- ✓ **Implementation of results , used in *Circular T* since 1 March 2017.**

4 - Relations of UTC and TAI with predictions of UTC(k) disseminated by GNSS.

$$[\text{UTC}-\text{UTC}(\text{USNO})_{\text{GPS}}] = C_0', [\text{TAI}-\text{UTC}(\text{USNO})_{\text{GPS}}] = 37 \text{ s} + C_0'$$

$$[\text{UTC}-\text{UTC}(\text{SU})_{\text{GLONASS}}] = C_1', [\text{TAI}-\text{UTC}(\text{SU})_{\text{GLONASS}}] = 37 \text{ s} + C_1'$$

For this edition of *Circular T*, $\sigma_0' = 1.0 \text{ ns}$, $\sigma_1' = 6.9 \text{ ns}$

2017	0h	UTC	MJD	C_0'/ns	N_0	C_1'/ns	N_1'
	FEB	25	57809	3.2	90	210.5	82
	FEB	26	57810	2.3	88	215.3	66
	FEB	27	57811	0.8	89	216.8	86
	FEB	28	57812	2.7	89	218.0	42
	MAR	1	57813	3.4	90	13.5	85
	MAR	2	57814	1.1	72	12.0	79
	MAR	3	57815	2.7	89	8.8	87
	MAR	4	57816	3.5	89	7.1	87
	MAR	5	57817	4.2	90	8.5	90
	MAR	6	57818	3.0	89	10.1	87
	MAR	7	57819	3.1	89	11.6	89

Part II: Templates of GNSS times

- ◆ Recommendation 11 (2011) on « Finalization and publication of templates on geodetic and timing references »
 - Ongoing, most templates have been published between 2012 and 2016
 - Some templates still need updating; e.g. to be independent of leap second insertion

- ◆ Templates available at <http://www.unoosa.org/oosa/en/ourwork/icg/resources/Regl-ref.html>

Present status of Time templates

GNSS time	Published/updated	Update needed
GPS time	2012	Leap second
GLONASS time	2014	Under way
Galileo System time	Updated 2016	-
EGNOS	2015	-
IGS time	2012	V2 Leap second
BeiDou System time	2016	
QZSS time	2016	
Navic		

Provision of templates and updates as of 15 November 2017

Part III: IGS Workshop

- ◆ IGS workshop in Paris 3-7 July 2017 <http://igsworkshop2017.ign.fr/>

- ◆ Timing session (M. Coleman, G. Petit)
6 papers, 4 posters

08:30 - 10:00

Timing

– 08:30-08:45

[The Study of GNSS System Time Difference Monitoring](#)

J. Zhang, H. Yuan, W. Guang, W. Li, Z. Gao

– 08:45-09:00

[Calibration of DCBs in timing GNSS stations](#)

P. Defraigne, W. Huang

– 09:00-09:15

[Sub 10-16 frequency transfer with IPPP](#)

G. Petit, S. Loyer, F. Perosanz

– 09:15-09:30

[BeiDou and Galileo Carrier-Phase Time Transfer toward TAI Computation](#)

B. Sun, Y. Ge, M. Duyang, L. Zhang, X. Yang, W. Qin, M. Wu, H. Yang

– 09:30-09:45

[GNSS space clocks assessment based on different IGS and MGEX data](#)

T.T. Thai, G. Signorile, I. Sesia

– 09:45-10:00

[Improved GNSS-Based Precise Orbit Determination by using highly accurate clocks](#)

A. Sušnik, R. Dach, K. Wang, M. Meindl, M. Rothacher, T. Romanyuk, I. Selmke, U. Hugentobler, Erik Schönemann, W. Enderle

- ◆ Side meeting of ICG WG S on July 7 (see below discussion under Rec #21)

Part IV: Status of past Recommendations

- ◆ **Rec #11 « Finalization and publication of templates on geodetic and timing references »**
 - Status of templates given above in Part II
- ◆ **Rec #16-A « Information on the works related to the proposed redefinition of UTC »**
 - See above in Part I
- ◆ **Rec #19 « Official provision of a rapid UTC (UTC_r) by the BIPM »**
 - See above in Part I
- ◆ **Rec #20 « BIPM publication of [UTC – GNSS times] and [UTC – UTC(k)_{GNSS}] »**
 - The BIPM Time Dpt is starting studies to incorporate Galileo and BeiDou data in its analysis for UTC computation. This includes the provision of [UTC – GNSS times] and [UTC – UTC(k)_{GNSS}] for these GNSS.
 - Report will be given at ICG-13.
- ◆ **Rec #21 « On the monitoring of offsets between GNSS times »**
 - See below discussion on GNSS time offsets

WG-S recommendation proposed at ICG-11 (2016) on organizing a workshop to discuss GNSS time offsets among the systems

Discussion/Analyses:

Recognizing that GNSS time offsets can affect interoperability, some Providers are broadcasting time offsets relative to other systems. In order to better assess the advantages of this type of offset, further discussion among timing experts is needed.

Recommendation:

The ICG WG-S should work with WG-D, to include BIPM and the IGS, to organize an expert workshop on timing to discuss GNSS time offsets among the systems. The workshop will take place in conjunction with the IGS Workshop, to be held in or near Paris, on 3 – 7 July 2017.

- ✓ The Workshop was held on 7 July 2017
- ✓ No contact with the WG-D timing experts for the organization
- ✓ Proposals were made for the implementation of a special time scale or ensemble time to be used as a reference to provide GNSS offsets, a « UTC-type » time scale
- ✓ Time experts at the Workshop did not support this approach

GNSS system times offsets / evaluation and broadcast

- ◆ Broadcast of GNSS system times offsets is « necessary » for the systems interoperability
 - GPS-Galileo offset (GGTO) is currently evaluated and broadcast by Galileo (using a GPS/Galileo calibrated chain)
 - Strategy is to be defined for the procedure of evaluation of all system time offsets (by Service Providers)
 - Different options could be
 - a) Each GNSS computes offsets with respect to all other systems, and broadcasts all values that it determines;
 - b) Arbitrarily adopt one GNSS system time as the reference and disseminate all offsets referred to it;
 - c) Arbitrarily adopt one recognized realization of UTC, namely one UTC(k) in the BIPM list, as the reference (this implies specific links to the chosen UTC(k));
- ◆ Options to **avoid**
 - **Implement a new time scale or a new ensemble time** as a common reference to avoid the proliferation of time scales
- ◆ The BIPM is keen to work together with GNSS experts with the common aim to find a solution ensuring interoperability and enforcing the value of common reference time scales

GNSS system times offsets / evaluation and broadcast

- ◆ WG D added a 4th « recommends » at ICG-11 to foster studies on GNSS time offsets determination

In order to promote GNSS compatibility and interoperability, GNSS time relevant organizations actively develop methods to monitor the offsets between GNSS times and share the monitoring data and relevant research results

- ◆ Proposal to slightly modify as :

*In order to promote GNSS compatibility and interoperability, GNSS **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 discuss a solution with the relevant experts in WG D and S***