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- I. BIPM Circular T and UTCr, updates
 - II. GPS calibrations for UTC
 - III. Templates of GNSS times
 - IV. CCTF Task group on timescales definition

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BIPM Time Department

11th ICG Meeting

6-11 November 2016

Bureau
| **I**nternational des
| **P**oids et
| **M**esures

Part I: BIPM Circular T and UTCr, updates

- ◆ New form of Circular T in January 2016
- ◆ Fully clickable web version <ftp://ftp2.bipm.org/pub/tai/Circular-T/cirthtm/cirt.xxx.html>
- ◆ Explanatory Supplement of BIPM *Circular T* available on the ftp server at <ftp://ftp2.bipm.org/pub/tai/publication/notes/>.

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The contents of the sections of BIPM *Circular T* are fully described in the document "Explanatory supplement to BIPM *Circular T*" available at ftp://ftp2.bipm.org/pub/tai/publication/notes/explanatory_supplement_v0.1.pdf

① - Difference between UTC and its local realizations UTC(k) and corresponding uncertainties. From 2015 July 1, 0h UTC, $TAI-UTC = 36$ s. From 2017 January 1, 0h UTC, $TAI-UTC = 37$ s.

Date 2016 0h UTC		MJD	AUG 29 57629	SEP 3 57634	SEP 8 57639	SEP 13 57644	SEP 18 57649	SEP 23 57654	SEP 28 57659	Uncertainty/ns			Notes
Laboratory k			[UTC-UTC(k)]/ns						k_A	k_B	k_C		
AOS (Borowiec)	123		-5.4	-4.4	-3.7	-3.6	-3.2	-2.7	-1.5	0.4	2.7	2.7	
APL (Laurel)	123		0.1	1.1	1.4	1.1	1.4	1.8	2.7	0.3	10.9	10.9	
AUS (Sydney)	123		739.2	757.2	779.6	796.8	811.3	834.3	862.1	0.4	5.9	5.9	
BEV (Wien)	123		22.2	24.1	25.8	25.0	22.0	21.2	29.0	0.4	5.1	5.1	
BIM (Sofiya)	123		4507.0	4525.1	4543.9	4571.9	4605.4	4642.5	4670.3	1.5	9.2	9.4	
BIRM (Beijing)	123		-	1.0	0.0	-2.0	-4.6	0.9	5.4	1.5	20.0	20.1	
BY (Minsk)	123		-3.2	-3.6	-3.8	-3.6	-4.3	-4.7	-4.5	1.5	8.6	8.8	
CAO (Cagliari)	123		-15056.5	-15163.0	-15258.3	-15366.6	-15467.5	-15566.4	-15673.6	8.0	20.0	21.6	
CH (Bern-Wabern)	123		3.3	3.0	3.5	3.7	4.9	4.7	4.7	0.3	1.6	1.7	
CNES (Toulouse)	123		-0.1	-3.0	-5.1	-7.0	-4.7	-3.1	-1.9	0.4	4.1	4.1	
CNM (Queretaro)	123		-13.4	-13.1	-10.1	-5.4	-1.1	0.6	3.2	2.5	11.1	11.4	
CNMP (Panama)	123		-	-	-	-	-	-	-	-	-	-	
DFNT (Tunis)	123		5968.2	6158.4	6354.0	6565.2	6762.7	6955.7	7160.7	0.7	20.0	20.0	
DMDM (Belgrade)	123		20.2	9.9	8.1	3.4	7.2	-0.6	0.0	0.4	7.3	7.3	
DTAG (Frankfurt/M)	123		135.9	128.5	125.4	120.8	126.5	135.3	129.4	0.3	7.6	7.6	
EIM (Thessaloniki)	123		-4.3	-1.1	-8.6	-4.5	9.4	8.9	8.3	2.5	7.9	8.2	
ESTC (Noordwijk)	123		-1.2	-1.6	-1.8	-1.2	1.0	2.8	2.8	0.4	5.5	5.5	
HKO (Hong Kong)	123		421.6	426.2	430.3	443.4	450.5	462.2	476.5	0.4	7.3	7.3	
IFAG (Wetzell)	123		-937.9	-943.9	-942.1	-935.2	-938.0	-929.2	-936.9	0.4	5.5	5.5	
IGNA (Buenos Aires)	123		-	-	-	-	-	-	-	-	-	-	
IMBH (Sarajevo)	123		-	-	-	-	-	-	-	-	-	-	
INCP (Lima)	123		144.0	149.4	163.0	170.2	-21.6	-9.8	9.4	5.0	20.0	20.6	(1)
INPL (Jerusalem)	123		135.5	135.9	145.8	148.3	155.4	170.0	174.5	1.5	7.7	7.9	
INTI (Buenos Aires)	123		36.5	45.7	67.3	74.3	83.5	89.7	88.1	2.5	20.0	20.2	
INXE (Rio de Janeiro)	123		-19.7	-14.4	-11.7	-18.4	-24.5	-24.0	-23.6	0.4	20.0	20.0	
IT (Torino)	123		2.0	2.8	3.4	4.3	4.4	3.7	3.0	0.3	1.3	1.4	

Section 4 on [UTC-GNSS times]

- ◆ New section 4 provides only the values for the relations of UTC and TAI with predictions of UTC(k) disseminated by GNSS (as decided at the 20th Meeting of the CCTF). The relations of UTC and TAI with the GNSS System Times are published on the ftp server.

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

$$[\text{UTC}-\text{UTC}(\text{USNO_GPS})] = C_0', [\text{TAI}-\text{UTC}(\text{USNO_GPS})] = 36 \text{ s} + C_0'$$

$$[\text{UTC}-\text{UTC}(\text{SU_GLONASS})] = C_1', [\text{TAI}-\text{UTC}(\text{SU_GLONASS})] = 36 \text{ s} + C_1'$$

For this edition of circular, $\sigma_0' = 1.0 \text{ ns}$, $\sigma_1' = 6.8 \text{ ns}$

2016	0h UTC	MJD	C_0'/ns	N_0	C_1'/ns	N_1'
	AUG 29	57629	0.0	89	255.0	82
	AUG 30	57630	0.8	90	250.5	90
	AUG 31	57631	0.0	88	247.1	87
	SEP 1	57632	-0.7	89	243.2	79
	SEP 2	57633	-0.6	89	240.3	89
	SEP 3	57634	0.1	90	238.6	56
	SEP 4	57635	1.2	89	237.6	82
	SEP 5	57636	1.2	89	237.5	82
	SEP 6	57637	0.4	89	237.4	78
	SEP 7	57638	-0.3	90	236.8	89
	SEP 8	57639	-0.9	88	236.5	85
	SEP 9	57640	-1.9	77	235.2	80
	SEP 10	57641	-2.8	89	240.5	84
	SEP 11	57642	-0.9	90	255.0	79
	SEP 12	57643	-1.3	89	262.9	87
	SEP 13	57644	-1.4	86	261.4	81
	SEP 14	57645	0.1	89	254.7	69

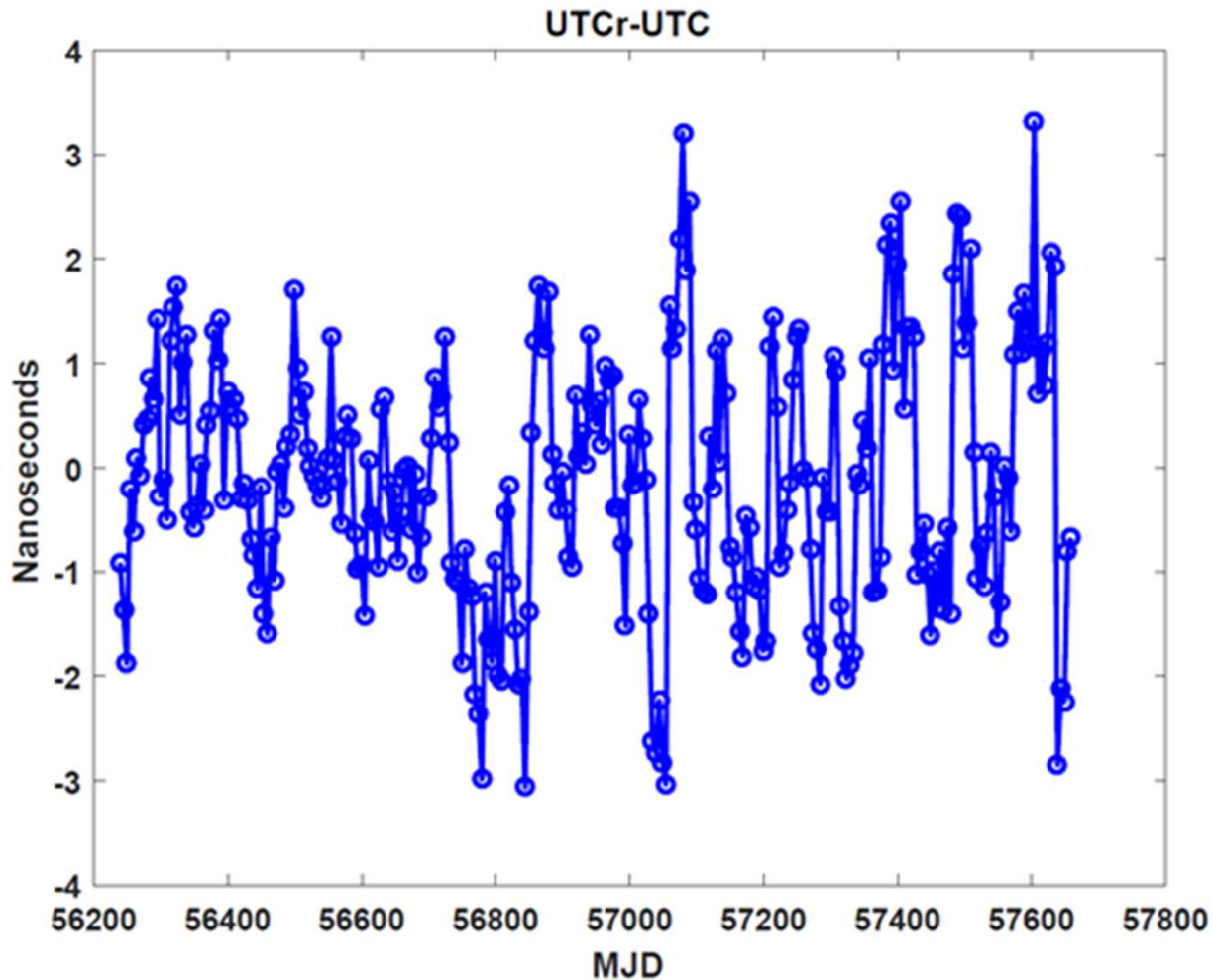
Section 5 on Time links

- ◆ New section 5 provides
 - more detailed information on the equipment used;
 - more reliable calibration uncertainties, and traceability to the original info.

5 - Time links used for the computation of TAI, calibrations information and corresponding uncertainties.

Link	Type	Equipment	Cal_ID1	/ Cal_ID2	u_{Stb}/ns	u_{Cal}/ns	u_{Ag}/ns	Al/ns	YYMM
APL /PTB	GPSPPP	AP__ /PT02	NA_AI	/ 1001-2014	0.3	11.2	10	24.3	1511
AUS /PTB	GPSPPP	AU01 /PT02	1002-2010	/ 1001-2014	0.3	5.8	3		
BIM /PTB	GPS MC	BM37 /PT07	2004-2008	/ 1005-2008	1.5	9.2	6		
BIRM/PTB	GPS MC	BIRM /PT07	NC	/ 1005-2008	1.5	20.0			
BY /PTB	GPS MC	BY46 /PT07	NA	/ 1005-2008	1.5	8.6	5		
CAO /PTB	GPS MC	CA__ /PT07	NC	/ 1005-2008	8.0	20.0			
CNES/PTB	GPSPPP	CS22 /PT02	1101-2016	/ 1001-2014	0.3	4.0	0		
CNM /PTB	GPS MC	CN00 /PT07	NA_AI	/ 1005-2008	2.5	11.2	10	-27.3	0804
CNMP/PTB		NL							
DFNT/PTB	GPS P3	DN__ /PT02	NC_AI	/ 1001-2014	0.7	20.0		10.3	1507
DMDM/PTB	GPSPPP	ZM68 /PT02	NA	/ 1001-2014	0.3	7.3	2		
DTAG/PTB	GPSPPP	DT01 /PT02	NA	/ 1001-2014	0.3	7.6	3		
EIM /PTB	GPS MC	EI__ /PT07	1011-2007	/ 1005-2008	2.5	7.8	6		
ESTC/PTB	GPSPPP	ES04 /PT02	1012-2012	/ 1001-2014	0.3	5.4	2		
HKO /PTB	GPSPPP	HKO2 /PT02	NA_AI	/ 1001-2014	0.3	7.3	2	11.6	1509
IFAG/PTB	GPSPPP	IF13 /PT02	1011-2011	/ 1001-2014	0.3	5.4	2		
IGNA/PTB		NL							
IMBH/PTB		NL							
INCP/PTB	GPS MC	CP__ /PT07	NC	/ 1005-2008	5.0	20.0			
INPL/PTB	GPS P3	IL02 /PT02	NA_AI	/ 1001-2014	1.5	7.7	3	-46.8	1212
INTI/PTB	GPS MC	IN__ /PT07	NC	/ 1005-2008	2.5	20.0			

Rapid UTC (UTCr)



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Uninterrupted weekly
publication since July 2013
46 participants
~ 70% of the clocks in UTC
Difference [UTC-UTCr] is
minimized (steering to UTC
after publication of *BIPM
Circular T*)

$-3.1 \text{ ns} \leq [\text{UTC}-\text{UTCr}] \leq +3.3 \text{ ns}$
Mean -0.1 ns
STD 1.2 ns

New Time Department database

- ◆ Provides information on UTC/UTCr and participating laboratories
- ◆ <http://webtai.bipm.org/database/html/>

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BIPM Time Department Data Base

General | **Participation guidelines** | **Interactive plots** | **GNSS equipment** | **Calibration** | **Clocks** | **Contact us**

In this web site, information can be found on equipment in UTC contributing laboratories
To obtain these information, go to tabs :

General

- Laboratories info** = laboratories' location and RMO
- Laboratories codes** = full list of participating labs and their BIPM codes
- UTC/UTCr Contributors** = contributing laboratories to UTC and UTCr

Participation guidelines = full documentation and guidelines for UTC and UTCr participation

Interactive plots

- UTC(k) and GNSS times** = Interactive plot of UTC(k) and GNSS system times wrt UTC/UTCr

GNSS equipments

- all** = list of all GNSS equipment whose data are submitted to BIPM
- by laboratory** = list of GNSS equipment from a given lab

Calibration

- all** = list of all calibrated GNSS equipment
- by laboratory** = GNSS equipment calibration in a lab
- by receiver** = summary of calibrations per equipment

Clocks

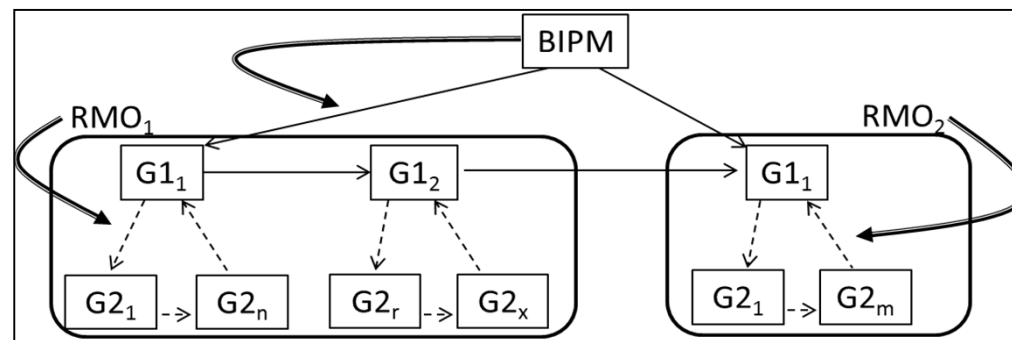
- Global stat** = list of all clocks contributing to UTC
- by laboratory** = list of clocks from a given lab
- Obtain BIPM clock code** = support tool to determine your own BIPM clock code before submitting data to BIPM

18/07/16 : BIPM Internal availability
14/09/16 : Web availability

Last site modification : 14/09/2016

Part II: GPS calibrations for UTC

- ◆ Maintain the calibration of the time transfer facilities in laboratories contributing to UTC.
- ◆ Use the calibration trips contributed by RMOs and individual laboratories in a consistent and optimal manner.
- ◆ Optimize the set of u_B uncertainties for UTC.
- ◆ Two groups of laboratories
 - Group 1: Calibration trips regularly carried out by the BIPM
 - Group 2: Other laboratories. Calibration trips for group 2 are performed under responsibility of the RMOs.
 - Group 1 laboratories are proposed by the RMOs. About 10 G1 labs (list may evolve with time).



Status of calibrations

- ◆ 2014 Group 1 trip: Results published, used since September 2015.
- ◆ 2016 Group 1 trip under way
 - Stability from 2014 to 2016 below 1 ns for all visits so far.
- ◆ Group 2 trips started
 - About 20 laboratories calibrated or in the process of being calibrated.
- ◆ Present uncertainty: 1.5 ns Group 1, 2.5 ns Group 2 (conventional).
- ◆ Goal of 1.5 ns systematic uncertainty for all links within reach.

Calibrations web page

<http://www.bipm.org/jsp/en/TimeCalibrations.jsp>

On line 09/04/2015

Intended to host all reports of UTC calibrations

The screenshot shows the BIPM website interface. At the top left is the logo for 'Bureau International des Poids et Mesures' with the tagline: '= the intergovernmental organization through which Member States act together on matters related to measurement science and measurement standards.' To the right is a search facility and navigation links for 'Site map', 'News', and 'Contact us'. A dark blue navigation bar contains the following menu items: ABOUT US, WORLDWIDE METROLOGY, INTERNATIONAL EQUIVALENCE, MEASUREMENT UNITS, SERVICES, PUBLICATIONS, MEETINGS. Below this is a breadcrumb trail: '> You are here: BIPM work programme > time > calibrations of time transfer equipment'. The main heading is 'BIPM calibrations of time transfer equipment'. Below the heading are four tabs: Introduction, Documentation, Current files, and Archive. The 'Introduction' tab is active. The text under this tab explains that the BIPM Time Department manages the calibration of time transfer systems used to generate UTC. It states that calibrations may be carried out by the BIPM, RMOs, individual time laboratories, or other entities like manufacturers. It provides access to calibration results and reports for all techniques contributing to UTC. It notes that starting in 2015, calibrations in contributing laboratories follow specific guidelines. It explains that current calibration results are labeled with a 'Cal_ID' for tracing, which is used in Section 6 of Circular T. It defines the calibration identifier format as 'znnn-YYYY', where 'z' is the type of calibration, 'nnn' is assigned by the BIPM, and 'YYYY' is the year. It lists three types of calibration: z=0 for TWSTFT links, z=1 for GNSS systems with BIPM supervision, and z=2 for GNSS systems calibrated with other techniques. It also mentions that calibrations made before 2014 are included in the current scheme by assigning a Cal_ID when a full report is available.

Provision of BIPM technical services per Member State

- Chemistry
- Electricity
- Ionizing Radiation
- Mass
- Time

Related articles

- Time scales
- BIPM calibration and measurement services
- Comparisons piloted by the BIPM

www.bipm.org

Part III: 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 due to last leap second insertion

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

Present status of templates

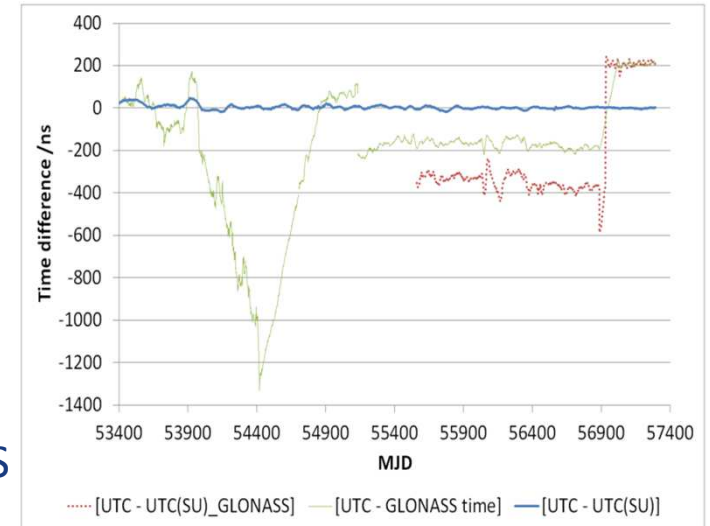
GNSS time	Published/updated	Update needed
GPS time	2012	Leap second
GLONASS time	2014	-
Galileo System time	Update 2016	-
EGNOS	2015	-
IGS time	2012	V2 Leap second
BeiDou	Draft 2016	
QZSS		
IRNSS		

Provision of templates and updates by 15 January 2017

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:
 - The absolute calibration by VNIIFTRI of the BIPM receiver identified by TTS4#136 in GLONASS signals LIC, L2C, L1P, L2P (June 2015);
 - Measurements for the calibration of receivers at AOS relative to BIPM TTS4#136 (Sept/Oct 2016), preliminary results indicate an offset ~ 204 ns;
 - Final files for October 2016 will be made available to the BIPM for analysis this week, with possible implementation in *Circular T* results computation.

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Part IV: CCTF Task group on timescales definition

- ◆ ITU has undertaken studies, and requested input on the feasibility of achieving a continuous reference time scale;
- ◆ In fact, the discussion has been about « stopping leap second insertions in UTC »;
- ◆ There is no formal definition of UTC (nor TAI) issued from metrology, so
 - Rec. ITU-R TF. 460-6 has been (wrongly) interpreted as defining UTC.
- ◆ 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 that until WRC-23 Rec. 460-6 will continue to apply.

CCTF Task Group: Mission

- ◆ Mission
 - Review the present status of definition of time scales and their applications;
 - Provide the definitions (in a metrological context) of the existing time scales – TAI, UTC;
 - Discuss on the time scale adapted for reference in metrology applications, for adoption after 2023;
 - Develop draft recommendations on the items above to be proposed to the CCTF, which if approved, will submit them to the CIPM (2017) for its adoption, and as the basis of draft resolutions of the CGPM (2018).

- ◆ First meeting 28/9/2016