Report on Rapid UTC (UTCr)

BIPM Time Department

20th CCTF Meeting
17-18 September 2015

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Mesures

Summary

- Rapid UTC project
- Characteristics of UTCr
- UTCr computation
- Comparisons between UTCr and UTC

Rapid UTC project

- UTC is not adapted for real and quasi-real time applications.
  - UTC is calculated with one-month data batches, and available monthly in *BIPM Circular T* under the form of [*UTC-UTC*(*k*)] at five-day intervals;
  - Extrapolation of values over 10 to 45 days based on prediction models is necessary to many applications.
- The Rapid UTC project (UTCr) was presented at the CCTF(2012)
- Evolution since CCTF(2012)
  - November 2012: Introduction of drift from UTC in UTCr clock prediction
  - April 2013: Final report to the CCTF WG on TAI
  - June 2013: Go-ahead from the WG on TAI
  - July 2013: UTCr an official BIPM product

Characteristics of UTCr

- Based on daily data reported (daily) by contributing laboratories;
- Weekly solution, generated quasi automatically.
  - Product identified by the week number = YYWW
- Computation interval of 27 to 31 days (sliding solution);
- Weekly access to daily values of [UTCr-UTC(k)]

- Stability of UTCr expected to be about similar to UTC since participating laboratories represent at least 70% of the clocks in UTC.
- UTCr algorithm originally similar to UTC but evolved differently
  - Quadratic frequency prediction since September 2011 in UTC, November 2012 in UTCr;
  - New weighting procedure implemented January 2014 in UTC, not in UTCr.
- Accuracy ensured by simple steering in time to UTC

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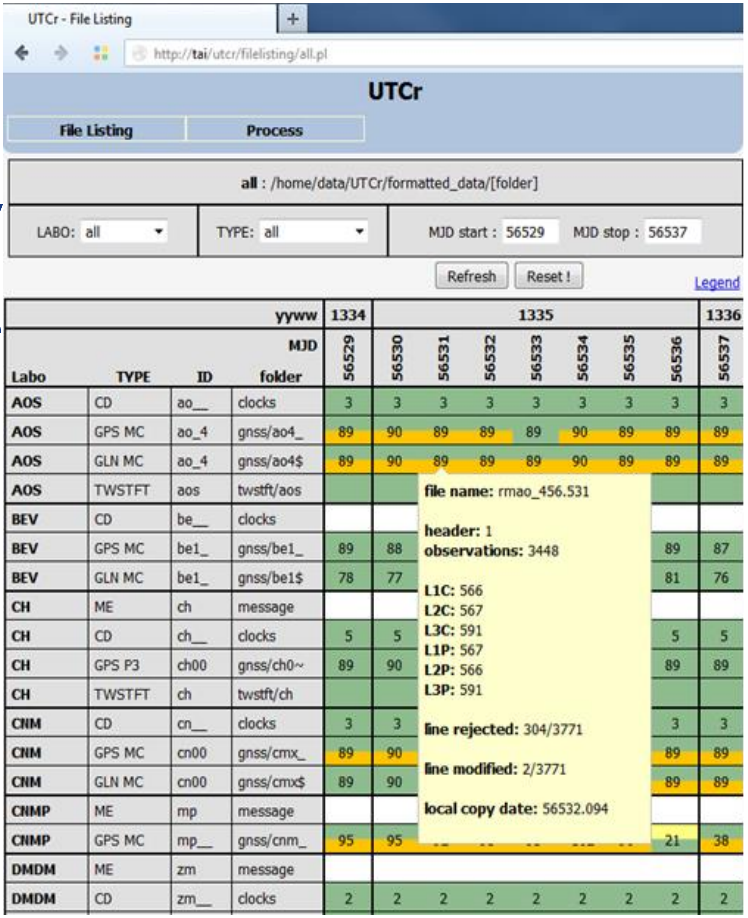
Four steps of UTCr computation: 1/4

1. Data checking
   - Daily data, reported daily by laboratories.
   - Data of day D must be uploaded before day D+2, 12:00 UTC on ftp server, following standard file naming conventions (see guidelines in
ftp://tai.bipm.org/UTCr/Documents/)
   - Automatic tasks carried out:
     - detection of input data
     - sending reminders to labs!
     - checking the format of recognized data
     - report on unknown or new data file



UTCr - File Listing

http://tai/utcr/filelisting/all.pl

UTCr

File Listing | Process

all : /home/data/UTCr/formatted_data/[folder]

LABO: all | TYPE: all | MJD start : 56529 | MJD stop : 56537

Refresh | Reset ! | Legend

			yyww	1334	1335							1336
Labo	TYPE	ID	folder / MJD	56529	56530	56531	56532	56533	56534	56535	56536	56537
AOS	CD	ao__	clocks	3	3	3	3	3	3	3	3	3
AOS	GPS MC	ao_4	gnss/ao4_	89	90	89	89	89	90	89	89	89
AOS	GLN MC	ao_4	gnss/ao4$	89	90	89	89	89	90	89	89	89
AOS	TWSTFT	aos	twstft/aos									
BEV	CD	be__	clocks									
BEV	GPS MC	be1_	gnss/be1_	89	88						89	87
BEV	GLN MC	be1_	gnss/be1$	78	77						81	76
CH	ME	ch	message									
CH	CD	ch__	clocks	5	5						5	5
CH	GPS P3	ch00	gnss/ch0~	89	90						89	89
CH	TWSTFT	ch	twstft/ch									
CNM	CD	cn__	clocks	3	3						3	3
CNM	GPS MC	cn00	gnss/cmx_	89	90						89	89
CNM	GLN MC	cn00	gnss/cmx$	89	90						89	89
CNMP	ME	mp	message									
CNMP	GPS MC	mp__	gnss/cnm_	95	95						21	38
DMDM	ME	zm	message									
DMDM	CD	zm__	clocks	2	2	2	2	2	2	2	2	2

file name: rmao_456.531

header: 1
observations: 3448

L1C: 566
L2C: 567
L3C: 591
L1P: 567
L2P: 566
L3P: 591

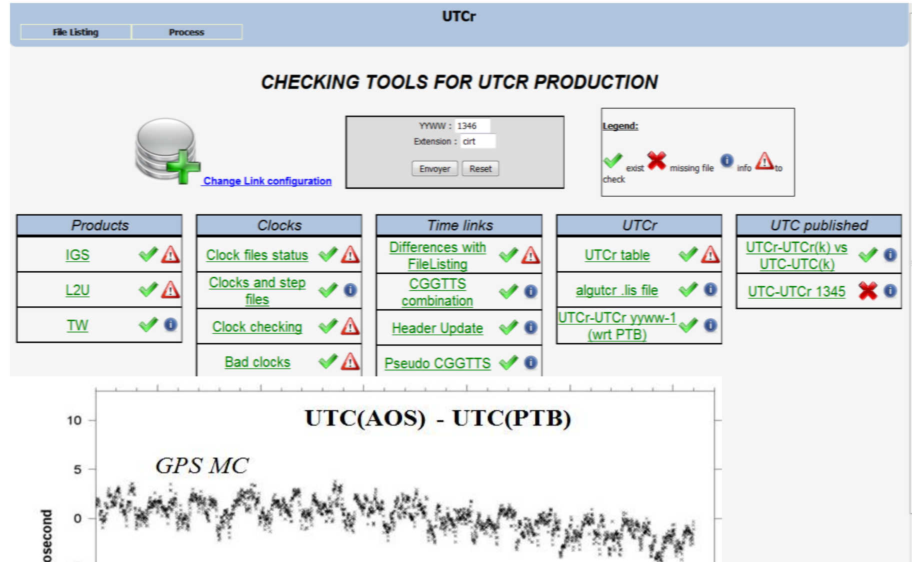
line rejected: 304/3771

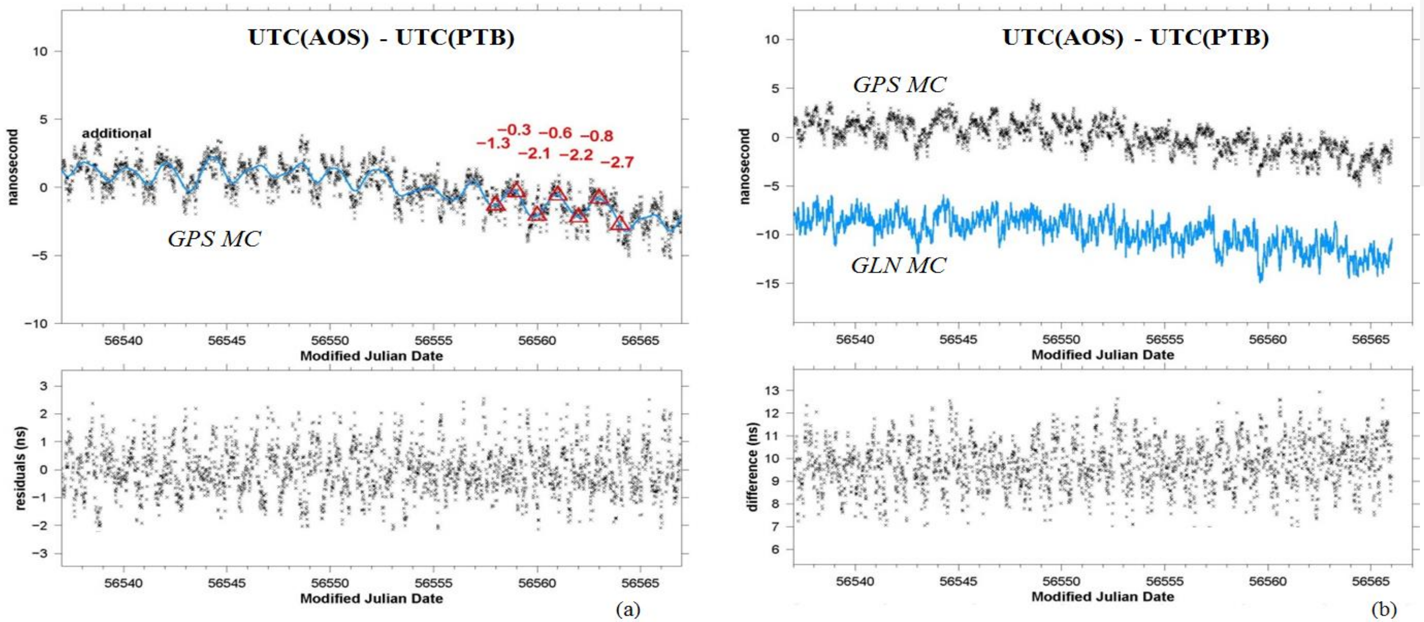
line modified: 2/3771

local copy date: 56532.094

Four steps of UTCr computation: 2/4

2. Computation of time links
   - TW when available
   - GPS P3
   - GPS MC





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Four steps of UTCr computation: 3/4

3. Stability algorithm

- Algorithm similar to original UTC's ALGOS, with quadratic prediction (since November 2012) for $h_i'(t)$.

$$UTCr - h_j = \sum_{i=1}^{N} w_i \left[h_i'(t) - x_{i,j}(t) \right]$$

- Daily clock data reported at 0h UTC
- Computation interval between 27 and 31 days, starting with a "TAI standard date" and ending with Sunday of the week to be published.
- Weight computed from the clock stability over 11 past 30-day intervals vs. The most predictable clocks have a bigger weight in UTC.
- Maximum weight = 2.5/Nclocks, 4/Nclocks in UTC algorithm.
- Test for "abnormal behavior" (different in UTCr and in UTC).

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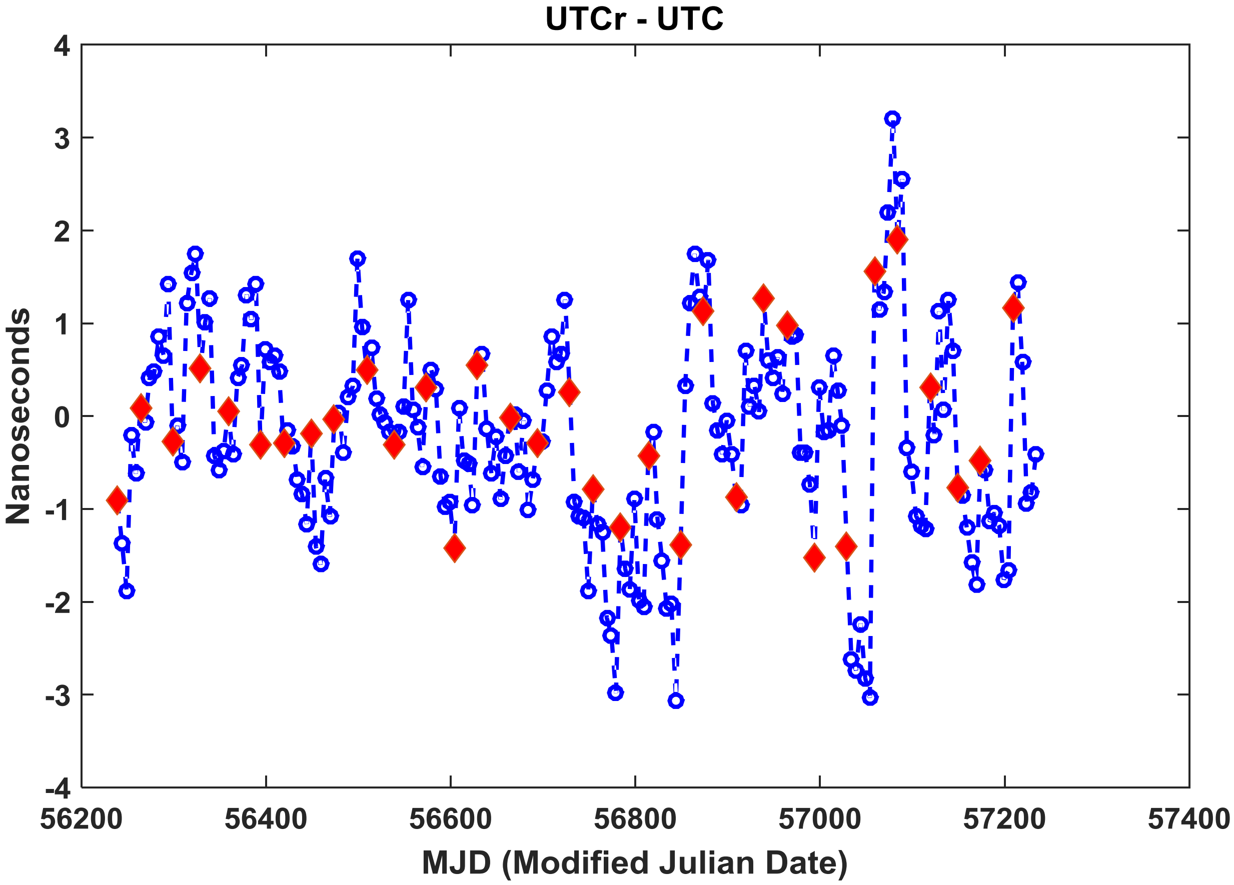
Four steps of UTCr computation: 4/4

4. Steering to UTC

Each month, after CirT computation, the past UTCr Clock data [UTCr-Clock] are replaced by the newly computed [UTC-Clock]. See red diamonds on the plot. This ensures the steering of UTCr to UTC.



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Publication of UTCr

Every Wednesday before 18:00 UTC on ftp://tai.bipm.org/UTCr/Results/ and on the regular Time Dpt ftp server.

Also ASCII files with UTCr-UTC(k)

Results of the official UTCr product since July 2013;

Back results of the pilot experiment stage in subdirectory Results/pilot_experiment;

UTCr_1344
2013 NOVEMBER 06, 12h UTC

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Computed values of [UTCr-UTC(k)]

Date 2013 0h UTC	OCT 28	OCT 29	OCT 30	OCT 31	NOV 1	NOV 2	NOV 3
MJD	56593	56594	56595	56596	56597	56598	56599
Laboratory k	[UTCr-UTC(k)]/ns						
AOS (Borowiec)	0.3	0.6	0.1	-0.3	-0.4	-1.2	-1.0
BEV (Wien)	-36.1	-37.0	-31.8	-25.5	-26.1	-20.5	-20.9
CH (Bern-Wabern)	-3.7	-6.4	-7.6	-8.3	-8.2	-9.1	-9.5
CNM (Queretaro)	-5.4	-6.4	-5.0	-5.8	-5.3	-5.9	-6.6
CNMP (Panama)	0.0	-1.6	-8.5	-13.2	-23.9	-17.1	-25.4
DMDM (Belgrade)	-13.1	-16.6	-17.5	-22.3	-30.5	-31.0	-29.4
DTAG (Frankfurt/M)	240.8	240.5	239.0	239.9	238.4	235.1	233.7
IFAG (Wettzell)	-863.1	-863.1	-865.7	-871.3	-875.1	-876.9	-875.4
IGNA (Buenos Aires)	4621.9	4637.8	4654.7	4669.3	4686.0	4705.1	4724.0
INTI (Buenos Aires)	62.2	61.0	61.3	60.7	67.8	75.9	73.1
IT (Torino)	-8.8	-9.2	-8.9	-9.0	-9.2	-10.3	-10.0
KRIS (Daejeon)	-16.0	-16.3	-15.8	-15.7	-15.3	-15.7	-15.0
LT (Vilnius)	410.7	402.9	393.9	396.9	391.9	389.0	382.2
MSL (Lower Hutt)	782.4	781.8	791.7	802.6	813.9	828.0	842.6
NAO (Mizusawa)	-20.3	-23.1	-23.2	-20.5	-23.4	-23.8	-25.4
NICT (Tokyo)	10.9	10.6	10.4	10.2	10.0	8.9	8.3
NIM (Beijing)	-7.8	-7.7	-7.8	-9.1	-8.5	-9.7	-9.9
NIMT (Pathumthani)	0.1	1.8	2.5	-2.1	-2.3	-1.0	0.0
NIST (Boulder)	-1.4	-1.9	-2.7	-3.5	-3.5	-4.3	-3.9
NMIJ (Tsukuba)	0.6	0.3	0.0	-0.4	-0.3	-1.1	-1.2
NMLS (Sepang)	1119.1	1104.1	1084.3	1072.6	1053.4	1037.7	1018.2
NPLI (New-Delhi)	-3.7	-3.4	-3.7	-4.2	-4.0	-3.6	-3.3
NRC (Ottawa)	-22.6	-19.6	-22.1	-20.6	-26.5	-26.6	-22.8
NRL (Washington DC)	-4.6	-4.4	-4.2	-4.1	-3.4	-2.1	-1.1
NTSC (Lintong)	-0.1	-0.2	-1.3	0.7	-2.6	-1.9	-3.6
ONRJ (Rio de Janeiro)	-11.8	-12.1	-13.0	-13.5	-14.8	-14.3	-15.0
OP (Paris)	-3.1	-2.8	-3.1	-3.3	-3.2	-3.6	-3.4
ORB (Bruxelles)	-11.4	-10.6	-10.7	-12.9	-12.4	-15.2	-17.3
PL (Warszawa)	38.2	38.8	35.7	32.6	29.9	32.5	29.1
PTB (Braunschweig)	-6.9	-6.6	-7.1	-7.7	-8.1	-8.7	-8.5
ROA (San Fernando)	0.4	0.6	0.2	-1.1	-1.8	-3.2	-4.0
SCL (Hong Kong)	33.7	35.6	27.5	34.7	29.3	32.4	28.1
SG (Singapore)	-17.2	-17.9	-19.2	-20.6	-19.2	-20.2	-19.4
SP (Boras)	-6.4	-5.7	-6.3	-6.9	-7.2	-7.6	-7.5
SU (Moskva)	-2.0	-1.7	-2.1	-2.4	-2.2	-2.6	-1.9
TL (Chung-Li)	-5.6	-6.2	-6.9	-7.4	-7.8	-8.9	-8.1
UME (Gebze-Kocaeli)	1363.3	1367.5	1369.9	1370.5	1376.8	1380.7	1379.1
USNO (Washington DC)	-3.4	-3.8	-4.2	-5.0	-5.1	-5.3	-5.5
VSL (Delft)	-23.0	-22.2	-22.0	-20.5	-18.3	-18.8	-12.9

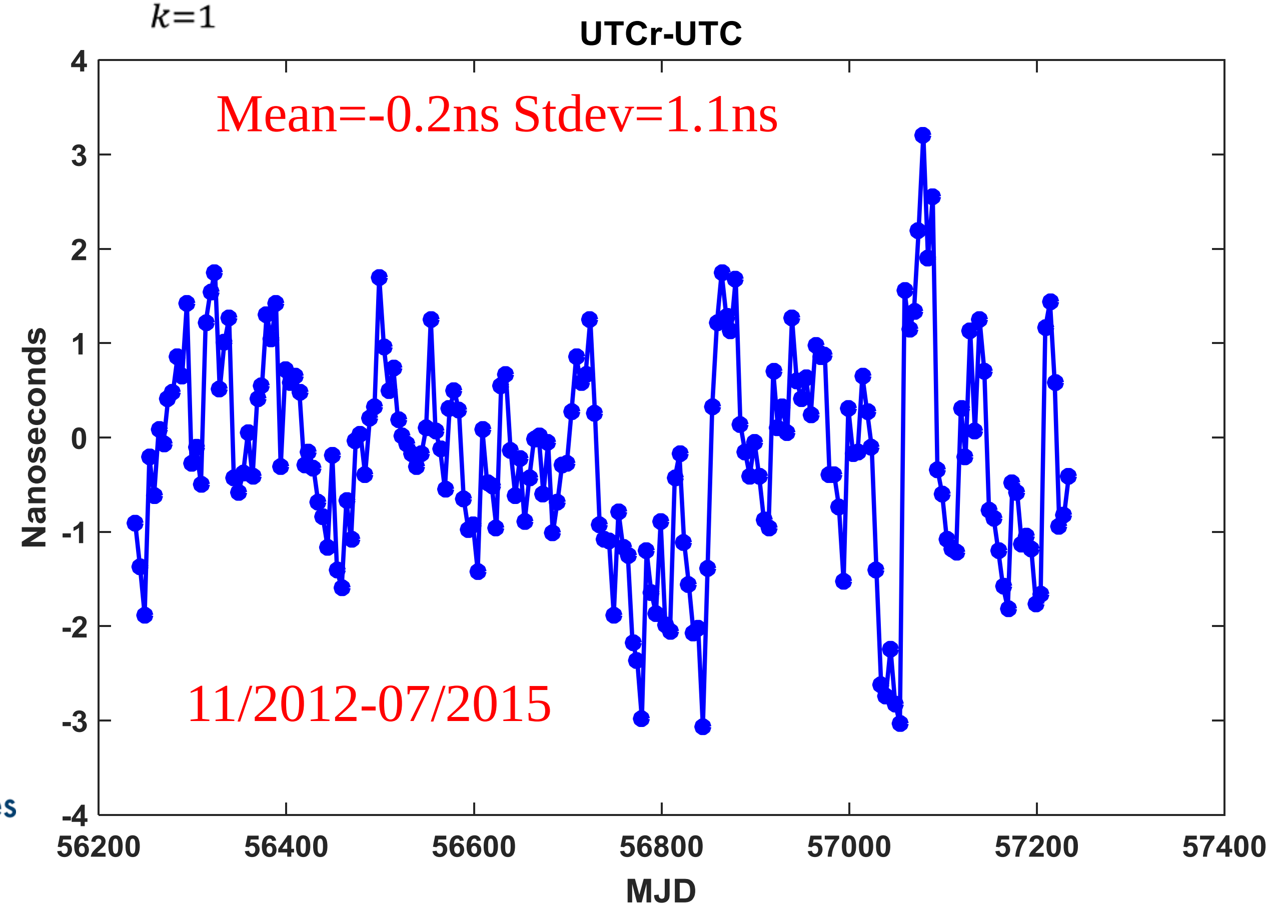
UTC remains available from the monthly Circular T at (http://www.bipm.org/jsp/en/TimeFtp.jsp?TypePub=publication).

Comparisons between UTCr and UTC

Not a single way to estimate UTCr-UTC.

We use a weighted average over the laboratories participating to UTCr:

$$D(t_j) = \sum_{k=1}^{N_k} W_k\big([UTCr - UTC(k)](t_j) - [UTC - UTC(k)](t_j)\big)$$



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Conclusions

- UTCr started as a pilot experiment in January 2012
- Declared an official product in July 2013 (week 1336)
- **Published *Metrologia* 51 33, 2014**

- Impact of UTCr
  - on UTC contributing laboratories: More frequent assessing of the UTC(K) steering, and consequently better stability and accuracy of [UTC(k)]; Enhanced traceability to UTC.
  - on users of UTC(K): Access to a better “local” reference, and indirectly, better traceability to the UTC “global” reference;
  - on GNSS: Better synchronization of GNSS times to UTC, through improved UTC and UTC(k) predictions.
- UTC laboratories wishing to participate, see the information in ftp://tai.bipm.org/UTCr/Documents/

THANK YOU

Thank you to all participating laboratories