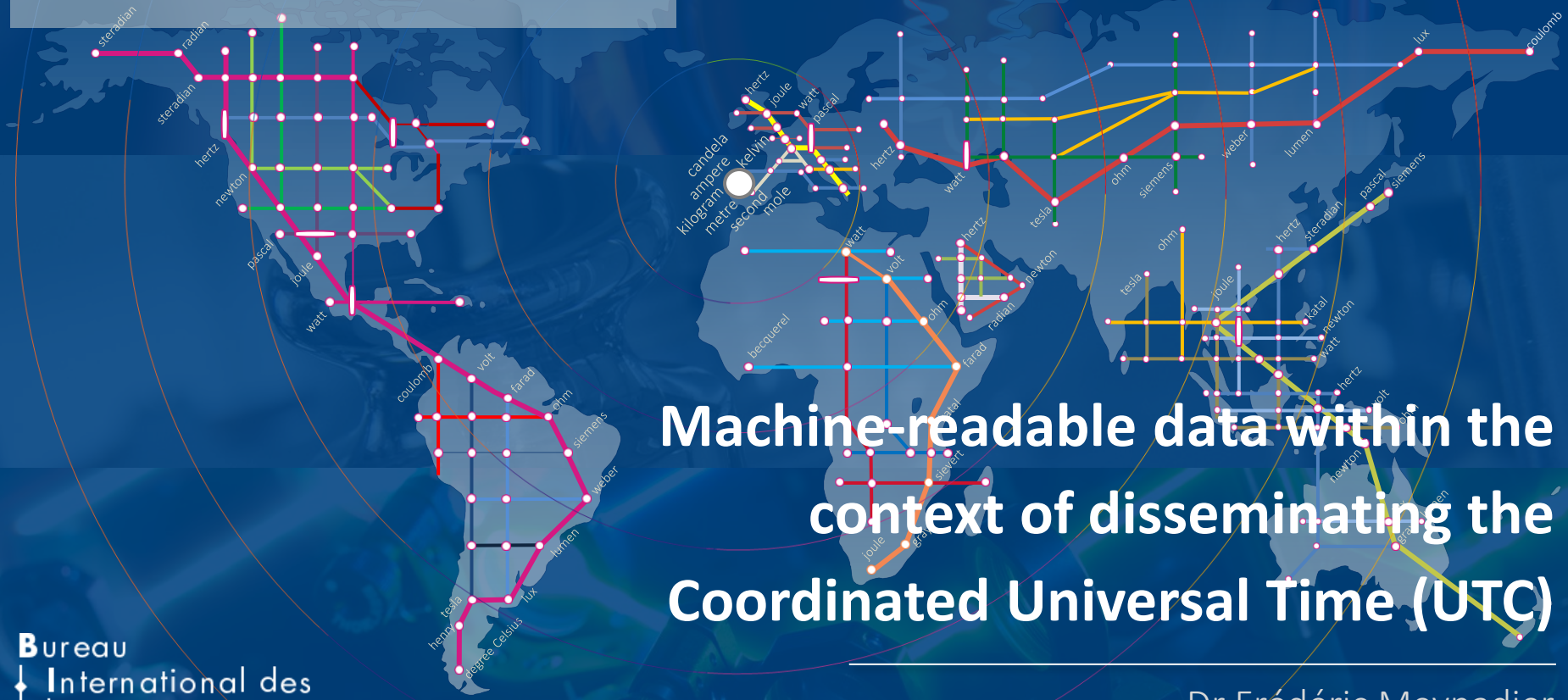
SciDataCon 2022 – 22 June 2022

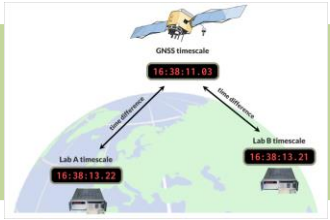


Machine-readable data within the context of disseminating the Coordinated Universal Time (UTC)

Dr Frédéric Meynadier
BIPM Time Department

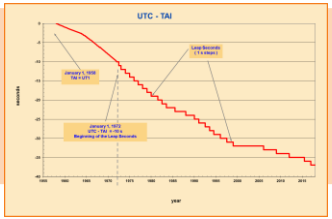
Bureau International des Poids et Mesures

Calculation of the Coordinated Universal Time (UTC)



450 atomic clocks in 80 laboratories — *weighted average* → **EAL** Échelle Atomique Libre
stability: 3×10^{-16} @ 30-40 days

10 primary and secondary frequency standards — *frequency steering* → **TAI** Temps Atomique International
accuracy: $\approx 10^{-16}$



Measurement of Earth's rotation (IERS) — *leap seconds* → **UTC Coordinated Universal Time**
[UTC – UTC(k)] BIPM Circular T

Bureau International des Poids et Mesures

The General Conference on Weights and Measures (CGPM), at its 26th meeting, […]
states that […]
UTC produced by the BIPM, based on TAI, is the only recommended time scale for international reference and the basis of civil time in most countries,

Content of Circular T

Bureau International des Poids et Mesures

CIRCULAR T 413 — ISSN 1143-1393

2022 JUNE 13, 13h UTC

BUREAU INTERNATIONAL DES POIDS ET MESURES
THE INTERGOVERNMENTAL ORGANIZATION ESTABLISHED BY THE METRE CONVENTION
PAVILLON DE BRETEUIL F-92312 SEVRES CEDEX TEL. +33 1 45 07 70 70 tai@bipm.org

The contents of the sections of BIPM *Circular T* are fully described in the document " Explanatory supplement to BIPM Circular T " available at https://webtai.bipm.org/ftp/pub/tai/other-products/notes/explanatory_supplement_v0.6.pdf

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

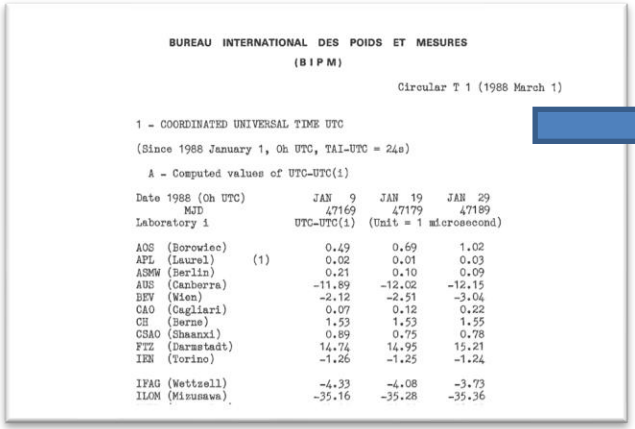
Date 2022 0h UTC			APR 30	MAY 5	MAY 10	MAY 15	MAY 20	MAY 25	MAY 30	Uncertainty/ns			Notes
		MJD	59699	59704	59709	59714	59719	59724	59729	u_A	u_B	u	
Laboratory *k*			[*UTC-UTC*(*k*)]/ns										
AGGO	(La Plata)	123	612.7	614.3	624.5	659.1	662.9	672.1	694.7	1.0	20.0	20.0	
AOS	(Borowiec)	123	0.4	0.3	-0.5	-0.7	-1.2	-1.3	-1.2	0.3	3.2	3.2	
APL	(Laurel)	123	-2.5	-2.4	0.2	-0.8	-0.9	-1.6	-	0.7	20.0	20.0	
AUS	(Sydney)	123	-514.9	-520.7	-513.4	-504.3	-501.9	-499.7	-509.4	0.3	11.2	11.2	
BEV	(Wien)	123	-47.6	-44.9	-47.0	-43.3	-36.8	-36.0	-25.7	0.3	2.8	2.8	
BFKH	(Budapest)	123	4768.8	4802.6	4834.8	4864.7	4901.3	4929.8	4968.0	1.5	20.0	20.1	
BIM	(Sofiya)	123	16119.3	16135.6	16132.9	16154.5	16188.2	16206.6	16230.8	0.3	7.3	7.3	
BIRM	(Beijing)	123	9.5	12.7	11.5	12.5	8.6	14.8	22.8	0.3	3.1	3.1	
BOM	(Skopje)	123	-	-	-	-	-	-	-				
BY	(Minsk)	123	-0.1	-0.2	-0.5	-1.1	-1.3	-0.7	-0.9	1.5	3.0	3.3	
CAO	(Cagliari)	123	-35526.8	-35648.6	-35758.7	-35884.0	-36004.6	-36122.9	-36238.8	1.5	20.0	20.1	
CH	(Bern-Wabern)	123	1.7	0.8	0.9	0.2	-1.5	-2.8	-2.7	0.3	1.7	1.8	
CNES	(Toulouse)	123	2.1	-0.5	-2.7	-3.0	-1.3	1.3	4.2	0.3	2.8	2.8	
CNM	(Queretaro)	123	6.6	9.4	12.9	6.1	3.4	5.0	4.8	1.5	4.0	4.3	
CNMP	(Panama)	123	12.0	19.9	12.7	-2.0	7.0	13.0	16.7	0.7	5.3	5.3	
DFNT	(Tunis)	123	2375.0	2469.9	2557.9	2648.8	2733.4	2844.4	2957.2	0.7	20.0	20.0	
DLR	(Oberpfaffenhofen)	123	-7.6	-9.2	-8.2	-6.4	-4.8	-2.7	-3.8	0.7	2.8	2.9	

Every month, we publish the difference between UTC and its local realizations UTC(k) during the previous month (5 days intervals).

Started in 1988
-> the « telex » era !

Dissemination of the data

- Historically : printed on paper and sent by mail…
- Text (ASCII) file sent by e-mail or available by FTP
- HTML « interactive », with links to plots



BUREAU INTERNATIONAL DES POIDS ET MESURES
(B I P M)

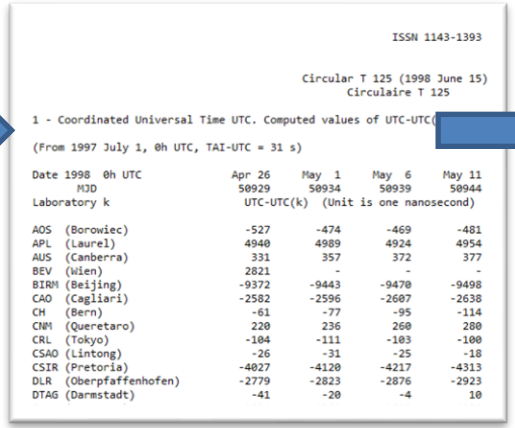
Circular T 1 (1988 March 1)

1 - COORDINATED UNIVERSAL TIME UTC

(Since 1988 January 1, 0h UTC, TAI-UTC = 24s)

A - Computed values of UTC-UTC(i)

Date 1988 (0h UTC) MJD		JAN 9 47169	JAN 19 47179	JAN 29 47189
Laboratory i		UTC-UTC(i)	(Unit = 1 microsecond)	
AOS (Borowiec)		0.49	0.69	1.02
APL (Laurel)	(1)	0.02	0.01	0.03
ASMW (Berlin)		0.21	0.10	0.09
AUS (Canberra)		-11.89	-12.02	-12.15
BEV (Wien)		-2.12	-2.51	-3.04
CAO (Cagliari)		0.07	0.12	0.22
CH (Berne)		1.53	1.53	1.55
CSAO (Shaanxi)		0.89	0.75	0.78
FTZ (Darmstadt)		14.74	14.95	15.21
IEN (Torino)		-1.26	-1.25	-1.24
IFAG (Wettzell)		-4.33	-4.08	-3.73
ILOM (Mizusawa)		-35.16	-35.28	-35.36



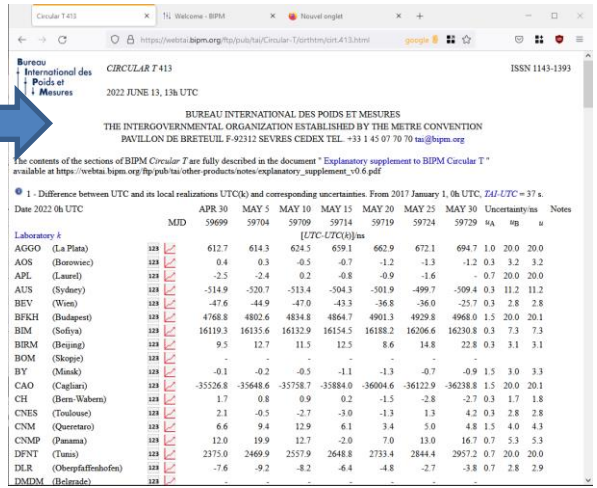
ISSN 1143-1393

Circular T 125 (1998 June 15)
Circulaire T 125

1 - Coordinated Universal Time UTC. Computed values of UTC-UTC(

(From 1997 July 1, 0h UTC, TAI-UTC = 31 s)

Date 1998 0h UTC MJD		Apr 26 50929	May 1 50934	May 6 50939	May 11 50944
Laboratory k		UTC-UTC(k)	(Unit is one nanosecond)		
AOS (Borowiec)		-527	-474	-469	-481
APL (Laurel)		4940	4989	4924	4954
AUS (Canberra)		331	357	372	377
BEV (Wien)		2821	-	-	-
BIRM (Beijing)		-9372	-9443	-9470	-9498
CAO (Cagliari)		-2582	-2596	-2607	-2638
CH (Bern)		-61	-77	-95	-114
CNM (Queretaro)		220	236	260	280
CRL (Tokyo)		-104	-111	-103	-100
CSAO (Lintong)		-26	-31	-25	-18
CSIR (Pretoria)		-4027	-4120	-4217	-4313
DLR (Oberpfaffenhofen)		-2779	-2823	-2876	-2923
DTAG (Darmstadt)		-41	-20	-4	10



Bureau International des Poids et Mesures

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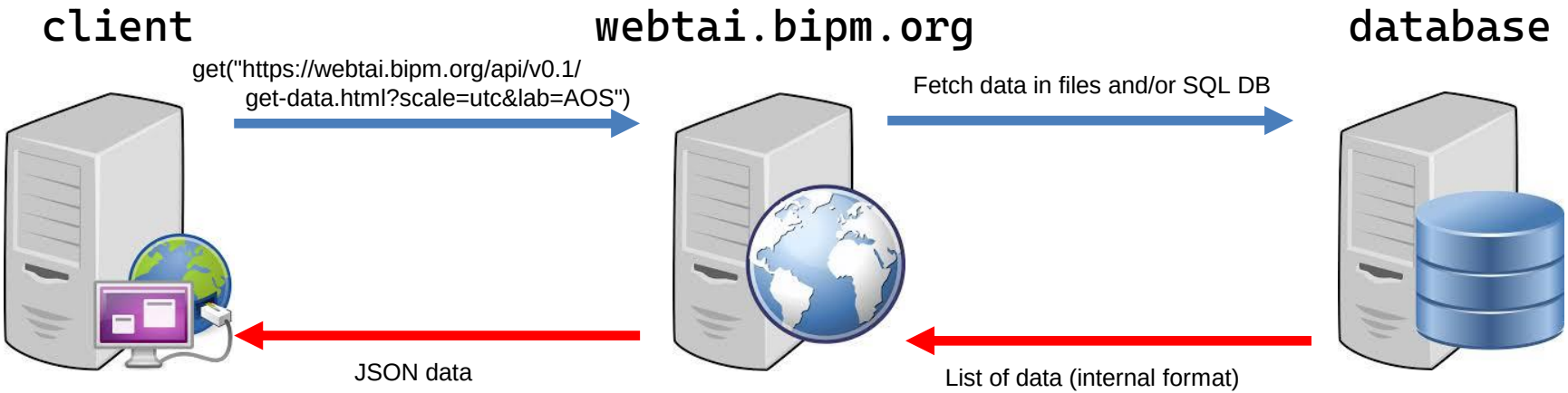
1 - Difference between UTC and its local realizations UTC(k) and corresponding uncertainties. From 2017 January 1, 0h UTC, *TAI-UTC* = 37 s.

Date 2022 0h UTC		MJD	APR 30 59699	MAY 5 59704	MAY 10 59709	MAY 15 59714	MAY 20 59719	MAY 25 59724	MAY 30 59729	Uncertainty/ns u_A	u_B	u	Notes
Laboratory *k*			[*UTC-UTC(k)*]/ns										
AGGO (La Plata)			612.7	614.3	624.5	659.1	662.9	672.1	694.7	1.0	20.0	20.0	
AOS (Borowiec)			0.4	0.3	-0.5	-0.7	-1.2	-1.3	-1.2	0.3	3.2	3.2	
APL (Laurel)			-2.5	-2.4	0.2	-0.8	-0.9	-1.6	-	0.7	20.0	20.0	
AUS (Sydney)			-514.9	-520.7	-513.4	-504.3	-501.9	-499.7	-509.4	0.3	11.2	11.2	
BEV (Wien)			-47.6	-44.9	-47.0	-43.3	-36.8	-36.0	-25.7	0.3	2.8	2.8	
BFKH (Budapest)			4768.8	4802.6	4834.8	4864.7	4901.3	4929.8	4968.0	1.5	20.0	20.1	
BIM (Sofiya)			16119.3	16135.6	16132.9	16154.5	16188.2	16206.6	16230.8	0.3	7.3	7.3	
BIRM (Beijing)			9.5	12.7	11.5	12.5	8.6	14.8	22.8	0.3	3.1	3.1	
BOM (Skopje)			-	-	-	-	-	-	-				
BY (Minsk)			-0.1	-0.2	-0.5	-1.1	-1.3	-0.7	-0.9	1.5	3.0	3.3	
CAO (Cagliari)			-35526.8	-35648.6	-35758.7	-35884.0	-36004.6	-36122.9	-36238.8	1.5	20.0	20.1	
CH (Bern-Wabern)			1.7	0.8	0.9	0.2	-1.5	-2.8	-2.7	0.3	1.7	1.8	
CNES (Toulouse)			2.1	-0.5	-2.7	-3.0	-1.3	1.3	4.2	0.3	2.8	2.8	
CNM (Queretaro)			6.6	9.4	12.9	6.1	3.4	5.0	4.8	1.5	4.0	4.3	
CNMP (Panama)			12.0	19.9	12.7	-2.0	7.0	13.0	16.7	0.7	5.3	5.3	
DFNT (Tunis)			2375.0	2469.9	2557.9	2648.8	2733.4	2844.4	2957.2	0.7	20.0	20.0	
DLR (Oberpfaffenhofen)			-7.6	-9.2	-8.2	-6.4	-4.8	-2.7	-3.8	0.7	2.8	2.9	
DMDM (Belgrade)			-	-	-	-	-	-	-				

https://webtai.bipm.org/ftp/pub/tai/Circular-T/

API Principle




```
data:
  0:
    y:          [...]
    x:          [...]
    name:       "UTC-UTC(AOS)"
success:        true
api_version:    "0.1"
```


Bureau International des Poids et Mesures

v0.2 prototype

Available data:

- **UTC / UTCr - UTC(k)**
- **UTC-GNSS time scales**
- Calibration (in dev)

Output formats: CSV, JSON

README at https://webtai.bipm.org/api/v0.2-beta/index.html

Not stable – open to feedback and feature requests !

Ideas : XML, other data such has calibration of the second ?

Units are defined in documentation -> no digital units representation yet

Entirely developped in-house (A. Harmegnies, with help from others)

Bureau International des Poids et Mesures

Examples

Using wget

```
wget -O utc-utc_aos.json "https://webtai.bipm.org/api/v0.1/get-data.html?scale=utc&lab=AOS"
```

Using cURL

```
curl -k --url "https://webtai.bipm.org/api/v0.1/get-data.html?scale=utc&lab=AOS" > utc-utc_aos.json
```

Using Perl

```
#!/usr/bin/perl

use LWP::UserAgent;
my $ua = LWP::UserAgent->new;
my $response = $ua->get("https://webtai.bipm.org/api/v0.1/get-data.html?scale=utc&lab=AOS") ;
if ($response->is_success) { print $response->decoded_content; }
```

Using Python

```
import requests
r = requests.get("https://webtai.bipm.org/api/v0.1/get-data.html?scale=utc&lab=AOS")
print(r.text)
```

Bureau International des Poids et Mesures

Usage example

```python
import requests
import json
import numpy as np
import matplotlib.pyplot as plt
import mjdutils.datetimemjd as mjdutils

labo = "PTB"
year = 2020

# Calculate first and last mjd of the period
first_day = mjdutils.date(year, 1, 1)
last_day = min(mjdutils.date(year + 1, 1, 1), mjdutils.date.today())

mjd1 = first_day.mjd
mjd2 = last_day.mjd

# Build API request URL
bipm_url = ("https://webtai.bipm.org/api/v0.2-beta/"
            "get-data.html?scale=utc"
            "&lab={}&mjd1={}&mjd2={}").format(labo, mjd1, mjd2)

# Retrieve data and store it
json_string = requests.get(bipm_url)
json_dict = json.loads(json_string.text)

# Print statistics
print("Between {} and {}, published values of |UTC({})-UTC| < {} ns".format(
    first_day.strftime("%c"),
    last_day.strftime("%c"),
    labo,
    max(np.abs(json_dict['data'][0]['y']))
))

# Plot data
fig, ax = plt.subplots()
ax.set_title(json_dict['data'][0]['name'])
ax.set_xlabel('MJD')
ax.set_ylabel(r'$\Delta t /ns$')
ax.plot(json_dict['data'][0]['x'], json_dict['data'][0]['y'])
plt.show()
```

Bureau International des Poids et Mesures

Visit https://webtai.bipm.org/api !

Feedback welcome…

Thank you

Bureau International des Poids et Mesures