CGPM

Draft Resolution D

“On the use and future development of UTC”

Noël Dimarcq, CCTF President
Patrizia Tavella, BIPM Time Dept. Director

November 2022

Working together to promote and advance the global comparability of measurements

CGPM

Projet de résolution D

« Sur l'utilisation et l'évolution future de l'UTC »

27e réunion de la Conférence générale des poids et mesures

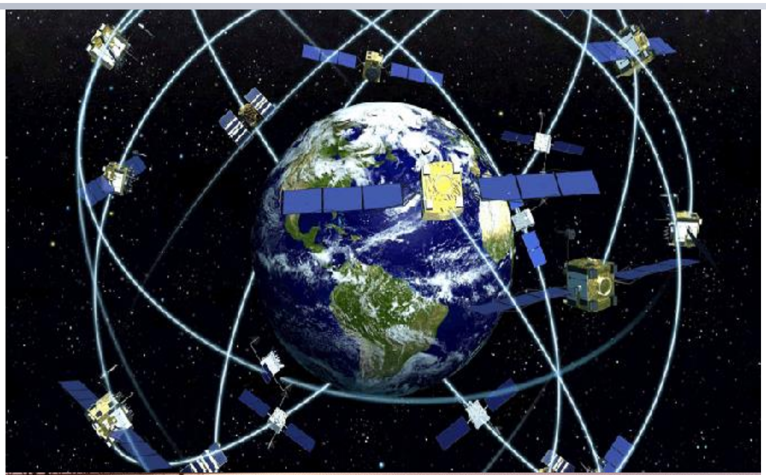
Noël Dimarcq, Président du CCTF
Patrizia Tavella, Directrice BIPM Time Dept

November 2022

Current situation

Technological and digital applications which underpin national critical infrastructures are based on an overall synchronization.

The main requirements for the common time scale is that it be continuous, monotonic, reliable, and easily available.



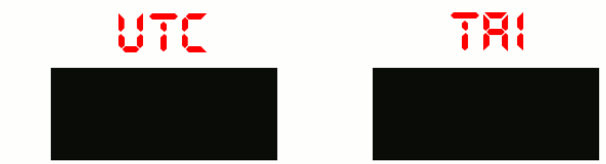
Reference time scales and leap seconds

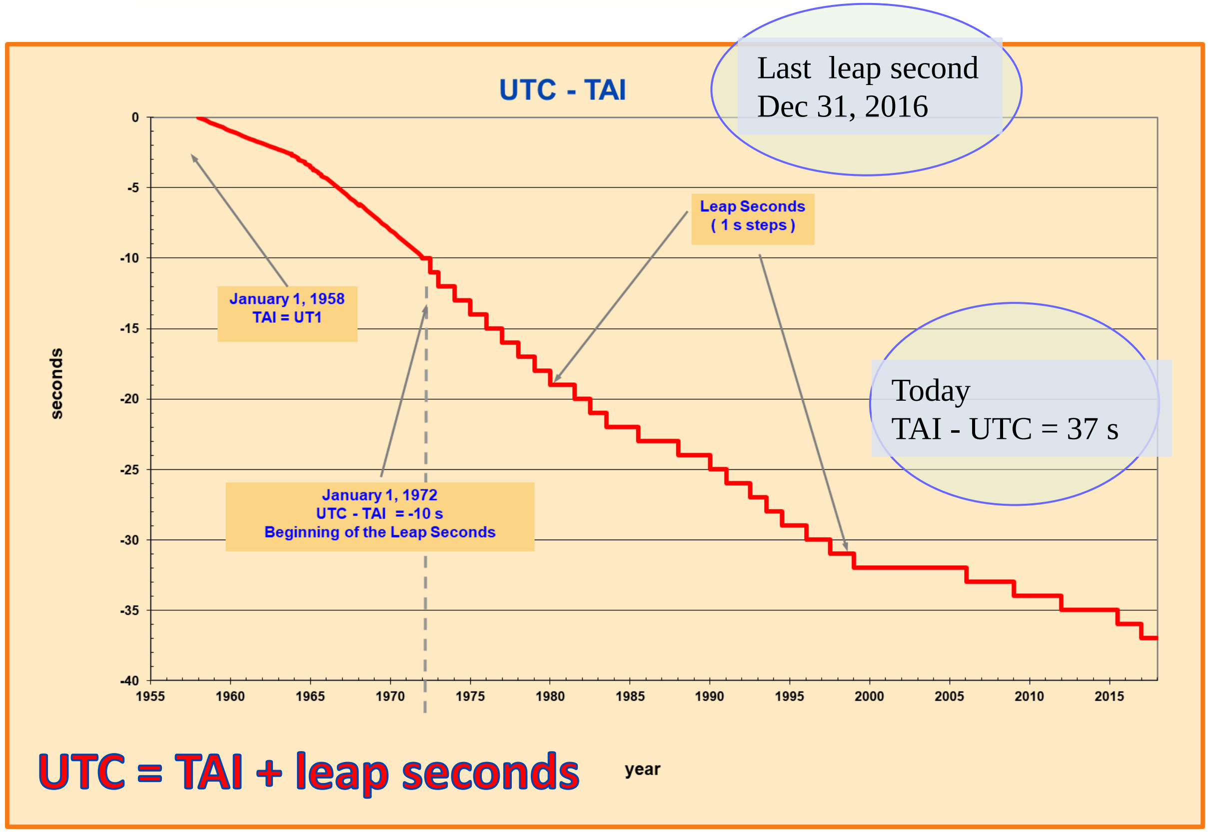
The International Atomic Time (TAI) is constructed by BIPM relying on the weighted average of 450 clocks in 85 laboratories and the frequency steering by ~ 10 primary and secondary frequency standards.

Since 1972, **UTC is obtained from TAI plus leap seconds**.

The Universal Time (UT1) is defined by the Earth rotational angle which is affected by random fluctuations.

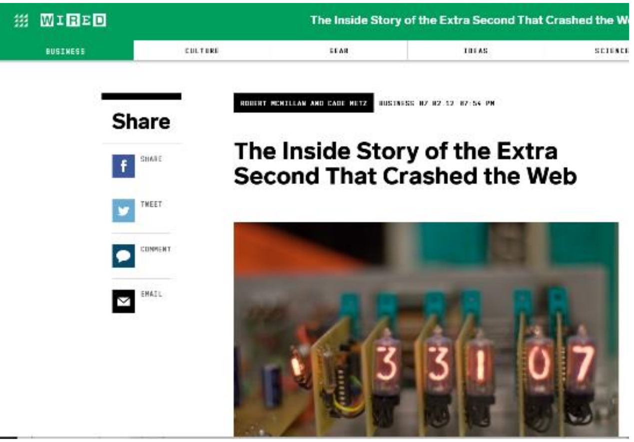
When the difference between UT1 and UTC becomes too large, an integer second is inserted to UTC to ensure |UTC - UT1| < 1 second.





23:59:59
23:59:60
00:00:00

The digital networks cannot cope with unpredictable leap seconds


WIRED — The Inside Story of the Extra Second That Crashed the W

BUSINESS CULTURE GEAR IDEAS SCIENCE

Share

The Inside Story of the Extra Second That Crashed the Web


Liberty Times Net

https://3c.ltn.com.tw/news/18985/2

61 seconds in a minute? Understand the computer and the stock market enemy "leap second"

2015/07/01 06:27

Text/Reporter Liu Jiqing

The impact of leap seconds-computer systems, financial market preparations


The Telegraph

Home Video News World Sport Business Money Comment Culture Travel Life Wo

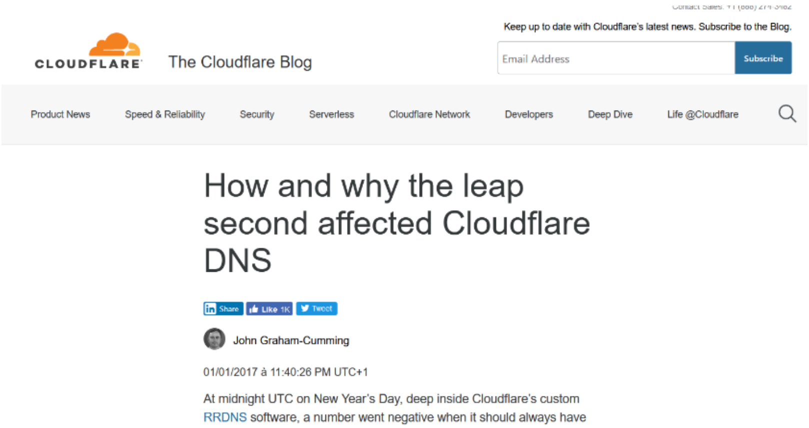
Politics Investigations Obits Education Science Earth Weather Health Royal Celebrity

Science News | Dinosaurs | Space | Night Sky | Evolution | Picture Galleries | Science Video

HOME » NEWS » SCIENCE » SCIENCE NEWS

Leap Second confuses Twitter and Android

Users reported problems with Android and Twitter as the leap second was added to atomic time


Keep up to date with Cloudflare's latest news. Subscribe to the Blog.

CLOUDFLARE The Cloudflare Blog

Product News Speed & Reliability Security Serverless Cloudflare Network Developers Deep Dive Life @Cloudflare

How and why the leap second affected Cloudflare DNS

John Graham-Cumming

01/01/2017 à 11:40:26 PM UTC+1

At midnight UTC on New Year's Day, deep inside Cloudflare's custom RRDNS software, a number went negative when it should always have


IDG TECH(Talk) IoT 2-minute Linux tips Newsletters Resources/White Papers

NETWORKWORLD FROM IDG

INSIDER Sign In | Register

'Leap second' snafu affects Oracle clusterware

By Chris Kanaracus

U.S. Correspondent, IDG News Service | JANUARY 06, 2009 12:00 AM PT


CIO US DIGITAL MAGAZINE EVENTS & AWARDS PROGRAMS VIDEO NEWSLETTERS RESOURCE LIBRARY

RELATED STORIES Time Waits for No One: 'Leap Seconds' May Be Cut | Security Implications of the Humble Computer Clock | The Big Promise of Big Data | Hadoop Enhance

NEWS

Leap Second Bedevils Web Systems Over Weekend

Reddit, LinkedIn and other sites were knocked offline by an extra second added to the official time

By Joab Jackson

U.S. Correspondent, IDG News Service | JULY 02, 2012 08:00 AM PT

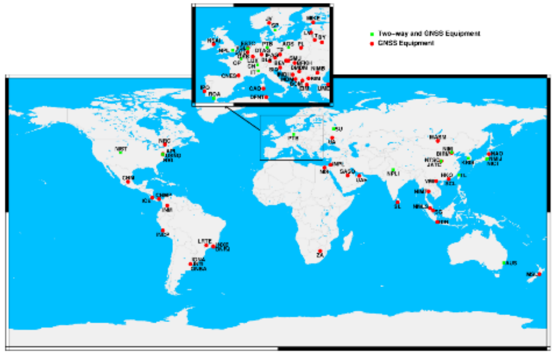
Time travels on the network

Computer operating systems are not easily able to handle a minute with 61 seconds

Consultative Committee on Time and Frequency User Survey (2021)

- > 200 answers
- The large majority asks to get rid of discontinuities in UTC
- Other time scales are used, instead of UTC, as continuous time scales

Coordinated Universal Time UTC is the international time standard



UTC is supported by the work of:

- **BIPM** and the 85 time laboratories providing data and realizing real-time traceability under the authority of the General Conference of Weights and Measures, where all states are represented
- the International Earth Rotation and Reference Systems Service - **IERS** computing and publishing the difference versus the Earth rotation angle UT1-UTC,
- the International Telecommunication Union, **ITU-R**, to ensure it is used and correctly transmitted (ITU-R TF.460-6 (2002): *Standard-frequency and time-signal emissions)*

→ But, users underpinning critical infrastructures, need a continuous and unique timescale.
Increasingly UTC is not being used by:

- **most of the GNSSs,**
- **the digital network giants (eg GAFA and Alibaba),**
- **the most widely used Internet time synchronization protocols as NTP and PTP**

Several “ah hoc” methods have been developed to avoid leap seconds

- **Ignore leap seconds after an initial synchronization**
  - GPS, Galileo, BeiDou system times.
  - Most current versions of Windows (till next synchronization)
- **Stop clock for 2 seconds at 23:59:59 or 00:00:00**
  - Network Time Protocol, Posix time on many computers
  - Two seconds have same name
  - Problems with causality, time ordering, time intervals
  - Leap second has no indicator
- **Reduce frequency of clock over some interval**
  - Google (24 h before), Microsoft, Facebook (18 h after), Alibaba (12 h before – 12 h after) …
  - Google smear is now being proposed as a new « international standard »

→ All of these methods are not in agreement with UTC on the leap second day, and many disagree with each other
Users cannot tell which method is used by a time source, especially a posteriori
Leap second and the alternative methods threatens the resilience of the synchronization
GPS system time, which is continuous and easily accessible, is already considered as a time and frequency reference and could become, de facto, the international standard time.

It is urgent to revise the leap second process in UTC

Solution to progress towards a continuous UTC

Increase the tolerance in|UT1 - UTC| to a new limit (e.g. 1 min reached after 1 century or 1 hr reached after 5000 yrs) or to an unlimited value (= the difference UT1 – UTC will be let growing with no limit).

→ **UTC remains linked to UT1**, the Earth's rotation angle, whose origin is the reference meridian of Greenwich.

In the daily life, there is no change for the general public since the evolution of |UT1 - UTC| will remain negligible compared to the +/- 15 min seasonal day variations, for centuries. The general perception of conformity to astronomical phenomena is not challenged.

Users needing the knowledge of UT1-UTC find accurate and real time estimations by the services of IERS, NASA, GNSS, ITU-R broadcast signals

In the '70s UTC was used as approximation to UT1 mostly for navigation with traditional optical instruments.

Approximation UTC ≈ UT1 corresponds to an uncertainty in the position up to 400 m (at the equator). It is used only in low accuracy applications (as amateurs telescope pointing).

But it is not adapted for high precision applications (as high accuracy astronomy and space applications) that are already using the IERS and NASA estimates with 10 microsecond uncertainty, corresponding to about 0.3 cm uncertainty in the position

Overall acceptability and support to the enlargement of the tolerance in |UT1 - UTC|

CCTF, CIPM, ITU-T, ITU-R, IAU, IUGG, URSI, IGS, GAFA, GNSS providers, IT stakeholders, Vatican,… …

We met several delegations, including the Vatican. The Vatican expert helped in understanding the principle of astronomical conformity historically linked to civil timekeeping:

- Some irregularities in the Earth rotation can be observed but not predicted with sufficient uncertainty.
- Need of more and better data (and better models) to predict more accurately the agreement of UTC with the Earth rotation (work of future generations)

U.R.S.I.

INTERNATIONAL UNION OF RADIO SCIENCE
UNION RADIO-SCIENTIFIQUE INTERNATIONALE
info@ursi.org www.ursi.org

XXXIVth General Assembly and Scientific Symposium
Rome 2021

Council IV
Vote on URSI Resolutions

GASS 2021 : Vote on URSI Resolutions and Recommendation

R1. Resolution on the need for a continuous reference time scale

The URSI Council,

INTERNATIONAL TELECOMMUNICATION UNION
TELECOMMUNICATION STANDARDIZATION SECTOR
STUDY PERIOD 2017-2020

SG15-TD780/PLEN
STUDY GROUP 15
Original: English

Question(s):	10, 11, 12, 13, 14/15	E-Meeting, 6-17 December 2021

TD

Source:	Chairman WP3/15
Title:	WP3 liaison statements
Purpose:	Admin

IGS INTERNATIONAL GNSS SERVICE

Statement on Leap Second

ITFS2021 PETITION TO **ITU-R WP 7A**

To Whom it may concern,

We, the ITSF2021 community, participants, and guest audience, we all do understand that, the further continuation of handling *UTC leap second* introduces a high risk of failure for IT and Industry4.0 (OT). Although the leap-second problem has always existed, currently with exponentially growing automation and the close interdependence of entire Industry4.0 systems, there is recommendation for immediate suspension of the *UTC leap-second*. Currently considered the first in history negative leap-second makes us especially us worry.

Lp.	Name & Surname	Company	Sign
1.	TOMASZ WIDOMSKI	ELPROMA	
2.	ROBERT URBANIAK	PIKTIME SYS.	
3.	HEIKO GERSTUNG	MEINBERG	
4.	Umut Keten	Türk Telekom	
5.	[illegible]	NetInsight	
6	[illegible]	[illegible]	
7.	Stavros [illegible]	[illegible]	
8.	Indranil Dutta	[illegible]	
9.	STEVE NEWCOMBE	CHRONOS TECHNOLOGY	
10	JAIME JARAMILLO	Xona SPACE Systems	
11.	MAREK [illegible]	ORANGE POLSKA	
12.	RICARDO PIRIZ	GMV	
13.	BOIME gilles	OROLIA	
14.	KOHEI SUZUKI	SEIKO Solutions Inc	
15.	Fred STEINHAUSER	OMICRON electronics	
16.	Angus [illegible]	Edge Networks	
17.	[illegible]	ADVA	
18.	RICHARD [illegible]	[illegible]	
19.	Marc Weiss	Marc Weiss Consulting	
20.	Robert Lapp	Meinberg	
21.	Rob [illegible]	Meinberg	
22.	Douglas Arnold	IEEE	
23	[illegible]	SPACE RESEARCH CENTRE [illegible]	
24	Ahmad Byagowi	OCP-TAP Project lead	Ahmad

WORKING DRAFT – NOT FOR PUBLICATION

Industry Perspectives & Insights on Impacts of Leap Seconds Practice in UTC Time Scale

Companies and trade association members from IT, Timing and Electric Power industries articulate their insights into impacts of leap seconds practice in UTC time scale on their products and services, as well as their customers. From this collective experience, a shared preference emerges for a continuous UTC time scale without additional leap seconds.

Contact information at these organizations is available from Dr. Patrizia.Tavella@bipm.org.

May 1, 2022

Amazon 1
IBM 2
IQD Frequency Products 3
Meinberg 4
Microsoft 8
OMICRON electronics 13
OpenPMU 14
Orolia 15
Oscilloquartz 16
Sync-n-Scale 25

BIPM and ITU-R working together

ITU is a liaison to the CCTF, BIPM is a sector member of ITU-R
Develop a common way forward so that both organisations continue to address the needs for internationally-recognised timing and synchronisation by

Ensuring a Continuous UTC + Efficient protocols for the transmission of UTC and (UT1- UTC) for end-users

- **1972**: the practice of inserting leap second was introduced in a ITU-R Rec (UTC was corrected before by frequency steps)
- **2000**: start of the discussion on continuous UTC
- **2015**: ITU WRC *Resolution 655 recommends "*To strengthen the cooperation between ITU-R and BIPM, CIPM, CGPM, as well as other relevant organizations, and to carry out a dialogue concerning the expertise of each organization"
- **2018**: *Resolution 2 of the 26th CGPM "On the definition of time scales"* :
  - confirms 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,
  - recommends that all relevant unions and organizations work together to develop a common understanding
- **2020**: the BIPM and ITU-R signed an MoU for mutual assistance
  - to the ITU-R in its role to set standards concerning time signals and frequency standard emissions, protocols, and dissemination procedure,
  - to the BIPM in its role of defining and realizing measurement standards and reference time-scales
- Preparation to the ITU WRC in **2023**: BIPM/NMIs contribute to the ITU-R WP7A activity that has recently published a report on UTC *(https://www.itu.int/pub/R-REP-TF/en)*

Draft resolution D - On the use and future development of Universal Coordinated Time (UTC)

Process in two steps:

1. **CGPM 2022**: decide to enlarge the tolerance in |UT1 - UTC| and approve the implementation date (by or before 2035)
2. **CGPM 2026:** approve the new tolerance (e.g. 1 min reached after 1 century or 1 hr reached after 5000 yrs) or to an unlimited value (= the difference UT1 – UTC will be let growing with no limit), and approve also the periodic review process to take into account new discoveries and improved understanding for the irregularities in the Earth rotation

→ 2035 is the best trade-off on the implementation date between:

- the need of updating systems and address legal issues
- the important issues that
    - discontinuities in UTC and different ad-hoc solutions currently implemented cause confusion and put at risk the resilience of critical national infrastructures,
    - the current Earth acceleration may lead to **a possible negative leap seconds** in the next decade,
    - one of the GNSS time scales may be use de facto as the international standard

Draft resolution D - On the use and future development of Universal Coordinated Time (UTC)

decides that the maximum value for the difference (UT1-UTC) will be increased in, or before, 2035,

requests that the CIPM consult with the ITU, and other organizations that may be impacted by this decision in order to

- propose a new maximum value for the difference (UT1-UTC) that will ensure the continuity of UTC for at least a century,
- prepare a plan to implement by, or before, 2035 the proposed new maximum value for the difference (UT1-UTC),
- propose a time period for the review by the CGPM of the new maximum value following its implementation, so that it can maintain control on the applicability and acceptability of the value implemented,
- draft a resolution including these proposals for agreement at the 28th meeting of the CGPM (2026),

encourages the BIPM to work with relevant organizations to identify the need for updates in the different services that disseminate the value of the difference (UT1-UTC) and to ensure the correct understanding and use of the new maximum value.

CGPM

Special thanks to the dedicated CCTF and CIPM WGs, external experts and representatives of NMIs, IOs or stakeholders, the BIPM Director and Time Department for fruitful discussions, support and contribution

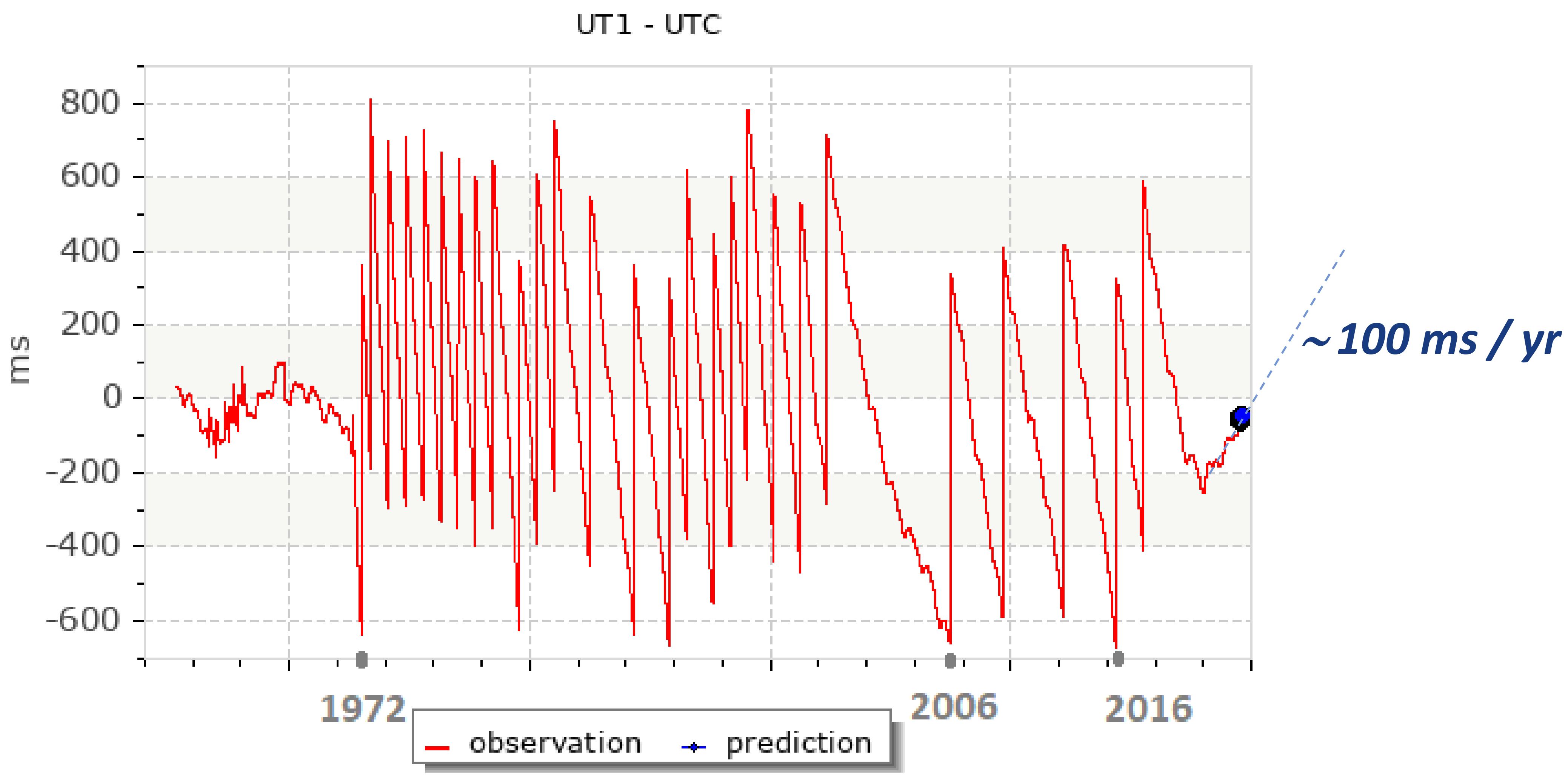
Thanks for your attention

27th meeting
of the General Conference
on Weights and Measures

27e réunion
de la Conférence générale
des poids et mesures

Extra slides

Possible negative leap second in 10 years?

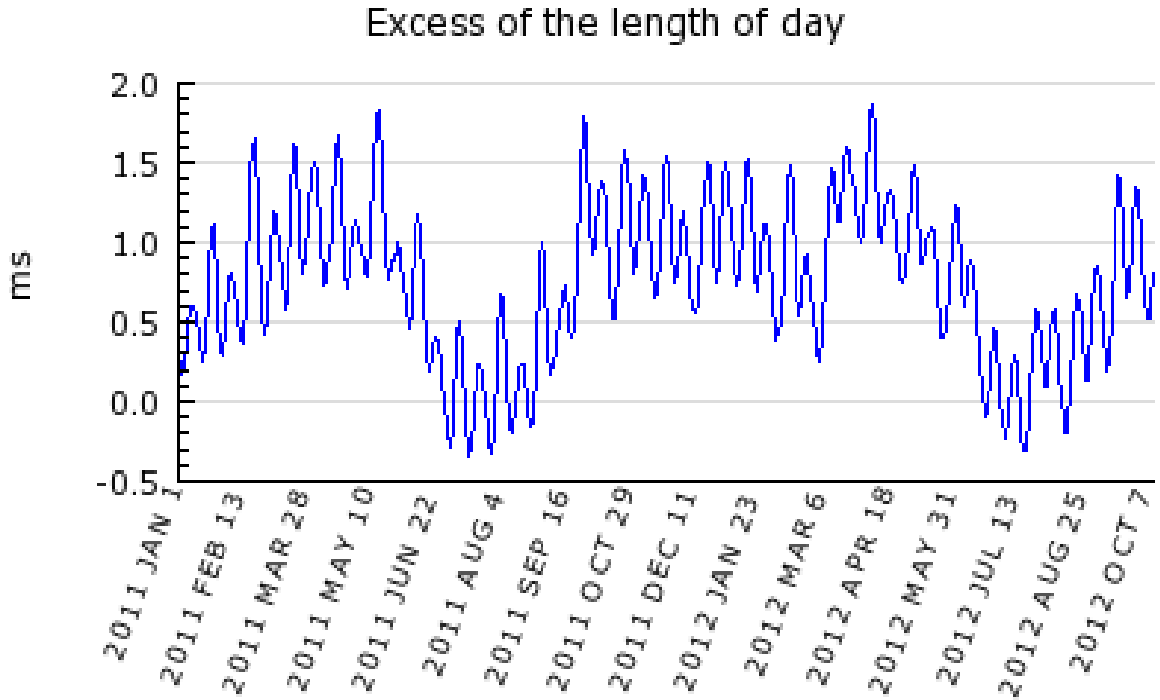


Difference between Earth rotation UT1 and UTC.
The current leap second system was initialized in 1972, and a positive step in UT1-UTC was introduced each time the difference approached approximately -500 ms.
https://eoc.obspm.fr/index.php?index=realtime&lang=en

Random variations of the time scale linked to Earth rotation

The earth rotation rate fluctuates due to :

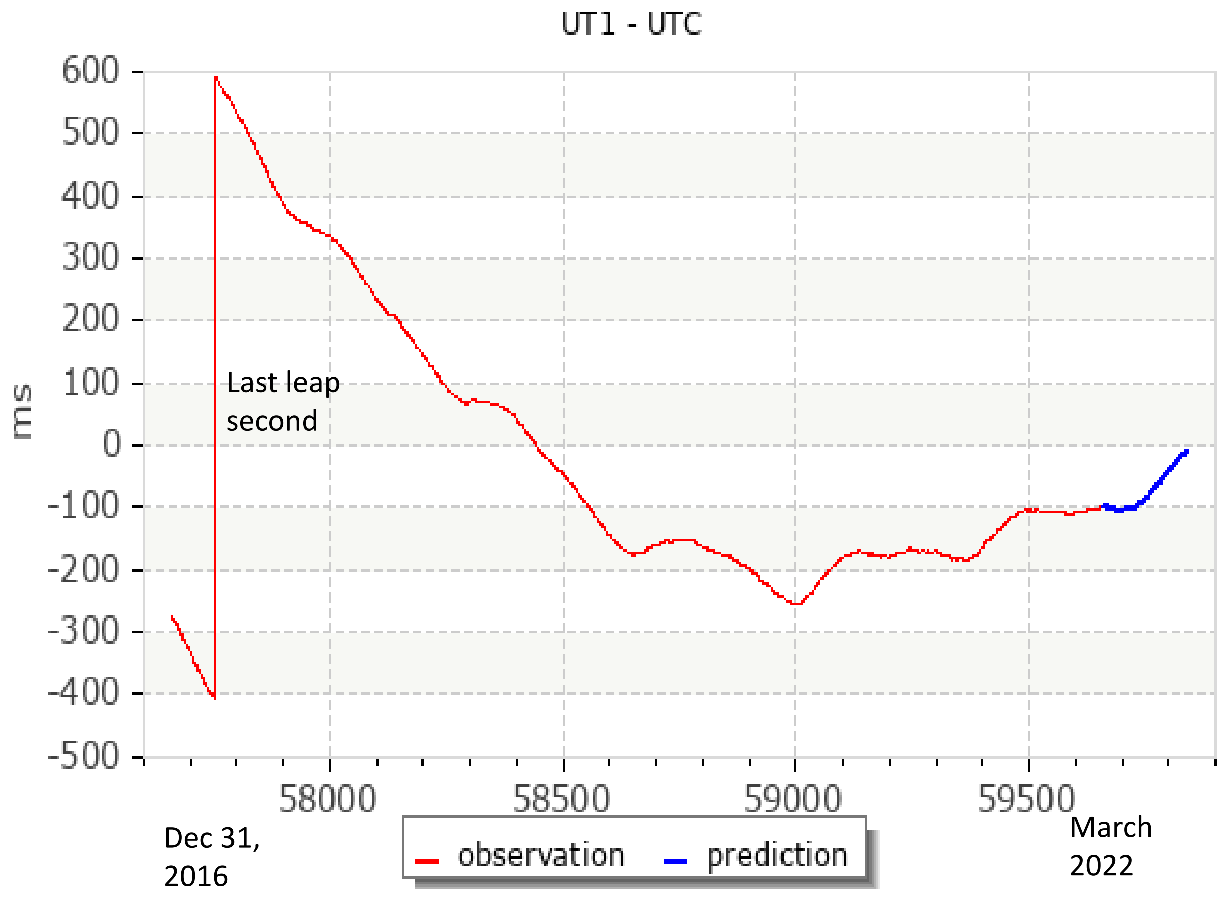
- tides (Moon, Sun)
- inner effects (core – mantle interface)
- atmosphere and meteorological effects
- hydrological effects
- seisms (earthquakes, tsunamis, …)



→ Variations (drift) of the difference |UT1 - UTC|

between the atomic time scale UTC and the Earth rotational angle time scale UT1

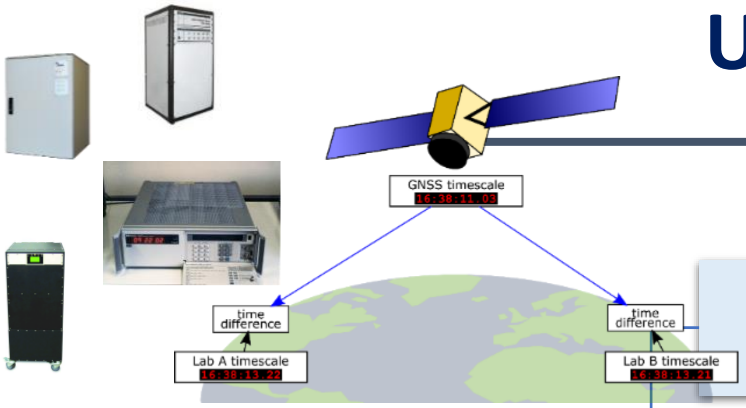
Monitoring and prediction of UT1-UTC



A negative leap second will be necessary?
Never introduced and often not even included as option

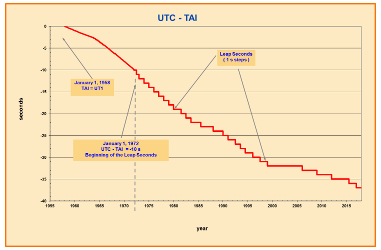
Plot from https://eoc.obspm.fr/index.php?index=realtime&lang=en

UTC and UT1 time scales



≈ 450 atomic clocks in 80 laboratories

≈ 10 primary and secondary frequency standards



Measurement of Earth's rotation (IERS)

weighted average **EAL**

frequency steering **TAI**

leap seconds **UTC**

Echelle Atomique Libre
freq stability
3×10^{-16}
@ 30-40 days

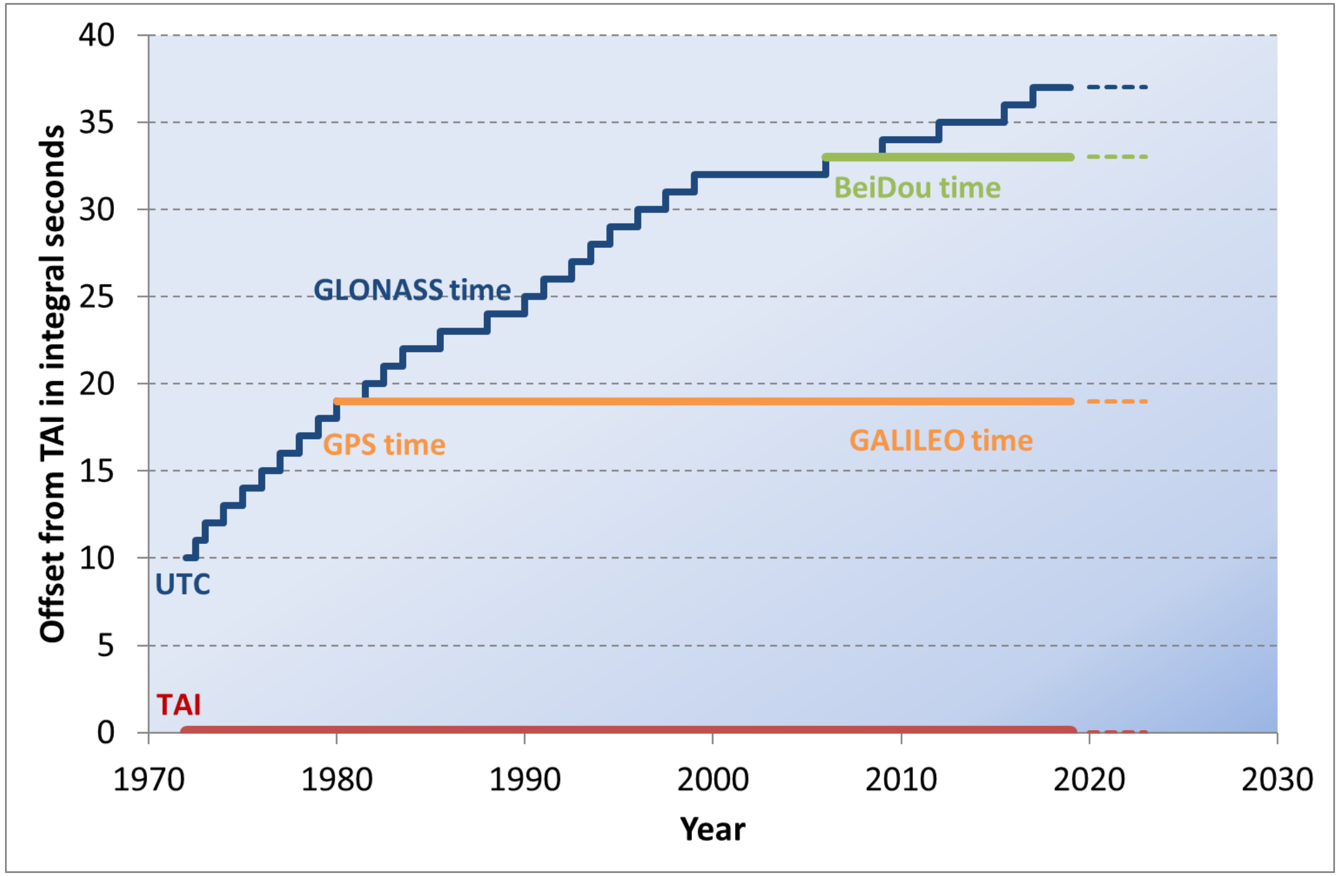
International Atomic Time
freq accuracy $\sim 10^{-16}$

Coordinated Universal Time

[*UTC* - *UTC*(*k*)] **BIPM *Circular T***

Leap seconds in Global Navigation Satellite System time scales

Navigation using GNSS signals prefers a continuous time scale, and the GNSS system time does not use leap seconds (except GLONASS which applies leap seconds). These time scales are easily available all over the world, are commonly used as time and frequency references, and differ from each other and from UTC by several seconds



CIPM Task Group on Continuous UTC

Members:
- Martin Sene (UK)
- Fedor Bulygin (Russia)
- Jim Olthoff (USA)
- Yuning Duan (China)
- Joachim Ullrich (Germany)
- Takashi Usuda (Japan)
- Gert Rietveld (NL)
- Martin Milton (BIPM)
- Patrizia Tavella (BIPM, CCTF)
- Noel Dimarcq (CCTF)

Kick-off of the TG in January 2022 – report to the CIPM in June 2022

Work on the accompanying doc of the draft resolution D to be used as basis for disseminating the information in all countries