Towards a consensus on a continuous UTC and update on BIPM activities related to GNSS

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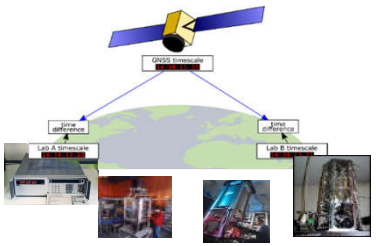
Construction of the Coordinated Universal Time



National time laboratories realize real-time approximations **UTC(k)**

≈ 450 atomic clocks
≈ 10 primary frequency standards

in ~ 85 laboratories

TAI

International Atomic Time

Measurement of Earth's rotation UT1 (IERS)

leap seconds

UTC

Coordinated Universal Time
|UT1 – UTC| < 1 s

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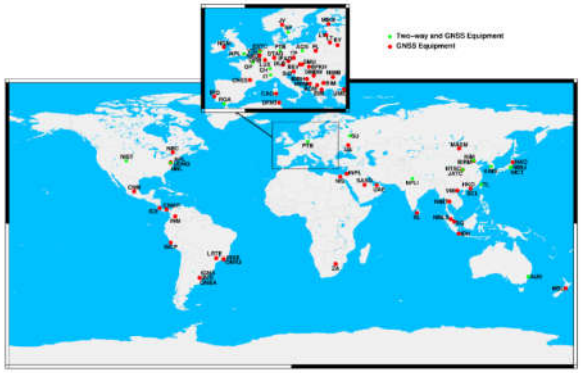
The offset [***UTC*** - ***UTC(k)***] is published in **BIPM *Circular T***

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
- the International Earth Rotation and Reference Systems Service IERS
  - ✓ computing and publishing the difference versus the Earth rotation angle UT1 - UTC,
- the work of the ITU-R to ensure it is used and correctly transmitted, also by GNSS signals
  - ✓ (ITU-R TF.460-6 (2002): *Standard-frequency and time-signal emissions)*

GNSS and RNSS broadcast a time dissemination service with

- a prediction of GNSSTime – UTC (modulo 1 s)
- the number of leap second between GNSSTime and UTC,

Users get UTC

In some cases also

- a prediction of UT1 - UTC,

Users get UT1

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Systems underpinning critical infrastructures, need a continuous timescale
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) …

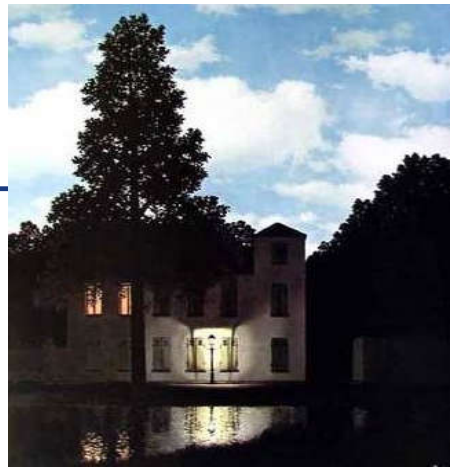
All of these methods are not in agreement with UTC on the leap second day, and many disagree with each other

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

The leap second process in UTC needs to be revised

Solution: Increase tolerance of |UT1 - UTC|

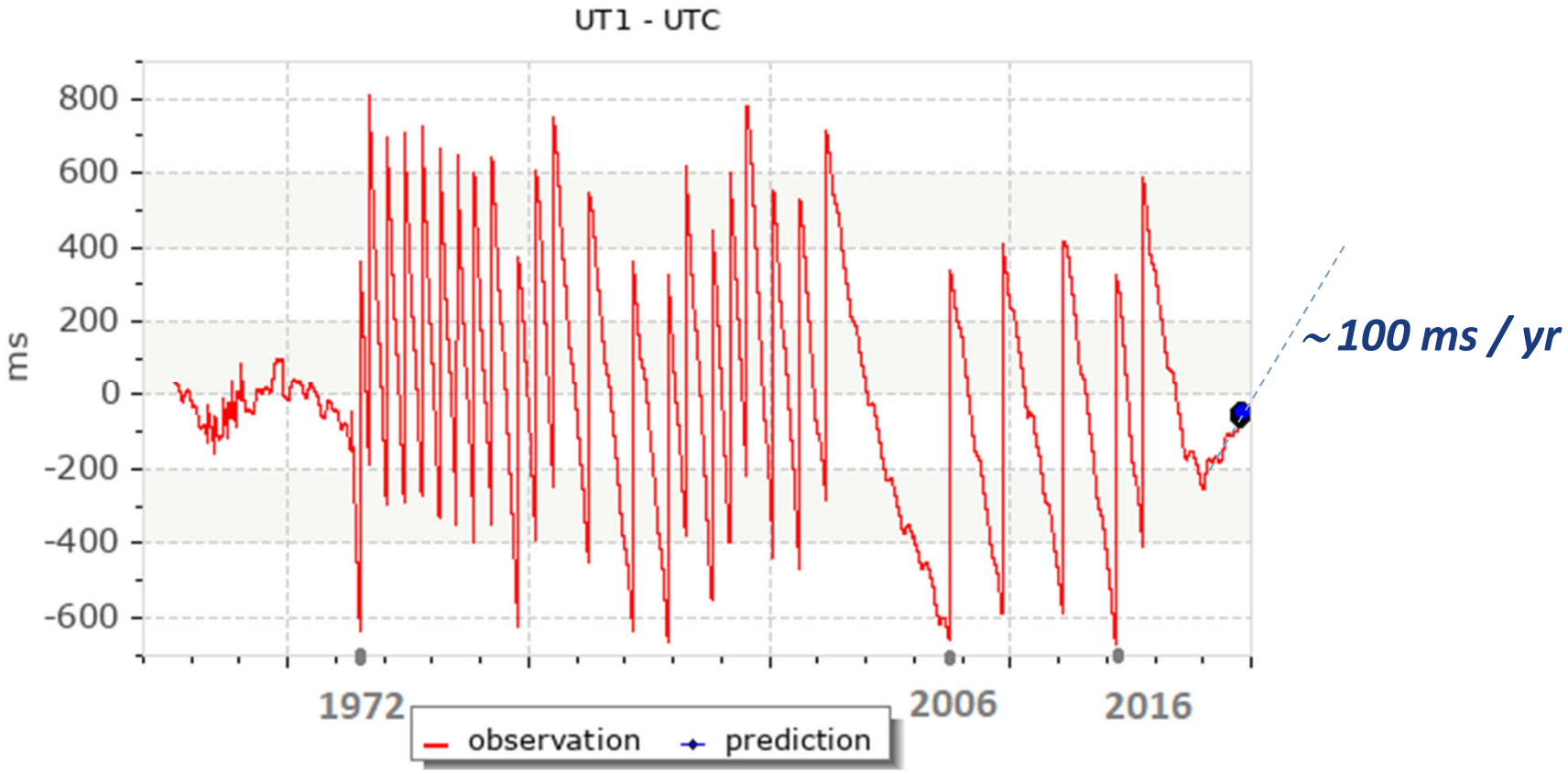


- If limit of |UT1 - UTC| < 100 or XXX seconds
  - No leap seconds for a century or more at current rate of increase
  - Tolerance could be one hour (change of time zone)

- UTC remains linked to UT1, the Earth's rotation angle, the origin is the reference meridian of Greenwich
- UTC is approximately UT1 within the 15 min of seasonal day variation for centuries. For the general public this is a "no event"

- UTC supports the digital systems and the operations of complex systems as GNSS
- Limit the risk of incidents due to discontinuities or multiple time scales

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

November 2022

The 27th meeting of the *General Conference on Weights and Measures* (CGPM) will consider a draft resolution
https://www.bipm.org/en/cgpm-2022

« On the use and future development of UTC »

recognizing *that the use of UTC* ***as the unique reference time scale for all applications****, including advanced digital networks and satellite systems, calls for its clear and unambiguous specification as* ***a continuous time scale****, with a well-understood traceability chain,*

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.*

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Impact on GNSS and RNSS

GNSS and RNSS broadcast a time dissemination service with

- a prediction of GNSSTime – UTC (modulo 1 s)

No change

- the number of leap second between GNSSTime and UTC,

Will remain frozen

In some cases also

- a prediction of UT1 - UTC,

|UT1 – UTC| will be > 1 s

This quantity will reman < 60 s for probably 100 years

For most accurate applications:

UT1-UTC is measured and published by International Earth Rotation and Reference Systems Service (IERS), and other services, with microsecond accuracy

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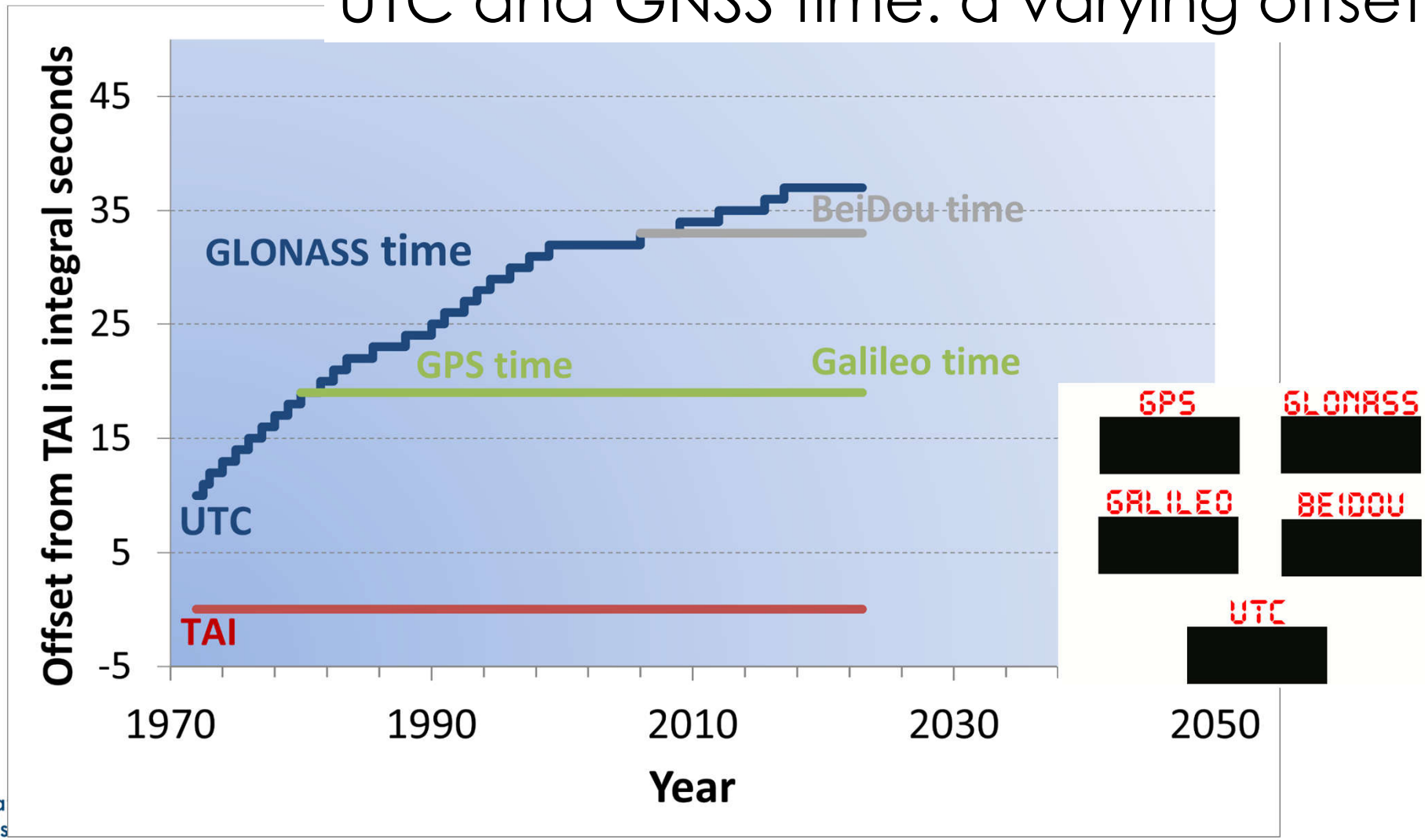
UTC and GNSS time: a varying offset



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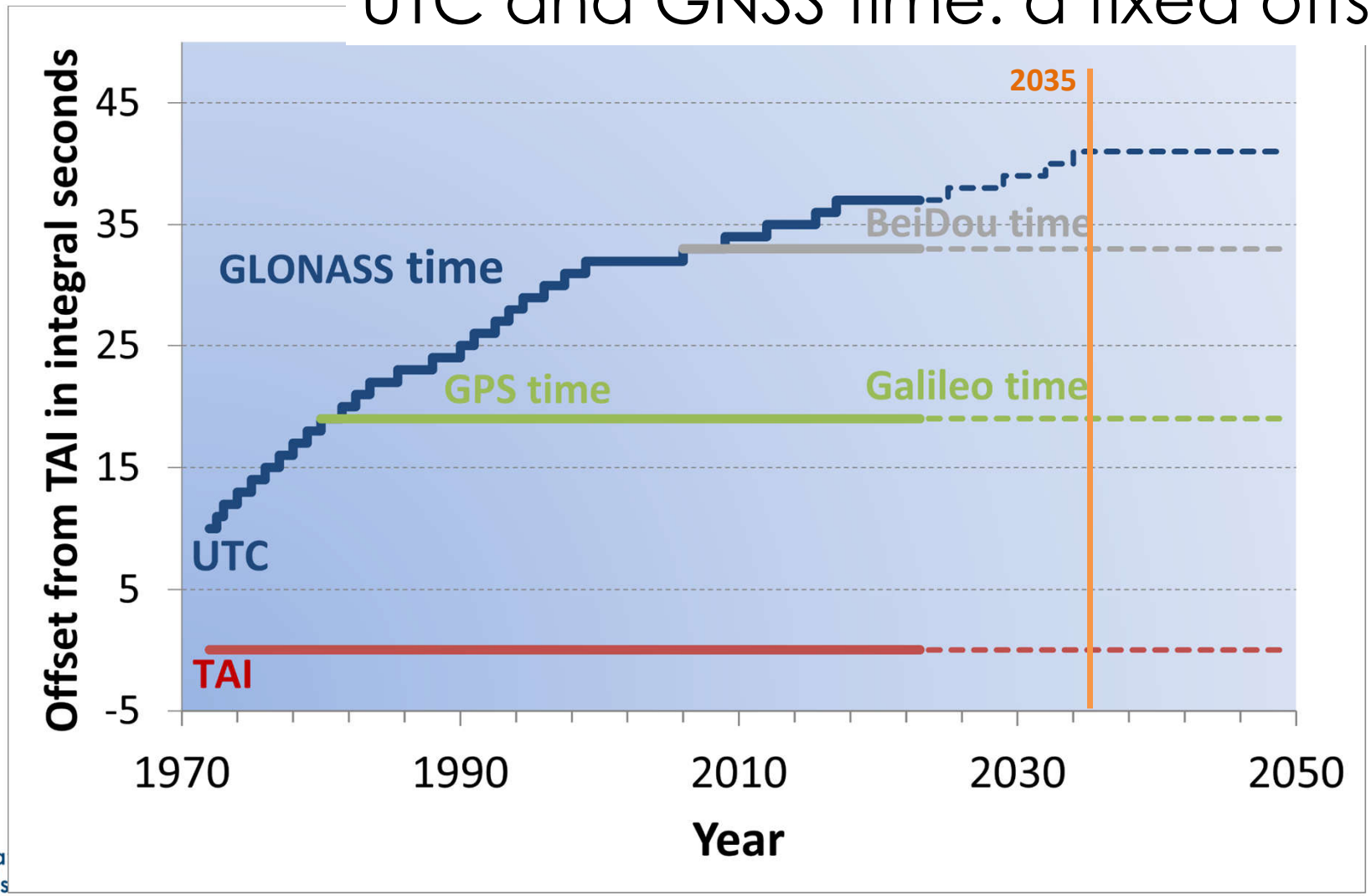
UTC and GNSS time: a fixed offset



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Thanks for your attention

and for your support in disseminating UTC

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