

Towards a Continuous UTC

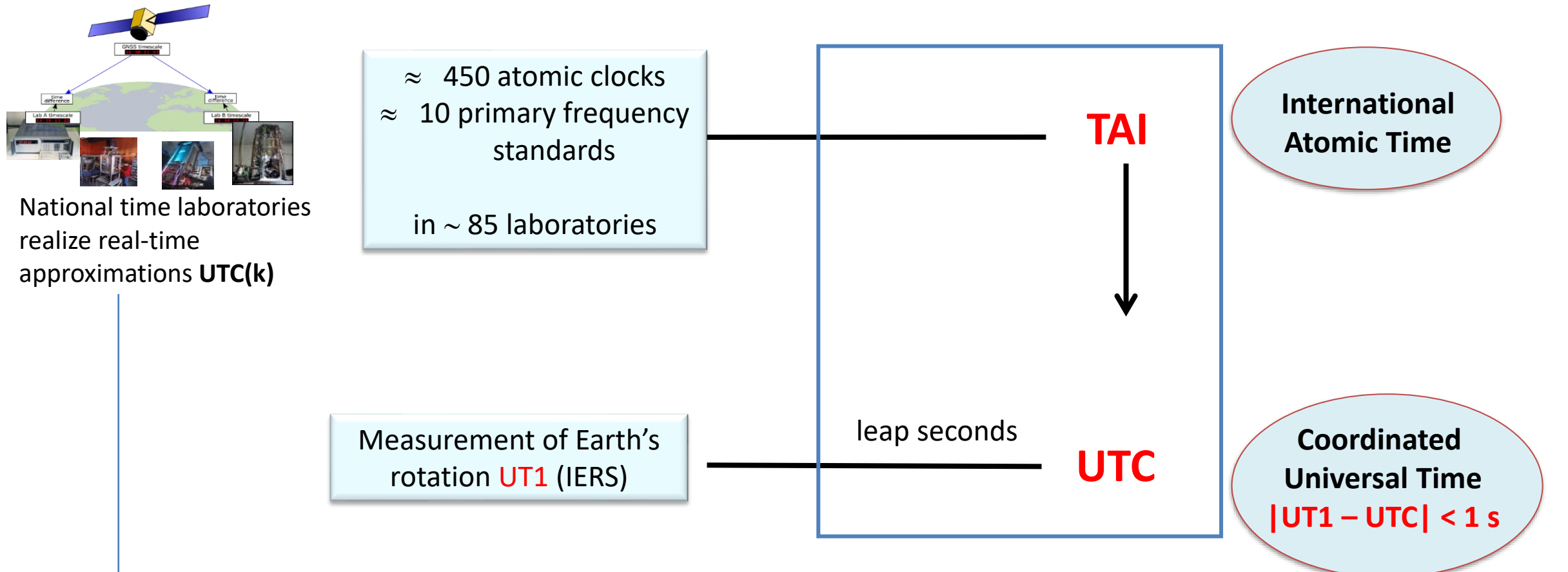
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BIPM Time Department

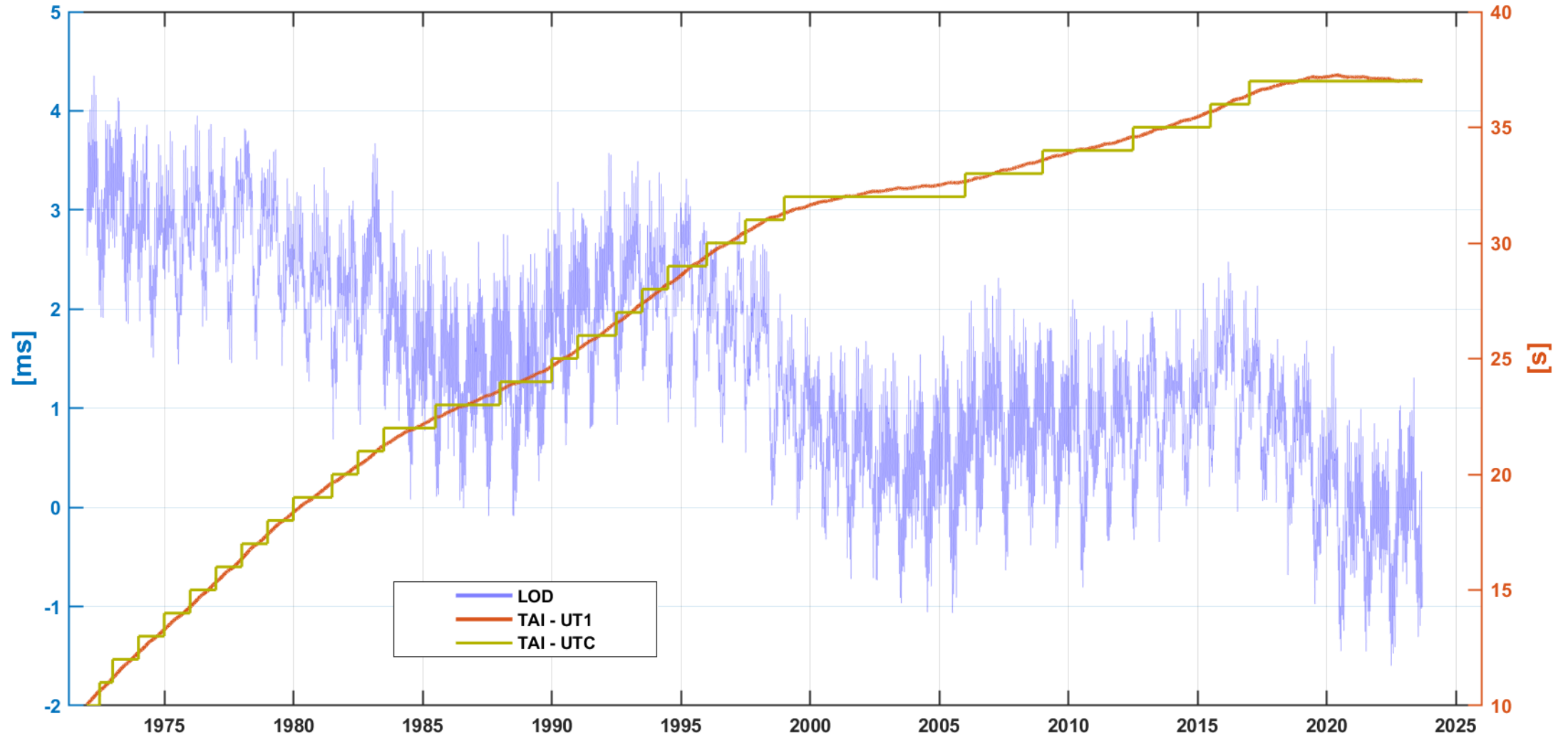
ICG 17 – 17/10/2023 Madrid WG-D



Construction of the Coordinated Universal Time



LOD and Past Leap Second Introduction



Dealing of Leap Second by Critical Infrastructure

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 (smearing)
 - 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

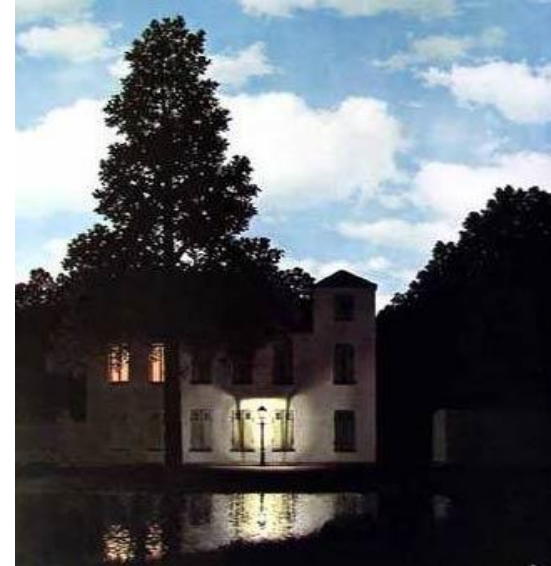
Solution to Progress Towards a Continuous UTC

Increase the tolerance in $|UT1 - UTC|$ to a new limit (e.g. 1 min reached after about 1 century or 1 hr reached after about 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





Resolution 4

“On the use and future development of UTC”

November 2022

A decorative graphic on the right side of the slide. It consists of numerous overlapping, concentric arcs in a variety of colors including red, orange, yellow, green, blue, and purple. The arcs are arranged in a way that they appear to swirl or spiral inward towards the center of the slide.

Working together to
promote and advance
the global comparability
of measurements

CGPM 2022 Resolution 4

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.

Impact on GNSS and RNSS

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,

No change

Will remain frozen

In some cases also

- a prediction of **UT1 - UTC**,

|UT1 – UTC| will be > 1 s

This quantity will remain < 60 s for probably 100 years

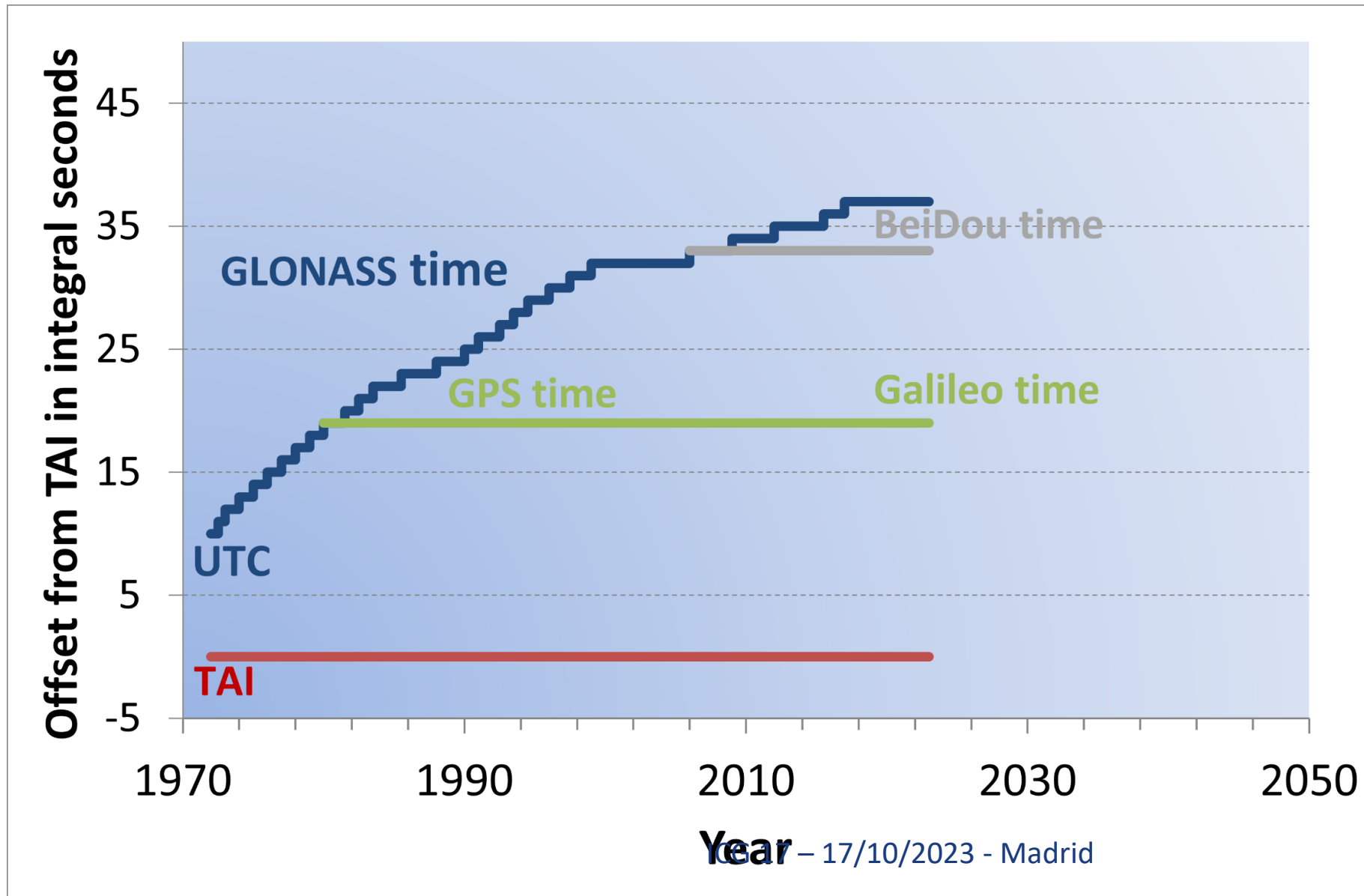
For most accurate applications:

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

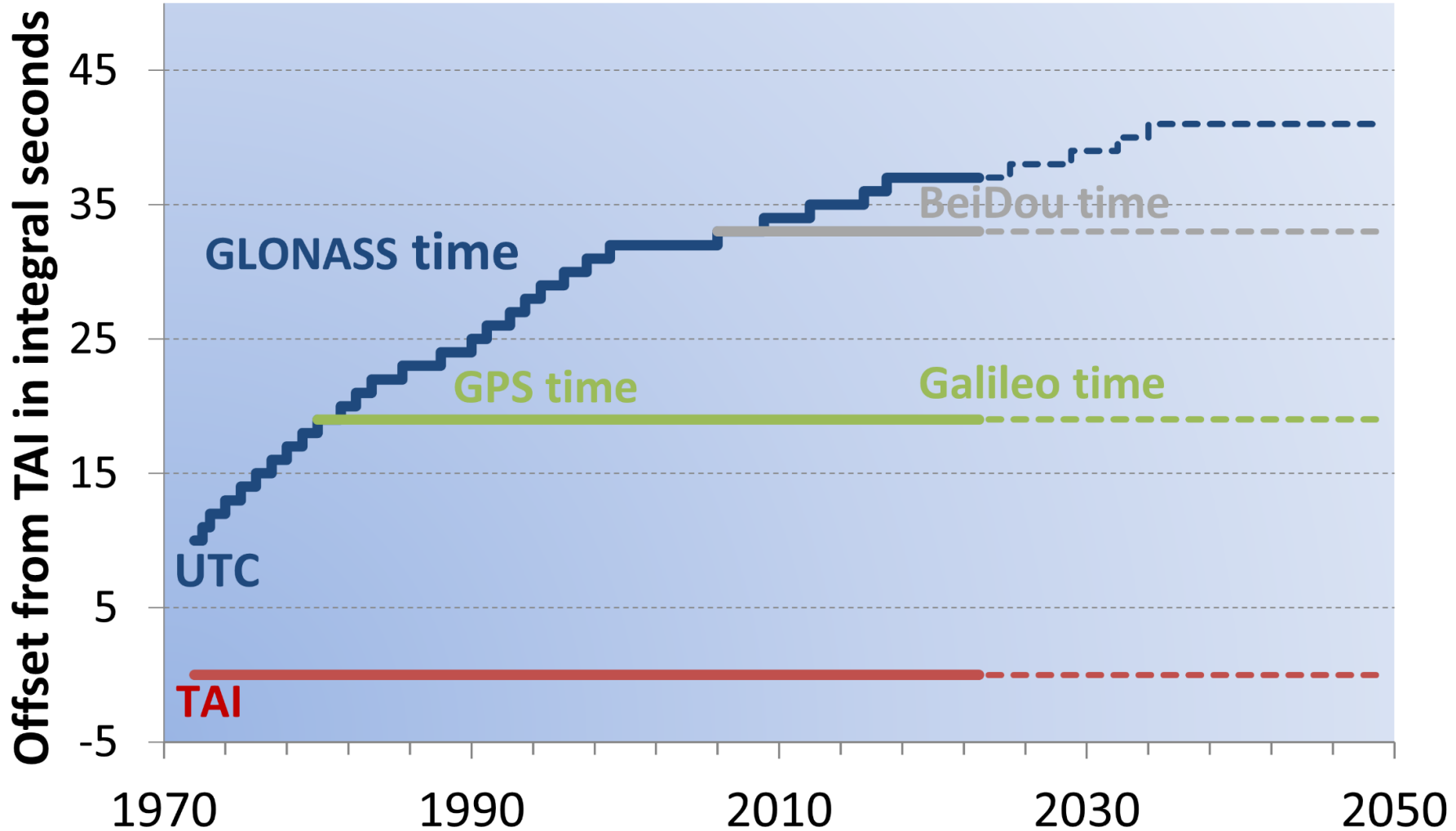
To be confirmed:

- GPS, QZSS, Beidou allow 64 seconds
- Galileo not broadcasting
- Glonass allows 1 s but new generation has 256 seconds
- Others?

UTC and GNSS time: a Varying Offset



UTC and GNSS time: a Fixed Offset



Towards Continuous UTC

A task group was created:

<https://www.bipm.org/en/committees/cc/cctf/wg/cctf-tgutc>

- to prepare a draft resolution for CGPM 2026 (new tolerance UT1-UTC, implementation date and procedure)
- to support the ITU preparation to the World Radio Conference in Nov 2023
- *A liaison to the GNSS/RNSS is important. Pascale Defraigne, chair of the CCTF WG on GNSS, is working on it. Thanks for your feedback*



Next Steps, What Should We Do?

3 options:

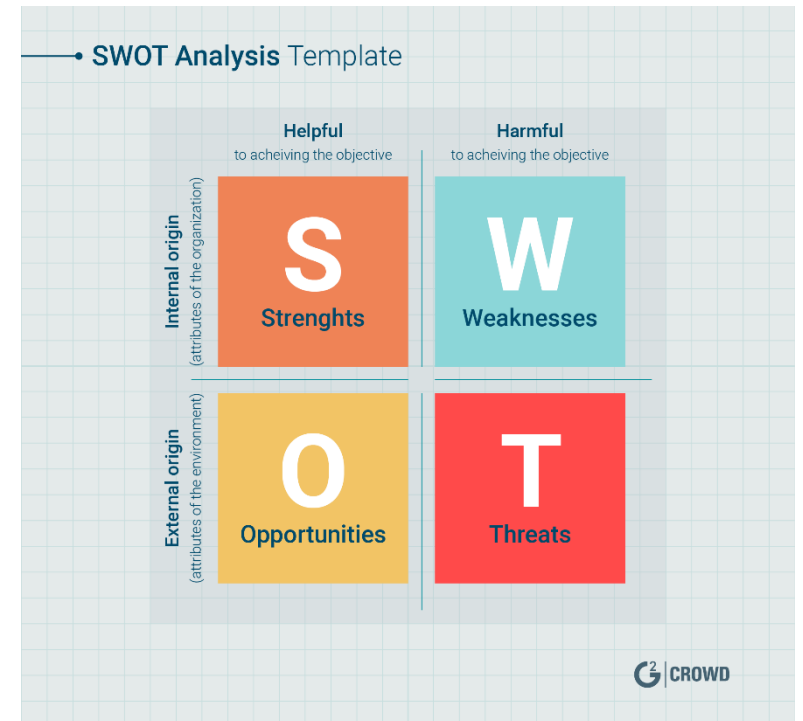
- 1 minute or 256 seconds (or 5 minutes)
- 1 hour (daylight saving time)
- No limit yet (next generations will decide when to align UTC to UT1)

SWOT analysis on the value and the implementation procedure

Relationship to time zone

Use of UTC as proxy of UT1

Shall we define the procedure for alignment far in the future?



Please join our work towards the CGPM 2026 for a sound and useful decision on continuous UTC

Is the Earth Pushing for a Quick Implementation ?



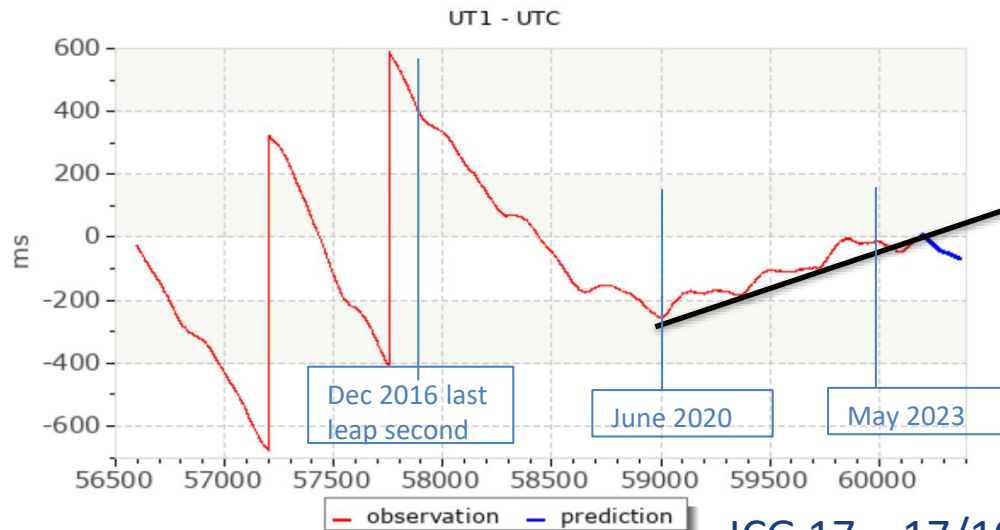
LATEST EARTH ORIENTATION PARAMETERS

Look at the latest evolution of the Earth rotation changes and their prediction

I want to look at the latest days and day prediction Remove tidal variations from UT1/LOD¹

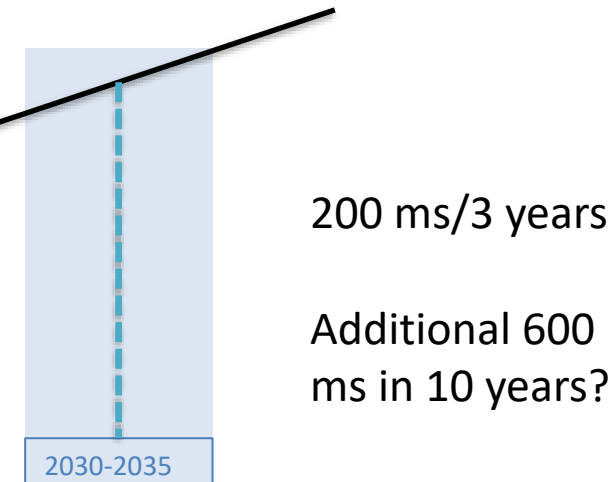
EOP C04 daily + 182 day prediction

- x / date
- y / date
- Polhody (x,-y)
- UT1-UTC / date
- UT1-TAI / date
- LOD / date
- dψ UAI 1980 / date
- dε UAI 1980 / date
- dX UAI 2000 / date
- dY UAI 2000 / date



<https://eoc.obspm.fr/index.php?index=realtim e&lang=en>

Possibility for the first negative leap second ?



*Thank you for your attention
and for your support in disseminating UTC*

