CELEBRATING 150 BIPM 1875 - 2025

CBKT

UTC, its computation and traceability. CCTF and CBKT

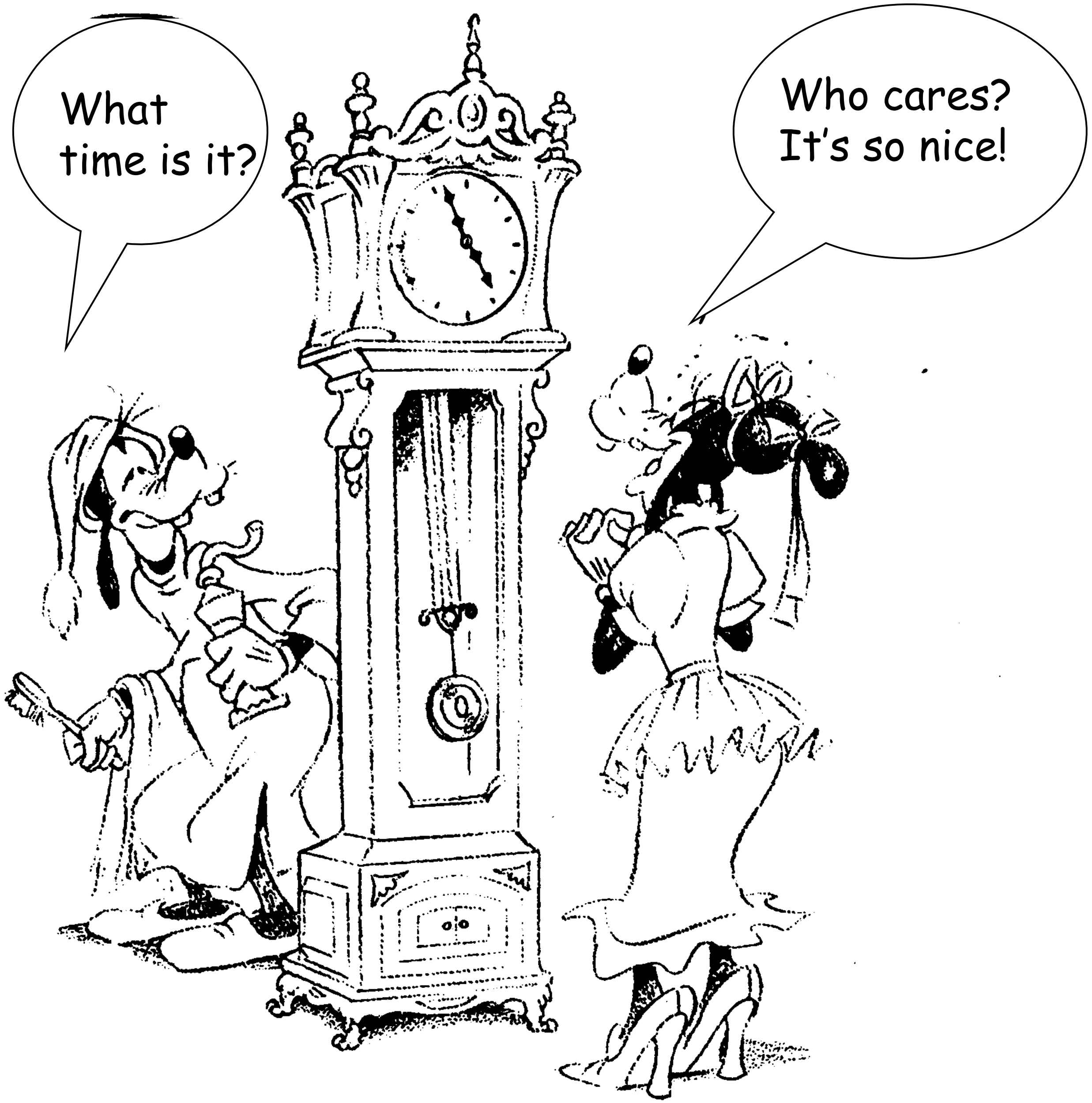
P. Tavella
Time Department, BIPM

Bureau International des Poids et Mesures

UTC

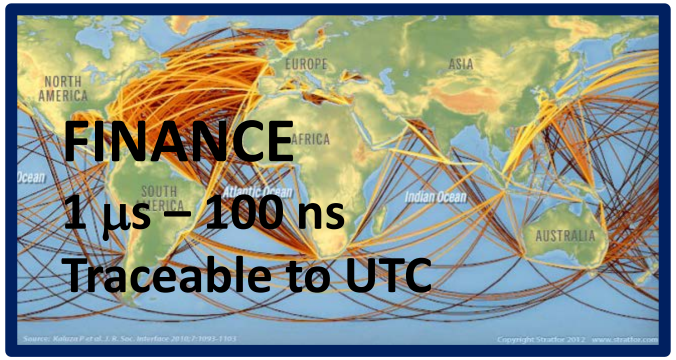
Sponsored by BIPM and UFFC

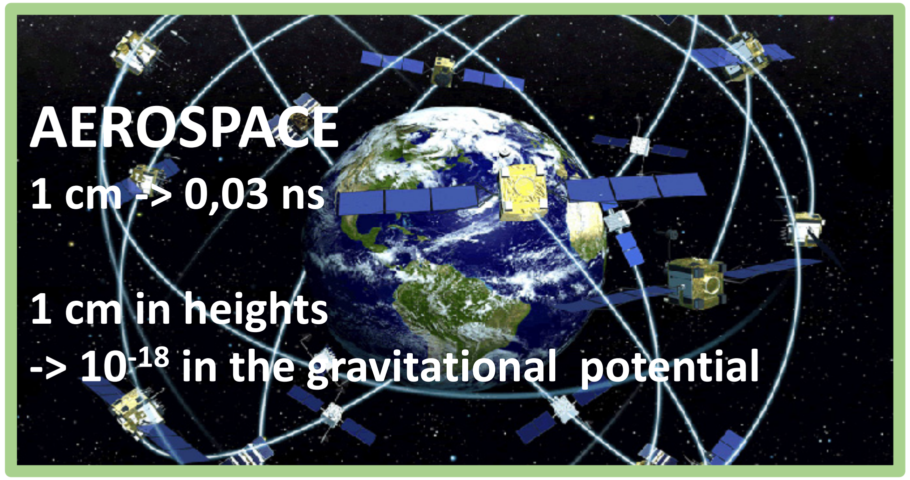
UFFC

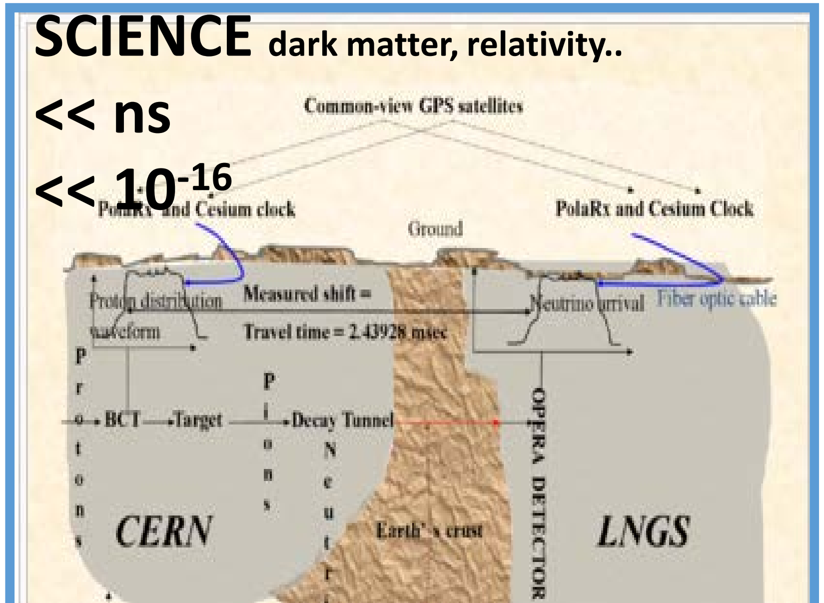


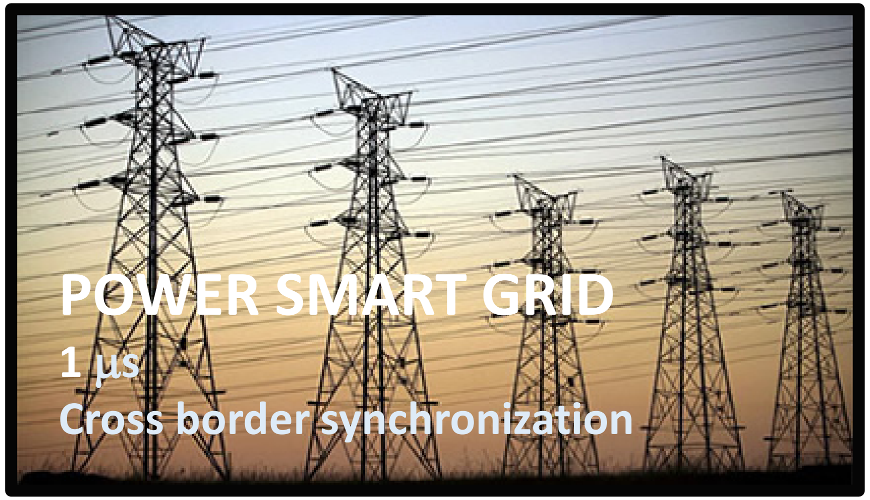
Bureau International des Poids et Mesures

What time is it?









What time is it?

The international reference time scale for all the applications is the

Coordinated Universal Time UTC

computed and distributed by the Bureau International des Poids et Mesures (BIPM) in Sevres, France,

based on the readings of very precise atomic clocks kept all over the world by timekeeping laboratories

Resolution 2 of the 26th CGPM (2018)
On the definition of time scales

The General Conference on Weights and Measures (CGPM), at its 26th meeting,

recognizing that
•**the mission of the BIPM is to ensure and promote the global comparability of measurements**, including the provision of a coherent international system of units,

•**states** that
•**TAI is a continuous time scale produced by the BIPM based on the best realizations of the SI second, and is a realization of TT** as defined by IAU Resolution B1.9 (2000),

•**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,**

•**UTC differs from TAI only by an integral number of seconds** as published by the BIPM,

•**traceability to UTC is obtained through local real-time realizations "UTC(*k*)" maintained by laboratories contributing data to the calculation of UTC, identified by "*k*",**

Full text on
https://www.bipm.org/en/committees/cg/cgpm/26-2018/resolution-2

What time is it? How do we get UTC?

In almost each country a national time scale is used as the reference for legal time and synchronization. This can be:

- UTC(k) = a real time approximation of UTC realized by a time laboratory “k”, inside the National Metrology Institute or in a Designated Institute which is part of the metrological infrastructure of a country. This national time laboratory contributes to UTC by providing its clock data to the BIPM and it is listed in the BIPM Circular T

Uncertainty = a few ns

Traceability to UTC
CCTF WGMRA Guideline 9
https://www.bipm.org/en/committees/cc/cctf/wg/cctf-wgmra

- A national clock synchronized to the UTC(k) of another country, by a direct connection (GNSS, fibre…) or by the Network Time Protocol on the Internet

Uncertainty = 10 - 100 ns

Traceability to UTC
CCTF WGMRA Guideline 9
https://www.bipm.org/en/committees/cc/cctf/wg/cctf-wgmra

- a national clock synchronized through the GNSS and other time dissemination services

Uncertainty = 1 – 100 microseconds
Traceability under discussion

see Michael talk

What is UTC(k) ?

what you do in the lab!

The reference time scale in each country is (usually) UTC(k)

see Andrew, Ben talks

It is a real-time local approximation of the Coordinated Universal Time realized by the laboratory “k”

see UZNIM, NICT, ICE, INRIM experience

This is realized and disseminated in **real-time**

This is (usually) the basis for the legal time and the synchronization in the country

The “k” laboratory is contributing to the computation of UTC with its clocks

Only laboratories contributing to UTC can use the naming UTC(k) for their time scale

The BIPM computes UTC:
a unique, accessible, universal, international reference time scale

what we do at the BIPM!

- We compute the Coordinated Universal Time based on your free running atomic clocks (not UTC(k)) every months

see Gianna, Francesca talks

- The definitive reference results are the deviation

  UTC – UTC(k)

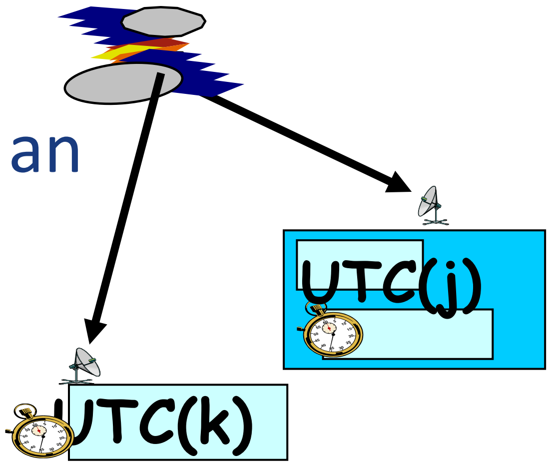
- We compute a provisional weekly rapid solution called rapid UTC = UTCr

- We compute also the Terrestrial Time TT(BIPM) based on the optimal use of Primary Frequency Standards for advanced scientific use

How can we do that?

see Aurelie talks

- We need the measures of your free running clocks
- We need the measures of your Primary and Secondary Frequency Standards to ensure the accuracy of UTC
- We need also the comparison between your local UTC(k) and an external UTC(j)



Comparison obtained by:

- **GNSS Common or All in view**
- **GNSS (Integer) Precise Point Positioning**
- **Two Way Satellite Time Frequency Transfer**
- **In future Optical fibers, other space techniques…**

See Andrew, Bharath, Giulio, Pascale, Calvin talks

See Tara talks

- We need to ensure that all the time transfer measures used to generate UTC are **calibrated.**
- Calibrations may be carried out by the BIPM, by the RMOs, by G1, G2 or other time laboratories or, in some cases, by other entities such as manufacturers.
- All the calibration results are to be documented. We provide a data base containing all the calibration info and reports.

How to enter in UTC?

http://webtai.bipm.org/database/

Bureau International des Poids et Mesures

BIPM Time Department Data Base

Participation | Equipments | Calibrations | Resources | Web services | Home

Website content description

Participation

Laboratories : full list of participating labs and their related information

Current status : current laboratories participation to UTC and UTCr

Geographical map : Geographical distribution of partcipating laboratories

Rules & guidelines : Full documentation and guidelines for UTC and UTCr participation

Dissemination services : Time dissemination services list and Time signals emissions

Equipments

Clocks : list of clocks by laboratory

GNSS : list of all GNSS equipments in UTC participating laboratories and their calibration status

TWSTFT : list of all TWSTFT equipments in UTC participating laboratories and their calibration status

source of UTC(k) : Equipment and source of UTC(k) of the laboratories contributing to TAI

PSFS : Access to PSFS evaluation reports

Calibrations : Documentation

GNSS status : list of GNSS calibration exercices (past and future)

GNSS results : results of GNSS calibration exercices

TWSTFT status : list of TWSTFT calibration exercices

Resources

Graphs

[UTC-UTC(k)] : Interactive plot of UTC(k) wrt UTC/UTCr

[UTC-GNSS] : Interactive plot GNSS times wrt UTC

PSFS contributions : Plot with Primary and Secondary Frequency Standards participating to TAI

Check the technical and administrative requirements.
When you feel ready at the technical level and your institute is compliant with BIPM rules, propose your contribution to the UTC

All details by Aurelie
Frederic will explain the connection to the SI Reference Point
Yuko, Bharath, Anders talks on the data quality check

One step more: the Mutual Recognition Arrangement

- **If you want to sell calibration services and issue certificates, you need a step more** demonstrating that your national measurements and certificates are equivalent to those of any other country
- You need to prove that your national standards are equivalent to others participating to the key comparison, i.e. CCTF- K001.UTC
- You need to demonstrate that you work in a Quality system
- You can then publish Calibration and Measurement Capability - CMC in the Key Comparison data Base - KCDB and offer services to the customers

KCDB

CIPM MRA

See CCTF WGMRA Guideline 7 (201509) Participation in the ongoing key comparison in time CCTF-K001.UTC, https://www.bipm.org/en/committees/cc/cctf/wg/cctf-wgmra

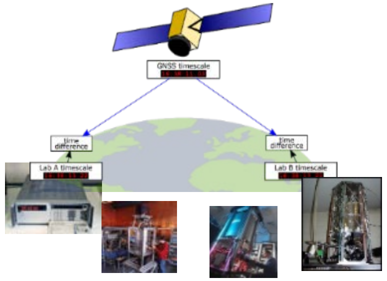
The International Atomic Time and the Universal Time Coordinated are the ultimate time reference but available

in deferred time

Local time scale UTC(k) are realised by national laboratories

in real-time

Construction of the Coordinated Universal Time



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

≈ 450 atomic clocks
≈ 15 primary frequency standards

in ~ 85 laboratories

TAI

International Atomic Time

Measurement of Earth's rotation UT1 (by IERS International Earth Rotation and Reference Systems Service)

leap seconds

UTC

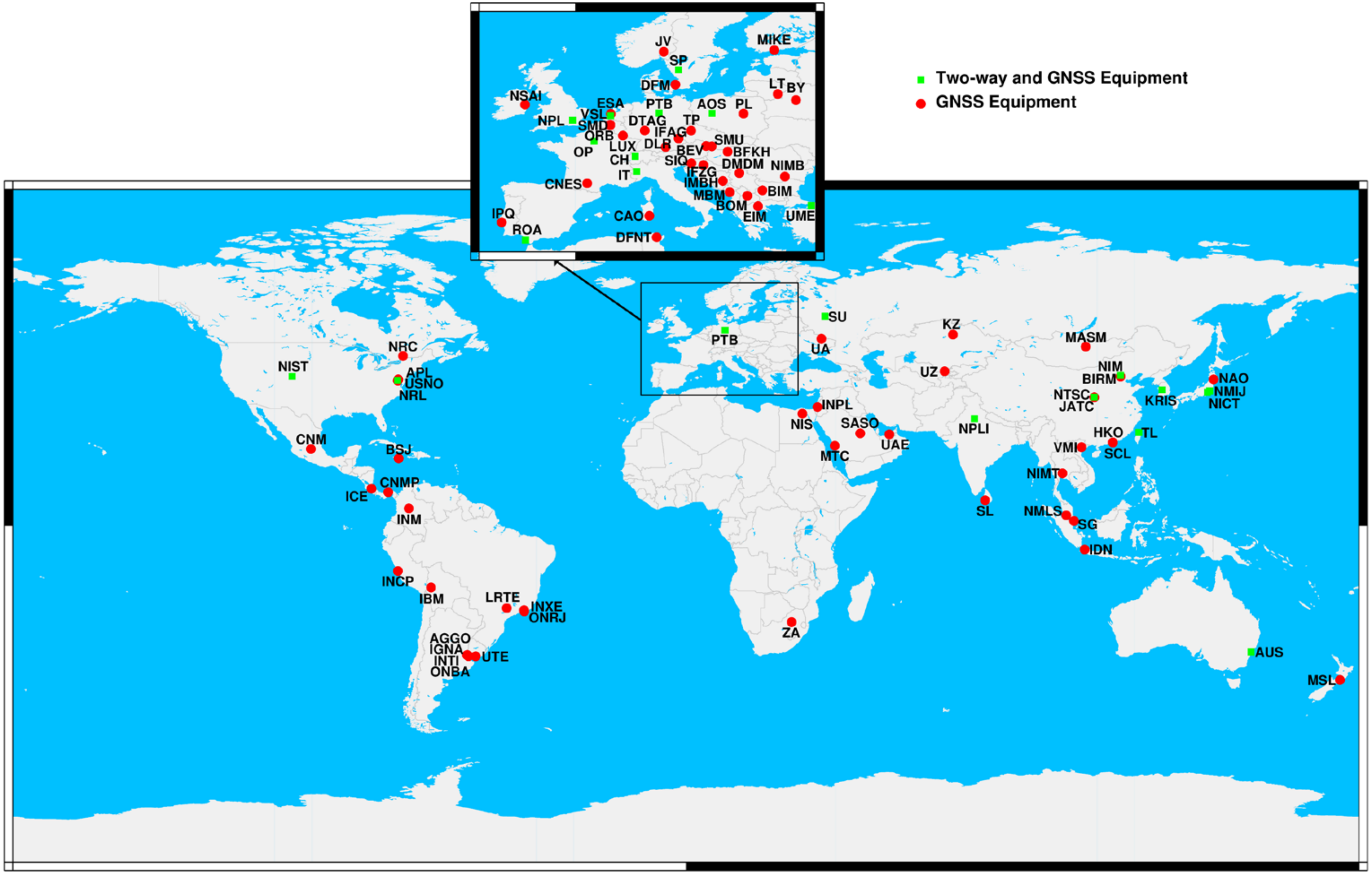
Coordinated Universal Time

|UT1 – UTC| < 1 s

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

UTC definitive results each month
UTC Rapid solution each week
UTC(k) are national realizations in real time

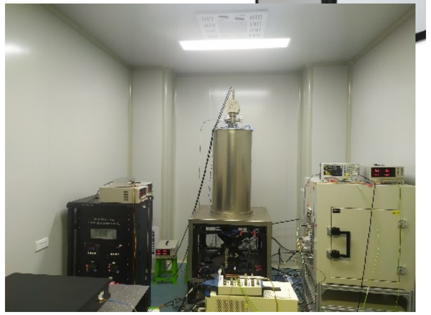
UTC is based on ≈ 450 atomic clocks kept in ≈ 85 laboratories in the world



About 450 Clocks participating in UTC

- Cesium clocks 55%
- Hydrogen masers 35%
- Others 10%

PTB-CS1
PTB-CS2



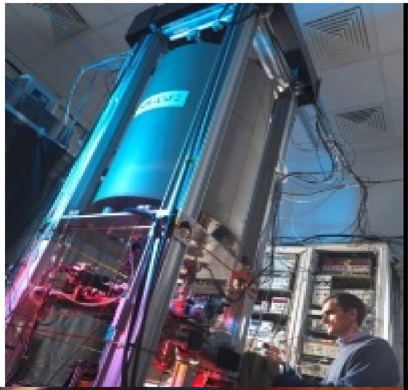
NTSC and USNO Rubidium Fountain

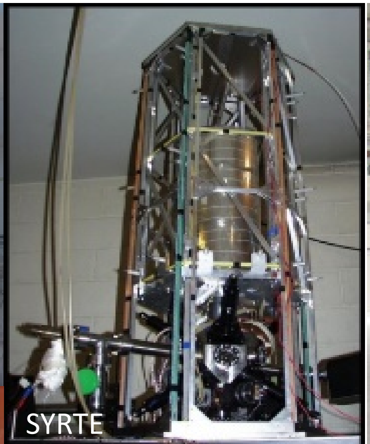
Primary frequency standards

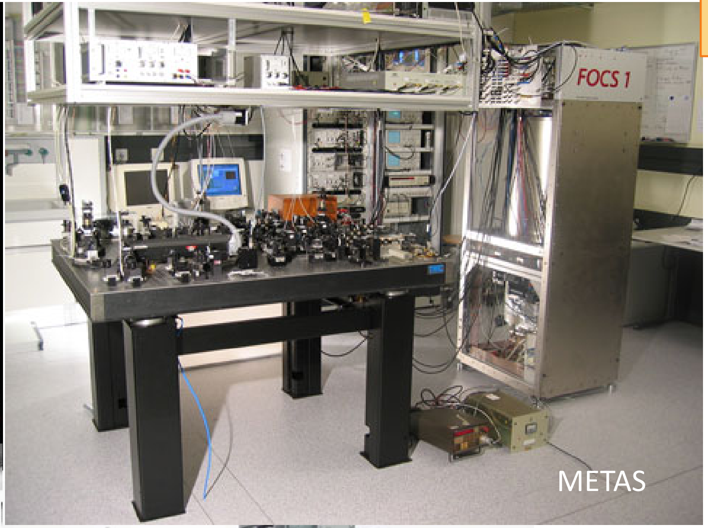
About 12 laboratories operate primary frequency standards. Their uncertainty can be evaluated a priori by examining the different effects perturbing the Cesium atom

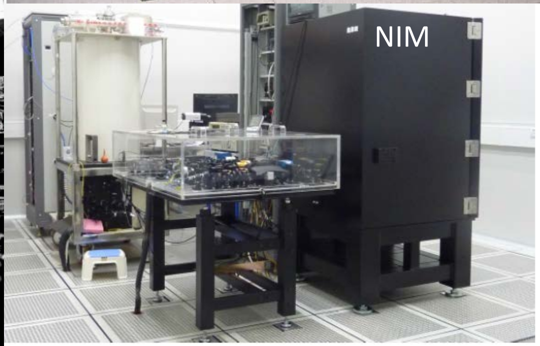
The uncertainty of Caesium primary fountains can reach 10^{-16}

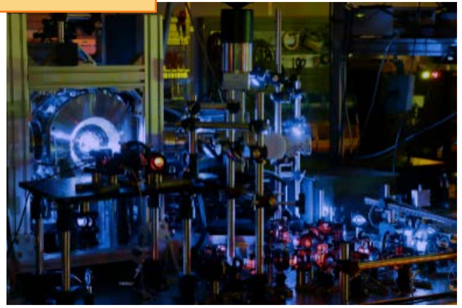
3 nanoseconds accumulated in ~~1~~ 100 year



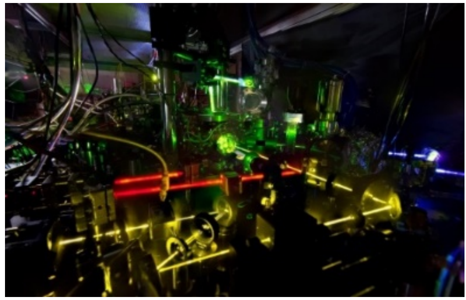




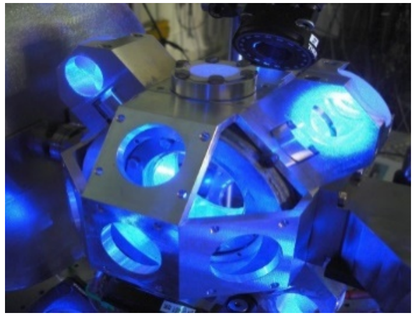




Sr lattice Clock (Photo: NICT)



Yb Lattice Clock (Photo: NIST)



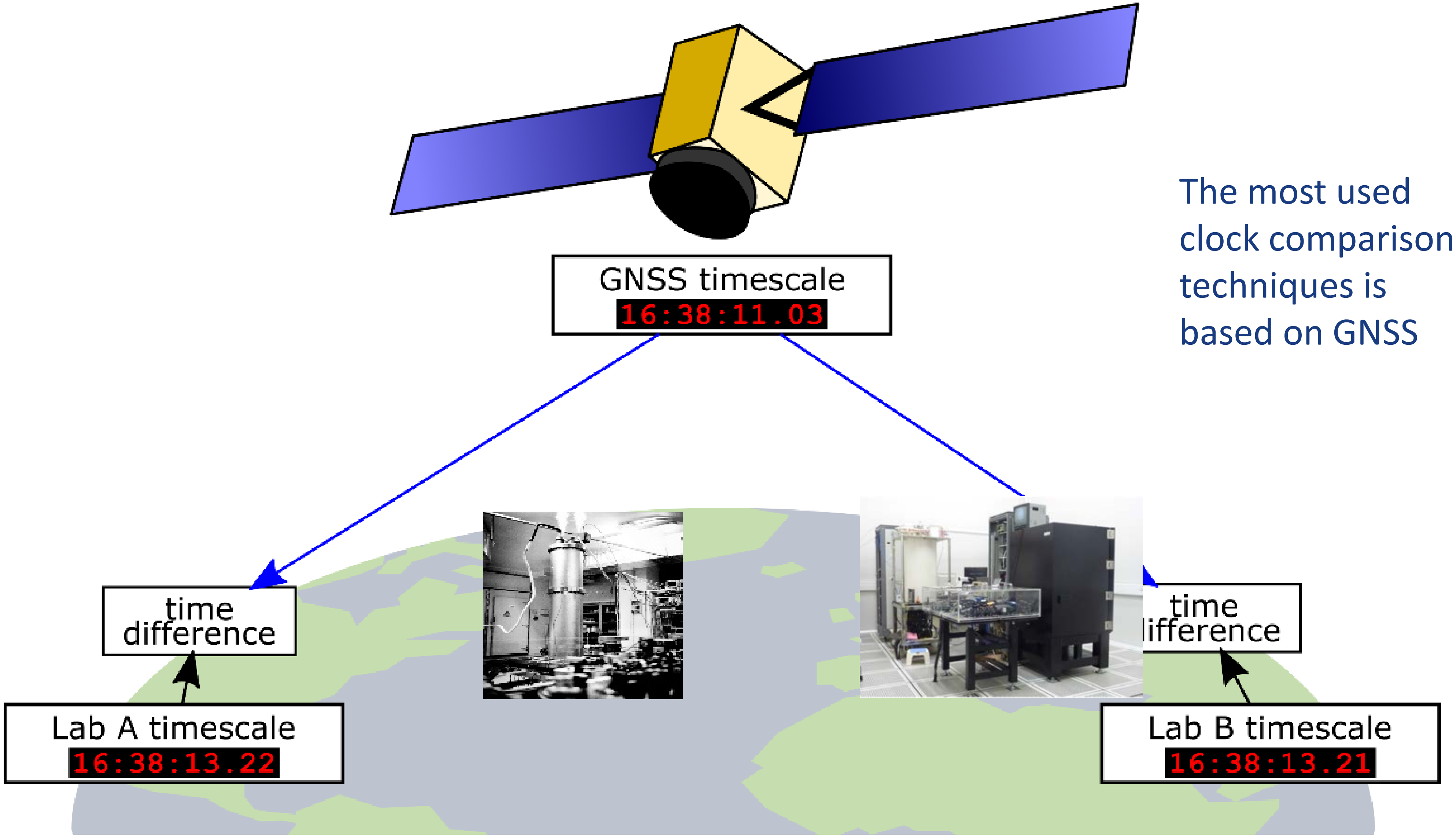
Sr Clock (Photo: LNE–SYRTE)

Progress in the construction of optical frequency standards allows now 10^{-18} accuracy

This is why we are working on the redefinition of the second

Stay tuned, with the contribution of all NMIs and CCTF colleagues we are working towards a redefinition of the second by 2030 or 2034

Clocks need to be compared

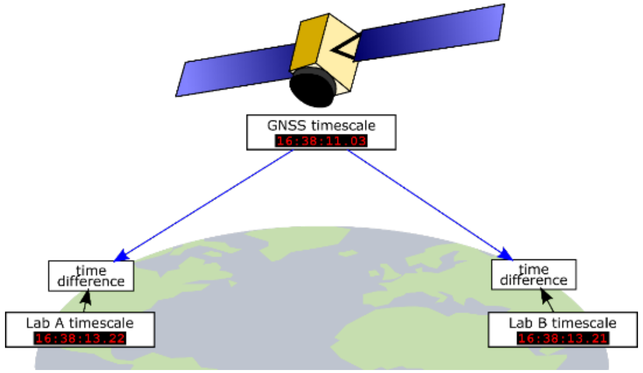


The most used clock comparison techniques is based on GNSS

Clocks in different laboratories are compared by suitable **time and frequency transfer techniques**

Global Navigation Satellite Systems (GNSS)

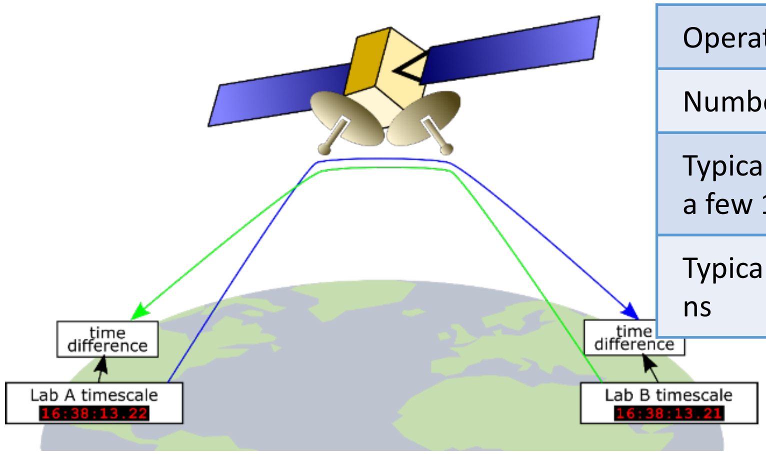
GNSS are based on time broadcasting from satellites to ground receivers (one-way time transfer). Distant labs equipped with GNSS receivers periodically compare their clocks to the broadcasted time and send the result to the BIPM.
Typical algorithms are All in View, Common View, and Precise Point Positioning



Operational since ~ 1980
Number of links : all contributing laboratories
Typical freq. transfer accuracy @1d : a few 10^{-15}
Typical time transfer accuracy : a few ns

Two-Way Satellite Time & Freq. Transfer (TWSTFT)

dedicated ground terminals simultaneously receive and transmit time transfer signals (two-way time transfer) on geostationary telecom satellites.
Two-way method cancels out (at first order) the propagation time of the signal.



Operational since ~2000
Number of links : 18
Typical freq. transfer accuracy @1d : a few 10-15
Typical time transfer accuracy : $\gtrsim$ 1 ns

Progress in GNSS measures

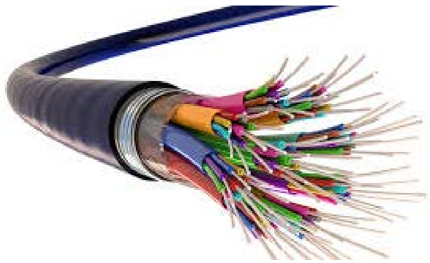
GPS+ GLONASS + Beidou + Galileo
IPPP : Precise Point Positioning with integer ambiguity resolution

Progress in TWSTFT

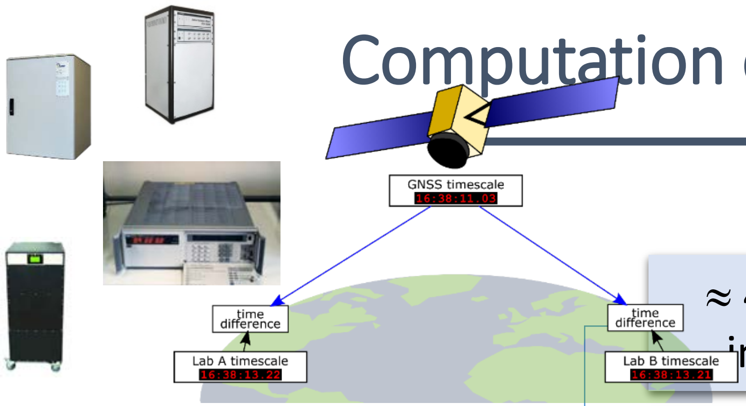
Software Designed Radio and TWSTFT Carrier Phase

In development : Optical Fiber links

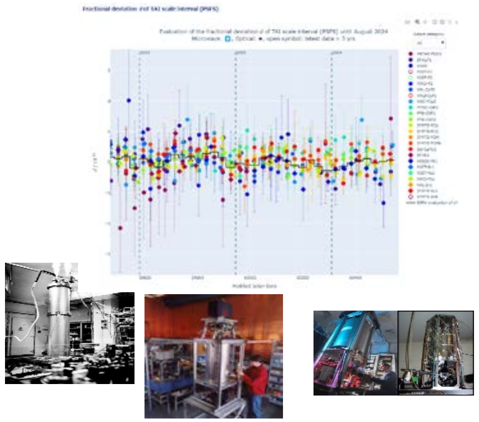
A growing number of UTC laboratories are gaining access to fiber links dedicated to time and frequency. Although few of them are currently interconnected by operational, high-duty cycle links, this number is expected to grow quickly during the next decade.



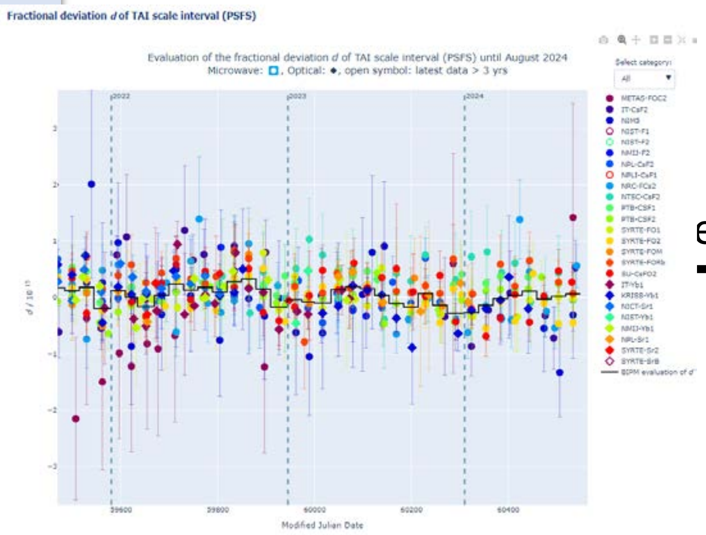
Computation of UTC (monthly) at the BIPM

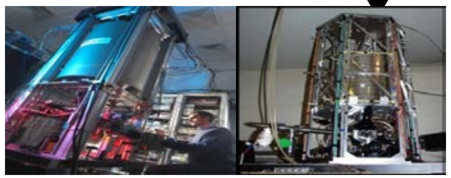


≈ 450 atomic clocks
in 85 laboratories



≈ 10-15 primary and secondary frequency standards





weighted average

EAL

ering

TAI

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

International Atomic Time
freq accuracy ~10^{-16}

Coordinated Universal Time UTC is in agreement with the rotational angle of the Earth UT1

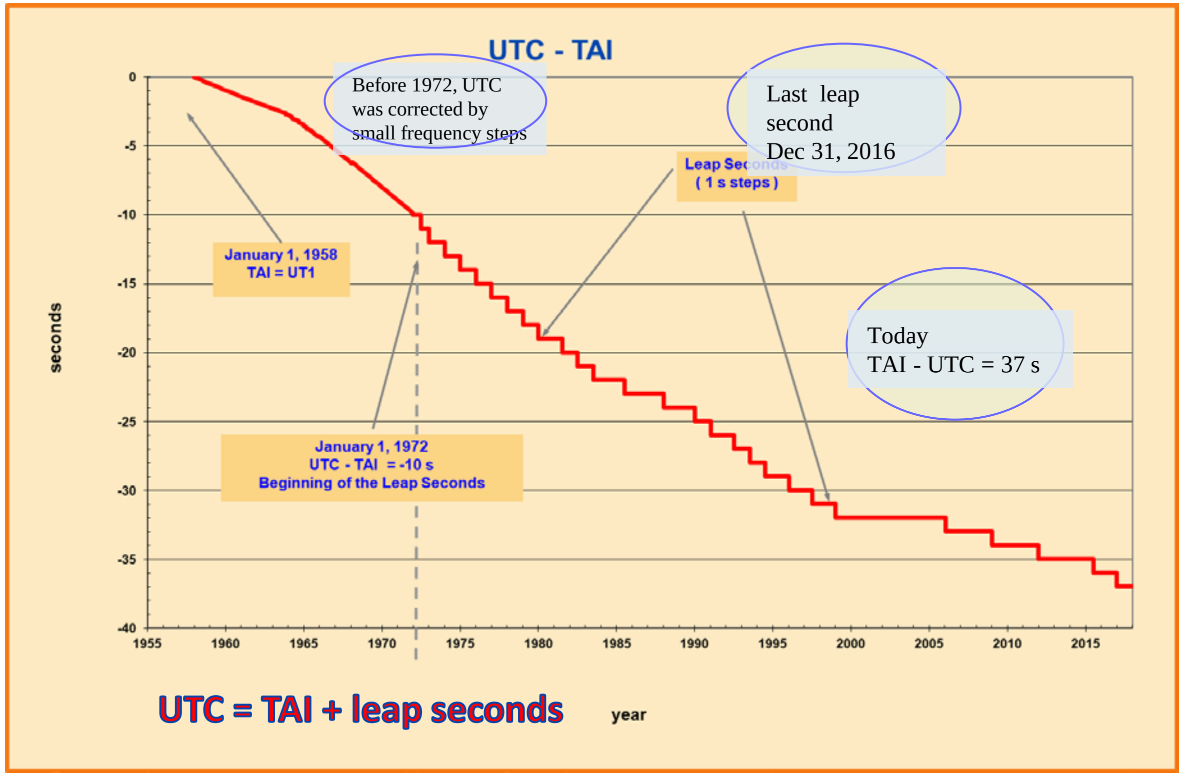
Timekeeping is related to the rotation of the Earth.

The real time timekeeping is based on atomic clocks and, since 1972, UTC is obtained from the International Atomic Time (TAI) plus leap seconds.

When the difference between the Earth rotational angle UT1 time scale and UTC reaches 0.9 second, an integer second is inserted to UTC to keep it within 1 s of UT1.

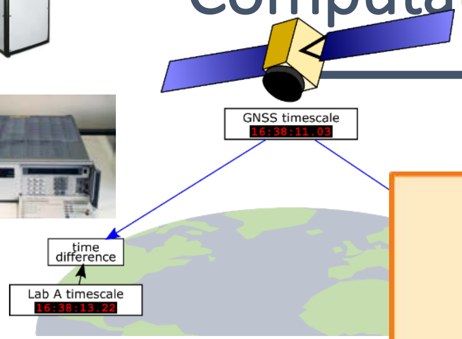
|UTC - UT1| < 1 second

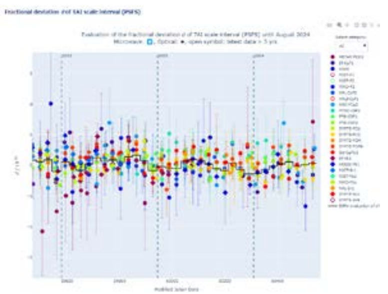
UTC = TAI + n seconds

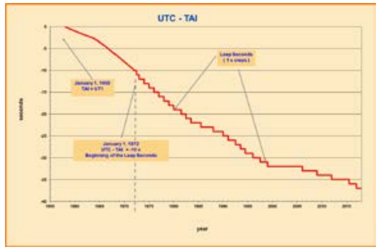


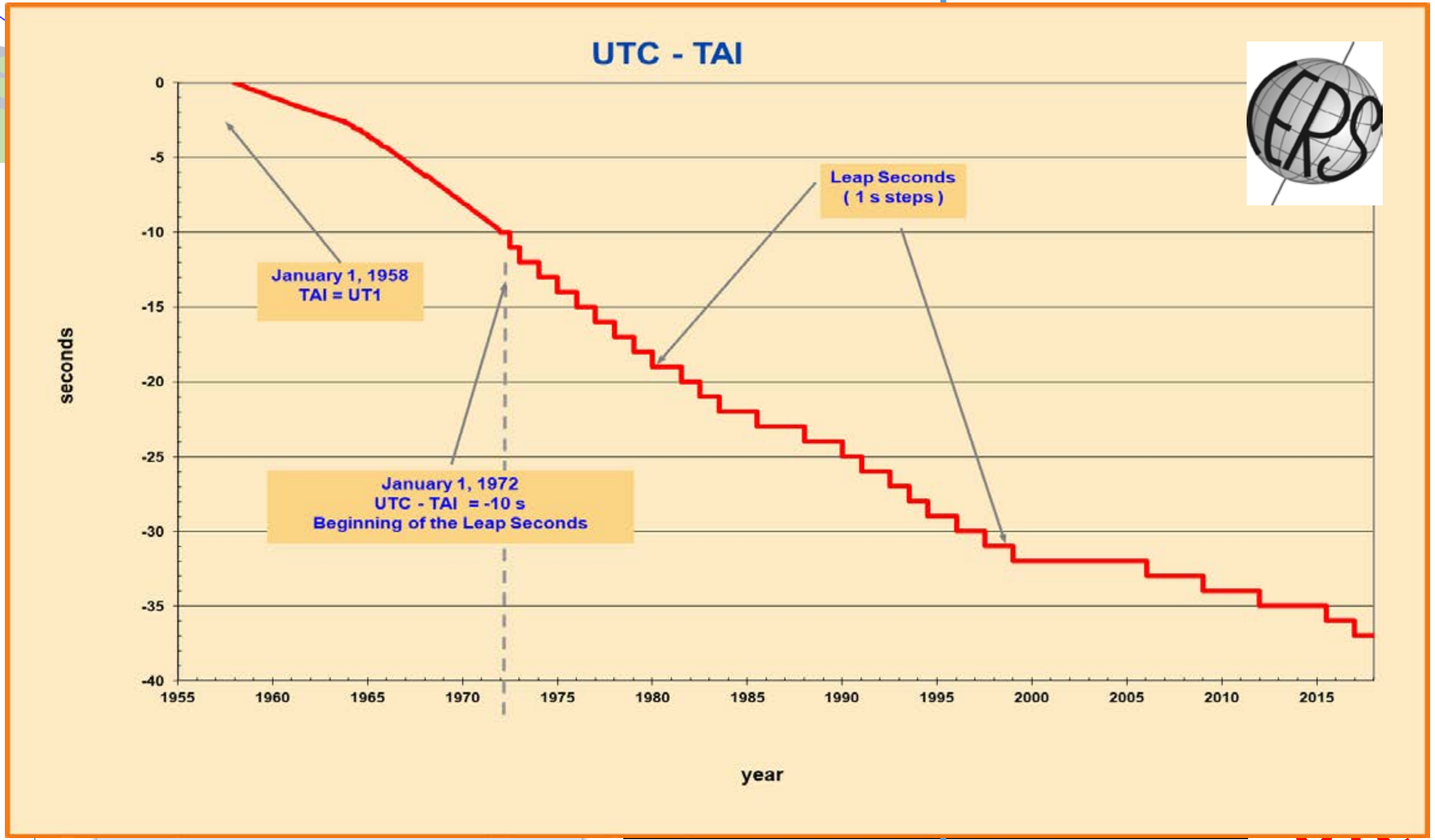
The process to insert the leap second and the code to transmit DUT1= UT1-UTC are described in Rec ITU-R TF 460-6

Computation of UTC (monthly) at the BIPM









Echelle Atomique Libre

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

International Atomic Time

freq accuracy $\sim 10^{-16}$

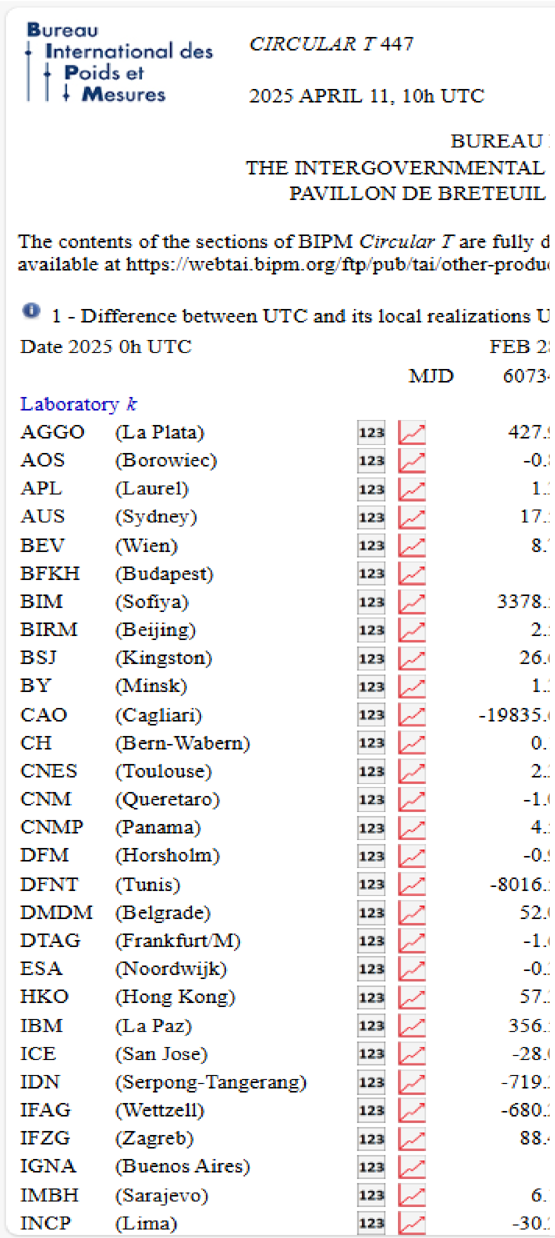
Coordinated Universal Time

Earth's rotation (IERS)

[UTC - UTC(k)]

BIPM *Circular T*

The results are the differences **UTC- UTC(k)** of the previous month (or week with the rapid UTC solution)



Bureau International des Poids et Mesures

CIRCULAR T 447

2025 APRIL 11, 10h UTC

BUREAU

THE INTERGOVERNMENTAL

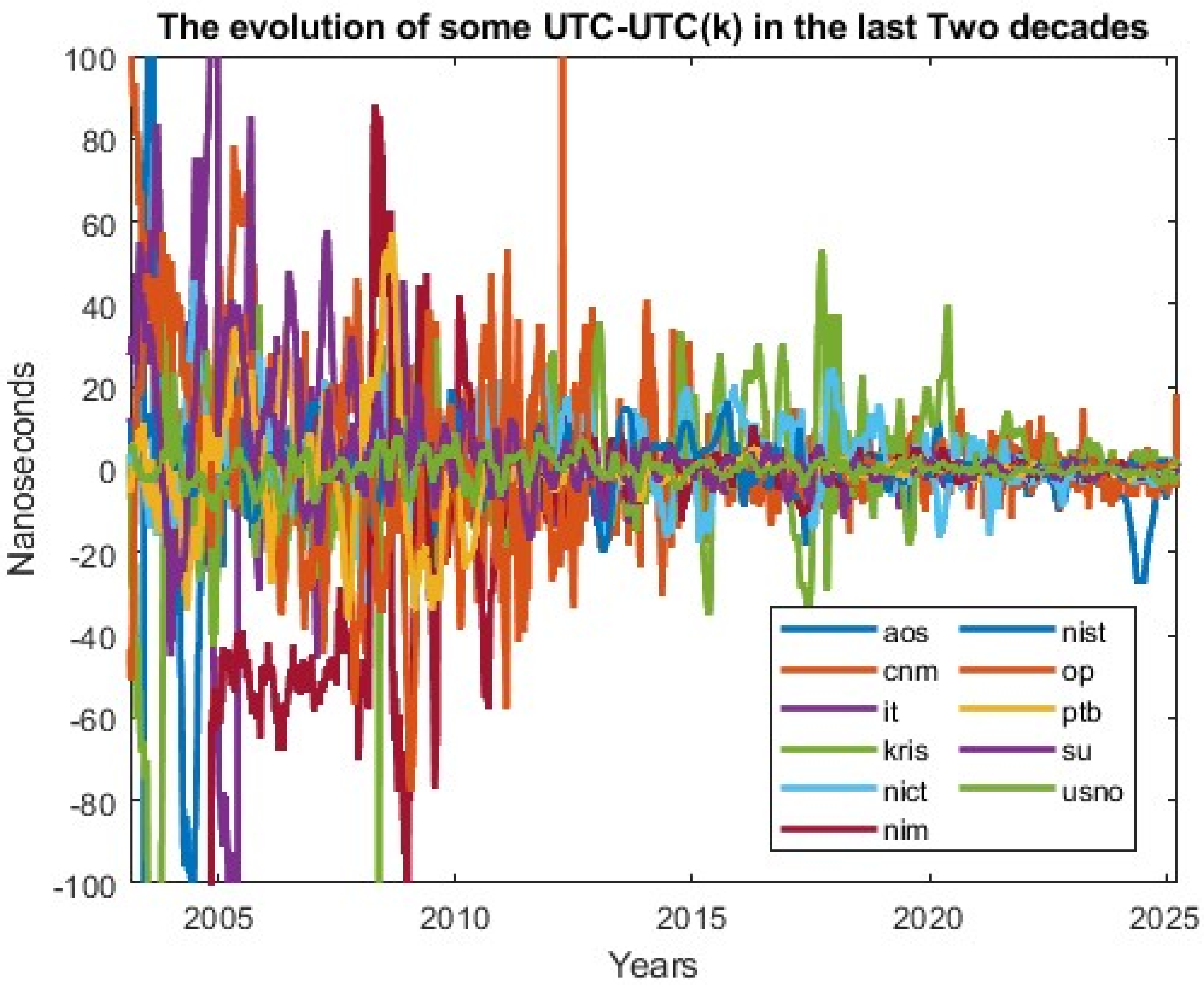
PAVILLON DE BRETEUIL

The contents of the sections of BIPM *Circular T* are fully d

available at https://webtai.bipm.org/ftp/pub/tai/other-produ

1 - Difference between UTC and its local realizations U

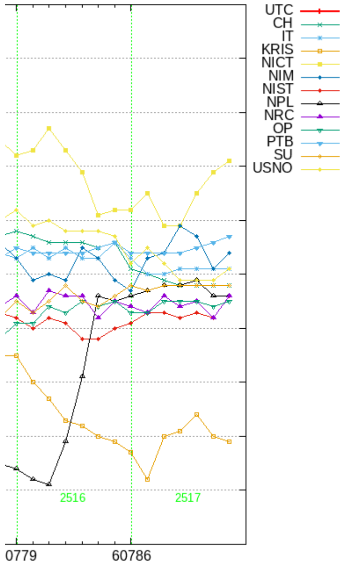
Date 2025 0h UTC		MJD	FEB 2
			6073
Laboratory *k*			
AGGO	(La Plata)		427.
AOS	(Borowiec)		-0.
APL	(Laurel)		1.
AUS	(Sydney)		17.
BEV	(Wien)		8.
BFKH	(Budapest)		
BIM	(Sofiya)		3378.
BIRM	(Beijing)		2.
BSJ	(Kingston)		26.
BY	(Minsk)		1.
CAO	(Cagliari)		-19835.
CH	(Bern-Wabern)		0.
CNES	(Toulouse)		2.
CNM	(Queretaro)		-1.
CNMP	(Panama)		4.
DFM	(Horsholm)		-0.
DFNT	(Tunis)		-8016.
DMDM	(Belgrade)		52.
DTAG	(Frankfurt/M)		-1.
ESA	(Noordwijk)		-0.
HKO	(Hong Kong)		57.
IBM	(La Paz)		356.
ICE	(San Jose)		-28.
IDN	(Serpong-Tangerang)		-719.
IFAG	(Wettzell)		-680.
IFZG	(Zagreb)		88.
IGNA	(Buenos Aires)		
IMBH	(Sarajevo)		6.
INCP	(Lima)		-30.



at 1-2 ns (many

20 ns)

tainty at best



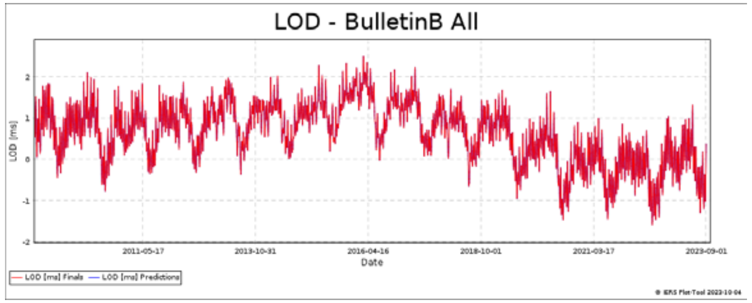
Coordinated Universal Time

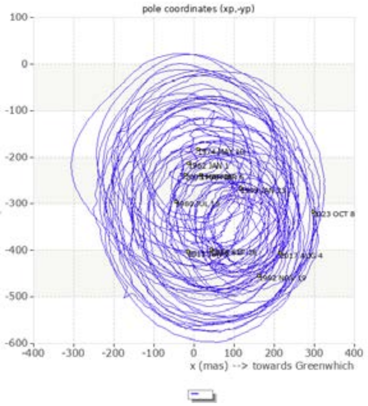
something is changing…

the CCTF at work…

the Earth rotation rate is not constant, and not enough well known to be predictable

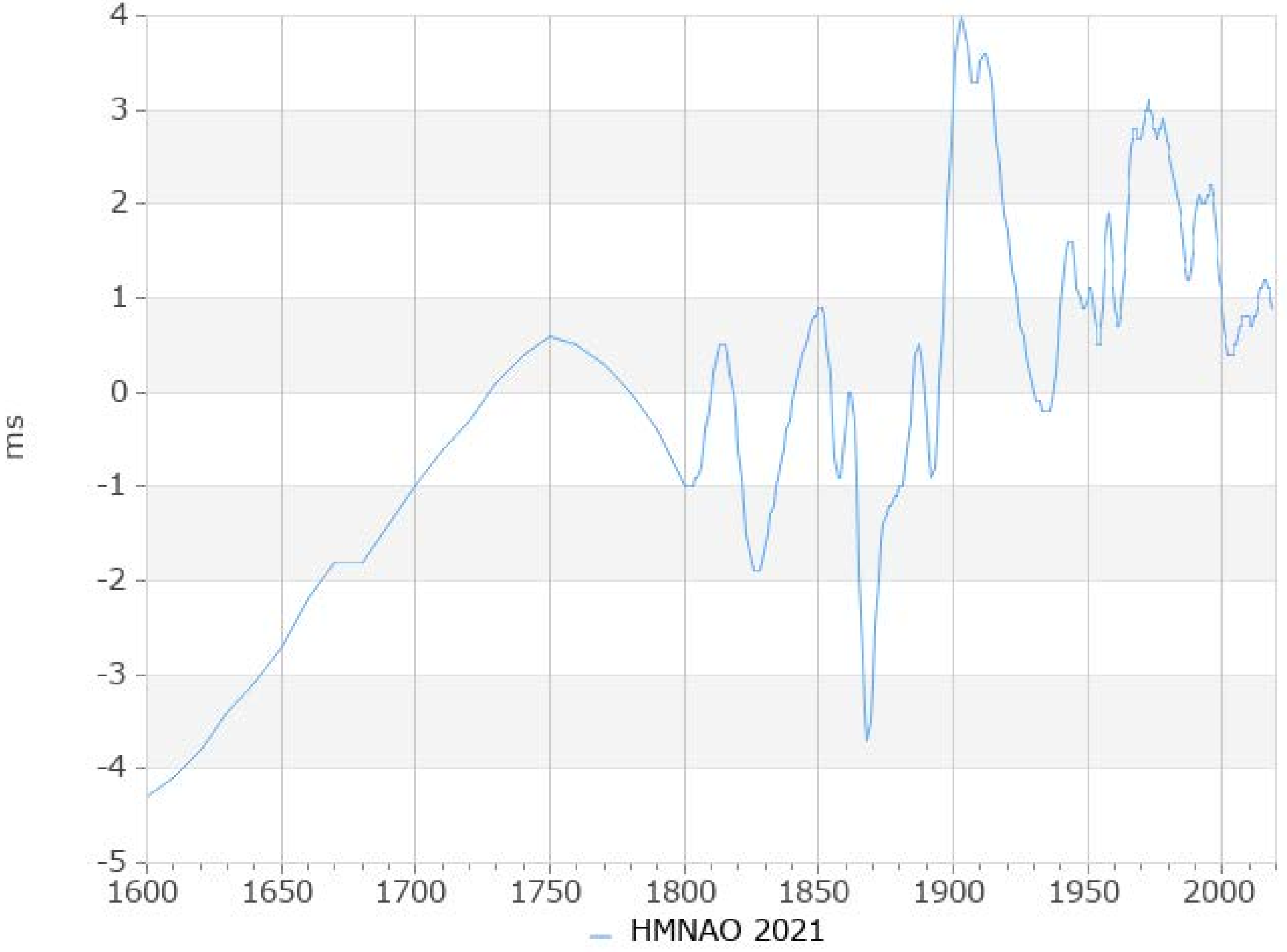
the leap second is decided with 6 month notice, when necessary





Secular slowing down

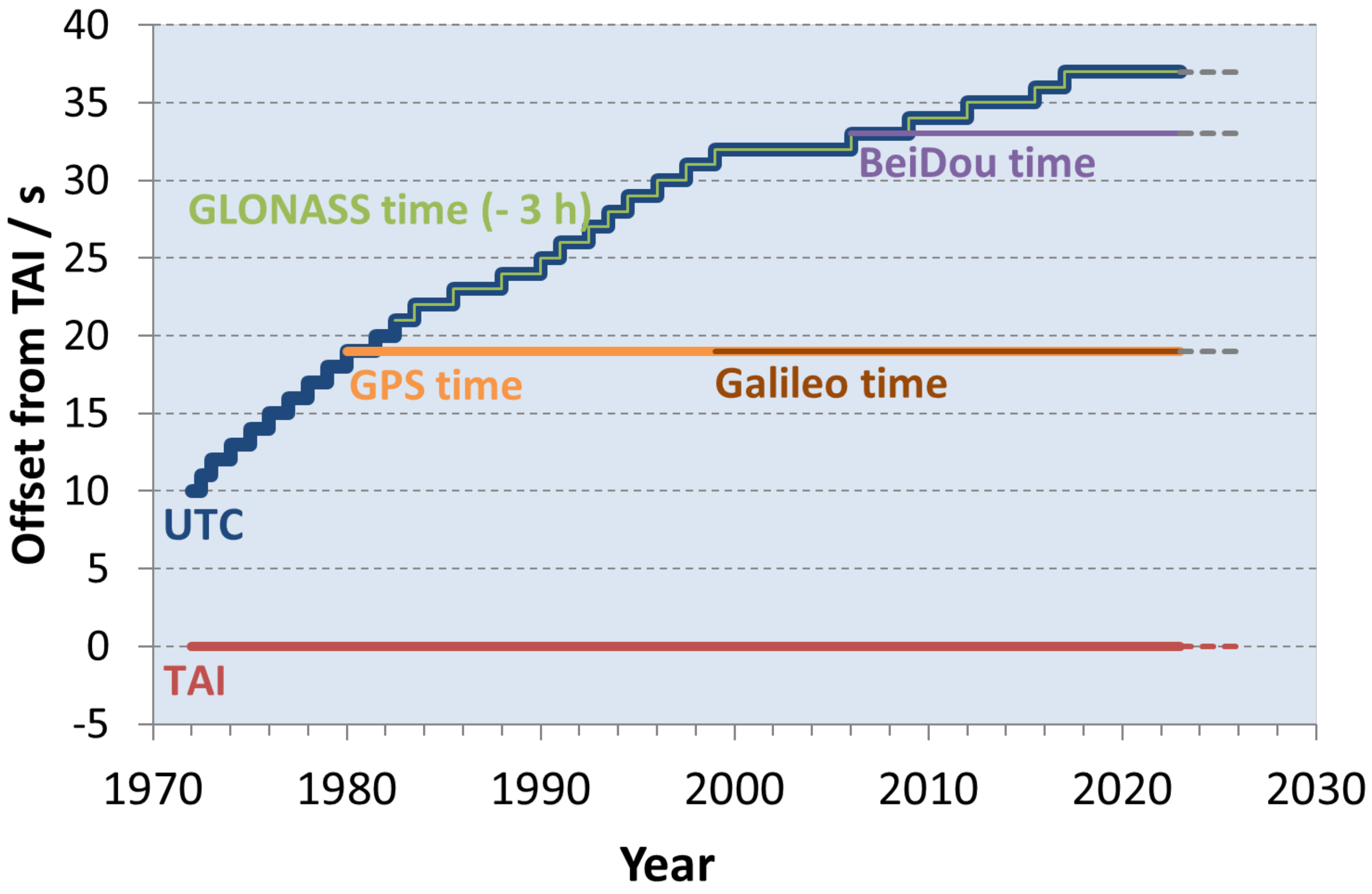
LENGTH OF DAY exceeding 86400 s



http://www.iers.org *International Earth Rotation and Reference Systems Service*

Global Navigation Satellite System (GNSS) need a continuous time scale

GNSSs prefer a continuous time scale and do not add leap seconds on their GNSS time scale (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



The digital networks cannot cope with unpredictable leap seconds

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

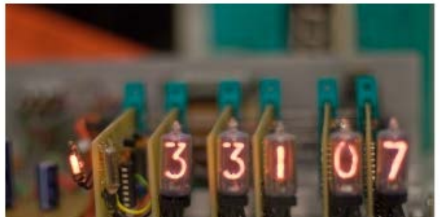
BUSINESS | CULTURE | GEAR | IDEAS | SCIENCE

Share

SHARE · TWEET · COMMENT · EMAIL

ROBERT MCMILLAN AND CADE METZ · BUSINESS 07.02.12 07:54 PM

The Inside Story of the Extra Second That Crashed the Web



自由時報 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

Consultative Committee on Time and Frequency User Survey (2021)

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

The Telegraph

Home | Video | News | World | Sport | Business | Money | Comment | Culture | Travel | Lif

Politics | Investigations | Obits | Education | Science | Earth | Weather | Health | Royal | C

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

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

NETWORKWORLD FROM IDG

'Leap second' snafu affects Oracle clusterware

By Chris Kanaracus

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

DIGITAL MAGAZINE | EVENTS & AWARDS PROGRAMS | VIDEO

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

Leap second hits Qantas air bookings, while Reddit and Mozilla stutter

The addition of an extra second between Saturday and Sunday to account for the slowing rotation of the Earth affected flight check-ins in Australia, and hit popular websites including Yelp and Foursquare

More than 400 Qantas flights were delayed when the 'leap second' confused web servers on Sunday. Photograph: Mark Baker/AP

Time travels on the network

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

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

Engineering at Meta

Open Source | Platforms | Infrastructure Systems | Physical Infrastructure | Video Engine

POSTED ON JULY 25, 2022 TO PRODUCTION ENGINEERING

It's time to leave the leap second in the past

By Oleg Obleukhov, Ahmad Byagowi

The leap second concept was first introduced in 1972 by the International Earth Rotation

https://engineering.fb.com/2022/07/25/production-engineering/its-time-to-leave-the-leap-second-in-the-past/

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

XXXIVth General Assembly and Scientific Symposium
Rome 2021

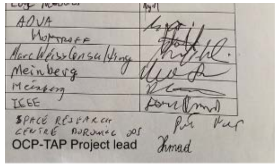
Council IV
Vote on URSI Resolutions

GASS 2021 : Vote on URSI Resolutions and Recommendation

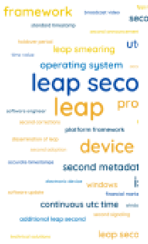
R1. Resolution on the need for a continuous reference time scale

The URSI Council,

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 a
available from Dr. Patr

May 1, 2022

IGS INTERNATIONAL GNSS SERVICE

Statement on Leap Second

The International GNSS Service (IGS) publishes many GNSS analysis products based on satellite data collected from a network of over 400 ground stations. In keeping with the IGS's legacy conventions, data and product records have timestamps aligned to TAI – 19 seconds making its timescale consistent with GPS System Time, Galileo System Time and QZSS System Time. These timestamps vary, however, with respect to UTC depending on the present number of leap seconds.

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

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,

When?

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,

What?

– prepare a plan to implement by, or before, 2035 the proposed new maximum value for the difference (UT1-UTC),

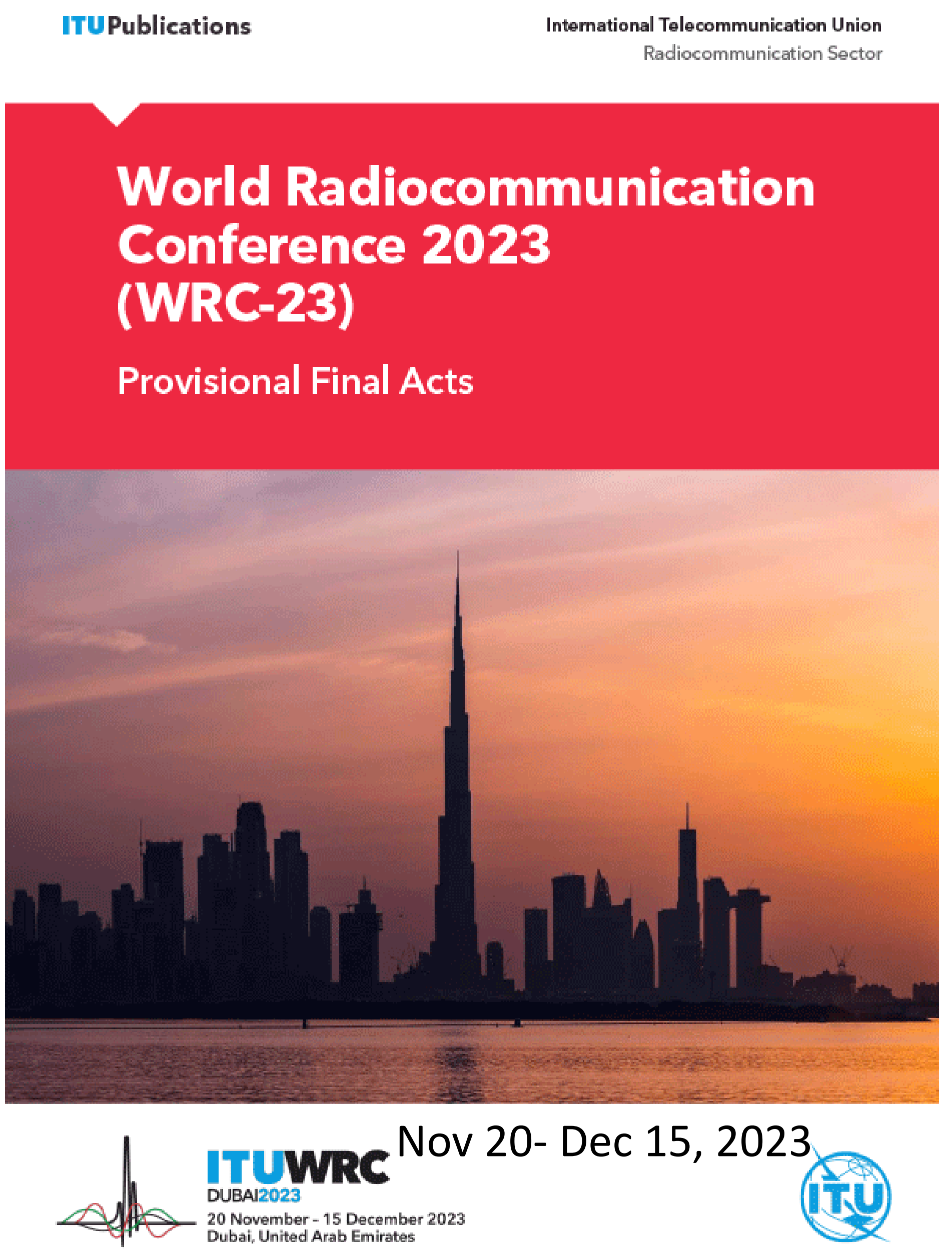
– propose a time period for the review by the CGPM of the new maximum value following its implementation, so that it can maintain control on the applicability and acceptability of the value implemented,

– draft a resolution including these proposals for agreement at the 28th meeting of the CGPM (2026)

Next step

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.

ENDORSED by



Nov 20- Dec 15, 2023

https://www.itu.int/en/itunews/Documents/2023/2023-02/2023_ITUNews02-en.pdf

The International Telecom Union – R is responsible for setting standards concerning time signals and frequency standard emission by radio systems

The CCTF Task Group in working to *prepare the draft resolution for the CGPM 2026*

1) **Provide the value of the new limit for UTC-UT1 to ensure a continuous UTC over one century.**
   2 options:
   - 100 seconds (or 5 min) => continuity about one century
   - 1 hour (can be applied as daylight saving time/ time zone) and it similar to No limit => continuity about one millennium

2) Provide the date of implementation (in or before 2035) :

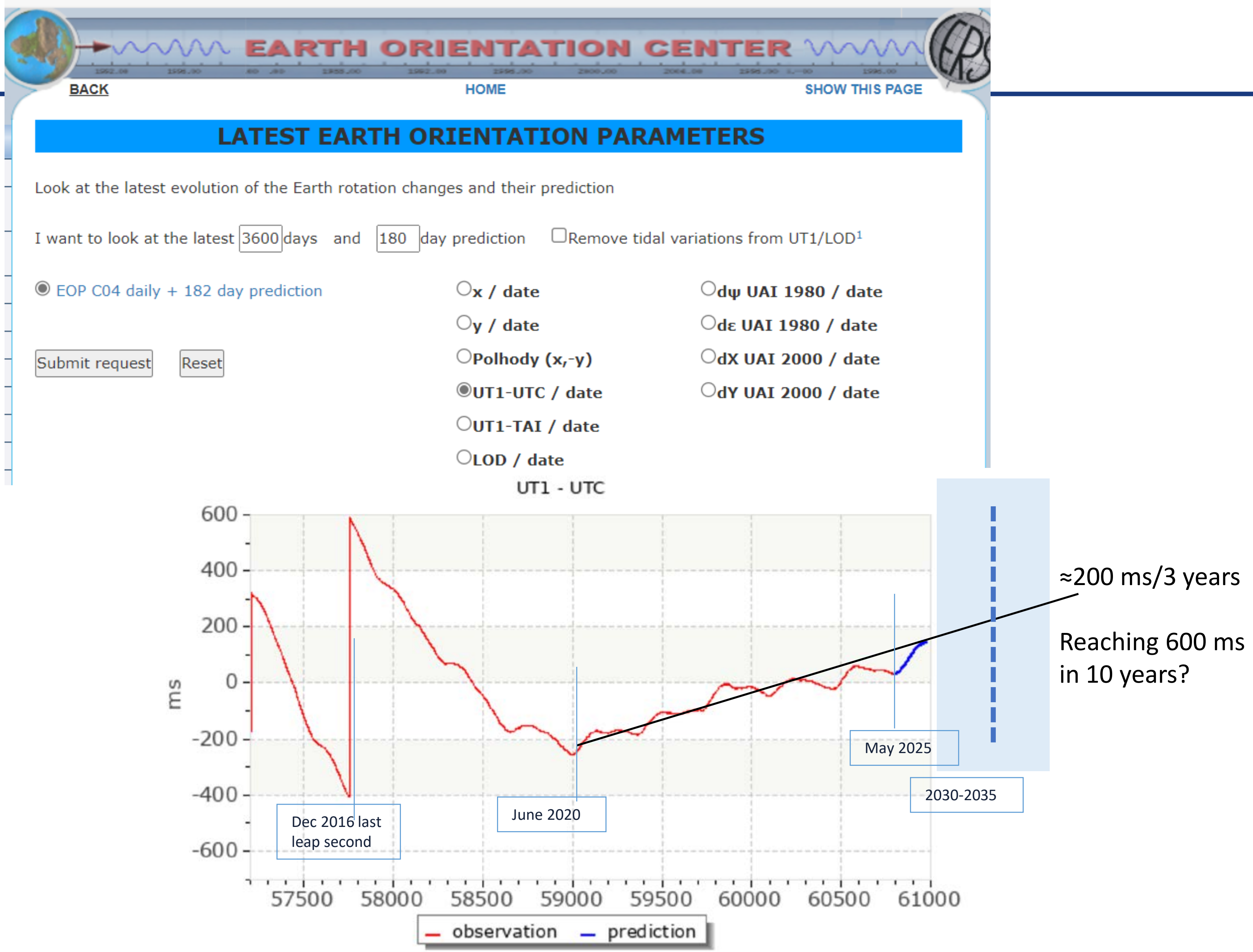
Some countries recommend 2035 to update technological systems, other countries and user communities are urging the change

Ready for a negative leap second?

CGPM draft resolution in progress

Is the Earth deciding for us?

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



We receive requests from BIPM member states and stakeholders NOT to allow a negative leap second

Possibility for the first negative leap second ?

A negative leap second coming soon?

almost as likely as not to experience a negative leap second in the next 12 years

March 27 on Nature: UTC as
now defined will require a negative discontinuity by 2029 (could have been in 2026)

https://www.nature.com/articles/d41586-024-00850-x

A global timekeeping problem postponed by global warming

https://doi.org/10.1038/s41586-024-07170-0

Received: 4 August 2023

Accepted: 6 February 2024

[redacted]

Check for updates

Duncan Carr Agnew[1]

The historical association of time with the rotation of Earth has meant that Coordinated Universal Time (UTC) closely follows this rotation[1]. Because the rotation rate is not constant, UTC contains discontinuities (leap seconds), which complicates its use in computer networks[2]. Since 1972, all UTC discontinuities have required that a leap second be added[3]. Here we show that increased melting of ice in Greenland and Antarctica, measured by satellite gravity[4,5], has decreased the angular velocity of Earth more rapidly than before. Removing this effect from the observed angular velocity shows that since 1972, the angular velocity of the liquid core of Earth has been decreasing at a constant rate that has steadily increased the angular velocity of the rest of the Earth. Extrapolating the trends for the core and other relevant phenomena to predict future Earth orientation shows that UTC as now defined will require a negative discontinuity by 2029. This will pose an unprecedented problem for computer network timing and may require changes in UTC to be made earlier than is planned. If polar ice melting had not recently accelerated, this problem would occur 3 years earlier: global warming is already affecting global timekeeping.

An important risk of a negative leap second could definitely push towards a quicker change in UTC

Why the timekeeping and GNSS communities should start preparing.

DEMETRIOS MATSAKIS, MASTERCLOCK

DENNIS MCCARTHY, U.S. NAVAL OBSERVATORY, CONTRACTOR

https://insidegnss.com/will-we-have-a-negative-leap-second/

No reliable prediction is possible in the long term, let's observe the Earth rotation and let's the future generations decide

L. Zotov, C. Bizouard, C.K. Shum, C. Zhang, N. Sidorenkov, V. Yushkin, "Analysis of Earth's polar motion and length of day trends in comparison with estimates using second degree stokes coefficients from satellite gravimetry", *Advances in Space Research* **69**, 308–318 (2022). https://doi.org/10.1016/j.asr.2021.09.010

Join BIPM-IERS workshop on Earth rotation modelling (March 13/27, 2025)

→ Gathering experts of Earth rotation mod... ...aluate a probability range for a negative leap second

Each model takes into account o... ...effects (no « gl... model) :

- Global mean sea level...
- Core-mantl...
- C...
- ...
- M...
- At... ...effects
- Cli... ...sses

+ Purely statistical predi...

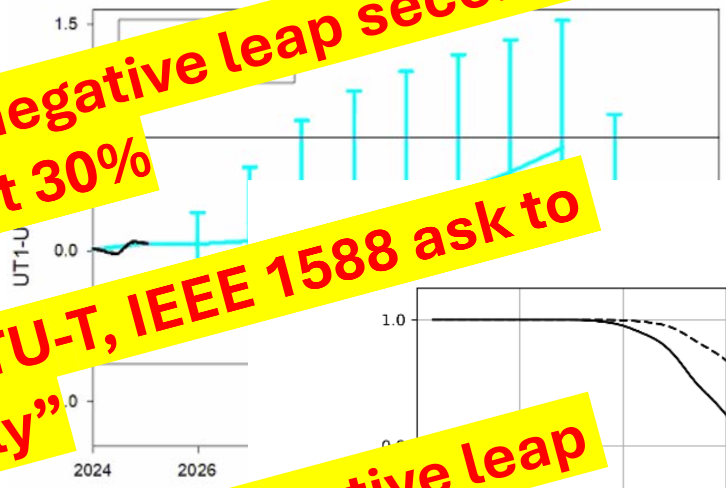
Starting from different expertise and point of view,

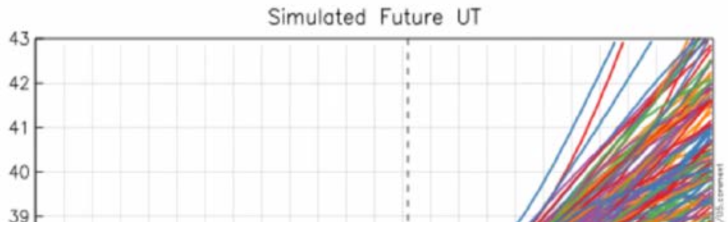
it has been estimated that

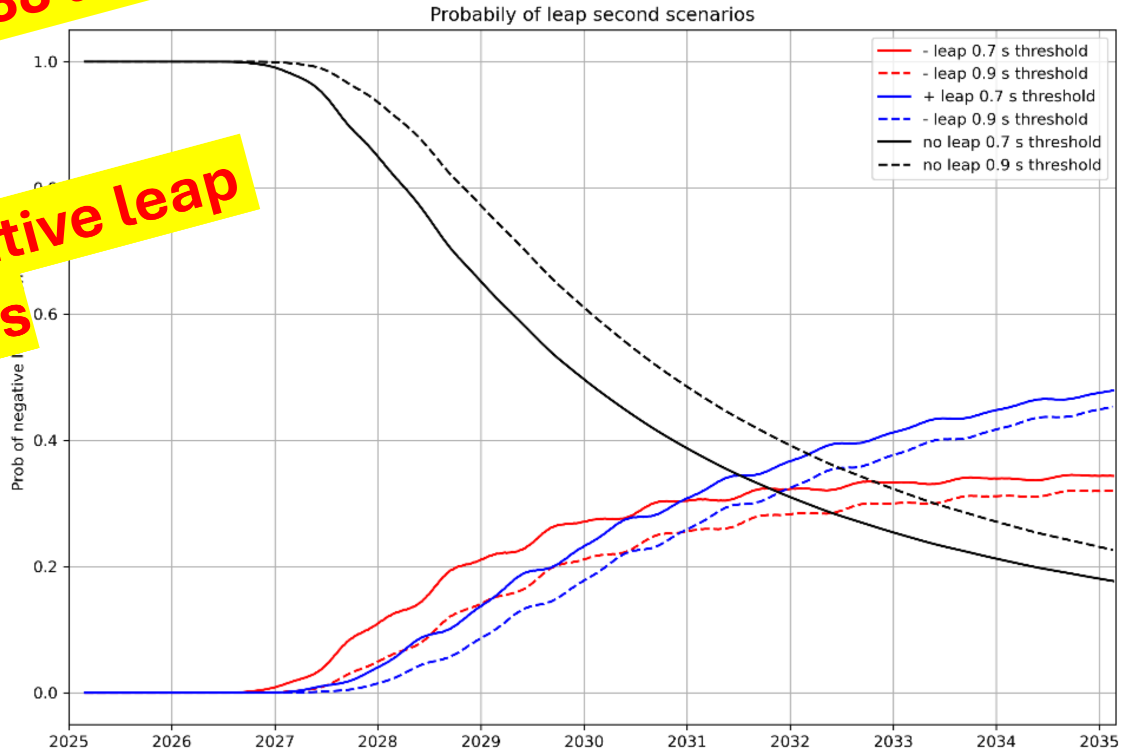
The probability of having a negative leap second in the next 10 years is about 30%

RMOs, industries, IERS, ITU-T, IEEE 1588 ask to change UTC “immediately”

If we want to avoid the risk of a negative leap second 2027 or 2028 are the choices

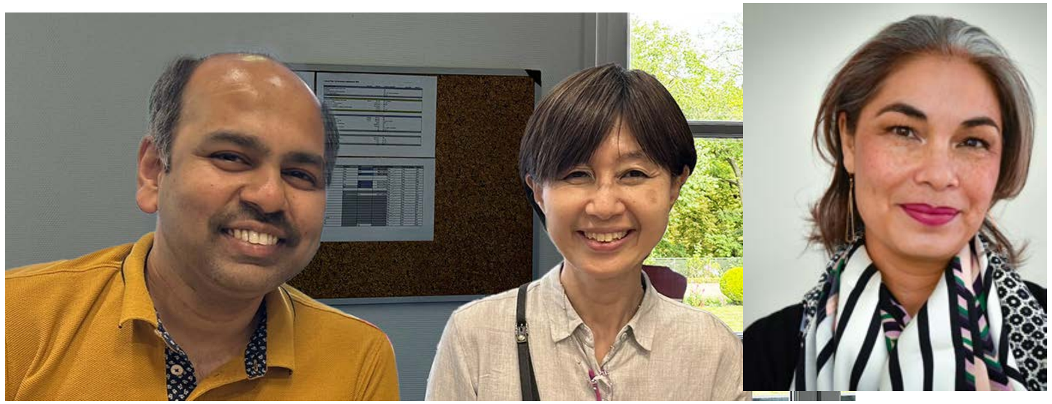






This school is part of the CCTF program

Sharing Resources for Capacity Building to Improve the (Inter) National Timekeeping



The CCTF programs is based on secondees:

- Dr Bharat Vattikonda, from NPL India (October 23 - September 24)
- Dr Yuko Hanado, formerly NICT Japan (in 2019 and April - July 24)
- Dr Tara Fortier, from NIST USA (September 24 - August 25)

→Development of training tools: videos, guidelines, software modules..

→Organizing online or in presence training events, summer schools, Technical Exchanges

CCTF TECHNICAL EXCHANGES ON TIME AND FREQUENCY BEST PRACTICE IN NMIS

These online technical exchange meetings are organized by different Working Groups of CCTF to share b...

VIEW

TIME TRANSFER THROUGH GNSS PSEUDORANGE MEASUREMENTS

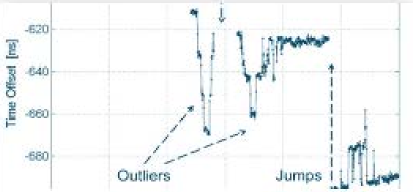
This course aims at providing knowledge and processing capacity to obtain time transfer through GNSS...

VIEW

TIME & FREQUENCY CAPACITY BUILDING BY RESOURCE SHARING

According to the Recommendation CCTF 3 (2022) "On the establishment of a UTC capacity building program...

VIEW



CLOCK DATA CHECKING

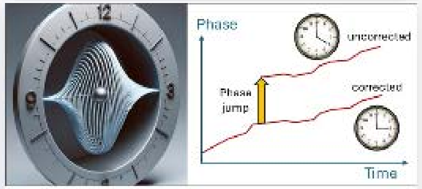
This course aims at providing the knowledge of preliminary inspection of the Clocks Data which is the primary..

VIEW

TIME SCALE ALGORITHMS BASICS TO APPLICATIONS

This course introduces the fundamental process of timescale computation, guiding participants...

VIEW



VALIDATING CLOCK DATA FORMAT WITH BIPM CONVENTION

Course Summary: To contribute to UTC, laboratories must submit continuous clock data reflecting the...

VIEW

Current Time & Frequency Courses on BIPM e-Learning

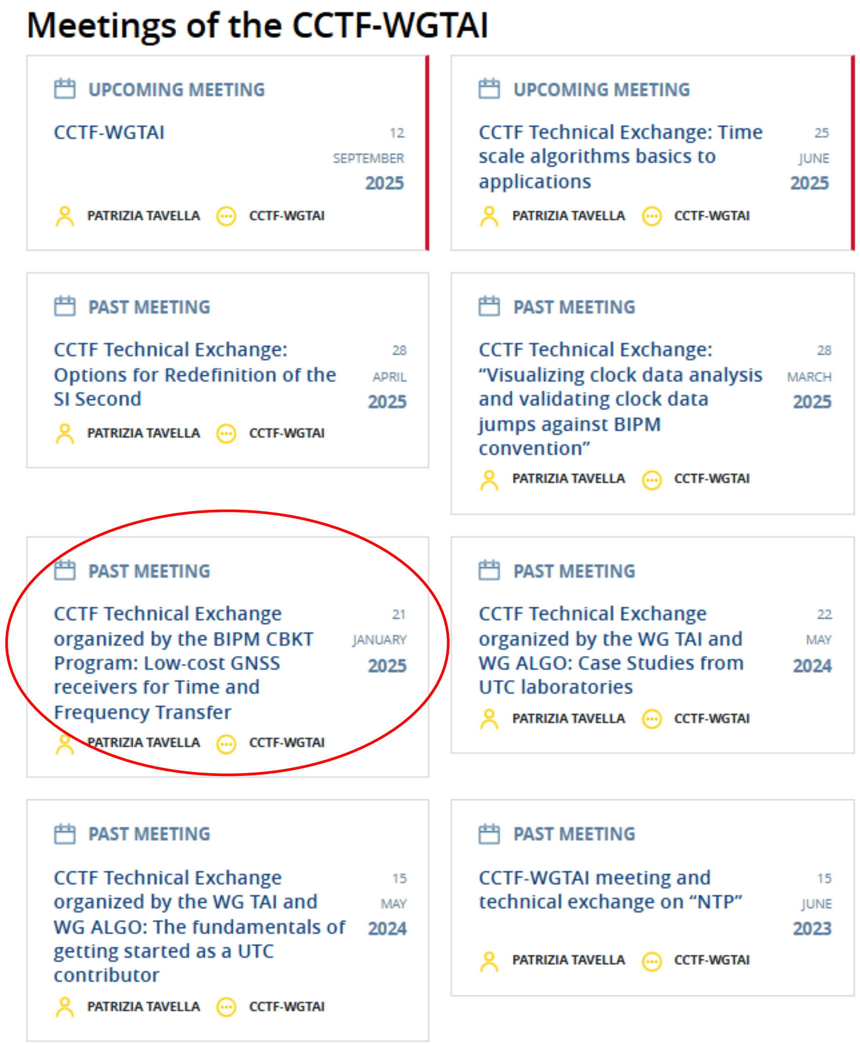
- Time transfer through GNSS Pseudorange measurements
- Clock Data checking
- Time scale Algorithm basics to applications
- Validating clock data format with BIPM Convention
- CCTF Technical Exchanges on time & Frequency best practices
- Time and Frequency capacity building resources

→ **Organizing online or in presence training events, summer schools, Technical Exchanges** https://e-learning.bipm.org/course/view.php?id=82

https://www.bipm.org/en/committees/cc/cctf/wg/cctf-wgtai/meetings

- EURAMET training school in ROA, Spain (Oct. 2024)
- APMP Time Scale Workshop organized in NPLI, India (Nov. 2024)
- BIPM-SIM UTC Summer School in conjunction with the Joint EFTF/IFCS conf. in Queretaro, Mexico May 7-9, 2025
- **BIPM UTC Summer School in conjunction with the 24th meeting of the CCTF at the BIPM, September 2025.**

- **Technical Exchanges:**
  - January 21, 2025: “Low-cost GNSS receivers”
  - March 28, 2025: “Visualizing clock data analysis and validating clock data jumps against BIPM convention”
  - April 28, 2025: “Options for Redefinition of the SI Second”
  - June 25, 2025: “Time scale algorithms basics to applications”
  - July 9, 2025: “GNSS CGGTTS format for remote clock comparisons through pseudorange measurements.”



Thanks for your attention and for your interest
Thanks to UFFC
Thanks to the BIPM time dept, to our Secondees, and to the BIPM Meeting Office

CELEBRATING 150 BIPM 1875 – 2025

UFFC