



19th meeting of the Directors of NMIs and Member States Representatives 25-26 October 2016

« Decision of the WRC (2015) on the leap second »

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Time scales TAI, UTC

Definitions

UT1 (IERS): Universal time
(mean diurnal motion of the sun as observed on the prime meridian) taking into account the polar motion →
astronomers, maritime navigation,..



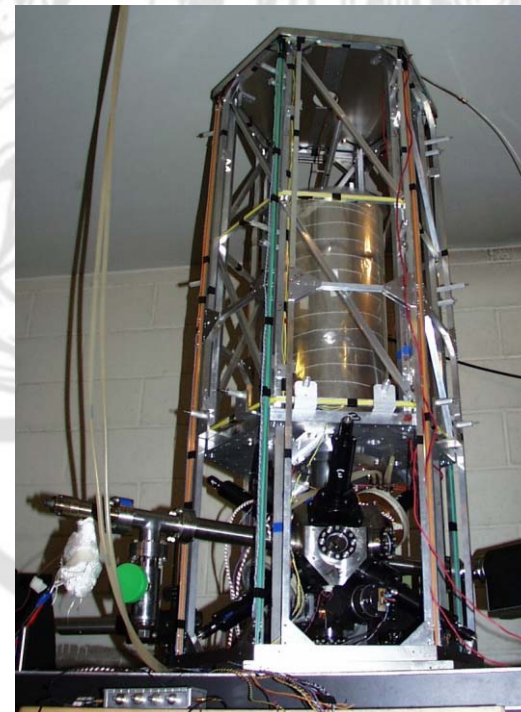
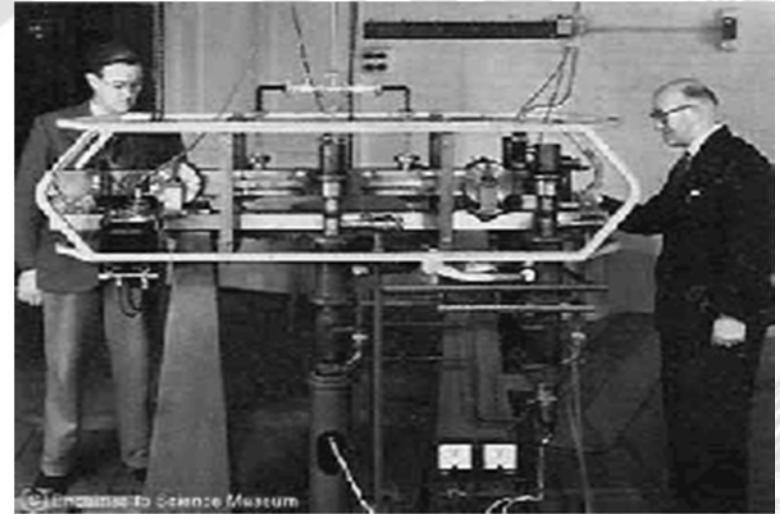
Time scales TAI, UTC

Definitions

International Atomic Time (TAI) is the time reference coordinate established by the Bureau International de l'Heure (now BIPM) on the basis of the readings of atomic clocks operating in various establishments in accordance with the definition of the second, the unit of time of the International System of Units.

TAI is a coordinate time scale defined in a geocentric reference frame with the SI second as realized on the rotating geoid as the scale unit.

→ metrologists, scientists,..



Time scales TAI, UTC

Definitions

◆ UTC (ITU_BIPM_IERS): Time scale corresponding exactly in rate with TAI but differs from it by an integer number of seconds → navigation, telecommunications, citizens, industries,.. (Basis of coordinated dissemination of standard frequency and time signal)

Departure of UTC from UT1 should not exceed ± 0.9 s

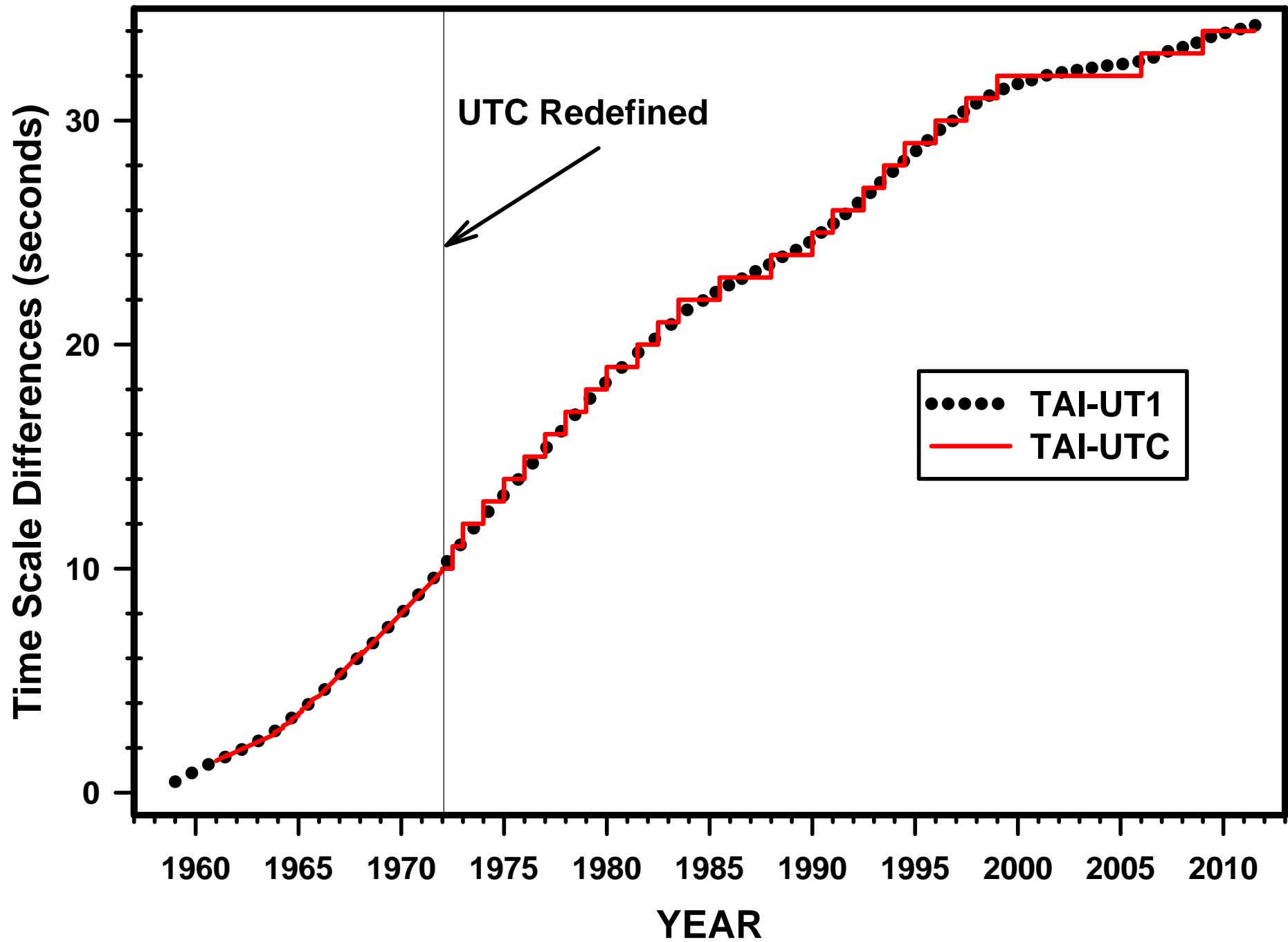
BUREAU INTERNATIONAL DES POIDS ET MESURES

Key comparison CCTF-K001.UTC - Results
Degrees of equivalence $D_k = [UTC - UTC(k)]$ for July 2015
Computed 2015 AUGUST 10, 10h UTC

Coordinated Universal Time UTC and its local realizations UTC(k) in National Metrology Institutes and Designated Institutes.
Computed values of $[UTC - UTC(k)]$ and uncertainties valid for the period of this publication

Date 2015 0h UTC MJD Laboratory <i>k</i>	JUL 1 57204	JUL 6 57209	JUL 11 57214	JUL 16 57219	JUL 21 57224	JUL 26 57229	JUL 31 57234	Uncertainty/ns <i>U_k</i>
	$[UTC - UTC(k)]/ns$							
BelGIM	6.3	5.3	4.9	6.1	7.1	6.5	7.0	14.4
BEV	-28.3	-23.8	-23.0	-17.3	-3.0	12.2	27.3	6.2
BIM	2481.7	2494.3	2506.8	2503.8	2516.5	2525.3	2537.7	14.4
CENAM	1.8	4.5	6.1	8.2	11.2	-1.1	-3.6	11.6
CENAMEP AIP	-	-	-	-57.2	-104.3	-150.6	-90.5	12.4
DEF-NAT	10630.8	10818.7	11016.0	11191.6	11358.9	11547.1	11741.1	40.0
DMDM	-12.1	2.8	7.6	-6.0	-7.4	-6.8	-5.0	14.0
EIM	7.5	18.2	9.3	17.5	5.3	5.7	14.7	18.0
ESA	1.3	3.4	1.1	-1.6	1.0	0.6	-0.5	10.0
FMTC	919.2	913.5	933.7	939.0	918.3	925.3	952.1	10.8
GUM	-29.9	-40.3	-32.6	-24.9	-12.0	-3.8	-3.3	10.0
IMBIH	-185.0	-102.1	-17.8	-20.0	-13.2	-10.2	-1.3	14.2
INM	1054.6	1064.5	1077.3	1082.0	1089.1	1079.1	1069.8	41.0
INMETRO	-24.6	-24.8	-38.1	-34.0	-34.2	-34.1	-32.4	40.0
INPL	36.7	42.2	44.3	37.3	31.4	33.5	42.2	40.0
INRIM	-3.8	-2.9	-2.1	-1.3	-1.7	-1.8	-1.4	2.6
INTI	16.8	36.9	45.5	46.1	58.9	56.4	65.6	40.4
IPE/ASCR	-29.4	-31.7	-30.0	-32.7	-34.7	-	-	10.2
JV	-43.2	-44.3	-47.0	-47.0	-39.2	-22.8	-39.5	41.2
KazInMetr	-811.7	-799.8	-784.2	-778.9	-763.5	-753.6	-750.9	14.4
KEBS	-45.1	-334.5	-612.2	-894.1	-1173.7	-1460.5	-1753.5	40.2
KIM-LIPI	494.8	504.4	526.6	546.6	573.6	584.2	620.6	40.2
KRISS	18.5	20.6	22.0	23.1	23.2	24.2	26.0	10.0
LNE/SYRTE	-1.9	-1.7	-1.8	-1.6	-1.5	-1.7	-1.7	2.6
MASM	-	-	-	-	-	-	-	-
METAS	21.7	20.6	17.2	13.7	10.9	8.8	7.0	2.6

Time scales TAI, UTC



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Summary of the Story/actions

◆ Question ITU-R 236/7 (2000)

1. What are the requirements for globally-accepted time scales for use both in navigation and telecommunications systems, and for civil time-keeping?
2. What are the present and future requirements for the tolerance limit between UTC and UT1?
3. Does the current leap second procedure satisfy user needs, or should an alternative procedure be developed?

◆ WRC-12 decision contained in Resolution 653 which invited further study to be reported on the agenda for its next meeting in 2015

◆ WRC-15 decision contained in resolution 655 which invites (see next slides) to report on the progress of this resolution to WRC- 23

Bureau

◆ **I**nternational des

◆ **P**oids et

◆ **M**esures



Time scales TAI, UTC

Resolves to invite the ITU Radiocommunication sector

- To strengthen the cooperation between ITU-R and **BIPM, the International Committee for Weights and Measures (CIPM), CGPM**, as well as other relevant organizations, and to carry out a dialogue concerning the expertise of each organization;
- To further and more widely study in cooperation with the relevant international organizations, concerned industries and user groups, through the participation of membership, the various aspects of current and potential future reference time scales, introducing their impacts and applications;
- To provide advice on the content and structure of time signals to be disseminated by radiocommunication systems, using the combined expertise of the relevant organizations;
- To prepare one or more reports containing the results of studies that should include one or more proposals to determine the reference time scale and address other issues mentioned in 1,2 and 3 above,

Time scales TAI, UTC

Instructs the Director of the Radiocommunication Bureau

- To invite the relevant international organizations such as the International Maritime Organization (IMO), the International Aviation Organization (ICAO), **CGPM, CIPM, BIPM**, the International Earth Rotation and Reference System Service (IERS), the International Union of Geodesy and Geophysics (IUGG), the International Union of Radio Science (URSI), the International Organization for Standardization (ISO), the World Meteorological Organization (WMO) and the International Astronomical Organization (IAU) to participate in the work mentioned in *Resolves to invite the ITU Radiocommunication sector*

Time scales TAI, UTC

Terms of Reference of the Task Group:

- a) To make a review of the present status
- b) To elaborate definitions of TAI, UTC
- c) To propose appropriate recommendations for consideration by the CCTF in June 2017, afterwards by the CIPM, and finally by the CGPM in 2018
- d) To propose the definition of the time scale to be adopted as a reference for metrological applications after WRC-23

Time scales TAI, UTC 2016 → → → 2018

◆ BIPM actions

– CCTF

- ◆ CCTF WG TAI (early 2016): establishment of the Task Group on Time Scales Definition (TGTSD): 28 September 2016
- ◆ TGTSD
 - June 2016 - January 2017: discussion and preparation of texts of recommendations
 - February – March 2017: final versions agreed within TG, circulation to WG TAI
 - May 2017: Final versions to be submitted to the 21st meeting of the CCTF (June)
- ◆ 21st Meeting of the CCTF_8-9 June 2017: discussion and approval of recommendations to be submitted to the CIPM for its session in October-November 2017.

– CIPM

- ◆ October 2017: Discussion and (possible adoption) of recommendations from CCTF. CIPM will decide on the submission to the CGPM (November 2018) of these recommendations as Draft Resolutions.

Time scales TAI, UTC 2018 → → → 2022

◆ BIPM actions (cont.)

– CGPM (November 2018)

- ◆ Approval (possible) of resolutions on time scales definition, and (possible) resolution on the time scale to be adopted as reference for metrology after the revocation of Res. ITU-R TF. 460-6

– BIPM (2019-2022)

- ◆ dissemination of information on the post-2023 reference time scale for metrology
- ◆ Coordination with the different communities of users, some education necessary – Interaction with the different international unions
- ◆ Coordination with the ITU-R on the provision of the reference time scale for radio/telecommunications (via WP7A, SG7, CCTF, CIPM), in preparation for WRC-23

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Thank you for your attention

Questions?

Issues

Why?

- ◆ Frequency of leap seconds will increase
 - Increasing public annoyance
- ◆ Software issues
 - Unpredictable: can't be programmed in advance
 - Dealing with days of 86,401 seconds
 - Time-stamping 23h 59m 60s
- ◆ Communications problems
 - coordination of events during a leap second
- ◆ Growth of time scales
- ◆ Expensive to implement



23:59:60

Concerns

- ◆ Navigation
 - 1 second ~ 2/5 kilometer at the equator
- ◆ Legacy computer software
 - Assumption that UT1=UTC near enough?
- ◆ Legal definitions
 - Mean solar time?