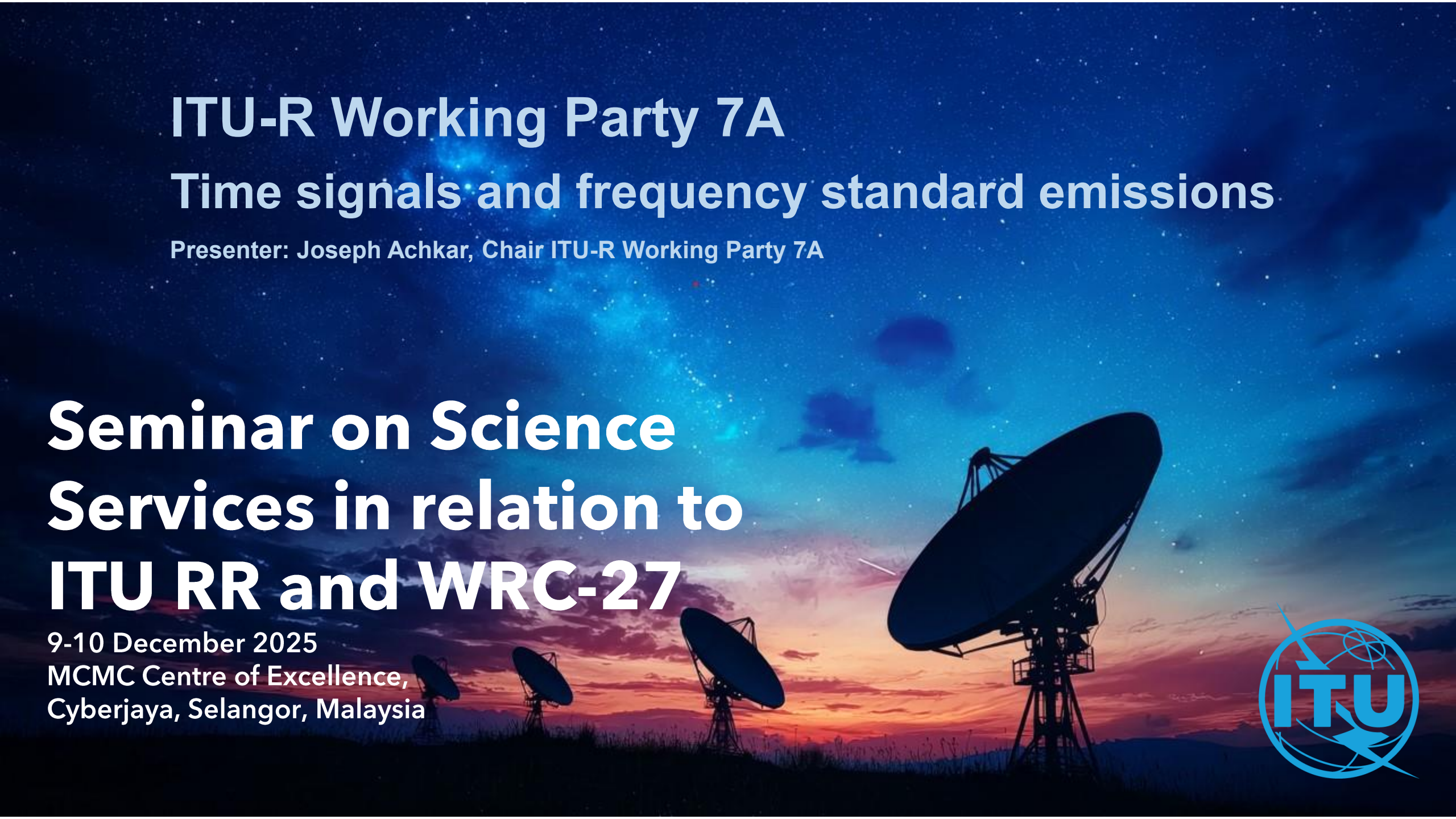
ITU-R Working Party 7A

Time signals and frequency standard emissions

Presenter: Joseph Achkar, Chair ITU-R Working Party 7A

Seminar on Science Services in relation to ITU RR and WRC-27

9-10 December 2025
MCMC Centre of Excellence,
Cyberjaya, Selangor, Malaysia



Scope

- Working Party 7A covers standard frequency and time signal services, both terrestrial and satellite. Its scope includes the dissemination, reception and exchange of standard frequency and time signals and coordination of these services, including the application of satellite techniques on a worldwide basis.

- The goals of WP 7A activities are to develop and maintain ITU-R Recommendations and Reports in the TF Series and Handbooks relevant to standard-frequency and time-signal (SFTS) activities, covering the fundamentals of the SFTS generation, measurements and data processing.

- ITU-R Recommendations are of paramount importance to telecommunication administrations and industry, radionavigation, electric power generation, space technology, scientific, metrological and meteorological activities.

Scope

ITU-R Recommendations cover the following topics:

- Terrestrial SFTS transmissions (including HF, VHF, UHF broadcasts), television broadcasts, microwave link, **coaxial and optical cables**;

- Space-based SFTS transmissions (including navigation satellites) and communication satellites and meteorological satellites;

- Time and frequency technology - including frequency standards and clocks -, measurement systems, performance characterization of oscillators and clocks, time scales and time codes.

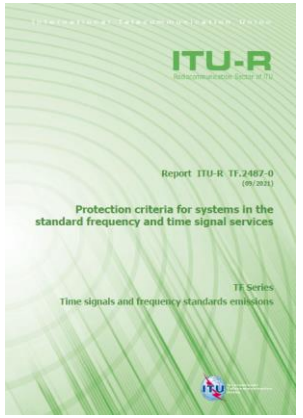
ITU-R Recommendations

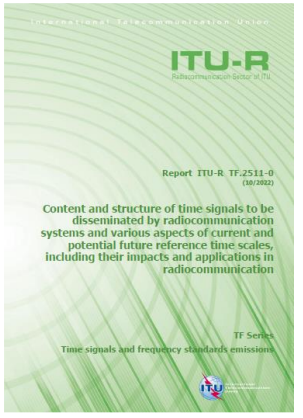
WP 7A has produced **14** recommendations (RA) in the TF series (in force), including:

- Recommendation TF.374-6 (2014) - Precise frequency and time-signal transmissions
  ➔ Frequency assignments for SFTS transmissions
- Recommendation TF.460-6 (2002) - Standard-frequency and time-signal emissions
  ➔ incorporated by reference in the RR. This recommendation, describing the process of inserting leap seconds in UTC and the code format for the transmission of DUT1 (predicted difference UT1 - UTC), has been at the centre of discussions for 25 years+.
- Recommendation TF.583-6 (2003) – Time codes
- Recommendation TF.768-7 (2011) – Standard frequencies and time signals
- Recommendation TF.1153-4 (2015) – The operational use of two-way satellite time and frequency transfer employing pseudorandom noise codes ➔ used in the international clocks comparison network for UTC computation (along with other techniques)

Supplements (last updated in 2022) published on the SG 7 website

ITU-R Reports

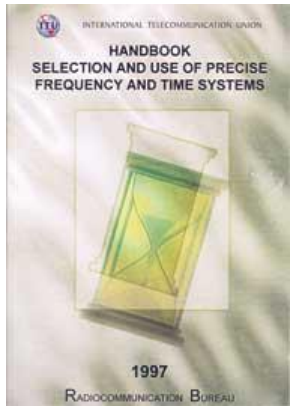


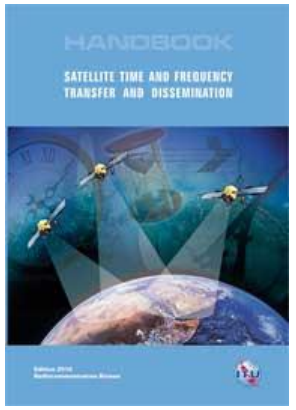


WP 7A has produced **2** reports (SG 7):

- Report TF.2487 (2021) - Protection criteria for systems in the standard frequency and time signal services. The systems affected are those operating at 4 996 kHz in Russia; 9 996 kHz in Russia; 14 996 kHz in Russia; 20 kHz globally; 40 kHz in Japan; 50 kHz in Russia; 60 kHz in the United Kingdom, the United States, and Japan; 66.6 kHz in Russia; 68.5 kHz in China; 77.5 kHz in Germany; 100 kHz in China; and 162 kHz in France.
  ➔ The aim of this Report is to provide protection criteria for SFTS systems.
  This information should be used for studies regarding the sharing/compatibility with other services and systems (e.g. non-beam WPT systems)
- Report TF.2511 (2022) - Content and structure of time signals to be disseminated by radiocommunication systems and various aspects of current and potential future reference time scales, including their impacts and applications in radiocommunication ➔ This report was developed to address information regarding time signals to be disseminated, in response to "***resolves*** *to invite the ITU Radiocommunication Sector"* **4 of Resolution 655 (WRC-15)**

ITU-R Handbooks





WP 7A has developed **2** handbooks (BR):

- HDB.31 (1997) - Selection and Use of Precise Frequency and Time Systems (Currently being updated)

user guide

active | archived

Group	Title	Chair / Rapporteur	ToR	Subscribe/ unsubscribe	Share	Mailing list	Conversation history
ACTIVE SUBSCRIPTIONS							
ITU-R > Study Groups > SG 7 > **WP 7A**	Correspondence Group on Revision and update of Selection and use of precise frequency and time systems Handbook	Co-Chairs : Elisa F. Arias and Andreas Bauch felicitas.arias@obspm.fr; andreas.bauch@ptb.de				rwp7a-cg-hb-supfts@lists.itu.int	

- HDB.55 (2010) - Satellite Time and Frequency Transfer and Dissemination

ITU-R Questions, Resolutions and Opinions

WP 7A has also drafted the following documents (RA, SG 7):

- **10** Questions (RA), under consideration to date

- **1** Resolution ITU-R 28-2 (RA, 2012) - Standard-frequency and time-signal emissions (first drafted in 1963 (CCIR), then revised six times) ➔ refers to provisions of Article 26 of the RR

- **2** Opinions:
  - Op. ITU-R 71-2 (RA, 1993) - Documentation of time transmissions ➔ refers to Res. ITU-R 28 and UTC
  - Op. ITU-R 99-1 (SG 7, 2017) - Time scale based on pulsar timing

The Radio Regulations 2024 and UTC

- ✓ Vol.1 - Articles (Chapter I - Articles **1.14**, 2.5 and 2.6; Chapter VI – Article **26** SFTS service)
- ✓ Vol.2 - Appendices (4, 9, 10 and 25)
- ✓ Vol.3 - Resolutions and Recommendations [Resolution **655** (REV.WRC-23) - Definition of time scale and dissemination of time signals via radiocommunication systems]
- ✓ Vol.4 - ITU-R Recommendations incorporated by reference (Rec. ITU-R TF.**460-6** Standard-frequency and time-signal emissions)

Allocated frequencies to SFTS and SFTSS services

SFTS service						
Allocated frequencies by WRCs						
19,95	20,05	kHz				
2 495,00	2 505,00	kHz	2 498,00	2 502,00	kHz	Region 1
4 995,00	5 005,00	kHz				
9 995,00	10 005,00	kHz				
14 990,00	15 010,00	kHz				
19 990,00	20 010,00	kHz				
24 990,00	25 010,00	kHz				

SFTS service			
Frequencies used, designated by other conferences (see No. 5.56 of the RR)			
14,00	19,95	kHz	
20,05	70,00	kHz	
72,00	84,00	kHz	Region 1
86,00	90,00	kHz	Region 1

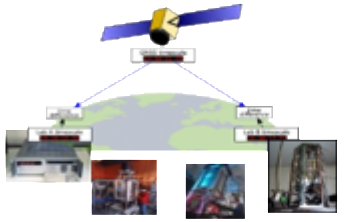
SFTSS service			
Allocated frequencies			
400,05	400,15	MHz	
4 200,00	4 204,00	MHz	space-to-Earth
6 425,00	6 429,00	MHz	Earth-to-space
13,40	14,00	GHz	Earth-to-space
20,20	21,20	GHz	space-to-Earth
25,25	27,00	GHz	Earth-to-space
30,00	31,30	GHz	space-to-Earth

SFTS from signals from other services

SFTS from signals from other services				
100,00		kHz	Radionavigation service	Loran-C
162,00		kHz	Broadcasting service	ALS162
1 164,00	1 300,00	MHz	Radionavigation-satellite service	GPS/GLONASS/Galileo/Beidou
1 559,00	1 610,00	MHz	Radionavigation-satellite service	GPS/GLONASS/Galileo/Beidou
4,00	8,00	GHz	Fixed-satellite service	TWSTFT
10,70	14.50	GHz	Fixed-satellite service	TWSTFT

The future of the UTC time scale

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 (IERS)

leap seconds

UTC → **Coordinated Universal Time**

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

The future of the UTC time scale

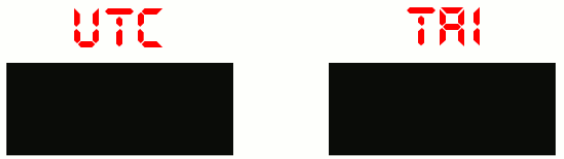
UTC in agreement with UT1

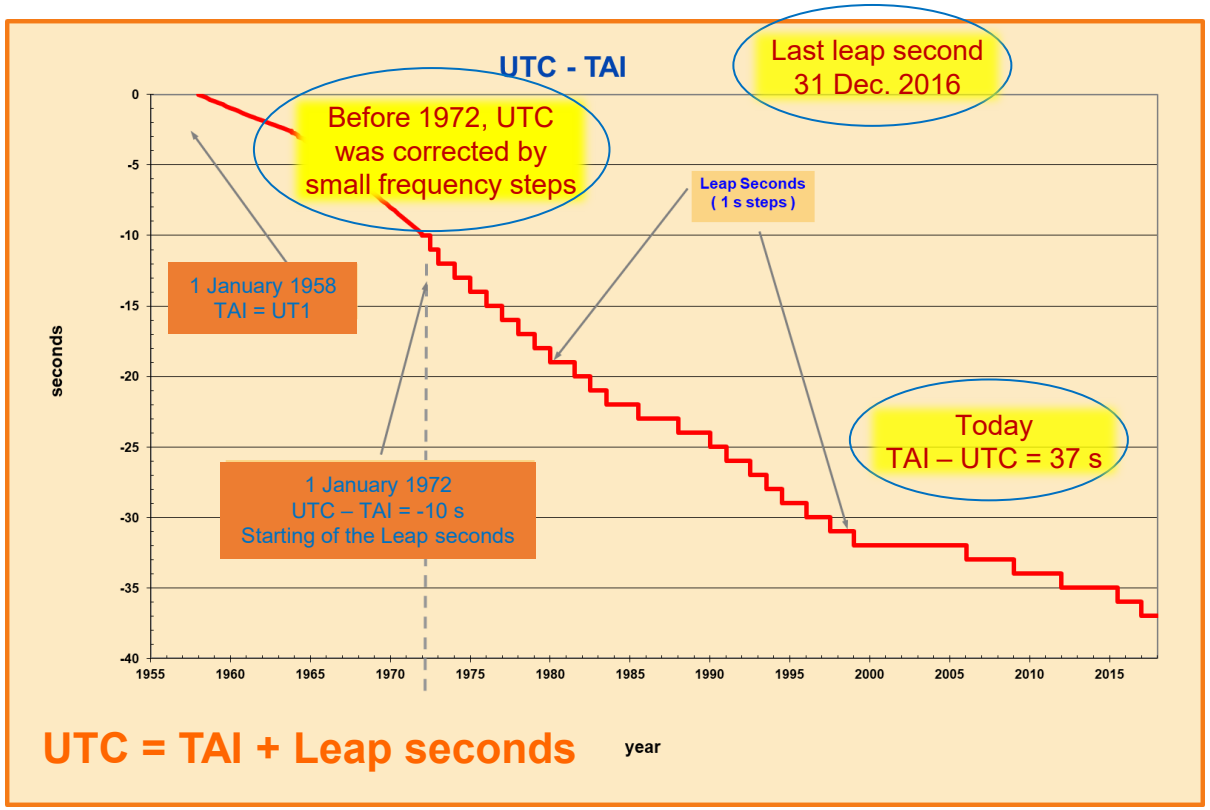
- Timekeeping is related to the rotation of the Earth.
- The real time timekeeping is based on atomic clocks and, since 1972, UTC is obtained from the TAI plus leap seconds.
- When the difference between the Earth rotational angle UT1 and UTC reaches 0.8 s, an integer second is inserted to UTC to keep it within 0.9 s of UT1.

|UTC - UT1| < 0.9 second
UTC = TAI + n seconds

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

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



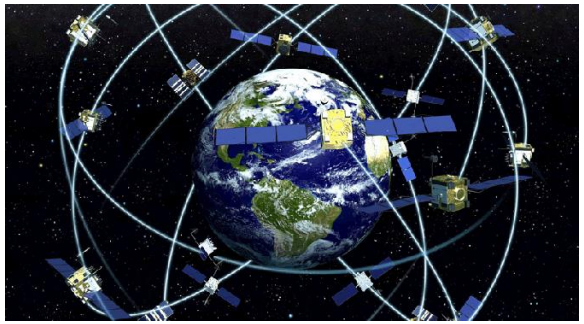


The future of the UTC time scale

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.

Based on **Rep. ITU-R TF.2511**



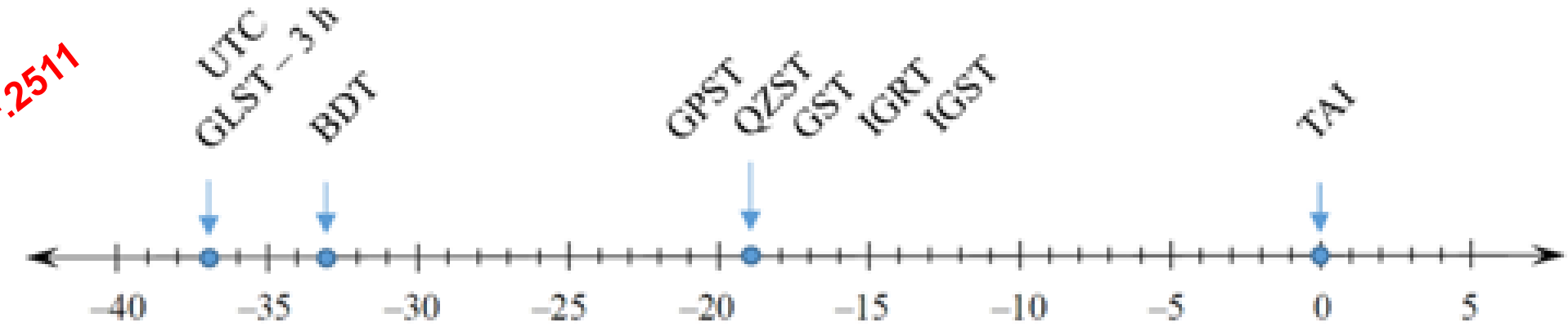
The future of the UTC time scale

Leap seconds in GNSS (GPS, GLONASS, Beidou, Galileo) times

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.

Relationship between time scales as at the mid 2023; offsets are owed almost entirely to leap seconds. GLST is put to UTC(SU) + 3 hours to align the GLONASS system time with local Moscow

Rep. ITU-R TF.2511



The future of the UTC time scale

The digital networks cannot cope with unpredictable leap seconds
Several “ad 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**
  - NTP, Portable Operating System Interface POSIX time incl. Unix, Linux, MacOS
  - 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 »

Based on **Rep. ITU-R TF.2511**

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.

The future of the UTC time scale

ITU and BIPM working together

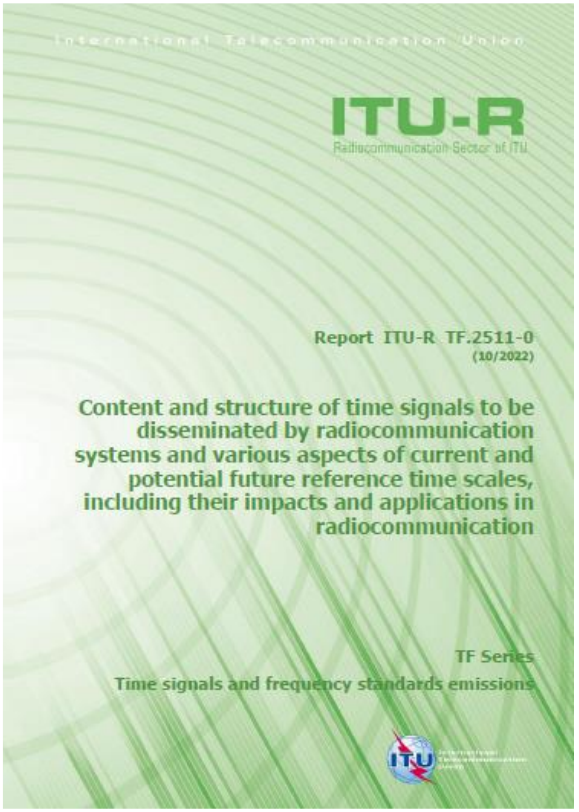
- MoU signed between BIPM and ITU (2020)
- Special session with the BIPM on Resolution 655 (WRC-15), Nov. 2022

- ITU News Magazine on UTC, No. 2, April 2023 itu/publication/s-gen-news-2023-2/
- BIPM hosted the June 2023 meeting of ITU-R WP 7A

Resolution 655 (WRC-15) - Report ITU-R TF.2511

Advantages and disadvantages of using the current UTC - Impact on:

- RNSS, MSS, FSS and BSS
- Mobile service, Radio astronomy service
- Maritime mobile service, incl. Global Maritime Distress and Safety Service (GMDSS)
- Aeronautical mobile service and Radiodetermination service
- Maritime navigation, Astronomy, Geodesy
- Radio Sciences, Time metrology and traceability
- IT and Industry 4.0, Digital systems, time-stamping service
- Financial services, Continuous international reference for time on the IERS and EOP users, other applications.



Most user groups would like to see the stop of leap seconds (positive or negative) as soon as possible

Resolution 655 (REV.WRC-23)

Key outcomes of WRC-23 on UTC issue

- ✓ **E**ndorsement of the decision by the BIPM to adopt continuous UTC as the time reference
- ✓ **I**TU-R to cooperate further with the BIPM, to define a new maximum value for UT1 – UTC and on the implementation date, in a Draft resolution to be adopted by the CGPM in 2026
- ✓ **R**evision of Resolution **655** (**WRC-15**) on Definition of time scale and dissemination of time signals via radiocommunication systems, paving the way to update Recommendation ITU-R **TF.460-6**

Result of consensus reached

Resolution 655 (REV.WRC-23)

The World Radiocommunication Conference (Dubai, 2023),

realizing

that, in BIPM, a Task Group has been created to prepare a draft resolution for CGPM in 2026 related to the new maximum value of the difference between UT1 and UTC, and, in the spirit of close collaboration with ITU, the ITU-R group in charge of the subject has been invited to participate in this Task Group,

Resolution 655 (REV.WRC-23)

The World Radiocommunication Conference (Dubai, 2023),

recognizing

…

g) that, in Resolution 4 on the use and future development of UTC, the 27th meeting of the CGPM (2022) decided that the maximum value for the difference allowed between UT1 and UTC will be increased in, or before, 2035;

…

k) that the maximum value for the difference between UT1 and UTC should be **no less than 100 seconds**, taking into account the constraints of the technological systems expected to be used to disseminate this value,

…

Based on **Rep. ITU-R TF.2511**

resolves

1 that, until the implementation of continuous UTC (see *recognizing g)*), UTC as described in Recommendation ITU-R TF.460-6 shall continue to apply; ../..

Resolution 655 (REV.WRC-23)

The World Radiocommunication Conference (Dubai, 2023),

resolves

Based on **Rep. ITU-R TF.2511**

../..

2 that ITU-R cooperate further with BIPM, CIPM and CGPM in response to the consultation in *realizing*, to define a new maximum value for the difference between UT1 and UTC and on the implementation date for continuous UTC, possibly in 2035;

3 that ITU-R conduct studies, as appropriate, related to actions consequential upon *resolves* 1 and 2 to provide new and revised ITU-R Reports and Recommendations, such as, but not limited to, **a revision to Recommendation ITU-R TF.460-6**;

Input from **CGPM 2026**

4 to establish a transition period for implementation and allow for the possibility to **disseminate the increased difference between UT1 and UTC** via radiocommunication system until 2035, but no later than 2040, in cases where existing equipment cannot be replaced earlier;

5 to maintain the name "UTC" as contained in Recommendation ITU-R TF.460-6 when it is revised,

Draft

Adopt new process could accelerate very early implementation

Resolution 655 (REV.WRC-23) - Progress

Radiocommunication Study Groups

Source: Document 7A/TEMP/11

Subject: Question ITU-R 236-3/7,
Resolution **655 (Rev.WRC-23)**

Annex 2 to
Document 7A/51-E
24 March 2025
English only

Annex 2 to Working Party 7A Chair's Report

WORKING DOCUMENT TOWARDS A DRAFT REVISION OF RECOMMENDATION ITU-R TF.460-6*

Standard- frequency and time- signal emissions

(Question ITU-R ~~102~~236-3/7)

(1970-1974-1978-1982-1986-1997-2002-20XX)

Resolution 655 (REV.WRC-23) - Progress

BR

➔ Bring this Resolution to the attention of IMO, ICAO, CGPM, CCTF, CIPM, BIPM, IERS, IUGG, URSI, ISO, WMO, IAU, IEEE and IETF

WP 7A

➔ Cooperate further with BIPM, CIPM and CGPM to define a new maximum value for the difference between UT1 and UTC and on the implementation date for continuous UTC

WP 7A

➔ WD Draft Revision of Recommendation ITU-R TF.460-6 - Standard frequency and time signal emissions (*but not limited to*)

➔ WDP Draft New Report ITU-R TF.[UTC_DISSEMINATION] - Content and structure of time signals to be disseminated by radiocom systems, including wired technologies

➔ NOTE to be prepared and sent to the BR

BR Director

➔ Report on the progress of this Resolution to WRC-27

Resolution 655 (REV.WRC-23) - Progress

TG met 1, 2 or 3 times a year (2023, 2024, 2025, …)

CCTF Working Groups

Solution to progress towards a continuous UTC

- ✓ **Increase the tolerance in |UT1 - UTC| to a new limit** (e.g. 100 s reached after 1 century or **1 h** reached after 5000 years)
- ✓ **UTC remains linked to UT1.** UT1 can be regarded as a time determined by the rotation of the Earth.
- ✓ **Users needing the knowledge of UT1 - UTC** find accurate and real time estimations by the services of IERS, NASA, GNSS, ITU-R broadcast signals

CCTF Task Group "Towards continuous UTC" (CCTF-TGUTC)

Co-Chairs

Dr Tetsuya Ido
Senior Researcher
Applied Electromagnetic Research Institute, Space-Time Laboratory
National Institute of Information and Communications Technology
Japan

Dr Patrizia Tavella
Bureau international des poids et mesures
France

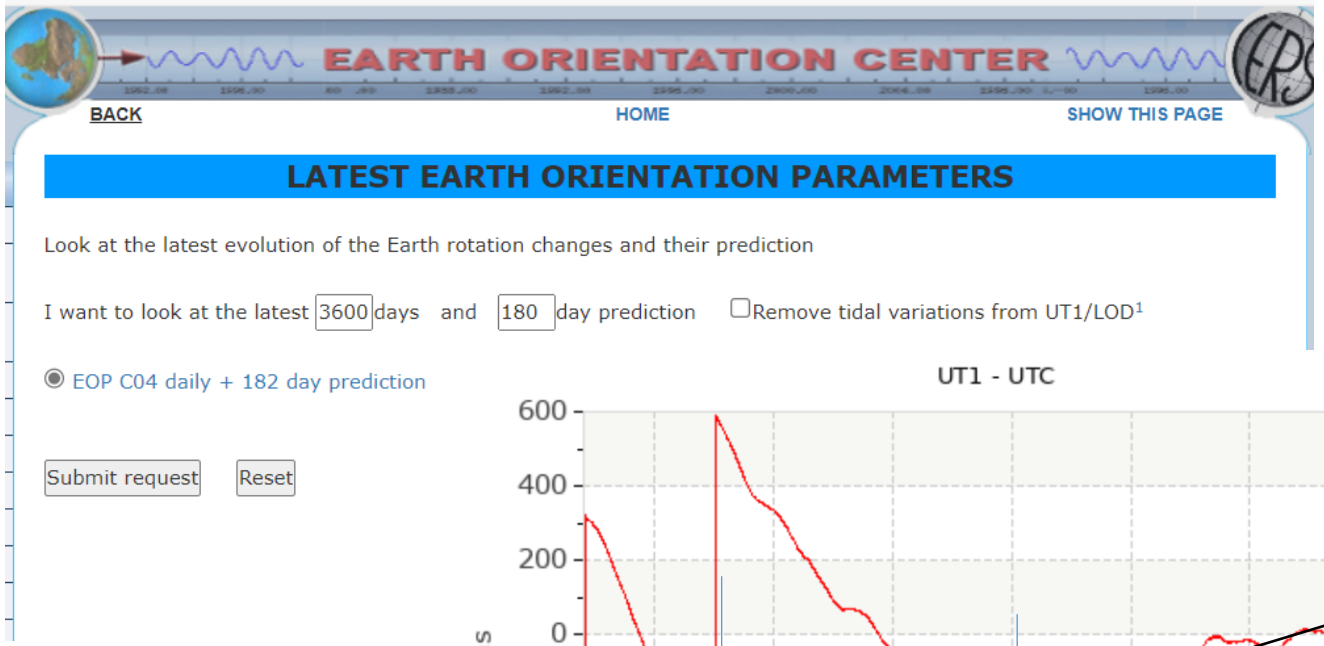
ALL MEMBERS

Membership

- UTC colleagues also involved in the ITU WP7A
- UTC colleague with a relationship with GNSS providers
- RMO TCTF Chairs
- CCTF Liaison representatives: IAU, IGS, IUGG, URSI, ITU
- Experts invited by the Chairs

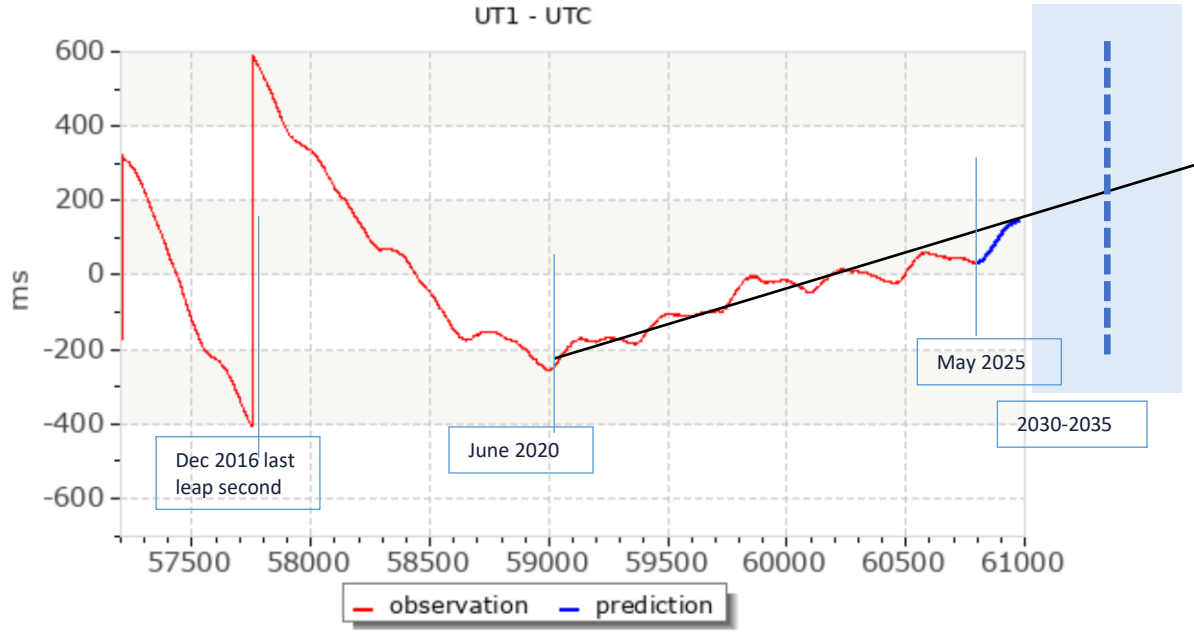
Compliant with **Rep. ITU-R TF.2511**

Resolution 655 (REV.WRC-23) - Progress



CCTF Working Groups

CCTF Task Group "Towards continuous UTC" (CCTF-TGUTC)



≈ 200 ms/3 years

Reaching 600 ms in 10 years?

Possibility for the first negative leap second?

Resolution 655 (REV.WRC-23) - Progress

DRAFT

Approved by CCTF-25

That the CGPM 2026

decides that

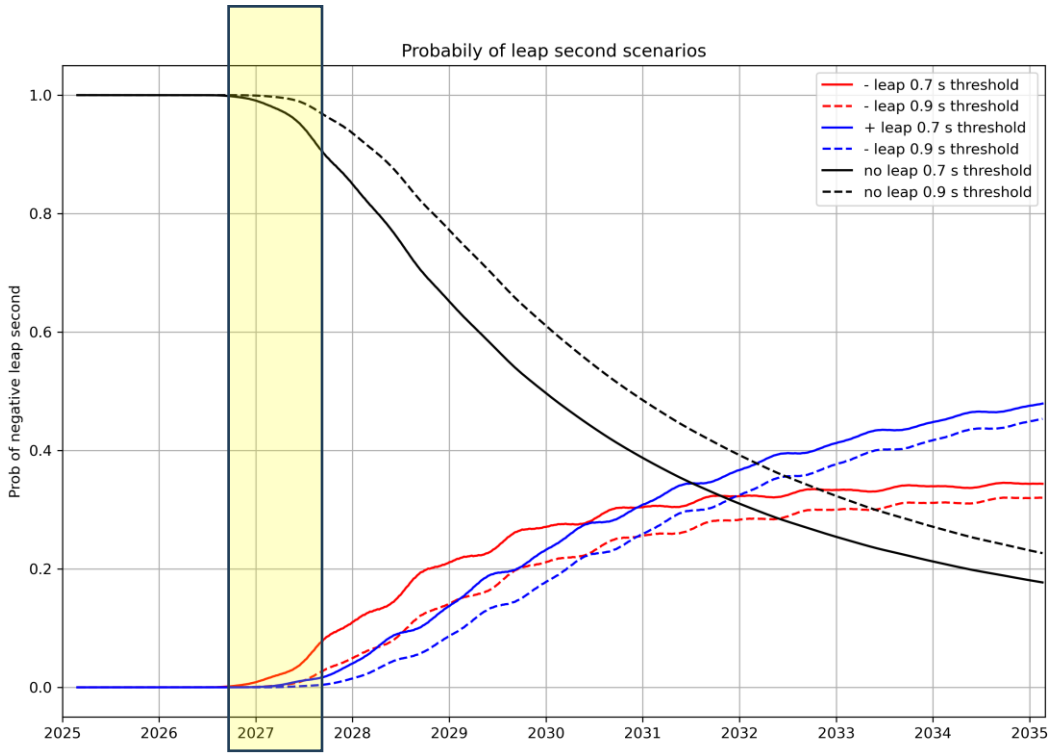
- continuous UTC will become effective on **20 May 2027** (**or 2028** to be decided in January 2026)
- the maximum value for the difference |UT1-UTC| will be **3600 seconds** (1 hour), ensuring the long term continuity for UTC for several centuries

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 %

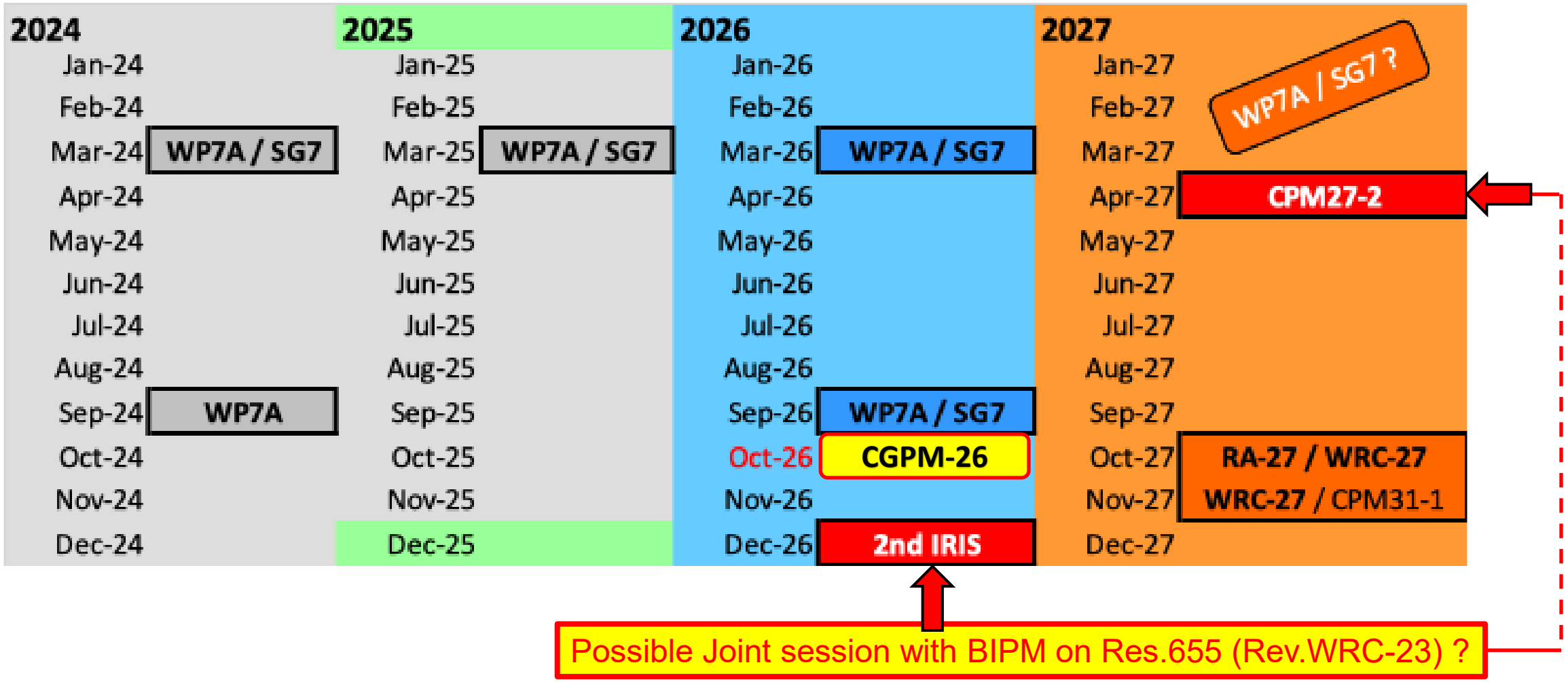
To avoid the risk of a negative leap second, 2027 or 2028 are the choices

CCTF Working Groups

CCTF Task Group "Towards continuous UTC" (CCTF-TGUTC)



Resolution 655 (REV.WRC-23) – draft timetable



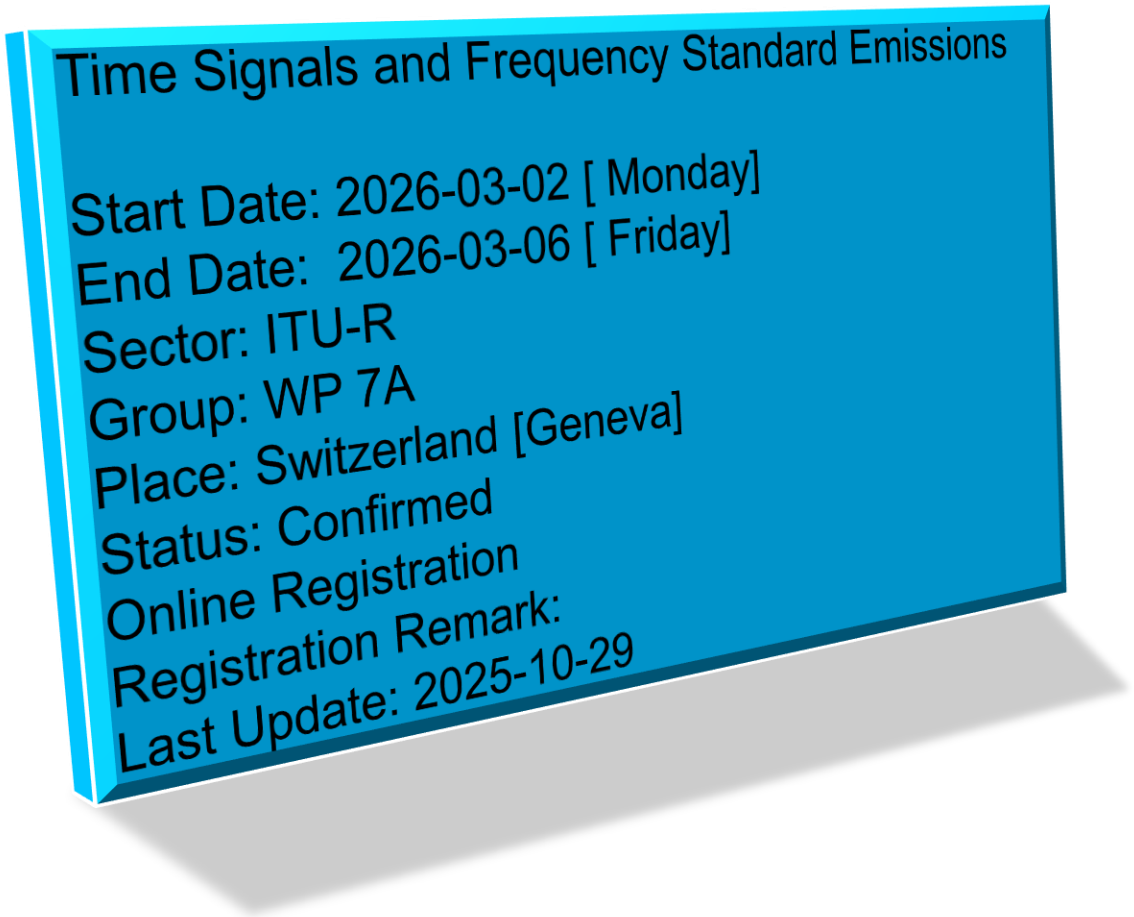
WRC-27 Agenda Item preparations with WP 7A contributing

- **1.2** Possible revisions of sharing conditions in the band **13.75-14 GHz** to allow the use of uplink fixed-satellite service earth stations with smaller antenna sizes [Resolution 129 (WRC-23)] ➔ RLS sent to WP 4A (Document 4A/160, Sept. 2024) referring to SFTSS service, specifically to Rec. ITU-R TF.1153 for clocks comparisons as part of UTC computation

- **1.9** Appropriate regulatory actions to update **Appendix 26** to the **R**adio **R**egulations in support of aeronautical mobile (OR) high frequency modernization [Resolution 411 (WRC-23)] ➔ RLS sent to WP 5B (Document 5B/131, Sept. 2024) referring to 14 990-15 010 kHz allocated to the SFTS service

- **1.15** Possible new or modified space research service (space-to-space) **allocations**, for future development of communications **on the lunar surface** and **between lunar orbit and the lunar surface** [Resolution 680 (WRC-23)] ➔ RLS sent to WP 7B (Document 7B/95, Sept. 2024) referring to 400.05-400.15 MHz and 25.25-27 GHz allocated to the SFTSS service

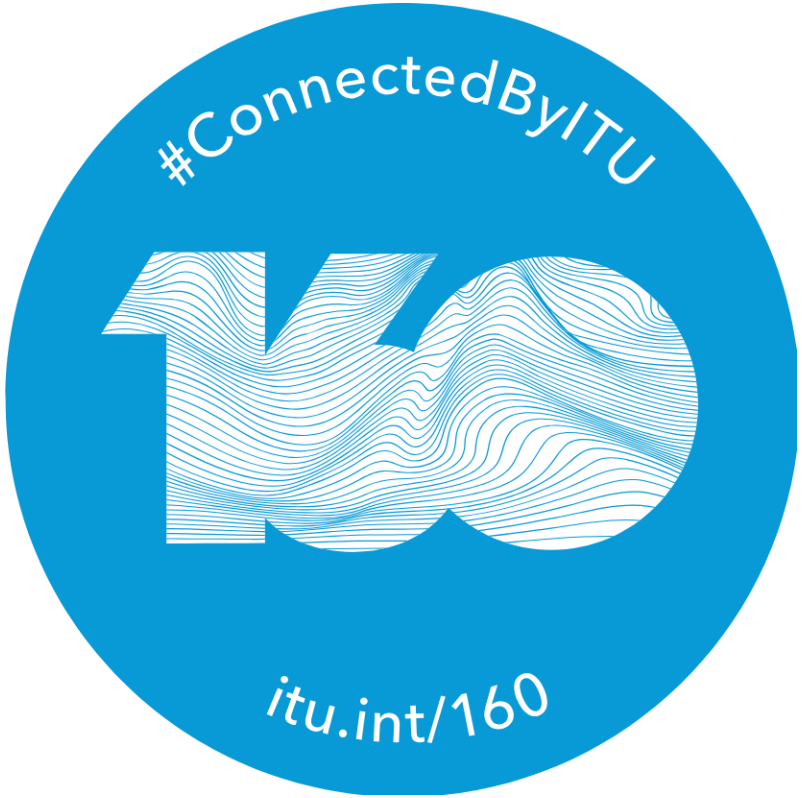
Radiocommunication Study Groups



ITU membership are requested to submit contributions by electronic mail to:
rsg7@itu.int

with copy to
joseph.achkar@observatoiredeparis.psl.eu
vadim.nozdrin@itu.int

Radiocommunication Study Groups



Thank you!