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TIME METROLOGY STANDARDS

STANDARDS POUR LA MÉTROLOGIE DU TEMPS

DIVISION A / FUNCTIONAL WORKING GROUP TIME METROLOGY STANDARDS (TMS)

STANDARDS POUR LA MÉTROLOGIE DU TEMPS

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TRIENNIAL REPORT 2021-2024

1. Introduction

The Working Group on Time Metrology Standards (WG TMS) is a functional working group of Division A established to maintain interaction between the astronomical and the time and frequency metrology communities.

The definitions of the unit of time and of the reference time scale are the responsibility of the General Conference on Weights and Measures (CGPM); the realization and maintenance of the international time scale Coordinated Universal Time (UTC) is the responsibility of the International Bureau of Weights and Measures (BIPM), in close coordination with institutes that maintain and disseminate physical realizations of UTC, denoted by UTC(k) and with assistance from the International Earth Rotation and Reference Systems Service (IERS). The unit interval of UTC is by definition the SI second; the realization of UTC is based on the combination of data of atomic clocks operated in institutes located all around the world.

One natural time reference for astronomy is UT1, which is derived from the rotation

of the Earth and includes some of its non-uniformities. The difference between UT1 and UTC is computed and disseminated by the IERS. Since 1972 the difference between UT1 and UTC has been artificially maintained smaller than 0.9 s by applying a procedure described in the Resolution ITU-R TF. 460-6, known as the leap second insertion in UTC. In consequence, users have real-time access to UT1 through the value of UTC with about 1 second precision. Applications requiring precise UT1 should use the values of UT1 UTC predicted and disseminated by the IERS.

Other time references exist for some applications; they are not intended for extensive use, but only for the purposes of a system. This is the case for the atomic time scales realized by the global navigation satellite systems (GNSS). They are close to UTC by construction, in some cases with an offset due to leap seconds, but they are not necessarily formally traceable to it.

Several space agencies have started the implementation of new projects on the Moon. They involve lunar exploration and the operation of satellites or satellite systems around the Moon. The scientific community has started work on the establishment of proposals for time and space lunar references. In particular the WG on Time Metrology Standards is participating in discussions on the realization of a time reference for the Moon.

The activities of this WG during the triennium 2021-2024 have been related to:
- The actions towards a continuous UTC; - The actions towards a redefinition of the SI second; - The discussions on the realization of a time reference in cis-lunar space; - Support to the proposal of a non-GA IAU Symposium in Argentina.

2. Membership

Changes in membership occurred during the period. Catherine Hohenkerk (HM NAO, UK) retired and left the WG TMS; she was replaced by Steven Bell (HM NAO, UK). Frédéric Meynadier (BIPM) became a member in 2023.

3. Actions towards a continuous UTC

The discussions on the possibility of realizing a continuous UTC, without leap seconds, progressed during the period of this report. An important milestone has been the recognition by the International Telecommunication Union of the authority of the CGPM on the definition of the international reference time scale UTC. By this, it was clarified that the ITU is responsible for the dissemination of UTC, and that any modification of the time scale or of the procedure for synchronizing UTC to UT1 is under the responsibility of the CGPM.

The Working Party 7A (WP7A) of the Radiocommunication Sector of the ITU (ITU-R) deals with Time signals and frequency standard emissions. It is thus responsible on matters relating to the dissemination of UTC. WP7A worked during the period on a report containing information and studies on Content and structure of time signals to be disseminated by radiocommunication systems and various aspects of current and potential future reference time scales, including impacts and applications in radiocommunications. This report has been published by the ITU as Report ITU-R TF.2511-0 in October 2022 (ITU-R 2022). The WG TMS participated to the preparation of the report, contributing the chapter 6.7 devoted to the impact on astronomy.

The CGPM met in November 2022, and adopted Resolution 4 On the use and future development of UTC (CGPM 2022), deciding that the maximum value for the difference

(UT1 UTC) will be increased in, or before, 2035. The ITU-R approved the revised Resolution 655 (WRC-23) at the World Radiocommunication Conference held in Dubai, the United Arab Emirates, between November 20 and December 15, which formally recognizes Resolution 2 of the 26th CGPM (2018) on the definition of UTC and Resolution 4 of the 27th CGPM (2022). Resolution 655 describes 1) that the UTC is defined by Resolution 2 of the 26th CGPM (2018) and 2) that ITU-R is responsible in disseminating the UTC signal by means of radio. It should be noted that until the implementation of continuous UTC as planned in Resolution 4 of the CGPM (2022), UTC as described in Recommendation ITU-R TF.460-6 shall continue to apply. The next CGPM, in 2026, after consultation with the ITU-R and other organizations that might be impacted, will decide on a new maximum value for the difference (UT1 UTC) that will ensure the continuity of UTC for at least a century, and prepare a plan to implement by, or before, 2035 the proposed new maximum value.

4. Actions towards a redefinition of the SI second

The WG TMS took no particular action on the redefinition of the SI second, but kept updated on the evolution of the process at the Consultative Committee for Time and Frequency (CCTF), at the Consultative Committee for Units (CCU) and at the CGPM. There is no impact of a redefinition on astronomical work, but it is important that our community follow the process. The IAU is a liaison of the CCTF, and the CCU, with a representative who participates in the meetings and is aware of the work and recommendations. Also, the IAU is invited to the meetings of the CGPM.

For information, according to Resolution 5 of the CGPM (CGPM 2022), proposals for the choice of preferred species or ensemble of species for the new definition of the SI second are to be submitted at the 2026 CGPM, in view of the adoption of a new definition by the CGPM 2030.

5. Time reference in cis-lunar space

A Group on Lunar Time Scale was created in the WG TMS in Summer 2023. The aim of this group is to exchange ideas on the time reference to the Moon and to liaise with other groups, including IAU bodies. The group held a video meeting in August 2023, and a member was appointed as the contact person with Commission A3. Further communication within the group was by e-mail.

6. Support to the proposal of a non-GA IAU Symposium in Argentina

The WG TMS gave support to the proposal of a non-GA IAU Symposium on 4-8 August 2025 in Argentina, on Advancing reference systems, ephemeris and standards. From the Earth and the Moon to solar system bodies. After considering that such a large discussion has not taken place at the IAU in the last 20 years, and the location of the meeting in South America, the WG members agreed on a letter of support and on collaborating by appointing two members in the Scientific Organizing Committee.

7. References

CGPM 2022, *27th meeting of the CGPM*, 15-18 November 2022, available at https://www.bipm.org/en/cgpm-2022 ITU-R 2022, *Report ITU-R TF.2511-0*, 2022, available at https://www.itu.int/pub/R-REP-TF.2511 WRC-23, World Radiocommunication Conference 2023 (WRC-23), *Final Acts*, R-ACT-WRC.15-2023.pdf, pp. 398 400.

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