# Roadmap for the redefinition of the SI second

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The hyperfine transition of the atom of caesium 133 has provided the definition of the second since 1967 [1]. This definition should be understood as the definition of the unit of proper time applying in a small spatial domain where the caesium atom is moving.

Primary frequency standards maintained in a small number of metrology institutes realize the SI second with relative standard uncertainty of a few parts in $10^{16}$.

Although this uncertainty is sufficient for the current metrology service applications, new perspectives have been opened with the rapid development of ultra-accurate standards at the level of parts in $10^{18}$.

In response to this rapid development, and with the aim of motivating metrology institutes to better coordinate their activities, the International Committee for Weights and Measures (CIPM) maintains a list of transitions recommended as secondary representations of the second (SRS) [2]. This list contains frequencies and ratios of seven optical transitions (ions and neutral atoms) and a microwave rubidium standard. The estimated standard uncertainties recommended in the list are limited by their comparisons to the caesium frequency, and reach some $10^{-16}$ in relative.

Time and frequency comparisons for current applications are by using the satellites of Global Navigation Satellite Systems (GNSS), mainly the US Global Positioning System (GPS), and by two-way time and frequency transfer through telecommunications satellites (TWSTFT). Remote comparison of caesium fountains is possible using TWSTFT and the best GPS solutions; they also allow their use in the computation of International Atomic Time for the calibration of the unit interval. However, these techniques are not accurate enough for allowing the comparison of the new optical standards. Along short baselines, relying institutes on the same continent optic fibre links provide an excellent solution. But work is to be done for extending the comparisons to intercontinental links [3, 4].

In view of this rapid evolution, the time and frequency metrology community is going further in a discussion on a possible redefinition of the SI second, based on an optical transition.

The Consultative Committee for Time and Frequency is working on a roadmap which establishes the steps to follow on the way to the redefinition, which could happen by 2026. Their comparison represents one of the major milestones.

## References

1. 13th General Conference on Weights and Measures, Resolution 1, *Metrologia* **4**(1), 1968, pp. 41-45.

2. Recommended values of standard frequencies, http://www.bipm.org/en/publications/mises-en-pratique/standard-frequencies.html.

3. H. S. Margolis et al., “International Timescales with optical clocks” *EFTF and IFCS*, 2013, pp. 908-911.

4. F. Riehle, “Optical clock networks” *Nature Photonics* 11, 2017, pp. 25-31, doi:10.1038/nphoton.2016.235.