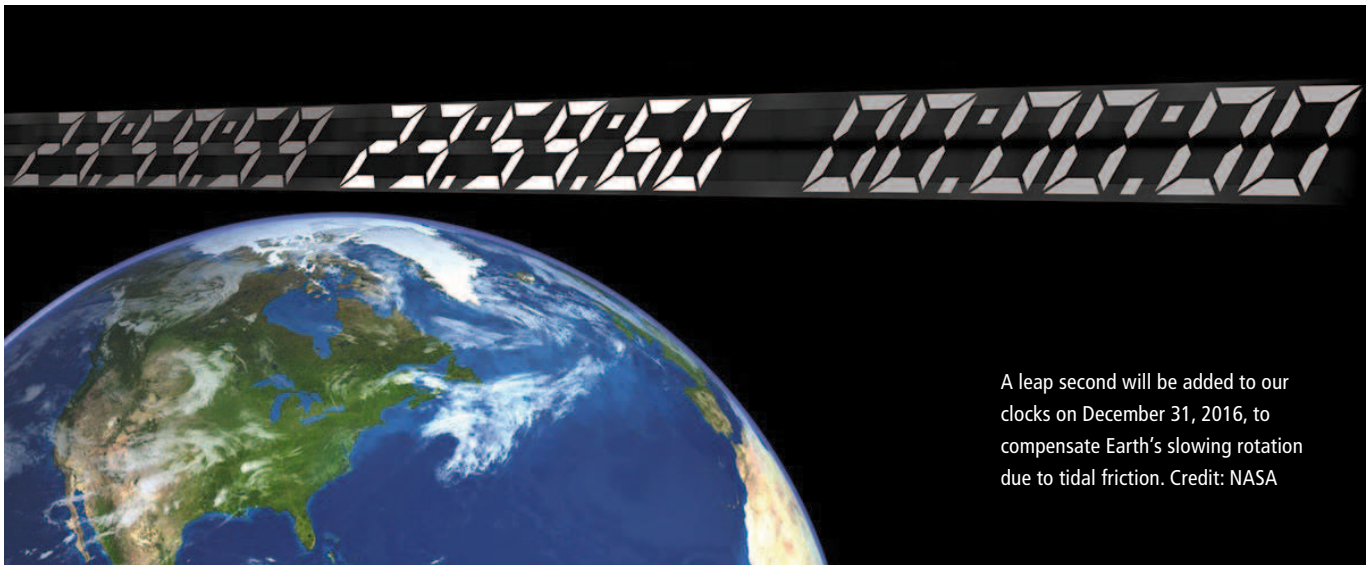
Journal for Occultation Astronomy

Leap Seconds

Mike Kretlow, IOTA/ES, mike@kretlow.de



A leap second will be added to our clocks on December 31, 2016, to compensate Earth's slowing rotation due to tidal friction. Credit: NASA

As announced by the International Earth Rotation and Reference Systems Service (IERS) in its Bulletin C52 on July 6, 2016, a leap second will be added on December 31, 2016. This extra second will be added after 23:59:59 UTC [Fig. 1]. Thus, from 2017 January 1, 0h UTC, until further notice, the difference between UTC and the International Atomic Time (TAI) will be TAI - UTC = 37s. Most practical problems and applications in dynamical astronomy make use of the Terrestrial Time (TT) as (continuous) time scale. TT is a uniform time scale, based on the SI-second, which is currently defined and realized by the International Atomic Time (TAI): TT (TAI) = TAI + 32.184 s. Thus, the difference between UTC (clocks, observation timings) and TT (theory, calculations) is important and has to be taken into account (in programs etc.).

Leap seconds have been added 26 times since UTC replaced GMT in 1972, the most recent ones were added June 30, 2015 and June 30, 2012. The latter one caused some computer issues, especially Linux based servers and (web) services had problems (deadlock bug). In fact, the leap second concept has pros and cons and is discussed by scientists and organizations since the IERS distributed a questionnaire about Coordinated Universal Time (UTC) in 1999. But the scientific community has failed to achieve an agreement on this topic, in 2015 the decision was (again) deferred to 2023. The crunch question is: should we adjust our clocks to the Earth's slowing rotation or to uniformly ticking atomic clocks?

Why do we need a leap second?

The time unit (second) has been for long defined on base of the daily rotation of the Earth. This changed in the 1950ies, when the second was defined using atomic clocks. Thus, two alternative time scales were in use:

- International Atomic Time (TAI), a high-precision (physical) time scale realized by a network of atomic clocks.
- Universal Time 1 (UT1), an astronomical definition based on the motion of the Sun in the sky, a modern redefinition which replaced the older concept of the Greenwich Mean Time (GMT).

These two time scales did not match up exactly over time, because tidal friction within the Earth is (on a long-term scale) continuously slowing down the rotation of our planet (over the past 50 years, the measured variation was between -1 and +4 milliseconds per day compared to atomic time day). Thus, as precise time reference to be used for civilian time, a third definition was introduced as practical compromise: the Coordinated Universal Time (UTC), which is defined such that

- the difference UTC – TAI is always an integral number of seconds.
- the difference UTC – UT1 never exceeds 0.9 seconds.

This is realized by inserting (or deleting) an UTC leap second whenever UTC and UT1 drift apart by more than half a second. UTC "ticks" uniformly in SI-seconds (like TAI), which is technically desirable. On the other hand the coupling to the day-night-rhythm remains preserved, which is also important for a civil time scale. Nevertheless, there are problems associated with the leap second and therefore the scientific community is searching for alternatives.

References

IERS Bulletin C (leap second announcement), 2016 Jul 06.
https://datacenter.iers.org/eop/-/somos/5Rgv/latest/16