Time To Get In Sync

by Prof. Richard B. Langley

"Time waits for no one," Mick Jagger lamented in song when he turned 30. But on the evening of June 30th, our clocks will stand still for a moment, waiting for the passage of a "leap second."

The International Earth Rotation and Reference Frames Service (the world's time monitor) has decreed that the last day of June will contain an extra second. Rather than the usual 86,400 seconds in a day, June 30th will have precisely 86,401 seconds.

National time-keeping centres around the globe, such as the National Research Council in Ottawa, will insert this extra second or leap second into their master clocks so that they remain synchronized with an international time standard. All other clocks that get their time from a master clock will be updated similarly. This includes all of the so-called time servers on the Internet, which keep our computer clocks in sync.

This global time standard is called UTC or Coordinated Universal Time. The standard was established in the 1960s once it was demonstrated that the newly developed atomic clocks could keep time with unprecedented precision and that clocks, even if they were on different continents, could be synchronized with each other to a fraction of a microsecond.

UTC is the time system kept in most countries straddling or bordering the prime meridian at zero degrees of longitude. The civil time systems in regions to the east and west of the prime meridian are typically offset by an integral number of hours from UTC. Atlantic Time, for example, is currently three hours behind UTC, so the leap second will occur here just before 9 p.m.

UTC (and the various zone or regional time scales related to it such as Atlantic Time) has replaced the previously used time scale based on the Earth's rotation with respect to the sun for most civil time-keeping purposes.

Although the Earth appears to rotate uniformly with night following day since time immemorial, the Earth actually does not spin at a constant rate. It fluctuates slightly due to a variety of causes including variations in winds and ocean currents, the motions of the Earth's fluid core, and the friction of tidal currents flowing along the bottom of the oceans.

Tidal friction and the other effects has resulted in a long-term or secular decrease in the Earth's rate of rotation resulting in an increase in the length of the solar day of a little over 1 millisecond per day per century. Currently, the length of the day is roughly 2 milliseconds longer than it was in the early 1800s when it was exactly 86,400 seconds. This means that over a period of 1,000 days, a clock keeping time based on the rotation of the Earth, a time scale known as UT1, would lose about 2 seconds compared to UTC, which is based on the atomic second and referenced to the period of the Earth's rotation around 1820.

To keep UTC to within 0.9 second of UT1, leap seconds are periodically added to UTC. While tidal friction is the primary reason for adding these leap seconds, the other factors responsible for the variation in the Earth's spin contribute as well. In fact, negative leap seconds are theoretically possible, although all leap seconds to date have been positive.

The last leap second occurred on June 30th, 2012. There have been 25 leap seconds added to UTC since the current system began in 1972. Leap seconds are applied either on December 31st or June 30th. Two thirds of them have occurred on New Years Eves with the rest taking place at the end of June like the one coming up.

The world runs on UTC. Everything from financial transactions to air traffic control depends on UTC and so these systems will have to properly accommodate the leap second when it happens. This includes satellite navigation systems. The Global Positioning System itself is unaffected by the introduction of a leap second because it has its own time system, GPS (System) Time, which is not adjusted for leap seconds. GPS Time was set equal to UTC back in 1980 and is currently 16 seconds ahead of it. On July 1st, this offset will increase to 17 seconds. GPS does provide UTC to its users by transmitting the necessary adjustment data in the satellite signals, permitting a receiver to compute UTC from GPS Time.

The upcoming leap second might be the last. The International Telecommunication Union is considering a proposal that leap seconds be abolished. The justification for the proposal is that leap seconds are cumbersome and their incorrect use could lead to problems with time-dependent infrastructure including safety-of-life navigation systems.

At an ITU meeting in Geneva in January 2012, national delegates debated a motion to eliminate the use of leap seconds in the UTC time scale. However, there was no agreement with countries evenly split in favour of, against, and undecided about abolishing leap seconds. Many of the undecided delegates said they were not sufficiently informed about the proposal to make a decision. The ITU will next consider the proposal in November 2015.

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