

Royal Astronomical Society statement on use of leap-seconds in Coordinated Universal Time

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Coordinated Universal Time (UTC) and its close synchronisation with the rotation of the Earth are the result of scientific understanding developed organically over several centuries. Central to this modern understanding is that there are two distinct aspects to time keeping:

- high precision absolute time-keeping based on fundamental physical principles;
- time-keeping based on the rotation of Earth rotation (mean solar time).

Science learned to distinguish these two aspects during the 20th century and thus time-keeping services have evolved to address user requirements for both precision timing and mean solar time. UTC with leap seconds emerged in 1972 as a reasonable compromise to serve both sets of requirements.

There is a current proposal to the International Telecommunications Union (ITU) to remove leap seconds from UTC. If agreed, this would change UTC so as to serve only precision timing requirements. The proponents of change consider leap-seconds to be a problem for precision timing applications and thus quite reasonably are seeking solutions. But the proposed solution is unprofessional in that it seeks to solve a problem for one group of UTC users (those concerned with precision timing) by exporting problems to other UTC users who use it to derive mean solar time. For this reason the proposal has been opposed by people who are aware of the issue and of the extra burdens it would place on them. These have mainly come from the astronomy community, whose Earth-based telescopes require mean solar time in order to point at objects in space and can use the present UTC as a good estimate of mean solar time. The abolition of leap seconds will quickly render this impossible and impose extra costs in terms of changes to software and procedures.

What is very worrying is that the current specialist debate has not engaged with other groups who use the present UTC. The Society urges, that before the proposal is considered by ITU, there must be a broader study and public debate to understand how UTC is used across our modern civilisation. For example there are other scientific issues that should be brought into the debate:

- Solar time controls many phenomena in the Earth's environment – because the Sun powers those phenomena through its emission of electromagnetic radiation and the solar wind. These include issues within the expertise of the Society's membership, e.g. the ionosphere and radiations belts, but also extend to many other geoscience areas. Studies of all these disciplines need solar time for analysis of data and for scheduling of regular monitoring observations and do so by derivation from UTC. The proposed change would cause UTC to drift with respect to solar time and thus would introduce phase shifts into measurements made at fixed UTC times. The change will impose extra costs to adapt analysis techniques and the scheduling of measurements.
- Like astronomical telescopes, satellite ground stations require mean solar time in order to point at objects in space (e.g. the scientific spacecraft that contribute so much to the objectives of the Society). They can use the present UTC as a good estimate of mean solar time. As with telescopes the abolition of leap seconds will impose extra costs through changes to software and operating procedures.
- Time-stamping of science data. Quality of time-stamping is critical in many areas of science – especially the study of dynamic phenomena (which are found across all areas of interest to the Society) and in measurement techniques that require time correlation of data from different sources (e.g. the very-long baseline interferometry used in radio astronomy and some parts of magnetospheric physics). The issue here is not precision versus solar time but rather the need

for clarity on the systems used in time-stamping. What is vital to science that the good management of changes in time systems, e.g. clear visibility of changes, adequate lead time to make and test changes to systems that add time-stamps to data. The present proposal lacks clarity (by re-using the UTC name while changing what it means) and seeks to implement changes much too quickly.

- Our modern understanding of time-keeping is deeply embedded in contemporary technical culture through a wealth of literature (text books, web pages etc) and in the skills of working scientists and engineers around the world. It seems unwise to make changes that will invalidate the existing literature and skills. The issue here is to make changes in a way that builds on current knowledge and skills - and not to undermine them.

It is also important that wider debate explore the use of mean solar time outside science and bring appropriate expertise to bear on the debate. One important example is whether civil/legal time should be based on precision time or mean solar time. This has been a topic in the present specialist debate but could benefit from bringing in other viewpoints - especially those outside science and technology.

In this statement we also wish to challenge the notion that leap seconds threaten safe use of GPS.

- The intellectual challenge of building GPS technology has been high and has involved knowledge from many areas of science. For example, in areas of RAS science it has involved (a) engineering applications of general relativity to specify behaviour of clocks on satellites and (b) understanding of space weather to reduce both systematic and random position errors caused by the space plasma environment.
- Existing studies¹ show that GPS usage is vulnerable to natural interference, such as the random space weather errors above, as well as a wide range of human interference, both inadvertent and hostile. Much effort is being devoted to mitigation of such interference. Nonetheless it is clear that complete elimination of interference is not a practical option and thus that safety critical activities cannot, and will not, rely on sole use of GPS for position data.

Given this context we believe that it is a distraction to claim that leap seconds are a significant safety issue for GPS. The GPS community clearly has the ability to resolve time-keeping issues without placing extra burdens on other users of the existing UTC time system.

The Society strongly recommends that the proposal to abolish leap seconds be shelved and that the ITU work to promote a broader and public debate. This debate should first identify user requirements for time-keeping (both for precision timing and for solar time) and then develop solutions to satisfy all those requirements. The real need is to focus the substantial intellectual effort available into enhancing the current time systems so that they can support all users and not just a subset.

¹Vulnerability assessment of the transportation infrastructure relying on the Global Positioning System, Final Report, 29 August 2001. Prepared by the John A. Volpe National Transportation Systems Center, Cambridge, Massachusetts. <http://www.volpe.dot.gov/gps/gpsvuln.html>