# Astronomical timekeeping strategies to accommodate possible changes to UTC

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UTC may be redefined without leap seconds. This would significantly affect many astronomical software systems.

*No time scale has been immune to change*

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The most prominent subject of public interest, (and one that has engaged much of the attention of your Council during the past year,) was the proposing an amended form of the *Nautical Almanac*. The Lords Commissioners of the Admiralty, being desirous that the National Ephemeris should be remodelled, so as to meet the increasing wants and intelligence of the navy, and also the demands of astronomers, referred the consideration of the subject to the Council of the Astronomical Society. A Committee was formed, with the co-operation of the most distinguished navigators and astronomers of the empire, and an elaborate Report drawn up, recommending various alterations and additions. This has been approved of by the proper authorities; and the *Nautical Almanac* of 1834 will appear in strict conformity with the plan advised.

The most important *alteration* is the substitution of *mean* for apparent solar time in all the data of the Ephemeris. It was with considerable reluctance, and after viewing the subject in every light, that the Committee resolved upon this material departure from the mode adopted by Maskelyne, and rendered familiar by the practice of more than half a century; but, as chronometers are to be found in perhaps every ship which relies upon astronomical means for her guidance, and as mean time must necessarily be obtained where chronometers are used, it was deemed safer to dismiss apparent solar time altogether as unnecessary, and as being a source of confusion. The advantages, as to simplicity, of exchanging a varying for a constant measure of duration, and of assimilating the computations of the navigator and of the astronomer, are too obvious to be dwelt upon; and, in the opinion of all the naval officers present, no serious or lasting inconvenience from the change is likely to be felt.

The Admiralty of 1831 understood the different time scales. They recognized a distinction between a rarely-if-ever-reset private ship's chronometer, measuring time intervals with its log of offsets and rates, and a public clock, continually reset by astronomy to record an epoch. They deemed that most navigators already had the requisite tools for a change in time scale.

Despite objection by the IAU, the Admiralty redefined GMT by 12 hours in 1925.

The BIH and BIPM have made adjustments to TAI since its inception, including major changes as of 1977 and 1995.

The IAU has redefined UT (UT1) as of 1956, 1984, 1997, and 2003; TT (TDT) in 1991 and 2000; and TDB in 1991 and 2006.

Using the language of the 1831 Admiralty, the monthly issue of BIPM Circular T demonstrates that the best chronometers in the world are only clocks after they compare how different they are and reset themselves, and TT(BIPM*nn*) retrospectively resets TT(TAI).

In conjunction with other international agencies, the ITU-R have been seriously reconsidering the existence of leap seconds in UTC for six years. Several proposals have suggested abandoning leap seconds, either immediately or after an interval of a few years. Despite considerable effort in surveys, polls, conferences, correspondence, and public review processes the fate of leap seconds in UTC is still not clear.

The AAS DDA recently reviewed implications and consequences
`http://www.aas.org/policy/DDA-UTCreport.pdf`
This resulted in the AAS Leap Second Committee
`http://www.aas.org/policy/LeapSecondCommittee.html`
Other jurisdictions still have open input channels to the ITU-R process.

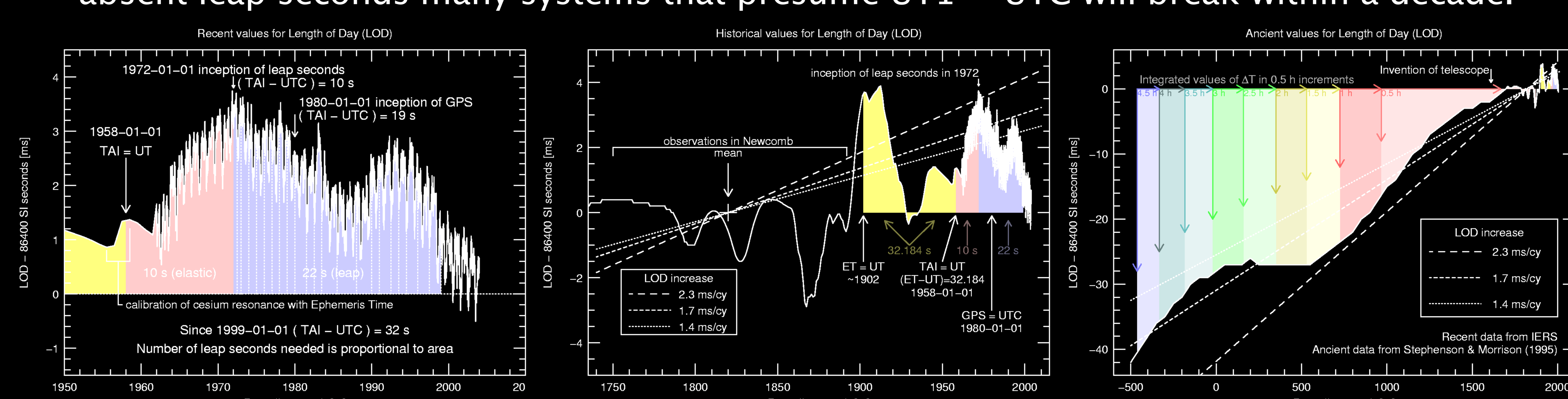
The 1884 International Meridian Conference was called to address a new need in technological civilization:
We must all be able to agree on what time it is.
Questions that conference did not answer are faced by the ITU-R now:
What do we mean "What time is it?", and how closely do we need to agree?

For most civil purposes time is only relevant to the nearest minute; leap seconds are unnoticeable. For many astronomical purposes time is only relevant to the nearest second; leap seconds are inconsequential (in the moment, but they add consequentially).

Applications that require time to better than one second must recognize that ascertaining the "true" time is a process dependent on external sources and systems. Correct operation of the process demands verifying how each element in the chain of provenance, real-time and ex post facto data acquisition and reduction, obtains and handles its notion of time. UTC, with or without leap seconds, may not be the optimal time scale. As did the navigators of the Admiralty's fleet in 1833, each element of the system may have to keep a log of how its chronometer differs from "true" time.

Applications such as telescope pointing and satellite tracking inherently rely on UT1. Much existing software for these applications dates to the 1960s when the only conceivable time scale was explicitly tracking Earth rotation as closely as possible. Spacecraft tracking software that does not acknowledge UT1 - UTC introduces a time of arrival error of up to 1 μs. In the absence of leap seconds this error becomes unbounded, and telescope pointing will also be affected.

The IAU 2000 resolutions decreed changes in conventional models for Earth rotation which were implemented in 2003. In conjunction with changes for celestial coordinate systems, almost no telescope pointing or satellite tracking software currently conforms to IAU convention. During this century all software must be rewritten to conform, but absent leap seconds many systems that presume UT1 = UTC will break within a decade.




**Know time scale needs & dependencies of applications & systems**

**Be prepared for change from external sources of time scales**

**Participate in the creation of standards and infrastructure, such as a "navigator's log" of offsets between our system ~~clocks~~ chronometers and master clock(s), with or without leap seconds**

*Change happens. Are your systems ready?*