

RESULTS FROM THE 2011 IERS EARTH ORIENTATION CENTER SURVEY ABOUT A POSSIBLE UTC REDEFINITION

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The Earth Orientation Product Center is responsible for the prediction and announcement of the leap second (Bulletin C) and the announcement of the value of DUT1 truncated at 0.1 s for transmission with time signals. A first survey made in 2002 show that 89% of IERS users were satisfied by the current determination of UTC, including leap seconds introductions. With the increasing number of users belonging to the various communities, it was felt necessary to take a new survey to find out the strength of opinion for maintaining or changing the present system before the proposal of redefining UTC is discussed at the ITU-R meeting which will be held in Geneva in January 2012.

INTRODUCTION

The legal time scale UTC (Coordinated Universal Time) is derived from TAI (Temps Atomique International) by the insertion of leap seconds in order to maintain UTC within ± 0.9 s of the time scale based on the Earth's rotation UT1, *i.e.* $|\text{UT1}-\text{UTC}| < 0.9$ s. This system was introduced in 1972. Several years ago, some communities particularly involved in telecommunications and navigation systems proposed a revision of the UTC definition, aiming to eliminate leap seconds in order to have a continuous time scale. This has been a topic of discussions for nearly 20 years.

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The first survey taken in 2002 showed that a large majority of IERS users were satisfied by the current determination of UTC, including leap seconds introductions.¹ With the increasing number of users belonging to the various communities, it was felt necessary to take a new survey to find out the strength of opinion for maintaining or changing the present system before the proposal of redefining UTC be discussed at the ITU-R meeting, which will be held in Geneva in January 2012.

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QUESTIONNAIRE TO SURVEY OPINIONS CONCERNING A POSSIBLE REDEFINITION OF UTC

The Survey Language

Universal Time, the conventional measure of Earth rotation is the traditional basis for civil timekeeping. Clocks worldwide are synchronized via Coordinated Universal Time (UTC), an atomic time scale recommended by the Radiocommunications Sector of the International Telecommunications Union (ITU-R) and calculated by the Bureau International des Poids et Mesures (BIPM) on the basis of atomic clock data from around the world.

UTC is computed from TAI by the introduction of leap seconds such that UTC is maintained within 1 second of UT1. Since 1972, these leap seconds have been added on December 31 or June 30, at the rate of about one every 18 months. Since 1 January 2009, 0:00 UTC, UTC-TAI= -34 s.

After years of discussions within the scientific community, a proposal to fundamentally redefine UTC will come to a conclusive vote in January 2012 at the ITU-R in Geneva. If this proposal is approved, it would be effective five years later. It would halt the intercalary adjustments known as leap seconds that maintain UTC as a form of Universal Time. Then, UTC would not keep pace with Earth rotation and the value of DUT1 would become unconstrained. Therefore UTC would no longer be directly useful for various technical applications which rely on it being less than 1 second from UT1. Such applications would require a separate access to UT1, such as through the publication of DUT1 by other means.

The objective of the survey is to find out the strength of opinion for maintaining or changing the present system.

Two references:

1. Nelson, R.A., McCarthy, D.D., Malys, S., Levine, J., Guinot, B., Fliegel, H.F., Beard, R.L., and Bartholomew, T.R. "The leap second: its history and possible future." *Metrologia*, Vol. 38, 2001, pp. 509-529 <http://www.cl.cam.ac.uk/~mgk25/time/metrologia-leapsecond.pdf>
2. Finkleman, D., Seago, J.H., and Seidelmann, P.K. "The Debate over UTC and Leap Seconds." Proceedings of the AIAA/AAS Astrodynamics Specialist Conference, Toronto, Canada, 2010. <http://www.agi.com/downloads/resources/user-resources/downloads/whitepapers/DebateOverUTCandLeapSeconds.pdf>

The Survey Options

1. I am satisfied with the current definition of UTC which includes leap second adjustments.
2. I prefer that UTC be redefined as a uniformly increasing atomic timescale without leap seconds and constantly offset from TAI. Consequently, UTC would increasingly diverge from the Earth's rotation.
3. I have another preference.
4. I have no opinion or preference.
5. Comments.

The Survey Results

The following figures give respectively the global results and statistics concerning the domains of activities, as well as the number of answer per country.

INQUIRY ABOUT THE REDEFINITION OF UTC
GLOBAL RESULTS

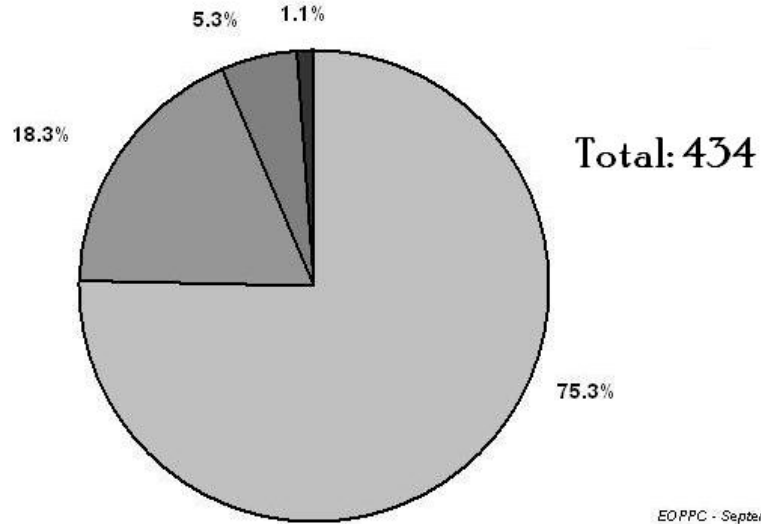


Figure 1. Global results.

INQUIRY ABOUT THE REDEFINITION OF UTC
FIELDS OF ACTIVITY

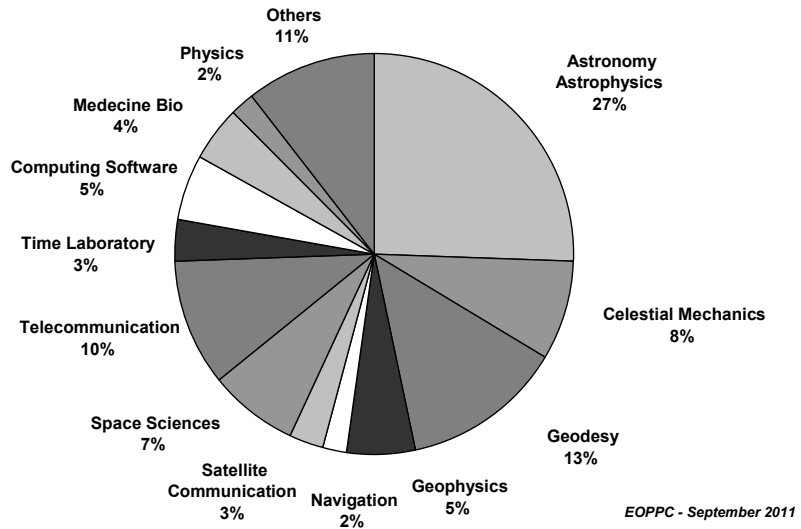


Figure 2. Fields of activities.

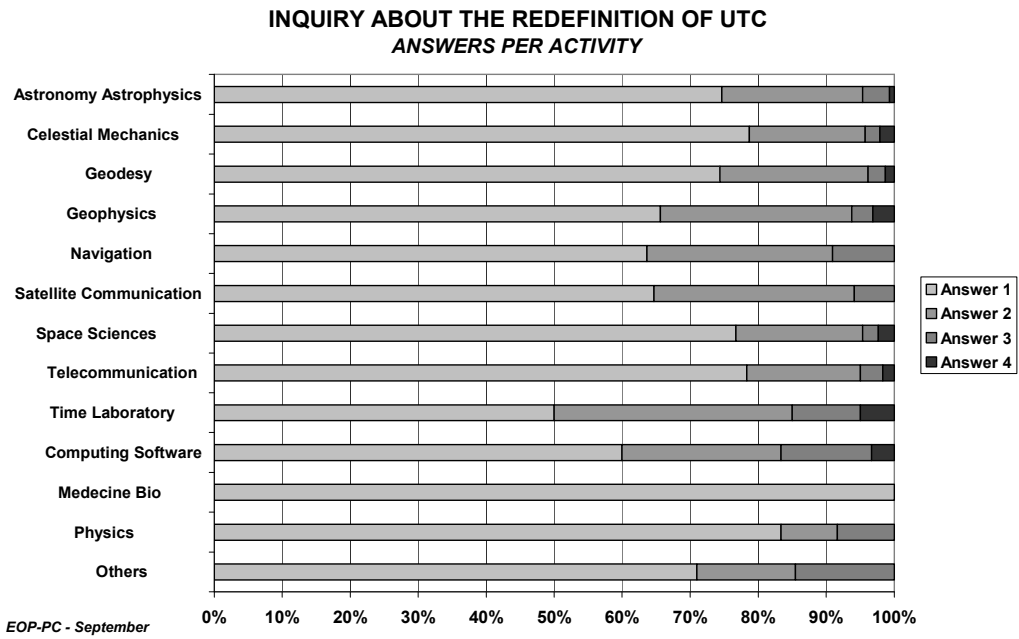


Figure 3. Percentage of answers per field of activity.

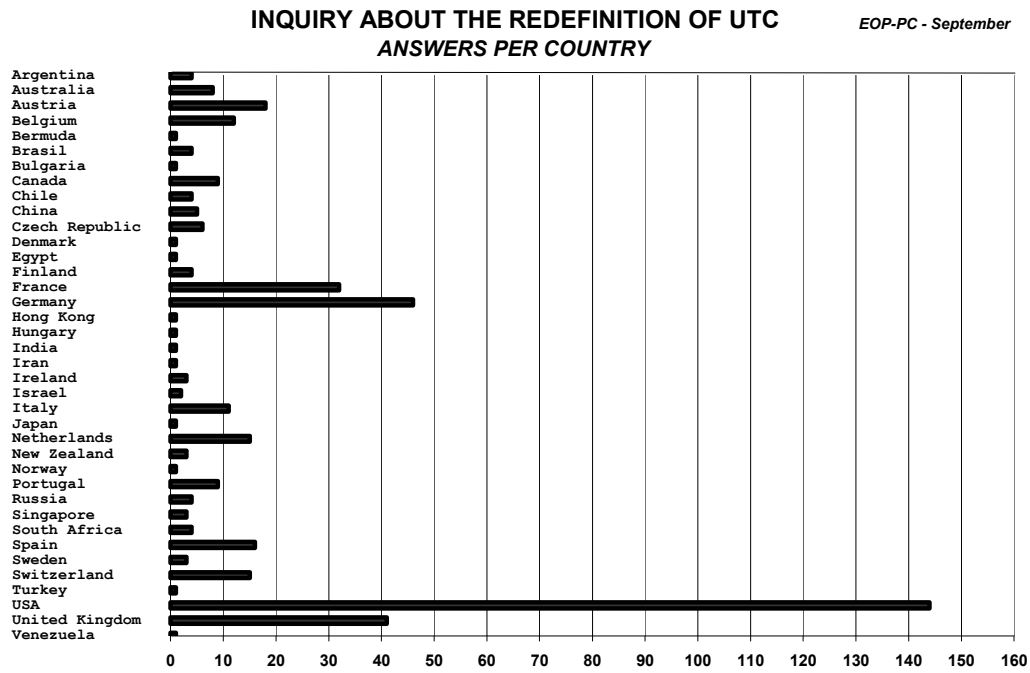


Figure 4. Statistics concerning the number of answers per country.

COMMENTS TO THE QUESTIONNAIRE

We have selected hereafter the most pertinent and representative answers. These are listed without any hierarchical order.

General Arguments Favoring the Status-Quo (75%)

- The present system, working well, is a good compromise between Earth rotation and atomic time.
- Arguments to change are not sufficient compared to the advantages of a coordinated UTC time scale linked to the Earth rotation.
- Any changes in these areas will likely cause substantial confusion and disasters (principle of security).
- In particular, risk of confusion and problems in the case of the increase of the tolerance UT1-UTC
- A majority of UTC users are not aware of the difference between UT1 and UTC. If the new definition is adopted, they should. When the difference DUT1 increases, 30s, 10 min, 1 hour, a lot of problems will arise.
- There is too much software with the assumption of UTC being coordinated with the Earth rotation. The costs of change would be important. Unforeseen problems could happen.
- No reason to maintain 3 separate time scales (GPS, TAI, and UTC) differing by a constant offset.
- In many countries legal time is based on solar time.
- No strong argument to change. The current system works. “If it ain't broke, don't fix it!”
- Few problems were reported after the 2009 leap second introduction.
- In a few decades, who will remember the origin of the procedure?
- There is no strong justification to adopt a time scale no longer related to the rotation of the Earth.
- More time should be needed to evaluate the consequences of such a change (UNESCO statement).

General Arguments Favoring a Change (19%)

- Ambiguity of date at the occurrence of a positive leap second which is potentially dangerous.
- Separating the two concepts (angle for UT1, time for UTC) would be an improvement for high-accuracy applications.
- Leap-seconds were a good idea in 1972 when people just had a few inaccurate analog clocks, but now so much equipment has a clock, it is a nightmare to correct it all.
- Ignoring leap seconds will not be a significant problem for civil purposes.
- Analyzing the performance of the time servers during the 2008/2009 leap second showed a worrying percentage of (otherwise well configured and well maintained) systems being a second out of sync with everyone else for hours and in some cases even days!

- Having a time scale that is discontinuous causes a lot of problems with writing and maintaining software for processing non-ground-based astronomical missions.
- There is no technical reason for keeping the existing system other than TRADITION.
- Designing, operating and testing time service equipment for leap seconds require tremendous efforts.
- Most databases can't deal with leap seconds and interval calculations can't. For this reason we need to unwind leap seconds.
- The handling of leap seconds adds a considerable complexity for equipment manufacturers and for operators in order to prepare and pre-program for the insertion/removal of a leap second.
- The leap seconds represent a nuisance for the modern applications requiring time synchronization

Other Proposals

- It would be useful for leap seconds to be scheduled further in advance.
- With the ubiquitous use of NTP, I believe there is now an opportunity to separate civil time from the high-precision time/frequency dissemination services.
- Time correction applied on a deterministic date, and more rarely on 01 January 00:00 every 10 years. Or even better, to apply them each 29 February.
- A better representation can preserve the existing and traditional meaning of UTC as civil time while also alleviating the problems faced by software systems.

SUMMARY

The statistics mostly reflect the statements of communities of time scales users. As of 10 September 2011, there were 443 responses to the questionnaire; 9 of these were discarded having been considered wacky.

Over the 434 remaining answers, about 75% favor the *status quo*, i.e., no change in the current definition including leap seconds. 19% favor switching to the new UTC definition, i.e., continuous time scale no leap second. 5% favor another solution, mostly requiring the prediction of the leap second with a longer schedule in advance. 1% has no opinion.

Let us note that globally and except for the time community where 50% are for the *status quo*, the percentages of users favoring and opposed to the *status quo* is similar, with a majority favoring the *status quo* whatever the domain of activity.

Answers and comments to the questionnaire are fully available at the following web site: <http://hpiers.obspm.fr/eop-pc/questionnaire/result.php>

REFERENCES

¹ Gambis, D., Bizouard, C., Francou, G., and Carlucci, T., “Leap Second Results of the Survey made in Spring 2002 by the IERS,” in: Proceedings of the ITU-R SRG Colloquium on the UTC Timescale, IEN Galileo Ferraris, Torino, Italy, 28-29 May 2003. (URL http://www.ucolick.org/~sla/leapsecs/torino/gambis_leap.pdf)