(Preprint) AAS 13-501

THE COLLOQUIUM ON REQUIREMENTS FOR UTC AND CIVIL TIMEKEEPING ON EARTH

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On May 29 and May 30, 2013, the Colloquium on *Requirements for UTC and Civil Timekeeping on Earth* was hosted in Charlottesville, Virginia by the University of Virginia (UVa), the UVa Astronomy Department, and the Jefferson Scholars Foundation. This paper highlights various technical perspectives supporting requirements and various recommendations discussed by colloquium participants.

INTRODUCTION

In response to some colloquium participants and other professionals, and in keeping with earlier proceedings,[1] the authors have provided an extended summary of the proceedings of the colloquium on *Requirements for UTC and Civil Timekeeping on Earth*. This summary highlights some of the perspectives (which are not necessarily the perspectives of the authors) discussed during the meeting in relation to requirements surrounding the topic of redefining the civil timescale Coordinated Universal Time. However, this summary is no substitute for the wealth of detailed information to be discovered by careful review of the succeeding manuscripts and discussions; rather, it is hoped that the highlighting of specific points here encourages the reader to explore the remainder of the proceedings thoroughly. The reader should appreciate that words like "need", "must", "shall", "necessary", "obligation", "fundamental", and of course, "required" throughout these proceedings are generally indicative of some lurking requirements; regrettably, many of these have gone unrecognized by this overview for the sake of brevity.

REQUIREMENT TO IDENTIFY REQUIREMENTS

The ITU-R study process mandated an overarching "meta-requirement" to identify requirements for civil-timekeeping on Earth via ITU-R Study Question 236/7,[2] which asked "What are the requirements for globally-accepted time scales […] for civil time-keeping?" and "What are the requirements for the tolerance limit between UTC and UT1?" The ITU-R further directed "that the results of the above studies should be included in (a) Recommendation(s)". However, the progression of sanctioned studies has resulted in poorly identified requirements, delaying

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changes to Recommendation TF.460-6 with few signs of large administrations altering their 2012 positions.

The continuing delay constitutes a "self-forming solution" as users invent their own technical solutions beyond the ITU-R Recommendation, with unrecognized requirements manifest through the adoption of unsanctioned approaches. For example, one already sees the Google "leap smear", the Advanced Television Standards Committee (ATSC) ordering broadcasts synchronized to GPS time, and IEEE 1588—the Precise Time Protocol (PTP) for clock-synchronization based on International Atomic Time (TAI)—adopted by the ITU-T.[3] There may be a time limit at which too many engineers will have ignored the ITU-R, with various large administrations around the world making their own decisions, if requirements are not responsibly recognized and addressed through a resultant ITU-R Recommendation in 2015.

Technology has greatly advanced since UTC was defined with leap seconds, with precise timing being at the heart of much of it. Technical advances have included the invention of GPS (which provides precise time as well as location), the operational development of the Internet, and cellular telephone technology. Although there are occasional glitches, substantial difficulties are hard to identify. At the highest level, the problem to be solved by the ITU-R is unclear. Is it to fix the occasional glitch, or, is there software that does not handle time correctly? An occasional problem with particular software is fixable. Conversely, it would be ill-conceived to presume that there will be no significant risks or significant costs associated with redefining UTC.

Improving technology will almost certainly force changes to time-transfer conventions and protocols in coming decades, and once it becomes obvious that major changes need to happen, that could be an opportune point at which to consider broader timekeeping issues. Thus, current efforts seem to be forcing action prematurely onto a poorly-defined problem. Unfortunately, the process which resulted in a Recommendation to abolish future leap seconds appeared upside-down and motivated by politics. Such a process should have started by reaching a consensus on the definition of the problem before proposing a solution.

REQUIREMENT TO RECOGNIZE USERS

To satisfy the overarching ITU-R requirement to identify requirements for civil-timekeeping on Earth, the populations of the technical and non-technical users of time must be identified. Although there is a family of dynamical time scales to fulfill the requirements of relativity theory, for civil timekeeping, most users seek a very specific frame of reference—one that approximates the notion of a 'Newtonian time' as people considered it a century ago. The issue of the UTC definition is seen as a discussion among time experts of a particular sort, but there are other expert consumers of accurate timekeeping that possibly have not been approached and about whom there is inadequate awareness. Original research shows unexpected levels of technical interest in civil timekeeping within some communities potentially dismissed as 'non-technical' and, therefore, outside the scope of ITU-R consideration.

REQUIREMENT FOR INTERNATIONAL COORDINATION AND CONSENSUS

There is a requirement to coordinate legal conventions for time nationally and internationally for the common interest globally, and, thus, international consensus is needed when asking permission to make a big change to the world's system of civil timekeeping. The proposal to cease future leap seconds always lacked unanimity within the ITU-R and its study groups, yet it is the habit of the ITU-R to resolve by consensus rather than by debate and vote. The ITU-R is chartered under the United Nations, so the decision-making process is organized along national borders instead of various technical camps. Nations without time services remain affected by any decision to change UTC, as they receive useful signals from outside their borders.

The reasons why countries choose their positions are often well-hidden; particular interest groups have the ear of national governments, whereas others with very different opinions are not heard for completely unrelated reasons. By proposing the cessation of future leap seconds, the United States advocated a position of change from a working standard. It is becoming easier at this time in history to rally international support against a position of the United States if it is perceived as emanating from the Department of Defense. Furthermore, when the United States appears on one side of an issue in a global assembly, and China and Russia appear on the other side, it conjures visions of the Non-Aligned Movement and makes it harder to move forward.

If a referential uniform timescale is created with legal effect, then the definition of the civil day changes. If this violates people's senses of what a 'day' is, the ridicule could be politically dangerous. There is also concern about legal contracts, because time is fundamental to all contractual documents. Thus, social, economic, and political concerns seem to be bigger drivers than the technical issues of trying to decide which timescale to use. These concerns are almost impossible to quantify, partly because many do not understand the future impact of the change.

REQUIREMENT FOR TERMINOLOGICAL INTEGRITY

Words can have a way of changing their meaning over time without the terminology also changing, and technical terminology can become ambiguous despite our best efforts. But that is no reason to neglect the requirement to preserve the integrity of precise terminology. It is our present responsibility to not make things any worse by increasing polysemy, and to protect the labels 'Universal Time' (UT) and 'Coordinated Universal Time' (UTC), as terms of art.

Universal Time

The term 'Universal Time' is a case where an underlying technical definition evolved from the label over time. Nobody has used 'Universal Time' in the purely generic sense of 'global time' in the last one-hundred years. Rather, textbooks have always supported the understanding of 'Universal Time' as a scale representing the rotation of the Earth and a realization of mean solar time. This understanding is evident in original documents from the CCIR[*] adopting UTC specifications. Reassignment of the term 'UTC' to a scale unconnected to Earth rotation violates established protocols for international standards.

Traditionally, 'Universal Time', or 'UT', has been correct when one is not being specific about sub-second differences, and 'UTC' is technically correct when additional precision is intended. 'GMT' has suffered from scientific ambiguity, yet still enjoys recognition and usage by a variety of global media outlets and the general public in place of 'UTC'. Within the European Union, political decisions via Directives of the European Commission seem unnecessary to manage the terminological differences of 'GMT', 'UT', and 'UTC' across various translations of legislation; instead, translation guidance is quite feasible and much simpler. Institutions like the International Earth Rotation and Reference Systems Service (IERS), the International Astronomical Union (IAU), the International Standards Organization (ISO), *etc*., are where terminology can be legitimately defined. In most cases, civil timescales intend to represent mean solar time, which UTC as currently defined closely provides. Unfortunately, the translation symmetry between 'GMT', UT', and 'UTC' will become broken if UTC is redefined without a change of name.

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[*] *Comité consultatif international pour la radio*, forerunner of the ITU-R

Many countries do not rely on the term ‘UTC’ in their legal codes but that has not been a legal impediment to their use of UTC. This is because the interpretation of legal specifications for time is controlled by regulations crafted by experts. There is also historical case law and precedent for dealing with co-existing timescales, and even today the Gregorian calendar is used for international purposes where cultural calendars are used internally. If the name of the civil scale is changed from ‘UTC’ to something else, then the name change exposes the cost of the decision to redefine civil timekeeping, because documentation would be required to change regardless.

Atomic Time

UTC is not available from the BIPM in real time, but originates from various national standards. If one adds the integral offset (TAI−UTC) to broadcast UTC, a real-time version of TAI results. There is a semantic issue as to whether the term ‘TAI’ refers to a background observational timescale that only the International Bureau of Weights and Measures (BIPM) distributes. Because time services outside the BIPM distribute UTC closely approximating UTC(BIPM), everyone uses the term ‘TAI’ in reference to UTC plus (TAI−UTC). One might be compelled to label the national outputs as something like ‘TAI(k)’, where k identified the national source, to facilitate a technical distinction, but for most engineering purposes the difference between TAI(k) and TAI(BIPM) is insignificant. Politics are in the semantics, and there is a requirement to overcome semantic issues so that people can write documentation.

A “Continuous Reference” Time Scale

Neither term ‘continuous’ nor ‘discontinuous’ is an apt description of UTC. The notion of *continuity* (in the sense of an uninterrupted sequence) seems technically appropriate for the definition of UTC via TF.460-6, but not necessarily appropriate for numerous operational realizations of UTC that handle leap seconds unconventionally. There is doubt as to whether the notion of *mathematical continuity* applies, because UTC labels are sexagesimal and not a single scalar variable. The term ‘uniform’ might substitute for ‘continuous’, except that UTC consists purely of uniform SI seconds, but UTC units of minutes, hours, and days can vary in their duration. From the context of historical use and recent use within Resolution 653 of the ITU-R World Radio Conference (WRC-12), the terms “discontinuous” and “continuous” are better replaced by the terms “intercalated” and “unintercalated”, respectively, as with the calendar.

REQUIREMENT FOR SYNCHRONIZATION WITH THE SYNODIC DAY

The difference between a *general* timekeeping system and a *civil* timekeeping system is that the latter has some connection to the synodic day. Throughout its evolution, the second (SI) has emulated the mean-solar second both in name and in duration: from being defined as $^{1}/_{86400}$ of a mean solar day, to being based on a fraction of the tropical year, to having an atomic definition. This has allowed clocks on Earth to maintain synchronization with the synodic day without large adjustment. The seven-year period (1998 - 2005) with no leap second reveals just how closely the SI second is calibrated to the mean-solar second. No responsible timekeeping professional argues for a rate noticeably different from solar time, because the inherent requirement for solar synchronicity is implicit; rather, the debatable aspect is the level of divergence between mean solar time and precise clocks.

Eliminating leap seconds from UTC is exactly like the ancient Egyptian calendar system which had 365 days per year out of convenience, but did not survive as it lost coherence with nature. Indeed, the apparent point behind leap-minute and leap-hour proposals is to eventually deal with embargoed leap seconds to maintain synchronization with the synodic day. Otherwise, the proposal to eliminate the leap second creates a disjunction between ‘days’ and ‘dates’ which civilization must consider. But it would be sociologically disturbing if a political ‘date’ no longer corresponded with the natural 'day'. Also, the assignment of the word 'day' to the informal SI unit of duration of 86400 SI seconds presents an added complication. In order to keep these things tightly coupled together, and to avoid as much trouble as possible, the leap second appears to provide a nearly optimal solution for civil timekeeping in the end.

Because synchronization to the synodic day is a fundamental attribute of civil timekeeping on Earth, the fundamental issue is whether to replace the current system of one-second rollbacks with much larger rollbacks that occur more rarely. But discussions about an adjustment that is supposed to be happen decades into the future, in terms of our current world environment, seems unrealistic. Delegates to the 1884 Meridian Conference had no insight as to what would happen in the future, and we are now arguably in the same position, because we do not have any certainty about the future. Because of this uncertainty, no one expects a workable scheme to schedule a single adjustment decades into the future. By the time the first leap minute becomes effective, most likely another cycle of changes to timekeeping systems will have happened. One is left to surmise that the intention of proposing leap minutes and leap hours is to never allow them to happen, because once a decision is made to change to long-term adjustments, timekeeping technology becomes essentially decoupled from Earth rotation. Furthermore, it is not possible to accurately predict long-term Earth rotation by simply assuming constant angular deceleration and parabolic ΔT, because there are interim effects which oppose the constant deceleration of the Earth.

Finally, any alternative to the leap second requires unambiguous representation across all time zones. Presently, some time zones are established as having offsets by quarter-hours from Universal Time. A leap minute is particularly disadvantaged because it only works if time zones are offset integral hours from UT. There is no authority that can dictate that sovereign nations must go to zones offset from UT by integral hours to make leap minutes work.

REQUIREMENT TO CONSIDER DIFFERENT OPTIONS

Few options are expected to come out of any ITU-R study process. This is because options need to be sufficiently clear and distinguishable from one another to discuss the benefits and costs of each one, and the level of effort to properly assess each option would discourage the generation of a long list of options. Nevertheless, there is a requirement to seriously assess other options beyond "UTC without leap seconds" versus "UTC with leap seconds." This is necessary to address WRC-12 Resolution 653,[4] which invited consideration of "the feasibility of achieving a continuous reference time-scale, whether by the modification of UTC or some other method," with the modification of UTC already lacking consensus.

More than One Timescale

The current UTC standard serves well as a politically acceptable omnibus timescale for civil timekeeping on Earth, but it is too much to expect to have one timescale for all purposes; different applications have different requirements and there is a need for multiple timescales. Because it is impossible to always use one scale, one should let the application determine which timescale is to be used and then choose the timescale that is appropriate. Society already lives with many available timescales: every time zone is a different timescale based on UTC. However, NTP servers are usually expected to provide UTC, and there is the potential for differences over networks, if servers transmit something else like GPS time or TAI without proper specification.

REQUIREMENT FOR SOFTWARE SUPPORT

There is a requirement to deal with existing software problems regardless of the future definition of UTC. Some applications are breaking because developers have not implemented UTC correctly. Most programmers are not experts on precise time and have an inflexible understanding of time standards, and software developers continue to work from pre-existing programs and existing APIs that do not correctly account for the definition of UTC. Workarounds which attempt to fix the broken software become another layer of broken software on top of the original breakage, which becomes impossible to manage and has economic consequences. An impressive amount of time and effort working around the leap second is therefore noticed.

Regardless, a decision to alter timescales for civil use must be made on the *actual* merits of the timescale and not as a 'quick-fix' for software bugs. There is presumably much astronomical software, space-systems software, and defense-systems software that assumes UTC, UT1, and Greenwich Mean Time are all roughly equivalent. Right now those applications are unknown because they are not broken, but breakage would emerge if UTC is redefined—perhaps not all at once or in obvious ways. There is also a continuing need to deal with software problems handling past leap seconds, even if future leap seconds were suppressed.

Awareness of the potential for things to break is required if UTC is redefined, and preparations should occur before any decision is made (including cost estimates). The software issue is very much "Y2K-like", and from that experience, two options are expected to arise: one can either effect proper repairs (which means different things depending on the context of the application), or more likely, one will not have insufficient budget to effect proper repairs and there will be innumerable workarounds. Thus, if UTC is redefined, there is concern over the proliferation of workarounds that imitate what UTC does now, but with different assumptions being made depending on the immediate problem to be solved, and without concern to manage the incompatibilities. Suppression of *status-quo* UTC could actually multiply the number of time scales that use leap seconds, making systems more complex and less reliable.

Instead, application programming interfaces (APIs) are required based on existing standards that are rich enough to do what true experts need, encapsulated within a general-purpose library with appropriate defaults that will do the correct thing for the rest of the world. Most technicians are apolitical and seek ways to make systems work right, but current time APIs have not been developed by subject-matter experts. And even when developed by programming experts they have not captured the richness of time scales.

Unfortunately, many leap-second problems have been entirely avoidable and were caused by an available software patch or bug fix not being installed in advance (one only hears about the problems of systems that have not been updated). Additionally, some trouble is totally unrelated to the leap second and completely unexpected, such as when the U.S. Naval Observatory set their NTP servers to the wrong year in 2012, or when stormy weather causes power fluctuations and communication outages. It is difficult to predict how one system will respond relative to another system, and thus it is difficult to predict how the entire ensemble will behave.

The availability of time via GPS makes for more possibilities, and a TAI-like atomic timescale would be useful to distribute, from which intercalated UTC could be calculated. Today, software interfaces do not always have easy access to TAI-like time, because code that works with TAI or the equivalent can go through a lot of effort to get it; it essentially looks at UTC, which is reasonably accessible, and then subtracts out leap seconds. (There may be exceptions where operating systems support two different clock models that provide *monotonic time* to measure duration intervals, and a *real-time clock* to provide time stamping.) Explicitly exposing TAI-like time as a tool to be used in parallel with UTC could affirm or deny the speculation that a timescale without leap seconds is truly better than one with leap seconds, because people will choose the one that works best.

REQUIREMENT TO CONSIDER SOCIETAL CONCERNS

Professional timekeeping serves purposes valuable to society. Throughout history, even relatively primitive societies established professional institutions in charge of measuring time. The original ITU-R Study Question[2] may have been flawed from the societal perspective, because it emphasized a "globally acceptable" timescale instead of the most "globally available" timescale, *i.e.*, the default timescale for much of the public that does not focus on such things. What people on the street find available needs to be considered, not what experts find agreeable.

Yet, there is a danger in going to the public and asking "What do you think of the leap second?" To discover requirements for civil timekeeping, and to find out whether a change will bother the general public or not, investigative techniques from anthropological research are probably the most useful for identifying the breadth of the global community. For example, there is actually a great deal of sophistication taking place in the timing of ritual practices such as prayers, and the *Astronomical Almanac* is of critical importance for Islamic practice. The *Astronomical Almanac* is with respect to Universal Time (UT), and prayer times are disseminated to people who rely on UTC to know when to pray. Many are not content with pure astronomical calculations and would not like the idea of a timescale that goes without frequent monitoring and without awareness that clocks needs to be adjusted to something external.

A proposal to cease leap seconds also seems less likely to succeed when one considers the myriad of societal and cultural viewpoints behind the administrations of the ITU-R. ITU-R study groups have constrained their consideration to technical arguments primarily. Because eliminating the leap second may not benefit many societal elements, there is some doubt that those elements would support changing a working standard. National abstentions—by saying "we need more information"—appear as a safe position and offers *de facto* support for the *status quo*.

Of course, some cultural expectations for civil timescales cannot be met. For example, there is an implicit expectation that one should be able to easily convert from the smallest discernible unit to the largest. But our cultural inheritance has become a mishmash of atomic seconds, a day with multiple meanings, and a calendar year of varying duration. Regardless of the definition of UTC, civil timescales will never be truly scalable, and it would be a losing proposition to argue that a redefined UTC provides timekeeping simplicity by offering scalability.

REQUIREMENT FOR TECHNOLOGICAL CONTINGENCIES

Although the addition of leap seconds to a timescale based on SI seconds might seem inelegant, it may be the best that can be had for civil timekeeping on Earth. Otherwise, technical decisions about the future are likely going to be made on whether a change from the *status quo* will cause more trouble and expense than not changing (possibly ignoring other valid considerations). Thus, there is a requirement to anticipate the unforeseen technical consequences of any decision to alter the existing system versus keeping it.

If historic leap-second information is available, one can use TAI-like time stamps to record data wherever an unintercalated linear scale is needed, and these time stamps can then be converted to UTC and then to local time. However, there are both technical and political issues with proposing GPS time as part of any solution. GPS time is convenient, and better than anything else that can be had right now, but it is not authoritative. In sophisticated systems (such as GPS), it is still necessary to have human monitoring, rather than trust automated algorithms to discover all potential anomalies. A requirement for human management over timekeeping systems is not mitigated by a redefinition of UTC, or the addition of another time scale. Although society has become increasingly dependent on GNSS and GPS specifically, government efforts are not specifically targeting a civilian market to provide a robust GPS backup. "Targets of opportunity" from a dense infrastructure of available signals, might be used for navigation at some point in the future over terrestrial sources, but these sources are a potential victim of the same threats that would render GPS inoperable during hostilities.

Reprocessing data archives onto a different timescale is not a globally acceptable technological contingency; there may be other external operations that still use UTC so proper UTC handling does not go away. Redefining "Coordinated Universal Time" will not change the meaning or requirements for "Universal Time." Observational data will continue to exist, and users will have to deal with the different timescales regardless of whatever is done to UTC in the future.

REQUIREMENT FOR ACCESSIBILITY

The updates to leap-second tables have not seemed onerous to many precision users, because the process involves typing one line no less than every six months. Yet some NTP servers remain misconfigured after leap-second announcements, and there are also some systems where people dare not make changes, so un-automated changes will not happen. Thus, there appears to be a need to find some mechanism where historic leap-second information can be received passively. Specifically, the distribution should be something that a stand-alone system could safely use without having to worry about exposing the system to risk (contracting a computer virus, disclosing that the system exists, *etc*.). There is also a need to transport leap seconds into systems where no software updates can be made. And there is a need to standardize on conventional formats. IERS could improve the method of distributing leap second information, and that could improve the availability and accuracy of UT within computer networks, but the IERS is not a telecommunications entity.

If one wants an authenticated timestamp, then one should be prepared to pay for that service, because there is legal liability and a warranty implied with a signed timestamp. Issues of traceability and auditing, billing, and legal warranty all come into the issue. Radio signals are no longer considered precise enough for time coordination between individual laboratories, so there is the question of who still depends on precision UTC dissemination via radio broadcasts. There are radio receivers still under manufacture to detect wireless time-signal service signals, and legacy equipment is in use. Yet some high-precision radio receivers can no longer lock onto an accurate time because WWVB changed the signal modulation to be more suitable to reaching radio-controlled wall clocks and wrist watches. Although a strong market for radio-controlled clocks exists, GPS receivers are becoming increasingly more common and less expensive. GPS is already well known, well tested, well publicized, trusted and reliable, and several national GNSS systems are expected to be available that disseminate traceable time based on the SI second, allowing synchronization of local clocks to national standards with some quantifiable error. But discussion of GNSS is tangential to the *definition* of UTC: GNSS is useful as a conduit for time distribution, but it is not a definition for UTC and it does not answer the question that has been asked by the ITU-R.

It is an ongoing argument as to whether the ITU has domain over the Internet. Yet, because the Network Time Protocol (NTP) and POSIX chose to use—or rather abuse—the name UTC, they follow the radio standard. NTP is maintained quite independently of the ITU, and if NTP made a poor choice by using UTC as its reference scale, NTP could choose a different scale in the same way that the ITU-R might choose to change what it recommends for radio broadcasts.

REQUIREMENT FOR EDUCATION

There is a requirement that those inside and outside the ITU-R study process remain educated on civil-timekeeping. Collecting information from other groups is part of the study process right now, but most researchers are absolutely unaware of leap seconds or what is going on with the local timescale. The same techniques for communicating with the general public apply for the astronomical community and other scientific communities at large, because most of technical terms of timekeeping specialists have little meaning to the average astronomer or scientist.

For example, many astronomers are astrophysicists dealing with data from spacecraft which can be somewhat disconnected from Earth rotation. What is traditionally considered 'fundamental astronomy' is not taught much anymore. The pointing of telescopes and antennae is now done by a minority of astronomers for the convenience of the majority. This does not mean that astronomers will not complain loudly if a fundamental change to timekeeping creates breakage, and the majority may not realize why the breakage happened. Most astronomers will not bother to respond to polls on this issue, and those that respond will be divided in their answers, depending on their activities.

Although professional opinion polls have usually expressed strong preference for the *status quo*, the vast majority of the public has no idea that leap seconds are happening, no idea what the consequences will be, and their opinions about the subject can be almost random. The general public lacks appreciation for the fact that there are multiple timescales and the need to deal with multiple timescales. Thus, the issue of civil timekeeping is ultimately an educational one. The definitions necessary to understand the prime-meridian system and the definition of the day already exist, but wider understanding is needed.

CONCLUSION

As a source of atomic frequency, and as a realization of Universal Time (or, if one prefers, mean solar time at Greenwich), the civil-timekeeping standard known as Coordinated Universal Time (UTC) became a politically acceptable omnibus timescale. Within the past decade, the relevance of UTC's solar-timekeeping function has been questioned within the study groups of the ITU-R, the international agency which maintains the definition of UTC. However, when asked in 2012, the ITU-R did not accept a recommendation to decouple civil timekeeping from Earth rotation by ceasing leap seconds, but instead called for added study and invited the consideration of an unintercalated timescale for civil use by either "the modification of UTC or some other method."

It is hoped that these proceedings can assist the current study process. Regardless of the future definition of UTC, there will be a requirement to maintain a concept of uniform duration (atomic time) and a requirement to maintain a concept of (mean) solar time. Substantial changes to the current definition of UTC via TF.460, and thus to the global system of civil-timekeeping, first demands a cautious review of the requirements for civil timekeeping on Earth. A significant redefinition of UTC must recognize users of civil timekeeping and identify their needs foremost, and then meet with international consensus. The outcome must maintain the terminological integrity of specialized technical vocabulary such as 'Universal Time' to comply with international standards generally. In addition to synchronization with the synodic day, other societal concerns need continued expert investigation. There is a further need to consider different options and to anticipate their effects on existing applications in advance. Passive access to both atomic and astronomical time also seems necessary, as is a growing need to educate technical and non-technical users about civil timekeeping and the consequences of changing it.

Finally, it seems noteworthy that ITU-R Recommendation TF.1552 (suppressed in 2011) specifically recommended "that in applications requiring a uniform time scale TAI be recovered from UTC." Furthermore, ITU-R Recommendation TF.460 was already amended in 2002 to recommend dissemination of 'DTAI' (TAI−UTC) via time signals so that TAI can be recovered from UTC. Thus, former and existing ITU-R Recommendations already support the distribution of an unintercalated time scale by “some other method” and thereby appear to satisfy the current objectives of the ITU-R without alteration.

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