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ISSUES CONCERNING THE FUTURE OF UTC

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Historically, civil timekeeping has been based on mean solar time. With the discovery that the rotation of the Earth was not perfectly uniform, time scales based on the rotation of the Earth were differentiated from more uniform scales, with astronomical time still serving as the basis of calendars and time of day. UT1 is now the observationally determined time based on the rotation of the Earth, whereas International Atomic Time (TAI) is a precise uniform time scale determined from atomic clocks. Coordinated Universal Time (UTC) was introduced in 1972 as an atomic time scale referenced to TAI, but with epoch adjustments via leap seconds to remain within one second of UT1 for the purposes of civil timekeeping. A family of dynamical times was further established to satisfy the theory of relativity and the requirements of solar system ephemerides. A proposal to redefine UTC without leap seconds has been forwarded for final consideration by the Radiocommunications Assembly of the International Telecommunications Union (ITU) without having reached a consensus within the study group commissioned to resolve the study question. The question of whether to redefine UTC has been discussed, surveyed, and studied for over a decade, yet there is no public record of an analysis of requirements and no cost estimates of the various alternative options. The status of the leap second issue, user considerations and perspectives, and the unresolved issues concerning the proposed change to UTC will be overviewed in this paper. Due to the pervasiveness of the UTC time scale, concern is expressed that a fundamental change to UTC will require much technical activity, review, testing, and documentation changes. This will occur regardless of whether or not certain systems or applications functionally benefit from the change in definition, and may create additional work for applications which may not ordinarily deal with these technical details, or which are already satisfied and compliant with the status quo.

INTRODUCTION

Mean solar time was used for uniform-time measurement for millennia and has been used as the basis for civil time for centuries. Once the variability of the rotation of the Earth became detectable in the 20th century, Ephemeris Time was established as a theoretically uniform scale defined by the independent variable of solar-system ephemerides, which became the basis of the *Système International d'Unités* (*SI*) second in 1960. Universal Time stayed a measure of Earth rotation, serving as the global basis of civil timekeeping as it kept pace with the synodic day.

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At about the same time, precise timekeeping was developed based on atomic frequency standards. In the 1950s and 1960s, different timing centers used various technologies as frequency sources, and sought to coordinate their broadcast time scales with the rotation of the Earth by introducing small steps or changes in the length of the second.[1] The advent of spaceflight initiated more careful coordination of global timing centers, and as precision and techniques improved it became apparent that slight variations in the length of the broadcast second (or equivalently, in broadcast frequency), became increasingly inconvenient and potentially troublesome.[2]

When the *SI* second was redefined in 1967 in terms of the radiation from the hyperfine transition of the cesium-133 isotope, a background time scale called *International Atomic Time* (TAI) was maintained based on the accumulation of *SI* seconds from ensembles of atomic frequency standards.[3] However, pure atomic frequency was unsuitable for civil timekeeping because atomic frequency standards maintained a different rate than Universal Time of day. To avoid problems caused by varying the broadcast second, the epochs of the atomic scale were infrequently adjusted relative to TAI by inserting (positive) or neglecting (negative) leap seconds to remain within one second of UT1 for civil timekeeping. This system went into effect in 1972 and is called Coordinated Universal Time (UTC).[4]

By the 1970's, the operational difficulties concerning the definition and determination of Ephemeris Time were apparent, and a group of dynamical time scales based on the theory of relativity were developed. These evolved to be Terrestrial Time (TT), Barycentric Coordinate Time (TCB), Geocentric Coordinate Time (TCG), and Barycentric Dynamical Time (TDB).[5] More recently, highly specialized background time scales have been developed, each having some relationship to TAI or UTC. The reasons for their existence vary, including system security or avoiding leap seconds. Examples are GPS time, which approximates TAI plus 19 seconds, and communications systems that are intentionally offset from other scales for security purposes.[6]

Coordinated Universal Time (UTC)

Coordinated Universal Time (UTC) was adopted as a recommended means of broadcasting time signals by the International Radio Consultative Committee (CCIR)[*] after official consultation with affected scientific organizations, such as the International Astronomical Union (IAU). UTC provides the TAI frequency and time scale as an atomic realization of UT1 within ±0.9 seconds. UTC is the basis for time broadcasts by national time services and is the time distributed by other services. The predicted difference between UTC and UT1, known as DUT1, is made available to a precision of 0.1 seconds. Originally the Bureau of Longitude (BIH) was responsible for the international standardization of UTC. The International Bureau of Weights and Measures (BIPM) eventually took over responsibility for TAI, and the International Earth Rotation and Reference Systems Service (IERS) became responsible for UT1, DUT1, and leap second announcements.[7, 8, 9]

THE PROPOSAL TO REDEFINE UTC: 2000-2012

A proposal to redefine UTC by halting leap seconds after 2017 has been advanced from the Radiocommunications Sector of the International Telecommunications Union (ITU-R) Study Groups for the consideration by the ITU-R Radiocommunications Assembly in January, 2012. The proposal originates within ITU-R Working Party 7A, which appointed a Special Rapporteur

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Group (SRG) on the future of UTC in October 2000 to address the following ITU-R Study Question:[10, 11]

1. What are the requirements for globally-accepted time scales for use both in navigation and telecommunications systems, and for civil timekeeping?
2. What are the present and future requirements for the tolerance limit between UTC and UT1?
3. Does the current leap-second procedure satisfy user needs, or should an alternative procedure be developed?

The Study Question further decided that the "studies should be completed by 2002 at the latest" but this completion date has been continually extended up to the present (2011). User surveys and discussions have evidently taken place, but there have been no published studies that definitively answer the Study Question since its establishment.[12, 13, 14, 15] This is noteworthy because the Study Question decided that "the results of the above studies should be included in (a) Recommendation(s)." Study results would help resolve uncertainty about user requirements and provide insights regarding an optimum means for satisfying the users' needs.

The proposal to cease leap seconds is now quite long in the tooth.[16] By 2002 the SRG had already reportedly "converged to the opinion" to halt leap seconds, and called the ITU-R *Special Colloquium on the Future of UTC* in 2003 to present and discuss its judgment with interested and representative parties.[17] At the colloquium, which was advertised as "concluding" and for "drafting a recommendation to the ITU-R,"[18] the rapporteur group proffered the substitution of leap seconds with less-frequent *leap hours* to "satisfy all civil requirements and concerns" regarding potential problems with the definition of national time scales tied to Universal Time.[19, 20] However, continuing use of the titles "Coordinated Universal Time" and "UTC" was agreed to be potentially harmful and technically confusing because the label "Universal Time" is a technical term reserved for time of day based on Earth rotation.[21] The colloquium's consensus recommendation for a change of name was discounted by the SRG over concerns that it might cause "great confusion and complications in the ITU-R process." Afterward, the purpose of the colloquium was recharacterized to suggest that the SRG never had a conclusive proposal under consideration.[22, 23] ITU-R delegates from the USA and SRG later proposed a revised Recommendation within Working Party 7A calling for the replacement of leap seconds with leap hours, but the suggestion of leap hours was eventually deprecated. This resulted in the current proposal to simply discontinue leap seconds without an alternative adjustment mechanism.[24]

There have been limited studies of user requirements for time scales and accurate cost estimates are lacking. Surveys have favored the *status quo*, in most cases overwhelmingly. There has been no consensus on the subject of UTC redefinition in either Working Party 7A or its parent, Study Group 7. There have consistently been negative votes concerning the proposal. On a determination by the ITU-R that there was no technical basis for any objection, the proposed new definition was forwarded from Study Group 7 to the Radiocommunications Assembly of 2012.

ISSUES CONCERNING THE RECOMMENDATION TO REDEFINE UTC

There are a number of issues concerning the proposed redefinition of UTC that do not appear to have yet been satisfactorily addressed. There are differences of qualified opinions on the technical issues and in most cases supporting documentation is limited. There have been a number of papers written, including a special issue of *Metrologia* dedicated to the subject, which simply affirms that there are differences of opinion. The discovery of potential issues has not been exhausted due to a lack of methodology to address all relevant engineering requirements.[25] At best, here we can only attempt to increase awareness of the different issues and provide commentary

with the hope that these issues could be largely resolved before any final action is taken concerning the proposed redefinition of UTC.

Significance with respect to Radiocommunications

The current recommendation to redefine UTC was forwarded for consideration by the Radiocommunication Assembly on the grounds that opposition within the study groups could cite no technical issue related to radiocommunication. However, any radiocommunication issue at this time seems unremarkable compared to other technical, legal, and public issues. The major concern supposedly relevant to radiocommunication is the claim that "advances in telecommunications, navigation and related fields are moving towards the need for a single internationally recognized time scale to regulate and provide uniformity to these systems." Thus, navigation and communication systems need a continuous time scale.[20] The implication is that the presence of leap seconds makes UTC discontinuous, or worse, that "UTC is not a time scale on account of its discontinuities."[26] However, our calendar has leap days (February 29th) yet that does not make the calendar or its definition discontinuous. The existing UTC standard with leap seconds remains capable of time-tagging events unambiguously and with full atomic accuracy for centuries to come, while also satisfying long-standing requirements for civil clocks maintaining mean solar time.

Involvement of International Standards and Scientific Organizations

Currently there is a shortage of unified responses by many major stakeholder organizations. According to a summary by the former chairman of the SRG and Chairman of WP 7A…

> Studies and information gathering on the potential future of the UTC time scale have been conducted over the past ten years by special groups from the ITU-R, the IAU, the IERS, URSI, the American Astronomical Society, and others. The issue of a continuous time scale for general usage has been pushed aside or generally ignored by the scientific societies at large. Consequently, special study groups have been faced with little interest from the parent bodies, which has resulted in an inability for some to make informed decisions.[20]

Ordinarily, organizational abstentions would be regarded as contentment with the *status quo*, or at least evidence of ambivalence or a lack of consensus amongst professional memberships; however, ITU-R study groups have interpreted this situation as one of organizational neutrality or as "having no concern" about the subject of UTC redefinition.[27] Still, the five named organizations only represent a small fraction of the immense UTC user base, and ironically, the official positions of these named organizations are still largely indeterminate after a decade of consideration.

ITU-R. Direct discussions within ITU-R Study Group 7 and Working Party 7A have not led to a recognizable consensus after more than a decade; therefore, a questionnaire was circulated among the almost 200 member-state administrations of the ITU-R in 2010.[28] Approximately 5% of administrations responded to the questionnaire; but of those, most were already represented within Study Group 7 and Working Party 7A. This situation triggered the issuance of yet another questionnaire.[29] However, significant abstentions seeming reflect ignorance of the technical issues and their impact across the majority of ITU-R administrations.

International Astronomical Union (IAU). A special *IAU Working Group on the Definition of Coordinated Universal Time* was established in 2000, and after extensive consultation it concluded that there was "no strong consensus within the IAU either for or against a proposed change in the definition of UTC."[30] The group dissolved in 2006 understanding that no imminent action by the ITU-R was taking place.[31] However, IAU Commission 31 (Time) announced (via its website) that the IAU General Secretary responded to the 2010 ITU-R questionnaire, suggesting that the

IAU's "opinion has shifted toward eliminating leap seconds from UTC" since 2006.* The response was based on a letter from the Chair of Commission 31 who polled its nearly 100 members and received about six responses supporting the proposal and three opposing it.[32] However, after feedback from other IAU members of different Commissions, the IAU General Secretary directed the IAU's representative to the ITU-R to clarify that the IAU's importuned sector-member response to the ITU-R questionnaire did not represent the consensual opinion of its 10,000-member organization.

IERS. A 2003 survey by the IERS Earth Orientation Center suggested that the large majority of its users (88%) were satisfied by the current UTC determination method including leap second adjustments, and only 26% thought that changing the determination method would provide an improvement.[33] A 2011 survey in found that less than 20% of respondents favored the current proposal to cease leap seconds.[34] As a service of the IAU, the IERS does not have an organizational opinion on the matter of UTC redefinition; however, the IERS and the broader geosciences communities could be potentially deprived of public awareness if civil timekeeping is no longer based on Earth rotation.[35]

The International Union of Radio Science (URSI). URSI Commission J conducted its own survey in 1999-2000, with "about half the responses that were received were opposed to any change, while one-fourth were in favor of a change."[36] This survey might seem especially significant to the ITU-R having been commissioned by radio scientists; however, the ITU-R's SRG concluded that such fact-finding "did not provide any clear resolution."[37]

American Astronomical Society. The American Astronomical Society (AAS) Division of Dynamical Astronomy (DDA) produced a report to the AAS Council on the topic of UTC Redefinition in November 2005.[38] This report outlines arguments for and against change, suggested possible impact, but reached no conclusion or recommendation regarding UTC redefinition other than urging that the ITU-R take no action to allow all affected parties time to evaluate the technical merit of the recommendation.

Other scientific and international standards organizations should be officially consulted and involved with the proposal to redefine UTC. Considering the wide impact of UTC redefinition and its technical and non-technical ramifications, the ITU-R may no longer be sufficiently well positioned to broadly consider this issue. It has been recently proposed that responsibility for the definition of UTC should now be considered under the Meter Convention.[39]

Time Scale Nomenclature

When the conceptual definitions of time scales have changed, the names have also been changed to avoid confusion. In fact, the term *Universal Time* was encouraged to overcome a twelve-hour ambiguity with the previous term for mean solar time at Greenwich, *Greenwich Mean Time* (GMT).[40] In 1925 astronomical and navigational almanacs in the USA and Great Britain switched from the "astronomical day" which began and ended at noon to adopt the civil day beginning and ending at midnight; however, the British *Nautical Almanac* continued to label this new convention as GMT. Although the IAU has recommended since 1928 that "astronomers are advised not to use the letters GMT in any sense for the present," the acronym still survives as a common navigational synonym for UT1, and in non-astronomical usage as a synonym for Universal Time or UTC. [41, 42] Multiple issues are therefore perceived with regard to the need time-scale nomenclature.

* http://www.atnf.csiro.au/iau-comm31/activities.php

A civil standard decoupled from Earth rotation would be fundamentally different from existing and historical practice and the name UTC has been statutorily adopted in many countries. The lack of name change appears to alter the basis for civil timekeeping without the usual publicity required for such a conceptual and technical change. Universal Time remains a technical term reserved for Earth rotation. As was experienced with GMT, such terminology does not fall out of use easily. It would be legally, technically, and historically confusing to have a version of UTC with leap seconds and a version without leap seconds. It was concluded by the attendees of the ITU-R *Special Colloquium on the Future of UTC* in 2003 that "UTC without leap seconds" should omit any reference to "Universal Time" and that "International Time" (TI) might instead serve as a replacement label for "UTC without leap seconds."[43]

Applications dealing with historically UTC-tagged data cannot be spared from responsibly accounting for leap seconds, even if future leap seconds are abolished. It would be technically burdensome to have a historic version of UTC with leap seconds and a newer version of UTC without leap seconds—both called UTC. Many systems use an internal or background time scale (in the sense of a system of labeling epochs) such as TAI or GPS time to avoid leap seconds internally. These systems would not likely benefit from redefinition of UTC. Future systems would almost certainly be designed to use UTC as a uniform scale; these future systems would be serious disadvantaged should they discover that UTC is not historically uniform when processing historic data. Also, scientists and analysts, both now and in the future, would be inhibited from converting archives of historical UTC data onto a new uniform civil time scale once and for all, if both the past and future scales were identically called UTC.[44] Ironically then, the lack of a change of name could encourage the retention and proliferation of so-called internal "pseudo time scales" in future systems that must process historical data.[20]

Alternative Time Scales

In the past, a new time scale was introduced whenever technical requirements dictated such. Today, there are a staggering number of technically precise time scales available, most of which were invented in the last half-century.[45] With the exception of UT1, all modern scales are functionally related to, or approximate the rate of, TAI. Therefore, it seems reasonable to suggest that TAI be made available and used as a time scale without leap seconds, and as a source of determining precision time interval whenever necessary, rather than create yet another atomic time standard parallel to TAI called UTC. The suggested use of TAI* as an internal reference scale for operational systems has been explicitly recommended in the past by the Director of the BIPM, the Consultative Committee on Time and Frequency (CCTF), and the ITU-R via Recommendations TF.485-2, TF.536-2, and TF.1552.[46, 47, 48] The recommendation to broadcast DTAI = TAI – UTC for this purpose is still prescribed by Recommendation TF.460-6.

The ITU-R study group responsible for these Recommendations have noted that "TAI is not an option for applications needing a continuous reference" as it has no means of dissemination and is not physically represented.[49] It has also been noted that "GPS time is not a reference time scale but is instead an internal time for GPS system synchronization."[50] Nevertheless, many operational systems rely on high-precision GPS signals to establish internal reference time scales, such as CDMA cellular telephone networks.[51] Moreover, the DTAI is easily deduced from external data and added to UTC to recover TAI, as UTC is basically TAI with leap second adjustments. Therefore, if a time scale without leap seconds is required, a time scale comparable to

* "TAI" actually refers to TAI(k) = UTC(k) + DTAI, with "UTC(k)" being a realization from a contributing timing center , k symbolizing an identifying acronym of a particular time service, and DTAI equaling TAI – UTC.

GPS time or TAI could be introduced, not as a replacement but as an addition. For applications that only need precise time interval, differences between TAI or GPS time epochs suffice. For those who need only precise frequency without regard to epoch, *status-quo* UTC provides this already.

User Preferences

The opinions of the wide range of users who will be affected by the proposed change should be sought by official means. There have not been broad studies of who is using UTC or assessments of impact of the change on these different types of users, including costs. This is not surprising, however, as there is significant expense associated with accurate cost analyses, and organizations are likely unwilling to make such investments until they are necessary. Nevertheless, user surveys thus far have indicated that the majority of the respondents prefer retaining the *status quo*. The former Chairman of the SRG and Chairman of Working Party 7A acknowledges that recently reported issues involving leap seconds are small in number and seemingly result in "only minor anomalies," that users continue to express satisfaction with the status quo, and that contingency procedures already exist in situations where leap seconds might or might not be an issue:

> The 2005 [leap second] event allowed the ITU-R to collect further documentation on leap second problems experienced in the areas of communication, navigation and other electronic systems. […] From the small number of responses collected from international bodies, timing laboratories, satellite agencies and network engineers, it appeared that only minor anomalies occurred, mostly on GPS driven equipment and on NTP time servers. At the same time, a few of the responses indicated their satisfaction with the present UTC system. It was noted by some that the early announcement of the leap second application by the IERS allowed them to avoid or fix any potential anomaly. In one case a computer network was shut down about an hour before the leap second occurred and brought back into operation an hour afterwards. The indications were that system operators using time information have learned to cope with the irregularities by one means or another, service disruption being one method.[20]

Thus, a major concern is that there is no publicly available documentation that adequately or consistently justifies a proposed redefinition of UTC or expresses overwhelming user dissatisfaction with the *status quo*.

Software and Hardware Modifications

Global navigation satellite systems (GNSS) are often cited as applications benefiting from the elimination of leap seconds.[52] However, GPS as a system is not particularly affected by leap seconds, and UTC redefinition may require changes to end-user software, where the difference between UTC and UT1 are expected to be less than 1 second, such as spacecraft and ground observing systems that equate UTC and UT. [53, 54, 55] Even systems requiring no changes from UTC redefinition will still need to be thoroughly investigated and tested to determine this for a fact. This would be an unnecessary cost incurred by systems already compliant with the existing standard.

Alternate implementations of timekeeping systems in software systems which preserve Universal Time may provide compromises that could simplify the solution of the problem. [56, 57] There is limited evidence that organizations and professionals with expertise on many types of software have been consulted, and the status of any formal communications with computer-science and software development organizations regarding the proposal is unclear. Computer scientists and software developers would be a useful source of information about methods to handle the current UTC and what would be involved in any possible change to UTC.[58]

Timing signals are now widely distributed by telecommunications networks with varying accuracies.[59] Because computers are not very good time pieces, many systems frequently and auto-

matically check for time updates. The costs of changing software due to a change in the definition of UTC are not well established, whereas the distribution of UTC with leap seconds on computer networks is already being facilitated and would be expected to be facilitated, if no change were made.[60, 61] There are many software development firms that would be affected by this proposed change (if nothing else, documentation would need to be revised).

Distribution of UT1

The IERS will continue to estimate UT1. The need will remain to provide UT1 and DUT1 in an easily accessible manner to the many users.[62, 63] Also, as DUT1 becomes non-negligible, there will be increasing numbers of users of UT1 data. Throughout the long discussion concerning the proposed redefinition of UTC, but there has not been specific information as to what data would be made available and how it would be distributed after the change, even though distribution of UTC, UT1, and DUT1 is fundamentally a telecommunications matter. It would be naïve to presume that every user of UT has a computer network by which information access is unlimited, and it is unknown how robust UT1 / DUT1 servers are to network denial-of-service attacks or other service outages.

Legal Considerations

In almost all countries the official (regulatory) time is realized as a fixed offset from some national frequency standard synchronized to UTC. In some nations statutory basis for official time is specified in relation to mean solar time at Greenwich or Universal Time; in other countries it is explicitly designated as Coordinated Universal Time.[64] For nations where statutory basis is Universal Time; the proposed redefinition of UTC defines a scale that increasingly deviates from the legal prescription without bound, resulting in a *de facto* change in the legal time. There would at least be a need for statutory and regulatory changes to national legal systems for which astronomical time is the explicit standard. For countries where statute explicitly designates Coordinated Universal Time, there may be a question as to whether there is clear understanding of the consequences of decoupling civil time from Earth rotation by legislators, as representatives of the general public. They could be confusion as to whether UTC still represents Earth rotation and astronomical time as the implicit standard.

Non-Technical and Non-Scientific Applications

There may be a variety of societal practices that are linked to Universal Time, the impact of which is presently unclear. One particular issue, which has been raised but not pursued within the precision time and time-interval community, is religious activities or religious preferences.[65] Sacred holidays which are astronomically determined, and calendars which have been refined through the ages to maintain concordance with the heavens in the long term, exemplify a philosophy supported by religious texts that time reckoning by astronomical means is divinely established.[66, 67]. Local clocks and almanacs (or equivalent software) serve as intermediates for certain ritual customs that depend on actual sightings of the Sun or the Moon, whenever it is impractical for individuals to accomplish accurate astronomical sightings. For example, daily prayer times may be regulated by astronomical time of day and the apparent position of the Sun; such times are functions of Universal Time, luni-solar ephemerides, and the worshipper's location on Earth. If the definition of UTC is a consideration in the scheduling of worship activities, the degree to which religions might endorse the decoupling of clock time from Earth rotation is not well documented, and the consequences do not seem to have yet been thoroughly explored or dismissed by religious authorities, who may or may not have vested reliance or strong philosophical preferences regarding the representation and distribution of astronomical time.

Re-education

There is presumably a large amount of technical and educational literature reliant upon or citing the current definition of UTC, which would need to be revised if UTC is redefined.[68] Much literature and textbooks are dedicated to explaining the definition of UTC and its relationship with other time scales. To fundamentally different definitions of UTC and their dates of implementation will need to be clearly documented, perhaps taking many decades for understanding to propagate through user communities.

Celestial Navigation and Almanacs

Celestial navigation is no longer routinely used, but it is still widely taught and critically relied upon as a backup to electronic navigation aids.[69] There may be questions or confusion concerning the necessary corrections to a time scale not tied to the rotation of the Earth during a nautical emergency. Similarly Universal Time is used in national almanacs. A change in the definition of UTC might necessitate changes to almanacs and might present challenges on how to conveniently provide data and to educate almanac users of the change.[70, 71]

Rate of Rotation of the Earth

There is a long term slowing in the rate of rotation of the Earth that would indicate that sometime in the future the rate of leap seconds should increase. Currently the rotation rate of Earth is not closely following the long term trend, so predicting the short-term rate of leap second insertion remains inaccurate. Also, there seems to be conflicting opinions as to the consequences of increasingly frequent leap seconds. Some experts speculate that problems "will become worse when multiple leap seconds per year will be required."[72] Others suggest that a primary problem with leap seconds is their unusual rarity; if so, their increased frequency should lead to more awareness, better support, and improved infrastructure.[73] Regardless, the system of leap seconds was introduced at a time when the rate of insertion was already anticipated to be twice per year (with guidelines suggesting that these insertions take place primarily at the end of June and December), with two adjustments introduced during calendar year 1972.

Long-Term Societal Effects

Because the issue of decoupling civil time and Earth rotation has not been seriously contemplated before now, the long-term philosophical and sociological concerns do not appear to have been carefully assayed.[74] If mankind formally severs its timekeeping from the motion of the sky, it remains unclear how the two might ever be returned again. The cessation of leap seconds now would remove future expectations that timekeeping and telecommunications equipment have built-in capability to maintain intercalary adjustments, creating technological barriers for realigning global timekeeping practices back to the heavens.[75] Long-term adjustment scenarios have been contemplated, such as so-called leap hours or adding a number of seconds or minutes to the end of each century, but these alternatives have all of the drawbacks of the current definition and without the benefits.

A PROPOSED APPROACH

Based on the lack of responses from ITU-R member administrations regarding recent ITU-R Questionnaires on the issue of the UTC redefinition, it seems that most administrations are not sufficiently informed to make decisions concerning the issue involved. Hence, the 2012 Radiocommunications Assembly may not be the most appropriate time or place for a conclusive decision concerning the definition of UTC. Before any final action is taken on a proposed redefinition of UTC, the following activity would seem prudent.

1. Study Question ITU-R 236/7 explicitly decided that the study results should be included in whatever Recommendation was brought before the ITU-R. Because there is no publicly available study outcome that adequately or consistently justifies a proposed redefinition of UTC, the current Recommendation should be withdrawn and Study Question should be reconsidered.
2. Because the ITU-R Working Party 7A has not been able to establish a conclusive and consensual study outcome after more than decade of consideration, international standards and scientific organizations should become more involved to help determine what stakeholder organizations and user groups outside the ITU-R should become involved in the decision.
3. User requirements for time scales like UTC, UT1, and TAI should be well established from the study efforts. The means to satisfy established user requirements should be documented and pursued.
4. A consensus (unanimity) should formally be sought between international standards organizations, scientific organizations, and national governments before changes to existing conventions are exercised.

The 1960's paradigm for having a singly transmitted time scale has already been disrupted by worldwide exposure and easy access to high accuracy GNSS signals, so consideration should be given to making existing, more-uniform alternatives to UTC more visible. One possible solution to all concerns would be the distribution of TAI through the broadcast of DTAI. This compromise would require *no change* to Recommendation 460-6 because the transmission of DTAI is already recommended by Recommendation 460-6. Unfortunately its operational implementation has been seemingly delayed owing to the inconclusiveness of Study Question ITU-R 236/7 and ceaseless uncertainty regarding the future status of Recommendation 460. Therefore, simple defeat of the proposed revision to Recommendation 460-6 by the ITU-R Radiocommunication Assembly could retire the debate long enough for timing centers and hardware manufacturers to begin the broadcast distribution of DTAI such that users can realize TAI(k) = UTC(k) + DTAI alongside UTC(k) wherever warranted.

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