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|  | | CPG15(15)084 Annex IV-15 |
| Norway, Bergen, 14th - 18th September 2015 | | |  |
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CEPT BRIEF ON AGENDA ITEM 1.14

1.14 to consider the feasibility of achieving a continuous reference time-scale, whether by the modification of coordinated universal time (UTC) or some other method, and take appropriate action, in accordance with Resolution 653 (WRC 12)

# ISSUE

This agenda item will consider the feasibility of achieving a continuous reference time-scale, whether by modification of coordinated universal time (UTC) or by some other method, and take appropriate actions in accordance to Resolution 653 (WRC-12).

Resolution 653 (WRC-12) invites ITU-R “to conduct the necessary studies on the feasibility of achieving a continuous reference time-scale for dissemination by radiocommunication systems”; and “to study issues related to the possible implementation of a continuous reference time-scale (including technical and operational factors)”.

# CEPT position

* CEPT has not agreed on an ECP on this issue
* CEPT does not support introduction of a continuous reference atomic time-scale based on TAI to be broadcasted on an equal basis with UTC (Method B).

# Background

This agenda item was created as a result of the outcome of RA-12 following discussion of the proposed modifications to ITU-R Recommendation TF 460-6 proposing to discontinue the insertion of leap seconds in the definition of UTC. The approval of the recommendation was sent to RA-12 as there was no consensus in working party 7A and Study Group 7 after extensive debate over several years.

At RA-12 there was an even balance between those administrations in favour of the draft revision of the Recommendation and those opposing it. A large third group of administrations indicated that they had not participated actively in the work of Study Group 7 and Working Party 7A and that more time/information was required to form an opinion. As a result RA-12 decided not to approve the draft revision, and that instead it be returned to ITU-R Study Group 7 to consider other technical options, in addition to those already considered in the preparation of the draft revision. These additional studies should take account of broader implications and include consultations with appropriate external organisations. A key element of this compromise package was that the Chairman of RA-12 would include a proposal for an Agenda item at WRC-15 to discuss the issue and ensure wider discussion in the framework of WRC preparation.

Why is UTC not a continuous time-scale?

For millennia time was measured as a consequence of Earth rotation around its axis and around the Sun where 24 hours marked the crossing of the Sun at the meridian. Universal time is a measure of time that conforms to the mean diurnal motion of the Sun as observed at the prime meridian. The unit of time, the second, used to be considered as the fraction 1/86400 of the mean solar day. This definition was sufficient at a time when no telecommunication systems existed and navigation was based on celestial observation.

However because of the irregular rotation rate of the Earth the duration of a day is not constant, this became noticeable when systems (i.e. telecommunications etc.) began to rely on a precise and constant time scale. A first attempt to create a constant time scale was made by introducing the ephemeris second in 1960. Later on in 1967 the SI second (close to the ephemeris second of 1952) was defined as the duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium 133 atom.

From 1967 time became linked to the atomic SI second whatever the irregularities of the Earth rotation making the days longer or shorter when measured with the new atomic time scale.

This time difference between the atomic time and the universal time was initially about 1s per year. This is the background to the issue which has arisen implementing the system using this time discontinuity.

Coordinated Universal Time (UTC) is the international standard time scale for all practical timekeeping in the modern world. Recommendation ITU-R [TF.460-6](http://www.itu.int/rec/R-REC-TF.460-6-200202-I/en) which is incorporated by reference in the Radio Regulations provides the official definition of UTC. UTC is maintained by the International Bureau of Weights and Measures (BIPM) by the contribution from timing laboratories throughout the world, operating atomic clocks, and data from the International Earth Rotation and Reference Systems Service (IERS).

UTC is a time scale based on atomic time but synchronized with the universal time UT1 in such a way that the difference between UTC and the mean solar time UT1 is always less than 0.9 s, it was introduced in 1960. Since 1972 the practice to solve this problem is to adjust UTC by inserting or deleting a second whenever the difference with the universal time became close to 0.6 s.

In 1972 it became necessary to introduce two leap seconds. After 1972 there was a need to insert one leap second per year. However in recent years the slowing of the Earth rotation has reduced slightly and this has resulted in leap seconds being applied far less frequently. Currently this is about once every 3 to 4 year.

Preliminary analysis of possible solutions to satisfy the issue

CPM15-2 (Conference Preparatory Meeting) met in Geneva during 23rd March to 2nd April 2015 revised CPM text on AI 1.14 which now includes the following 4 methods to satisfy the agenda item ;

* After a transition period of at least 5 years, remove the procedure of leap second insertion in the definition of UTC in order to provide a continuous time-scale and either retain or change the name of UTC (Method A1/A2);
* Keep the current definition of UTC and disseminate a continuous time-scale based on the International Atomic Time (TAI) along with UTC (Method B);
* Keep the current definition of UTC and enable the recovery of TAI, or other continuous timescales, from the current implementation of UTC (Method C1/C2);
* No change in definition of UTC in the Radio Regulations (Method D).

Suppressing the insertion of leap seconds in the definition of UTC (Method A1/A2)

The first method proposes to achieve a continuous time-scale by ending the insertion of leap seconds, revising the definition of UTC and removing the incorporation by reference of Recommendation ITU R TF.460.6 in the Radio Regulations.

On one side some administrations consider it a significant issue that if leap seconds are no longer used for the first time in human history UTC will no longer bear any relation to the physical attributes of the planet and will diverge from mean solar time at the prime meridian by around 1 minute per century.

Some systems currently relying on the use of leap seconds in UTC will not be able to adapt to the new definition of UTC without manual intervention to insert corrections regularly. It will then be necessary to change or update the software and in some cases also the hardware operating these systems (backward compatibility is not ensured) which will lead to costs. Failure of these systems and some new systems relying on UT1 caused by inadequate software or human factors could increase.

One example of systems relying on UT1 are telescopes. Pointing correctly to a celestial object requires to know the location of the telescope and the value of UT1. For low resolution telescopes such as amateur instruments the approximation of UT1 through UTC is sufficient but for large instruments the precise knowledge of UT1 is necessary. In the first case software will need to be updated in order to recover UT1 from UTC, if it were not the case in one century the telescope would point where the celestial object was one minute ago but not at the time of observation. In the second case things would not change because the difference between UTC and UT1 would continue to be disseminated, however it would be important to check if the current software accepts a difference between UTC and UT1 larger than 1 second.

Furthermore it may be necessary to modify legal and technical documents on both the international and national levels since many of them refer to the UTC time-scale for time measurements.

ISO TC 37 indicated that retaining the name UTC with a new definition would result in polysemy (ambiguity), i.e. having multiple meanings, which contravenes the principles of Standards making. It would become unclear whether the term UTC refers to the old definition with leap seconds or the new definition without. For this reason some administrations consider that the name Coordinated Universal Time should not be retained for a time scale without leap seconds that would no longer be aligned closely with Universal Time (Method A2). Some other administrations however consider that the continued use of the name “Coordinated Universal Time” (UTC) will avoid confusion and maintain consistency, as UTC will continue to be “universally” used and “coordinated” worldwide (Method A1).

On the other side the use of UTC without leap seconds will establish a continuous reference time-scale, based on atomic time, from which other specialized continuous time-scales with or without fixed offset can be derived. A UTC time scale without leap seconds can result in the use of only one continuous reference time scale for all telecommunication systems making it truly universal.

The definition of civil time based on UTC will not change as the deviation between UTC without leap second and solar time although increasing will be negligible on a human scale as it should be approximately one minute per century which is far less than the difference between solar time and local time in most of the places on Earth. It is worth noticing that with the definition of the SI second the difference between the duration of a mean solar day measured through astronomical observation and the duration of a day measured with the SI second has never been more than 3 ms. Some administrations are of the opinion that indicating that UTC will no longer bear any relation to the physical attributes of planet Earth is grossly exaggerated.

Suppression of the use of leap seconds in UTC will eliminate the software, protocols, or coordination necessary to insert leap second.

Because leap seconds adjustments are irregular they are therefore inserted manually rather than automatically, many systems in operation worldwide will not notice that the insertions have ceased altogether.

Applications such as astronomy or celestial navigation requiring a precise knowledge of UT1 will not be affected as the precise link between UT1 and UTC will be preserved. The International Earth Rotation and Reference Systems Service (IERS) publishes electronically in the IERS Bulletin A (weekly) near real time predictions of UT1-UTC over one year that give users access to UT1 with a precision that is 100,000 times better than that available from present broadcast UTC.

Disseminating a continuous time-scale along with UTC as currently defined (Method B)

Because of the above disadvantages it is proposed to consider keeping the current UTC time-scale without changes but bringing into use a continuous time-scale based on TAI on an equal basis.

This method allows operation of the systems using the current UTC time-scale without any changes and costs and also allows elimination of many of the problems related to corrective action i.e. because in each case the most suitable time-scale can be chosen and applied for a particular system.

However to implement this solution it is necessary to study the possibility of disseminating the continuous time-scale TAI together with UTC and if results are positive prepare appropriate proposals for modification of Recommendation ITU-R TF.460-6. Furthermore the two time-scales will need to be differentiated in a truly fail-safe manner leading to probable modification of application software and hardware in order to differentiate between the two time-scales and may be cumbersome and costly.

To keep the current definition of UTC and to amend Recommendation ITU-R TF.460-6 to reflect the way to extract a continuous time-scale from UTC (Method C1/C2)

Under this proposal the current definition of UTC with leap second is kept and Recommendation ITU-R TF.460-6 is revised to include new definitions that can be used to recreate TAI or another continuous time-scale from UTC.

Methods C1 and C2 have the advantage for systems requiring a time close to UT1 by no more than 0.9 s to continue to operate without any update and for others that prefer to use a continuous time-scale to use it, by knowing the offset from UTC.

In order for a system to take advantage of this change it will need its software updated in order to use the difference figure to extract the continuous timescale from UTC.

This solution satisfies the needs of all communities with minimal change to the status quo. UTC is unchanged and continues to be the single broadcasted timescale. The needs of users who require a close link between UTC and UT1 will continue to be met because there is no change to UTC. This means that there is no risk of system failure for systems which rely on the close connection between UT1 and UTC. At the same time the needs of users who require a continuous timescale is met because the difference figure between UTC and the continuous timescale will be available.

However, for systems that will continue to use UTC the insertion or deletion of leap seconds is continued with the associated risks and consequences.

Under Method C1 Recommendation ITU-R TF.460-6 is amended to clearly state that using TAI is an acceptable alternative for those requiring a continuous time-scale and that it can be derived from UTC using a difference offset integer seconds number. This implies that the correction between TAI and UTC is disseminated and available to all parties.

An advantage of Method C1 is that it will avoid the proliferation of continuous time scales because TAI will be the only continuous timescale. Existing users of other continuous timescales can easily derive those timescales from TAI.

Method C2 is similar to Method C1 except that Recommendation ITU-R TF.460-6 would be amended to include additional definitions, corrections and/or materials with respect to the feasibility of using continuous system time-scales for radiocommunication systems.

An advantage of Method C2 is that it takes into account that some radiocommunication systems, such as global navigation satellite systems (GNSS), reproduce internal timescales for synchronization and make it available for usage by other radio communication systems. Introducing additional definitions, corrections and/or materials with respect to the feasibility of using continuous system time-scales for radiocommunication systems will help to avoid confusion among users and to make clear relations between UTC and system times.

Both Methods C1 and C2 require changes to Recommendation ITU-R TF.460-6. In order to implement these changes a new WRC Resolution or an amendment to the existing WRC Resolution 653 will be required.

No change to the Radio Regulations (Method D)

This new method on No Change to the Radio Regulations was added at CPM15-2 following proposal from 6 administrations. This method was based on the argument that the results of the ITU-R studies are inconclusive, and postponing the decision would allow administrations to get a better understanding of the implications of modifying UTC.

The advantages and disadvantages of all the various options proposed can be summarised in tabular form as follows:

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| Description of Method | Advantages | Disadvantages |
| * After a transition period of at least 5 years, remove the procedure of leap second insertion in the definition of UTC in order to provide a continuous time-scale and retain the name of UTC;   (CPM Method A1) | Single broadcast continuous timescale which is beneficial for telecommunications systems  Removes risk of system failure due to incorrectly adding leap seconds  Remove the risk of time tagging ambiguity when the leap second is the simple repetition of the previous second  Most legislation etc. unchanged | Results in polysemy  No backward compatibility for some existing equipment unless correction is applied for systems aligned to the earth rotation with risk of error  Some documentation requires change  Lose link between time and earth’s movements (about 1 minute per century) |
| * After a transition period of at least 5 years, remove the procedure of leap second insertion in the definition of UTC in order to provide a continuous time-scale and the name of UTC is changed;   (CPM Method A2) | Single broadcast continuous timescale which is beneficial for telecommunications systems  Removes risk of system failure due to incorrectly adding leap seconds  Remove the risk of time tagging ambiguity when the leap second is the simple repetition of the previous second | No backward compatibility for some existing equipment unless correction is applied for systems aligned to the earth rotation with risk of error  Significant changes to legislation, etc.  Lose link between time and earth’s movements (about 1 minute per century) |
| * Keep the current definition of UTC and disseminate a continuous time-scale based on the International Atomic Time (TAI) along with UTC;   (CPM Method B) Note - no support expressed for this option in CPT. | No changes to civil timescale  No changes to legislation  System owners can choose most appropriate timescale | Retains risk of system failure due to leap seconds being applied wrongly in systems using UTC  Possibility of confusion between UTC and TAI |
| * Keep the current definition of UTC and enable the recovery of TAI, from the current implementation of UTC.   (CPM Method C1) | Single broadcast timescale  No change to civil timekeeping  No risk to existing equipment relying on connection between UTC and UT1  No changes to legislation etc.  Clear option for those wanting continuous timescale  Avoids proliferation of continuous timescales | Retains risk of system failure due to leap seconds being applied wrongly  Risk of interoperability problems with systems using UTC and others using TAI  For a system to take advantage of the change it will need its software updated in order to use the offset to extract the continuous timescale from UTC. |
| * Method C2 is similar to Method C1 except that Recommendation ITU-R TF.460-6 would be amended to include additional definitions, corrections and/or materials with respect to the feasibility of using continuous system time-scales for radiocommunication systems.   (CPM Method C2) | Single broadcast timescale  No change to civil timekeeping  No changes to legislation etc.  Clear option for those wanting continuous timescale | Retains risk of system failure due to leap seconds being applied wrongly  Risk of multiple continuous timescales leading to confusion as well as interoperability problems.  For a system to take advantage of the change it will need its software updated in order to use the offset to extract the continuous timescale from UTC. |
| * No change to the Radio Regulations. * (CPM Method D) | Single broadcast timescale  No change to civil timekeeping  No changes to legislation etc. | Retains risk of system failure due to leap seconds being applied wrongly  No continuous time-scale, the agenda item is not solved |

# List of relevant documents

* ITU-R Recommendation TF 460-6 - Standard-frequency and time-signal emissions
* Resolution 653 (WRC-12)
* Study Group 7 chairman report to RA-12, Document 7/1001
* http://www.itu.int/md/R12-CPM15.02-R-0001/en
* Recommendation ITU-R TF.686-3
* ITU/BIPM workshop presentations (19-20 Sep 2013)
* (<http://www.itu.int/ITU-R/index.asp?category=conferences&rlink=itu-bipm-workshop-13&lang=en>)

# Actions to be taken

none

# Relevant information from outside CEPT

## European Union (date of proposal)

## Regional telecommunication organisations:

APT (1 September 2015)

* APT Members are supportive of the studies undertaken by ITU-R WP 7A on the feasibility of achieving a continuous reference time-scale.
* A continuous international reference time-scale proposed by Method A1/A2 of the CPM Report is beneficial for most users, and an appropriate implementation of continuous international time-scale should be developed and agreed by relevant international organizations.
* A continuous international reference time-scale can be achieved, proposed by Method A1/A2 of the CPM Report, by stopping the insertion of leap seconds in UTC.
* Suppression of leap seconds proposed by Method A1/A2 of the CPM Report reduces the risk of operator error and increases the reliability of systems that depend upon time.
* The dissemination of two “standard” time-scales proposed by Method B of the CPM Report might bring significant risks of confusion, and it would be critical for the two scales to be differentiated in a truly fail-safe manner.
* Considering its wide applications, the change of the name of UTC proposed by Method A2 of the CPM Report must be treated with worldwide caution on both the international and national levels.
* To allow for an adequate period of time for legacy systems reliant on the use of leap seconds to adapt to the change in UTC, the application of the suppression of leap second adjustments to UTC will be effective no less than five years after the date of entry into force of the Final Acts of the WRC-15
* APT Members support Method A1 of the CPM Report to WRC-15, which is to achieve a continuous time-scale by stopping the insertion of leap seconds in UTC and to retain the name of UTC

ATU (1 September 2015)

No ATU common position

[ECOWAS COMMISSION ECONOMIC COMMUNITY OF WEST AFRICAN STATES

ECOWAS common position

Supports method D (NOC) as option 1 and method C1 as option 2]

Arab Spectrum Mangement Group (1 September 2015)

* ACP: NOC
* No change in definition of UTC as specified in Recommendation ITU R TF.460-6, which will
* remain the only time-scale which is broadcast in order to avoid any confusion

CITEL (11 Nov 2014)

IAP supporting Method A1

RCC (1 September 2015)

RСС position

The RCC Administrations support keeping unchanged the definition of the Coordinated Universal Time (UTC) specified in RR No 1.14 and in Recommendation ITU-R TF.460-6.

## International organisations

IATA (date of proposal)

ICAO (September 2015)

NO ICAO position on AI 1.14

IMO (December 2014)

Draft IMO position

IMO requests that the importance of the maritime systems is acknowledged in deciding on this agenda item and attempt to minimize the impact on maritime services.

NATO (September 2015)

NATO Military Position

NATO will continue to monitor the progress on this item and will evaluate the potential impact on military systems, but NATO has determined that if modified UTC were adopted, a transition period of 5 years or more would be required to implement this change.

SFCG (September 2015 )

SFCG is of the opinion that space science satellite operations and launches would benefit from a continuous time scale that is unambiguous in its application.

## OTHER INTERNATIONAL AND REGIONAL ORGANISATIONS

ESA (September 2014)

Supports SFCG positions

Eurocontrol (September 2015)

No position on AI 1.14

International Astronomical Union (IAU)

CRAF

No position on AI 1.14

[CRAF has decided to adopt the position of the International Astronomical Union (IAU) which has not yet been finalized.]