Radiocommunication Study Groups

REPORT ON
POSSIBLE REVISION OF THE UTC TIME SCALE

49th Meeting of the CGSIC
Timing Subcommittee
22 September 2009

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TOPICS

Question on the Future of UTC

Study Activities

Proposed Modification

Activities

Summary of Views (Favoring, neutral and opposed)

Conclusions

Letter from Director BIPM to Secretary General, ITU (1999)

Sent at the Request of the CCTF

Issues were raised in the CCTF concerning discontinuities in UTC creating problems in coordinating telecommunications systems

Time as used in navigation satellite and telecommunications systems could possibly lead to multiple independent timekeeping systems (e.g. GPS Time) vice UTC.

Difficulties in computer systems and networks to adjust for time steps or leap seconds

ITU-R issued new Question ITU-R 236/7, The Future of The UTC Time Scale

The Future of The UTC Time Scale

Question ITU-R 236/7
(2000)

1. What are the requirements for globally-accepted time scales for use both in navigation and telecommunications systems, and for civil time-keeping?
    - Accuracy, Stability, Based on the SI Second
    - Uniformity, Accessibility
    - Reliability
    - Availability
    - Civil / National Timekeeping

2. What are the present and future requirements for the tolerance limit between UTC and UT1?
    - |UT1 – UTC| Tolerance of 0.9 seconds
    - Could a Greater Tolerance be Accommodated?

3. Does the current leap second procedure satisfy user needs, or should an alternative procedure be developed?
    - Availability of Leap Second Information for Users
    - Alternatives Used (Establishing System Independent Time)
    - Relationship of Telecom & NAVSAT System Internal Time to Time Scales

ITU-R TF.460-6 STANDARD-FREQUENCY AND TIME-SIGNAL EMISSIONS
(1970-1974-1978-1982-1986-1997-2002)

To maintain worldwide coordination of standard frequency and time signals

Disseminate standard frequency and time signals in conformity with the SI second

Continuing need for UT immediate availability to an uncertainty of 0.1 second

TAI - International reference timescale of atomic time based on SI second as realized on a rotating geoid. Continuous scale from origin 1 Jan 1958

UTC - Basis of coordinated dissemination of standard frequency and time signals. Corresponds exactly in rate with TAI but differs by integral number of seconds.

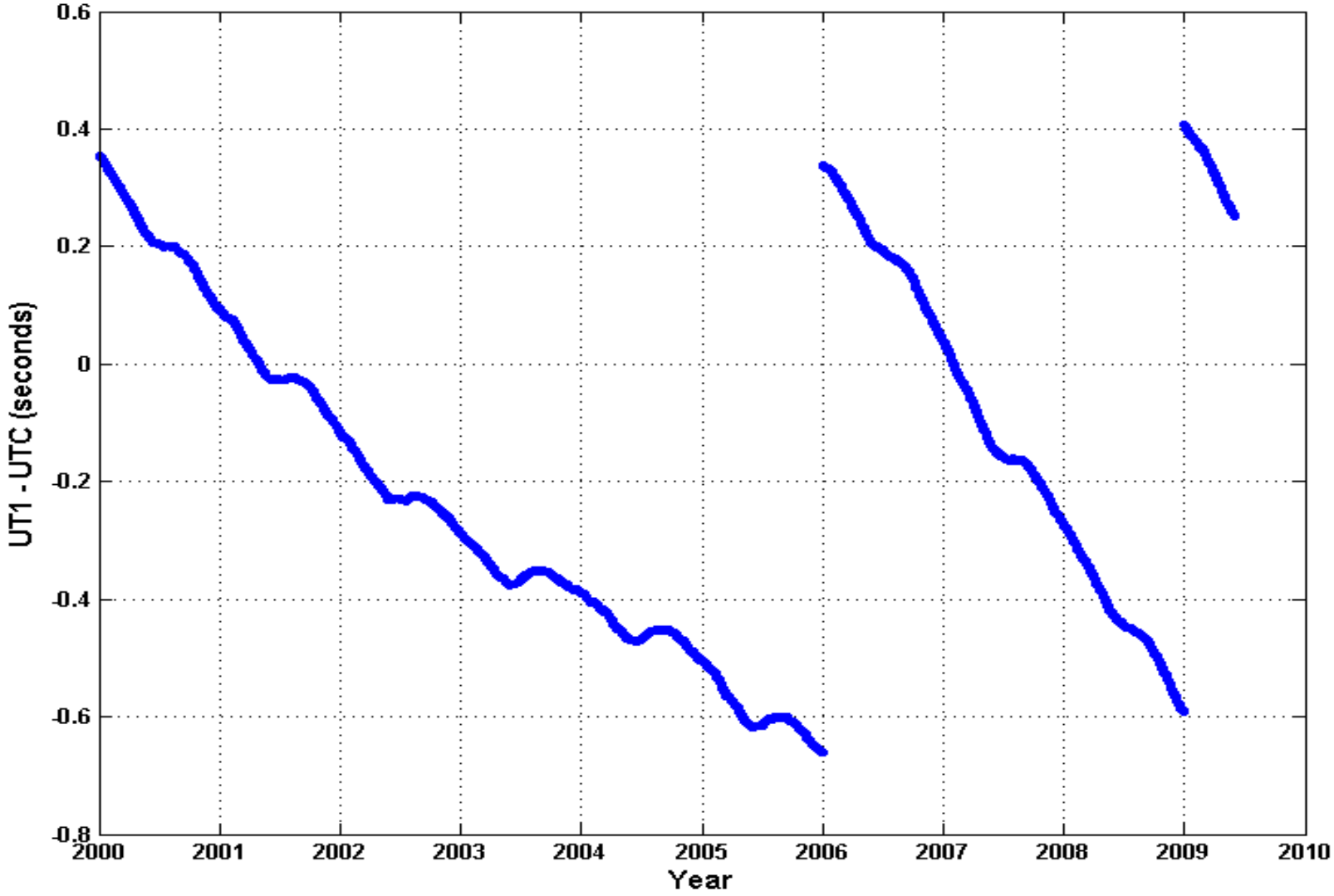
UTC scale adjusted by insertion or deletion of seconds to ensure agreement with UT1

DUT1 - Dissemination to include *predicted difference* UT1 – UTC

(values given by IERS in integral multiples of 0.1 s)

Leaps Seconds may be introduced as the last second of a UTC month
December and June Preferred, March and September second choice

UT1 - UTC


0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
UT1 - UTC (seconds)
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year

ACTIVITIES

Overall Working Party Special Rapporteur Group efforts were generally ignored

Surveys were inconclusive and data calls were less than fruitful

Astronomical community at large has moved to dynamic relativistic time scales based on TT (1980)

Definition of Spatial Reference Systems are benefiting from new capabilities such as GPS

Assessment of developments in radio- and tele-commnication are indicative:

- **Ad hoc time in systems are driven by need for "Real-time" accuracy and precision**
- **"Local Time" determined by statistical process of many standards/clocks are being employed in new systems - UTC(k)**
- **Telecommunications capabilities increasing by distributed syntonized operation (CDMA Network)**

Summary of Views Favoring

Interests in space activities, global navigation satellite systems, telecommunications, network synchronization, and electric power distribution have requested continuous time scales

Digital time distribution systems cannot deal efficiently with leap seconds

Impacts of inserting leap seconds in regions of the East where it occurs during working hours are more significant and can be major if it occurs other than 1 January

As systems become more complex and interdependent, the chances for significant disruptions by the introduction of leap seconds will increase

Reports on the December 2005 leap second event show problems were detected at the hardware level for some Network Time Protocol (NTP) servers,

- Official procedure for the application of the leap second was not universally followed
- Different communities applied different methods that led to inconsistencies in time and frequency measurements during the 100-120 seconds before the event
- Some systems were interrupted several hours before and after the event to prevent operational mishaps

There is a general misunderstanding of the definition and uses of time scales and time synchronization systems

- Confusion on using and accessing International Atomic time (TAI), UTC, Global Positioning System (GPS) and Global Satellite Navigation System (GLONASS) times
- Situation is compounded by the proliferation of continuous "pseudo time scales"

Summary of Views Favoring
(Continued)

International and national organization experts in the different fields related to time-keeping (the Consultative Committee for Time and Frequency , ITU-T, and Bureau des Longitude) support a continuous time scale

National administrations have recommended allowing sufficient time before the effective date of any new definition to allow any necessary changes in software, hardware and procedures

Activities that would benefit from suppression of the leap second include: geodesy - accurate access to UT1; networks; space activities - launch schedules; highly precise timing applications;

Summary of Views
Neutral or Recommending More Study

International Astronomical Union (IAU), American Astronomical Society (AAS), the Jet Propulsion Laboratory (JPL), Union Radio Scientifique Internationale (URSI) Commission J and the National Radio Astronomy Observatory (NRAO)

Consultation should continue with other relevant international organizations

Summary of Views
Opposing or Identifying Potential Difficulties

Existing software and methodology based on 35 years of experience - changing procedures and legacy software may be challenging

Formats for transmitting the offset UT1-UTC would need to be modified

Astronomical systems based on earth orientation could be affected

Keeping the name UTC could be confusing

Educational aspects and existing documentation could be invalidated by the change

Technical evidence of problems related to leap seconds does not justify a change

Problems reported were judged to be minor and amenable to technical solutions

Some professional organizations have strongly opposed the change, arguing that social and cultural factors also need to be considered

Current definition of UTC which appears to be satisfactory

Conclusions

Material shows an evolutionary drift of opinion over the duration of the effort, while some organizations initially opposed may now be counted in the neutral camp

Major scientific and GNSS organizations have not yet weighed in on the subject

- There has been ample opportunity and encouragement to contribute
- The lack of response has been interpreted as having no concern and thus no established opinion

Little information on quantitative costs has been provided

- The few estimates offered seem to be guesses at best
- Few observers noted there are costs associated with maintaining the status quo that may or may not be mitigated

Most experts in time metrology agree on the necessity for the change and offer technical support

The Consultative Committee on Time and Frequency strongly recommends enough time should be given to allow for any necessary software and systems modifications

More Conclusions

Documents demonstrate a clear misunderstanding of the definitions and applications of time scales and system times for internal synchronization

- **Indications that users have the choice between UTC, TAI, UT1, GPS Time for their applications is incorrect**
- **UTC is the only international standard time scale, represented by local approximations in time laboratories, that should be used for worldwide time coordination and measurement traceability**
- **TAI is not an option for applications needing a continuous reference as it has no means of dissemination, and it is not physically represented by clocks**
- **GPS time is not a reference time scale, it is an internal time for GPS system synchronization, as other GNSS system times would be**
- **A variety of continuous internal system time scales have proliferated to provide a solution to the problems associated with discontinuities in UTC**

The existence of multiple time scales creates potential problems in operational use as well as conceptual confusion on the proper definition and roles of time references

Only UTC can be disseminated