

The Future of the Leap Second

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Coordinated Universal Time (UTC)

- Begun in 1960 as cooperative effort of U.S. Naval Observatory and Royal Greenwich Observatory to make coordinated changes to clocks
- Epoch and frequency adjusted to match UT1 corrected for seasonal variations (UT2)
- Details of UTC system were formalized by International Radio Consultative Committee (CCIR) of International Telecommunication Union (ITU) in 1962
- in 1965 BIH defined UTC with respect to atomic time
- Name Coordinated Universal Time (UTC) adopted by IAU in 1967
- From 1961 to 1972 UTC contained both frequency offsets and fractional (less than 1 s) steps to maintain agreement with UT2 within about 0.1 s
- Current UTC adopted beginning in 1972
 - no changes in frequency
 - leap seconds so that $|\text{UT1}-\text{UTC}| < 0.9 \text{ s}$

UTC consistent with previous definitions of legal time

ITU-R RECOMMENDATION TF.460-6 STANDARD-FREQUENCY AND TIME-SIGNAL EMISSIONS

(1970-1974-1978-1982-1986-1997-2002)

- Worldwide coordination of standard time and frequency transmission
- Conformity with the SI second
- UTC - Basis 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
 - Leap Seconds may be introduced as the last second of a UTC month - December and June preferred, March and September possible
- Dissemination of DUT1
 - predicted UT1 – UTC in integral multiples of 0.1 s

ITU-R (International Telecommunications Union- Radiocommunications)

- International organization within the United Nations System
 - governments and private sector coordinate global telecom networks and services
- Mission:
 - Under the provisions of the Constitution and Convention (Geneva, 1992), the mission of the ITU Radiocommunication Sector is, *inter alia*, to ensure rational, equitable, efficient and economical use of the radiofrequency spectrum by all radiocommunication services, including those using satellite orbits, and to carry out studies and adopt recommendations on radiocommunication matters.
- Follow on to CCIR which defined UTC to facilitate radiocommunications
- Currently accepted by all international organizations as having the responsibility for the definition of UTC

ITU-R Working Party 7A

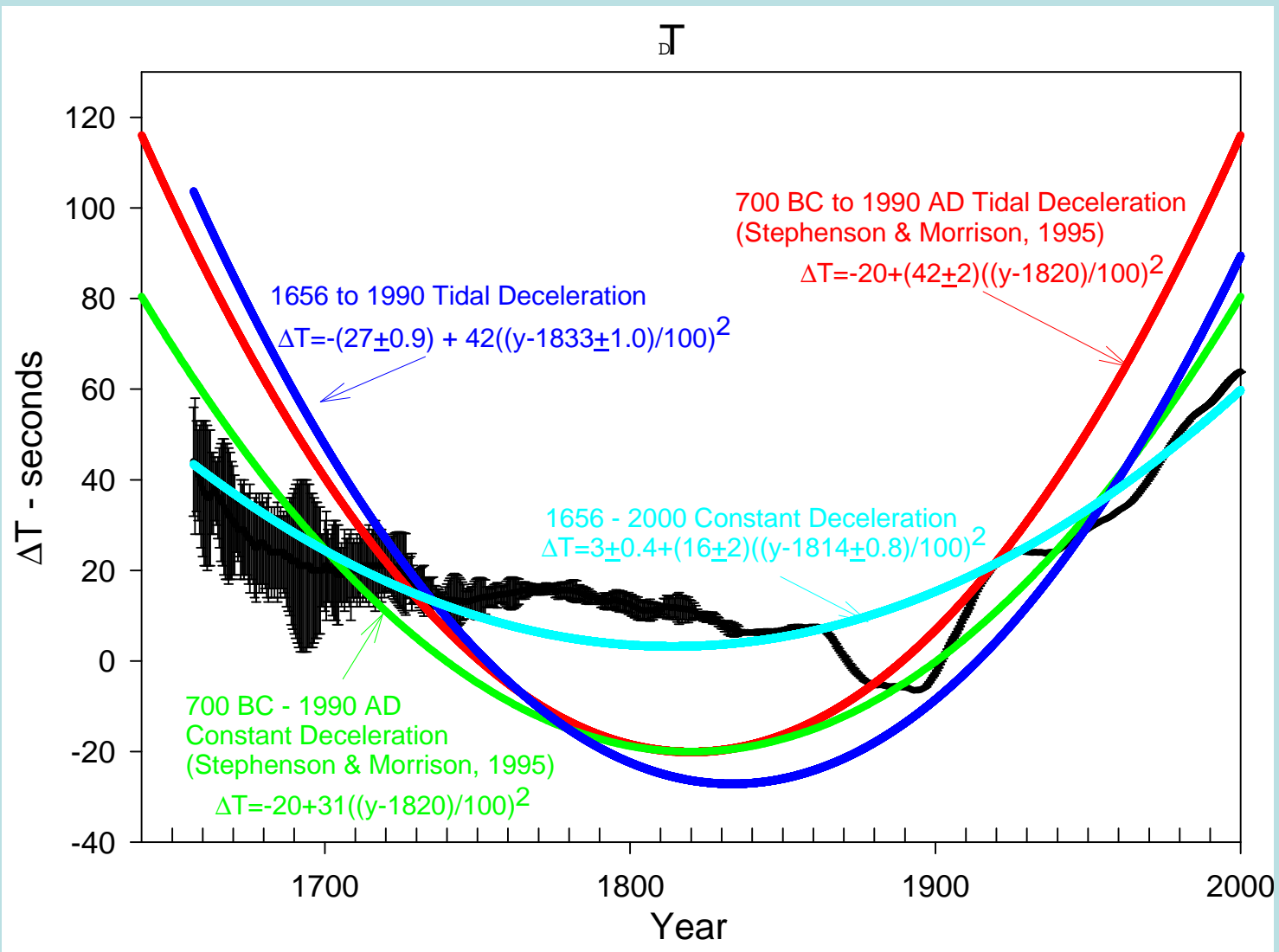
Time Signals and Frequency Standard Emissions

- Responsible for Standard Frequency and Time Signal (STFS) services, both terrestrial and satellite
- Scope includes dissemination, reception and exchange of STFS services and worldwide coordination of these services, including satellite techniques
- Mission
 - Develop and maintain ITU-R Recommendations in the TF Series and Handbooks relevant to SFTS activities, covering the fundamentals of the SFTS generation, measurements and data processing
 - Terrestrial SFTS transmissions, including HF, VHF, UHF broadcasts; television broadcasts; microwave link; coaxial and optical cables
 - Space-based SFTS transmissions, including navigation satellites; communication satellites; meteorological satellites
 - Time and frequency technology, including frequency standards and clocks; measurement systems; performance characterization; time scales; time codes
- Recommendations directed to
 - Telecommunication administrations and industry
 - Radio navigation, electric power generation, space technology, scientific and metrological activities

Causes for concern

- Frequency of leap seconds will increase
 - Increasing public annoyance
- Software issues
 - Unpredictable: can't be programmed in advance
 - Dealing with days of 86,401 seconds
 - Time-stamping 23h 59m 60s
- Communications problems
 - coordination of events during a leap second
- Growth of time scales

Secular deceleration



ITU-R Question 236/7

1. What are the requirements for globally-accepted time scales for use both in navigation/telecommunication systems, and for civil time keeping?
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?

further :

Results of the above studies should be included in Recommendation(s); studies should be completed by 2006.

This Question should be brought to the attention of the Bureau International des Poids et Mesures (BIPM), the International Earth Rotation Service (IERS), Study Group 13 of the Telecommunication Standardization Sector and Radiocommunication Study Group 8.

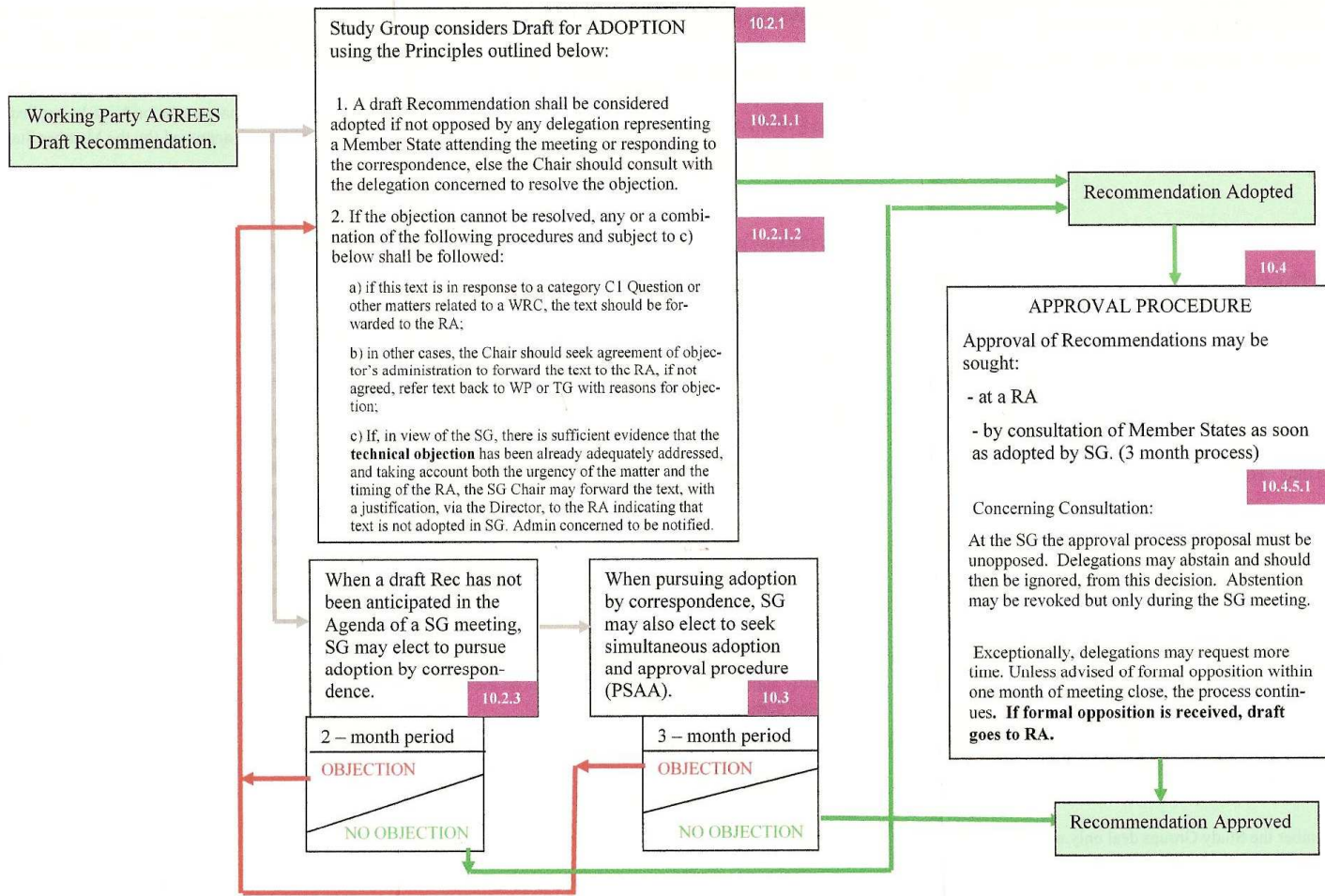
Procedure

ITU-R RECOMMENDATION (New or Revised) AND QUESTION APPROVAL PROCESS

(From ITU-R Resolution 1-4, modified by RAG 12)

(also applied to Recommendation deletion)

■ = relevant section from ITU-R Res. 1-4



Current Proposal

- UTC should be used to designate the time in all international telecommunication activities and in all official documents of ITU
- Leap second adjustments to UTC should cease on 1 January five years after approval by the appropriate World Radiocommunication Conference
- UTC frequency should be used as the ultimate reference for standard-frequency emissions
- Transmission of time signals should not deviate from UTC by more than 100 microseconds
- Emitted standard frequencies should not deviate by more than 1 part in 10^{11} from the UTC frequency
- Time signals emitted from each transmitting station should bear a known relation to the phase of the carrier
- Invites the IERS and the service providers of Global Navigation Satellite Systems to offer convenient access to values of UT1–UTC so that users have access to UT1

Will there be a change?

- **Preliminary Draft Recommendation TF.460-7 prepared by Working Party Oct 2008**
 - France, Germany, Italy, China, Russia U. S. support change with sufficient lead time
 - U. K. strongly opposed
- **Revised April 2008, discussed October 2008**
 - France, Germany, Italy, Russia support change with sufficient lead time
 - China wants more study
 - U. K. strongly opposed
- **Draft Report of Activities and Documentation prepared in October 2008**
- **Most significant outstanding issue being possible effective date**
 - *revised Recommendation would not be effective until the expected date of entry into force of the appropriate World Radiocommunication Conference Final Acts (as early as 2013)*
- **To be taken up again at Meeting in September 2009**
- **If acceptable would be forwarded to Study Group 7 for Formal Coordination and Approval**

RECOMMENDATION CCTF 3 (2009): On the weakness of present definition of UTC

The Consultative Committee for Time and Frequency,

considering that

- **The use of Coordinated Universal Time (UTC) as defined in 1972 is negatively affected by steps caused by the unpredictable insertion of an unpredictable number of leap seconds;**
- **This definition of UTC can not meet the requirements of many existing and future systems needing uniform time;**
- **Alternate time scales, not affected by leap seconds, are being developed and have started to proliferate;**
- **The need to represent the Earth's rotation angle in celestial reference systems for use in maritime celestial navigation is either no longer required or can easily be met through values of UT1-UTC as published by IERS;**
- **UT1 can fully satisfy needs related to the determination of Earth rotation angle;**
- **There must be sufficient lead time allowed for satellite and land based navigation system software developers to accommodate any change in the definition of UTC;**
- **Over the last ten years a number of national and international technical organizations have expressed increasing concerns about the present definition of UTC and the concomitant proliferation of alternate time scales.**

recommends that

National and international agencies and relevant scientific unions concerned with the definition of international time scales urgently consider decisions regarding the future definition of UTC so that international agreement can be reached as soon as possible.