

50th CGSIC Meeting - Timing Subcommittee

Portland, Oregon, 20 September 2010

Chair: **Włodzimierz Lewandowski, BIPM**,
Co-Chair: **Victor Zhang, NIST**

14:00 Presentation of special guest MP Tadeusz Sławecki

14:05 Introduction – *Włodzimierz Lewandowski, BIPM*

14:20 Report from NIST – *Victor Zhang, NIST*

14:50 Report from USNO – *Demetrios Matsakis, USNO*

15:20 Break

15:40 ITU works on new definition of UTC – *Ron Beard, NRL*

15:55 New GNSS time receivers – *Robert Urbaniak, PikTime Systems*

**16:10 Update on Time and Navigation Exhibition at the Smithsonian
– *Carlene E. Stephens, National Museum of American History - to be confirmed***

16:25 Discussion

17:30 Session End

Special guest:

MP Tadeusz Sławewski

- **Member of Parliament**
- **Deputy-Chair of Polish Parliamentary Group on Space**
- **Deputy-Chair of Parliamentary Commission on Education, Science and Youth**



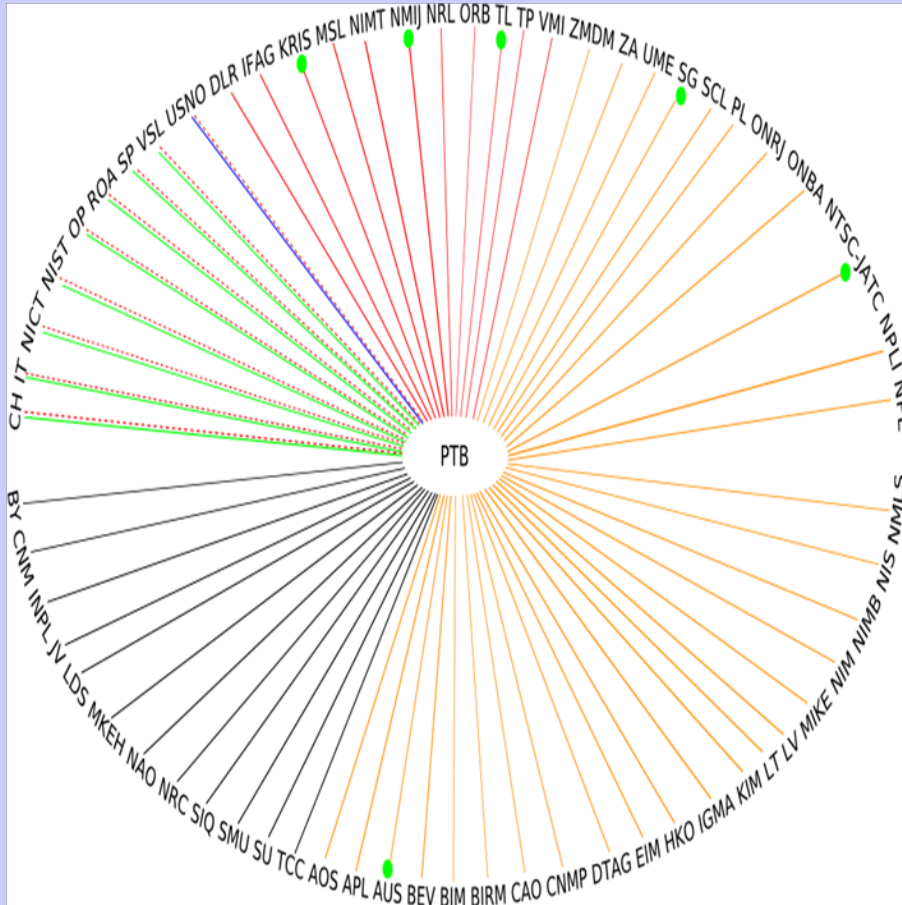
AREAS BEING SERVED

- **UTC**
- **International Timing Centers**
- **GNSS interoperability**
- **Telecommunications Industries**
- **NASA/JPL Deep Space Network**
- **NIST Global Time Service**
- **Power Grids and other Industries**
- **As Research and Comparison Tool**
- **Other**

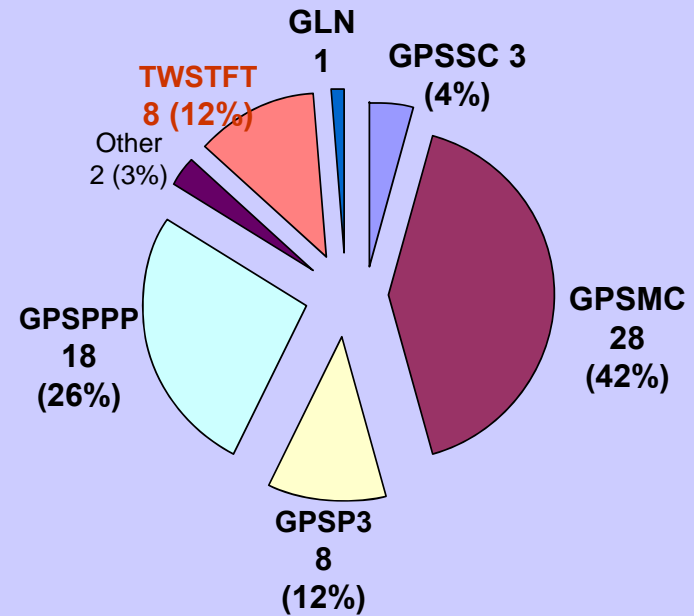
Outline of presentation

- **BIPM time transfer studies**
- **Change in the definition of international time scales (ITU, CCTF)**
 - UTC
 - TAI
 - Leap second
- **Relation between satellite time scales**
 - GPS time
 - Glonass time
 - Galileo system time
 - Compass system time
- **Chinese COMPASS system**
- **Mecca time**

Present UTC network of 69 Labs



Time Transfer Techniques used in UTC (July 2010)



Adieu USNO-PTB X-band

The last records of the USNO-PTB TW X-band time link:

Dear Dirk,

... the X-band satellite service is being permanently discontinued as of June 21, 1000UTC

Jonathan, 11.06.2010 18:16

+ ~~~

Dear Jonathan,

just a minute ago, I switched off our X-band TWSTFT station.

Dirk, Friday, June 18, 2010 9:53 AM

+ ~~~

A light went out, though the flame lives on

Demetrios, Friday, June 18, 2010 4:05 PM

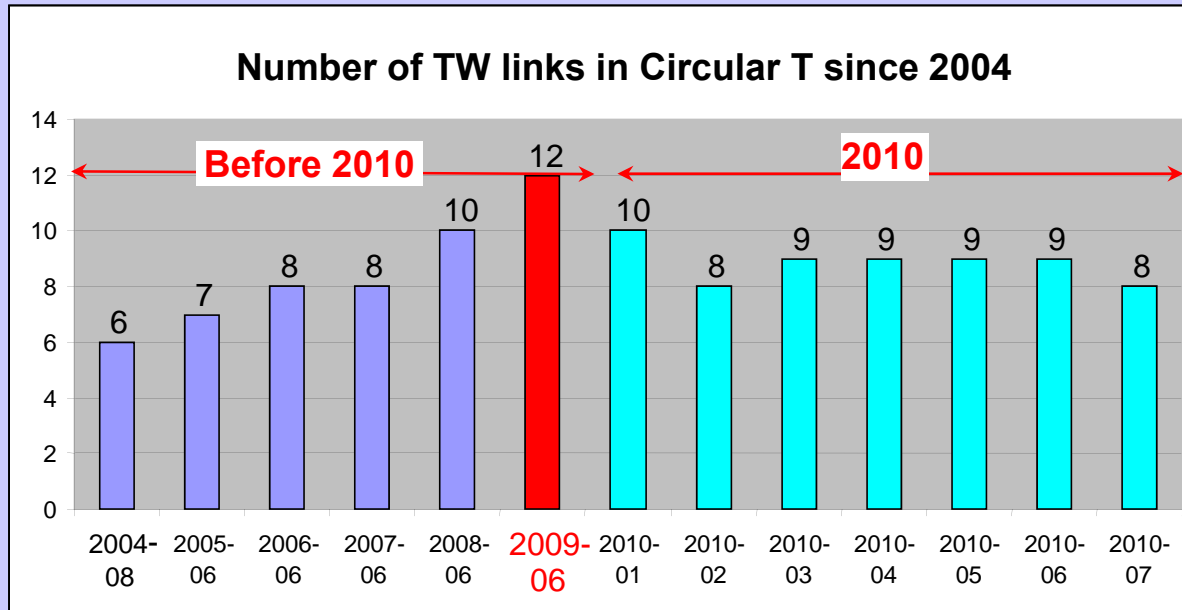
Evolution of TW in UTC: General

→ Comparison last three years: 2008, 2009, 2010 to see its evolution tendency

Three major indicators:

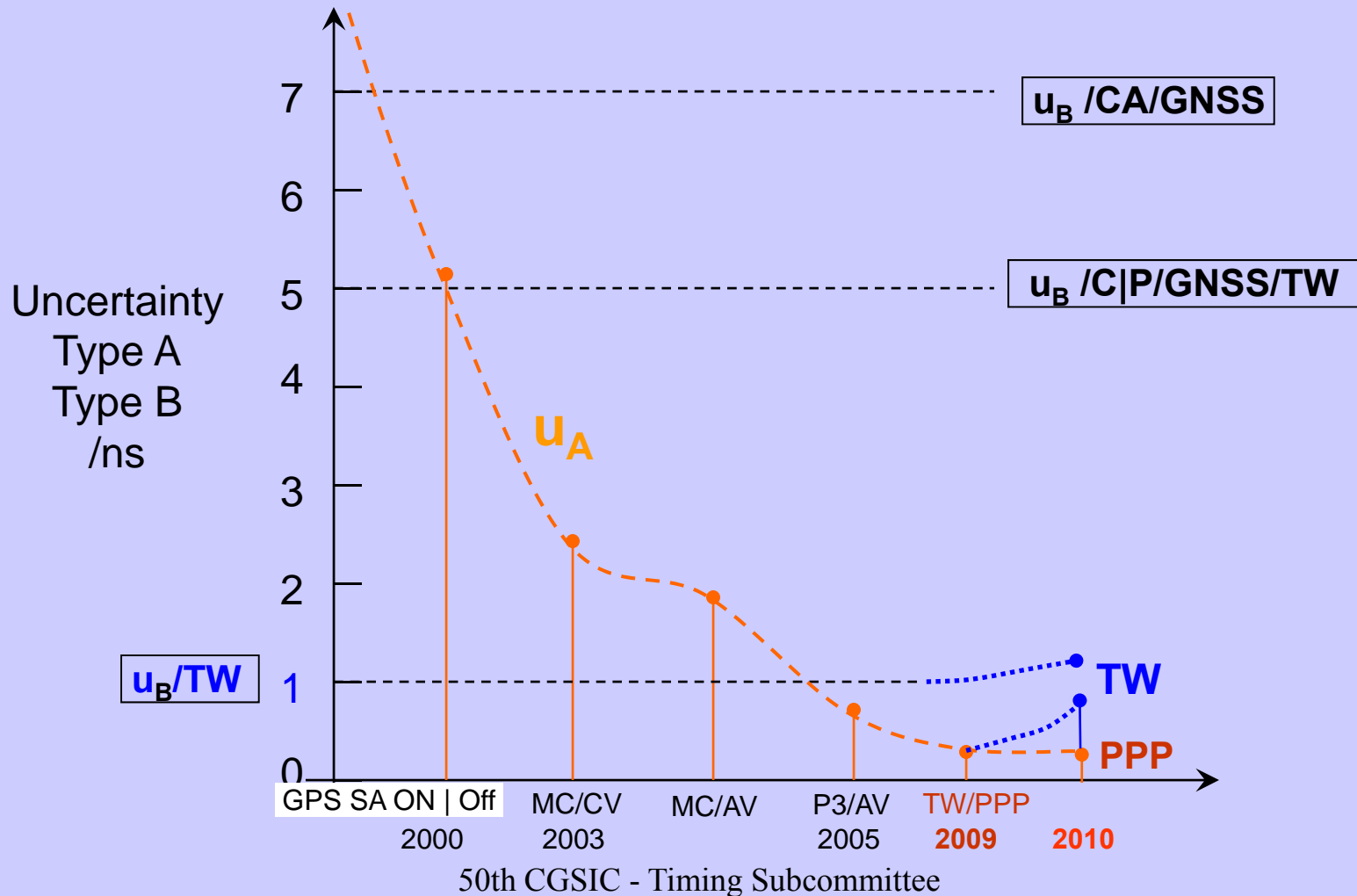
1. Participation
2. u_A : stability of the TW links
3. u_B : Calibration

Evolution of TW in UTC: Participation



- Gradually increased for 5 years 2004-2009
- Reached summit mid-2009
- Stabilised at 8-9 since 2010

Evolution of TW in UTC : 10 year tendency



Evolution of TW in UTC: Summary

Present situation:

- Decrease the Number of TW participation in UTC (xBand, NICT modem)
- u_B of major contributors to UTC is 5 ns NIST,NICT,NTSC,TL,ROA etc.
- u_A the stability is degrading (diurnals)
- Not clear where leads us this situation ?

Future of TW in UTC: General

The Key word: GPS PPP:

$u_A=0.3\text{ns}$ is a challenge and a tool to strengthen UTC TW

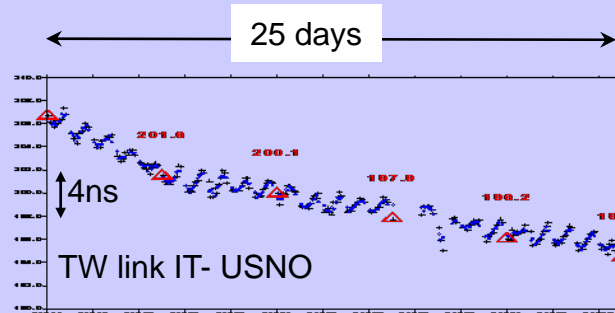
With the help of GPS PPP, we can:

- Improve the TW stability (u_A)
- Improve the TW calibration (u_B , inter-continental)
- Use the InDirect TW links (Asia-Asia-Europe)

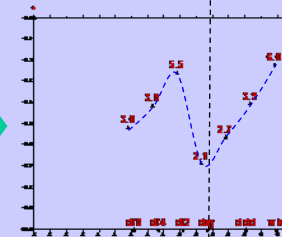
→→ Increase the participants of TW in UTC

Future of TW in UTC: diurnal & jump

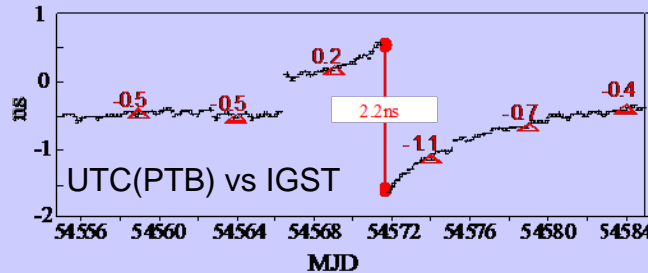
Diurnals in TW



TDev/s⁻¹⁰
day



Jump in GPS PPP



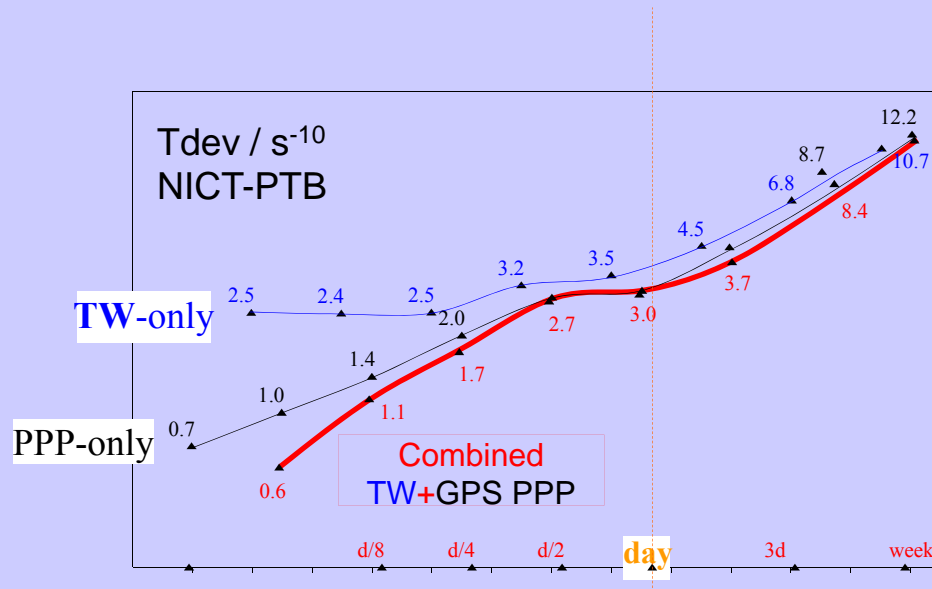
→ None of the two has a dominant advantage

Future of TW in UTC: TW vs PPP

<u>Comparison</u>	<u>TW</u>	<u>GPS PPP</u>
Calibration	~1ns	~5ns
Transfer limit	baseline	global
Distance	~dependent	~independent
Atmosphere effect	free	correction
Diurnals	yes	free
Data processing	simple/independ.	complex/depend.
Cost	expensive	less expense

→ Combining TW and PPP to take the Advantages and reduce the disAdvantages

Future of TW in UTC: combination

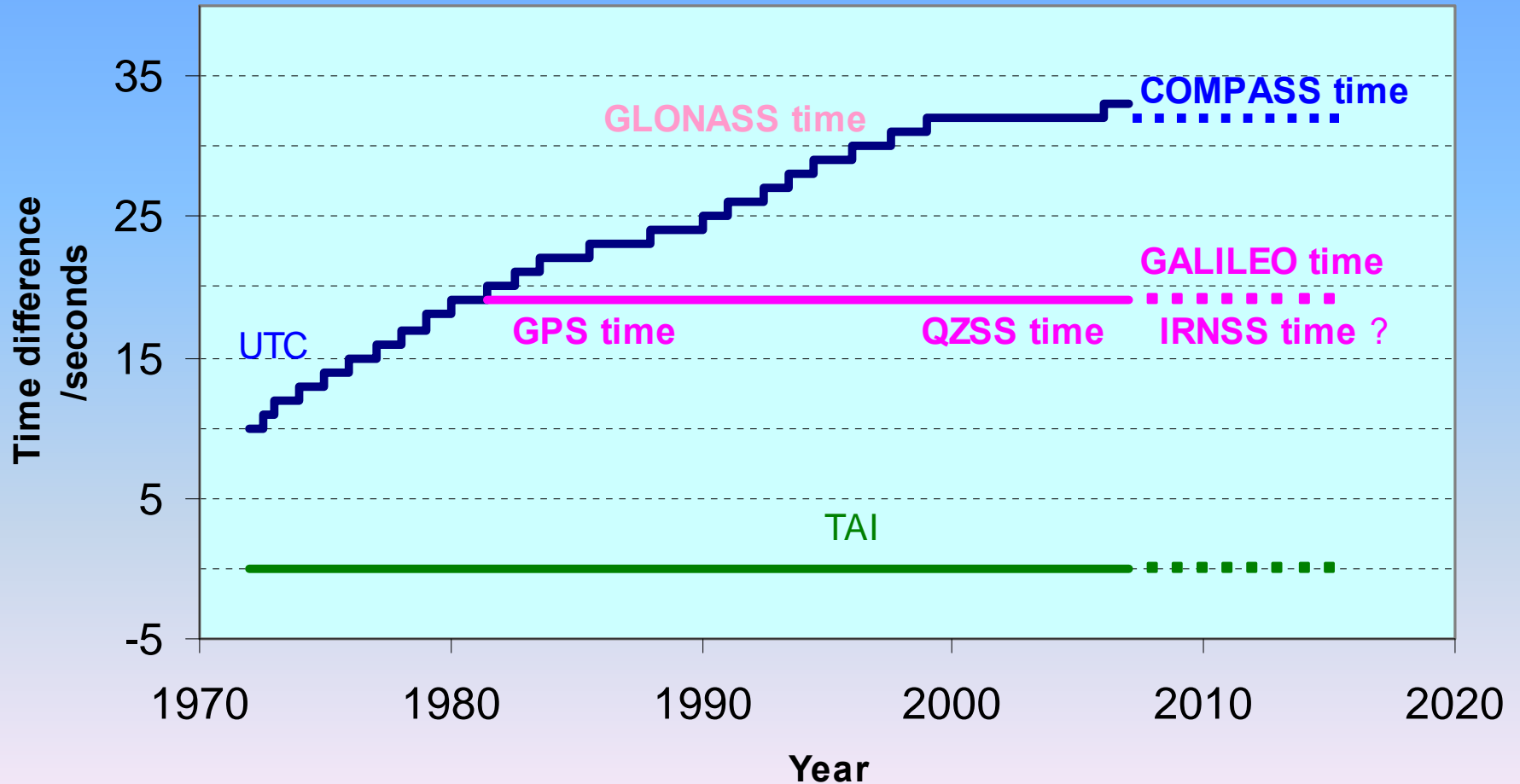


Gain in the Tdev by the combination:

- Repair/Reduce the faults in raw data
- Improve short term stability
- Increase robustness



[TAI - Time scale (i)]



System times

- **GPS time: steered to UTC(USNO) modulo 1s**
 - ✓ $[\text{TAI} - \text{GPS time}] = 19 \text{ s} + C_0$
 - ✓ $[\text{UTC} - \text{GPS time}] = -15 \text{ s} + C_0$
 - ✓ Tolerance is $1 \mu\text{s}$
- **GLONASS time: steered to UTC(SU) with leap second**
 - ✓ $[\text{TAI} - \text{GLONASS time}] = 34 \text{ s} + C_1$
 - ✓ $[\text{UTC} - \text{GLONASS time}] = C_1$
 - ✓ Tolerance is 1 ms
- **Galileo time: steered to a set of EU UTC(k); using GPS time seconds, GGTO**
 - ✓ $[\text{TAI} - \text{Galileo time}] = 19 \text{ s} + C_2$
 - ✓ $[\text{UTC} - \text{Galileo time}] = -15 \text{ s} + C_2$
 - ✓ Tolerance is 50 ns
- **COMPASS time: will be steered to set of Chinese UTC(k)**
 - ✓ $[\text{TAI} - \text{COMPASS time}] = 33 \text{ s} + C_3$
 - ✓ $[\text{UTC} - \text{COMPASS time}] = -1 \text{ s} + C_3$
 - ✓ Tolerance is 100 ns



Babel Tower

ITU meeting on redefinition of UTC Geneva, 4 -11 October 2010

To avoid proliferation of time scales ITU plans to stop application of leap seconds to UTC

- **September 2009: ITU Working Party 7A submitted to Study Group 7 draft recommendation on stopping leap second**
- **2010: it is expected that Study Group 7 will submit draft recommendation to Radiocommunication Assembly**
- **January 2012: if 70 % member states agree Radiocommunication Assembly will approve recommendation**
- **About 2020: application of leap second should stop and UTC will become a continuous time scale**
- **But two administrations are opposing: British and Chinese**

Recommendation CCTF 4 (2009) (1)

Concerning adoption of a common terrestrial reference system by the CGPM

The Consultative Committee for Time and Frequency,

considering that

- there exists at present only a few global satellite navigation systems but that new ones are being created and in the future there may be many more,
- different time and geodesy reference systems, which are in use in these navigation systems, produce additional ambiguities for users regarding interpretation of navigation and timing solutions and render systems interoperability more difficult,
- although the international terrestrial reference system ITRS is recommended by relevant scientific unions, it has not yet been adopted by an intergovernmental organization,
- such an adoption by the appropriate intergovernmental organization would lead to more user convenience regarding unification of navigation and timing solutions and systems interoperability;

**International Committee on Global
Navigation Satellite Systems (ICG)
Torino, Italy
18 - 22 October 2010**

ICG Draft Recommendation

International Committee on Global Navigation Satellite Systems (ICG)

considering

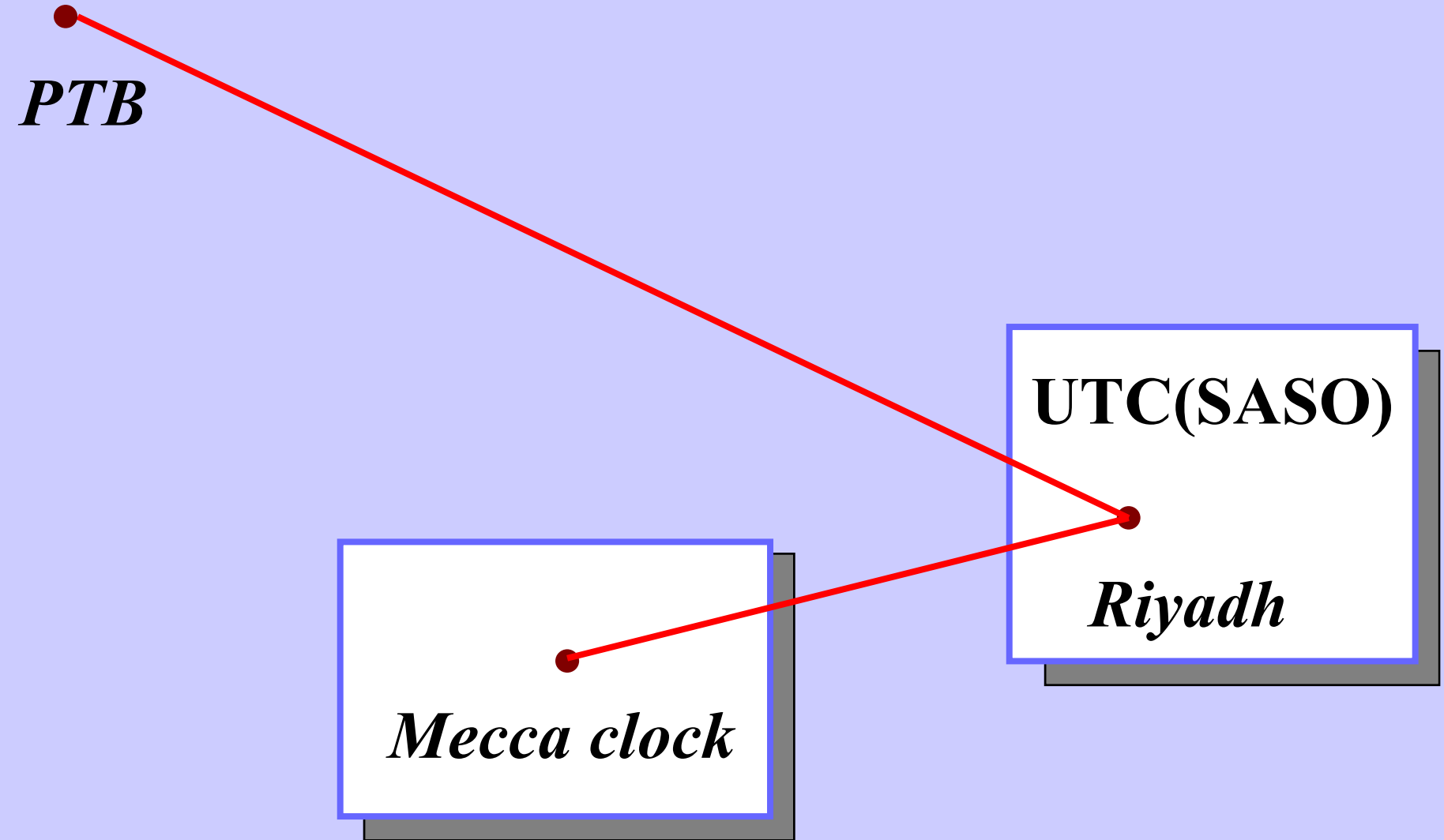
- the international value of having many GNSS operational with a composite contribution of several tens of satellites,
- the desirability of using all systems interchangeably,
- the use by GPS of references very close to UTC and ITRF,
- the GLONASS efforts to approach UTC and ITRF,
- the Galileo design referring to UTC and ITRF,
- that other important satellite navigation systems are now being designed and developed*),

recommends

- that the reference times (modulo 1 s) of satellite navigation systems be synchronized as closely as possible to UTC,
- that the reference frames for these systems be in conformity with the ITRF,
- that these systems broadcast, in addition to their own System Time (ST):
 1. the time difference between ST and a real-time realization of UTC,
 2. a prediction of the time differences between ST and UTC.

*) Compass, IRNSS, QZSS, various SBAS, ...

SAUDI ARABIA TIME LINKS



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