Multi-Technique Combination for UTC/TAI Time/Frequency Transfers

- progress since CCTF2009

Z. Jiang, G. Petit and W. Lewandowski

Time Department
Bureau International des Poids et Measures
zjiang@bipm.org

Outline

- Background: the status before and after CCTF 2009
- The change of the strategy of the primary technique for UTC time transfer
- Use of the multi-techniques through form of the combinations of different time transfer links
- A quick look at the GLN PPP

Background 1/3

Techniques for UTC links in 2009

TW: Two-Way Satellite Time Frequency transfer (Geostationary Telecommunication Satellites)

GNSS: Global Navigation Satellite System: GPS, Glonass (GLN)

In 2008

29 labs operate at least **two** techniques; **9** operate the **three**;

In the coming future

Galileo, Compass, T2L2 … …

Lab	GPS	GLN	TW
AOS	GPS	GLN	TW
AUS	GPS		TW
CH	GPS		TW
IT	GPS	GLN	TW
KIM	GPS	GLN	
KRIS	GPS	GLN	TW
KZ	GPS	GLN	
LDS	GPS	GLN	
MIKE	GPS	GLN	
NICT	GPS		TW
NIM	GPS		TW *
NIS	GPS	GLN	
NIST	GPS	GLN	TW
NMIJ	GPS		TW
NPL	GPS		TW
NRL	GPS	GLN	TW
NPLI	GPS	GLN	
NTSC	GPS		TW
OP	GPS	GLN	TW
PTB	GPS	GLN	TW
ROA	GPS		TW
SG	GPS	GLN	TW
SP	GPS		TW
SU	GPS	GLN	
TL	GPS		TW
UME	GPS	GLN	
USNO	GPS	GLN	TW
VSL	GPS	GLN	TW
ZA	GPS	GLN	

Background and status 2/3

- 2004: studies in the GLN time transfer
- 2006: tests to use GPS PPP
- Since 2005, studies in use of the multi-techniques
  - at ALGOS level
  - Generate a solution using a major technique with the contributions of another techniques

  ➔The simplest and the best is to combine two different techniques:

  - the combination of TW+GNSS ➔ TW+PPP
  - the combination of GPS+GLN

Background and status 3/3

- 2009: report to CCTF2009
- 2009: GPS PPP and GLN introduced in UTC
- 2010: Combination of TW+PPP introduced in UTC
- 2011: Combination of GPS+GLN introduced in UTC

Change of the T/F transfer Strategies

Before 2009:

- Use either TW or GPS
  i.e. use only one technique
- Use TW before GPS

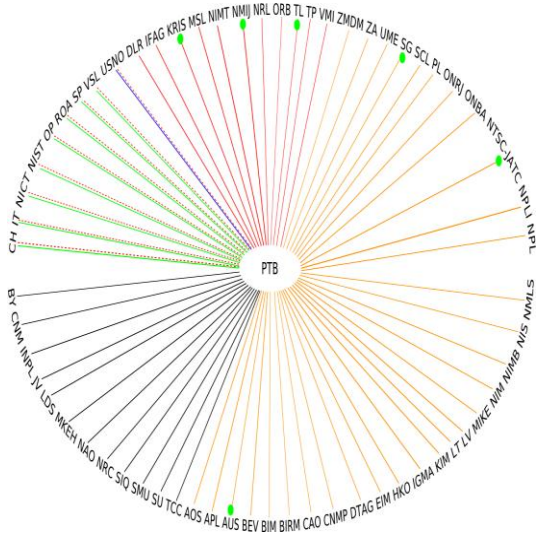
➔ *Single-technique strategy*

Since 2009:

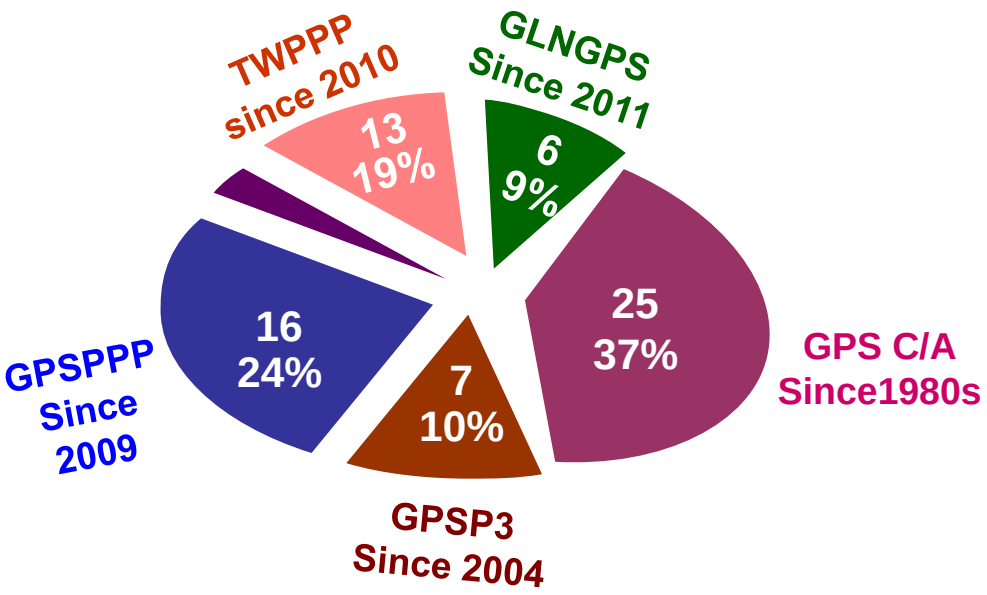
- Use either TW or GPS or GLN or combinations
- Use the combination before a single technique

➔ *Multi-technique strategy*

UTC multi-technique time transfers



6 Techniques
68 UTC links, Jul. 2012

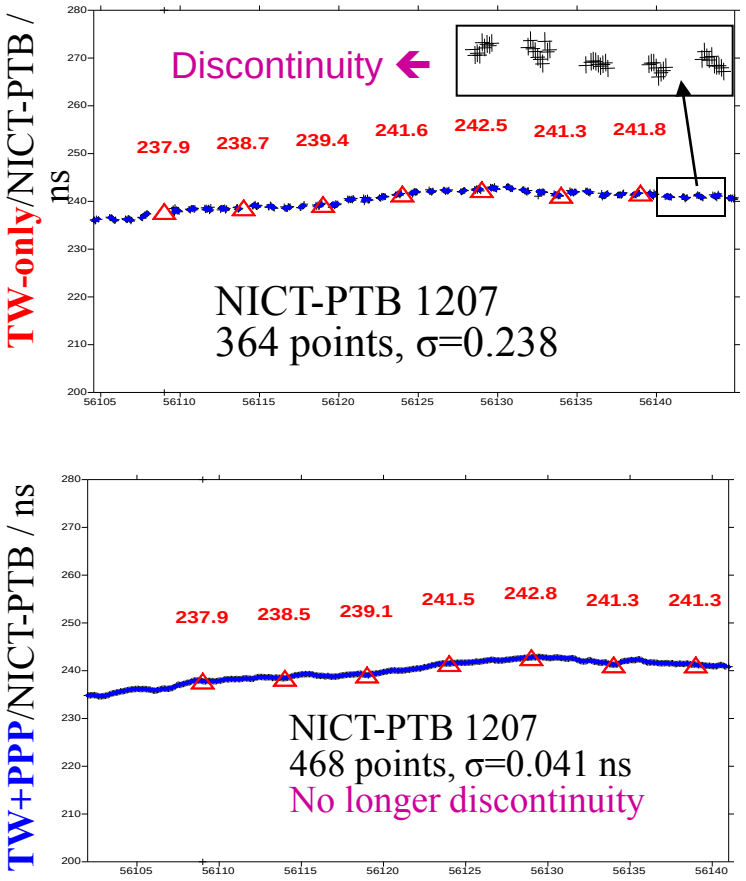


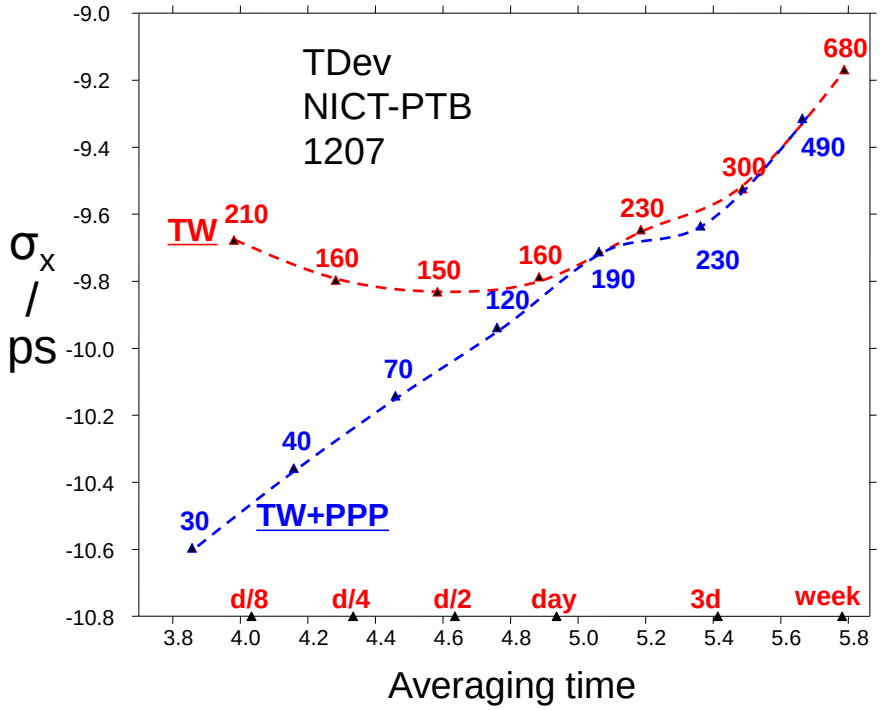
➔**In total, 28% of the UTC links are of the combined links**

Combination of TW and GNSS 1/3

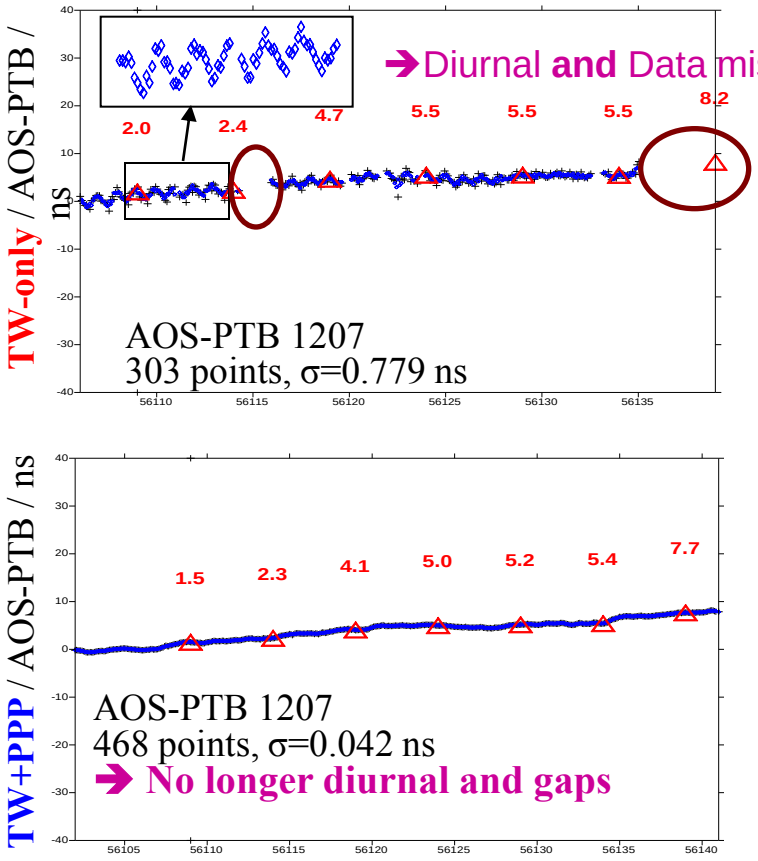
1. Give a better robustness thanks to independence of TW and GNSS;
2. Repair the faults: gaps, jumps, discontinuities and drift in both TW and GNSS;
3. Keep the TW calibration and GNSS CP short term stability;
4. Reduce the diurnals in TW

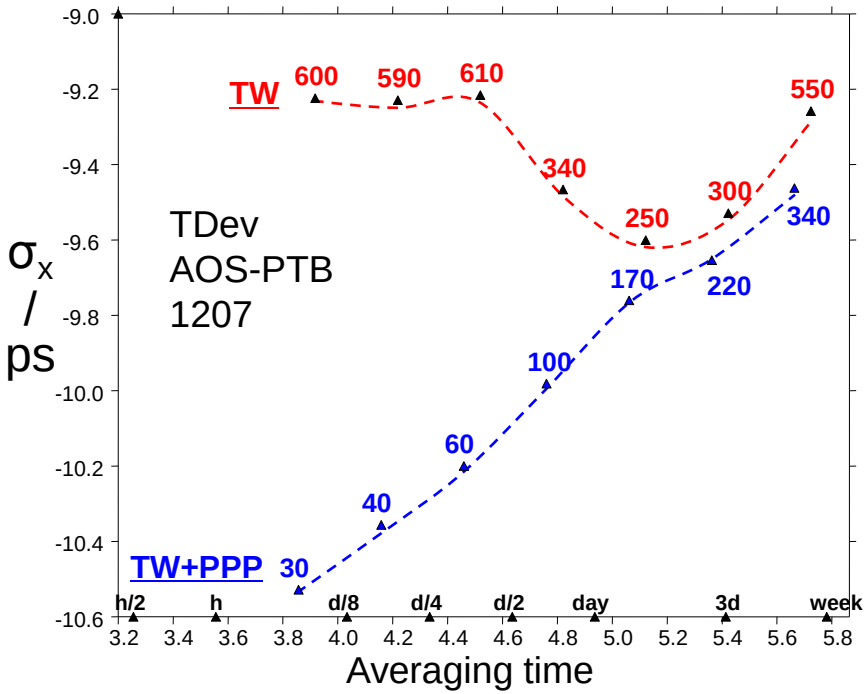
TW Asia-Europe Links via AM2 2/3





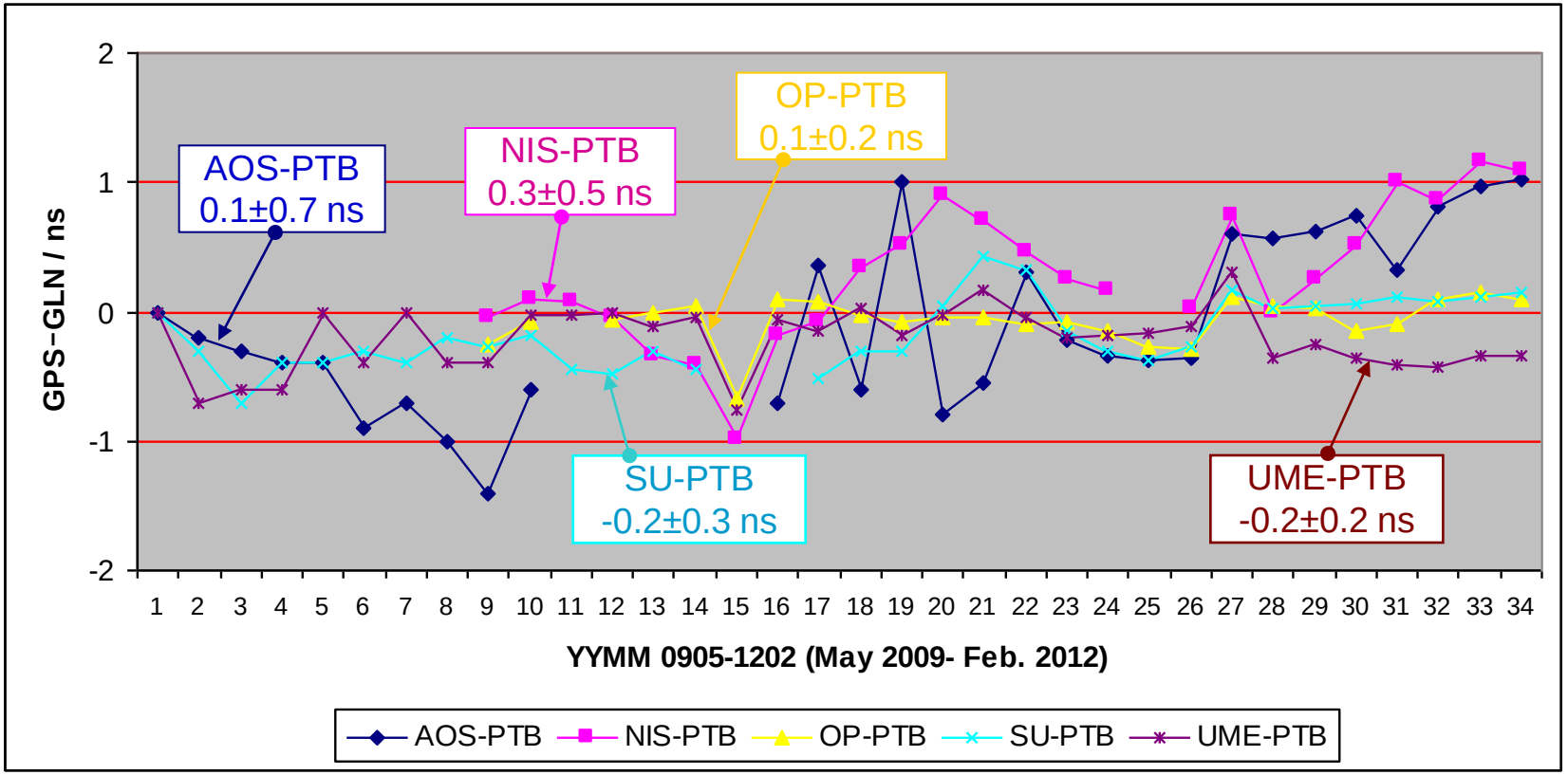
TW Europe-Europe Links via T-11N 3/3



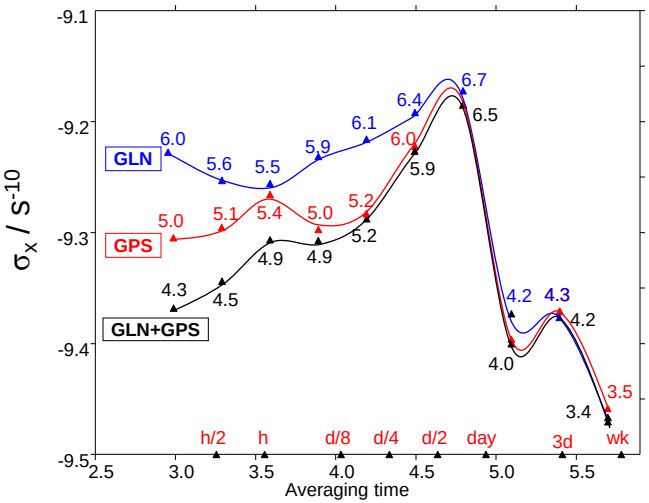


Combination GLN+GPS 1/2

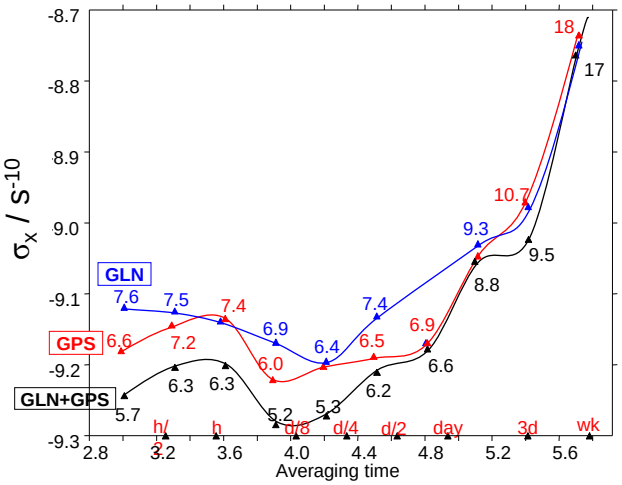
Consistency between GPS C/A and GLN L1C over **34** months' comparison. The disagreement of the calibrations between GPS and GLN are well below the uncertainties



Combination GLN+GPS 2/2



SU-PTB / UTC 1102



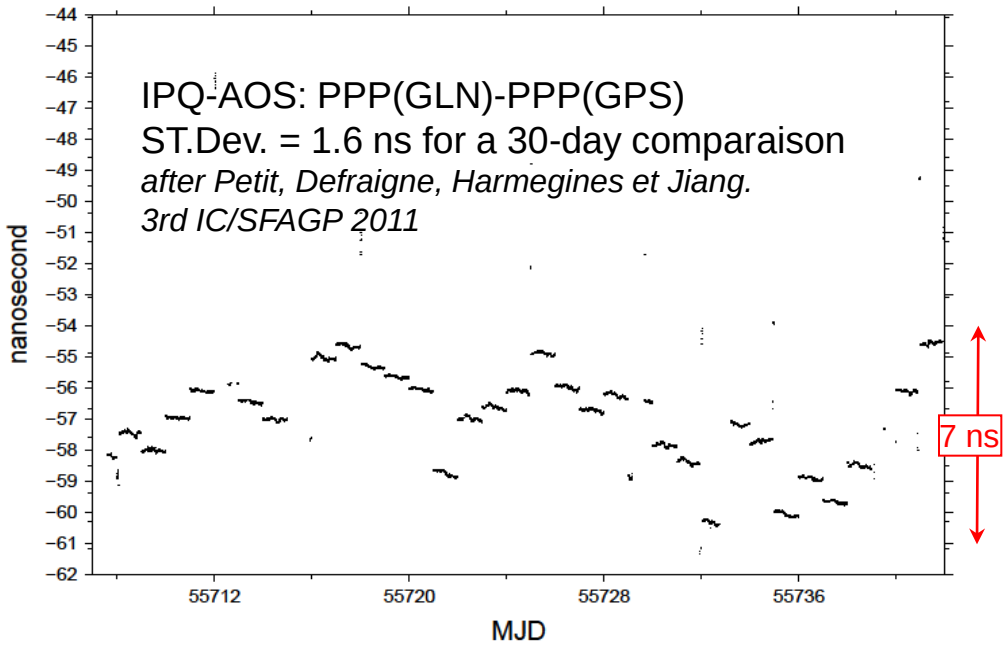
INPL-PTB / UTC 1110

A monthly Comparison of the time deviations between GPS-only, GLN-only and GPS+GLN combined links for the baselines SU-PTB and INPL-PTB. Both are the UTC time links

GLNPPP

- We have tried a simple computation of GLN PPP without the frequency bias corrections (FBC)
- When computing a link, the effect of frequency biases somewhat cancels
- But the residual instability is at the level of **1.6 ns**, quite large for a PPP link

➔the GLNPPP cannot be used in UTC without the frequency bias corrections



Summary

1. The multi-technique combination is an *effective strategy to improve the UTC/TAI*
2. Combinations of multi-technique links proves considerable gains in **R**obustness, **A**ccuracy and **P**recision
3. GLN PPP is not ready yet for UTC application
4. The BIPM will maintain the multi-techniques time transfer for UTC

Thank you