Calibration of dual frequency (geodetic) GPS receivers for TAI

G. Petit and L. Tisserand
BIPM

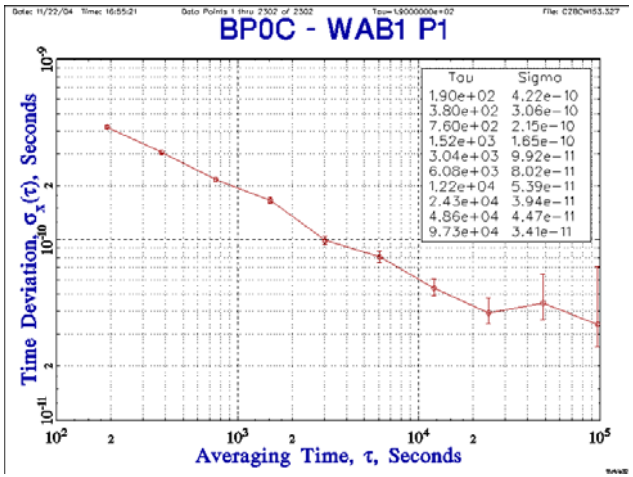
Rationale

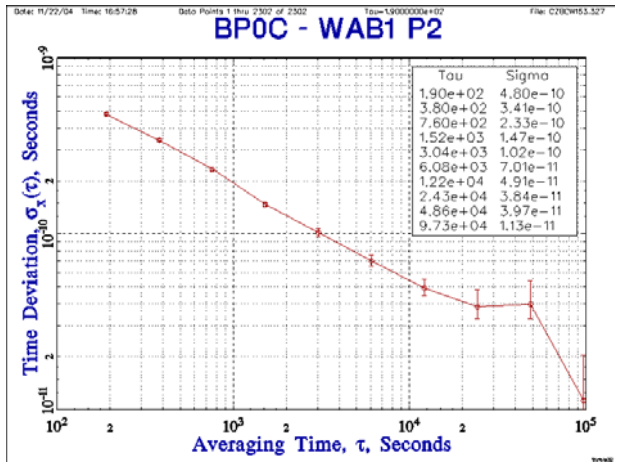
Some 25 laboratories,.

- ORB (Belgium): Z12-T since June 2002, PolaRx2
- NPL (UK): Z12-T since 2002
- NICT (CRL) (Japan): Z12-T since July 2002, Euro-80
- IEN (Italy): Z12-T since July 2002
- LNE-SYRTE (France): Z12-T since July 2002, PolaRx2, Euro-80
- USNO (USA): Z12-T since 2002
- SP (Sweden): Javad since July 2004
- DLR (Germany): Z12-T since 2002, PolaRx2
- METAS (Switzerland): GeTT since October 2002, + Z12-T since July 2004
- PTB (Germany): Z12-T since October 2002, PolaRx2 since 2006
- NMIJ (Japan): Z12-T since November 2002, Euro-80
- TL (Taiwan): Z12-T since December 2002, Euro-80
- IFAG (Germany): Z12-T since December 2002
- NRC (Canada): Z12-T since March 2003
- NTSC (China): Z12-T since June 2004
- KRISS (Korea): Z12-T since 2005, Euro-80
- ROA (Spain): PolaRx2 since 2005
- TCC (Chile): PolaRx2 since 2006
- NMIA (Australia), NIMT (Thailand), MSL (New Zealand), other: Euro-80
- AOS (Poland): TTS-3

Uncertainty of differential calibration

- For a geodetic receiver: Measurement of the phase relation of the input frequency vs 1PPS-in
- Statistical uncertainty of differential measurements well below 0.1 ns for a few hours averaging time at each frequency: no problem.





- Cable measurements
- Global uncertainty expected of order 2 ns at P1/P2
- Should be reflected in the observed repeatability of calibration results

Ashtech Z12-T (used as traveling receiver)

- No more commercially available
- Provides C/A, P1, P2 and L1, L2.
- Accepts 20 MHz input frequency.
- Can synchronize its internal time scale to external through 1PPS-in.
- Define “internal reference” as a particular event related to a 20MHz-in phase transition.
- [In some series of receivers: can synchronize the 1PPS-out to its internal time scale so that it gives another access to the “internal reference”]

Z12-T calibrations results: repeatability

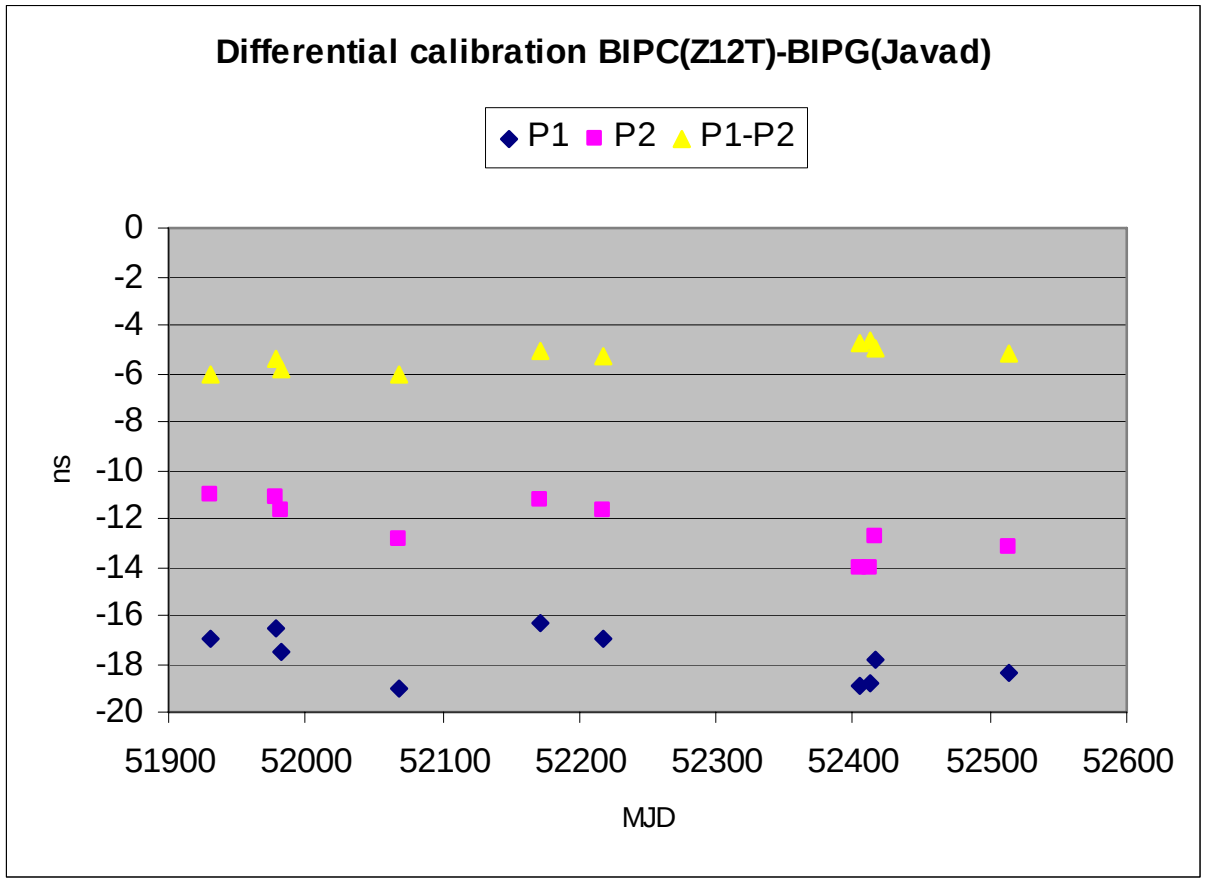
- A few years of history of repeated Z12-T calibrations
- 1-2 ns consistency possible, but few very conclusive results, mostly because the calibration set-up was different from the operational set-up (BIPM fault) or the operational set-up changed with time.

Receiver	Date	Ref.	P1 result	P2 result
BP0M	05/2004	BIPC	Ref - 0.3 ns	Ref + 2.0 ns
BP0M	02/2005	BIPC	Ref - 0.8 ns	Ref + 2.8 ns
BP0M	03/2005	BIPC	Ref - 1.2 ns	Ref + 2.3 ns
BP0M	02/2006	BIPC	Ref - 2.0 ns	Ref + 2.2 ns
PTBB	07/2002	BIPC	Ref - 1.5 ns	Ref - 3.4 ns
PTBB	06/2003	BIPC	Ref - 0.6 ns	Ref - 2.6 ns
PTBB	08/2004	BIPC	Ref - 1.6 ns	Ref - 2.9 ns
OPMT	03/2001	BIPC	Ref + 4.9 ns	Ref + 0.2 ns
OPMT	02/2002	BIPC	Ref + 6.0 ns	Ref + 1.3 ns
OPMT	06/2004	BIPC	Ref + 8.8 ns	Ref + 4.5 ns

Set-up changes:
No splitter
1 splitter
2 splitters

Z12-T calibrations results: repeatability (2)

- Regular comparisons with Javad receiver kept at the BIPM: 10 measurements in 2001-2002, each lasting several days (or 1-2 days with different set-up)
  - ΔP1 dispersion of results: 2.7 ns p/p (1.0 ns RMS)
  - ΔP2 dispersion of results: 3.1 ns p/p (1.2 ns RMS)
  - Δ(P1-P2) dispersion of results: 1.4 ns p/p (0.5 ns RMS)



Septentrio PolaRx2

- Provides C/A, P1, P2 and L1, L2.
- Accepts 10 MHz input frequency.
- Can synchronize its internal time scale to external through 1PPS-in.
- Define “internal reference” as the measurement latching (see reference manual).
- Can synchronize the 1PPS-out to its internal time scale so that this gives access to the “internal reference”

Calibration campaigns with traveling Z12-T

2004

- LNE-SYRTE (France): Z12-T
- IEN (Italy): Z12-T
- ORB (Belgium): Z12-T (2 units)
- PTB (Germany): Z12-T
- NPL (UK): Z12-T
- Obs Besançon (OP): Z12-T
- METAS (Switzerland): GeTT + Z12-T
- CNES (OP): Z12-T

2005

- TL (Taiwan): Z12-T , (Euro-80)
- NICT (CRL) (Japan): Z12-T , PolaRx2, (Euro-80)
- NMIJ (Japan): Z12-T, (Euro-80)
- NTSC (China): Z12-T
- KRISS (Korea): Z12-T(2 units) , (Euro-80)
- (NMIA (Australia), NIMT (Thailand): Euro-80)

2006

- ORB (Belgium): Z12-T (2 units), PolaRx2 (2 units)
- IFAG (Germany): Z12-T , PolaRx2 (2 units)
- PTB (Germany): Z12-T
- DLR (Germany): Z12-T, PolaRx2 (2 units)
- ROA (Spain): PolaRx2,
- LNE-SYRTE (France): Z12-T, PolaRx2
- ….

Other receivers

- Javad
- Euro-80
- TTS-3
- GTR50
- Novatel
- …….

Conclusions

•Dual-frequency GPS time receivers (i.e. insensitive to power cycles) are now common-place in the TAI network. Several different systems are currently in operation.

•Calibration of Z12-T systems providing P3 measurements has been operational for some years. Calibration of new systems has started.

•Laboratories should keep their system in a stable (and simple) set-up.

•Other systems using C/A and (P2-P1) are operationally used. Some tests needed to check consistency of mixed links.