SOME COMMENTS ON GNSS CALIBRATION GUIDELINES

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CCTF WG GNSS September 14, 2015

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Relative calibration target

- INT DLY P1 and P2 for GPS >>> Receiver calibration

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CGGTTS GPS/GLONASS DATA FORMAT VERSION = 02
REV DATE = 2015-07-30
RCVR = Z-XII3T                          R2CGGTTS v5.1
CH = 12 (GPS)
IMS = Z-XII3T
LAB = OP
X = +4202777.38 m (GPS)
Y =  +171367.99 m (GPS)
Z = +4778660.18 m (GPS)
FRAME = ITRF, PZ-90->ITRF Dx = 0.0 m, Dy = 0.0 m, Dz = 0.0 m, ds =
0.0, Rx = 0.0, Ry = 0.0, Rz = 0.000000
COMMENTS = delay P1 P2 cal BIPM
INT DLY =  310.2 ns (GPS P1),  321.6 ns (GPS P2)
CAB DLY =  156.5 ns (GPS)
REF DLY =  100.2 ns
REF = HM0889
CKSUM = D8
```

- TOT DLY P3 = INT DLY P3 + CAB DLY – REF DLY

  >>> **Link calibration required by BIPM for UTC links**

Equations

- Equations in the guidelines
- We suggest to add all equations like

$$\begin{aligned}\mathrm{INTDLY(P1)V} &= \mathrm{RAWDIF(P1)V\_T} + [\mathrm{INTDLY(P1)T} + \mathrm{CABDLY/T} - \mathrm{REFDLY/T\_V}] \\ &\quad - \mathrm{CABDLY/V} + \mathrm{REFDLY/V\_T} \\ \mathrm{INTDLY(P2)V} &= \mathrm{RAWDIF(P2)V\_T} + [\mathrm{INTDLY(P2)T} + \mathrm{CABDLY/T} - \mathrm{REFDLY/T\_V}] \\ &\quad - \mathrm{CABDLY/V} + \mathrm{REFDLY/V\_T}\end{aligned}$$

- We suggest all figures to appear explicitely

$$P3 = 2.546 \times P1 - 1.546 \times P2$$

Data processing [1/2]

- Guidelines ask for **RAWDIF**, which do not carry useful information, except in the case of offset/drift inside data.
- Why not consider the delays **CABDLY** and **REFDLY** when available for data processing ?

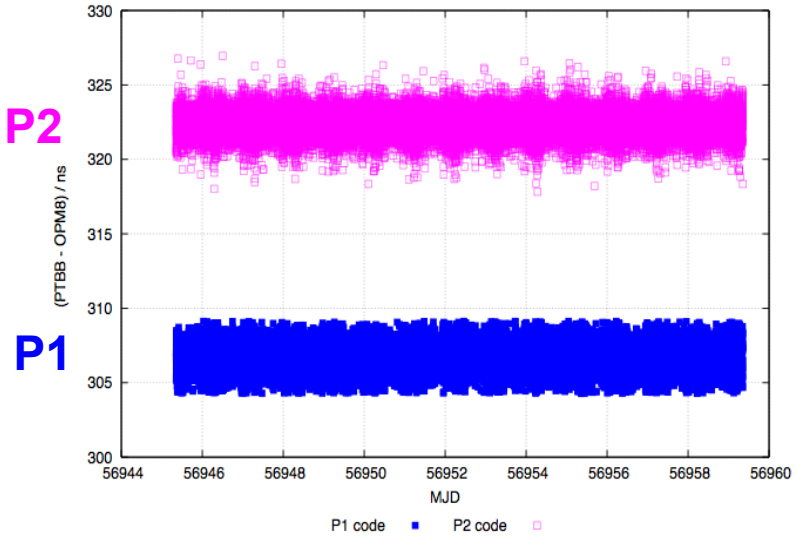
  (Stability analysis would remain unchanged)

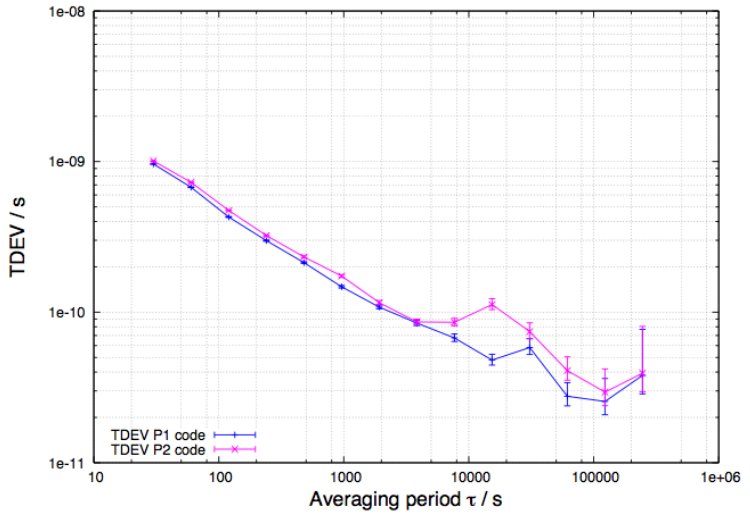
- **REFDLY** are the measurements on site
- **INTDLY/SYSDLY** are the results of a calibration campaign

  >>> All this eventually leading to **TOTDLY**

Data processing [2/2]

When using CAB DLY and REF DLY in data processing :





>> direct access to INT DLY P1 and P2

>> Identical stability analysis

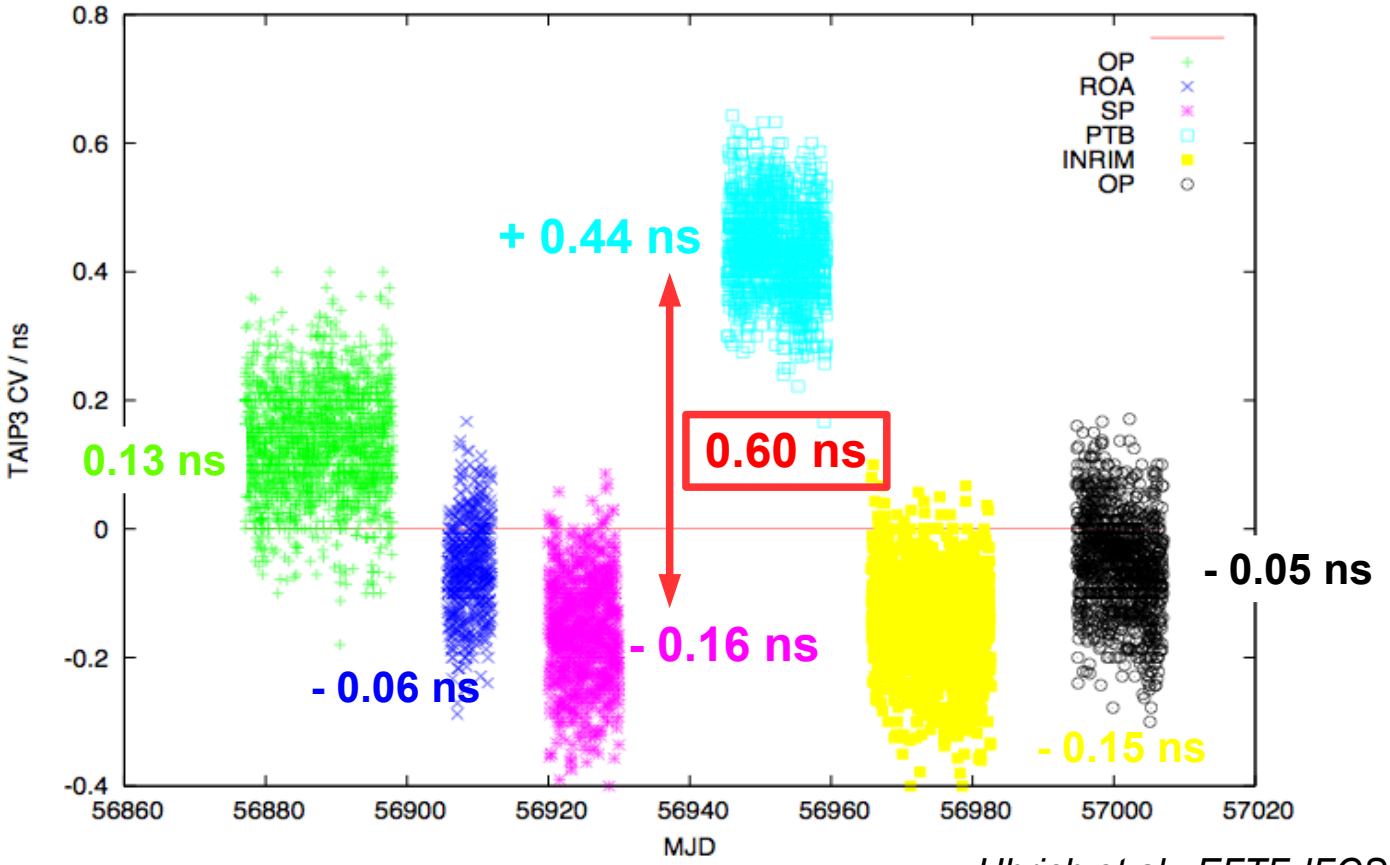
Validation of the results [1/3]

TAIP3 CV after calibration	OPM7 (ns)	Standard deviation (ns)	OPM8 (ns)	Standard deviation (ns)
OPMT (start)	0.26	0.66	0.12	0.65
RO_5	- 0.07	**0.70**	**- 0.02**	**0.70**
RO_6	0.09	**0.40**	0.16	**0.41**
SP01	- 0.25	0.50	- 0.09	0.49
SP02	- 0.14	0.50	**0.02**	0.60
PT07	**0.32**	0.61	- 0.11	0.62
PT10	0.26	0.65	- 0.18	0.65
PTBB	0.29	0.53	- 0.14	0.53
GTRB	- 0.05	0.63	0.10	0.63
GTRI	- 0.02	0.65	0.13	0.65
IENG	0.06	0.47	**0.20**	0.48
OPMT (end)	**0.00**	0.61	0.07	0.61

Uhrich et al., EFTF-IFCS 2015

Validation of the results [2/3]

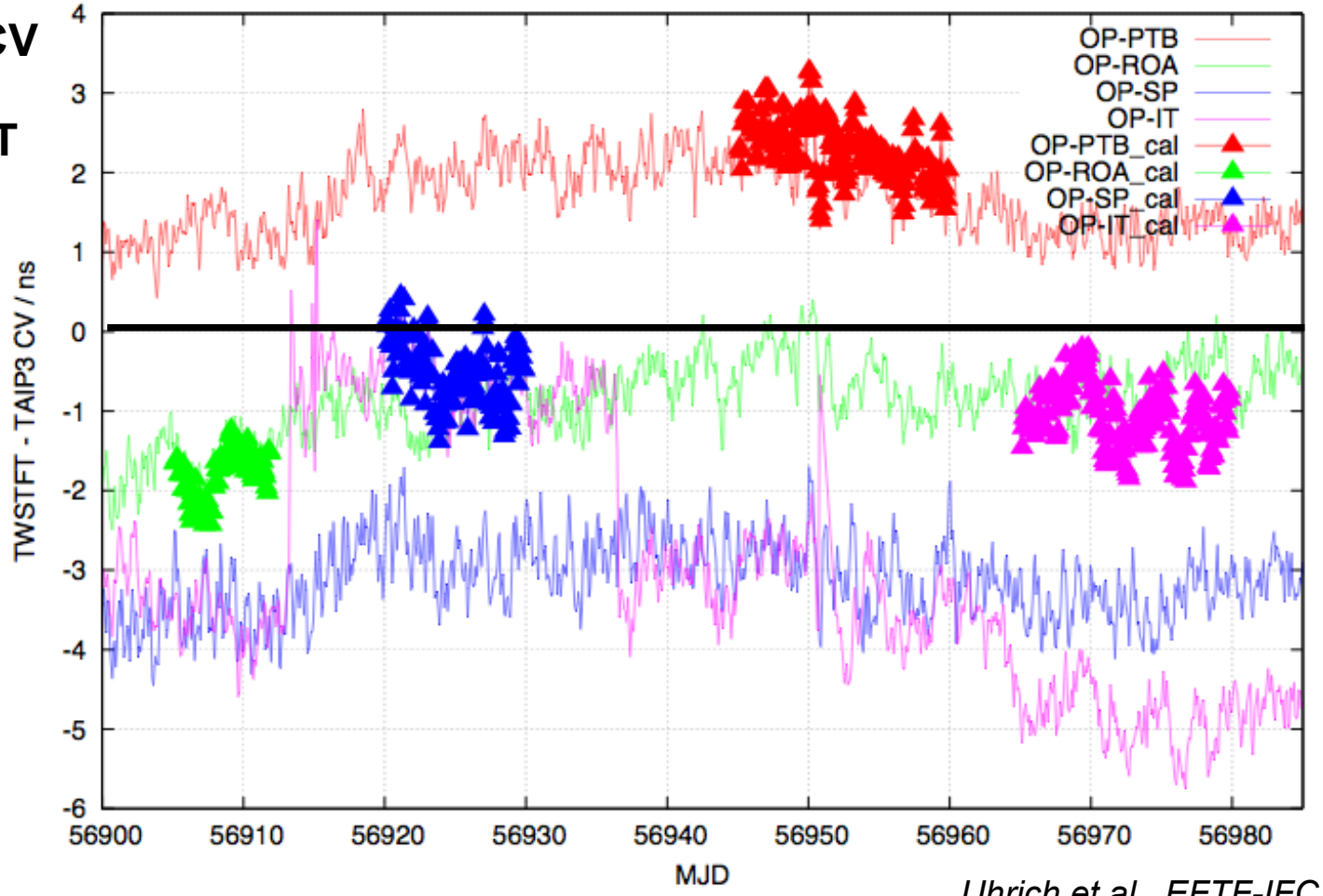
TAIP3 CV between both traveling units



Uhrich et al., EFTF-IFCS 2015

Validation of the results [3/3]

TAIP3 CV against TWSTFT



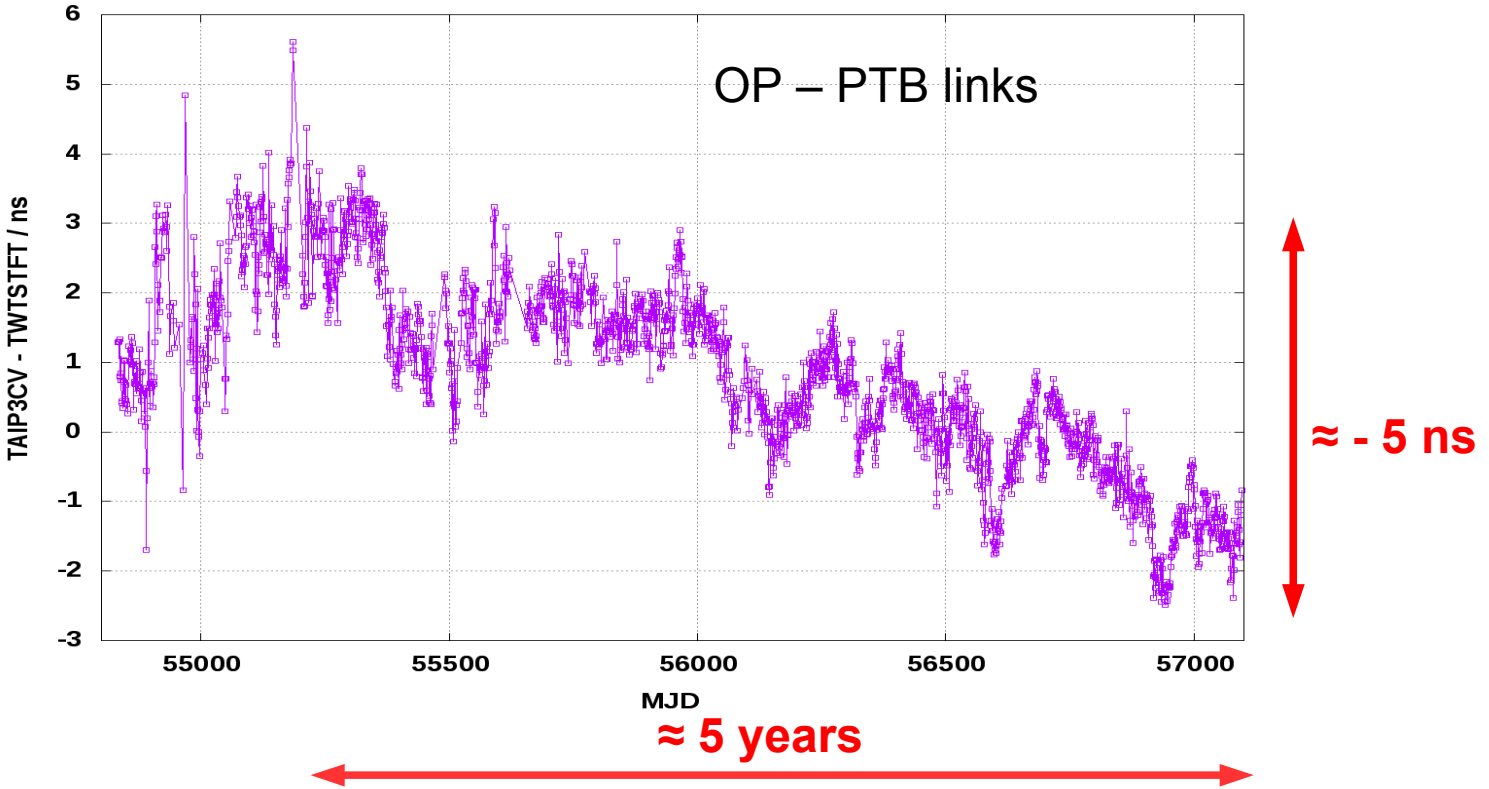
Uhrich et al., EFTF-IFCS 2015

Calibration uncertainty [1/2]

- Conventional GNSS link uncertainty values ?

  [*not the case for TWSTFT in Circular T ...*]
- Conventional measurement uncertainties (TIC, ocilloscope, VNA, …) ?
- Conventional uncertainties for other effects (coordinates residuals, multipaths, …) ?
- To publish actual calibration results in BIPM website ?
- k = 1 ? k = 2 (*EURAMET*) ?
- Conventional degradation after 2 years without calibration ?

Calibration uncertainty [2/2]



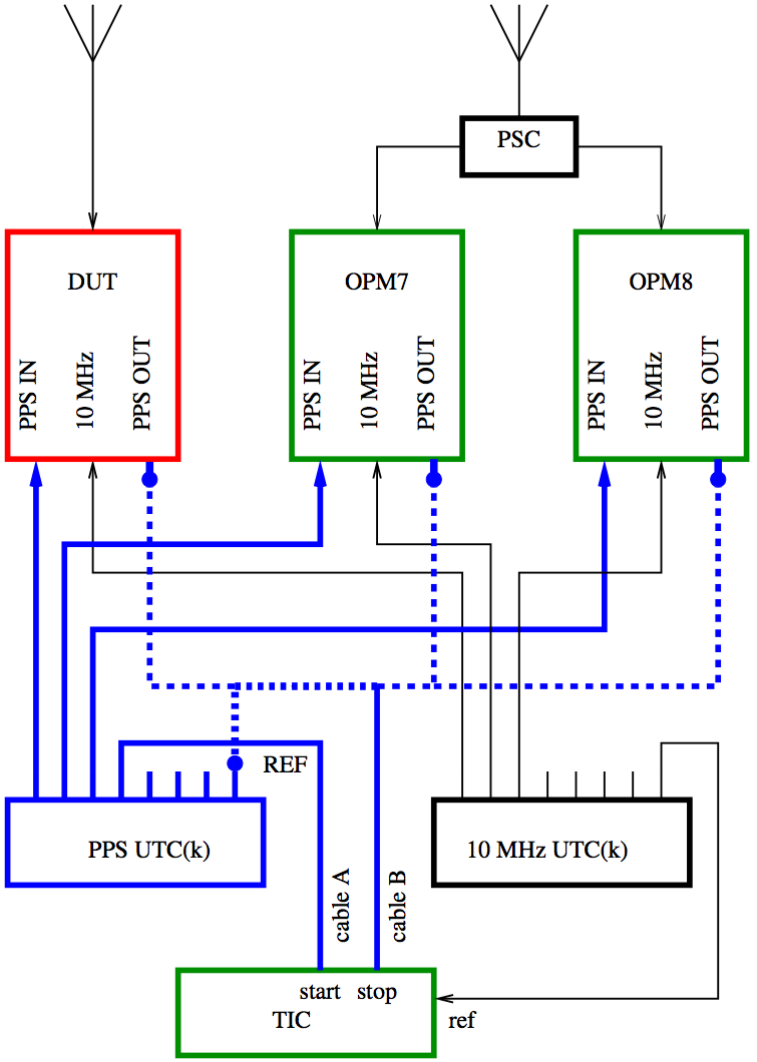
Miscellaneous [1/2]

- All signal distribution delays (1 PPS) should be measured by using a differential technique
- All trigger levels should be accurately defined :
  - Either from GNSS receiver manufacterer
  - Or from local signal distribution characteristics
  - Or even by agreement inside the WG
- Techniques for antenna cable delay measurements should be consistent

  [see : *Rovera et al., EFTF-IFCS 2015*]

Miscellaneous [2/2]

For Septentrio PolaRx receivers (*warm up > 2 h*)



Cable A : arbitrary
Cable B : test signal

Delays =
Cable B – Cable A

Role of Group 1 laboratories [1/2]

- To welcome a remote equipment at home ?
- To send a traveling equipment to remote site ?

  (together with a calibration procedure)
- To attend calibration in remote site ?
- To provide raw data to BIPM ?
- To process raw data according to the guidelines ?
- To release a calibration report according to the guidelines (RAWDIF, ...) ?

Role of Group 1 laboratories [2/2]

- To be responsible for the link uncertainty (against campaign reference receiver *which is not in PTB*) ?
- Propagation of uncertainty in TAI ?
- GPS P-code unavailable beyond 2020 >>

  Which code ? Which signal (RINEX or CGGTTS) ?
- Other GNSS software developments ?
- Reference number RMO and BIPM ?
- Funding ?

  >> EURAMET: 28 labs + 3 Group 1 >> 9 labs/Group 1

- We are grateful to **P. Defraigne (ROB)** for having provided freely her TAIP3 processing software and to **BIPM** for providing it in a user friendly way.
- We use **International GNSS Service (IGS)** products and **National Resources Canada (NRCan) PPP** software for some computations.
- Thank you to **G. Petit** (**BIPM**) for consistent dialog on the subject over the years.