

CCTF Working Group on GNSS time transfer

Report biennium 2015-2017

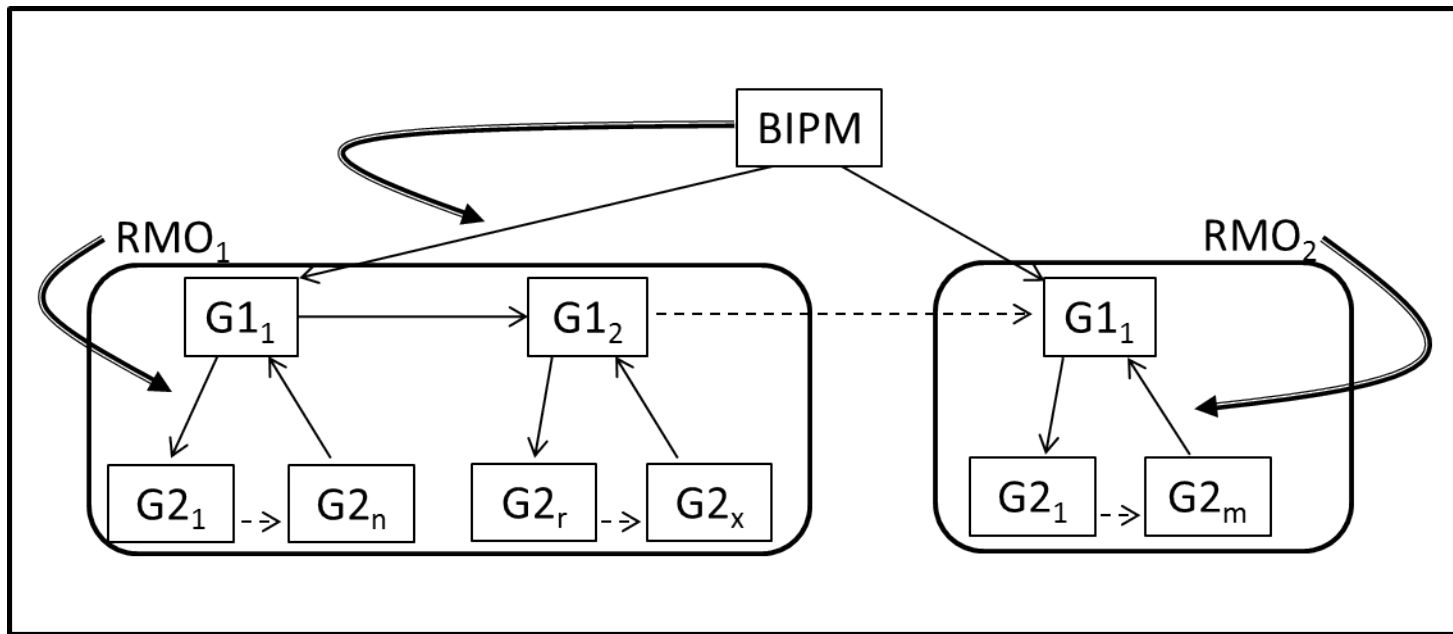
Pascale Defraigne, chair
Royal Observatory of Belgium

Outline

- **Calibration Status**
- **Use of new GNSS -constellations**
- **Precise Point Positioning**
- **Long-term variations between TW and GPS time transfer**
- **Recommendation to the CCTF**

Calibration guidelines

A new version of the guidelines (version 3.2) was proposed by the WG and made available in <ftp://tai.bipm.org/TFG/GNSS-Calibration-Results/Guidelines/>



Trips of differential calibration with closure

Group 1 laboratories :

EURAMET: OP, PTB, ROA

SIM: NIST, USNO

APMP: NICT, NIM, TL

COOMET: SU

Calibration status

- “Group1” calibration :

1. 1 complete trip in 4 phases January 2014 to June 2015,
cal_Id=1001-2014,
results available on the BIPM web page.

2. Partial trip started in March 2016, TL, NICT, NIM, PTB, ROA, OP
cal_Id=1001-2016,
results available on the BIPM web page.
Uncertainty = 1.5 ns

- “Group2” calibration :

15 Laboratories were calibrated by Group1 or BIPM

Calibration status (2)

Reference :

delays P1 and P2 ensemble of Group 1 laboratories

- Stability of this reference between the 2015 and 2017 Group 1 campaigns : < 0.5 ns
- The reference for C1 was also defined

Uncertainties :

- standard procedure defined in the guidelines
- u_{CAL} generally 1.0 to 1.5 ns

Next steps :

- absolute calibration and link with the references
- multi-constellations

Defining CALEX format

```

2.0
CGGTTS header
#####
CGGTTS header = provides all information needed for the
header of the CGGTTS format (INT DLY, CAB DLY, REF DLY)
SYSDLY = INTDLY + CABDLY may be used in CGGTTS V2E
TOTDLY = SYSDLY + REFDLY may be used in CGGTTS V2E
TOTDLY can be directly removed from the PPP solutions
Other CALEX TYPEs to be defined
#####
CALEX VERSION
CALEX TYPE
COMMENT
COMMENT
COMMENT
COMMENT
COMMENT
COMMENT
COMMENT
END OF HEADER
START OF STATION CAL
LABO / RINEX / BIPM
REC # / TYPE
ANT # / TYPE
GNSS / CAL_ID
VALID FROM
LAB REFERENCE
# / DLY / TYPE=VAL
DLY / VAL / COMMENT
DLY / VAL / COMMENT
VALID FROM
DLY / VAL / COMMENT
END OF STATION CAL
START OF STATION CAL
LABO / RINEX / BIPM
REC # / TYPE
ANT # / TYPE
GNSS / CAL_ID
VALID FROM
LAB REFERENCE
# / DLY / TYPE=VAL
DLY / VAL / COMMENT

```

```

OP                OPMT                OP02
02942              ASHTECH Z-XII3T
00019              3S-02-TSADM          NONE
GPS                1001-2014
  2015   04   01
  REF = UTC(OP)
  2 INTDLY P1 =   310.2   P2 =   321.6
    CABDLY          156.5
    REFDLY          100.1
  2015   08   27
    REFDLY          155.9

```

```

PTB                PTBB                PT02
RT820013901        ASHTECH Z-XII3T
CR15930            ASH700936E          SNOW
GPS                1001-2014
  2015   04   01
  REF = UTC(PTB)
  2 INTDLY P1 =   303.9   P2 =   319.3
    CABDLY          301.7

```

Use of multi-constellations

- Several multi-constellation receivers in several time labs
- R2CGGTTS V7 available for GPS, GLONASS and Galileo.
From RINEX 3 to CGGTTS results in the format V2E.
- Calibration ongoing : from GPS / Absolute

GPS Precise Point Positioning

State of the art

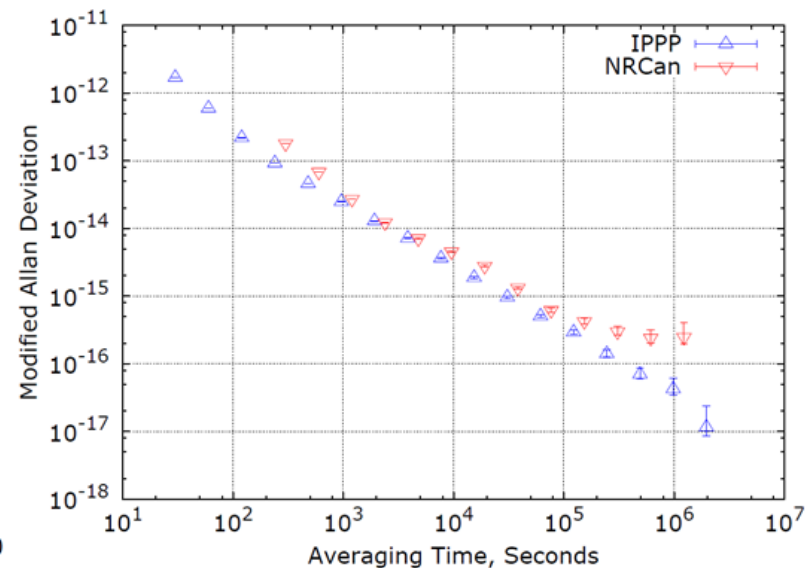
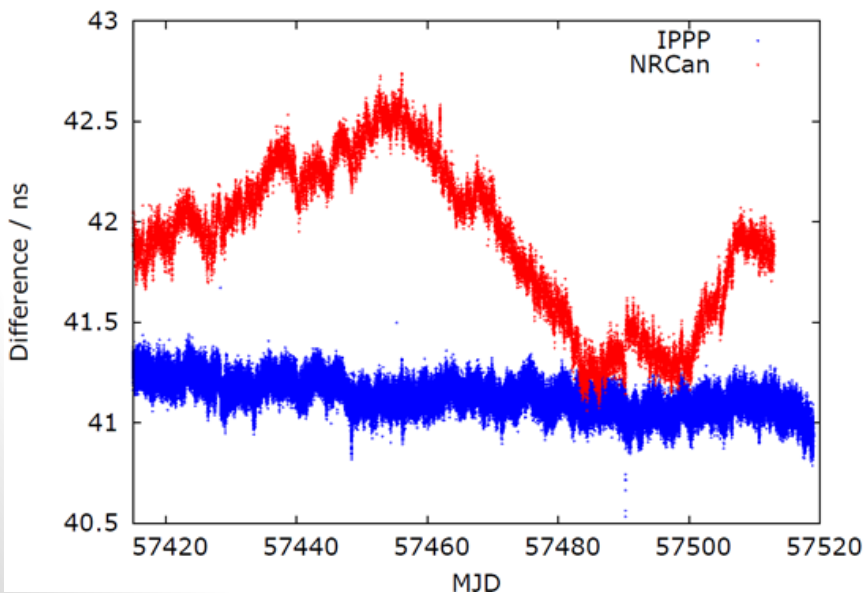
- GPS only
- PPP algorithm solving the carrier phase ambiguities as integer numbers.
- Allows frequency transfer accuracy of 1×10^{-16} at a few day averaging time.

GPS PPP State of the art

IPPP and PPP vs. 420-km fibre link: best result

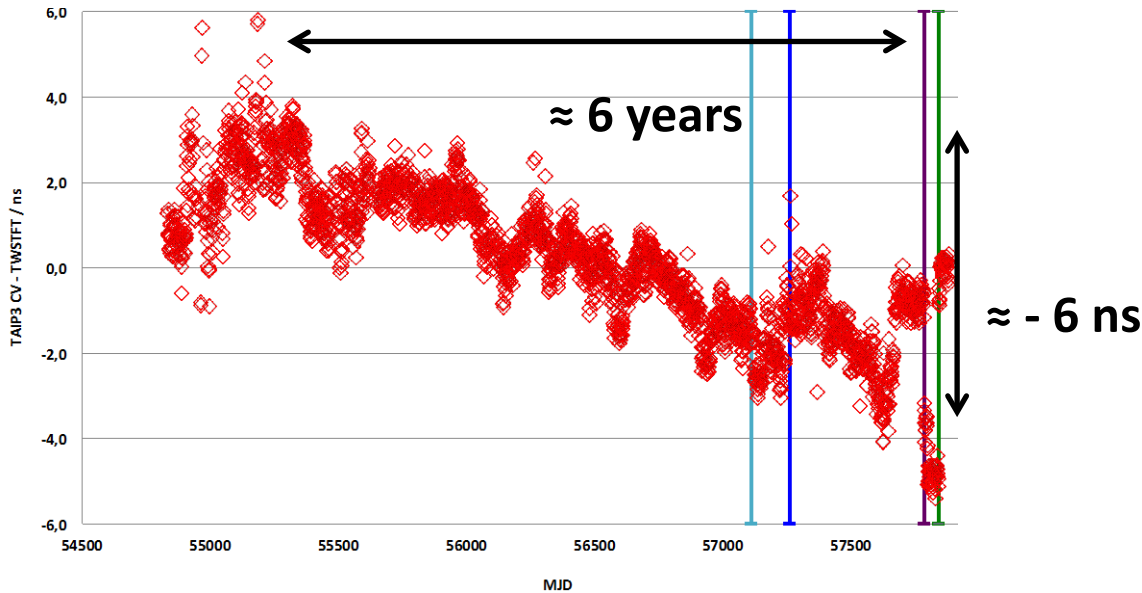
- ◆ Monthly IPPP computation of AOS-GUM link.
- ◆ Longest continuous IPPP solution: 104 days
- ◆ (IPPP – Fibre) crosses 1×10^{-16} at about 4 day averaging, **low 10^{-17} at 15-20 days**
- ◆ (IPPP – Fibre) frequency difference – **2.1×10^{-17}** .
- ◆ Classical PPP limited $\sim 2-3 \times 10^{-16}$

Blue = IPPP – Fibre link
Red = NRCan – Fibre link



Long-term variations between TWSTFT and GPS time transfer

OP-PTB TW-GPS



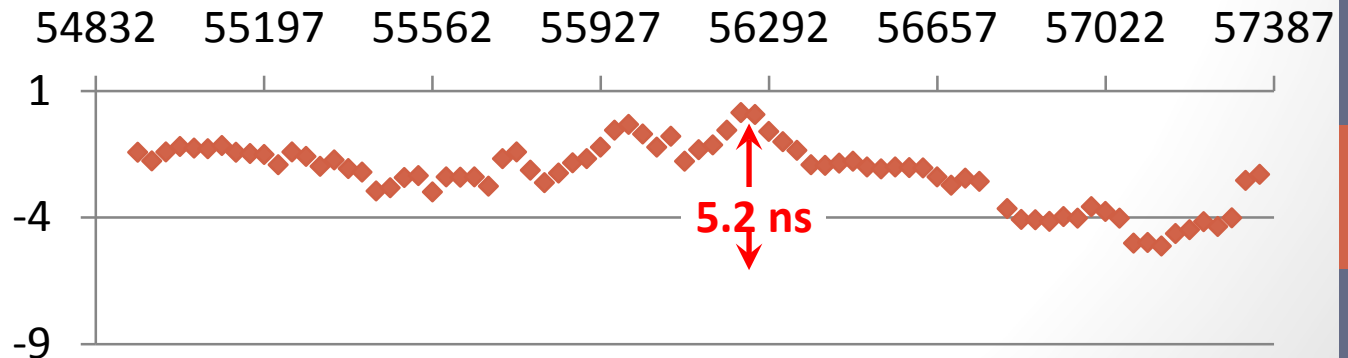
TWSTFT 2014

BIPM G1 #1001-2014

BIPM G1 #1001-2016

TWSTFT 2016

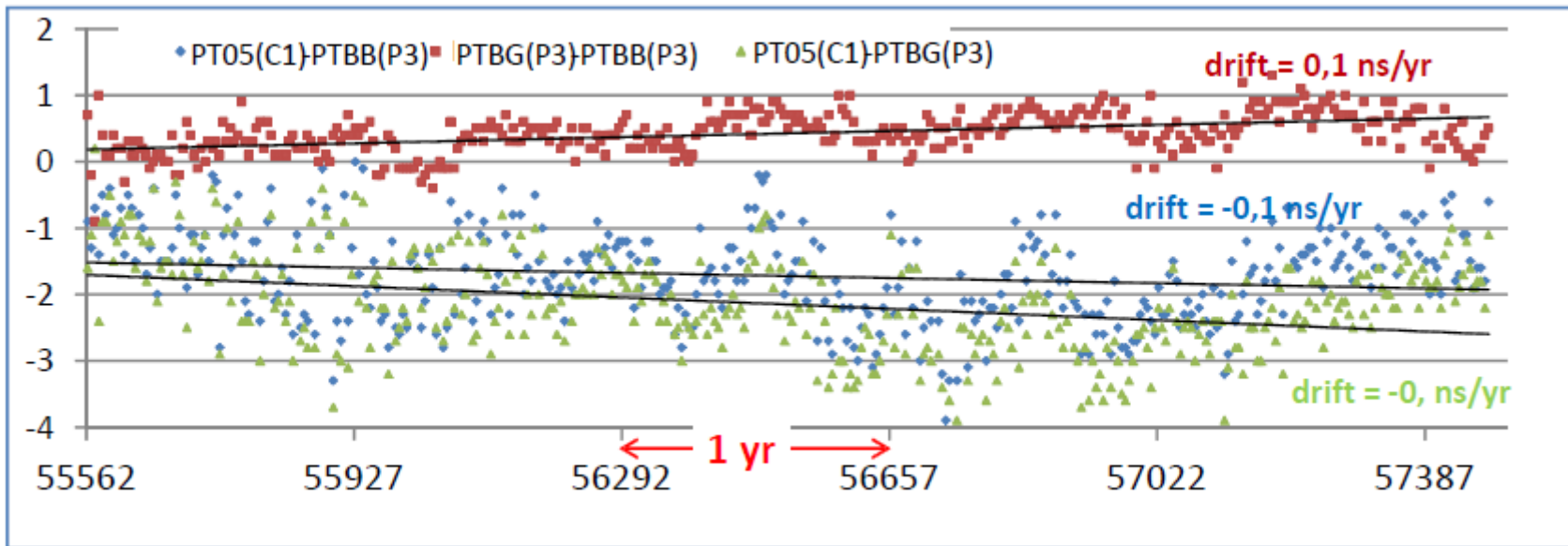
NIST-PTB TW-GPS



Long-term variations between TWSTFT and GPS time transfer

Analyses of Common Clock Differences
And Double Clock Differences

Exemple at PTB



Recommendation to the CCTF