CCTF WG on GNSS time transfer

2012-2015

Summary of the activities

Terms of Reference

- to report to the CCTF on the state of the art in GNSS time and frequency transfer and to provide recommendations concerning receiving systems, calibration and data processing;
- in collaboration with the BIPM, to gather and share the information and the experience on available equipment, characterization of the hardware delays, data processing and scientific results;
- to maintain contacts with the receiver manufacturers in order to inform them about our needs;
- to stimulate the collection and analysis of code and carrier phase data from all GNSS constellations;
- to stimulate the development of calibration procedures in agreement with new GNSS receiving systems;
- to establish contacts with the parallel scientific communities working on the definition of the receiver output standards;
- to study the clock results formats in agreement with the user needs.

members

Chairman: Dr Pascale Defraigne (ORB)

Secretary: Dr Gérard Petit (BIPM)

Members:

- ~~One representative from the CCTF-WGTAI~~;
- One representative of the CCTF-WGATFT; TBD
- Experts from laboratories contributing to UTC;
- Experts from the International GNSS Service (IGS);
- Experts from time/frequency sections of NMIs;
- Members of the BIPM Time Department, one of them acting as the WG secretary

Agenda

1. **P. Defraigne**: Introduction, summary of items in the WG report to the CCTF

2. **G. Petit**: Group 1-2 calibration : update on results and plans for changes in Circular T

3. **P. Uhrich**: Some comments on the Calibrations guidelines

4. **S. Römisch**: Calibration campaign between NIST, OP and PTB

5. **P. Defraigne**: Receiver P1-P2 stability analysis and comparison with calibration results

COFFEE

6. **Z. Jiang**: A low cost GPS calibrator for the G2 calibrations

7. **M. Wouters**: A low-cost time-transfer system to support dissemination of national standards

8. **D. Matsakis** : Carrier Phase frequency biases in receivers used for UTC-generation

9. Discussion of Recommendations to the CCTF, to recommend that: (20-30 min)

CGGTTS 1/3

V2E : extended version of the format 2.0

- Published in *Metrologia* 2015 **52** G1

With a link to
http://metrologia.bipm.org/guides-stds-conventions/2015/G1.pdf

- Includes :
  GPS
  GLONASS
  Galileo
  BeiDou
  QZSS

- Single-frequency (L1 band) OR 2-frequency (the combination of the broadcast clocks → ONLY one combination)

CGGTTS 2/3

- 13 minute tracks

  + Explains that interpolations should be done if for some reasons some files use 5-minute tracks

  (but not for the computation of TAI)

- No mixed CGGTTS files will be provided, each file will contain only the results for a given constellation and all the results reported will be associated with the same code measurement or the same ionosphere-free combination.

- The number of lines in the header can be variable as the hardware delays can be presented as SYSDLY (INTDLY+CABDLY) or TOTDLY (INTDLY+CABDLY+REFDLY)

- The CAL_ID must appear after the INTDLY (or SYSDLY or TOTDLY)

- The title "PRN" in the line header is replaced by "SAT"

- The constellation code for GPS was blank, it is now "G"

- The constellation code was "1" for GLONASS, is now "R"

- The Issue of Ephemeris (IOE) for GLONASS which was not specified is now defined as the index between 1 and 96

CGGTTS 3/3

```
Case 2: ionospheric measurements available, single-frequency or dual-frequency results
CGGTTS       GENERIC DATA FORMAT VERSION = 2E
REV DATE = 2014-02-20
RCVR = RRRRRRRRR
CH = 12
IMS = IIIIIIIII
LAB = ABC
X = +4027881.79 m
Y =  +306998.67 m                          or  SYS DLY =  or  TOT DLY =
Z = +4919499.36 m
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 = NO COMMENTS
INT DLY =   53.9 ns (GLO C1),   49.8 ns (GLO C2)        CAL_ID = 1nnn-yyyy
CAB DLY =   237.0 ns
REF DLY =  149.6 ns
REF = UTC(ABC)
CKSUM = 3B
```

```
SAT CL  MJD   STTIME TRKL ELV AZTH  REFSV       SRSV     REFSYS      SRSYS   DSG IOE MDTR SMDT MDIO SMDI MSIO SMSI ISG FR HC FRC CK
            hhmmss   s  .1dg .1dg   .1ns       .1ps/s    .1ns       .1ps/s .1ns     .1ns.1ps/s.1ns.1ps/s.1ns.1ps/s.1ns
R24 FF 57000 000600  780 347  394  +1186342     +0        163         +0   40   2  141  +22   23   -1   23   -1  29 +2  0 L3P 5C
R05 FF 57000 000600  780  70 2325   +22617      +6        165         -3   53   2  646 +606  131   -9  131   -9  37 +1  0 L3P 8C
R17 FF 57000 000600  780 539 1217  -1407831    -36        154        -54   20   2  100   -8   24   +0   24    0  13 +4  0 L3P 7A
R16 FF 57000 000600  780 370 3022   +308130    -18        246        -28   29   2  134  -22   63   +4   63    4  21 -1  0 L3P 80
```

Calibration guidelines (1)
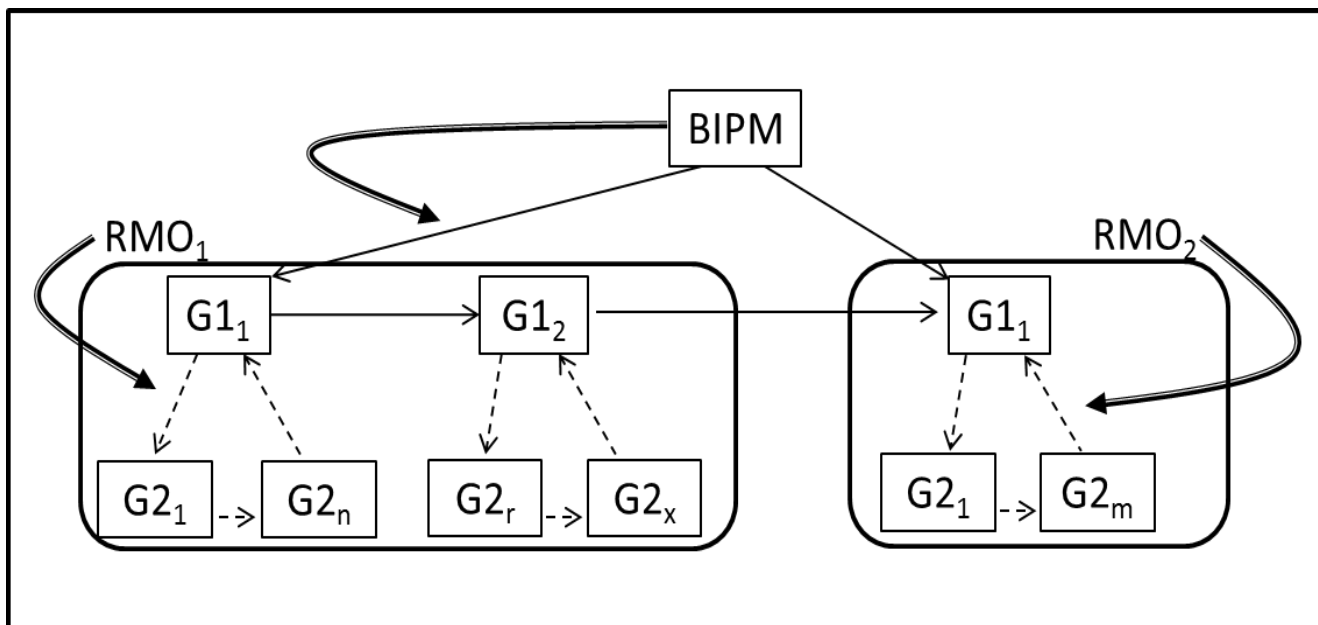
1. BIPM will organize the calibration of some stations (called "group 1" here after) in each RMO,
2. the RMOs, together with these "group 1" laboratories, will organize calibration campaigns for the other laboratories (called "group 2") of their region.
3. In addition, the BIPM will conduct "Group 2" trips as necessary to accommodate special cases, using either one BIPM system or a "Group 1" system as a reference.

Calibration guidelines (2)

- Procedure is based on "differential calibration with closure" trips
- the reference values are provided by a set of systems operated in selected (G1) laboratories.
- The guidelines for calibration procedure have been defined for the different receiver types used as traveling or station equipment
- The standard process of calculation is also defined as well as a Template of calibration report to the BIPM.
- ftp://tai.bipm.org/TFG/GNSS-Calibration-Results/Guidelines/
- Calibration uncertainty : conventional value depending only on the technique (single-frequency or dual-frequency) and the age of the oldest calibration trip

Calibration guidelines (3)

The Group 1 laboratories per RMO have been designated:

- **EURAMET**: OP, PTB, ROA

- **SIM**: NIST, USNO

- **APMP**: NICT, NIM, TL

- **COOMET**: SU

- no G1 laboratories in **AFRIMETS** and **GULFMET**.

A first G1 trip was organized by the BIPM in 2014, the results are available at

ftp://tai.bipm.org/TFG/GNSS-Calibration-Results/1001-2014/.

Calex format

Single file reporting all the calibration results

```
1.3                                                        CALEX VERSION
CGTTS header                                               CALEX TYPE
##########################################################  COMMENT
CGTTS header = provides all information needed for the     COMMENT
header of the CGTTS format (INT DLY, CAB DLY, REF DLY)     COMMENT
SYS DLY = INT DLY + CAB DLY may be used in CGTTS V3        COMMENT
TOT DLY = SYS DLY – REF DLY may be used in CGTTS V3        COMMENT
TOT DLY can be directly removed from the PPP solutions     COMMENT
Other CALEX TYPEs to be defined                           COMMENT
##########################################################  COMMENT
                                                           END OF HEADER
                                                           START OF STATION CAL
USNO            USN3            US03                        LABO / RINEX / BIPM
RT920012203                ASHTECH Z–XII3T                 REC # / TYPE
KW5-0258                   AOAD/M_T       NONE             ANT # / TYPE
GPS                        1008-2014                       GNSS / CAL_ID
 2004    10    01      0     0     00                       VALID FROM
 REF = UTC(USNO)                                           LAB REFERENCE
 2 TOTDLY P1=    287.9 P2=    304.1                        # / DLY / TYPE=VAL
                                                           END OF STATION CAL

 …
```

PPP

- Look for continuous PPP solutions (comparison of optical clocks)
  - Long batches/moving windows/ …
  - Solving Integer ambiguities : need for specific clock products → need for continuation of the collaboration with the geodetic community
- Need synchronized measurements of code an phase in the receiver → need for continuation of the collaboration with the receiver manufacturers

Recommendations to the CCTF

- the calibration guidelines be applied and Group 2 calibration be organized;

- receiver manufacturer and R2CGGTTS provider implement the CGGTTS format V2E in their new issues

- The receiver manufacturers minimize the offset between the latching of code and carrier phase measurements.

WG Meetings

[Meeting_PTTI2012](#) (28 Nov 2012)

[Meeting_EFTF-IFCS 2013](#) (24 July 2013)

[Meeting_PTTI2013](#) (4 December 2013)

[Meeting_EFTF2014](#) (24 June 2014)

[Meeting_EFTF-IFCS 2015](#) (13 April 2015)

[Meeting_CCTF2015](#) (15 September 2015)