GPS calibrations for UTC

BIPM Time Department

CCTF WG on TAI
7 June 2017
21st CCTF Meeting
8-9 June 2017
The BIPM scheme for GNSS calibrations

Status of GPS G1 and G2 calibrations

Improving the dissemination of results:
- Changes in the BIPM Circular T
- Calibrations web page
- Time department database

Recent and future actions
Cooperation with RMOs has been established, and Calibration guidelines written during 2014.

New scheme in place in 2015 for GPS P1/P2 (P3)
- BIPM calibrates the systems in laboratories G1
- RMOs are responsible for calibrations of laboratories G2 in the regions, and for submitting reports to the BIPM.
Status of G1 and G2 calibrations

- **Group 1 (2016) under way (9 visits total, 8 completed)**
  - APMP-EURAMET results published 01/2017; SIM results soon

- **Group 2: 21 Cal_Id (trips) attributed.**
  - 11 Cal_Id (trips), with 20 G2 labs, completed.
Implementation for Circular T

- January 2016: New form of Circular T with additional information
- \( u_{CAL}(t) = (u_{CAL0}^2 + u_{AG}^2 + u_{AL}^2)^{1/2} \)
  - Typically \( u_{CAL0} \) is 1.5 ns for G1, 2.5 ns (default) for G2 trips (closure), 4 ns (default) for “golden system” (no closure).

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http://www.bipm.org/jsp/en/TimeCalibrations.jsp

On line 09/04/2015

Intended to host all reports of UTC calibrations

WARNING: ftp contents have been moved from ftp://tai.bipm.org/TFG/.. to ftp://ftp2.bipm.org/pub/taι/.. on 24/03/2016.
- Contents can also be accessed through the Time Dpt database.


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BIPM Guidelines: latest features

- « BIPM Guidelines for GNSS calibrations » Update v3.2 in February 2016
- Covers evolution of a calibrated system between two calibration exercises
  - Change in set-up (affecting only REFDLY)
  - or change in some elements (antenna cable?)
  - or replacement of a full system
  - or ...
- What should be done?
  - If change affects only REFDLY AND if calibration results are expressed as INTDLY or SYSDLY, just measure and report the new REFDLY value. No change in Calibration Identifier (Cal_Id) nor in $u_{\text{CAL}}$.
  - In all other cases, the laboratory should perform and report a “transfer of calibration”
Transfer of calibration / Alignment

- **Transfer of calibration (TC)**
  - Typically done by simultaneous operation of two systems in common-clock;
    - Either the new receiver in parallel to the old one
    - Or using a backup receiver to bridge between the new system/set-up and the old one
  - Short report to be transmitted to the BIPM;
  - Cal_Id (znnn-YYYY) will be expanded to reflect the TC
    - Same system as was initially calibrated: New Cal_Id = znnn-YYYY-TC1
    - New system: New Cal_Id = znnn-YYYY-SSSS-TC1 where SSSS is the originally calibrated system
    - TC counter can be incremented (TC2, TC3 ...), each time with a report
    - BIPM will slightly expand $u_{\text{CAL}}$ (e.g. by 0.5 ns in quadrature).

- **Alignment (AL)**
  - Done by the BIPM when no other solution
    - BIPM will slightly expand $u_{\text{CAL}}$ (e.g. by 0.5 / 1 ns in quadrature).

- We are trying to implement such report of info in Circular T ...
One single file to gather all calibration history, similar to IGS Antex

To be maintained by the BIPM

Should be linked to the BIPM database, under development...

Sample Calex file: BIPM_2016712.clx

```
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
TODDLY = SYSDLY + REFDLY may be used in CGGTTS V2E
TODDLY can be directly removed from the PPF solutions
Other CALEX TYPES to be defined

CALEX VERSION
CALEX TYPE
COMMENT
COMMENT
COMMENT
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
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ANT # / TYPE
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# / DLY / TYPE=VAL
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OP      OPMT      OP02
02942    ASHTECH Z-XII3T
00019    38-02-TSADM   NONE
GPS
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
2015 04 01
REF = UTC(PTB)
2 INTDLY P1 = 303.9 P2 = 319.3
CABDLY   301.7
Future actions

- G1 2016 trip to be finished and findings to be published

- More G2 trips.
  - More/different G1 labs needed?

- GPS L1C and other codes

- Complete the information on calibrations in BIPM publications
  - Transfer of calibration / Alignments

- Link to the new method for computation of uncertainties in [UTC-UTC(k)]
THANK YOU

Thanks to all Group 1 and other participating laboratories!