Laboratory Update

Andreas Bauch, PTB

CGSIC Timing Subcommittee
2021-09-20
Aerial view of Braunschweig campus

- National Metrology Institute of Germany since 1887,
- Governed by the Federal Ministry for Economy and Energy
- 2150 staff, 240 Mio. € budget
Activities in time and frequency

- Development and operation of atomic clocks
- Realization of UTC(PTB) and legal time
- Dissemination of legal time, support of industry
- International cooperation
Involvement in international metrology

UTC and TAI are realized by BIPM, based on inputs of some 80 timing institutes, operating some 400 atomic clocks.
Involvement in international metrology

**Circular T**

5 - Time links used for the computation of TAI, calibrations information and corresponding uncertainties.

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<thead>
<tr>
<th>Link</th>
<th>Type</th>
<th>Equipment</th>
<th>Cal_ID1/Cal_ID2</th>
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<th>uCal/ns</th>
<th>uAg/ns</th>
<th>Al/ns</th>
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PTB serves as the pivot for GPS time comparisons and TWSTFT, evaluated and used by the BIPM, because of

- Geographical position (TWSTFT to US and to Asia),
- Equipment in redundancy and reliably operated,
- Predictable, stable time scale UTC(PTB).
Involvement in international metrology

1st GPS receiver operated in PTB, a gift from National Bureau of Standards 1982
Mission of the Time Dissemination Working Group in the GNSS context:

- Maintain a set of redundant receivers for all kinds of signals
- Operate IGS station PTBB (since year 2000)
- Monitor inter-receiver biases
- Support the use of GPS and Galileo signals for timing applications in different user communities
- Support the Galileo timing system through collaboration with the Galileo Time Service Provider and the Galileo Reference Centre
- Support BIPM calibration activities by determining GNSS signal delays in installations of G2 laboratories in Europe and elsewhere
Two sites with GNSS-antenna installations
All receivers connected to signals representing UTC(PTB)

2 receivers GPS L1, L2 only: (PT07, PTBT)

6 Rec. multi-GNSS (PT09 – PT12, PTBB, PTBM)
4 Rec. multi-GNSS on loan / under contract
Observation of individual GNSS satellites

Data GZGRCP59.426 indiv. GPS SV observations

Data EZGRCP59.426 indiv. Galileo SV observations
Observation of individual GNSS satellites

Apparently different quality of broadcast ephemerides and clocks

Way around:

BIPM evaluates all links in post-processing using precise orbit and clock products provided by IGS;

For local and continental comparisons, the legacy Common-View method is fully appropriate.
Equipment monitoring in PTB
CV of GPS L3P data

Equipment monitoring in PTB
CV of Galileo L3E data.
GNSS system time monitoring at PTB

GPS reception in PTB: Recording of REFSYS, with PT09 and PT13 (Septentrio PolaRx) and PT10 (Mesit GTR51)

Galileo reception in PTB: Recording of REFSYS with PT09 and PT13 (Septentrio PolaRx) and PT10 (Mesit GTR51)
GNSS navigation message monitoring at PTB
Comparing GNSS with TWSTFT at PTB

Major effort during 2021 as TWSTFT link configuration was changed twice

Thanks to Frédéric MEYNADIER, BIPM
PTB serves as one of the three European G1 labs, supporting BIPM for providing receiver delay determination, including Galileo signal delay delays since 2020.

- 1011-2020 ORB (Bruxelles)
- 1013-2020 ESTEC (ESA)
- 1014-2020 BKG (Geodetic Observatory Wettzell, Germany)
- 1011-2021 INRIM (Italy)
- 1201-2021 JV (Norway)
- 1013-2021 UFE (Czech Republic) and VSL (the Netherlands)
- 1016-2021 DLR (Germany) – BEV (Austria) ongoing
Example from 2020:

Support of German Air Force, setting up a new time lab

GPS and Galileo CV between PTB after GPS and Galileo delays were applied.

WTD 61 operates a comm. Cs clock
Other time and frequency activities

In the department:
• Operation of the clock ensemble (5 active masers, 2 passive masers, 6 commercial Cs clocks, legacy primary clocks CS1 and CS2
• Operation and „perfection“ of Cs fountain clocks CSF1 and CSF2
• Development and operation of several optical frequency standards
• Integration of optical frequency standards into the time scale generation (WIP)

In the working group:
• Dissemination of legal time via long-wave DCF77 and telephone service
• Dissemination of 1 PPS and 10 MHz via optical fibers to Deutsche Telekom (and other user groups in the future)
• IT-based dissemination for the public and for restricted users, in cooperation with PTB IT-sector.
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