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BIPM GPS CALIBRATION TRIPS

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For almost 20 years, the BIPM has conducted differential calibrations of GPS equipment located in time laboratories who contribute to TAI. Repeated determinations of the differential time corrections for the GPS time equipment located in the national laboratories are needed for:

- improving the accuracy of the access to UTC of participating laboratories;
- providing valuable information about the stability of GPS time equipment.

Usually the uncertainty of such differential calibrations estimated for the period of comparison, is 3 ns (1 σ).

For these calibrations, the GPS time equipment located at the Observatoire de Paris (OP) was chosen as reference. To check the reproducibility of the measurements, the calibrations were organized as round trips beginning and ending at the OP. Over the years, the OP GPS time receiver has been compared many times with the National Institute of Standards and Technology (NIST) absolutely-calibrated reference GPS time receiver. The difference between these two has never exceeded a few nanoseconds (see Appendix I).

Following a suggestion at the 4th meeting of the CCDS Working Group on TWSTFT, the BIPM begun in 1996 a series of differential calibrations of GPS equipment located in time laboratories equipped with two-way stations. These measurements serve as provisional differential calibrations of the two-way equipment at the laboratories, and an independent check of TWSTFT differential calibrations (see Appendix II).

The BIPM is committed to continuing these calibrations, as far as resources will allow. It is expected, however, that the regional metrological organizations will take care of the calibrations within their regions, and the BIPM will continue calibrations between regions.

Since last CCTF in 2001, the BIPM conducted seven calibrations trips involving twenty laboratories. In March 2004 started a calibration in South and North Americas, involving ten laboratories.

All BIPM calibration reports are available on:
http://www1.bipm.org/en/scientific/tai/publications.html

Appendix I

Some past calibrations between NIST and OP are provided in table below: *d* are differential time corrections to be added to [*UTC*(NIST)-*UTC*(OP)], and *u(d)* are estimated uncertainties for the periods of comparisons.

Date	*d*/ns	*u(d)*/ns	Reference
July 1983	0.0	2.0	[1]
January 1985	–7.0#	13.0	[2]
September 1986	0.7*	2.0	[3]
October 1986	–1.4*	2.0	[3]
January 1988	–3.8*	3.0	[4]
April 1988	0.6*	3.0	[5]
March 1995	–3.7*	1.0	[6]
May 1996	–0.7*	1.5	[7]
May 2002	–5.0*	3.0	[8]
July 2003	–5.6*	1.9	[9]
December 2003	-4.6*	3.0	[10]

NBS03 receiver at NIST
* NBS10 receiver at NIST

This comparison is subject of a EFTF'2004 paper.

References

[1] D. Allan, D. Davis, M.A. Weiss, Personal communication, 1983.

[2] J. Buisson, Personal communication, 1985.

[3] W. Lewandowski, M. A. Weiss, "A Calibration of GPS Equipment at Time and Frequency Standards Laboratories in the USA and Europe", *Metrologia,* **24**, pp. 181-186, 1987.

[4] BIPM Calibration Certificate of 19 January 1988.

[5] BIPM Letter of 15 June 1988, BG/9G.69.

[6] M.A. Weiss, "Calibration of OP Receiver AOA51 Against NIST Receiver NBS10" March 1995.

[7] M.A. Weiss, "Calibration of OP Receiver AOA51 Against NIST Receiver NBS10" March 1996.

[8] W. Lewandowski, P. Moussay, "Determination of the differential time corrections for GPS time equipment located at the OP, IEN, ROA, PTB, NIST, and USNO", *BIPM Report -2002/02*, July 2002.

[9] M.A. Weiss, "Calibration of OP Receiver AOA51 Against NIST Receiver NBS10" July 2003.

[10] W. Lewandowski, L. Tisserand, "Determination of the differential time corrections for GPS time equipment located at the OP, PTB, AOS, KRIS, CRL, NIST, USNO and APL", *BIPM Report -2004/06*, March 2004.

Appendix II

A Simultaneous Calibration of the IEN/PTB Time Link by GPS CV and TWSTFT Portable Equipment

In June 2003, a simultaneous calibration of the IEN/PTB time link by GPS CV and TWSTFT portable equipment was conducted by the Technical University of Graz (TUG) for TWSTFT, and by the BIPM for GPS CV. Below is provided comparioson of two calibrations.

Table 1. IEN/PTB link TWSTFT and GPS CV link before applying calibration corrections.

Date 2003 (MJD)	[*UTC(IEN) – UTC(PTB)*] /ns		(TWSTFT – GPS) /ns
	TWSTFT (*Circular T*)	GPS	
4 June (52794)	–30.1	–35.4	5.3
9 June (52799)	–38.6	–43.8	5.2
14 June (52804)	–47.1	–49.9	2.8
19 June (52809)	–52.6	–59.4	6.8
24 June (52814)	–49.5	–53.2	3.7
29 June (52819)	–49.0	–54.5	5.5
4 July (52824)	–53.6	–58.1	4.5
9 July (52829)	–48.4	–55.3	6.9
14 July (52834)	–55.2	–60.3	5.1
19 July (52839)	–61.9	–70.1	8.2
24 July (52844)	–54.0	–57.1	3.1
29 July (52849)	–56.7	–59.8	3.1

Table 2. IEN IEN/PTB link TWSTFT and GPS CV link after applying calibration corrections:

−1.0 ns for TWSTFT
+3.2 ns for GPS CV

Date 2003 (MJD)	[*UTC(IEN) – UTC(PTB)*] /ns		(TWSTFT – GPS) /ns
	TWSTFT	GPS	
4 June (52794)	–31.1	–32.2	1.1
9 June (52799)	–39.6	–40.6	1.0
14 June (52804)	–48.1	–46.7	–1.4
19 June (52809)	–53.6	–56.2	2.6
24 June (52814)	–50.5	–50.0	–0.5
29 June (52819)	–50.0	–51.3	1.3
4 July (52824)	–54.6	–54.9	0.3
9 July (52829)	–49.4	–52.1	2.7
14 July (52834)	–56.2	–57.1	0.9
19 July (52839)	–62.9	–66.9	4.0
24 July (52844)	–55.0	–53.9	–1.1
29 July (52849)	–57.7	–56.6	–1.1

Table 3. Differences between TWSTFT and GPS before and after applying calibration corrections for IEN/PTB link by TWSTFT and GPS, for the period 4 June – 29 July 2004 .

UTC(IEN) – UTC(PTB)	(TWSTFT – GPS) /ns	
	Mean	rms
Before calibration corrections	5.0	1.7
After calibration corrections	0.8	1.7

This calibration is subject of a EFTF'2004 paper.