

2016 Group 1 GPS calibration trip

Summary

The 2016 visit to Group 1 laboratories started in March 2016.

The trip is decomposed into several phases, each separated with closures at the BIPM.

- Phase 1 (March-September 2016). BIPM-TL-NICT-NIM-BIPM with the traveling receivers BP1C and BP0U; In addition, a visit to NTSC was organized to check results of a previous Group 2 trip by NIM.
- Phase 2 (October-December 2016): BIPM-PTB-ROA-OP-BIPM with the traveling receivers BP1C and BP0U;
- Phase 3 (To Be Continued)

Following work described in [BIPM Technical Memorandum 243](#), calibration results for code C1 (L1C) have been added to the original Group 1 P1/P2 calibration. Starting with this report for the second Group 1 trip, results are provided for the GPS codes P1, P2 and C1.

This report provides intermediate results which are determined with respect to one BIPM receiver.

Final results for all three codes for all Group 1 receivers are determined in a separate document [BIPM Technical Memorandum 266](#).

Trip 1001-2016: Report of phase 2

1. Description of equipment and operations

1.1 Traveling equipment

- Traveling systems:

Two systems are included in the BIPM traveling calibrator: BP1C and BP0U, see Table 1 and the report of operations [1001-2016-phase2-cv.pdf](#).

The long term stability of the two systems is described in the [BIPM Technical Memorandum 204](#).

- Other traveling equipment:

See Annex 1 of the [Guidelines](#).

1.2 Visited equipment

See a summary in Table 1. The detailed information on the set-up and the measurements performed is in the report of operations [1001-2016-phase2-cv.pdf](#).

For reasons mentioned in section 3, two receivers (BP1J and BP1X) from the BIPM have been included as backup systems to check the closure. BP1J is also treated as a visited system for which a G1-compatible solution is generated, so that it may act as reference receiver in future trips.

Table 1. Summary information on phase 2 of the calibration trip 1001-2016

Institute	Status of equipment	Dates of measurement	BIPM code	RINEX name	Receiver type
BIPM	Traveling		BP1C	BP1C	Septentrio PolaRx3eTR
BIPM	Traveling		BP0U	BP0U	Dicom GTR50
BIPM	BIPM reference	57650-57657	BP0R	BP0R	Septentrio PolaRx2eTR
BIPM	BIPM backup	57646-57657	BP1J	BP1J	Septentrio PolaRx4
BIPM	BIPM backup	57646-57657	BP1X	BP1X	Dicom GTR51
PTB	G1 reference	57671-57678	PT02	PTBB	Ashtech Z12T
PTB	G1 backup	57671-57678	PT03	PTBG	Ashtech Z12T
PTB	G1 backup	57671-57678	PT07	PT07	Dicom GTR50
PTB	G1 backup	57676-57678	PT09	PT09	Septentrio PolaRx4
PTB	G1 backup	57671-57678	PT10	PT10	Dicom GTR51
ROA	G1 reference	57689-57696	RO_5	RO_5	Dicom GTR50
ROA	G1 backup	57689-57696	RO_6	RO_6	Septentrio PolaRx3
ROA	G1 backup	57689-57696	RO_7	RO_7	Septentrio PolaRx4
ROA	G1 backup	57689-57696	RO_8	RO_8	Dicom GTR51
ROA	G1 backup	57689-57696	RO_9	RO_9	Septentrio PolaRx4
OP	G1 reference	57711-57721	OP02	OPMT	Ashtech Z12T
OP	G1 backup	57711-57721	OP71	OP71	Septentrio PolaRx4
OP	G1 backup	57711-57721	OPM9	OPM9	Dicom GTR51
BIPM	BIPM reference	57727-57733	BP0R	BP0R	Septentrio PolaRx2eTR
BIPM	BIPM backup	57727-57733	BP1J	BP1J	Septentrio PolaRx4
BIPM	BIPM backup	57727-57733	BP1X	BP1X	Dicom GTR51

2. Data used

Rinex files have been obtained from all receivers participating to this trip.

3. Results of raw data processing

- The raw code differences have been generated by the DCLRINEX procedure (see [Guidelines Annex 3](#)). Each run for a pair of stations generates 3 files (summary .sum, data .dif, plot .pdf). Summary files and plots are available in [1001-2016-phase2-cv.pdf](#). All P1/P2 measurements are indicated with 2 digits numeric precision in order to minimize rounding errors in computing P3 values.
- As in Phase 1 of this trip, we noted that the phase measurements of BP0R are sometimes corrupted and could not be fully trusted to compute the baseline that is needed to compute the code differences. To overcome this, we used two other receivers (BP1J and BP1X), which have previously been compared to BP0R, as additional references to check the baselines and the results obtained from BP0R.

- For each pair (traveling – visited) or (traveling – reference):
 - Plots of the data differences and of the statistical analysis (Tdev) are in the report of operations [1001-2016-phase2-cv.pdf](#);
 - The inferred RAWDIF(P1), RAWDIF(P2) and RAWDIF(C1) are taken as the median of the raw differences. The associated uncertainties are taken as the floor of the Tdev values, with a minimum of 0.1 ns.
- Summary tables.

For this report, the BIPM system BP0R is considered to be the reference. However two other systems (BP1J and BP1X) are used as backups to check the behavior of BP0R and are listed in Table 2.1.

Table 2.1 Raw differential results for all pairs (Traveling – Reference) (ns) for three reference receivers at the BIPM.

Labo	Date	Pair	RAWDIF(P1)	Unc	RAWDIF(P2)	Unc	RAWDIF(C1)	Unc
BIPM	57646-57657	BP1C-BP0R	-59.44	0.1	-55.61	0.1	-60.83	0.1
BIPM	57727-57733	BP1C-BP0R	-59.75	0.1	-56.00	0.1	-61.11	0.1
BIPM	57650-57657	BP0U-BP0R	-95.19	0.1	-91.09	0.1	-98.12	0.1
BIPM	57728-57733	BP0U-BP0R	-95.30	0.1	-91.13	0.1	-98.41	0.1
BIPM	57646-57657	BP1C-BP1J	25.52	0.1	31.44	0.1	25.98	0.1
BIPM	57727-57733	BP1C-BP1J	25.45	0.1	31.41	0.1	25.93	0.1
BIPM	57650-57657	BP0U-BP1J	-10.07	0.1	-3.74	0.1	-11.21	0.1
BIPM	57728-57733	BP0U-BP1J	-10.05	0.1	-3.55	0.1	-11.33	0.1
BIPM	57646-57657	BP1C-BP1X	31.38	0.1	34.65	0.1	37.26	0.1
BIPM	57727-57733	BP1C-BP1X	31.51	0.1	34.72	0.1	37.42	0.1
BIPM	57650-57657	BP0U-BP1X	-4.36	0.1	-0.68	0.1	-0.08	0.1
BIPM	57728-57733	BP0U-BP1X	-4.08	0.1	-0.34	0.1	0.05	0.1

Table 2.2 Raw differential results for all pairs (Traveling – Visited) (ns)

Labo	Date	Pair	RAWDIF(P1)	Unc	RAWDIF(P2)	Unc	RAWDIF(C1)	Unc
PTB	57671-57678	BP1C-PTBB	-529.91	0.1	-539.54	0.1	-528.61	0.1
PTB	57671-57678	BPOU-PTBB	-565.19	0.1	-574.37	0.1	-565.58	0.1
PTB	57671-57678	BP1C-PTBG	-504.34	0.1	-521.15	0.1	-502.65	0.1
PTB	57671-57678	BPOU-PTBG	-539.61	0.1	-555.97	0.1	-539.62	0.1
PTB	57671-57678	BP1C-PT07	2.21	0.1	7.79	0.1	6.45	0.1
PTB	57671-57678	BPOU-PT07	-33.09	0.1	-27.01	0.1	-30.55	0.1
PTB	57676-57678	BP1C-PT09	-115.37	0.1	-108.94	0.1	-114.90	0.1
PTB	57676-57678	BPOU-PT09	-150.71	0.1	-143.80	0.1	-151.92	0.1
PTB	57671-57678	BP1C-PT10	1.98	0.1	7.91	0.1	8.13	0.1
PTB	57671-57678	BPOU-PT10	-33.36	0.1	-26.99	0.1	-28.87	0.1
ROA	57689-57696	BP1C-RO_5	-78.08	0.1	-72.60	0.1	-77.81	0.1
ROA	57689-57696	BPOU-RO_5	-118.26	0.1	-112.38	0.1	-119.64	0.1
ROA	57689-57696	BP1C-RO_6	39.88	0.1	46.72	0.1	40.30	0.1
ROA	57689-57696	BPOU-RO_6	-0.26	0.1	6.97	0.1	-1.49	0.1
ROA	57689-57696	BP1C-RO_7	-20.47	0.1	-13.58	0.1	-19.87	0.1
ROA	57689-57696	BPOU-RO_7	-60.58	0.1	-53.35	0.1	-61.65	0.1
ROA	57689-57696	BP1C-RO_8	-77.89	0.1	-72.64	0.1	-34.08	0.1
ROA	57689-57696	BPOU-RO_8	-118.10	0.1	-112.52	0.1	-75.95	0.1
ROA	57689-57696	BP1C-RO_9	-140.34	0.1	-133.86	0.1	-139.25	0.1
ROA	57689-57696	BPOU-RO_9	-180.52	0.1	-173.68	0.1	-181.11	0.1
OP	57711-57721	BP1C-OPMT	-310.74	0.1	-316.93	0.1	-309.50	0.1
OP	57711-57721	BPOU-OPMT	-369.54	0.1	-375.45	0.1	-369.96	0.1
OP	57711-57721	BP1C-OP71	6.12	0.1	13.12	0.1	6.58	0.1
OP	57711-57721	BPOU-OP71	-52.76	0.1	-45.52	0.1	-53.99	0.1
OP	57711-57721	BP1C-OPM9	-80.26	0.1	-71.25	0.1	-80.37	0.1
OP	57711-57721	BPOU-OPM9	-139.06	0.1	-129.70	0.1	-140.85	0.1
BIPM	57727-57733	BP1C-BP1J	25.45	0.1	31.41	0.1	25.93	0.1
BIPM	57728-57733	BPOU-BP1J	-10.05	0.1	-3.55	0.1	-11.33	0.1

4. Calibration results

In the first step, one computes ΔSYSDLY , the differences of SYSDLY for all pairs (Traveling-Reference) and (Traveling-Visited), from

$$\Delta\text{SYSDLY}_{A-B}(\text{Code}) = \text{RAWDIF}_{A-B}(\text{Code}) + \text{REFDLY}_A - \text{REFDLY}_B \quad (1)$$

where RAWDF(Code) is read in Table 2 and where the values REFDLY are in the report of operations [1001-2016-phase2-cv.pdf](#).

The ΔSYSDLY values are reported in Table 3 for the pairs Traveling-Reference (section 4.1) and in Table 4 for the pairs Traveling-Visited (section 4.2).

In the second step one computes ΔSYSDLY (Visited-Reference) for all visited systems.

$$\Delta\text{SYSDLY}_{V-R} = \Delta\text{SYSDLY}_{T-R} - \Delta\text{SYSDLY}_{T-V} \quad (2)$$

One can then compute ΔINTDLY (Visited-Reference) for all visited systems.

$$\Delta\text{INTDLY}_{V-R} = \Delta\text{SYSDLY}_{V-R} - \text{CABDLY}_V + \text{CABDLY}_R \quad (3)$$

where the values CABDLY are taken from the report of operations [1001-2016-phase2-cv.pdf](#);

Tables 5 reports the $\Delta\text{INTDLY}_{V-R}$ results for the pairs Visited-Reference (section 4.3).

Using assumed INTDLY_R values for the Reference system, Table 6 then reports INTDLY_V for all visited systems (section 4.4).

4.1 Traveling system with respect to the reference system

Table 3.1. Computed ΔSYSDLY values for the traveling systems with respect to BP0R used as a reference. The misclosures are also indicated. (all values in ns)

Pair	Date	REFDLY _T	REFDLY _R	Note	P1 (ns)		P2 (ns)		C1 (ns)	
					RAWDIF	ΔSYSDLY	RAWDIF	ΔSYSDLY	RAWDIF	ΔSYSDLY
BP1C-BP0R	57646-57657	256.4	268.9		-59.44	-71.94	-55.61	-68.11	-60.83	-73.33
BP1C-BP0R	57727-57733	256.5	269.0		-59.75	-72.25	-56.00	-68.50	-61.11	-73.61
		Misclos.				0.31		0.39		0.28
BP1C-BP0R		Mean				-72.10		-68.31		-73.47
BPOU-BP0R	57650-57657	52.6	268.9		-95.19	-311.49	-91.09	-307.39	-98.12	-314.42
BPOU-BP0R	57728-57733	52.6	269.0		-95.30	-311.70	-91.13	-307.53	-98.41	-314.81
		Misclos.				0.21		0.14		0.39
BPOU-BP0R		Mean				-311.60		-307.46		-314.62

Results for BP0R have been checked using BP1J and BP1X. Misclosures for BP1J and BP1X can be directly interpreted from the data in Table 3.2 and 3.3. However, the mean values of ΔSYSDLY obtained for (Traveling – BP1J) and (Traveling – BP1X) in Table 3.2 and 3.3 cannot be directly compared to those obtained for (Traveling – BP0R).

Table 3.2. Computed ΔSYSDLY values for the traveling systems with respect to BP1J used as a reference. The misclosures are also indicated. (all values in ns)

Pair	Date	REFDLY _T	REFDLY _R	Note	P1 (ns)		P2 (ns)		C1 (ns)	
					RAWDIF	ΔSYSDLY	RAWDIF	ΔSYSDLY	RAWDIF	ΔSYSDLY
BP1C-BP1J	57646-57657	256.4	180.0		25.52	101.92	31.44	107.84	25.98	102.38
BP1C-BP1J	57727-57733	256.5	179.9		25.45	102.05	31.41	108.01	25.93	102.53
		Misclos.				0.13		0.17		0.15
		Mean				101.99		107.93		102.46
BPOU-BP1J	57650-57657	52.6	180.0		-10.07	-137.47	-3.74	-131.14	-11.21	-138.61
BPOU-BP1J	57728-57733	52.6	179.9		-10.05	-137.35	-3.55	-130.85	-11.33	-138.63
		Misclos.				0.12		0.29		0.02
		Mean				-137.41		-131.00		-138.62

Table 3.3. Computed ΔSYSDLY values for the traveling systems with respect to BP1X used as a reference. The misclosures are also indicated. (all values in ns)

Pair	Date	REFDLY _T	REFDLY _R	Note	P1 (ns)		P2 (ns)		C1 (ns)	
					RAWDIF	ΔSYSDLY	RAWDIF	ΔSYSDLY	RAWDIF	ΔSYSDLY
BP1C-BP1X	57646-57657	256.4	42.6		31.38	245.18	34.65	248.45	37.26	251.06
BP1C-BP1X	57727-57733	256.5	42.6		31.51	245.41	34.72	248.62	37.42	251.32
		Misclos.				0.23		0.17		0.26
		Mean				245.30		248.54		251.19
BPOU-BP1X	57650-57657	52.6	42.6		-4.36	5.64	-0.68	9.32	-0.08	9.92
BPOU-BP1X	57728-57733	52.6	42.6		-4.08	5.92	-0.34	9.66	0.05	10.05
		Misclos.				0.28		0.34		0.13
		Mean				5.78		9.49		9.99

This is done in Table 3.4 using comparisons (BP1J-BP0R) and (BP1X-BP0R) obtained in December 2015. As can be seen from Table 3.4, the various evaluations of Δ SYSDLY for (BP1C-BP0R) vary by no more than about 0.2 ns. They are considered close enough so that, in the following, the directly measured values (BP1C-BP0R) and (BPOU-BP0R) will be used to compute the results of the Group 1 trip.

Table 3.4. Computed Δ SYSDLY mean values for the traveling systems with respect to BP0R computed directly (Table 3.1) or through BP1J (Table 3.2) or BP1X (Table 3.3). Numerical discrepancies of 0.01 ns are due to rounding (all values in ns).

		Δ SYSDLY P1	Δ SYSDLY P2	Δ SYSDLY C1
BP1C-BP0R	Mean value	-72.10	-68.31	-73.47
BP1C-BP1J	Mean value	101.99	107.93	102.46
BP1J-BP0R	Dec 2015	-174.1	-176.4	-175.9
BP1C-BP0R	Sum of above	-72.12	-68.48	-73.45
BP1C-BP1X	Mean value	245.30	248.54	251.19
BP1X-BP0R	Dec 2015	-317.5	-317.1	-324.7
BP1C-BP0R	Sum of above	-72.21	-68.57	-73.51
BPOU-BP0R	Mean value	-311.60	-307.46	-314.62
BPOU-BP1J	Mean value	-137.41	-131.00	-138.62
BP1J-BP0R	Dec 2015	-174.1	-176.4	-175.9
BPOU-BP0R	Sum of above	-311.51	-307.40	-314.52
BPOU-BP1X	Mean value	5.78	9.49	9.99
BP1X-BP0R	Dec 2015	-317.5	-317.1	-324.7
BPOU-BP0R	Sum of above	-311.72	-307.61	-314.72

4.2 Traveling system with respect to the visited systems

Table 4. Traveling vs. Visited systems (all values in ns)

Pair	Date	REFDLY _T	REFDLY _V	Note	P1 (ns)		P2 (ns)		C1 (ns)	
					RAWDIF	ΔSYSDLY	RAWDIF	ΔSYSDLY	RAWDIF	ΔSYSDLY
BP1C-PTBB	57671-57678	281.2	73.9		-529.91	-322.57	-539.54	-332.20	-528.61	-321.27
BPOU-PTBB	57671-57678	77.2	73.9		-565.19	-561.80	-574.37	-570.98	-565.58	-562.19
BP1C-PTBG	57671-57678	281.2	46.1		-504.34	-269.23	-521.15	-286.04	-502.65	-267.54
BPOU-PTBG	57671-57678	77.2	46.1		-539.61	-508.45	-555.97	-524.81	-539.62	-508.46
BP1C-PT07	57671-57678	281.2	43.3	*	2.21	240.15	7.79	245.73	6.45	244.39
BPOU-PT07	57671-57678	77.2	43.3	*	-33.09	0.90	-27.01	6.98	-30.55	3.44
BP1C-PT09	57676-57678	281.2	161.8		-115.37	4.03	-108.94	10.46	-114.90	4.50
BPOU-PT09	57676-57678	77.2	161.8		-150.71	-235.26	-143.80	-228.35	-151.92	-236.47
BP1C-PT10	57671-57678	281.2	52.0	*	1.98	231.19	7.91	237.12	8.13	237.34
BPOU-PT10	57671-57678	77.2	52.0	*	-33.36	-8.10	-26.99	-1.73	-28.87	-3.61
BP1C-RO_5	57689-57696	361.8	36.5	*	-78.08	247.24	-72.60	252.72	-77.81	247.51
BPOU-RO_5	57689-57696	162.8	36.5	*	-118.26	8.06	-112.38	13.94	-119.64	6.68
BP1C-RO_6	57689-57696	361.8	234.4		39.88	167.30	46.72	174.14	40.30	167.72
BPOU-RO_6	57689-57696	162.8	234.4		-0.26	-71.84	6.97	-64.61	-1.49	-73.07
BP1C-RO_7	57689-57696	361.8	194.6		-20.47	146.75	-13.58	153.64	-19.87	147.35
BPOU-RO_7	57689-57696	162.8	194.6		-60.58	-92.36	-53.35	-85.13	-61.65	-93.43
BP1C-RO_8	57689-57696	361.8	38.0	*	-77.89	245.93	-72.64	251.18	-34.08	289.74
BPOU-RO_8	57689-57696	162.8	38.0	*	-118.10	6.72	-112.52	12.30	-75.95	48.87
BP1C-RO_9	57689-57696	361.8	112.4		-140.34	109.08	-133.86	115.56	-139.25	110.17
BPOU-RO_9	57689-57696	162.8	112.4		-180.52	-130.10	-173.68	-123.26	-181.11	-130.69
BP1C-OPMT	57711-57721	284.6	155.9	(1)	-310.74	-182.04	-316.93	-188.23	-309.50	-180.80
BPOU-OPMT	57711-57721	104.5	155.9	(1)	-369.54	-420.94	-375.45	-426.85	-369.96	-421.36
BP1C-OP71	57711-57721	284.6	191.6		6.12	99.12	13.12	106.12	6.58	99.58
BPOU-OP71	57711-57721	104.5	191.6		-52.76	-139.86	-45.52	-132.62	-53.99	-141.09
BP1C-OPM9	57711-57721	284.6	60.5		-80.26	143.84	-71.25	152.85	-80.37	143.73
BPOU-OPM9	57711-57721	104.5	60.5		-139.06	-95.06	-129.70	-85.70	-140.85	-96.85
BP1C-BP1J	57727-57733	256.5	179.9		25.45	102.05	31.41	108.01	25.93	102.53
BPOU-BP1J	57728-57733	52.6	179.9		-10.05	-137.35	-3.55	-130.85	-11.33	-138.63

* GTR50/51 with REFDLY_V value introduced a priori.

(1) REFDLY_V value from a past measurement

4.3 Visited systems with respect to reference system

The Table 5 provides the values obtained by differencing Table 3.1 (BPOR reference) and Table 4. CABDLY values are taken from the report of operations [1001-2016-phase2-cv.pdf](#).

Table 5. Visited vs. BPOR Reference (all values in ns)

Pair	Date	CABDLY _V	CABDLY _R	Note	P1 (ns)		P2 (ns)		CI (ns)	
					ΔSYSDLY	ΔINTDLY	ΔSYSDLY	ΔINTDLY	ΔSYSDLY	ΔINTDLY
PTBB-BPOR via BP1C	2016.8	301.7	133.4		250.47	82.17	263.90	95.59	247.80	79.50
PTBB-BPOR via BPOU	2016.8	301.7	133.4		250.21	81.91	263.52	95.22	247.58	79.28
PTBG-BPOR via BP1C	2016.8	251.4	133.4		197.13	79.13	217.74	99.74	194.07	76.07
PTBG-BPOR via BPOU	2016.8	251.4	133.4		196.86	78.86	217.35	99.35	193.85	75.85
PT07-BPOR via BP1C	2016.8	245.8	133.4	*	-312.25	-424.65	-314.04	-426.44	-317.86	-430.26
PT07-BPOR via BPOU	2016.8	245.8	133.4	*	-312.50	-424.90	-314.44	-426.84	-318.06	-430.46
PT09-BPOR via BP1C	2016.8	223.7	133.4		-76.13	-166.43	-78.77	-169.07	-77.97	-168.27
PT09-BPOR via BPOU	2016.8	223.7	133.4		-76.34	-166.64	-79.11	-169.41	-78.15	-168.45
PT10-BPOR via BP1C	2016.8	250.0	133.4	*	-303.29	-419.89	-305.43	-422.03	-310.81	-427.41
PT10-BPOR via BPOU	2016.8	250.0	133.4	*	-303.50	-420.10	-305.73	-422.33	-311.01	-427.61
RO_5-BPOR via BP1C	2016.8	127.5	133.4	*	-319.34	-313.44	-321.03	-315.13	-320.98	-315.08
RO_5-BPOR via BPOU	2016.8	127.5	133.4	*	-319.66	-313.76	-321.40	-315.50	-321.30	-315.40
RO_6-BPOR via BP1C	2016.8	66.7	133.4		-239.40	-172.70	-242.45	-175.75	-241.19	-174.49
RO_6-BPOR via BPOU	2016.8	66.7	133.4		-239.76	-173.06	-242.85	-176.15	-241.55	-174.85
RO_7-BPOR via BP1C	2016.8	81.9	133.4		-218.85	-167.35	-221.95	-170.45	-220.82	-169.32
RO_7-BPOR via BPOU	2016.8	81.9	133.4		-219.24	-167.74	-222.33	-170.83	-221.19	-169.69
RO_8-BPOR via BP1C	2016.8	126.6	133.4	*	-318.03	-311.23	-319.49	-312.69	-363.21	-356.41
RO_8-BPOR via BPOU	2016.8	126.6	133.4	*	-318.32	-311.52	-319.76	-312.96	-363.49	-356.69
RO_9-BPOR via BP1C	2016.8	118.7	133.4		-181.18	-166.48	-183.87	-169.17	-183.64	-168.94
RO_9-BPOR via BPOU	2016.8	118.7	133.4		-181.50	-166.80	-184.20	-169.50	-183.93	-169.23
OPMT-BPOR via BP1C	2016.9	156.5	133.4		109.84	86.74	119.83	96.73	107.23	84.13
OPMT-BPOR via BPOU	2016.9	156.5	133.4		109.35	86.25	119.39	96.29	106.75	83.65
OP71-BPOR via BP1C	2016.9	128.7	133.4		-171.32	-166.62	-174.53	-169.83	-173.15	-168.45
OP71-BPOR via BPOU	2016.9	128.7	133.4		-171.74	-167.04	-174.84	-170.14	-173.53	-168.83
OPM9-BPOR via BP1C	2016.9	173.3	133.4		-216.04	-255.94	-221.26	-261.16	-217.30	-257.20
OPM9-BPOR via BPOU	2016.9	173.3	133.4		-216.54	-256.44	-221.76	-261.66	-217.77	-257.67
BP1J-BPOR via BP1C	2016.9	128.7	133.4		-174.15	-169.45	-176.32	-171.62	-176.00	-171.30
BP1J-BPOR via BPOU	2016.9	128.7	133.4		-174.25	-169.55	-176.61	-171.91	-175.99	-171.29

* GTR50/51 with CABDLY_V value introduced a priori.

4.4 Provisional INTDLY values of visited systems

Table 6 lists provisional INTDLY values of the visited systems using 1001-2014 Group 1 values for BP0R (P1=222.6 ns; P2=224.8 ns; C1=225.8 ns), see in [TM243 Group1-reference-values_V7.pdf](#). Final INTDLY values will be based on minimizing changes between 1001-2014 and 1001-2016, as described in [BIPM Technical Memorandum 266](#), and will be reported in the global report of the trip 1001-2016 available [here](#). Since two results can be computed from Table 5, using either BP1C or BP0U as traveling system, the values in Table 6 are the simple mean of the two results, and the difference between the two is indicated. We note that the difference $\Delta(\text{BP1C-BP0U})$ presents a systematic trend of order 0.3 ns, which is considered reasonable and covered in the uncertainty budget.

Table 6. Provisional INTDLY values of Visited systems using 1001-2014 reference values for the reference systems BP0R (all values in ns).

Pair	Date	Note	P1	P2	C1
			INTDLY _v	INTDLY _v	INTDLY _v
PTBB vs. BP0R	2016.8		304.64	320.21	305.19
$\Delta(\text{BP1C-BP0U})$			0.26	0.37	0.22
PTBG vs. BP0R	2016.8		301.59	324.34	301.76
$\Delta(\text{BP1C-BP0U})$			0.27	0.38	0.23
PT07 vs. BP0R	2016.8	(1)	-0.47	-0.14	-2.86
$\Delta(\text{BP1C-BP0U})$			0.25	0.40	0.19
PT09 vs. BP0R	2016.8		56.07	55.56	57.44
$\Delta(\text{BP1C-BP0U})$			0.20	0.34	0.18
PT10 vs. BP0R	2016.8	(1)	0.41	0.42	-3.91
$\Delta(\text{BP1C-BP0U})$			0.20	0.30	0.20
RO_5 vs. BP0R	2016.8	(1)	0.00	0.49	1.56
$\Delta(\text{BP1C-BP0U})$			0.31	0.38	0.31
RO_6 vs. BP0R	2016.8		49.72	48.85	51.13
$\Delta(\text{BP1C-BP0U})$			0.36	0.40	0.36
RO_7 vs. BP0R			55.06	54.16	56.30
$\Delta(\text{BP1C-BP0U})$	2016.8		0.38	0.38	0.37
RO_8 vs. BP0R		(1)	-0.17	0.58	-42.15
$\Delta(\text{BP1C-BP0U})$	2016.8		0.28	0.27	0.27
RO_9 vs. BP0R			55.96	55.47	56.72
$\Delta(\text{BP1C-BP0U})$	2016.8		0.31	0.33	0.29
OPMT vs. BP0R	2016.9		309.09	321.31	309.69
$\Delta(\text{BP1C-BP0U})$			0.49	0.44	0.49
OP71 vs. BP0R	2016.9		55.77	54.82	57.16
$\Delta(\text{BP1C-BP0U})$			0.41	0.31	0.38
OPM9 vs. BP0R	2016.9		-33.59	-36.61	-31.63
$\Delta(\text{BP1C-BP0U})$			0.49	0.50	0.47
BP1J vs. BP0R	2016.9		53.10	53.04	54.51
$\Delta(\text{BP1C-BP0U})$			0.09	0.29	-0.01

(1) For GTR50/51, results are changes with respect to values entered in the receiver

5 Uncertainty estimation

In this section, we determine the uncertainty of the differential calibration process i.e. we estimate all components that can affect the accuracy. We determine a value U_{CAL0} that is to be used as the accuracy of all P3/PPP links (Visited – Reference) at the epoch of calibration.

$$u_{CAL0} = \sqrt{u_a^2 + u_b^2}$$

with the statistical uncertainty u_a and the systematic uncertainty u_b . (all are 1-sigma).

The statistical uncertainty u_a originates from RAWDIF (see section 3) and is given by the statistical analysis of the raw code differences for (Traveling-Reference) and (Traveling-Visited).

The systematic uncertainty is given by $u_B = \sqrt{\sum_n u_{b,n}^2}$

where all possible terms to be considered in the sum are listed in Table 7 and some detail on their estimation is provided at the end of this section. Values appear separately for each code and for the difference of the two codes (P1, P2 and P1-P2) so as to compute a value u_{CAL} applicable to P3 links.

We choose to compute U_{CAL} using for u_b the uncertainty u_{bSYS} of $\Delta SYSDLY_{V-R}$ from equation (2)¹ Table 7 presents all components of the uncertainty budget along with the uncertainty u_{bSYS} of $\Delta SYSDLY_{V-R}$ from equation (2) and the resulting uncertainty value U_{CAL} .

Table 7. Uncertainty contributions. For all components of u_b , the P3 values are computed as $P1 + 1.545x(P1-P2)$

Unc.	Value C1/P1 (ns)	Value P2 (ns)	Value P1-P2 (ns)	Value P3 (ns)	Description
u_a (T-V)	0.1	0.1			RAWDIF (traveling-visited)
u_a (T-R)	0.1	0.1			RAWDIF (traveling-reference)
u_a	0.15	0.15		0.4	
“Misclosure”					
$u_{b,1}$	0.3	0.3	0.2		observed mis-closure
Systematic components related to RAWDIF					
$u_{b,11}$	0.1	0.1	0.1		Position error at reference
$u_{b,12}$	0.05	0.05	0.05		Position error at visited
$u_{b,13}$	0.3	0.3	0.4		Multipaths at reference
$u_{b,14}$	0.3	0.3	0.4		Multipaths at visited
Link of the Traveling system to the local UTC(k)					
$u_{b,21}$	0.5	0.5	0		REFDLY _T (at ref lab)
$u_{b,22}$	0.5	0.5	0		REFDLY _T (at visited lab)
$u_{b,TOT}$	0.9	0.9	0.6	1.3	
Link of the Reference system to its local UTC(k)					
$u_{b,31}$	0.5	0.5	0		REFDLY _R (at ref lab)
Link of the Visited system to its local UTC(k)					
$u_{b,32}$	0.5	0.5	0		REFDLY _V (at visited lab)
$u_{b,SYS}$	1.1	1.1	0.6	1.5	Components of equation (2)
u_{CAL}	1.1			1.5	Composed of u_a and $u_{b,SYS}$

¹ It is somewhat arbitrary to choose SYSDLY to estimate the link accuracy. This reflects the fact that the REFDLY is subject to change e.g. with change of reference clock or distribution and that its uncertainty should better be taken into account.

The components in Table 7 are separated in several categories:

- $u_{b,1}$ accounts for possible variations of the delays of the traveling systems during the trip. This is evaluated on the one hand by the observed misclosure (~ 0.3 ns average for each code, 0.3 ns for P1-P2, see Table 3.1), on the other hand by the observed discrepancies between the results of the two traveling receivers (~ 0.3 ns average for each code, < 0.2 ns for P1-P2, see Table 6). The chosen values represent an average of both evaluations.
- $u_{b,11}$ and $u_{b,12}$ account for errors in the differential position (Travel – Local). In general they are estimated to be 1.5 cm (50 ps) because the standard uncertainty of the differential positioning obtained with the data used for calibration is typically at or below this level. Due to the possible problem with BPOR (see section 3), $u_{b,11}$ has been estimated more conservatively at 0.1 ns.
- $u_{b,13}$ and $u_{b,14}$ account for multipaths. This is difficult to estimate and a conservative estimate of 0.3 ns is conventionally used.
- $u_{b,21}$ and $u_{b,22}$ account for the measurement between the reference point of the traveling system and the local UTC(k). They include at least one measurement with a TIC and are taken to be 0.5 ns.
- $u_{b,31}$ and $u_{b,32}$ account similarly for the measurement between the reference point of the local system and the local UTC(k). They include at least one measurement with a TIC and are taken to be 0.5 ns.

Version history

V1.0 2016/12/15:

V1.1 2017/01/18: Cosmetic changes. No change to numerical results. P3 u_a uncertainty component computed as RSS from the independent P1 and P2 values.