2018 Group 1 GPS calibration trip

Summary

The 2018 visit to Group 1 laboratories is the third Group 1 trip and started in March 2018.
The trip is decomposed into several phases, each enclosed with closure at the BIPM. Some phases may be run in parallel.

- Phase 1 (March-September 2018). BIPM-TL-NICT-NIM-BIPM with the traveling receivers BP1C and BP0U;
- Phase 2 (April-October 2018): BIPM-SU-BIPM with the traveling receivers BP1K;
- Phase 3 (November-xxxx): BIPM-PTB-ROA-OP-BIPM with the traveling receivers BP1C and BP1X;
- Phase 4 (To Be Continued)

Since 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 1001-2018: Report of phase 1

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 1001-2018-phase1-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 1001-2018-phase1-cv.pdf.
The receiver BP1J from the BIPM serves as a reference for the closure, with the receiver BP0R included as a backup system.

Table 1. Summary information on phase 1 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	58172-58184	BP1J	BP1J	Septentrio PolaRx4
BIPM	BIPM backup	58172-58184	BP0R	BP0R	Septentrio PolaRx2eTR
TL	G1 reference	58229-58248	TLT1	TLT1	Ashtech Z12T (1)
TL	G1 backup	58229-58248	TLT2	TLT2	Piktime TTS4
TL	G1 backup	58229-58248	TLT4	TLT4	Septentrio PolaRx4 TR
NICT	G1 reference	58270-58287	NC01	NC01	Septentrio PolaRx2eTR
NICT	G1 backup	58270-58287	NC5G	NC5G	Dicom GTR50
NICT	G1 backup	58270-58287	NC4S	NC4S	Septentrio PolaRx4 TR
NIM	G1 backup	58345-58356	IM03	IMEU	NIM-TF-GNSS-2J
NIM	G1 backup	58345-58356	IM05	BJNM	Septentrio PolaRx3eTR
NIM	G1 reference	58345-58356	IM06	IMEJ	Dicom GTR50
NIM	G1 backup	58345-58356	IM12	IMEL	Dicom GTR51
NIM	G1 backup	58345-58356	IM20	IM20	NIM-TF-GNSS-2J
NIM	G1 backup	58345-58356	IM21	IM21	NIM-TF-GNSS-3
NIM	G1 backup	58345-58356	IM30	TF10	NIM-TF-GNSS-3
NIM	G1 backup	58345-58356	IM31	TF11	NIM-TF-GNSS-3
BIPM	BIPM reference	58389-58403	BP1J	BP1J	Septentrio PolaRx4
BIPM	BIPM backup	58389-58403	BP0R	BP0R	Septentrio PolaRx2eTR

(1) TLT1 is a modified Z12T which internal reference is the 1PPS-in, see 1001-2018-phase1-cv.pdf

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 1001-2018-phase1-cv.pdf. All P1/P2 measurements are indicated with 2 digits numeric precision in order to minimize rounding errors in computing P3 values.

- 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 1001-2018-phase1-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 BP1J is considered to be the reference. However another system (BP0R) is used as a backup and is listed in Table 2.1.

Table 2.1 Raw differential results for all pairs (Traveling – Reference) (ns) for three reference receivers at the BIPM. Measurements for the local backup BP0R are also included.

Labo	Date	Pair	RAWDIF(P1)	Unc	RAWDIF(P2)	Unc	RAWDIF(C1)	Unc
BIPM	58172-58184	BP1C-BP1J	45.65	0.1	51.74	0.1	46.12	0.1
BIPM	58389-58403	BP1C-BP1J	45.33	0.1	51.25	0.1	45.89	0.1
BIPM	58172-58184	BP0U-BP1J	-8.76	0.1	-2.14	0.1	-10.11	0.1
BIPM	58389-58403	BP0U-BP1J	-8.51	0.1	-2.14	0.1	-9.81	0.1
BIPM	58172-58184	BP0R-BP1J	72.05	0.1	74.29	0.1	73.80	0.1
BIPM	58389-58403	BP0R-BP1J	71.97	0.1	74.08	0.1	73.78	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
TL	58229-58248	BP1C-TLT1	-372.50	0.1	-375.91	0.1	-370.46	0.1
TL	58229-58248	BP0U-TLT1	-423.73	0.1	-426.70	0.1	-423.50	0.1
TL	58229-58248	BP1C-TLT2	-37.45	0.1	-30.97	0.1	-37.36	0.1
TL	58229-58248	BP0U-TLT2	-88.62	0.1	-81.71	0.1	-90.30	0.1
TL	58229-58248	BP1C-TLT4	-75.06	0.1	-68.94	0.1	-74.56	0.1
TL	58229-58248	BP0U-TLT4	-126.29	0.1	-119.72	0.1	-127.57	0.1
NICT	58268-58273	BP1C-NC01	-192.91	0.1	-191.16	0.1	-194.01	0.1
NICT	58270-58273	BP0U-NC01	-233.31	0.1	-231.34	0.1	-236.29	0.1
NICT	58268-58273	BP1C-NC5G	-169.22	0.1	-163.59	0.1	-167.21	0.1
NICT	58270-58273	BP0U-NC5G	-209.54	0.1	-203.77	0.1	-209.43	0.1
NICT	58268-58273	BP1C-NC4S	-131.25	0.1	-125.19	0.1	-130.68	0.1
NICT	58270-58273	BP0U-NC4S	-171.59	0.1	-165.35	0.1	-172.94	0.1
NIM	58345-58356	BP1C-BJNM	37.13	0.2	35.49	0.2	37.34	0.2
NIM	58345-58356	BP0U-BJNM	-8.27	0.2	-9.56	0.2	-9.92	0.2
NIM	58345-58356	BP1C-IM20	-131.03	0.1	-143.71	0.1	-130.63	0.1
NIM	58345-58356	BP0U-IM20	-176.46	0.1	-188.96	0.1	-177.94	0.1
NIM	58350-58356	BP1C-IM21	-152.69	0.5	-139.45	0.5	-151.70	0.5
NIM	58350-58356	BP0U-IM21	-198.05	0.5	-184.49	0.5	-198.94	0.5
NIM	58345-58356	BP1C-IMEJ	-94.99	0.1	-89.33	0.1	-93.04	0.1
NIM	58345-58356	BP0U-IMEJ	-140.40	0.1	-134.42	0.1	-140.29	0.1
NIM	58345-58356	BP1C-IMEL	-88.96	0.1	-85.45	0.1	-82.98	0.1
NIM	58345-58356	BP0U-IMEL	-134.48	0.1	-130.71	0.1	-130.28	0.1
NIM	58345-58356	BP1C-IMEU	-200.42	0.1	-207.45	0.1	-199.90	0.1
NIM	58345-58356	BP0U-IMEU	-245.84	0.1	-252.54	0.1	-247.16	0.1
NIM	58345-58356	BP1C-TF10	-130.38	0.1	-113.37	0.1	-129.39	0.1
NIM	58345-58356	BP0U-TF10	-175.83	0.1	-158.81	0.1	-176.70	0.1
NIM	58345-58356	BP1C-TF11	-149.76	0.1	-133.59	0.1	-149.03	0.1
NIM	58351-58356	BP0U-TF11	-195.17	0.1	-178.66	0.1	-196.28	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

$$\Delta SYSDLY_{A\text{-}B}(Code) = RAWDIF_{A\text{-}B}(Code) + REFDLY_A - REFDLY_B \qquad (1)$$

where RAWDIF(Code) is read in Table 2 and where the values REFDLY are in the report of operations 1001-2018-phase1-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.

$$\Delta SYSDLY_{V\text{-}R} = \Delta SYSDLY_{T\text{-}R} - \Delta SYSDLY_{T\text{-}V.} \qquad (2)$$

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

$$\Delta INTDLY_{V\text{-}R} = \Delta SYSDLY_{V\text{-}R} - CABDLY_V + CABDLY_R \qquad (3)$$

where the values CABDLY are taken from the report of operations 1001-2018-phase1-cv.pdf;

Tables 5 reports the **ΔINTDLY$_{V-R}$** 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 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	58172-58184	237.8	181.5		45.65	101.95	51.74	108.04	46.12	102.42
BP1C-BP1J	58389-58403	237.9	181.6		45.33	101.63	51.25	107.55	45.89	102.19
		Misclos.				0.32		0.49		0.23
BP1C-BP1J		Mean				101.79		107.80		102.31
BP0U-BP1J	58172-58184	52.6	181.5		-8.76	-137.66	-2.14	-131.04	-10.11	-139.01
BP0U-BP1J	58389-58403	52.6	181.6		-8.51	-137.51	-2.14	-131.14	-9.81	-138.81
		Misclos.				0.15		0.10		0.20
BP0U-BP1J		Mean				-137.59		-131.09		-138.91

Results for the local backup BP0R vs. BP1J are shown in Table 3.2. The misclosure for this pair is an indicator of the relative instabilities of two receivers.

Table 3.2. Computed **ΔSYSDLY** values for the local backup with respect to BP1J used as a reference. All values in ns

Pair	Date	REFDLY$_T$	REFDLY$_R$	Note	P1 (ns)		P2 (ns)		C1 (ns)	
					RAWDIF	ΔSYSDLY	RAWDIF	ΔSYSDLY	RAWDIF	ΔSYSDLY
BP0R-BP1J	58172-58184	284.1	181.5		72.05	174.65	74.29	176.89	73.80	176.40
BP0R-BP1J	58389-58403	283.8	181.6		71.97	174.17	74.08	176.28	73.78	175.98
		Misclos.				0.48		0.61		0.42
		Mean				174.41		176.59		176.19

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-TLT1	58229-58248	240.7	0.0	(1)	-372.50	-131.80	-375.91	-135.21	-370.46	-129.76
BP0U-TLT1	58229-58248	52.6	0.0	(1)	-423.73	-371.13	-426.70	-374.10	-423.50	-370.90
BP1C-TLT2	58229-58248	240.7	24.5		-37.45	178.75	-30.97	185.23	-37.36	178.84
BP0U-TLT2	58229-58248	52.6	24.5		-88.62	-60.52	-81.71	-53.61	-90.30	-62.20
BP1C-TLT4	58229-58248	240.7	0.0		-75.06	165.64	-68.94	171.76	-74.56	166.14
BP0U-TLT4	58229-58248	52.6	0.0		-126.29	-73.69	-119.72	-67.12	-127.57	-74.97
BP1C-NC01	58268-58273	450.4	406.0		-192.91	-148.51	-191.16	-146.76	-194.01	-149.61
BP0U-NC01	58270-58273	252.0	406.0		-233.31	-387.31	-231.34	-385.34	-236.29	-390.29
BP1C-NC5G	58268-58273	450.4	168.3		-169.22	112.88	-163.59	118.51	-167.21	114.89
BP0U-NC5G	58270-58273	252.0	168.3		-209.54	-125.84	-203.77	-120.07	-209.43	-125.73
BP1C-NC4S	58268-58273	450.4	312.7		-131.25	6.45	-125.19	12.51	-130.68	7.02
BP0U-NC4S	58270-58273	252.0	312.7		-171.59	-232.29	-165.35	-226.05	-172.94	-233.64
BP1C-BJNM	58345-58356	378.4	331.6		37.13	83.93	35.49	82.29	37.34	84.14
BP0U-BJNM	58345-58356	184.7	331.6		-8.27	-155.17	-9.56	-156.46	-9.92	-156.82
BP1C-IM20	58345-58356	378.4	147.1		-131.03	100.27	-143.71	87.59	-130.63	100.67
BP0U-IM20	58345-58356	184.7	147.1		-176.46	-138.86	-188.96	-151.36	-177.94	-140.34
BP1C-IM21	58350-58356	378.4	131.5		-152.69	94.21	-139.45	107.45	-151.70	95.20
BP0U-IM21	58350-58356	184.7	131.5		-198.05	-144.85	-184.49	-131.29	-198.94	-145.74
BP1C-IMEJ	58345-58356	378.4	121.7		-94.99	161.71	-89.33	167.37	-93.04	163.66
BP0U-IMEJ	58345-58356	184.7	121.7		-140.40	-77.40	-134.42	-71.42	-140.29	-77.29
BP1C-IMEL	58345-58356	378.4	147.1		-88.96	142.34	-85.45	145.85	-82.98	148.32
BP0U-IMEL	58345-58356	184.7	147.1		-134.48	-96.88	-130.71	-93.11	-130.28	-92.68
BP1C-IMEU	58345-58356	378.4	120.1		-200.42	57.88	-207.45	50.85	-199.90	58.40
BP0U-IMEU	58345-58356	184.7	120.1		-245.84	-181.24	-252.54	-187.94	-247.16	-182.56
BP1C-TF10	58345-58356	378.4	153.0		-130.38	95.02	-113.37	112.03	-129.39	96.01
BP0U-TF10	58345-58356	184.7	153.0		-175.83	-144.13	-158.81	-127.11	-176.70	-145.00
BP1C-TF11	58345-58356	378.4	130.5		-149.76	98.14	-133.59	114.31	-149.03	98.87
BP0U-TF11	58351-58356	184.7	130.5		-195.17	-140.97	-178.66	-124.46	-196.28	-142.08

(1) No **$REFDLY_V$** information

4.3 Visited systems with respect to reference system

The Table 5 provides the values obtained by differencing Table 3.1 (BP1J reference) and Table 4. CABDLY values are taken from the report of operations 1001-2018-phase1-cv.pdf.

Table 5. Visited vs. BP1J Reference (all values in ns)

Pair	Date	$CABDLY_V$	$CABDLY_R$	Note	P1 (ns)		P2 (ns)		C1 (ns)	
					ΔSYSDLY	ΔINTDLY	ΔSYSDLY	ΔINTDLY	ΔSYSDLY	ΔINTDLY
TLT1-BP1J via BP1C	2018.3	0.0	128.7	(1)	233.59	362.29	243.01	371.71	232.07	360.77
TLT1-BP1J via BP0U	2018.3	0.0	128.7	(1)	233.55	362.25	243.01	371.71	231.99	360.69
TLT2-BP1J via BP1C	2018.3	140.3	128.7		-76.96	-88.56	-77.44	-89.04	-76.54	-88.14
TLT2-BP1J via BP0U	2018.3	140.3	128.7		-77.07	-88.67	-77.48	-89.08	-76.71	-88.31
TLT4-BP1J via BP1C	2018.3	0.0	128.7	(1)	-63.85	64.85	-63.97	64.74	-63.84	64.87
TLT4-BP1J via BP0U	2018.3	0.0	128.7	(1)	-63.90	64.81	-63.97	64.73	-63.94	64.76
NC01-BP1J via BP1C	2018.4	213.4	128.7		250.30	165.60	254.56	169.86	251.92	167.22
NC01-BP1J via BP0U	2018.4	213.4	128.7		249.73	165.03	254.25	169.55	251.38	166.68
NC5G-BP1J via BP1C	2018.4	268.7	128.7		-11.09	-151.09	-10.71	-150.72	-12.58	-152.59
NC5G-BP1J via BP0U	2018.4	268.7	128.7		-11.75	-151.75	-11.02	-151.02	-13.18	-153.18
NC4S-BP1J via BP1C	2018.4	0.0	128.7	(1)	95.34	224.04	95.29	223.99	95.29	223.99
NC4S-BP1J via BP0U	2018.4	0.0	128.7	(1)	94.71	223.41	94.96	223.66	94.73	223.43
BJNM-BP1J via BP1C	2018.6	125.0	128.7		17.86	21.56	25.51	29.21	18.17	21.87
BJNM-BP1J via BP0U	2018.6	125.0	128.7		17.59	21.29	25.37	29.07	17.91	21.61
IM20-BP1J via BP1C	2018.6	205.1	128.7		1.52	-74.88	20.21	-56.20	1.64	-74.77
IM20-BP1J via BP0U	2018.6	205.1	128.7		1.28	-75.13	20.27	-56.13	1.43	-74.97
IM21-BP1J via BP1C	2018.6	215.0	128.7		7.58	-78.72	0.35	-85.96	7.11	-79.20
IM21-BP1J via BP0U	2018.6	215.0	128.7		7.27	-79.04	0.20	-86.10	6.83	-79.47
IMEJ-BP1J via BP1C	2018.6	248.7	128.7		-59.92	-179.92	-59.58	-179.58	-61.35	-181.36
IMEJ-BP1J via BP0U	2018.6	248.7	128.7		-60.19	-180.19	-59.67	-179.67	-61.62	-181.62
IMEL-BP1J via BP1C	2018.6	201.4	128.7		-40.55	-113.25	-38.06	-110.76	-46.01	-118.72
IMEL-BP1J via BP0U	2018.6	201.4	128.7		-40.71	-113.41	-37.98	-110.68	-46.23	-118.93
IMEU-BP1J via BP1C	2018.6	250.3	128.7		43.91	-77.69	56.95	-64.66	43.91	-77.70
IMEU-BP1J via BP0U	2018.6	250.3	128.7		43.66	-77.95	56.85	-64.75	43.65	-77.95
TF10-BP1J via BP1C	2018.6	215.0	128.7		6.77	-79.53	-4.23	-90.54	6.30	-80.01
TF10-BP1J via BP0U	2018.6	215.0	128.7		6.55	-79.76	-3.98	-90.28	6.09	-80.21
TF11-BP1J via BP1C	2018.6	215.0	128.7		3.65	-82.65	-6.51	-92.82	3.44	-82.87
TF11-BP1J via BP0U	2018.6	215.0	128.7		3.39	-82.92	-6.63	-92.93	3.17	-83.13
BP0R-BP1J		133.4	128.7		174.41	169.71	176.59	171.89	176.19	171.49

(1) No **$CABDLY_V$** information

4.4 Provisional INTDLY values of visited systems

Table 6 lists provisional INTDLY values of the visited systems using 1001-2016 Group 1 values for BP1J (P1=53.0 ns; P2=52.6 ns; C1=54.4 ns), see here.
Final INTDLY values will be based on minimizing changes between 1001-2016 and 1001-2018, as described in BIPM Technical Memorandum 266, and will be reported in the global report of the trip 1001-2018 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 Δ(BP1C-BP0U) is somewhat larger at the NICT but otherwise does not present a very significant systematic trend. This is taken into account in component $u_{b,1}$ of the uncertainty budget in Table 7.

Table 6. Provisional INTDLY values of Visited systems using 1001-2016 reference values for the reference systems BP1J (all values in ns).

Pair	Date	Note	P1	P2	C1
			$INTDLY_V$	$INTDLY_V$	$INTDLY_V$
TLT1 vs. BP1J	2018.3	(1)	415.27	424.31	415.13
Δ(BP1C-BP0U)			0.02	0.00	0.06
TLT2 vs. BP1J			-35.61	-36.46	-33.82
Δ(BP1C-BP0U)			0.08	0.05	0.16
TLT4 vs. BP1J		(2)	117.83	117.34	119.21
Δ(BP1C-BP0U)			0.02	0.01	0.08
NC01 vs. BP1JC	2018.4		218.32	222.31	221.35
Δ(BP1C-BP0U)			0.55	0.31	0.52
NC5G vs. BP1J		(3)	0.09	0.24	0.02
Δ(BP1C-BP0U)			0.63	0.31	0.58
NC4S vs. BPIJ		(2)	276.73	276.43	278.11
Δ(BP1C-BP0U)			0.61	0.33	0.54
BJNM vs. BP1JC	2018.6		74.43	81.74	76.14
Δ(BP1C-BP0U)			0.25	0.14	0.23
IM20 vs. BP1J			-22.00	-3.56	-20.47
Δ(BP1C-BP0U)			0.22	-0.06	0.19
IM21 vs. BP1J			-25.88	-33.43	-24.93
Δ(BP1C-BP0U)			0.29	0.15	0.25
IMEJ vs. BP1J		(3)	-0.05	-0.02	-0.09
Δ(BP1C-BP0U)			0.24	0.10	0.25
IMEL vs. BP1J		(3)	-6.03	-3.81	-10.12
Δ(BP1C-BP0U)			0.13	-0.07	0.20
IMEU vs. BP1J			-24.82	-12.10	-23.42
Δ(BP1C-BP0U)			0.23	0.10	0.24
TF10 vs. BP1J			-26.64	-37.81	-25.71
Δ(BP1C-BP0U)			0.20	-0.25	0.19
TF11 vs. BP1J			-29.78	-40.27	-28.60
Δ(BP1C-BP0U)			0.24	0.12	0.24

(1) Results are Total Delay values (TOTDLY).
(2) Results are System Delay values (SYSDLY).
(3) 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}.

The value u_{CAL} =1.5 ns from Table 7 is applicable to P3/PPP links. The value u_{CAL} =1.1 ns is applicable to C1 links. Final values of u_{CAL} are consistent with the conventional value of 1.5 ns for P3/PPP links between G1 laboratories, as used in UTC computation, except for IM21 (ΔU_{CAL} = 0.5 ns) and for NICT receivers (ΔU_{CAL} = 0.8 ns, see note 1 at the end of this section).

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	See text below
"Misclosure"					
$u_{b,1}$	0.3	0.3	0.2		observed mis-closure
Systematic components related to RAWDIF					
$u_{b,11}$	0.05	0.05	0.05		Position error at reference
$u_{b,12}$	0.05	0.05	0.05		Position error at visited
$u_{b,13}$	0.2	0.2	0.3		Multipaths at reference
$u_{b,14}$	0.2	0.2	0.3		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) (1)
$u_{b,TOT}$	0.8	0.8	0.5	1.1	
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	0.5	1.3	Components of equation (2)
u_{CAL}	1.1			1.4	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_a(T-V) is larger for BJNM (0.2 ns) and for IM21 (0.5 ns). However the origin seems statistical for BJNM and mixed (both statistical and systematic) for IM21. The final u_a value is for BJNM: 0.2 ns for one code, 0.6 ns for P3 and for IM21: 0.5 ns for one code, 0.7 ns for P3.
- $u_{b,1}$ 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, 0.2 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.
- $u_{b,13}$ and $u_{b,14}$ account for multipaths. This is difficult to estimate and 0.2 ns is conventionally used, following a discussion in the CCTF working group on GNSS in 2017.
- $u_{b,21}$ 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.

(1) Note that the uncertainty $u_{b,22}$ is larger at NICT because the traveling system was positioned in a room distant from UTC(NICT). No direct connection to UTC(NICT) could be established and clock transport was used (Information from T. Gotoh on 22 June 2018). In the final results, an additional uncertainty $\mathbf{\Delta U_{CAL}}$ = 0.8 ns will be introduced for NICT receivers to account for a larger uncertainty $u_{b,22}$.

- $u_{b,31}$ 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 2018/10/19: Distribution of the report of phase 1.

V1.1 2018/11/15: Minor text edition and typos. No change to numerical results.