2018 Group 1 GNSS calibration trip (Cal_Id 1001-2018)

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 traveling receivers BP1C and BP0U;
- Phase 2 (April-October 2018): BIPM-SU-BIPM with traveling receiver BP1K;
- Phase 3 (November 2018-February 2019): BIPM-PTB-ROA-OP-BIPM with traveling receivers BP1C and BP1X;
- Phase 4 (March-September 2019): BIPM-USNO-NIST-BIPM with traveling receivers BP1C and BP25;

The full report of the Group 1 trip is split in several sub-reports

All files indexed in this report can be accessed here

- **Reports of operations and raw data processing (one for each phase)**

- 1001-2018-Phase1-cv.pdf
- 1001-2018-Phase2-cv.pdf
- 1001-2018-Phase3-cv.pdf
- 1001-2018-Phase4-cv.pdf

- **Excel sheet for differential calibration computations**

- 1001-2018-calcul.xls

- **Reports of differential calibration computations (one for each phase)**

- 1001-2018-Phase1-report.pdf
- 1001-2018-Phase2-report.pdf
- 1001-2018-Phase3-report.pdf
- 1001-2018-Phase4-report.pdf

- **Report on selecting reference values to compute final results of this trip**

See TM266_Group1-followon-values.pdf
In June 2020, the CCTF WG on GNSS decided to extend the G1/G2 calibration scheme to Galileo and fixed the initial reference for G1 Galileo results. TM266 has been extended accordingly.

- **Final results for the visited systems**

Table 1.1 lists the final values of GPS P1/P2/C1 INTDLY and Table 1.2 lists the Galileo E1/E5a values from the 1001-2018 Group 1 trip, along with information on the REFDLY and CABDLY values used in the processing of the calibration results.

For any link A-B, the uncertainty resulting from the calibration, $U_B(A\text{-}B)$, is computed as
$U_B(A\text{-}B)^2 = (U_{CAL0}{}^2 + \Delta U_{CAL}(A)^2 + \Delta U_{CAL}(B)^2)^{1/2}$ (1)

where U_{CAL0} is the conventional value chosen for the whole calibration trip and where ΔU_{CAL} is generally zero, except for some systems for specific reasons. See the reports of differential calibration computations for all information on U_{CAL0} and ΔU_{CAL}. The values ΔU_{CAL} are indicated in Tables 1.1 and 1.2.
For dual-frequency (P3 or E3) links, U_{CAL0} is 1.5 ns.
For single frequency links, U_{CAL0} is 1.2 ns but should be complemented by an additional component to represent systematic errors in the ionospheric model.

Table 1.1. Final GPS P1/P2/C1 INTDLY values from the 1001-2018 Group 1 trip. Values of REFDLY and CABDLY at the epoch of calibration are also indicated for reference (all values in ns). "Meas. Date" refers to the first day of the differential calibration, to which the calibration results can be applied.

System	BIPM code	Meas. Date	INTDLY P1	INTDLY P2	INTDLY C1	REFDLY	CABDLY	Note	Implem. date	ΔU_{CAL}
BP1J	BP1J		53.0	52.6	54.4		128.7	(1)		
BP21	BP21		28.4	27.3	30.6		140.8	(1)		
PHASE 1 (TL, NICT, NIM)										
TLT1	TLT1	2018/04/21	415.3	424.3	415.1	N/A	N/A	(2)	58421	0.0
TLT2	TLT2	2018/04/21	-35.6	-36.5	-33.8	24.5	140.3		58421	0.0
TLT4	TLT4	2018/04/21	117.8	117.3	119.2	0.0	N/A	(3)	58421	0.0
NC01	NC01	2018/06/01	218.3	222.3	221.4	406.0	213.4		58421	0.8
NC5G	NC5G	2018/06/01	-30.9	-19.0	-38.5	168.3	268.7	(4)	58421	0.8
NC4S	NC4S	2018/06/01	276.7	276.4	278.1	312.7	N/A	(3)	58421	0.8
BJNM	IM05	2018/08/15	74.4	81.7	76.1	331.6	125.0		58421	0.0
IM20	IM20	2018/08/15	-22.0	-3.6	-20.5	147.1	205.1		58421	0.0
IM21	IM21	2018/08/15	-25.9	-33.4	-24.9	131.5	215.0		58421	0.0
IMEJ	IM06	2018/08/15	-31.8	-18.4	-31.0	121.7	248.7	(4)	58421	0.0
IMEL	IM12	2018/08/15	-40.9	-40.4	-38.9	147.1	201.4	(4)	58421	0.5
IMEU	IM03	2018/08/15	-24.8	-12.1	-23.4	120.1	250.3		58421	0.0
TF10	IM30	2018/08/15	-26.6	-37.8	-25.7	153.0	215.0		58421	0.0
TF11	IM31	2018/08/15	-29.8	-40.3	-28.6	130.5	215.0		58421	0.0
PHASE 2 (SU)										
SU19	SU19	2018/05/26	-30.3	-28.9	-28.3	194.5	48.2		58451	0.0
SU31	SU31	2018/05/26	36.5	34.5	38.5	207.5	143.2	(4)	58451	0.0
SUCL	SUCL	2018/05/26	-35.6	-35.4	-33.6	207.5	128.2	(4)	58451	0.0
PHASE 3 (PTB, ROA, OP)										
PTBB	PT02	2018/11/20	305.5	320.7	306.1	74.6	301.7		58571	0.0
PTBG	PT03	2018/11/20	302.2	324.9	302.6	46.5	251.4		58571	0.0
PT07	PT07	2018/11/20	-36.9	-24.6	-35.5	43.4	245.8	(4)	58571	0.0
PT09	PT09	2018/11/20	56.7	55.7	58.1	183.2	198.7		58571	0.0
PT10	PT10	2018/11/20	-26.5	-33.2	-24.5	52.0	250.0		58571	0.0
RO_5	RO_5	2018/12/14	8.4	26.5	5.9	306.9	91.5	(4)	58571	0.0
RO_6	RO_6	2018/12/14	54.7	53.5	56.3	484.9	82.0		58571	0.0
RO_7	RO_7	2018/12/14	55.0	53.9	56.3	452.3	89.9		58571	0.0
RO_8	RO_8	2018/12/14	-22.8	-23.3	-20.6	20.4	202.7		58571	0.0
RO_9	RO_9	2018/12/14	55.5	54.4	56.9	451.8	59.7		58571	0.0
RO10	RO10	2018/12/14	28.6	27.5	30.4	5.1	204.8		58571	0.0

Table 1.1 (continued).

System	BIPM code	Meas. Date	INTDLY P1	INTDLY P2	INTDLY C1	REFDLY	CABDLY	Note	Implem. date	ΔU_{CAL}
OPMT	OP02	2019/01/17	308.4	320.2	309.0	155.9	156.5		58571	0.0
OP71	OP71	2019/01/17	55.2	53.8	56.7	191.7	128.7		58571	0.0
OPM9	OPM9	2019/01/17	-34.1	-37.3	-32.1	60.5	173.3		58571	0.0
PHASE 4 (USNO, NIST)										
USN6	USN6	2019/04/11	-7.4	-10.1	-7.0	N/A	N/A	(2)	58786	0.0
USN7	USN7	2019/04/11	204.8	200.8	207.1	N/A	N/A	(2)	58786	0.0
USN8	USN8	2019/04/11	199.5	196.4	201.8	N/A	N/A	(2)	58786	0.0
NIST	NIST	2019/08/04	-73.2	-72.1	-72.6	65.9	275.5		58786	0.0
NISG	NISG	2019/08/04	30.2	28.5	32.8	452.9	185.0		58786	0.0
NIS4	NIS4	2019/08/04	-9.8	-21.4	-9.4	129.4	298.0		58786	0.0
NISS	NISS	2019/08/04	46.0	46.4	47.9	301.0	298.9		58786	0.0

Notes:
(1) BP1J and BP21 are included in order to provide reference for BIPM-led specific calibrations.
(2) Results are Total Delay values (TOTDLY).
(3) Results are System Delay values (SYSDLY).
(4) For GTR50/51 the listed INTDLY values are total values. Direct results of the calibration are changes with respect to the values previously entered in the receiver (all values in ns):

BIPM code	P1	P2	C1
NC5G	0.1	0.2	0.0
IM06	-0.5	-0.5	-0.6
IM12	-7.4	-5.2	-11.5
SU31	-1.8	-2.3	-0.7
SUCL	-1.0	-0.9	0.2
PT07	0.0	-0.3	-0.1
RO_5	-1.9	-0.8	-1.5

Table 1.2. Final Galileo E1/E5a INTDLY values from the 1001-2018 Group 1 trip. Values of REFDLY and CABDLY at the epoch of calibration are also indicated for reference (all values in ns). "Meas. Date" refers to the first day of the differential calibration, to which the calibration results can be applied.

System	BIPM code	Meas. Date	INTDLY E1	INTDLY E5a	REFDLY	CABDLY	Note	Implem. date	ΔU_{CAL}
BP1J	BP1J		53.8	63.6		128.7	(1)		
BP21	BP21		30.7	30.9		140.8	(1)		
PT09	PT09	2018/11/20	57.6	66.3	183.2	198.7		58571	0.0
PT10	PT10	2018/11/20	-23.0	-34.4	52.0	250.0		58571	0.0
RO_7	RO_7	2018/12/14	55.6	64.2	452.3	89.9		58571	0.0
RO_8	RO_8	2018/12/14	-19.5	-22.5	20.4	202.7		58571	0.0
RO_9	RO_9	2018/12/14	56.2	65.3	451.8	59.7		58571	0.0
RO10	RO10	2018/12/14	30.4	31.3	5.1	204.8		58571	0.0
OP71	OP71	2019/01/17	56.0	64.8	191.7	128.7		58571	0.0
USN7	USN7	2019/04/11	207.1	208.8	N/A	N/A	(2,3)	58786	0.5
USN8	USN8	2019/04/11	201.8	203.6	N/A	N/A	(2,3)	58786	0.5
NISG	NISG	2019/08/04	32.5	33.0	452.9	185.0	(2)	58786	0.5

Notes:
(1) BP1J and BP21 are included in order to provide reference for BIPM-led specific calibrations.
(2) ΔU_{CAL} originates in uncertainty due to the lack of closure for the Galileo traveling receiver.
(3) Results are Total Delay values (TOTDLY).

- **Transfer of GPS calibration performed by PTB in April 2019**

In April 2019, the PTB installed a new GNSS receiver designated as PT13. A transfer of calibration was performed by PTB with respect to the receiver PT09, see the report by PTB.

Table 2 lists the final values of P1/P2/C1 INTDLY values obtained from the transfer of calibration, along with information on the REFDLY and CABDLY values used in the processing of the calibration results. The value ΔU_{CAL} for use in equation (1) has been computed from uncertainties given in the report by PTB. For UTC use, the ageing uncertainty will be based on the date of original calibration of PT09 i.e. 2018/11/20.

Table 2. Final P1/P2/C1 INTDLY values for PT13. Values of REFDLY with respect to UTC(k) and of CABDLY at the epoch of calibration are also indicated for reference (all values in ns). "Meas. Date" refers to the first day of the differential calibration, to which the calibration results can be applied. "Impl. Date" is the MJD when the results were implemented in the receiver.

System	BIPM code	Meas. Date	INTDLY P1	INTDLY P2	INTDLY C1	REFDLY	CABDLY	Note	ΔU_{CAL}	Impl.date
PTBB	PT13	2019/04/03	**29.7**	**27.2**	**31.7**	54.3	205.7		0.5	58691

Notes:

- **Transfer of Galileo calibration performed by PTB in June 2020**

In June 2020, after Galileo delays were added to the 1001-2018 results, the PTB performed a new transfer of calibration to determine PT13 delays with respect to the receiver PT09, see the report by PTB.

Table 3 lists the final values of E1/E5a INTDLY values obtained from the transfer of calibration, along with information on the REFDLY and CABDLY values used in the processing of the calibration results. The value ΔU_{CAL} for use in equation (1) has been computed from uncertainties given in the report by PTB. For UTC use, the ageing uncertainty will be based on the date of original calibration of PT09 i.e. 2018/11/20.

Table 3. Final E1/E5a INTDLY values for PT13. Values of REFDLY with respect to UTC(k) and of CABDLY at the epoch of calibration are also indicated for reference (all values in ns). "Meas. Date" refers to the first day of the differential calibration, to which the calibration results can be applied. "Impl. Date" is the MJD when the results were implemented in the receiver.

System	BIPM code	Meas. Date	INTDLY E1	INTDLY E5a	REFDLY	CABDLY	Note	ΔU_{CAL}	Impl.date
PTBB	PT13	2020/06/24	**32.0**	**31.7**	54.3	205.7		0.5	59031

Notes:

- **Transfer of calibration performed by TL in October 2018**

In October 2018, the TL re-installed the GNSS receiver TLT3 which was absent during the 1001-2018 visit and performed a transfer of calibration with respect to the receiver TLT1, see the report by TL.

Table 4 lists the final values of P1/P2/C1 INTDLY values obtained from the transfer of calibration, along with information on the REFDLY and CABDLY values used in the processing of the calibration results. The value ΔU_{CAL} for use in equation (1) has been set by default. For UTC use, the ageing uncertainty will be based on the date of original calibration of TLT1 i.e. 2018/04/21.

Table 4. Final P1/P2/C1 INTDLY values for TLT3. Values of REFDLY with respect to UTC(k) and of CABDLY at the epoch of calibration are also indicated for reference (all values in ns). "Meas. Date" refers to the first day of the differential calibration, to which the calibration results can be applied. "Impl. Date" is the MJD when the results were implemented in the receiver.

System	BIPM code	Meas. Date	INTDLY P1	INTDLY P2	INTDLY C1	REFDLY	CABDLY	Note	ΔU_{CAL}	Impl.date
TLT3	TLT3	2018/10/24	**-35.7**	**-32.2**	**-34.5**	25.5	143.6		1.0	58481

Notes:

Version history

V1.0 2018/11/15: Final APMP results from version V1.1 of the report 1001-2018-Phase1-report.pdf, to be implemented in G1 receivers as coordinated by the BIPM Time Department.
Draft COOMET results from V1.0 of the report 1001-2018-Phase2-report.pdf.

V1.1 2018/11/30: APMP results unchanged, but link to version V1.2 of the report 1001-2018-Phase1-report.pdf.
Final COOMET results, unchanged from draft, from V1.0 of the report 1001-2018-Phase2-report.pdf.

V1.2 2018/12/10: Correction in Table 1 to the NC5G INTDLY values, and a typo in TF10.

V1.3 2019/03/25: Final EURAMET results from version V1.0 of the report 1001-2018-Phase3-report.pdf to be implemented in G1 receivers as coordinated by the BIPM Time Department.

V1.4 2019/03/27: Correction to INTDLY values for RO_5. Implementation in G1 receivers set as MJD 58571.

V1.5 2019/07/24: Transfer of calibration performed by PTB in April 2019 to include a new receiver PT13.

V1.6 2019/10/21: Final SIM results from version V1.0 of the report 1001-2018-Phase4-report.pdf, to be implemented in G1 receivers as coordinated by the BIPM Time Department.

V1.7 2020/01/21: Correction to some PT13 information in Table 2 (Measurement date and ΔU_{CAL}).

V2.0 2020/06/20: Introduction of Galileo results based on version V2.0 of the reports 1001-2018-Phase3-report.pdf and 1001-2018-Phase4-report.pdf. Change of BP21 GPS INTDLY values due to change of its CABDLY value.

V2.1 2020/08/31: Transfer of calibration by PTB to provide Galileo results to PT13 (Table 3). Transfer of calibration by TL to provide GPS results for TLT3 (Table 4)