

GNSS calibration of INRIM and RISE receivers with respect to OP G1 (1018-2022)

Summary

In August 2022, the Laboratoire national de métrologie et d'essais, Systèmes de références Temps-Espace, Observatoire de Paris, Observatoire de Paris (OP) conducted a trip to calibrate GNSS equipment owned by the Istituto Nazionale di Ricerca Metrologica (INRIM) and the Research Institutes of Sweden AB (RISE). The trip started and finished at the OP, providing closure with respect to the OP Group1 reference receiver OP73.

The operations and report of measurements are described in the [report by OP](#).

• Final results for the calibrated systems

The INTDLY or SYSDLY values of the receivers given in Table 1 and Table 2 have been computed by OP based on the results of the Group 1 trip [1001-2020](#) for OP73 (GPS and Galileo) and should not be updated to reflect later changes in the conventional INTDLY values of the reference receiver.

For a P3/E3/PPP UTC link A-B involving any Group 1 and any receiver in this trip, the uncertainty resulting from the calibration, $U_B(A-B)$, is computed as

$$U_B(A-B) = (U_{CAL0}^2 + \Delta U_{CAL}(A)^2 + \Delta U_{CAL}(B)^2)^{1/2} \quad (1)$$

where $U_{CAL0} = 2.5$ ns is the conventional Group 2 value, and where ΔU_{CAL} (generally zero) is specified for each system.

Changes in the set-up of the receivers after the calibration must be accounted for as described in section A.3.6 of the most recent Calibration guidelines in <https://webtai.bipm.org/ftp/pub/tai/publication/gnss-calibration/guidelines/>.

Table 1. Final P1/P2 INTDLY values from the 1018-2022 exercise. Values of REF DLY and CAB DLY used to compute calibration results are also indicated for reference. All values are 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 should be implemented in the receiver.

System	BIPM	Meas. date	INTDLY P1	INTDLY P2	REF DLY	CAB DLY	Note	ΔU_{CAL}	Impl. date
GR01	IT11	2022/08/26	56.0	54.4	483.6	298.6		0.0	60095
GR02	IT12	2022/08/26	352.8	352.7	483.5	0.0	(1)	0.0	60095
GR04	IT14	2022/08/26	279.8	277.5	376.2	0.0	(1)	0.0	60095
GR05	IT15	2022/08/26	27.5	24.4	432.9	306.4		0.0	60095
GR06	IT16	2022/08/26	27.6	25.5	161.1	355.5		0.0	60095
INR5	IT08	2022/08/26	309.0	308.5	483.9	0.0	(1)	0.0	60095
INR6	IT09	2022/08/26	55.0	55.5	484.0	130.5		0.0	60095
GTRB	IT2_	2022/08/26	-37.1	-23.0	107.3	131.0		0.0	60095
IENG	IT10	2022/08/26	54.3	55.0	483.6	130.5		0.0	60095
SP03	SP03	2022/10/28	268.1	265.0	0.0	0.0	(2)	0.0	60095
SP05	SP05	2022/10/28	200.7	195.7	0.0	0.0	(2)	0.0	60095
RIT1	SP06	2022/10/28	273.7	269.7	0.0	0.0	(2)	0.0	60095
RIT2	SP07	2022/10/28	231.7	228.2	0.0	0.0	(2)	0.0	60095

Notes:

- (1) Results expressed in terms of SYSDLY
- (2) Results expressed in terms of TOTDLY

Table 2. Final E1/E5a INTDLY values from the 1018-2022 exercise. Values of REF DLY and CAB DLY used to compute calibration results are also indicated for reference. All values are 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 should be implemented in the receiver.

System	BIPM	Meas. date	INTDLY E1	INTDLY E5a	REF DLY	CAB DLY	Note	ΔU_{CAL}	Impl. date
GR01	IT11	2022/08/26	56.9	63.9	483.6	298.6	(3)	1.0	60095
GR02	IT12	2022/08/26	353.7	362.4	483.5	0.0	(1) (3)	1.0	60095
GR04	IT14	2022/08/26	282.1	281.9	376.2	0.0	(1) (3)	1.0	60095
GR05	IT15	2022/08/26	29.7	28.4	432.9	306.4	(3)	1.0	60095
GR06	IT16	2022/08/26	29.9	28.3	161.1	355.5	(3)	1.0	60095
INR5	IT08	2022/08/26	309.9	320.3	483.9	0.0	(1) (3)	1.0	60095
INR6	IT09	2022/08/26	55.8	65.1	484.0	130.5	(3)	1.0	60095
IENG	IT10	2022/08/26	55.1	64.5	483.6	130.5	(3)	1.0	60095
SP03	SP03	2022/10/28	270.5	282.9	0.0	0.0	(2) (3)	1.0	60095
SP05	SP05	2022/10/28	203.3	202.1	0.0	0.0	(2) (3)	1.0	60095
RIT1	SP06	2022/10/28	276.1	273.5	0.0	0.0	(2) (3)	1.0	60095
RIT2	SP07	2022/10/28	234.6	238.1	0.0	0.0	(2) (3)	1.0	60095

Notes:

- (1) Results expressed in terms of SYSDLY
- (2) Results expressed in terms of TOTDLY
- (3) Extra uncertainty due to misclosure values larger than usual

• Transfer of calibration performed by INRIM in July 2023

In July 2023, the INRIM calibrated a new GNSS receiver IT07 by transfer of calibration with respect to the receiver IT10, see the [report by INRIM](#) and the results in Table 2.

The value ΔU_{CAL} for use in equation (1) has been computed from information provided in the report. For UTC use, the ageing uncertainty will be based on the date of original calibration of IT10 i.e. 2022/08/26.

Table 2. Final P1/P2/E1/E5a INTDLY values for IT07. Values of REF DLY with respect to the indicated reference and of CAB DLY during the calibration are also indicated for reference. “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 should be implemented in the receiver.

System	BIPM	Meas. date	INTDLY P1	INTDLY P2	INTDLY E1	INTDLY E5a	REF DLY	CAB DLY	Note	ΔU_{CAL}	Impl. date
IENG	IT07	2023/07/01	26.8	27.4	29.1	31.0	372.7	130.5		0.4	

- **Transfer of calibration performed by RISE in August 2024**

In August 2024, RISE calibrated a new GNSS receiver SP08 by transfer of calibration with respect to the receiver SP07, see the [report by RISE](#) and the results in Table 3.

The value ΔU_{CAL} for use in equation (1) has been computed from information provided in the report. For UTC use, the ageing uncertainty will be based on the date of original calibration of SP07 i.e. 2022/10/28.

Table 3. Final P1/P2/E1/E5a TOTDLY values for SP08. “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 should be implemented in the receiver.

System	BIPM	Meas. date	TOTDLY P1	TOTDLY P2	TOTDLY E1	TOTDLY E5a	Note	ΔU_{CAL}	Impl. date
SP08	SP08	2024/08/23	266.5	264.7	269.0	268.1		0.4	

- **Transfer of calibration performed by RISE in November 2024**

In November 2024, RISE calibrated a new GNSS receiver SP09 by transfer of calibration with respect to the receiver SP07, see the [report by RISE](#) and the results in Table 3.

The value ΔU_{CAL} for use in equation (1) has been computed from information provided in the report. For UTC use, the ageing uncertainty will be based on the date of original calibration of SP07 i.e. 2022/10/28.

Table 3. Final P1/P2/E1/E5a TOTDLY values for SP08. “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 should be implemented in the receiver.

System	BIPM	Meas. date	TOTDLY P1	TOTDLY P2	TOTDLY E1	TOTDLY E5a	Note	ΔU_{CAL}	Impl. date
SP09	SP09	2024/11/11	224.5	220.5	227.3	231.3		0.4	

- **Transfer of calibration performed by RISE in August 2025**

In August 2025, RISE re-calibrated a GNSS receiver SP06 and SP08 by transfer of calibration with respect to the receiver SP07, see the [report by RISE](#) and the results in Table 4.

The value ΔU_{CAL} for use in equation (1) has been computed from information provided in the report. For UTC use, the ageing uncertainty will be based on the date of original calibration of SP07 i.e. 2022/10/28.

Table 4. Final P1/P2/E1/E5a TOTDLY values for SP06 SP08. “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 should be implemented in the receiver.

System	BIPM	Meas. date	TOTDLY P1	TOTDLY P2	TOTDLY E1	TOTDLY E5a	Note	ΔU_{CAL}	Impl. date
SP06	SP06	2025/08/21	272.6	270.3	275.0	272.9		0.4	

SP08	SP08	2025/08/21	265.4	265.6	267.9	267.3		0.4	

- **Transfer of calibration performed by INRIM in November 2025**

In November 2026, INRIM calibrated a new GNSS receiver SP09 by transfer of calibration with respect to the receiver IT05, see the [report by IT](#) and the results in Table 5.

The value DU_{CAL} for use in equation (1) has been computed from information provided in the report. For UTC use, the ageing uncertainty will be based on the date of original calibration of IT16 i.e. 2022/08/26.

Table 5. Final P1/P2/E1/E5a SYSDLY values for IT05. “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 should be implemented in the receiver.

System	BIPM	Meas. date	SYSDLY P1	SYSDLY P2	SYSDLY E1	SYSDLY E5a	REFDLY	Note	DU_{CAL}	Impl. date
INR5	IT05	2025/10/02	280.8	279.3	283.4	285.4	373.5		0.4	

Version history

V1.0 2023/03/22: Publication of results from V1.1 of the OP report.

V1.1 2023/07/12: Date typos in the text corrected

V1.2 2023/10/09: Transfer of calibration by INRIM added

V1.3 2024/09/25: Transfer of calibration by RISE added

V1.4 2024/12/12: Transfer of calibration by RISE added

V1.5 2025/09/22: Transfer of calibration by RISE added

V1.6 2025/12/01: Transfer of calibration by INRIM added