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Time and Frequency Division
National Institute of Standards and Technology
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Report of Calibration: Cal_Id:1012-2023

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Abstract

This is a preliminary report is a record of the calibration results of site receiver GMCP and INCP in Peru.

1 Description of the traveling GNSS receiver

The NIST Traveling System consists of Septentrio PolaRx5TR GNSS receiver unit (NB05), a Septentrio PolaNt-x MF.v2 antenna, an antenna cable (LMR 400), a laptop, a time interval counter (TIC) and two auxiliary cables (RG223 with BNC connectors) to be used for measuring the REFDLY for the traveling receiver. An HP53132A time interval counter is provided for measuring REFDLY. For more information, please refer to the NIST traveling receiver operator's manual.

2 Computing delays in the measurement setup

The difference in the total delay for a pair of co-located receivers is the sum of the delays incurred in the antenna cable(CABDLY) and the internal delay(INTDLY), minus the time offset at the latching point of the receiver as referenced to a fixed point, usually UTC(k)(REFDLY). The internal delay is comprised of both code- and frequency-dependent delays in the antenna and the receiver. After accounting for the baseline geometry, the difference in pseudoranges between a pair of receivers, say for P1, is given by

$$\mathrm{RAWDIF(P1)}_{\mathrm{A-B}} = \Delta\mathrm{CABDLY}_{\mathrm{A-B}} + \Delta\mathrm{INTDLY}_{\mathrm{A-B}} - \Delta\mathrm{REFDLY}_{\mathrm{A-B}}, \tag{1}$$

where $\mathrm{RAWDIF(P1)}_{\mathrm{A-B}}$ is the raw difference of pseudorange measurements of two receivers. Similarly for C1 and P2, $\mathrm{RAWDIF(C1/P2)}_{\mathrm{A-B}}$ is given by using the corresponding set of delays on the right-hand side of Eq.(1). The notation for the receivers A and B corresponds to the traveling- and station-receiver. $\Delta\mathrm{CABDLY}_{\mathrm{A-B}}$ and $\Delta\mathrm{REFDLY}_{\mathrm{A-B}}$ for NB05(A) and labv/NIST(B) are given in Table 1, referenced from Annexes—at the end of this report. We will refer to the visited laboratory receiver as labv. NISX and NB05 are NIST station- and traveling-receivers respectively. In this calibration campaign, we calibrate a total of three receivers in the visited laboratories. The procedure for measuring NB05 REFDLY (both $\mathrm{X_P}$ and $\mathrm{X_O}$) is outlined in the operating manual. The visited laboratories are responsible for the REFDLY and CABDLY values for their station receivers.

Table 1: REFDLY and CABDLY and their differences between traveling and station receivers

Pair	MJD	$\mathrm{REF_{DLY}}$ (NB05)	$\mathrm{REF_{DLY}}$ (labv)	$\mathrm{CAB_{DLY}}$ (NB05)	$\mathrm{CAB_{DLY}}$ (labv)	$\Delta\ \mathrm{REF_{DLY}}$ (ns)	$\Delta\mathrm{CAB_{DLY}}$ (ns)
NB05-NISX	60157-62	469.7	121.6	328.6	275.5	348.1	53.1
NB05-GMCP	60532-39	68.5	7.7	328.6	181.4	60.8	147.2

3 Computing raw difference of psuedoranges

The RINEX files for a pair of co-located receivers during the data acquisition period, MJD column in Table 1, are processed using *dclrinex* software provided by the BIPM that solves for the baseline between the phase centers of the two antennas from L1 and L2 phase differences [3, 4]. Subsequently, the P1 and P2 pseudorange differences are formed after accounting for the baseline. The results with the average values of RAWDIF are given in Table 2. The values for ΔINTDLY between a given pair of receivers are computed using Eq.(1) and are given in Table 3. NB05 and NISX are operated in auto compensation OFF mode.

Table 2: Computed raw differences: P1, P2, C1, E1, and E5.

Pair	RAWDIF(P1)	RAWDIF(C1)	RAWDIF(P2) (ns)	RAWDIF(E1)	RAWDIF(E5)
NB05-NISX	—	-292.7	—	—	—
NB05-GMCP	—	53.5	—	—	—

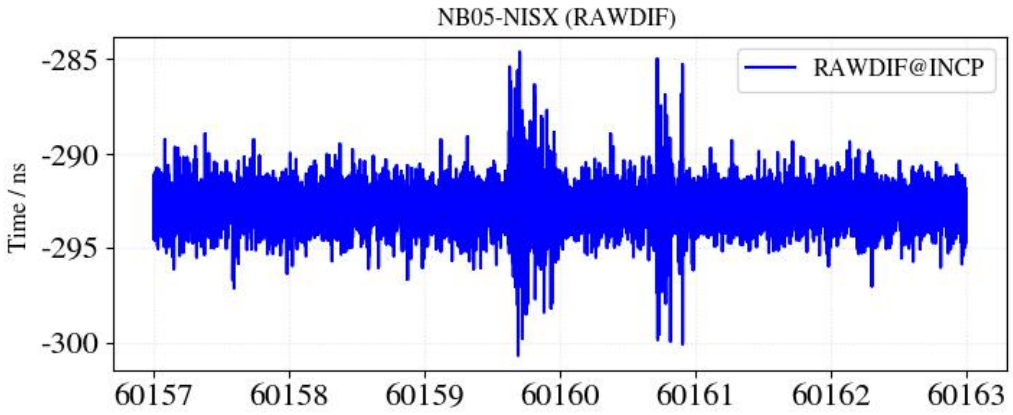

Figure 1: RAWDIF of NB05-NISX at NIST

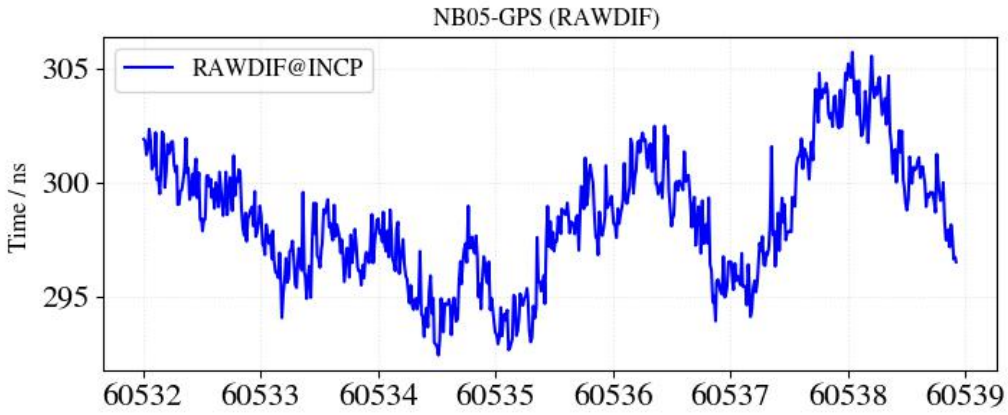

Figure 2: RAWDIF of NB05-GPS from CGGTTS with delays set to zero.

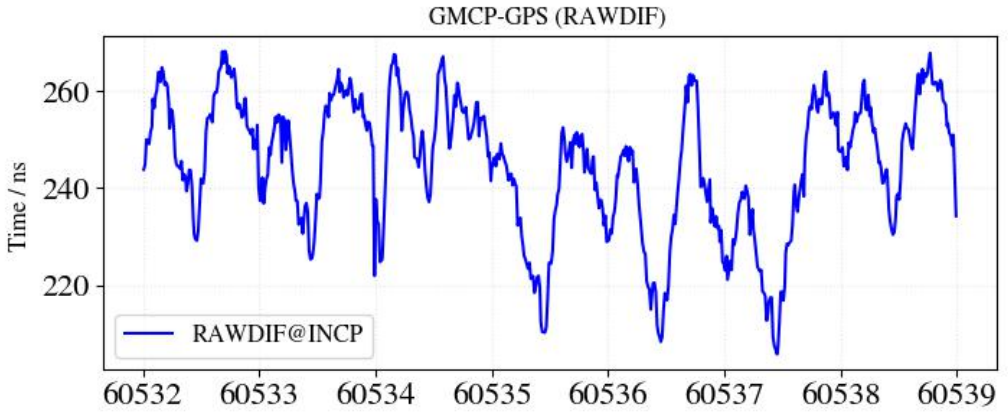

Figure 3: RAWDIF of GMCP-GPS from CGGTTS with delays set to zero.

Table 3: INTDLY difference: traveling and station receivers.

Pair	ΔINTDLY(P1)	ΔINTDLY(C1)	ΔINTDLY(P2)	ΔINTDLY(E1)	ΔINTDLY(E5)
			(ns)		
NB05-NISX	—	2.9	—	—	—
NB05-GMCP	—	-32.9	—	—	—

Table 4: INTDLY difference: station receivers.

Pair	INTDLY(P1)	INTDLY(C1)	INTDLY(P2)	INTDLY(E1)	INTDLY(E5)
			(ns)		
GMCP(TAI-104)-NISX	—	35.8	—	—	—

References

[1] ftp://ftp2.bipm.org/pub/tai/publication/gnss-calibration/guidelines/

[2] ftp://ftp2.bipm.org/pub/tai/publication/gnss-calibration/group1/1001-2018/1001-2020-phase3-report.pdf

[3] ftp://ftp2.bipm.org/pub/tai/publication/gnss-calibration/doc-soft/

[4] http://www.bipm.org/wg/CCTF/WGGNSS/Allowed/BIPM_guidelines_V3/Annex-3_Computation-procedure-Rinex_V2.pdf

Annex A - Information Sheet

Laboratory:	**NIST, Boulder, USA**
Date and hour of the beginning of measurements:	DOY150-225, 2023
Date and hour of the end of measurements:	

Information on the system		
	Local:	**Traveling:**
4-character BIPM code	**NIST**	**NB05**
Receiver maker and type: Receiver serial number:	PolaRxTR 5 S/N	PolaRxTR 5 S/N 3025300
1 PPS trigger level /V:	1	1
Antenna cable maker and type: Phase stabilized cable (Y/N):	Andrew FSJ-50A N	LMR 400 N
Length outside the building /m:	65	50
Antenna maker and type: Antenna serial number:	Novatel 702	Septentrio PolaNt-x MFv2
Temperature (if stabilized) /°C		

Measured delays /ns		
	Local:	**Traveling:**
Delay from local UTC to receiver 1 PPS-in (X_P)	66.7	327.8+85.8 = 413.6
Delay from 1 PPS-in to internal Reference (if different): (X_O)	54.9	56.07
Antenna cable delay: (X_C)	275.5	328.6
Splitter delay (if any):	N/A	N/A
Additional cable delay (if any):	N/A	N/A

Data used for the generation of CGGTTS files	
• INT DLY (or X_R+X_S) (GPS)† /ns:	28.16 (P1), 26.31(P2)
• INT DLY (or X_R+X_S) (Galileo) /ns:	30. 54 (E1), 31.15 (E5a)
• CAB DLY (or X_C) /ns:	275.5
• REF DLY (or X_P+X_O) /ns:	120
• Coordinates reference frame:	WGS84
X /m:	-1288398.60
Y /m:	-4721697.05
Z /m	4078625.45

General information	
• Rise time of the local UTC pulse:	3 ns
• Is the laboratory air conditioned:	yes
Set temperature value and uncertainty:	
Set humidity value and uncertainty:	

† Based on Cal_Id 1001-2020

Annex A - Information Sheet

Laboratory:	**INACAL**
Date and hour of the beginning of measurements:	2024-08-03 00:00 (UTC-5)
Date and hour of the end of measurements:	2024-08-07 11:59 (UTC-5)

Information on the system		
	Local:	**Traveling:**
4-character BIPM code	**IC__**	
Receiver maker and type: Receiver serial number:	NIST TAI-1 GMCP_60.492 FQC-00730 /00186-236-574-452 X16-96072	SEPTENTRIO PolaRx5TR 4701275
1 PPS trigger level /V:	1 V	
Antenna cable maker and type: Phase stabilized cable (Y/N):		
Length outside the building /m:		
Antenna maker and type: Antenna serial number:	NOVATEL GPS-701-GG Serial: 8529904760	SEPTENTRIO PolaNt-X MF.v2 5251
Temperature (if stabilized) /°C		

Measured delays /ns		
	Local:	**Traveling:**
Delay from local UTC to receiver 1 PPS-in (X_P)		25,623 ns
Delay from 1 PPS-in to internal Reference (if different): (X_O)		42,86 ns
Antenna cable delay: (X_C)		
Splitter delay (if any):		
Additional cable delay (if any):		

Data used for the generation of CGGTTS files	
INT DLY (or X_R+X_S) (GPS) /ns:	22,8
INT DLY (or X_R+X_S) (Galileo) /ns:	
CAB DLY (or X_C) /ns:	181,4
REF DLY (or X_P+X_O) /ns:	7,7
Coordinates reference frame:	ITRF
X	77 ° 0 min 26,280 s W
Y	12 ° 5 min 7,535 s S
Z	206,92 m

General information	
Rise time of the local UTC pulse:	
Is the laboratory air conditioned:	Yes