Link calibration of GNSS (GPS) receivers at NTSC

29 March, 2022

1. Description of equipment and operations

Link calibration of four GNSS receivers, which are NT02, NT03, NT04, and NT05, has been performed with respect to NTP3, which is previously calibrated within CAL_ID 1016-2018.

The GPS P3 total delay for each receiver was calibrated. Dates and receivers used for calibration are showed in Table 1. The complete information about the receiver set-up and the signal distribution system can be found in the Annex-A.

Table 1. Summary information of calibration campaign.

Institute	**Status of equipment**	**Dates of measurements**	**Receiver type**	**BIPM code**	**RINEX name**
NTSC	Reference	59467-59473	PolaRx4TR	NTP3	NTP3
NTSC	To be calibrated	59467-59473	GTR55	NT02	NT02
NTSC	To be calibrated	59467-59473	GTR55	NT03	NT03
NTSC	To be calibrated	59467-59473	GTR51	NT04	NT04
NTSC	To be calibrated	59467-59473	PolaRx5TR	NT05	NT05

2. Calibration procedure and results

The calibration has been performed based on GPS P3 CGGTTS files. Data from 2021-09-10 to 2021-09-16 (MJD 59467-59473) were used for this link calibration. UTC (NTSC) is the signal source for all receivers. Each receiver is connected to a dependent antenna. The operation mode of the NT05, PolaRx5TR receiver, is “auto-compensation ON” (which enable automatic PPS IN internal delay compensation for this receiver).

Table 2 summarizes the Common Clock Differences (CCD) mean values of GPS P3 for each receiver relative to the reference receiver NTP3. Annex A shows plots of raw data.

Table 2 GPS P3 CCD values (in ns).

Link	MJD	CCD mean values (GPS P3)	Sigma
NT02-NTP3	59467-59473	76.4	0.58
NT03-NTP3	59467-59473	81.9	0.57
NT04-NTP3	59467-59473	20.2	0.85
NT05-NTP3	59467-59473`	45.6	0.52

3. Uncertainty estimation

The uncertainty of total delay values is given by:

$$\mathrm{u_{CAL}} = \sqrt{\mathrm{u_a^2} + \mathrm{u_b^2}} \tag{1}$$

where u_a is statistical uncertainty u_a and u_b is systematic uncertainty. The u_a is related to the instability of the common clock data and determined by the Sigma in Table 2. The systematic uncertainty is given by:

$$\mathrm{u_b} = \sqrt{\sum_{i=1}^{n} \mathrm{u_{b,i}^2}} \tag{2}$$

Table 3 summarizes the systematic uncertainty for this link calibration campaign.

Table 3. Systematic uncertainty contributions (in ns).

Uncertainty	Value	Description
$\mathrm{u_{b1}}$	2.7	Calibration uncertainty of NTP3 (in Cirt 405)

4. Calibration results

The final results of the link calibration, TOTDLYs and U_{CAL}s are summarized in Table 4 for GPS P3 at NTSC.

Table 4 Summary of GPS relative calibration results (in ns).

Receiver	Date	TOTDLY (GPS P3)	U_{CAL}
NT02	2021-09	76.4	2.8
NT03	2021-09	81.9	2.8
NT04	2021-09	20.2	2.8
NT05	2021-09	45.6	2.8

Reference

[1] BIPM Circular T 405, 2021.

[2] BIPM. CAL_ID 1016-2018, Report for Calibration of G2 Laboratories NTSC and BIRM by NIM (V2.9), 2019.

ANNEX-A: Calibration information sheet and plots of raw data at NTSC

Information on the system		
	Reference:	**To be calibrated:**
4-character BIPM code	NTP3	NT02
• Receiver maker and type: Receiver serial number:	SEPT POLARX4TR 3102140	GTR55 1803027
1 PPS trigger level /V:	1	1
• Antenna cable maker and type: Phase stabilised cable (Y/N):	- Y	- Y
Length outside the building /m:	About 20m	About 30m
• Antenna maker and type: Antenna serial number:	SEPCHOKE_MC NONE 5392	NOV850 NMLK17480024E
Temperature (if stabilised) / ℃	23±0.5℃	23±0.5℃

Data used for the generation of NT02 CGGTTS files	
• Coordinates reference frame:	ITRF 2008
Latitude or X /m:	-1735233.48
Longitude or Y /m:	4976846.00
Height or Z /m:	3580528.42

General information for NT02	
• Rise time of the local UTC pulse:	3.2ns
• Is the laboratory air conditioned:	yes
Set temperature value and uncertainty:	23±0.5℃
Set humidity value and uncertainty:	55%±3%

Information on the system		
	Reference:	**To be calibrated:**
4-character BIPM code	NTP3	NT03
• Receiver maker and type: Receiver serial number:	SEPT POLARX4TR 3102140	GTR55 1906001
1 PPS trigger level /V:	1	1
• Antenna cable maker and type: Phase stabilised cable (Y/N):	- Y	- Y
Length outside the building /m:	About 20m	About 30m
• Antenna maker and type: Antenna serial number:	SEPCHOKE_MC NONE 5392	NOV850 NMLK19180035F
Temperature (if stabilised) / ℃	23±0.5℃	23±0.5℃

Data used for the generation of NT03 CGGTTS files	
• Coordinates reference frame:	ITRF 2008
Latitude or X /m:	-1735234.77
Longitude or Y /m:	4976845.08
Height or Z /m:	3580529.02

General information for NT03	
• Rise time of the local UTC pulse:	3.2ns
• Is the laboratory air conditioned:	yes
Set temperature value and uncertainty:	23±0.5℃
Set humidity value and uncertainty:	55%±3%

Information on the system		
	Reference:	**To be calibrated:**
4-character BIPM code	NTP3	NT04
• Receiver maker and type: Receiver serial number:	SEPT POLARX4TR 3102140	GTR51 1702044
1 PPS trigger level /V:	1	1
• Antenna cable maker and type: Phase stabilised cable (Y/N):	- Y	- Y
Length outside the building /m:	About 20m	About 30m
• Antenna maker and type: Antenna serial number:	SEPCHOKE_MC NONE 5392	NOV703GGG NEG17070064
Temperature (if stabilised) / ℃	23±0.5℃	23±0.5℃

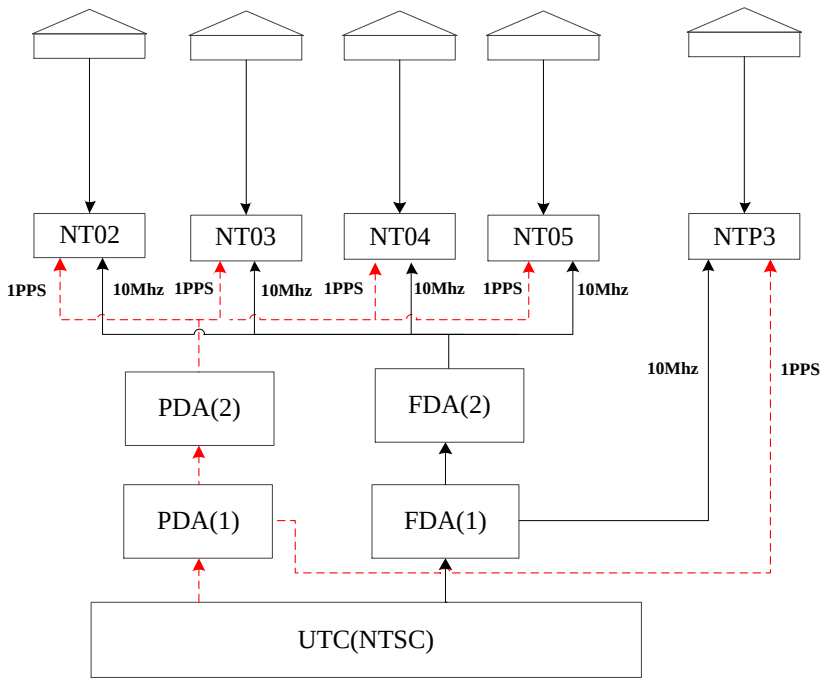
Data used for the generation of NT04 CGGTTS files	
• Coordinates reference frame:	ITRF 2008
Latitude or X /m:	- 1735232.94
Longitude or Y /m:	4976845.67
Height or Z /m:	3580529.15

General information for NT04	
• Rise time of the local UTC pulse:	3.2ns
• Is the laboratory air conditioned:	yes
Set temperature value and uncertainty:	23±0.5℃
Set humidity value and uncertainty:	55%±3%

Information on the system		
	Reference:	**To be calibrated:**
4-character BIPM code	NTP3	NT05
• Receiver maker and type: Receiver serial number:	SEPT POLARX4TR 3102140	SEPT POLARX5TR 4701420
1 PPS trigger level /V:	1	1
• Antenna cable maker and type: Phase stabilised cable (Y/N):	- Y	- Y
Length outside the building /m:	About 20m	About 30m
• Antenna maker and type: Antenna serial number:	SEPCHOKE_MC NONE 5392	SEPCHOKE_B3E6 5589
Temperature (if stabilised) / ℃	23±0.5℃	23±0.5℃

Data used for the generation of NT05 CGGTTS files	
• Coordinates reference frame:	ITRF 2008
Latitude or X /m:	-1735236.43
Longitude or Y /m:	4976844.75
Height or Z /m:	3580529.19

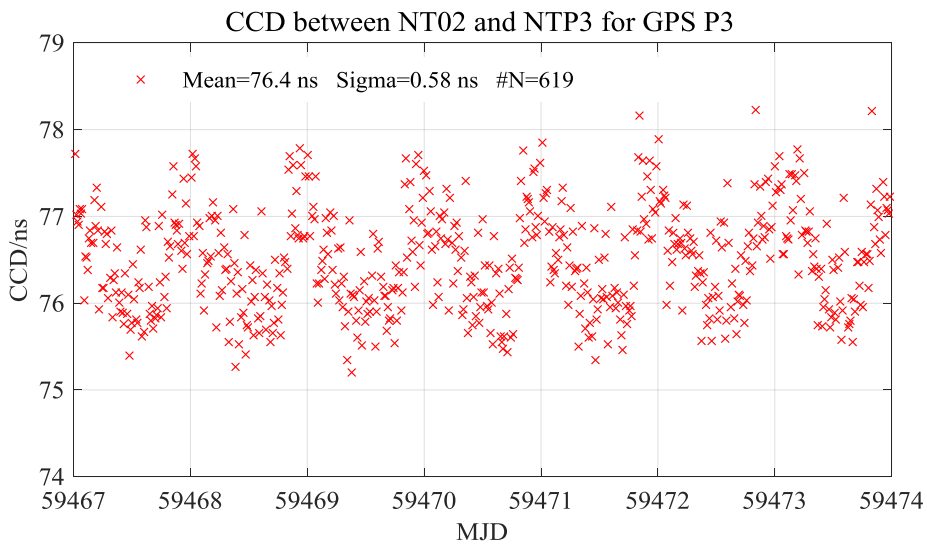
General information for NT05	
• Rise time of the local UTC pulse:	3.2ns
• Is the laboratory air conditioned:	yes
Set temperature value and uncertainty:	23±0.5℃
Set humidity value and uncertainty:	55%±3%



Receivers's set-up at NTSC

CCD Plots of raw data

NT02



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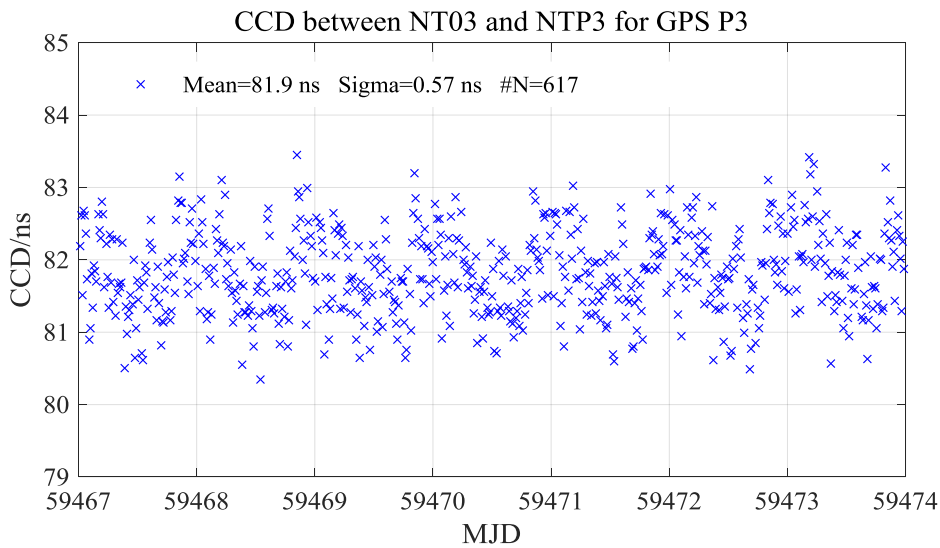

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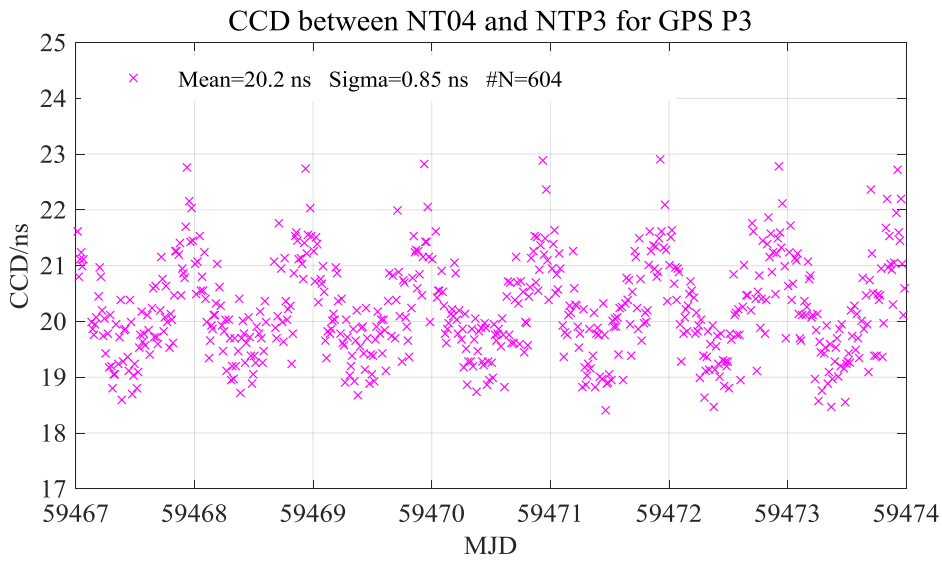
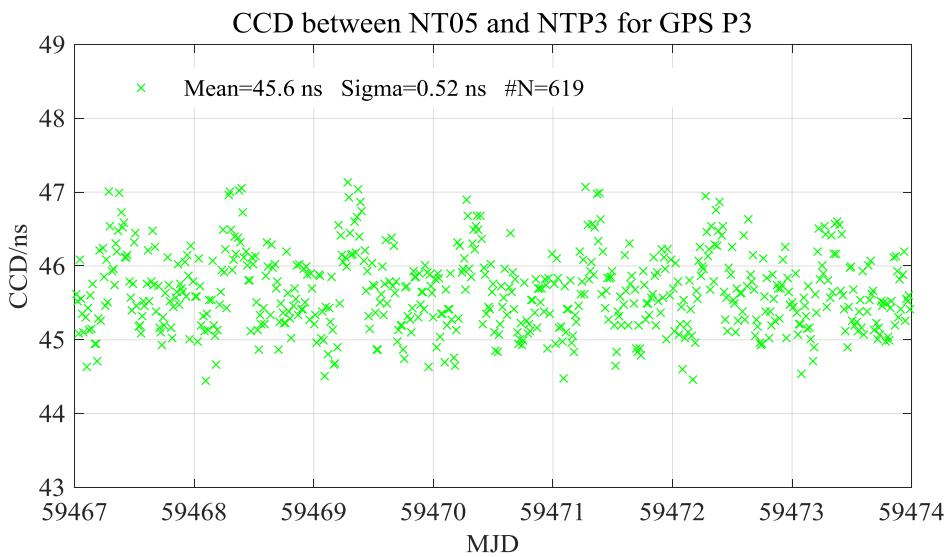


NT05



Notes: Mean is mean value of CCD. #N is the number of epoch.