

Calibration report for IM05

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The report is divided by five parts. The first part introduces the receivers to be calibrated. The second part describes the calibration principles briefly. The third and fourth parts describe the measurement results from the common clock difference (CCD) experiments and data processing and calculation of the calibration. In part 5, it is shown how the calibration uncertainties are evaluated. Annex 1 includes all the related measurement plots. Annex 2 includes the time deviation (TDEV) plots for the CCD results. Annex 3 includes all the information sheets.

1. Receiver information

IM05 is a time transfer receiver with GPS measurement. All information about the reference receiver and the receiver to be calibrated are list in table 1.

Table 1. Sites used for the calibration

Timing lab	Station name	BIPM code	Model	Role	Notes
NIM	IM06	IM06	Dicom GTR50	Reference receiver	Master
NIM	BJNM	IM05	Septentrio PolaRx3eTR	Receiver to be calibrated	Backup

2. Calibration principles

The basic calibration principles are described in [1]. The raw differences $RAWDIF(C1/P1/P2)_{A-B}$ between two receivers such as A and B, in the CCD experiments during the calibration, are given by

$$RAWDIF(C1/P1/P2)_{A-B} = \Delta CABDLY_{A-B} + \Delta INTDLY(C1/P1/P2)_{A-B} - \Delta REFDLY_{A-B} \quad (1)$$

where $RAWDIF(C1/P1/P2)_{A-B}$ are the differences of code measurements from Rinex or CGGTTS files without compensation of the antenna cable delay ($CABDLY$), the internal delay ($INTDLY$), and reference delay ($REFDLY$) from CGGTTS header. $\Delta CABDLY_{A-B}$, and $\Delta REFDLY_{A-B}$ are the differences of $CABDLY$ and $REFDLY$ between the station to be calibrated and the reference station separately, given in table 2.

Table 2. REFDLY and CABDLY differences between stations

Pair	MJD	$\Delta REFDLY$ (ns)	$\Delta CABDLY$ (ns)
BJNM-IM06	58969-58976	203.1	-123.7
BJNM-IM06	59058-59064	203.1	-123.7

3. Raw difference

Raw C1, P1 and P2 differences calculated between stations are given in table 3.

Table 3. Raw differences of GPS between stations

Pair	MJD	$\Delta C1$ (ns)	$\Delta P1$ (ns)	$\Delta P2$ (ns)
BJNM-IM06	58969-58976	-224.95	-225.69	-231.85
BJNM-IM06	59058-59064	-224.96	-225.85	-232.00

4. Calibration calculation

Table 4 shows *INTDLY* of station IM06 for GPS. $\Delta INTDLY_{A-B}$ values of *INTDLY* between the station to be calibrated and the reference station separately are computed using (1) and given in table 5. The *INTDLY* values of the station to be calibrated are given in table 6.

CGGTTS file headers

BJNM

MJD 58969-58976

INT DLY = 74.0 ns (GPS P1), 81.7 ns (GPS P2)

CAB DLY = 125.0 ns

REF DLY = 324.8 ns

IM06

MJD 58969-58976

INT DLY = -31.0 ns (GPS C1), -31.8 ns (GPS P1), -18.4 ns (GPS P2)

CAB DLY = 248.7 ns

REF DLY = 121.7 ns

Table 4. *INTDLY* of GPS for station IM06 from 1001-2018

Rcvr	C1 (ns)	P1 (ns)	P2 (ns)
IM06	-31.0	-31.8	-18.4

Table 5. *INTDLY* differences of GPS between stations

Pair	MJD	$\Delta INTDLY(C1)$ (ns)	$\Delta INTDLY(P1)$ (ns)	$\Delta INTDLY(P2)$ (ns)
BJNM-IM06	58969-58976	101.85	101.11	94.95
BJNM-IM06	59058-59064	101.84	100.95	94.80

Table 6. BJNM *INTDLY* values for GPS referenced to IM06

Rcvr	Data used	C1 (ns)	P1 (ns)	P2 (ns)
BJNM	MJD 58969-58976	70.9	69.3	76.6
BJNM	MJD 59058-59064	70.8	69.2	76.4

Note: The calibration results from the last measurements during MJD 59058-59064 should be applied.

5. Uncertainty evaluation

Here we evaluated the uncertainty from the sources as follows and got the

combined uncertainty as 1.0 ns conservatively for P codes. All the measurements related to the cable and reference delays were done with SR620 on the trigger level 1.0 V. And the uncertainties from position references and multipaths are just referenced to the description of the guideline. The u_a values are from TDEV of the corresponding CCD results shown in the figures in Annex 2. The misclosure values of IM05 calibration are the differences between the calibration values from the data of MJD 58969-58976 and MJD 59058-59064.

Table 7. Uncertainty contributions

Unc.	Value B1 (ns)	Value B2 (ns)	Value C1 (ns)	Value P1 (ns)	Value P2 (ns)	Description
u_a (T-V)	/	/	0	0	0	RAWDIF (traveling-visited)
u_a (T-R)	/	/	0.2	0.2	0.2	RAWDIF (traveling-reference)
u_a	/	/	0.2	0.2	0.2	
Misclosure						
$u_{b,1}$	/	/	0.1	0.1	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	0	0	Position error at visited
$u_{b,13}$	/	/	0.2	0.2	0.2	Multipaths at reference
$u_{b,14}$	/	/	0	0	0	Multipaths at visited
Link of the Traveling system to the local UTC(k)						
$u_{b,21}$	/	/	0.5	0.5	0.5	$REFDLY_T$ (at ref lab)
$u_{b,22}$	/	/	0	0	0	$REFDLY_T$ (at visited lab)
$u_{b,TOT}$	/	/	0.6	0.6	0.6	
Link of the Reference system to its local UTC(k)						
$u_{b,31}$	/	/	0.5	0.5	0.5	$REFDLY_R$ (at ref lab)
Link of the Visited system to its local UTC(k)						
$u_{b,32}$	/	/	0	0	0	$REFDLY_V$ (at visited lab)
$u_{b,SYS}$	/	/	0.8	0.8	0.8	Components of equation (2)
u_{CAL}	/	/	0.9	0.9	1.0	Composed of u_a and $u_{b,SYS}$
Antenna cable delays						
$u_{b,41}$	/	/	0.5	0.5	0.5	$CABDLY_R$
$u_{b,42}$	/	/	0	0	0	$CABDLY_V$
Combined Uncertainty: 1.0 ns						

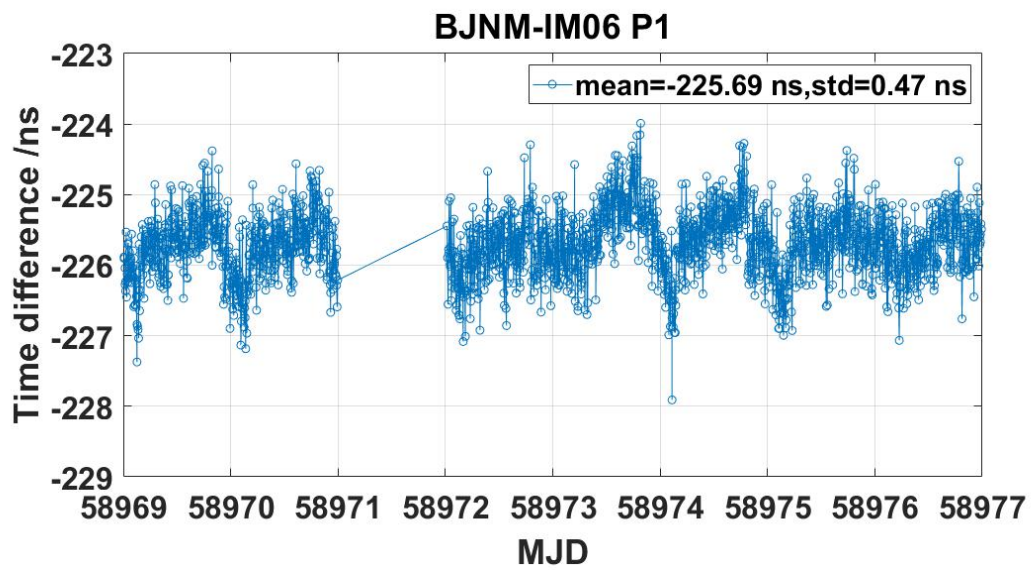
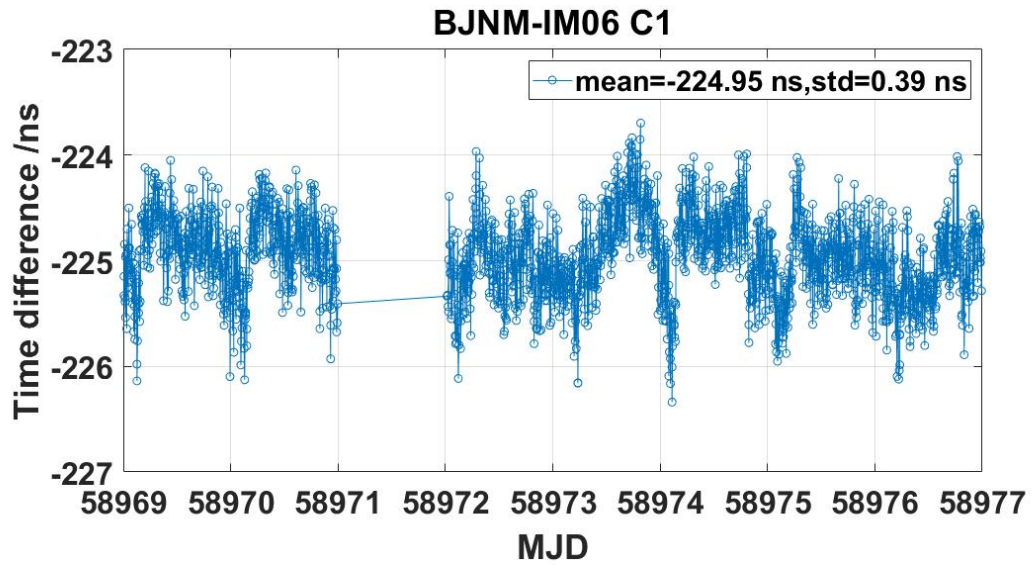
References:

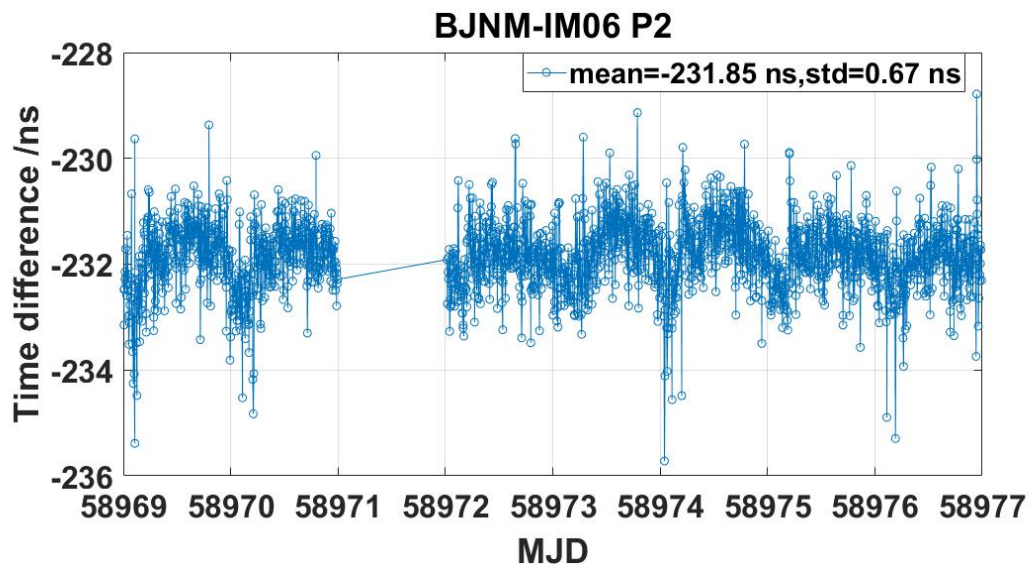
[1]. BIPM. BIPM guidelines for GNSS calibration(V3.2). 05, 02, 2016.

Annex 1: CCD results

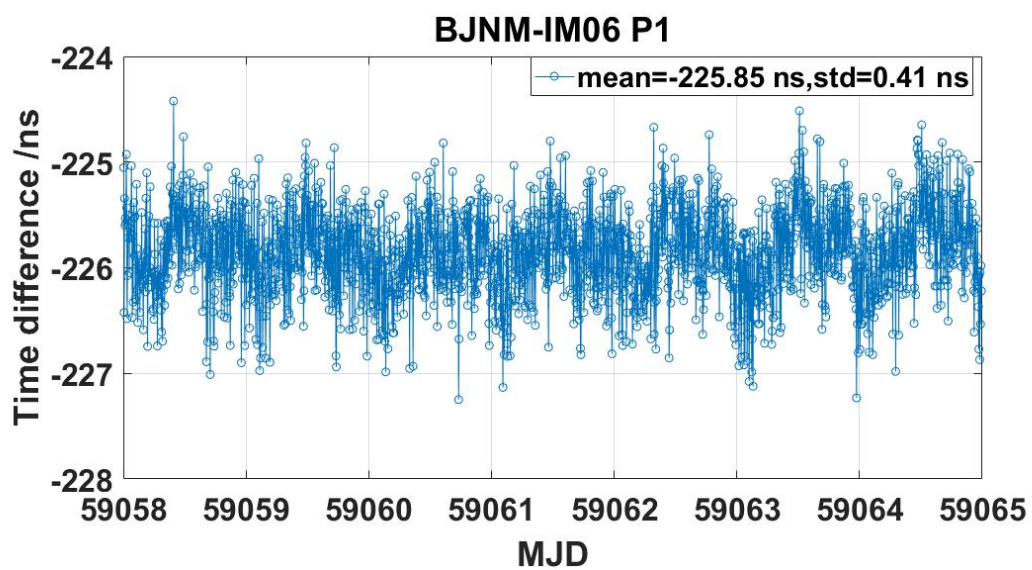
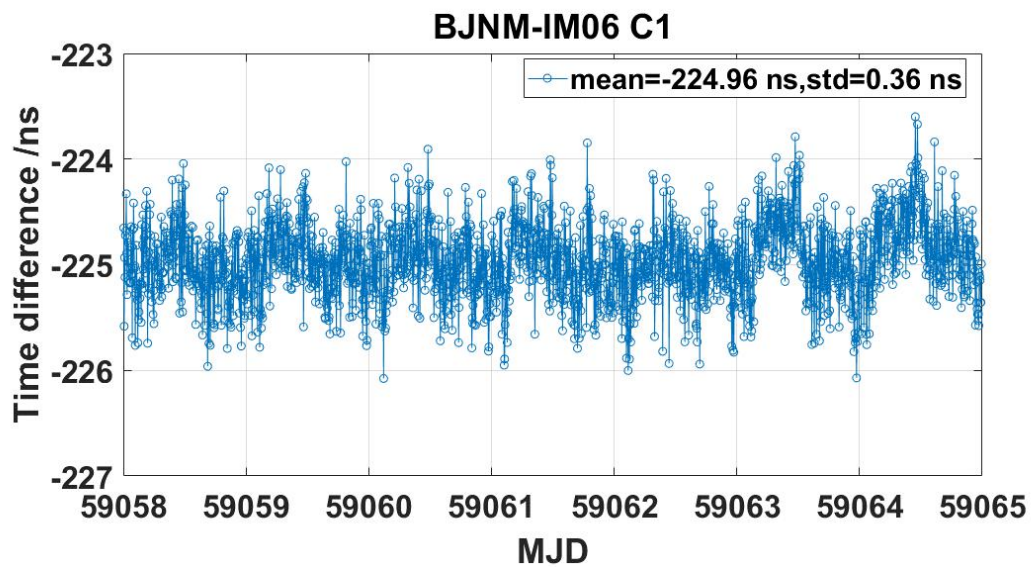
GPS using Rinex

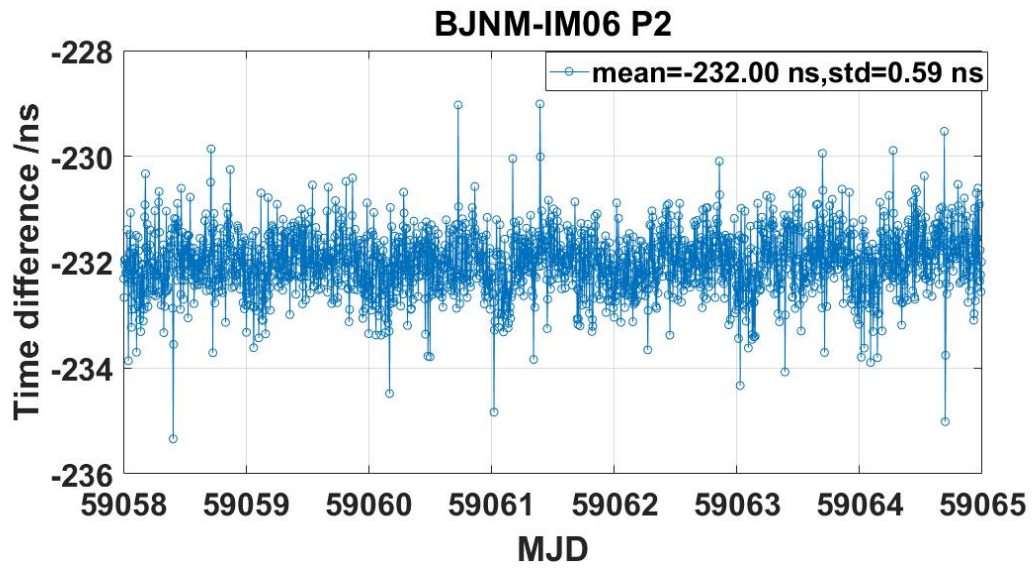
MJD 58969-58976





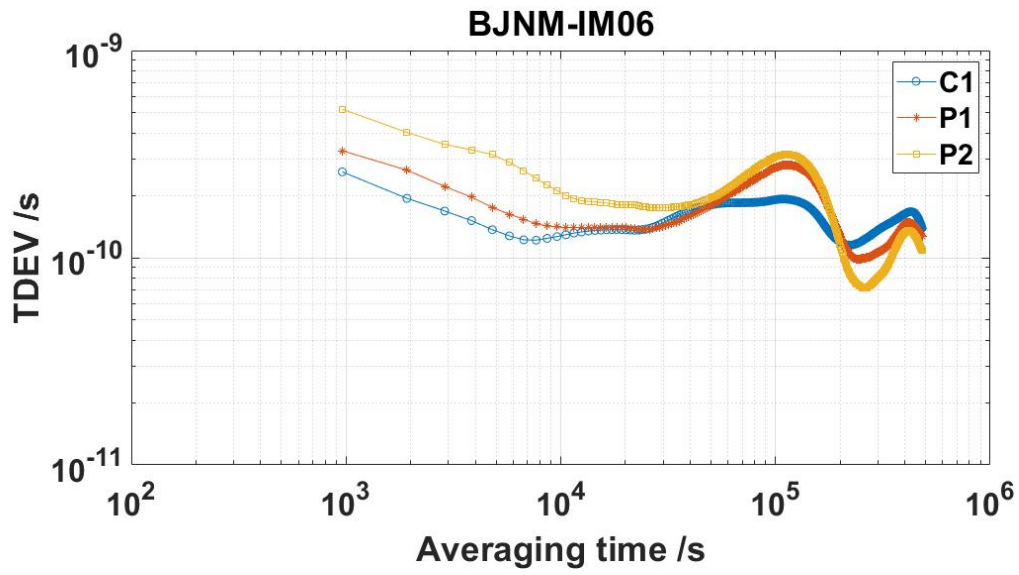
MJD 59058-59064



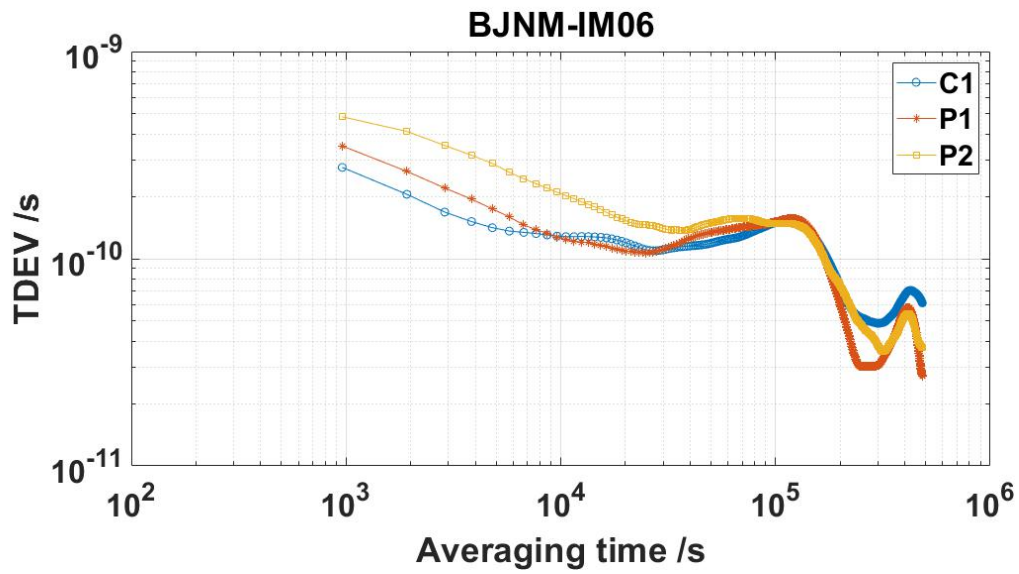


Annex 2: TDEV for CCD results:

MJD 58969-58976:



MJD 59058-59064:



Annex 3: Information Sheets

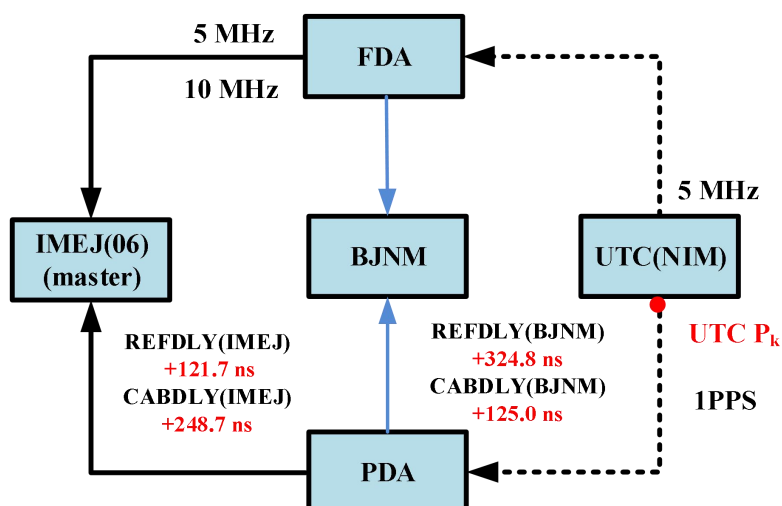
Information Sheet

(to be repeated for each calibrated system)

Laboratory:	NIM	
Date and hour of the beginning of measurements:	UTC time 0:00 am Apr. 30,2020	
Date and hour of the end of measurements:	UTC time 0:00 am May. 8, 2020	
Information on the system		
	Local:	Receiver to be calibrated:
4-character BIPM code	IM06	BJNM
Receiver maker and type: Receiver serial number:	maker:Dicom type: GTR50 serial number:1007011	maker: NIM type: SEPT POLARX3ETR serial number: 2001087
1 PPS trigger level /V:	0~2	0~2
Antenna cable maker and type: Phase stabilised cable (Y/N):	maker: type: Phase stabilised cable:N	maker: type: Phase stabilised cable:N
Length outside the building /m:	5 m	5 m
Antenna maker and type: Antenna serial number:	maker:Novatel type: GPS-702-GGG Serial number: NAE10220060	maker:Novatel type: NOV702GG Serial number: NAE09190046
Temperature (if stabilised) /°C		
Measured delays /ns		
	Local:	Receiver to be calibrated:
Delay from local UTC to receiver 1 PPS-in:	121.7	118.8
Delay from 1 PPS-in to internal Reference (if different):		206.0
Antenna cable delay:	248.7	125.0
Splitter delay (if any):		

Additional cable delay (if any):	
Data used for the generation of CGGTTS files (IM06)	
INT DLY (GPS) /ns:	-31.0 (GPS C1), -31.8 (GPS P1), -18.4 (GPS P2)
INT DLY (GLONASS) /ns:	0.0
CAB DLY /ns:	248.7
REF DLY /ns:	121.7
Coordinates reference frame:	ITRF
Latitude or X /m:	-2154288.06
Longitude or Y /m:	+4373440.56
Height or Z /m:	+4098884.94
Data used for the generation of CGGTTS files (BJNM)	
INT DLY (GPS) /ns:	0.0 ns (GPS C1), 74.0 ns (GPS P1), 81.7 ns (GPS P2)
INT DLY (BDS) /ns:	0.0 (BDS B1), 0.0 (BDS B2)
CAB DLY /ns:	125.0
REF DLY /ns:	324.8
Coordinates reference frame:	ITRF
Latitude or X /m:	-2154287.41
Longitude or Y /m:	+4373440.05
Height or Z /m:	+4098885.63
General information	
Rise time of the local UTC pulse	unknown
Is the laboratory air conditioned	Yes
Set temperature value and uncertainty:	26.0°C ±0.2 °C
Set humidity value and uncertainty:	21% ± 1%

Diagram of the experiment set-up



Information Sheet

(to be repeated for each calibrated system)

Laboratory:	NIM	
Date and hour of the beginning of measurements:	UTC time 0:00 am Jul. 28,2020	
Date and hour of the end of measurements:	UTC time 0:00 am Aug. 3,2020	
Information on the system		
	Local:	Receiver to be calibrated:
4-character BIPM code	IM06	BJNM
Receiver maker and type:	maker:Dicom	maker: NIM
Receiver serial number:	type: GTR50 serial number:1007011	type: SEPT POLARX3ETR serial number: 2001087
1 PPS trigger level /V:	0~2	0~2
Antenna cable maker and type:	maker:	maker:
Phase stabilised cable (Y/N):	type: Phase stabilised cable:N	type: Phase stabilised cable:N
Length outside the building /m:	5 m	5 m
Antenna maker and type:	maker:Novatel	maker:Novatel
Antenna serial number:	type: GPS-702-GGG Serial number: NAE10220060	type: NOV702GG Serial number: NAE09190046

Temperature (if stabilised) /°C		
Measured delays /ns		
	Local:	Receiver to be calibrated:
Delay from local UTC to receiver 1 PPS-in:	121.7	118.8
Delay from 1 PPS-in to internal Reference (if different):		206.0
Antenna cable delay:	248.7	125.0
Splitter delay (if any):		
Additional cable delay (if any):		
Data used for the generation of CGGTTS files (IM06)		
INT DLY (GPS) /ns:	-31.0 (GPS C1), -31.8 (GPS P1), -18.4 (GPS P2)	
INT DLY (GLONASS) /ns:	0.0	
CAB DLY /ns:	248.7	
REF DLY /ns:	121.7	
Coordinates reference frame:	ITRF	
Latitude or X /m:	-2154288.06	
Longitude or Y /m:	+4373440.56	
Height or Z /m:	+4098884.94	
Data used for the generation of CGGTTS files (BJNM)		
INT DLY (GPS) /ns:	70.9 ns (GPS C1), 69.3 ns (GPS P1), 76.6 ns (GPS P2)	
INT DLY (BDS) /ns:	0.0 (BDS B1), 0.0 (BDS B2)	
CAB DLY /ns:	125.0	
REF DLY /ns:	324.8	
Coordinates reference frame:	ITRF	
Latitude or X /m:	-2154287.41	
Longitude or Y /m:	+4373440.05	
Height or Z /m:	+4098885.63	
General information		
Rise time of the local UTC pulse	unknown	
Is the laboratory air conditioned	Yes	
Set temperature value and uncertainty:	26.0°C ±0.2 °C	
Set humidity value and uncertainty:	21% ± 1%	

Diagram of the experiment set-up

