中華電信研究院
Chunghwa Telecom Laboratories

2017 Group 2 GPS Calibration Trip
Cal_ID: 1013-2017

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Summary

The calibration trip is conducted by TL, started from January and ended in June 2017. This trip covered one G1 lab, TL, and three G2 labs, NIMT, NMIM and VMI. The report describes the details of the calibration. The annexes contain supplement information. During this campaign, NMIA provided technical supports and many valuable advices for the report.

1. Description of equipment and operations

1.1 Traveling equipment

In Fig. 1, the traveling system is the TL traveling equipment TRVL. The receiver in this system is a Topcon Euro 80 HE_GD. This dual-frequency receiver reports carrier phase measurements but cannot be referenced to an external 1 PPS or 5/10 MHz input signal. Hence, a time interval counter is used to reference the GPS receiver to the laboratory time standard. In this campaign, a dedicated PPS cable was supplied as parts of TRVL. If the cable is connected to UTC(k), the REFDLY of TRVL will be considered to zero; otherwise, the time difference between the reference point of TRVL and the local UTC(k) should be reported by visited labs.

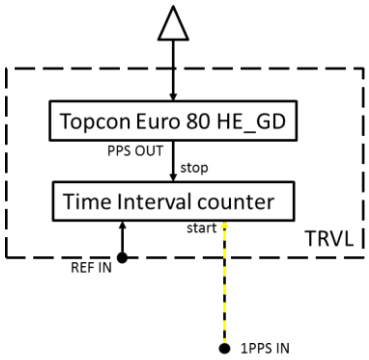


Fig. 1. Diagram of the TRVL. The REF IN is connected to 10 MHz with arbitrary coaxial cable. A dedicated cable is supplied to connect 1PPS and the start port of the counter inside.

The data processing chain we used generates a RINEX observation file with C1, P1 and P2 observations referenced to the external clock via the counter measurements. A modified version of r2cggtts then generates a CGGTTS file for a C1/P1/P2 observation. Precise antenna co-ordinates are obtained via a separate RINEX observation file which contains code and carrier phase observations, but not referenced to the external time standard.

According to the BIPM guidelines, the receiver must demonstrate sufficient stability over a time period comparable with the campaign. Due to external constraints, the campaign had to be completed within a strict timeframe which meant that the stability demonstration could not be undertaken for the anticipated duration of the campaign.

However, we do have data spanning about 13 years for this receiver (albeit with two long gaps), showing ± 1 ns scatter:

MJD	53000	53092	53195	53240	53284	53342	53524	53539	53630	53995	55009	57605
C1 delay (ns)	42.3	42.3	43.6	44.3	44.2	42.7	43.4	43.5	43.7	43.6	44.6	42.1

The reference receiver for these measurements was AU01, the NMIA primary receiver up until 2010. Uncertainties are at the ±0.5 ns level, due to a single cable delay measurement. Note that the AU01 C1 delay in these data has not been corrected to the BIPM-provided value.

1.2 Visited equipment

See the summary in Table 1. Detailed information on the set-up and on the measurements performed is given in the Annex.

Table 1. Summary information on the calibration trip

Institute	Status of equipment	Dates of measurement	Receiver type	BIPM code	RINEX name
TL	Traveling	57745 – 57758, 57897 – 57910	NMIA Topcon/Javad Euro-80 HE_GD	TRVL	TRVL
TL	G1 reference	57745 – 57758, 57897 – 57910	Ashtech Z12T	TLT1	TLT1
NIMT	G2 reference	57783 – 57819	NMIA Topcon/Javad Euro-80	MTTO	-
NMIM	G2 reference	57836 – 57854	NMIA Topcon/Javad Euro-80	LSM1	-
NMIM	G2 backup	57836 – 57854	Septentrio PolaRx2e TR	LS2P	LS2P
VMI	G2 reference	57867 – 57881	NMIA Topcon/Javad Euro-80	VM__	-
VMI	G2 backup	57867 – 57881	Septentrio Polarx3e TR	VM12	VN3P

2. Data used

The CGGTTS data are used for all analyses.

3. Results of raw data processing

The raw difference of a particular code is denoted by RAWDIF(code). The RAWDIF of the pairs is obtained from CGGTTS data. To meet the requirements in the BIPM guidelines, we define the RAW values as the uncorrected measurement, expressed as

$$\text{RAW} = \text{REFSV} + \text{MDIO} + \text{MDTR} + \text{INT DLY} + \text{CAB DLY} - \text{REF DLY}$$

for each station, each PRN, and each time stamp. The values shown on the right side are the readings in the CGGTTS data. The RAWDIF of the pair A-B is defined by

RAWDIF = median(RAW value of A – RAW value of B)

The inferred average value, is denoted RAWDIF, and its uncertainty from the statistical analysis. For each pair, plots of the data differences and of the statistical analysis (TDEV) are in Annex 1; The inferred RAWDIF(P1), RAWDIF(P2) and RAWDIF(C1) are taken as the median of the raw differences. The associated uncertainties are taken as the floor of the TDEV values, with a minimum of 0.1 ns. The results are summarized in Table 2.1 and Table 2.2.

Table 2.1 Raw differential results for all pairs (Traveling – Reference) (ns)

Pair	Date	RAWDIF(P1)	Unc	RAWDIF(P2)	Unc	RAWDIF(C1)	Unc
TRVL-TLT1	57745 – 57758	-241.03	0.1	-238.48	0.1	-238.22	0.1
TRVL-TLT1	57897 – 57910	-241.70	0.1	-239.53	0.1	-238.33	0.1

Table 2.2 Raw differential results for all pairs (Traveling – Visited) (ns)

Pair	Date	RAWDIF(P1)	Unc	RAWDIF(P2)	Unc	RAWDIF(C1)	Unc
TRVL-MTTO	57792 – 57822	-	-	-	-	-12.86	0.3
TRVL-LSM1	57836 – 57854	-	-	-	-	-2.92	0.1
TRVL- LS2P	57836 – 57854	56.15	0.1	66.87	0.1	55.90	0.1
TRVL-VM__	57867 – 57881	-	0.1	-	-	-81.43	-
TRVL-VM12	57867 – 57881	225.32	0.1	234.33	0.3	228.42	0.1

4. Calibration results

In the first step, we compute ΔSYSDLY, the differences of SYSDLY for all pairs (Traveling - Reference) and (Traveling-Visited), from

$$\Delta SYSDLY_{A\text{-}B}(Code) = RAWDIF_{A\text{-}B}(Code) + REFDLY_A - REFDLY_B \quad (1)$$

where RAWDIF(Code) is read from Table 2 and where the values REFDLY are in Annex 1.

The ΔSYSDLY values are reported in Table 3 for the pairs Traveling-Reference (section 4.1) and in Table 4 for the pairs Traveling-Visited (section 4.2).

In the second step we compute ΔSYSDLY (Visited-Reference) for all visited systems.

$$\Delta SYSDLY_{V\text{-}R} = \Delta SYSDLY_{T\text{-}R} - \Delta SYSDLY_{T\text{-}V} \quad (2)$$

We can compute ΔINTDLY (Visited - Reference) for all visited systems.

$$\Delta INTDLY_{V\text{-}R} = \Delta SYSDLY_{V\text{-}R} - CABDLY_V + CABDLY_R \quad (3)$$

where the values CABDLY are taken from Annex 1;

Tables 5 reports the $\Delta INTDLY_{V\text{-}R}$ results for the pairs Visited-Reference (section 4.3). Using assumed $INTDLY_R$ values for the Reference system, Table 7 then reports $INTDLY_V$ for all visited systems (section 5).

4.1. Traveling system with respect to the reference system

Table 3. Traveling vs. Reference system (all values in ns)

Pair	Date	$REFDLY_T$	$REFDLY_R$	P1 RAWDIF	P1 $\Delta SYSDLY_{T\text{-}R}$	P2 RAWDIF	P2 $\Delta SYSDLY_{T\text{-}R}$	C1 RAWDIF	C1 $\Delta SYSDLY_{T\text{-}R}$
TRVL-TLT1	57745 – 57758	0.0	0.0	-241.03	-241.03	-238.48	-238.48	-238.22	-238.22
TRVL-TLT1	57897 – 57911	0.0	0.0	-241.70	-241.70	-239.53	-239.53	-238.33	-238.33
Misclosure				-0.67	-0.67	-1.05	-1.05	-0.11	-0.11
Mean				-241.37	-241.37	-239.01	-239.01	-238.28	-238.28

4.2. Traveling system with respect to the visited systems

Table 4. Traveling vs. Visited systems (all values in ns)

Pair	Date	$REFDLY_T$	$REFDLY_V$	P1 RAWDIF	P1 $\Delta SYSDLY_{T\text{-}V}$	P2 RAWDIF	P2 $\Delta SYSDLY_{T\text{-}V}$	C1 RAWDIF	C1 $\Delta SYSDLY_{T\text{-}V}$
TRVL-MTTO	57792 – 57822	0.0	7.07	-	-	-	-	-12.86	-19.93
TRVL-LSM1	57836 – 57854	0.0	10.85	-	-	-	-	-2.92	-13.77
TRVL- LS2P	57836 – 57854	0.0	259.1	56.15	-202.95	66.87	-192.24	55.90	-203.20
TRVL-VM__	57867 – 57881	19.0 *	33.9	-	-	-	-	-81.43	-96.33
TRVL-VM12	57867 – 57881	19.0 *	243.94	225.32	0.38	234.33	9.39	228.42	3.48

* The PPS used for traveling equipment had a +19 ns delay against UTC(VMI).

4.3. Visited systems with respect to reference system

Table 5 provides the values obtained by differencing Table 3 and Table 4. CABDLY values are

taken from Annex 1.

Table 5. Visited vs. Reference (all values in ns)

Pair	Date	$CABDLY_V$	$CABDLY_R$	P1 $\Delta SYSDLY_{V-R}$	P1 $\Delta INTDLY_{V-R}$	P2 $\Delta SYSDLY_{V-R}$	P2 $\Delta INTDLY_{V-R}$	C1 $\Delta SYSDLY_{V-R}$	C1 $\Delta INTDLY_{V-R}$
MTTO-TLT1	57746 – 57757	165.4	0.0	-	-	-	-	-218.37	-383.77
LSM1-TLT1	57836 – 57854	155.4	0.0	-	-	-	-	-224.54	-379.94
LS2P-TLT1	57836 – 57854	157.53	0.0	-38.39	-195.92	-46.57	-204.10	-35.10	-192.63
VM__-TLT1	57867 – 57881	256.8	0.0	-	-	-	-	-141.95	-398.75
VM12-TLT1	57867 – 57881	124.3	0.0	-241.72	-366.02	-248.20	-372.49	-241.78	-366.08

4.4. Uncertainty estimation

In this section, we determine the uncertainty of the differential calibration process i.e. we estimate all components that can affect the accuracy. We determine a value u_{CAL} that is to be used as the accuracy of all P3/PPP links (Visited – Reference) at the epoch of calibration.

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

with the statistical uncertainty u_a and the systematic uncertainty u_b. (all are 1-sigma).

The statistical uncertainty u_a originates from RAWDIF (see section 3) and is given by the statistical analysis of the raw code differences for “Traveling-Reference” and “Traveling-Visited”. In Annex. 1, some values are very good for all codes, but some are poor for C1. We find the minimum for each TDEV curve, and then we choose the largest one among the minimums as the u_a.

The systematic uncertainty is given by

$$u_b = \sqrt{\sum_n u_{b,n}^2}$$

where all possible terms to be considered in the sum are to be listed in Table 6 and some detail on their estimation should be provided in Annex 1. Values appear separately for each frequency (C1/P1 and P2) so as to compute a value u_{CAL} applicable to P3 links. We choose to compute u_{CAL} using for u_b the uncertainty $u_{b,SYS}$ of $\Delta SYSDLY_{V-R}$ from equation (2). Table 6 presents all components of the uncertainty budget along with the uncertainty $u_{b,SYS}$ of $\Delta SYSDLY_{V-R}$ from equation (2) and the resulting uncertainty value u_{CAL}.

Table 6. Uncertainty contributions. Values P3 are computed as $2.545 \times \mathrm{P1} - 1.545 \times \mathrm{P2}$ for u_a and $\mathrm{P1} + 1.545 \times (\mathrm{P1} - \mathrm{P2})$ for u_b

Unc.	Value C1/P1 (ns)	Value P2 (ns)	Value P1-P2 (ns)	Value P3 (ns)	Description
u_a (T–V)	0.3	0.3	-	-	RAWDIF (traveling – visited)
u_a (T–R)	0.1	0.1	-	-	RAWDIF (traveling – reference)
u_a	0.3	0.3	-	0.9	
Misclosure					
$u_{b,1}$	0.7	1.1	0.4	-	observed misclosure
Systematic components related to RAWDIF					
$u_{b,11}$	0.1	0.1	0.1	-	Position error at reference
$u_{b,12}$	0.1	0.1	0.1	-	Position error at visited
$u_{b,13}$	0.3	0.3	0.4	-	Multipaths at reference
$u_{b,14}$	0.3	0.3	0.4	-	Multipaths at visited
Link of the Traveling system to the local UTC(k)					
$u_{b,21}$	0.5	0.5	0.0	-	$\mathrm{REFDLY_T}$ (at ref lab)
$u_{b,22}$	0.5	0.5	0.0	-	$\mathrm{REFDLY_T}$ (at visited lab)
$u_{b,TOT}$	1.1	1.4	0.7	1.5	
Link of the Reference system to its local UTC(k)					
$u_{b,31}$	0.5	0.5	0.0	-	$\mathrm{REFDLY_R}$ (at ref lab)
Link of the Visited system to its local UTC(k)					
$u_{b,32}$	0.5	0.5	0.0	-	$\mathrm{REFDLY_V}$ (at visited lab)
$u_{b,SYS}$	1.3	1.6	0.7	1.7	Components of equation (2)
u_{CAL}	-	-	-	1.9	Composed of u_a and $u_{b,SYS}$

The components in Table 6 are separated into several categories:

- $u_{b,1}$ accounts for possible variation of the delays of the traveling system during the trip. This is evaluated by the observed misclosure (0.7 ns for P1, 1.1 ns for P2, and 0.4 ns for P1-P2). See Table 3.
- $u_{b,11}$ and $u_{b,12}$ account for errors in the differential position (Travel – Local). In general they are estimated to be 3.0 cm (0.1 ns) because the standard uncertainty of the differential positioning obtained with the data used for calibration is typically at or below this level.
- $u_{b,13}$ and $u_{b,14}$ account for multipath. This is difficult to estimate and a conservative estimate of 0.3 ns is conventionally used.
- $u_{b,21}$ and $u_{b,22}$ account for the measurement between the reference point of the traveling system

and the local UTC(k). They include at least one measurement with a TIC and are taken to be 0.5 ns.

- $u_{b,31}$ and $u_{b,32}$ account similarly for the measurement between the reference point of the local system and the local UTC(k). They include at least one measurement with a TIC and are taken to be 0.5 ns.

5. Final results for the visited systems

Using the $INTDLY_R$ values reported in 1001-2016 for the Reference system TLT1 (transferred from the BIPM reference BP0R), Table 7 then reports INTDLY for all visited systems (section 4.4).

Final results are presented for each visited system as they need to be entered to produce timing data in the CGGTTS format, i.e. in the form of INTDLY (or SYSDLY if the antenna cable delays are not available).

The value u_{CAL}(Code) is obtained from Table 6. It is used by the BIPM to assign the value u_b which will apply to all links (Code) to which the system participates.

Table 7. Summary of final results

Reference system	Cal_Id	Date		INTDLY P1 /ns	INTDLY P2 /ns	INTDLY C1 /ns
TLT1	1001-2016	Feb. 10, 2017		415.0	424.1	414.9
Visited systems	Cal_Id	Date	u_{CAL} (P3) /ns	INTDLY P1 /ns	INTDLY P2 /ns	INTDLY C1 /ns
MTTO	1013-2017	Sep. 30, 2017	-	-	-	31.2
LSM1	1013-2017	Sep. 30, 2017	-	-	-	35.1
LS2P	1013-2017	Sep. 30, 2017	1.9	219.1	220.0	222.4
VM__	1013-2017	Sep. 30, 2017	-	-	-	16.2
VM12	1013-2017	Sep. 30, 2017	1.9	49.0	51.6	48.9

As a cross-check, we have supplementary data from previous calibrations of the three Topcon systems. These systems were built at NMIA and calibrated against receivers there. Table 8 summarizes these calibrations, including those of the reference receivers. The new C1 delay calibrations agree satisfactorily with those obtained previously.

Table 8. Comparison with previous calibrations of Topcon receivers

Receiver	Reference receiver	Date	C1 INTDLY (ns)	New C1 INTDLY (ns)
AU01	BP0N (BIPM calibration)	53337	37.5 ± 4.0	-
MTTO	AU01	53058	33.9 ± 4.5 †	31.2
LSM1	TRVL	53240	38.1 ± 3.3 †	35.1

VM__	AU01	53837	32.9 ± 4.5 † 13.9 ± 4.5 *	16.2

† A nominal uncertainty of 2 ns is assumed, and then added in quadrature with the uncertainty of the calibration of the reference receiver.

* A correction of 19 ns must be made because of the choice of REF DLY.

Annex 1. Information provided by each visited laboratory and the RAWDIF results

Information sheets (to be repeated for each calibrated system)

Laboratory:	TL
Date and hour of the beginning of measurements:	Dec. 24, 2016 (MJD 57746) 0 h UTC
Date and hour of the end of measurements:	Jun. 6, 2017 (MJD 57910) 23 h UTC

Information on the system

	Local:	Travelling:
4-character BIPM code	TLT1	TRVL
Receiver maker and type: Receiver serial number:	Ashtech Z-XII3T Metronome RT919994504	NMIA Topcon/Javad Euro-80 HE_GD
1 PPS trigger level /V:	1 V	0.5 V
Antenna cable maker and type: Phase stabilized cable (Y/N):	Andrew FSJ1-50A	LMR-400
Length outside the building /m:	~ 30 m	~ 40 m
Antenna maker and type: Antenna serial number:	SEPCHOKE_B3E6 SPKE 5006	Hemisphere A45 A452401000003
Temperature (if stabilised) /°C		

Measured delays /ns if needed fill box “Additional Information” further below)

	Local:	Travelling:
Delay from local UTC to receiver 1 PPS-in:	0.0 ns	0.0 ns
from 1 PPS-in to internal reference (if different)		
Antenna cable delay:	0.0 ns	0.0 ns
Splitter delay (if any):		
Additional cable delay (if any):		

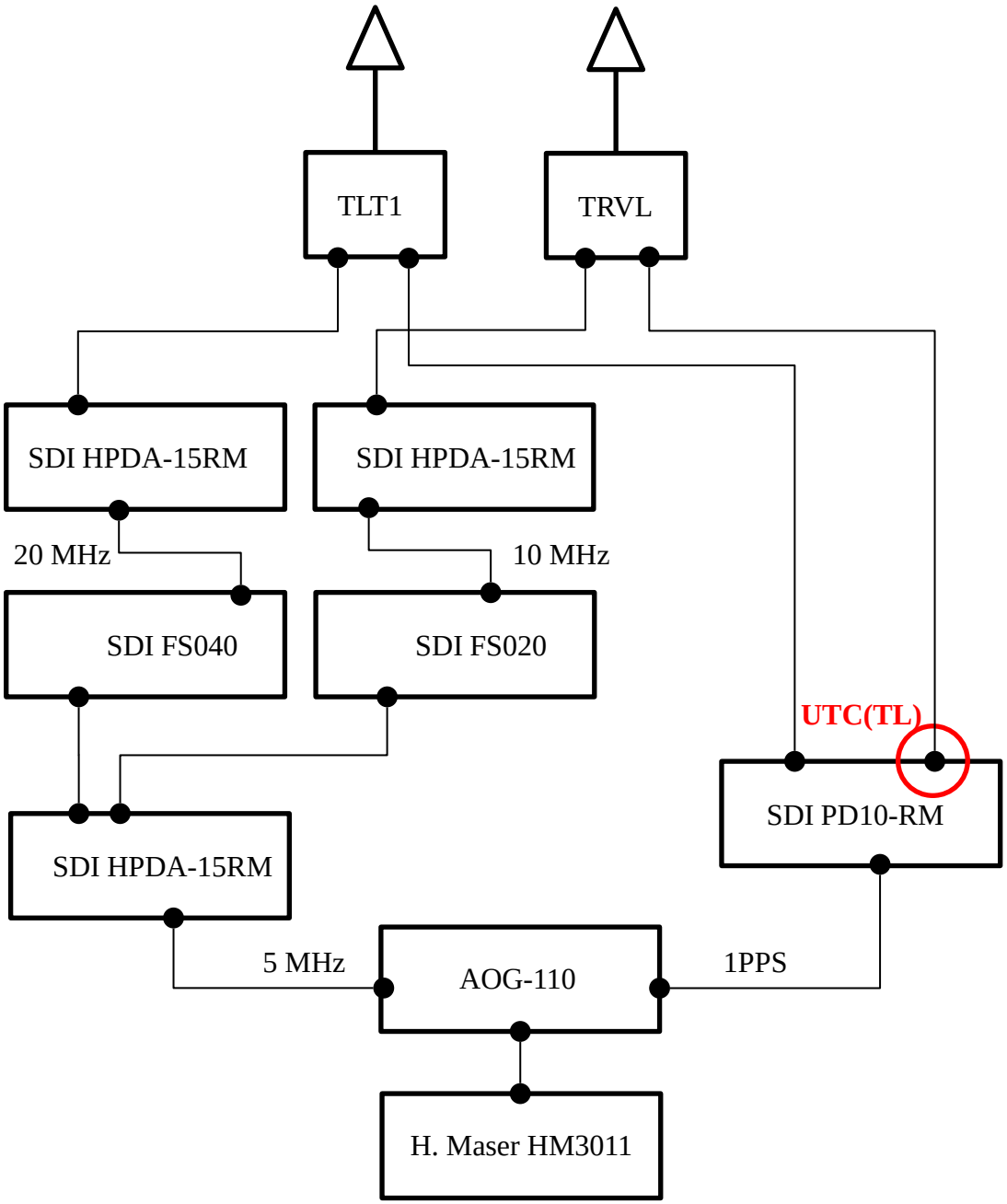
Data used for the generation of CGGTTS files

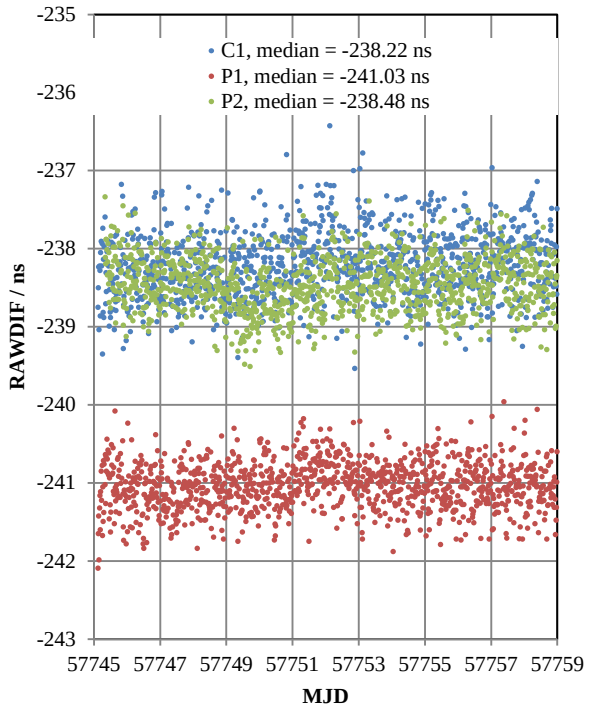
INT DLY (GPS) /ns:	C1: 414.95, P1: 415.05, P2: 424.48
INT DLY (GLONASS) /ns:	
CAB DLY /ns:	0.0
REF DLY /ns:	0.0
Coordinates reference frame:	WGS84
Latitude or X /m:	-2994425.48
Longitude or Y /m:	4951311.89
Height or Z /m:	2674498.36

General information

Rise time of the local UTC pulse:	3 ns
Is the laboratory air conditioned?	Yes
Set temperature value and uncertainty:	23 ± 1 °C
Set humidity value and uncertainty:	

Diagram of the experiment set-up

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P1, median = -241.03 ns
P2, median = -238.48 ns
RAWDIF / ns
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-237
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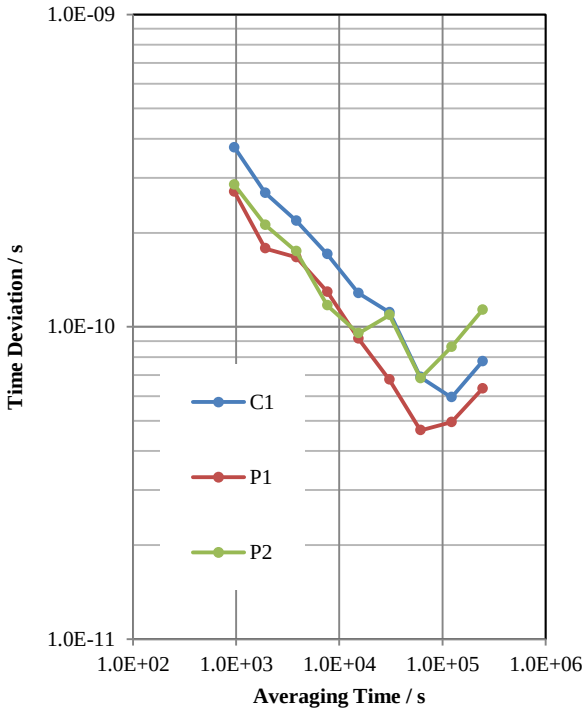
MJD


Time Deviation / s
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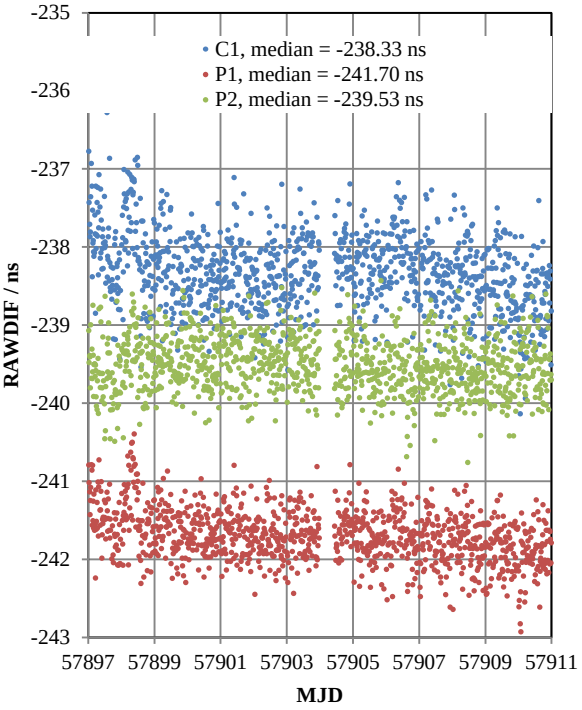
1.0E-10
1.0E-11
C1
P1
P2
1.0E+02 1.0E+03 1.0E+04 1.0E+05 1.0E+06
Averaging Time / s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P1, median = -241.70 ns
P2, median = -239.53 ns
RAWDIF / ns
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-237
-238
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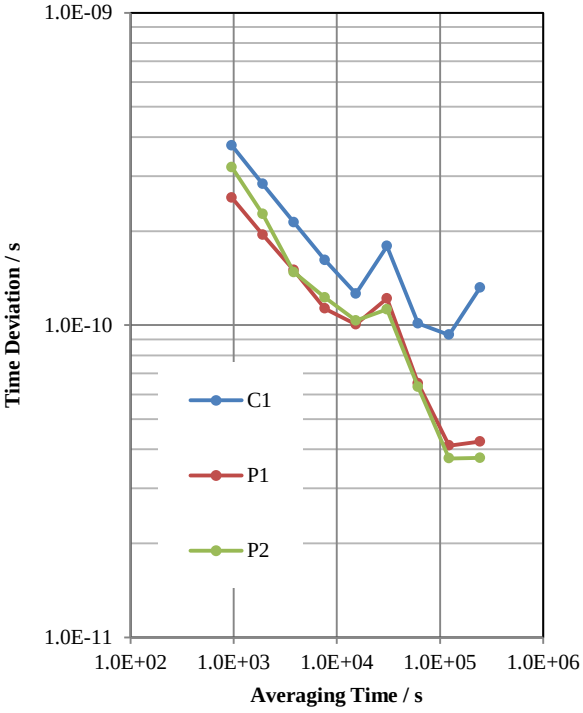
-243
57897 57899 57901 57903 57905 57907 57909 57911
MJD


Time Deviation / s
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1.0E-10
1.0E-11
C1
P1
P2
1.0E+02 1.0E+03 1.0E+04 1.0E+05 1.0E+06
Averaging Time / s


TLT1
TRVL

Information sheets (to be repeated for each calibrated system)

Laboratory:	NIMT
Date and hour of the beginning of measurements:	Jan. 30, 2017 (MJD 57783) 0 h UTC
Date and hour of the end of measurements:	Mar. 7, 2017 (MJD 57819) 23 h UTC

Information on the system

	Local:	Travelling:
4-character BIPM code	NIMT	TRVL
Receiver maker and type: Receiver serial number:	NMIA Topcon/Javad Euro-80	NMIA Topcon/Javad Euro-80
1 PPS trigger level /V:	1 V	0.5 V
Antenna cable maker and type: Phase stabilized cable (Y/N):	LMR-400	LMR-400
Length outside the building /m:	~ 30 m	~ 40 m
Antenna maker and type: Antenna serial number:	Javad L1/L2 00141	Hemisphere A45 A452401000003
Temperature (if stabilised) /°C		

Measured delays /ns if needed fill box “Additional Information” further below)

	Local:	Travelling:
Delay from local UTC to receiver 1 PPS-in:	7.07 ns	0.0 ns
from 1 PPS-in to internal reference (if different)		
Antenna cable delay:	165.52 ns	0.0 ns
Splitter delay (if any):		
Additional cable delay (if any):		

Data used for the generation of CGGTTS files

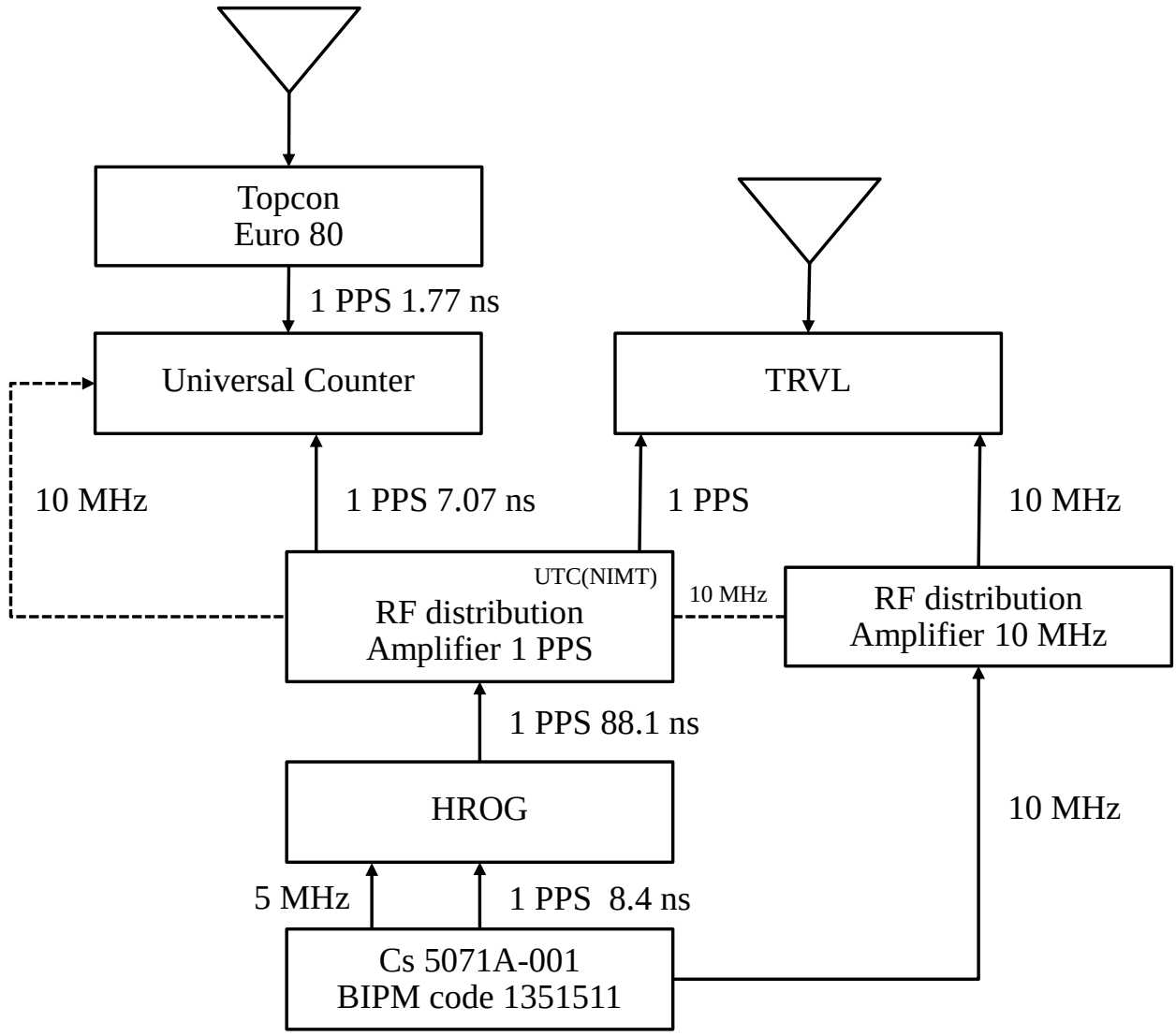
INT DLY (GPS) /ns:	C1: 42.9
INT DLY (GLONASS) /ns:	
CAB DLY /ns:	165.4
REF DLY /ns:	7.07
Coordinates reference frame:	ITRF2000 on 2005/08/26
Latitude or X /m:	-1150489.200
Longitude or Y /m:	6080853.999
Height or Z /m:	1537597.843

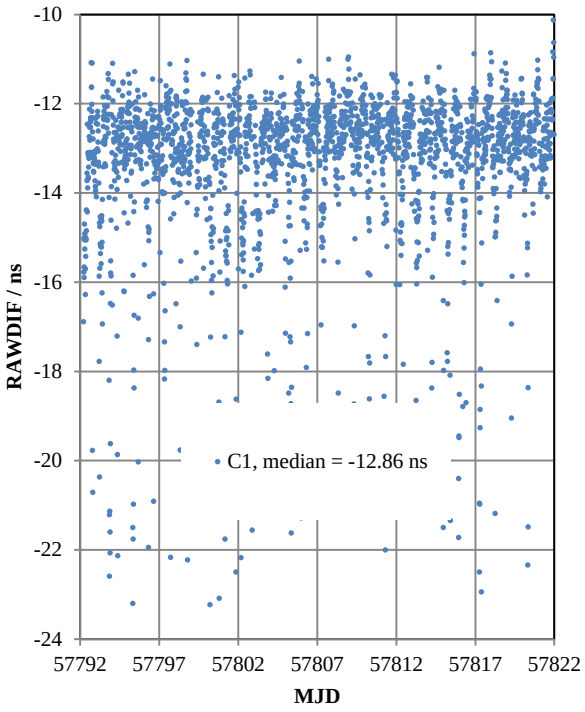
General information

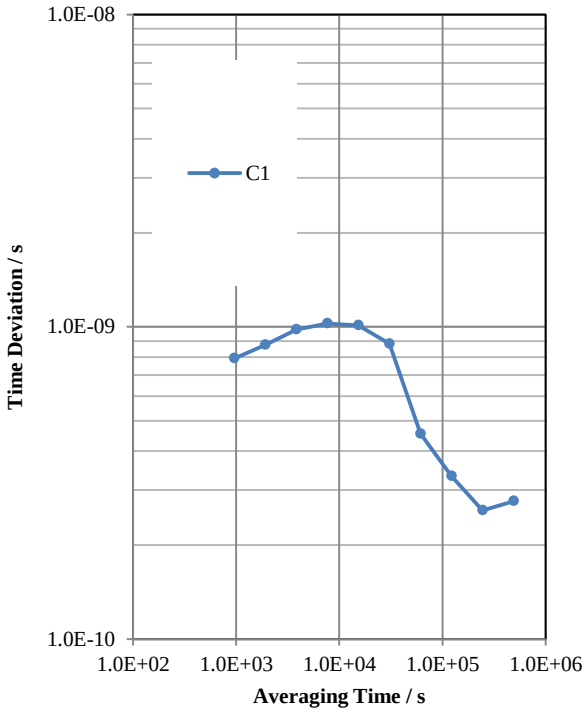
Rise time of the local UTC pulse:	6 ns
Is the laboratory air conditioned?	Yes

Set temperature value and uncertainty:	23 ± 2 ℃
Set humidity value and uncertainty:	50 ± 15 %RH

Diagram of the experiment set-up




-10
-12
-14
-16
-18
-20
-22
-24
RAWDIF / ns
C1, median = -12.86 ns
57792
57797
57802
57807
57812
57817
57822
MJD


1.0E-08
1.0E-09
1.0E-10
Time Deviation / s
C1
1.0E+02
1.0E+03
1.0E+04
1.0E+05
1.0E+06
Averaging Time / s


MTTO
TRVL

Information sheets (to be repeated for each calibrated system)

Laboratory:	National Metrology Institute of Malaysia (NMIM)
Date and hour of the beginning of measurements:	31 March 2017 (MJD 57843) / 00:00 UTC
Date and hour of the end of measurements:	10 April 2017 (MJD 57853) / 23:59 UTC

Information on the system

	Local:	Travelling:
4-character BIPM code	LSM1	TRVL
Receiver maker and type: Receiver serial number:	NMIA Topcon Javad Euro-80 JAVAD-01/CSIRO2001	NMIA Topcon/Javad Euro-80
1 PPS trigger level /V:	0.5 V	0.5 V
Antenna cable maker and type: Phase stabilized cable (Y/N):	Rojone Pty Ltd, PH 02 9829 1555 LOT 2001/06	LMR-400
Length outside the building /m:	~ 30 m	~ 40 m
Antenna maker and type: Antenna serial number:	Topcon Javad Choke Ring 00147	Hemisphere A45 A452401000003
Temperature (if stabilised) /°C		

Measured delays /ns if needed fill box “Additional Information” further below)

	Local:	Travelling:
Delay from local UTC to receiver 1 PPS-in:	10.85 ns	0.0 ns
from 1 PPS-in to internal reference (if different)		
Antenna cable delay:	155.4 ns	0.0 ns
Splitter delay (if any):		
Additional cable delay (if any):		

Data used for the generation of CGGTTS files

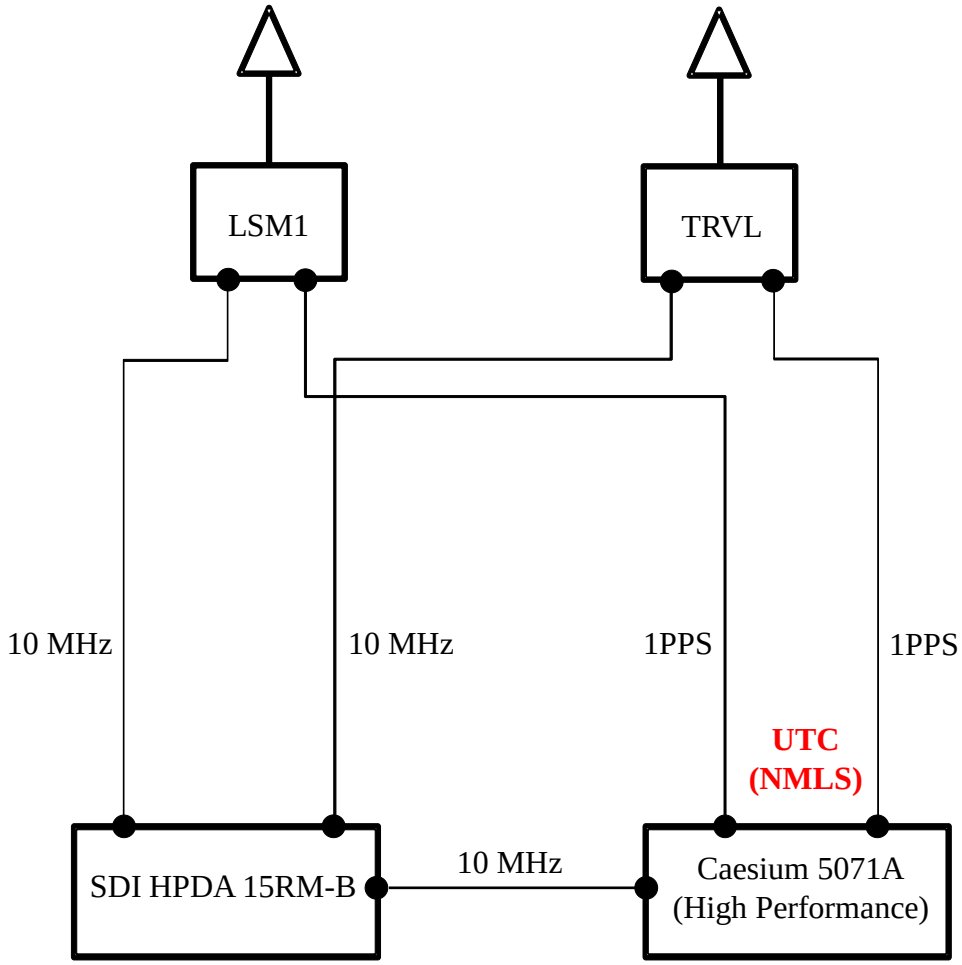
INT DLY (GPS) /ns:	C1: 19.4
INT DLY (GLONASS) /ns:	
CAB DLY /ns:	10.85
REF DLY /ns:	155.4
Coordinates reference frame:	
Latitude or X /m:	- 1295535.614
Longitude or Y /m:	+ 6237440.812
Height or Z /m:	+ 310809.199

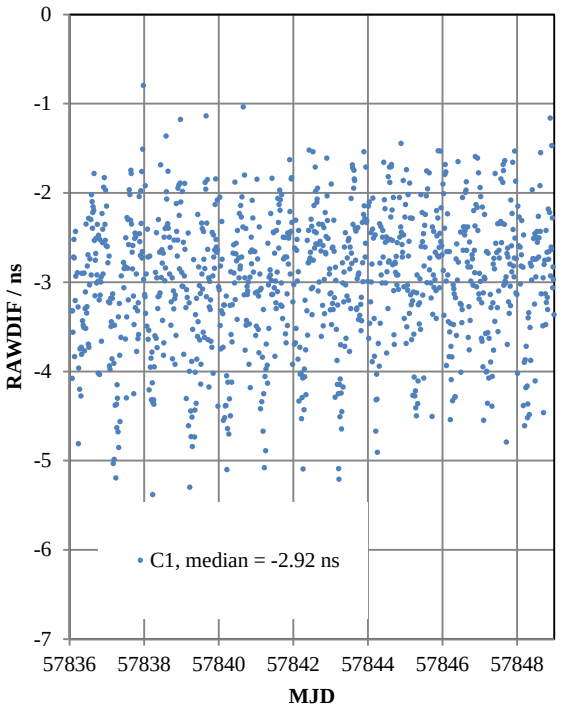
General information

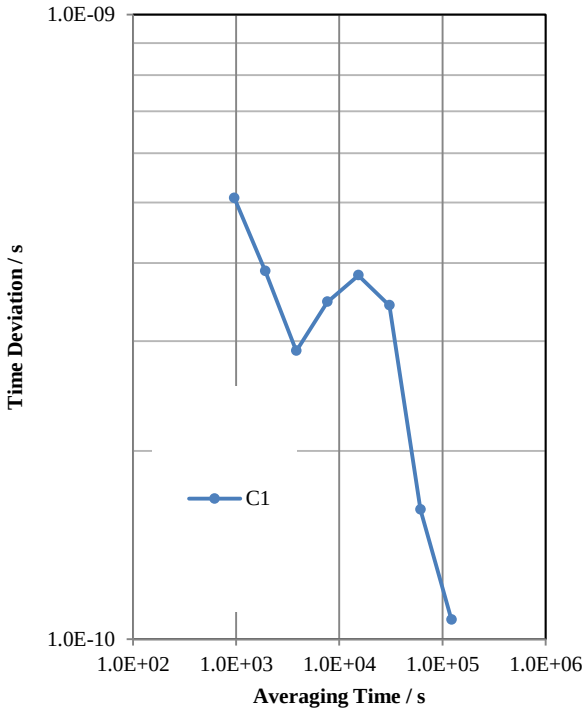
Rise time of the local UTC pulse:	5 ns
Is the laboratory air conditioned?	Yes
Set temperature value and uncertainty:	(24.5 ± 1.5)° C

Set humidity value and uncertainty:	(57.5 ± 8.5) % RH

Diagram of the experiment set-up




0
-1
-2
-3
-4
-5
-6
-7
RAWDIF / ns
C1, median = -2.92 ns
57836
57838
57840
57842
57844
57846
57848
MJD


1.0E-09
1.0E-10
Time Deviation / s
C1
1.0E+02
1.0E+03
1.0E+04
1.0E+05
1.0E+06
Averaging Time / s


TRVL
LSM1
LS2P

Information sheets (to be repeated for each calibrated system)

Laboratory:	National Metrology Institute of Malaysia (NMIM)
Date and hour of the beginning of measurements:	31 March 2017 (MJD 57843) / 00:00 UTC
Date and hour of the end of measurements:	10 April 2017 (MJD 57853) / 23:59 UTC

Information on the system

	Local:	Travelling:
4-character BIPM code	LS2P	TRVL
Receiver maker and type: Receiver serial number:	Septentrio PolaRx2eTR (firmware ver. 3.2.2) 3345	NMIA Topcon/Javad Euro-80
1 PPS trigger level /V:		0.5 V
Antenna cable maker and type: Phase stabilized cable (Y/N):	Belden-8219	LMR-400
Length outside the building /m:	~ 30 m	~ 40 m
Antenna maker and type: Antenna serial number:	Leica Geosystem AG 200355	Hemisphere A45 A452401000003
Temperature (if stabilised) /°C		

Measured delays /ns if needed fill box “Additional Information” further below)

	Local:	Travelling:
Delay from local UTC to receiver 1 PPS-in:	26.90 ± 0.26 ns	0.0 ns
from 1 PPS-in to internal reference (if different)	223.5 + 8.7 ± 0.2 ns *	
Antenna cable delay:	157.53 ns	0.0 ns
Splitter delay (if any):		
Additional cable delay (if any):		

* According to the Annex 1 in “BIPM guidelines for GNSS calibration”, the delay between the internal measurement latching and the 1 PPS output connector for receiver firmware 3.2.2 is –8.7 ns.

Data used for the generation of CGGTTS files

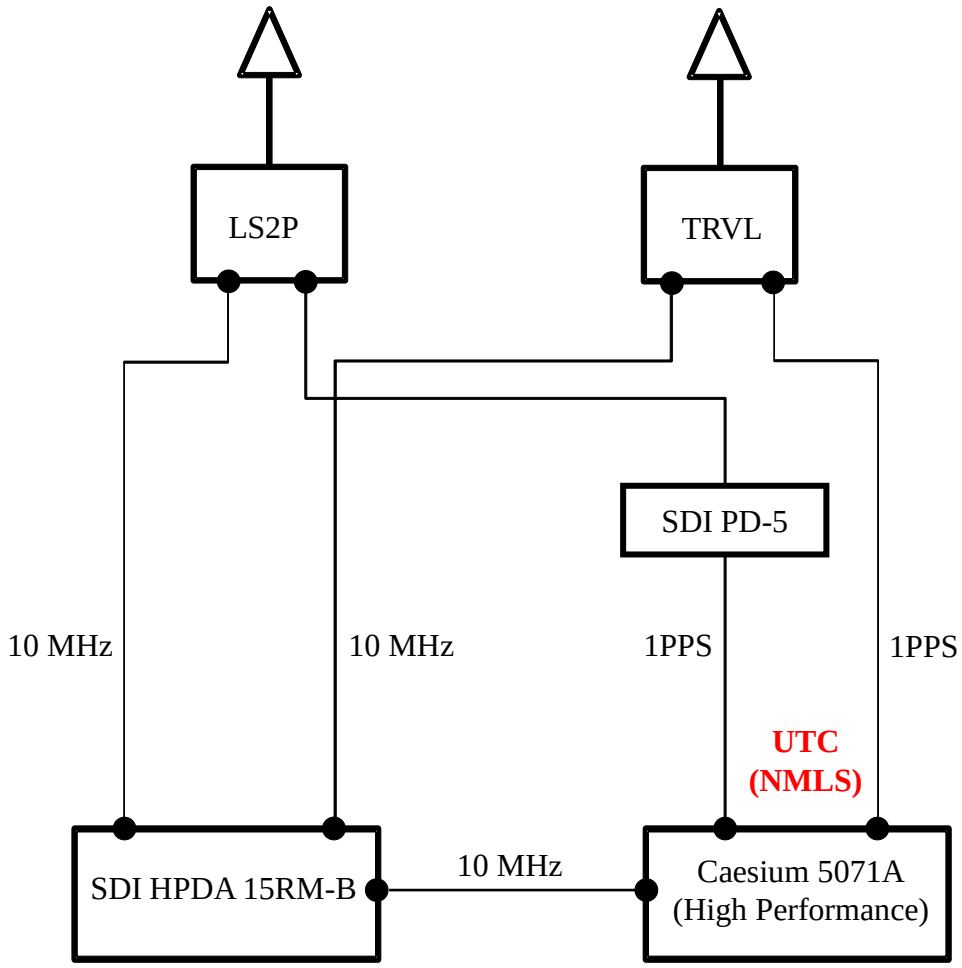
INT DLY (GPS) /ns:	C1: 0.0, P1: 0.0, P2: 0.0
INT DLY (GLONASS) /ns:	
CAB DLY /ns:	157.53
REF DLY /ns:	259.1
Coordinates reference frame:	
Latitude or X /m:	-1295538.5281
Longitude or Y /m:	+6237440.1403
Height or Z /m:	+310809.1973

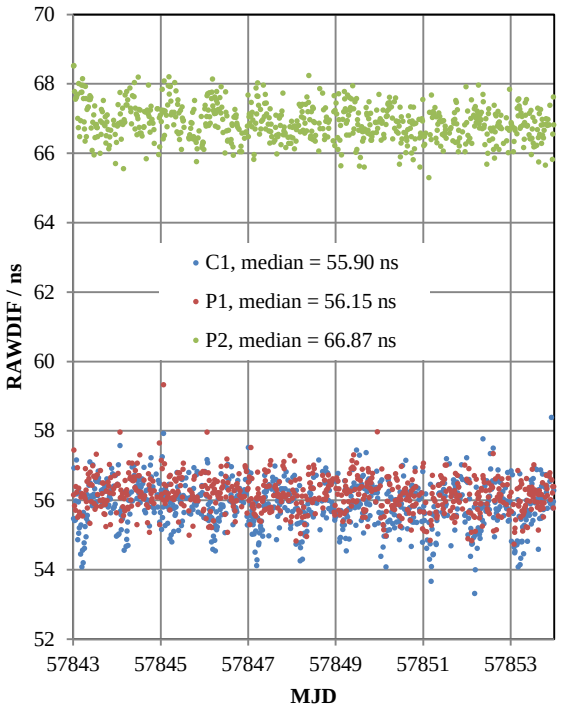
General information

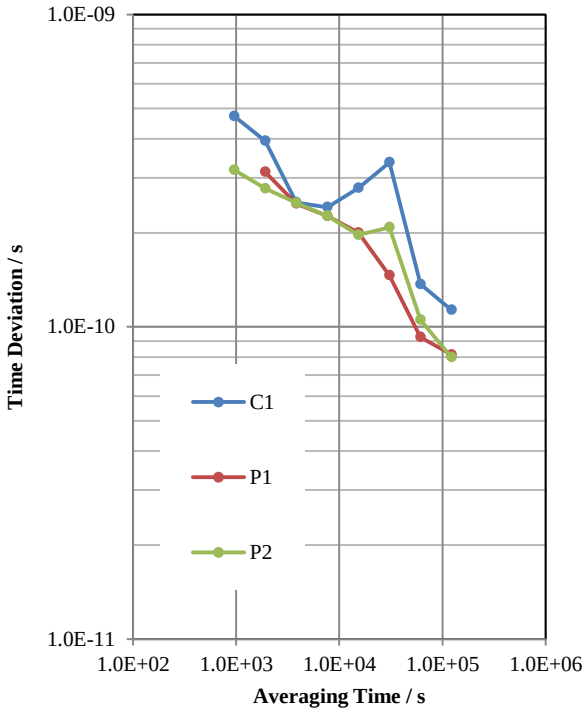
Rise time of the local UTC pulse:	5 ns
Is the laboratory air conditioned?	Yes

Set temperature value and uncertainty:	(24.5 ± 1.5)° C
Set humidity value and uncertainty:	(57.5 ± 8.5) % RH

Diagram of the experiment set-up




70
68
66
64
62
60
58
56
54
52
RAWDIF / ns
C1, median = 55.90 ns
P1, median = 56.15 ns
P2, median = 66.87 ns
57843
57845
57847
57849
57851
57853
MJD


1.0E-09
1.0E-10
1.0E-11
Time Deviation / s
C1
P1
P2
1.0E+02
1.0E+03
1.0E+04
1.0E+05
1.0E+06
Averaging Time / s


TRVL
LSM1
LS2P

VMI Information sheets

Laboratory:	VMI
Date and hour of the beginning of measurements:	April. 25, 2017 (MJD 57868) 0 h UTC
Date and hour of the end of measurements:	May. 7, 2017 (MJD 57881) 23 h UTC

Information on the system

	Local:	Travelling:
4-character BIPM code	VM__	TRVL
Receiver maker and type: Receiver serial number:	NMIA Topcon/Javad Euro-80 0409088	NMIA Topcon/Javad Euro-80
1 PPS trigger level /V:	0.5 V	0.5 V
Antenna cable maker and type: Phase stabilized cable (Y/N):		LMR-400
Length outside the building /m:	~ 40 m	~ 40 m
Antenna maker and type: Antenna serial number:	Javad L1/L2 3699	Hemisphere A45 A452401000003
Temperature (if stabilised) /°C		

Measured delays /ns if needed fill box “Additional Information” further below)

	Local:	Travelling:
Delay from local UTC to receiver 1 PPS-in:	33.9 ns	19.0 ns
from 1 PPS-in to internal reference (if different)		
Antenna cable delay:	256.8 ns	0.0 ns
Splitter delay (if any):		
Additional cable delay (if any):		

Data used for the generation of CGGTTS files

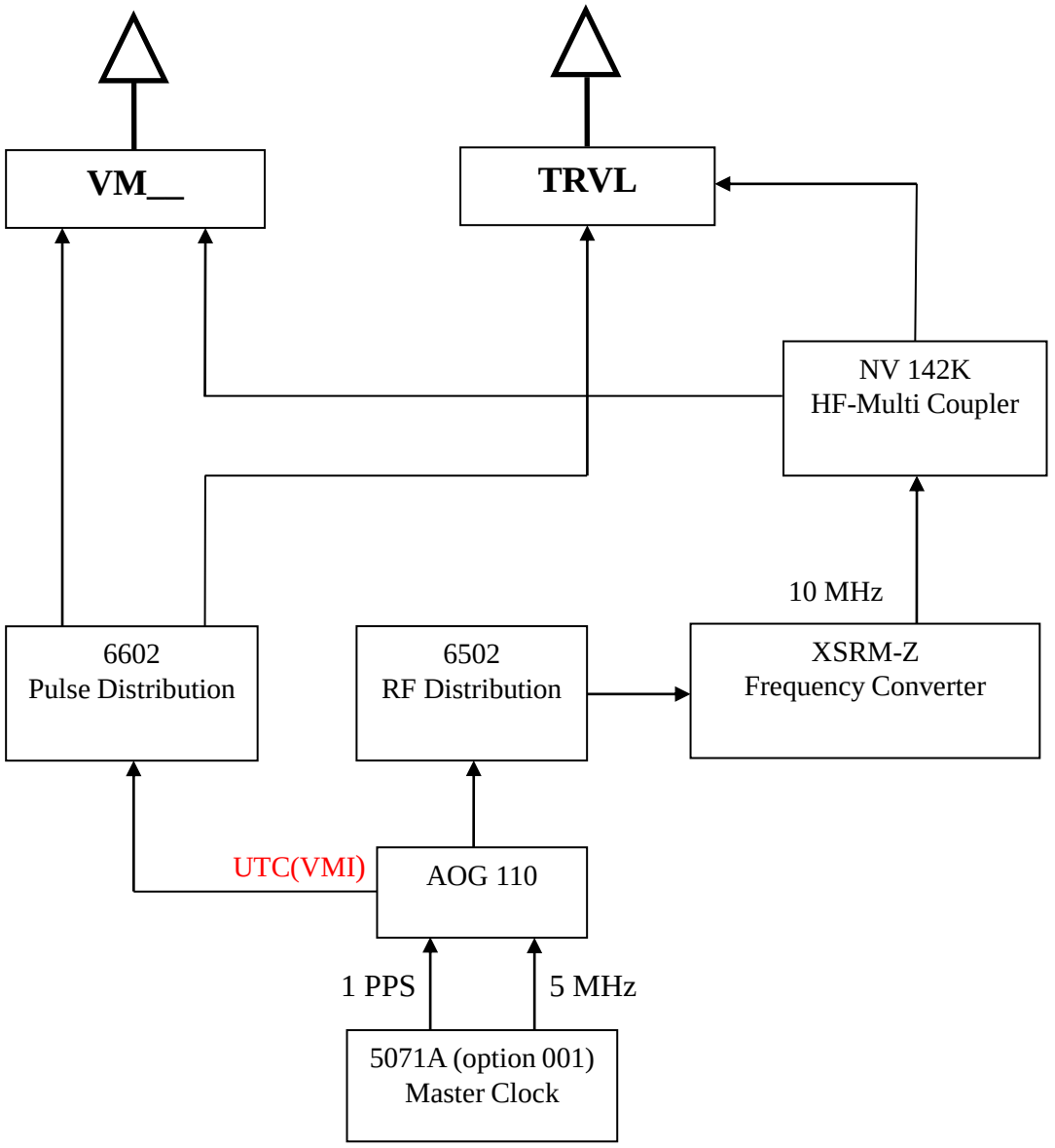
INT DLY (GPS) /ns:	C1: 41.9
INT DLY (GLONASS) /ns:	
CAB DLY /ns:	256.8
REF DLY /ns:	33.9
Coordinates reference frame:	
Latitude or X /m:	-1621749.664 m
Longitude or Y /m:	+5730124.407 m
Height or Z /m:	+2276255.083 m

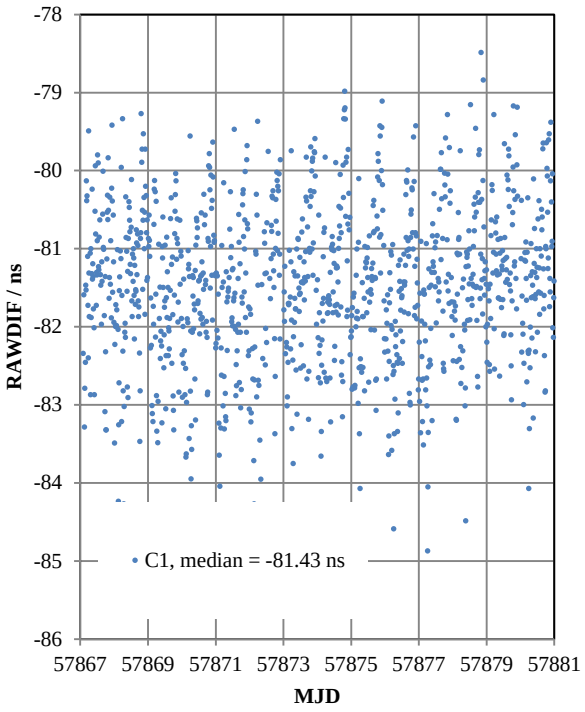
General information

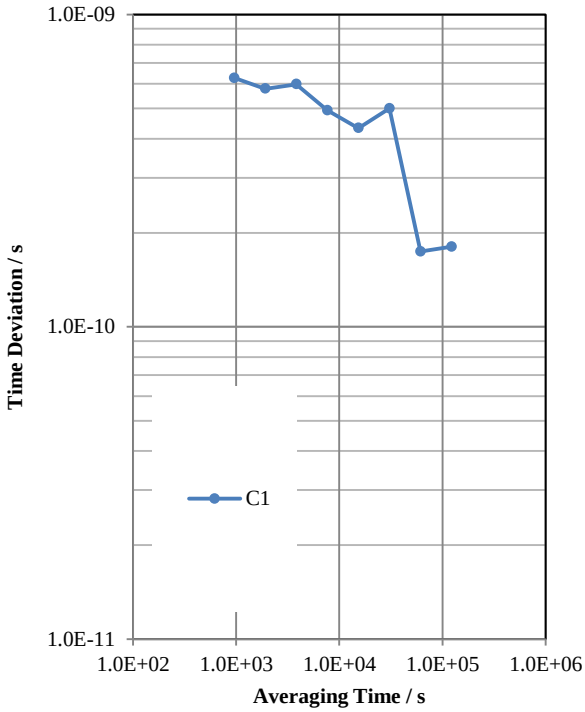
Rise time of the local UTC pulse:	2 ns
Is the laboratory air conditioned?	Yes

Set temperature value and uncertainty:	(23± 3) °C
Set humidity value and uncertainty:	<60 %RH

Diagram of the experiment set-up




-78
-79
-80
-81
-82
-83
-84
-85
-86
RAWDIF / ns
C1, median = -81.43 ns
57867 57869 57871 57873 57875 57877 57879 57881
MJD


1.0E-09
1.0E-10
1.0E-11
Time Deviation / s
C1
1.0E+02 1.0E+03 1.0E+04 1.0E+05 1.0E+06
Averaging Time / s


VN3P
TRVL
VM__

VMI Information sheets

Laboratory:	VMI
Date and hour of the beginning of measurements:	April. 25, 2017 (MJD 57868) 0 h UTC
Date and hour of the end of measurements:	May. 7, 2017 (MJD 57881) 23 h UTC

Information on the system

	Local:	Travelling:
4-character BIPM code	VN3P	TRVL
Receiver maker and type: Receiver serial number:	Septentrio PolaRx3eTR 2001088	NMIA Topcon/Javad Euro-80
1 PPS trigger level /V:		0.5 V
Antenna cable maker and type: Phase stabilized cable (Y/N):	Belden, Inc. MRG213 MIL-C-17 10/08	LMR-400
Length outside the building /m:	~ 25 m	~ 40 m
Antenna maker and type: Antenna serial number:	PolaNt_G 5025	Hemisphere A45 A452401000003
Temperature (if stabilised) /°C		

Measured delays /ns if needed fill box “Additional Information” further below)

	Local:	Travelling:
Delay from local UTC to receiver 1 PPS-in:	32.8 ns	19.0 ns
from 1 PPS-in to internal reference (if different)	211.14 ns	
Antenna cable delay:	124.3 ns	0.0 ns
Splitter delay (if any):		
Additional cable delay (if any):		

Data used for the generation of CGGTTS files

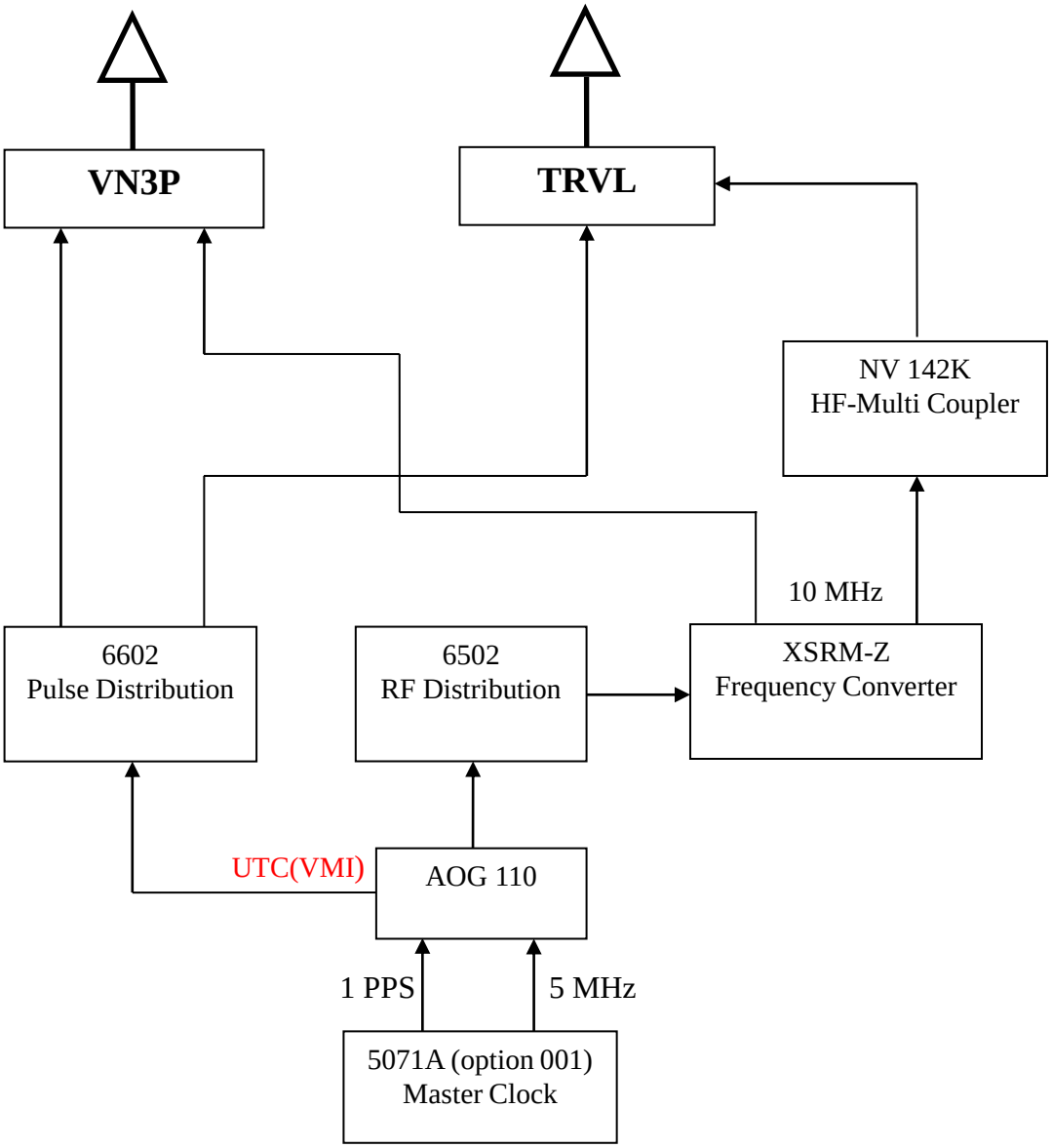
INT DLY (GPS) /ns:	C1: 0.0, P1: 0.0, P2: 0.0
INT DLY (GLONASS) /ns:	
CAB DLY /ns:	124.3
REF DLY /ns:	243.94
Coordinates reference frame:	
Latitude or X /m:	-1621745.9813
Longitude or Y /m:	+5730123.5317
Height or Z /m:	+2276254.1556

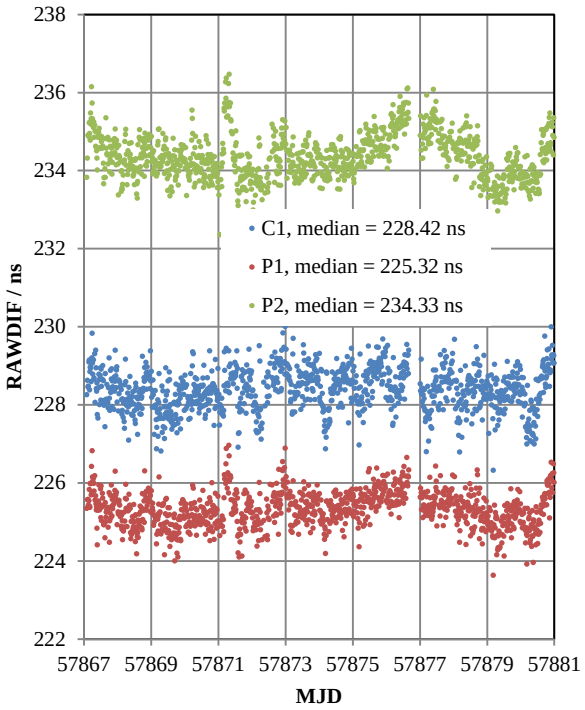
General information

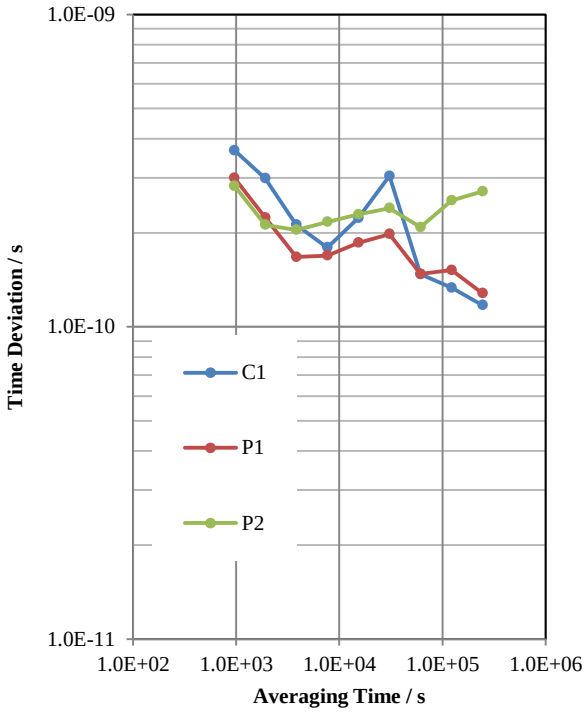
Rise time of the local UTC pulse:	2 ns
Is the laboratory air conditioned?	Yes

Set temperature value and uncertainty:	(23± 3) °C
Set humidity value and uncertainty:	<60 %RH

Diagram of the experiment set-up




238
236
234
232
230
228
226
224
222
RAWDIF / ns
C1, median = 228.42 ns
P1, median = 225.32 ns
P2, median = 234.33 ns
57867 57869 57871 57873 57875 57877 57879 57881
MJD


1.0E-09
1.0E-10
1.0E-11
Time Deviation / s
C1
P1
P2
1.0E+02 1.0E+03 1.0E+04 1.0E+05 1.0E+06
Averaging Time / s


VN3P
TRVL
VM__

Annex 2. Contact Information

NMI	Contact information
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