



Chunghwa Telecom Laboratories

2025 Group 2 GNSS Calibration Report

Cal_ID: 1016-2025

**National Standard Time and Frequency Lab
Telecommunication Laboratories, Chunghwa Telecom Co., Ltd.**

Calvin Shinn-Yan Lin and Wen-Hung Tseng

sylin@cht.com.tw

19/01/2026 Version 1 (new)

Summary

As one of the APMP G1 laboratories, TL conducted a relative calibration of the GNSS time transfer receivers of NIMT (National Institute of Metrology (Thailand), which acronym in BIPM list is NIMT), with respect to the calibrated TL receiver TLT5 which setup configuration is kept unchanged since 2022. The signal delays of TLT5 for GPS, Galileo, and Beidou were calibrated by BIPM as reported with CAL_ID 1001-2022 [1]. The receiver system TLM2 of TL was used as traveling equipment to transfer the signal delays of TLT5 to the visited GNSS receivers MTTI, MTTN, MTME, MT01, and MT02 of NIMT. The data were collected between [MJD 60976-61013 \(28th October 2025 – 4th December 2025\)](#) by simultaneous operation of pairs of co-located GNSS receivers. This campaign was declared to BIPM on 25th October 2025 and followed as closely as possible the BIPM Guideline [2]. The results provided are the visited receivers' internal delays for GPS C1, P1, and P2 signals, Galileo E1 and E5a signals, and Beidou BC, B5 signals. The results will be reported using Cal_ID 1016-2025.

1. Table of contents

List of Acronyms.....	3
1. Description of equipment and operations	4
1.1 Traveling System	4
1.2 Visited Receivers.....	4
2. Data Used.....	5
3. Results of Raw Data Processing	5
4. Calibration results	5
4.1 Traveling System with Respect to The Reference System	6
4.2 Traveling System with Respect to the Visited Systems	7
4.3 Visited Systems with Respect to Reference System	8
4.4 Uncertainty.....	9
5. Final results for the visited systems.....	14
Acknowledgements	16
Annex A: Information sheets	17
A.1 Information sheet of TLM2.....	17
A.2 Information sheet of NIMT.....	18
Annex B: Plots of raw data and Tdev analysis	36
B.1 reference vs. traveling	36
B.2 traveling vs. visited, MTTI.....	37
B.3 traveling vs. visited, MTME	39
B.4 traveling vs. visited, MTTN	40
B.5 traveling vs. visited, MT01	42
B.6 traveling vs. visited, MT02	43
B.3 reference vs. traveling, closure.....	45
Reference	46

List of Acronyms

BIPM	Bureau International des Poids et Mesures, Sèvres, France
CGGTTS	CCTF Generic GNSS Time Transfer Standard
APMP	The Asia Pacific Metrology Programme
IGS	International GNSS Service
PikTime	PikTime Systems, the manufacturer of TTS-5 GNSS receiver
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GAL	Galileo satellite navigation system
BDS	Beidou satellite navigation system
PPP	Precise Point Positioning
TL	Telecommunication Laboratories, Chunghwa Telecom, Taiwan
TLT5	TL G1 Reference receiver
TLM2	TL travelling receiver
NIMT	National Institute of Metrology, Thailand
UTC(NIMT)	The standard time scale of NIMT
MTTI	Visited receiver of NIMT
MTTN	Visited receiver of NIMT
MTME	Visited receiver of NIMT
MT01	Visited receiver of NIMT
MT01	Visited receiver of NIMT
RINEX	Receiver Independent Exchange Format
R2CGGTTS	RINEX-to CGGTTS conversion software, provided by ORB/BIPM
DCLRINEX	differential calibration software using the pseudoranges directly read in the RINEX files, provided by the BIPM
TDEV	Time Deviation
TIC	Time Interval Counter
CABDLY	the antenna cable delay;
INTDLY	the internal signal delay (antenna + receiver internal);
REFDLY	the offset between the UTC reference point in the laboratory and the reference point of the visited receiver
SYSDLY	INTDLY + CABDLY
TOTDLY	SYSDLY – REFDLY
CLPDLY	the offset between the calibration point of the laboratory and the reference point of the traveling receiver

1. Description of equipment and operations

1.1 Traveling System

The TL Traveling System consists of a GNSS receiver TLM2 (Septentrio PolaRx5TR, which auto compensation mode was set to “ON” during all calibration trip), an antenna (PolaNt-x MF.v2), 50 meters CFD-200 antenna cable, a laptop, and two auxiliary cables (RG-316 and RG-58 with BNC connectors) to connect the calibration reference point and 10 MHz frequency reference of visited lab. The detailed information can be found in Annex A.1, TLM2 information sheet.

The 1 PPS reference cable of traveling receiver was connected to the calibration point in the visited laboratory NIMT, the CLPDLY is 2.4 ns measured by NIMT in this campaign.

1.2 Visited Receivers

There were 5 GNSS receivers of NIMT which would be calibrated in this campaign. MTTI and MTME are Mesit GTR-55 receiver and were calibrated by TL at 2022 (CAL_ID 1016-2022); the other 3 receiver MTTN, MT02, and MT01 all are Septentrio PolaRx5 TR receiver and their compensation mode were all set to “ON”. We would calibrate their GPS P3, Galileo E3, and Beidou C3 links this time. Detailed information can be found in their information sheets in Annex A.2 Information sheet of MTTI, MTME, MTTN, MT01, and MT02.

Table 1. Summary information on the calibration trip

Institute	Status of equipment	Dates of measurement	Receiver type	BIPM code	RINEX name
TL	Traveling	60976-60990	Septentrio PolaRx5 TR	TLM2	TLM2
TL	Group 1 reference	-	Septentrio PolaRx5 TR	TLT5	TLT5
NIMT	Group 2	60999-61004	Mesit GTR-55	MTTI	MTTI
NIMT	Group 2	60999-61004	Mesit GTR-55	MTME	MTME
NIMT	Group 2	60999-61004	Septentrio PolaRx5 TR	MTTN	MTTN
NIMT	Group 2	60999-61004	Septentrio PolaRx5 TR	MT01	MT01
NIMT	Group 2	60999-61004	Septentrio PolaRx5 TR	MT02	MT02
TL	Traveling	61009-61013	Septentrio PolaRx5 TR	TLM2	TLM2
TL	Group 1 reference	-	Septentrio PolaRx5 TR	TLT5	TLT5

2. Data Used

Since the reference, traveling, and visited receivers are all GNSS geodetic receivers and provide RINEX files, we use their pseudoranges directly read in their RINEX files by the software ‘dclrinex’ which provided by BIPM [5] dedicated to differential calibration.

3. Results of Raw Data Processing

The raw code differences of the pairs of co-located receivers during the data acquisition period, MJD column in Table 2, are generated by dclrinex. The inferred raw calibration results are taken as the median of the raw differences. The associated uncertainties are taken as the floor of their Tdev values (see Annex B). The values for INTDLY between a given pair of receivers are computed using Eq. (7) and given in Table 7.1, 7.2, and 7.2.

Table 2. Summary information on the raw calibration results (all values in ns)

Pair	Date	C1	Unc	P1	Unc	P2	Unc	E1	Unc	E5a	Unc	BC	Unc	B5	Unc
TLT5-TLM2	60976-60990	23.37	0.02	23.42	0.02	21.62	0.04	23.39	0.05	21.31	0.04	23.40	0.09	21.27	0.08
TLM2-MTTI	60999-61004	-20.77	0.12	-22.10	0.10	-19.81	0.19	-20.59	0.11	-21.07	0.14	-19.98	0.25	-20.73	0.19
TLM2-MTME	60999-61004	-22.80	0.03	-21.97	0.04	-17.51	0.12	-23.30	0.10	-18.92	0.14	-22.48	0.09	-18.58	0.10
TLM2-MTTN	60999-61004	-60.79	0.04	-60.93	0.05	-57.66	0.02	-60.82	0.03	-60.42	0.06	-60.93	0.08	-60.42	0.02
TLM2-MT01	60999-61004	-40.03	0.07	-39.83	0.02	-36.45	0.04	-39.97	0.06	-39.84	0.05	-40.25	0.04	-39.82	0.08
TLM2-MT02	60999-61004	-39.87	0.08	-39.94	0.06	-36.74	0.07	-39.96	0.11	-39.83	0.03	-40.06	0.03	-39.83	0.09
TLT5-TLM2	61009-61013	22.46	0.19	22.56	0.06	20.69	0.04	22.48	0.20	20.38	0.06	22.46	0.25	20.34	0.07

4. Calibration results

From the definition, the raw calibration results of a pair of receivers are equal to their TOTDLY difference:

$$\text{TOTDLY}_{R(\text{code})} - \text{TOTDLY}_{T, TL(\text{code})} = \text{RAWDIF}_{R-T}(\text{code}) \quad (1)$$

Where the $\text{TOTDLY}_{R(\text{code})}$ and $\text{TOTDLY}_{T, TL(\text{code})}$ are the TOTDLY of reference receiver and traveling receiver at TL respectively; the $\text{RAWDIF}_{R-T}(\text{code})$ is the raw calibration result of the reference and traveling pair read from Table 2. The code can be GPS C1/P1/P2, GAL E1/E5a, and BDS BC/B5.

We note the calibration reference point of traveling receiver and UTC reference point of visited UTC lab may not be identical. For traveling receiver, its TOTDLY in reference and visited lab may be different, here we denote the TOTDLY of traveling receiver in reference lab TL to be $\text{TOTDLY}_{T, TL}(\text{code})$ and $\text{TOTDLY}_{T, NIMT}(\text{code})$ in visited

lab.

The TOTDLY can be also expressed using SYSDLY and REFDLY; and the REFDLY is equal to the CLPDLY plus the offset between the UTC reference point and calibration reference point in the lab:

$$REFDLY_{T, TL}(\text{code}) = CLPDLY_T(\text{code}) + \Delta\text{Ref_Clb}_{TL} \quad .(2)$$

Where the $\Delta\text{Ref_Clb}$ is the offset between the UTC reference point and calibration reference point in the laboratory, the value of $\Delta\text{Ref_Clb}_{TL}$ and $\Delta\text{Ref_Clb}_{NIMT}$ may be different, but the value $CLPDLY_T(\text{code})$ are all the same in the whole campaign because we use the same reference 1 PPS cable for the traveling receiver in this trip. We have:

$$\begin{aligned} \text{TOTDLY}_{T, TL}(\text{code}) &= \text{SYSDLY}_{T, TL}(\text{code}) - \text{REFDLY}_{T, TL}(\text{code}) \\ &= \text{SYSDLY}_{T, TL}(\text{code}) - [\text{CLPDLY}_T(\text{code}) + \Delta\text{Ref_Clb}_{TL}] \quad .(3) \end{aligned}$$

4.1 Traveling System with Respect to The Reference System

From Eq. (1), (2), and (3), the $\text{RAWDIF}_{R-T}(\text{code})$ can be express by

$$\begin{aligned} \text{RAWDIF}_{R-T}(\text{code}) &= [\text{SYSDLY}_R(\text{code}) - \text{REFDLY}_R(\text{code})] \\ &\quad - [\text{SYSDLY}_T(\text{code}) - \text{CLPDLY}_T(\text{code}) - \Delta\text{Ref_Clb}_{TL}] \quad \dots\dots (4) \end{aligned}$$

Table 3.1 Traveling vs. Reference system (GPS, all values in ns)

Pair	Date	C1	P1	P2	P1-P2
		RawDIF	RawDIF	RawDIF	RawDIF
TLT5-TLM2	60976-60990	23.37	23.42	21.62	1.80
TLT5-TLM2	61009-61013	22.46	22.56	20.69	1.88
Misclosure	-	-0.91	-0.86	-0.93	0.07
Mean	-	22.91	22.99	21.15	1.84

Table 3.2 Traveling vs. Reference system (Galileo, all values in ns)

Pair	Date	E1	E5a	E1-E5a
		RawDIF	RawDIF	RawDIF
TLT5-TLM2	60976-60990	23.39	21.31	2.08
TLT5-TLM2	61009-61013	22.48	20.38	2.10
Misclosure	-	-0.91	-0.93	0.01
Mean	-	22.94	20.85	2.09

Table 3.3 Traveling vs. Reference system (Beidou, all values in ns)

Pair	Date	BC	B5	BC-B5
		RawDIF	RawDIF	RawDIF
TLT5-TLM2	60976-60990	23.40	21.27	2.12
TLT5-TLM2	61009-61013	22.46	20.34	2.11
Misclosure	-	-0.94	-0.93	-0.01
Mean	-	22.93	20.81	2.12

Table 3.1, 3.2, and 3.2 are the raw difference values of traveling vs. reference receiver. We don't need to measure the REF DLY of the traveling and reference receivers because they will be cancelled out against each other in the derivation of INTDLY.

4.2 Traveling System with Respect to the Visited Systems

Like Eq. (4), the raw difference of traveling receiver at visited lab (NIMT) can be expressed:

$$\begin{aligned}
 \text{RAW DIF}_{T,V}(\text{code}) = & \\
 & [\text{SYSDLY}_T(\text{code}) - \text{CLPDLY}_T(\text{code}) - \Delta\text{Ref_Clb}_{\text{NIMT}}] \\
 & - [\text{SYSDLY}_V(\text{code}) - \text{REFDLY}_V(\text{code})] \quad \dots\dots\dots (5)
 \end{aligned}$$

The $\Delta\text{Ref_Clb}_{\text{NIMT}}$ is the offset from UTC(NIMT) reference point to the calibration reference point of NIMT.

Table 4.1 Traveling with respect to the visited system (GPS, all values in ns)

Pair	Date	$\Delta\text{Ref_Clb}_{\text{NIMT}}$	REFDLY _v	C1	P1	P2
				RawDIF	RawDIF	RawDIF
TLM2-MTTI	60999-61004	2.40	23.90	-20.77	-22.10	-19.81
TLM2-MTME	60999-61004	2.40	24.60	-22.80	-21.97	-17.51
TLM2-MTTN	60999-61004	2.40	35.20	-60.79	-60.93	-57.66
TLM2-MT01	60999-61004	2.40	29.40	-40.03	-39.83	-36.45
TLM2-MT02	60999-61004	2.40	29.40	-39.87	-39.94	-36.74

Table 4.2 Traveling with respect to the visited system (Galileo, all values in ns)

Pair	Date	$\Delta\text{Ref_Clb}_{\text{NIMT}}$	REFDLY _v	E1	E5a
				RawDIF	RawDIF
TLM2-MTTI	60999-61004	2.40	23.90	-20.59	-21.07
TLM2-MTME	60999-61004	2.40	24.60	-23.30	-18.92
TLM2-MTTN	60999-61004	2.40	35.20	-60.82	-60.42
TLM2-MT01	60999-61004	2.40	29.40	-39.97	-39.84

TLM2-MT02	60999-61004	2.40	29.40	-39.96	-39.83
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Table 4.3 Traveling with respect to the visited system (Beidou, all values in ns)

Pair	Date	$\Delta\text{Ref_Clb}_{\text{NIMT}}$	REFDLY _v	BC	B5
				RawDIF	RawDIF
TLM2-MTTI	60999-61004	2.40	23.90	-19.98	-20.73
TLM2-MTME	60999-61004	2.40	24.60	-22.48	-18.58
TLM2-MTTN	60999-61004	2.40	35.20	-60.93	-60.42
TLM2-MT01	60999-61004	2.40	29.40	-40.25	-39.82
TLM2-MT02	60999-61004	2.40	29.40	-40.06	-39.83

4.3 Visited Systems with Respect to Reference System

Combine Eq. (4) and (5), we get:

$$\text{RAWDIF}(\text{code})_{\text{R-T}} + \text{RAWDIF}(\text{code})_{\text{T-V}}$$

$$= [\text{SYSDLY}_{\text{R}}(\text{code}) - \text{REFDLY}_{\text{R}}(\text{code})] - [\text{SYSDLY}_{\text{V}}(\text{code}) - \text{REFDLY}_{\text{V}}(\text{code})]$$

$$+ \Delta\text{Ref_Clb}_{\text{TL}} - \Delta\text{Ref_Clb}_{\text{NIMT}}$$

$$= \text{TOTDLY}_{\text{R}}(\text{code}) - \text{TOTDLY}_{\text{V}}(\text{code}) + \Delta\text{Ref_Clb}_{\text{TL}} - \Delta\text{Ref_Clb}_{\text{NIMT}}$$

$$= \Delta\text{TOTDLY}_{\text{R-V}}(\text{code}) + \Delta\text{Ref_Clb}_{\text{TL}} - \Delta\text{Ref_Clb}_{\text{NIMT}}$$

or

$$\Delta\text{TOTDLY}_{\text{R-V}}(\text{code})$$

$$= \text{RAWDIF}(\text{code})_{\text{R-T}} + \text{RAWDIF}(\text{code})_{\text{T-V}} - \Delta\text{Ref_Clb}_{\text{TL}} + \Delta\text{Ref_Clb}_{\text{NIMT}} \quad \dots\dots (6)$$

In TL, the calibration reference point and the UTC(TL) reference point are identical, that is the $\Delta\text{Ref_Clb}_{\text{TL}} = 0$. The $\Delta\text{Ref_Clb}_{\text{NIMT}} = 2.4 \text{ ns}$ was measured by NIMT. The TOTDLY of traveling with respect to the visited system are listed in Table 5.1, 5.2, and 5.3.

Table 5.1 Visited system with respect to the reference system (GPS, all values in ns)

Pair	Date	$\Delta\text{Ref_Clb}_{\text{NIMT}}$	$\Delta\text{TOTDLY}_{\text{R-V}}$		
			C1	P1	P2
TLT5-MTTI	60999-61004	2.40	4.55	3.29	3.74
TLT5-MTME	60999-61004	2.40	2.51	3.42	6.04
TLT5-MTTN	60999-61004	2.40	-35.47	-35.54	-34.10
TLT5-MT01	60999-61004	2.40	-14.71	-14.44	-12.89
TLT5-MT02	60999-61004	2.40	-14.55	-14.55	-13.19

Table 5.2 Visited system with respect to the reference system (Galileo, all values in ns)

Pair	Date	$\Delta\text{Ref_Clb}_{\text{NIMT}}$	$\Delta\text{TOTDLY}_{\text{R-V}}$
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			E1	E5a
TLT5-MTTI	60999-61004	2.40	4.74	2.17
TLT5-MTME	60999-61004	2.40	2.04	4.32
TLT5-MTTN	60999-61004	2.40	-35.49	-37.17
TLT5-MT01	60999-61004	2.40	-14.64	-16.59
TLT5-MT02	60999-61004	2.40	-14.62	-16.58

Table 5.3 Visited system with respect to the reference system (Beidou, all values in ns)

Pair	Date	$\Delta\text{Ref_Cib}_{\text{NIMT}}$	$\Delta\text{TODLY}_{\text{R-V}}$	
			BC	B5
TLT5-MTTI	60999-61004	2.40	5.35	2.48
TLT5-MTME	60999-61004	2.40	2.85	4.63
TLT5-MTTN	60999-61004	2.40	-35.61	-37.21
TLT5-MT01	60999-61004	2.40	-14.92	-16.61
TLT5-MT02	60999-61004	2.40	-14.73	-16.62

4.4 Uncertainty

In this section, we use the same method as [1] to determine the uncertainty of INTDLY. We estimate all components that can affect accuracy and determine a value u_{CAL} that is to be used as the accuracy of all GPS P3, GAL E3, and GAL B3 links at the epoch of calibration.

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

Where u_a and u_b are the statistical uncertainty the systematic uncertainty respectively.

The statistical uncertainty u_a originates from the Tdev of each pair of RAWDIF listed in Table 2 (graphs can be found in Annex B). 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 u_b is given by

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

Uncertainty values in column P3 are calculated according to $u_{\text{P3}}^2 = u_{\text{P1}}^2 + (1.545 \times u_{\text{P1-P2}})^2$; for the Galileo delays are calculated according to $u_{\text{E3}}^2 = u_{\text{E1}}^2 + (1.261 \times u_{\text{E1-E5a}})^2$, for the Beidou delays are calculated according to $u_{\text{B3}}^2 = u_{\text{BC}}^2 + (1.261 \times u_{\text{BC-B5}})^2$. All possible terms to be considered in the summary are to be listed in Table 6.1 and 6.2. Values appear separately for each code (GPS C1, P1, and P2, GAL E1, and E5a, and BDS BC, and B5) to compute a value u_{CAL} applicable to GPS P3, GAL E3, and BDS B3. We choose to compute u_{CAL} using for u_b the uncertainty $u_{b,\text{TOT}}$ of $\Delta\text{TODLY}_{\text{R-V}}$ from Eq. (6). Table 6.1, 6.2, and 6.3

present all components of the uncertainty budget along with the uncertainty $u_{b,TOT}$ of $\Delta T_{OTDLY_{R-V}}$ from equation (6) and the resulting uncertainty value u_{CAL} . The items in Table 6 are separated into several categories.

- $u_{b,1}$ account for possible variation of the delays of the traveling receiver with respect to the reference receiver during this campaign. This is evaluated by the observed the mis-closure values in Table 3.1 , 3.2, and 3.3.
- $u_{b,11}$ and $u_{b,12}$ account for errors in the antenna coordinates. In general, they are estimated to be 3.0 cm (0.1 ns) because the standard uncertainty of the coordinates obtained with the data used for calibration is typically at or below this level. The $u_{b,13}$ and $u_{b,14}$ account for multipath effect. This is difficult to estimate, and 0.2 ns is conventionally used, following a discussion in the CCTF working group meeting on GNSS in 2017[6].
- $u_{b,21}$ and $u_{b,22}$ account for the measurement between the calibration reference point of the traveling receiver and the local UTC(k). $u_{b,21} = 0$ ns since the calibration reference point is the UTC(k) reference point in TL. $u_{b,22} = 0.5$ ns, it includes at least one measurement measured by NIMT and using **TIC Agilent 53230A**, trigger level 1.0 V.
- $u_{b,31}$ and $u_{b,32}$ account for the measurements between the reference point of the reference station and the local UTC(k). $u_{b,31} = 0.0$ ns since the reference receiver TLT5 did not use REFDLY during calibration and time transfer, its INTDLY is in fact the TOTDLY; $u_{b,32} = 0.5$ ns at the visited site NIMT, it includes the delay measurements from UTC(NIMT) point to the 1 PPS-in of MTTI, MTME, MTTN, MT01, and MT02 measured by NIMT.
- $u_{b,41}$ and $u_{b,42}$ account for the measurement of CABDLY. $u_{b,41} = 0$ ns since the reference receiver TLT5 did not use CABDLY in calibration and time transfer, its INTDLY is in fact the TOTDLY; $u_{b,42} = 0.5$ ns at the visited stations NIMT, it includes at least one measurement measured by PikTime.

Table 6.1 Uncertainty contributions of GPS link, Value $P3 = P1 + 1.545 \times (P1 - P2)$. All values in ns.

Unc.	C1	P1	P2	P1-P2	P3	Description
$u_{a,(T-R)}$	0.19	0.06	0.04	0.07	-	Tdev of RAWDIF of TLT5 vs. TLM2 during MJD 60976-60990 and 61009-61013
$u_{a,MTTI}(T-V)$	0.12	0.10	0.19	0.21	-	Tdev of RAWDIF of TLM2 vs. MTTI
$u_{a,MTME}(T-V)$	0.03	0.04	0.12	0.13		Tdev of RAWDIF of TLM2 vs. MTME
$u_{a,MTTN}(T-V)$	0.04	0.05	0.02	0.05		Tdev of RAWDIF of TLM2 vs. MTTN
$u_{a,MT01}(T-V)$	0.07	0.02	0.04	0.04		Tdev of RAWDIF of TLM2 vs. MT01
$u_{a,MT02}(T-V)$	0.08	0.06	0.07	0.09		Tdev of RAWDIF of TLM2 vs. MT02
$u_{a,MTTI}$	0.22	0.12	0.20	0.23	0.37	
$u_{a,MTME}$	0.19	0.07	0.13	0.15	0.24	
$u_{a,MTTN}$	0.19	0.08	0.05	0.09	0.16	
$u_{a,MT01}$	0.20	0.06	0.06	0.09	0.15	
$u_{a,MT02}$	0.21	0.08	0.08	0.12	0.20	

Misclosure						
$u_{b,1}$	-0.91	-0.86	-0.93	0.07	-	Observed misclosure of TLT5 vs. TLM2
Systematic components related to RAWDIF						
$u_{b,11}$	0.10	0.10	0.10	0.14	-	Position error at TL
$u_{b,12}$	0.10	0.10	0.10	0.14	-	Position error at NIMT
$u_{b,13}$	0.20	0.20	0.20	0.28	-	Multipath effect at TL
$u_{b,14}$	0.20	0.20	0.20	0.28	-	Multipath effect at NIMT
Link of the Traveling system to the local UTC(k) and CABDLY measurements						
$u_{b,21}$	0	0	0	-	-	$\Delta\text{Ref_Clb}_{\text{TL}}$ at TL, calibration point = UTC(TL) point
$u_{b,22}$	0.50	0.50	0.50	-	-	$\Delta\text{Ref_Clb}_{\text{NIMT}}$ at NIMT
$u_{b,\text{TOT}}$	1.08	1.04	1.10	0.45	1.25	Components of equation (6)
$u_{\text{CAL0, MTTI}}$					1.31	Composed of $u_{a, \text{MTTI}}$ and $u_{b, \text{TOT}}$
$u_{\text{CAL0, MTME}}$					1.28	Composed of $u_{a, \text{MTME}}$ and $u_{b, \text{TOT}}$
$u_{\text{CAL0, MTTN}}$					1.26	Composed of $u_{a, \text{MTTN}}$ and $u_{b, \text{TOT}}$
$u_{\text{CAL0, MT01}}$					1.26	Composed of $u_{a, \text{MT01}}$ and $u_{b, \text{TOT}}$
$u_{\text{CAL0, MT02}}$					1.27	Composed of $u_{a, \text{MT02}}$ and $u_{b, \text{TOT}}$
Link of the Reference system to its local UTC(k)						
$u_{b,31}$	0	0	0	-	-	TLT5 did not use REFDLY to calculate P3
Link of the Visited system to its local UTC(k)						
$u_{b,32}$	0.50	0.50	0.50	-	-	REFDLY of MTTI, MTME, MTTN, MT01, MT02, measured by NIMT, added if NIMT can change reference cables
Antenna cable delays						
$u_{b,41}$	0	0	0	-	-	TLT5 did not use CABDLY to calculate P3
$u_{b,42}$	0.50	0.50	0.50	-	-	CABDLY of of MTTI, MTME, MTTN, MT01, MT02, measured by NIMT
$u_{b,\text{INT}}$	1.29	1.26	1.31	0.45	1.44	Components of equation (7)
$u_{\text{CAL0, MTTI}}$					1.49	Composed of $u_{a, \text{MTTI}}$ and $u_{b,\text{INT}}$
$u_{\text{CAL0, MTME}}$					1.46	Composed of $u_{a, \text{MTME}}$ and $u_{b,\text{INT}}$
$u_{\text{CAL0, MTTN}}$					1.45	Composed of $u_{a, \text{MTTN}}$ and $u_{b,\text{INT}}$
$u_{\text{CAL0, MT01}}$					1.45	Composed of $u_{a, \text{MT01}}$ and $u_{b,\text{INT}}$
$u_{\text{CAL0, MT02}}$					1.45	Composed of $u_{a, \text{MT02}}$ and $u_{b,\text{INT}}$

Table 6.2 Uncertainty contributions of GAL link, $E3 = E1 + 1.261 \times (E1 - E5a)$, all values in ns

Unc.	E1	E5a	E1-E5a	E3	Description
$u_a(\text{T-R})$	0.20	0.06	0.21		Tdev of RAWDIF of TLT5 vs. TLM2 during MJD

					60976-60990 and 61009-61013
$u_{a, MTTI} (T-V)$	0.11	0.14	0.18		Tdev of RAWDIF of TLM2 vs. MTTI
$u_{a, MTME} (T-V)$	0.10	0.14	0.17		Tdev of RAWDIF of TLM2 vs. MTME
$u_{a, MTTN} (T-V)$	0.03	0.06	0.07		Tdev of RAWDIF of TLM2 vs. MTTN
$u_{a, MT01} (T-V)$	0.06	0.05	0.08		Tdev of RAWDIF of TLM2 vs. MT01
$u_{a, MT02} (T-V)$	0.11	0.03	0.11		Tdev of RAWDIF of TLM2 vs. MT02
$u_{a, MTTI}$	0.23	0.15	0.27	0.41	
$u_{a, MTME}$	0.22	0.15	0.27	0.41	
$u_{a, MTTN}$	0.20	0.08	0.22	0.34	
$u_{a, MT01}$	0.21	0.08	0.22	0.35	
$u_{a, MT02}$	0.23	0.07	0.24	0.38	
Misclosure					
$u_{b,1}$	-0.91	-0.93	0.01	-	Observed mis-closure of TLT5 vs. TLM2
Systematic components related to RAWDIF					
$u_{b,11}$	0.10	0.10	0.14	-	Position error at TL
$u_{b,12}$	0.10	0.10	0.14	-	Position error at NIMT
$u_{b,13}$	0.20	0.20	0.28	-	Multipath effect at TL
$u_{b,14}$	0.20	0.20	0.28	-	Multipath effect at NIMT
Link of the Traveling system to the local UTC(k)					
$u_{b,21}$	0	0	-	-	ΔRef_Clb_{TL} at TL, calibration point = UTC(TL) point
$u_{b,22}$	0.50	0.50	-	-	ΔRef_Clb_{NIMT} at NIMT
$u_{b,TOT}$	1.09	1.10	0.45	1.23	Components of equation (6)
$u_{CAL0, MTTI}$				1.29	Composed of $u_{a, MTTI}$ and $u_{b, TOT}$
$u_{CAL0, MTME}$				1.29	Composed of $u_{a, MTME}$ and $u_{b, TOT}$
$u_{CAL0, MTTN}$				1.27	Composed of $u_{a, MTTN}$ and $u_{b, TOT}$
$u_{CAL0, MT01}$				1.27	Composed of $u_{a, MT01}$ and $u_{b, TOT}$
$u_{CAL0, MT02}$				1.28	Composed of $u_{a, MT02}$ and $u_{b, TOT}$
Link of the Reference system to its local UTC(k)					
$u_{b,31}$	0	0	-	-	TLT5 did not use REF DLY to calculate E3
Link of the Visited system to its local UTC(k)					
$u_{b,32}$	0.50	0.50	-	-	REF DLY of MTTI, MTME, MTTN, MT01, MT02, measured by NIMT, added if NIMT can change reference cables
Antenna cable delays					
$u_{b,41}$	0	0	-	-	TLT5 did not use CAB DLY to calculate E3
$u_{b,42}$	0.50	0.50	-	-	CAB DLY of MTTI, MTME, MTTN, MT01, MT02, measured by NIMT

$u_{b,INT}$	1.30	1.31	0.45	1.41	Components of equation (7)
$u_{CAL0, MTTI}$				1.47	Composed of $u_{a, MTTI}$ and $u_{b,INT}$
$u_{CAL0, MTME}$				1.47	Composed of $u_{a, MTME}$ and $u_{b,INT}$
$u_{CAL0, MTTN}$				1.46	Composed of $u_{a, MTTN}$ and $u_{b,INT}$
$u_{CAL0, MT01}$				1.46	Composed of $u_{a, MT01}$ and $u_{b,INT}$
$u_{CAL0, MT02}$				1.46	Composed of $u_{a, MT02}$ and $u_{b,INT}$

Table 6.3 Uncertainty contributions of BDS link, $B3 = BC + 1.261 \times (BC - B5)$, all values in ns

Unc.	BC	B5	BC-B5	B3	Description
$u_a(T-R)$	0.25	0.07	0.26		Tdev of RAWDIF of TLT5 vs. TLM2 during MJD 60976-60990 and 61009-61013
$u_{a, MTTI} (T-V)$	0.25	0.19	0.31		Tdev of RAWDIF of TLM2 vs. MTTI
$u_{a, MTME} (T-V)$	0.09	0.10	0.13		Tdev of RAWDIF of TLM2 vs. MTME
$u_{a, MTTN} (T-V)$	0.08	0.02	0.08		Tdev of RAWDIF of TLM2 vs. MTTN
$u_{a, MT01} (T-V)$	0.04	0.08	0.09		Tdev of RAWDIF of TLM2 vs. MT01
$u_{a, MT02} (T-V)$	0.03	0.09	0.09		Tdev of RAWDIF of TLM2 vs. MT02
$u_{a, MTTI}$	0.35	0.21	0.41	0.63	
$u_{a, MTME}$	0.27	0.13	0.29	0.46	
$u_{a, MTTN}$	0.26	0.08	0.28	0.44	
$u_{a, MT01}$	0.25	0.11	0.28	0.43	
$u_{a, MT02}$	0.25	0.12	0.28	0.43	
Misclosure					
$u_{b,1}$	-0.94	-0.93	-0.01	-	Observed mis-closure of TLT5 vs. TLM2
Systematic components related to RAWDIF					
$u_{b,11}$	0.10	0.10	0.14	-	Position error at TL
$u_{b,12}$	0.10	0.10	0.14	-	Position error at NIMT
$u_{b,13}$	0.20	0.20	0.28	-	Multipath effect at TL
$u_{b,14}$	0.20	0.20	0.28	-	Multipath effect at NIMT
Link of the Traveling system to the local UTC(k)					
$u_{b,21}$	0	0	-	-	ΔRef_Clb_{TL} at TL, calibration point = UTC(TL) point
$u_{b,22}$	0.50	0.50	-	-	ΔRef_Clb_{NIMT} at NIMT
$u_{b,TOT}$	1.11	1.10	0.45	1.24	Components of equation (6)
$u_{CAL0, MTTI}$				1.39	Composed of $u_{a, MTTI}$ and $u_{b, TOT}$
$u_{CAL0, MTME}$				1.33	Composed of $u_{a, MTME}$ and $u_{b, TOT}$
$u_{CAL0, MTTN}$				1.32	Composed of $u_{a, MTTN}$ and $u_{b, TOT}$

$u_{CAL0, MT01}$				1.32	Composed of $u_{a, MT01}$ and $u_{b, TOT}$
$u_{CAL0, MT02}$				1.32	Composed of $u_{a, MT02}$ and $u_{b, TOT}$
Link of the Reference system to its local UTC(k)					
$u_{b,31}$	0	0	-	-	TLT5 did not use REFDLY to calculate E3
Link of the Visited system to its local UTC(k)					
$u_{b,32}$	0.50	0.50	-	-	REFDLY of MTTI, MTME, MTTN, MT01, MT02, measured by NIMT, added if NIMT can change reference cables
Antenna cable delays					
$u_{b,41}$	0	0	-	-	TLT5 did not use CABDLY to calculate E3
$u_{b,42}$	0.50	0.50	-	-	CABDLY of of MTTI, MTME, MTTN, MT01, MT02, measured by NIMT
$u_{b,INT}$	1.32	1.31	0.45	1.43	Components of equation (7)
$u_{CAL0, MTTI}$				1.56	Composed of $u_{a, MTTI}$ and $u_{b,INT}$
$u_{CAL0, MTME}$				1.50	Composed of $u_{a, MTME}$ and $u_{b,INT}$
$u_{CAL0, MTTN}$				1.50	Composed of $u_{a, MTTN}$ and $u_{b,INT}$
$u_{CAL0, MT01}$				1.50	Composed of $u_{a, MT01}$ and $u_{b,INT}$
$u_{CAL0, MT02}$				1.50	Composed of $u_{a, MT02}$ and $u_{b,INT}$

5. Final results for the visited systems

The 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. The value INTDLY for each visited station, $INTDLY_V$, can be obtained by using equation (7).

The calibrated INTDLYs of visited lab can be derived:

$$INTDLY_V(\text{code}) = TOTDLY_R(\text{code}) - \Delta TOTDLY_{R-V}(\text{code}) - CABDLY_V(\text{code}) + REFDLY_V(\text{code}) \quad \dots\dots (7)$$

Using the $TOTDLY_R$ values reported in ID 1001-2022 for the Reference system TLT5 and the values $CABDLY_V$, $REFDLY_V$, ΔRef_Clb_{NIMT} from the information sheet (Annex A), **Table 7.1, 7.2, and 7.3** then reports $INTDLY_V$ for all systems visited. The uncertainty value u_{cal} for P3, E3, and B3 is obtained from **Table 6.1, 6.2, and 6.3**. It is used by BIPM to assign the value u_b which will apply to all links to which the system participates.

Table 7.1 Summary of final results of GPS link

Reference System	Cal_Id	Date		INTDLY/ns		
				C1	P1	P2
TLT5	1001-2022	¹ Jan. 07, 2023		206.80	204.50	203.30
Visited stations	Cal_Id	Date	u _{CAL} (P3)/ ns	INTDLY/ns		
				C1	P1	P2
TLT5-MTTI	1016-2025	² 25 Oct, 2025	1.49	11.5	10.4	8.8
TLT5-MTME	1016-2025		1.46	14.4	11.2	7.4
TLT5-MTTN	1016-2025		1.45	26.8	24.5	21.9
TLT5-MT01	1016-2025		1.45	25.4	22.8	20.1
TLT5-MT02	1016-2025		1.45	24.2	21.9	19.3

Table 7.2 Summary of final results of GAL link

Reference System	Cal_Id	Date		INTDLY/ns	
				E1	E5a
TLT5	1001-2022	Jan. 07, 2023		206.80	204.60
Visited stations	Cal_Id	Date	u _{CAL} (E3)/ ns	INTDLY/ns	
				E1	E5a
TLT5-MTTI	1016-2025	25 Oct, 2025	1.47	11.3	11.6
TLT5-MTME	1016-2025		1.47	14.9	10.4
TLT5-MTTN	1016-2025		1.46	26.8	26.3
TLT5-MT01	1016-2025		1.46	25.3	25.1
TLT5-MT02	1016-2025		1.46	24.2	24.0

Table 7.3 Summary of final results of BDS link

Reference System	Cal_Id	Date		INTDLY/ns	
				BC	B5
TLT5	1001-2022	Jan. 07, 2023		206.60	204.00
Visited stations	Cal_Id	Date	u _{CAL} (B3)/ ns	INTDLY/ns	
				BC	B5
TLT5-MTTI	1016-2025	25 Oct, 2025	1.56	10.5	10.7
TLT5-MTME	1016-2025		1.50	13.8	9.5
TLT5-MTTN	1016-2025		1.50	26.7	25.7
TLT5-MT01	1016-2025		1.50	25.4	24.5
TLT5-MT02	1016-2025		1.50	24.1	23.4

¹ The date performed the calibration id 1001-2022² Traveling receiver measurement end date

Acknowledgements

The authors appreciate colleagues in NIMT for their efforts on installation of traveling equipment and data collection.

Annexes

Annex A: Information sheets

A.1 Information sheet of TLM2

Laboratory:	TL	
Date and hour of the beginning of measurements:	2025-10-28 00:00:00 UTC	
Date and hour of the end of measurements:	2025-12-04 23:59:00 UTC	
Information on the system		
	Local:	Travelling:
4-character BIPM code	TLT5	TLM2
● Receiver maker and type: Receiver serial number:	Septentrio PolaRx5TR 3227923	Septentrio PolaRx5TR 4701426
1 PPS trigger level /V:	1 V	1 V
● Antenna cable maker and type: Phase stabilised cable (Y/N):	Andrew FSJ yes	CFD-200 No
Length outside the building /m:	~ 30	~10 (total length 50 m)
● Antenna maker and type:/Serial number:	SEPCHOKE_B3E6 SPKE/5303	PolaNt-x MF.v2/23674
Temperature (if stabilised) /°C	23	23
Measured delays/ns		
	Local:	Travelling:
● Delay from local UTC to receiver 1 PPS-in:		
Delay from 1 PPS-in to internal Reference (if different):		
● Antenna cable delay:	No measurement	No measurement
Splitter delay (if any):	Null	(1)
Additional cable delay (if any):	Null	(1)
Data used for the generation of CGGTTS files		
● INT DLY (GPS) /ns:		
● INT DLY (GAL) /ns:		
● CAB DLY /ns:		
● REF DLY /ns:		
● Coordinates reference frame:	WGS-84	
Latitude or X /m:	-	
Longitude or Y /m:	-	
Height or Z /m:	-	
General information		
● Rise time of the local UTC pulse:	1 ns	
● Is the laboratory air conditioned:	Yes	
Set temperature value and uncertainty:	23 ± 1 °C	
Set humidity value and uncertainty:	No humidity control	

(1) For a trip with closure, it is not needed if the traveling equipment is used in the same set-up throughout.

A.2 Information sheet of NIMT

Laboratory: NIMT		
Date and hour of the beginning of measurements:	20 Nov 2025 UTC 00:00 (MJD 60999)	
Date and hour of the end of measurements:	25 Nov 2025 UTC 23:59 (MJD 61004)	
Information on the system		
	Local:	Travelling:
4-character BIPM code	MTTI	TLM2
• Receiver maker and type:	MESIT/GTR55	Septentrio/PolaRx5TR
Receiver serial number:	2010010	4701426
1 PPS trigger level /V:		
• Antenna cable maker and type:	Belden/H155PE	PEWC/CFD-200
Phase stabilised cable (Y/N):	N	N
Length outside the building /m:	50	50
• Antenna maker and type:	NovAtel/NOV850 NONE	Septentrio/PolaNt-x MF.v2
Antenna serial number:	NMLK20420007H	23674
Temperature (if stabilised) /°C		
Measured delays /ns		
Please tick the correct box depending on the receiver (1)		
	Local:	Travelling:
	REF point is PPSIN <input type="checkbox"/>	REF point is PPSIN <input type="checkbox"/>
• Delay from local UTC to receiver 1 PPS-in (REFDLY):	23.9	2.4
• Optional Delay from local UTC to receiver 1 PPS-Out:		
	REF point is PPSOUT <input type="checkbox"/>	REF point is PPSOUT <input type="checkbox"/>
• Delay from local UTC to receiver 1 PPS-Out (REFDLY):		
• Optional Delay from local UTC to receiver 1 PPS-in:		
	REF point. TTS 4/5 <input type="checkbox"/>	REF point. TTS 4/5 <input type="checkbox"/>

• Delay from local UTC to receiver 1 PPS-in:		
• Delay from 1 PPS-in to 10 MHz input receiver:		
• Computed 1PPS frequency offset correction:		
• Computed REF DLY by the receiver:		
	(Not to be filled)	REF point is calibration point <input type="checkbox"/>
• Delay from local UTC to traveling box calibration point:	(Not to be filled)	
	Other case <input type="checkbox"/>	Other case <input type="checkbox"/>
Please describe measurements and final REF DLY value		
• Antenna cable delay:	214.7	(2)
• Splitter delay (if any):		(2)
• Additional cable delay (if any):		(1)

Data used for the generation of CGGTTS files

Complete this section only if CGGTTS-format data were used for the calibration.

Please fill with the parameter values as configured in the receiver at the time of calibration

• INT DLY (GPS) /ns:	12.4 (GPS C1), 12.2 (GPS P1), 9.8 (GPS P2)
• INT DLY (Galileo) /ns:	12.6 (GAL E1), 12.4 (GAL E5a)
• INT DLY (BDS) /ns:	
• INT DLY (GLONASS) /ns:	
• CAB DLY /ns:	214.7
• REF DLY /ns:	23.9
• Coordinates reference frame:	ITRF2014
Latitude or X /m:	-1150479.3205
Longitude or Y /m:	+6080855.3403
Height or Z /m:	+1537596.5391

General information	
• Rise time of the local UTC pulse:	2 ns
• Is the laboratory air conditioned?	Yes
Set temperature value and uncertainty:	$(23.0 \pm 2.0) \text{ }^\circ\text{C}$
Set humidity value and uncertainty:	$(50 \pm 15) \text{ \%RH}$

Laboratory: NIMT	
Date and hour of the beginning of measurements:	20 Nov 2025 UTC 00:00 (MJD 60999)
Date and hour of the end of measurements:	25 Nov 2025 UTC 23:59 (MJD 61004)

Information on the system		
	Local:	Travelling:
4-character BIPM code	MTME	TLM2
• Receiver maker and type: Receiver serial number:	MESIT/GTR55 2202002	Septentrio/PolaRx5TR 4701426
1 PPS trigger level /V:		
• Antenna cable maker and type: Phase stabilised cable (Y/N):	Belden/H155PE N	PEWC/CFD-200 N
Length outside the building /m:	50	50
• Antenna maker and type: Antenna serial number:	NovAtel/NOV850 NONE NMLK21430018S	Septentrio/PolaNt-x MF.v2 23674
Temperature (if stabilised) /°C		

Measured delays /ns		
Please tick the correct box depending on the receiver (1)		
	Local:	Travelling:
	REF point is PPSIN <input type="checkbox"/>	REF point is PPSIN <input type="checkbox"/>
• Delay from local UTC to receiver 1 PPS-in (REFDLY):	24.6	
• Optional Delay from local UTC to receiver 1 PPS-Out:		
	REF point is PPSOUT <input type="checkbox"/>	REF point is PPSOUT <input type="checkbox"/>
• Delay from local UTC to receiver 1 PPS-Out (REFDLY):		
• Optional Delay from local UTC to receiver 1 PPS-in:		
	REF point. TTS 4/5 <input type="checkbox"/>	REF point. TTS 4/5 <input type="checkbox"/>
• Delay from local UTC to receiver 1 PPS-in:		

• Delay from 1 PPS-in to 10 MHz input receiver:		
• Computed 1PPS frequency offset correction:		
• Computed REFDLY by the receiver:		
	(Not to be filled)	REF point is calibration point <input type="checkbox"/>
• Delay from local UTC to traveling box calibration point:	(Not to be filled)	
	Other case <input type="checkbox"/>	Other case <input type="checkbox"/>
Please describe measurements and final REFDLY value		
• Antenna cable delay:	214.5	(2)
Splitter delay (if any):		(2)
Additional cable delay (if any):		(1)

Data used for the generation of CGGTTS files

Complete this section only if CGGTTS-format data were used for the calibration.

Please fill with the parameter values as configured in the receiver at the time of calibration

• INT DLY (GPS) /ns:	16.0 (GPS C1), 13.6 (GPS P1), 8.2 (GPS P2)
• INT DLY (Galileo) /ns:	16.9 (GAL E1), 10.90 (GAL E5a)
• INT DLY (BDS) /ns:	
• INT DLY (GLONASS) /ns:	
• CAB DLY /ns:	214.5
• REF DLY /ns:	24.6
• Coordinates reference frame:	ITRF2020
Latitude or X /m:	-1150480.71
Longitude or Y /m:	+6080855.20
Height or Z /m:	+1537596.54

General information

• Rise time of the local UTC pulse:	2 ns
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• Is the laboratory air conditioned?	Yes
Set temperature value and uncertainty:	$(23.0 \pm 2.0) ^\circ\text{C}$
Set humidity value and uncertainty:	$(50 \pm 15) \%.RH$

Laboratory: NIMT	
Date and hour of the beginning of measurements:	20 Nov 2025 UTC 00:00 (MJD 60999)
Date and hour of the end of measurements:	25 Nov 2025 UTC 23:59 (MJD 61004)

Information on the system		
	Local:	Travelling:
4-character BIPM code	MTTN	TLM2
• Receiver maker and type: Receiver serial number:	Septentrio/PolaRx5TR 3089903	Septentrio/PolaRx5TR 4701426
1 PPS trigger level /V:		
• Antenna cable maker and type: Phase stabilised cable (Y/N):	Belden/RG213 N	PEWC/CFD-200 N
Length outside the building /m:	50	50
• Antenna maker and type: Antenna serial number:	SEPCHOKE_B3E6_SPKE 6139	Septentrio/PolaNt-x MF.v2 23674
Temperature (if stabilised) /°C		

Measured delays /ns		
Please tick the correct box depending on the receiver (1)		
	Local:	Travelling:
	REF point is PPSIN <input type="checkbox"/>	REF point is PPSIN <input type="checkbox"/>
• Delay from local UTC to receiver 1 PPS-in (REFDLY):	35.2	
• Optional Delay from local UTC to receiver 1 PPS-Out:		
	REF point is PPSOUT <input type="checkbox"/>	REF point is PPSOUT <input type="checkbox"/>
• Delay from local UTC to receiver 1 PPS-Out (REFDLY):		
• Optional Delay from local UTC to receiver 1 PPS-in:		
	REF point. TTS 4/5 <input type="checkbox"/>	REF point. TTS 4/5 <input type="checkbox"/>
• Delay from local UTC to receiver 1 PPS-in:		

• Delay from 1 PPS-in to 10 MHz input receiver:		
• Computed 1PPS frequency offset correction:		
• Computed REFDLY by the receiver:		
	(Not to be filled)	REF point is calibration point <input type="checkbox"/>
• Delay from local UTC to traveling box calibration point:	(Not to be filled)	
	Other case <input type="checkbox"/>	Other case <input type="checkbox"/>
Please describe measurements and final REFDLY value		
• Antenna cable delay:	250.7	(2)
Splitter delay (if any):		(2)
Additional cable delay (if any):		(1)

Data used for the generation of CGGTTS files

Complete this section only if CGGTTS-format data were used for the calibration.

Please fill with the parameter values as configured in the receiver at the time of calibration

• INT DLY (GPS) /ns:	26.72 (GPS P1), 23.02 (GPS P2)
• INT DLY (Galileo) /ns:	25.45 (GAL E1), 27.31 (GAL E5a)
• INT DLY (BDS) /ns:	
• INT DLY (GLONASS) /ns:	
• CAB DLY /ns:	250.7
• REF DLY /ns:	35.2
• Coordinates reference frame:	ITRF2020
Latitude or X /m:	-1150482.33
Longitude or Y /m:	+6080854.72
Height or Z /m:	+1537596.45

General information

• Rise time of the local UTC pulse:	2 ns
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• Is the laboratory air conditioned?	Yes
Set temperature value and uncertainty:	$(23.0 \pm 2.0) \text{ }^\circ\text{C}$
Set humidity value and uncertainty:	$(50 \pm 15) \text{ \%RH}$

Laboratory: NIMT	
Date and hour of the beginning of measurements:	20 Nov 2025 UTC 00:00 (MJD 60999)
Date and hour of the end of measurements:	25 Nov 2025 UTC 23:59 (MJD 61004)

Information on the system		
	Local:	Travelling:
4-character BIPM code	MT01	TLM2
• Receiver maker and type: Receiver serial number:	Septentrio/PolaRx5TR 4701717	Septentrio/PolaRx5TR 4701426
1 PPS trigger level /V:		
• Antenna cable maker and type: Phase stabilised cable (Y/N):	Time microwave systems/LMR600 N	PEWC/CFD-200 N
Length outside the building /m:	50	50
• Antenna maker and type: Antenna serial number:	SEPCHOKE_B3E6_SPKE 6221	Septentrio/PolaNt-x MF.v2 23674
Temperature (if stabilised) /°C		

Measured delays /ns		
Please tick the correct box depending on the receiver (1)		
	Local:	Travelling:
	REF point is PPSIN <input type="checkbox"/>	REF point is PPSIN <input type="checkbox"/>
• Delay from local UTC to receiver 1 PPS-in (REFDLY):	29.4	
• Optional Delay from local UTC to receiver 1 PPS-Out:		
	REF point is PPSOUT <input type="checkbox"/>	REF point is PPSOUT <input type="checkbox"/>
• Delay from local UTC to receiver 1 PPS-Out (REFDLY):		
• Optional Delay from local UTC to receiver 1 PPS-in:		
	REF point. TTS 4/5 <input type="checkbox"/>	REF point. TTS 4/5 <input type="checkbox"/>
• Delay from local UTC to		

receiver 1 PPS-in:		
• Delay from 1 PPS-in to 10 MHz input receiver:		
• Computed 1PPS frequency offset correction:		
• Computed REFDLY by the receiver:		
	(Not to be filled)	REF point is calibration point <input type="checkbox"/>
• Delay from local UTC to traveling box calibration point:	(Not to be filled)	
	Other case <input type="checkbox"/>	Other case <input type="checkbox"/>
Please describe measurements and final REFDLY value		
• Antenna cable delay:	225.5	(2)
Splitter delay (if any):		(2)
Additional cable delay (if any):		(1)

Data used for the generation of CGGTTS files

Complete this section only if CGGTTS-format data were used for the calibration.

Please fill with the parameter values as configured in the receiver at the time of calibration

• INT DLY (GPS) /ns:	
• INT DLY (Galileo) /ns:	
• INT DLY (BDS) /ns:	
• INT DLY (GLONASS) /ns:	
• CAB DLY /ns:	225.5
• REF DLY /ns:	29.4
• Coordinates reference frame:	ITRF2020
Latitude or X /m:	-1150476.3171
Longitude or Y /m:	+6080850.9966
Height or Z /m:	+1537597.4760

General information

• Rise time of the local UTC pulse:	2 ns
• Is the laboratory air conditioned?	Yes
Set temperature value and uncertainty:	$(23.0 \pm 2.0) \text{ }^\circ\text{C}$
Set humidity value and uncertainty:	$(50 \pm 15) \text{ \%RH}$

Laboratory: NIMT	
Date and hour of the beginning of measurements:	20 Nov 2025 UTC 00:00 (MJD 60999)
Date and hour of the end of measurements:	25 Nov 2025 UTC 23:59 (MJD 61004)

Information on the system		
	Local:	Travelling:
4-character BIPM code	MT02	TLM2
• Receiver maker and type: Receiver serial number:	Septentrio/PolaRx5TR 4701716	Septentrio/PolaRx5TR 4701426
1 PPS trigger level /V:		
• Antenna cable maker and type: Phase stabilised cable (Y/N):	Time microwave systems/LMR600 N	PEWC/CFD-200 N
Length outside the building /m:	50	50
• Antenna maker and type: Antenna serial number:	SEPCHOKE_B3E6_SPKE 6227	Septentrio/PolaNt-x MF.v2 23674
Temperature (if stabilised) /°C		

Measured delays /ns		
Please tick the correct box depending on the receiver (1)		
	Local:	Travelling:
	REF point is PPSIN <input type="checkbox"/>	REF point is PPSIN <input type="checkbox"/>
• Delay from local UTC to receiver 1 PPS-in (REFDLY):	29.4	
• Optional Delay from local UTC to receiver 1 PPS-Out:		
	REF point is PPSOUT <input type="checkbox"/>	REF point is PPSOUT <input type="checkbox"/>
• Delay from local UTC to receiver 1 PPS-Out (REFDLY):		
• Optional Delay from local UTC to receiver 1 PPS-in:		
	REF point. TTS 4/5 <input type="checkbox"/>	REF point. TTS 4/5 <input type="checkbox"/>
• Delay from local UTC to		

receiver 1 PPS-in:		
• Delay from 1 PPS-in to 10 MHz input receiver:		
• Computed 1PPS frequency offset correction:		
• Computed REFDLY by the receiver:		
	(Not to be filled)	REF point is calibration point <input type="checkbox"/>
• Delay from local UTC to traveling box calibration point:	(Not to be filled)	
	Other case <input type="checkbox"/>	Other case <input type="checkbox"/>
Please describe measurements and final REFDLY value		
• Antenna cable delay:	226.6	(2)
Splitter delay (if any):		(2)
Additional cable delay (if any):		(1)

Data used for the generation of CGGTTS files

Complete this section only if CGGTTS-format data were used for the calibration.

Please fill with the parameter values as configured in the receiver at the time of calibration

• INT DLY (GPS) /ns:	
• INT DLY (Galileo) /ns:	
• INT DLY (BDS) /ns:	
• INT DLY (GLONASS) /ns:	
• CAB DLY /ns:	226.6
• REF DLY /ns:	29.4
• Coordinates reference frame:	ITRF2020
Latitude or X /m:	-1150481.4333
Longitude or Y /m:	+6080854.4884
Height or Z /m:	+1537598.8530

General information

• Rise time of the local UTC pulse:	2 ns
• Is the laboratory air conditioned?	Yes
Set temperature value and uncertainty:	$(23.0 \pm 2.0) \text{ }^\circ\text{C}$
Set humidity value and uncertainty:	$(50 \pm 15) \text{ \%RH}$

(1) Typical cases:

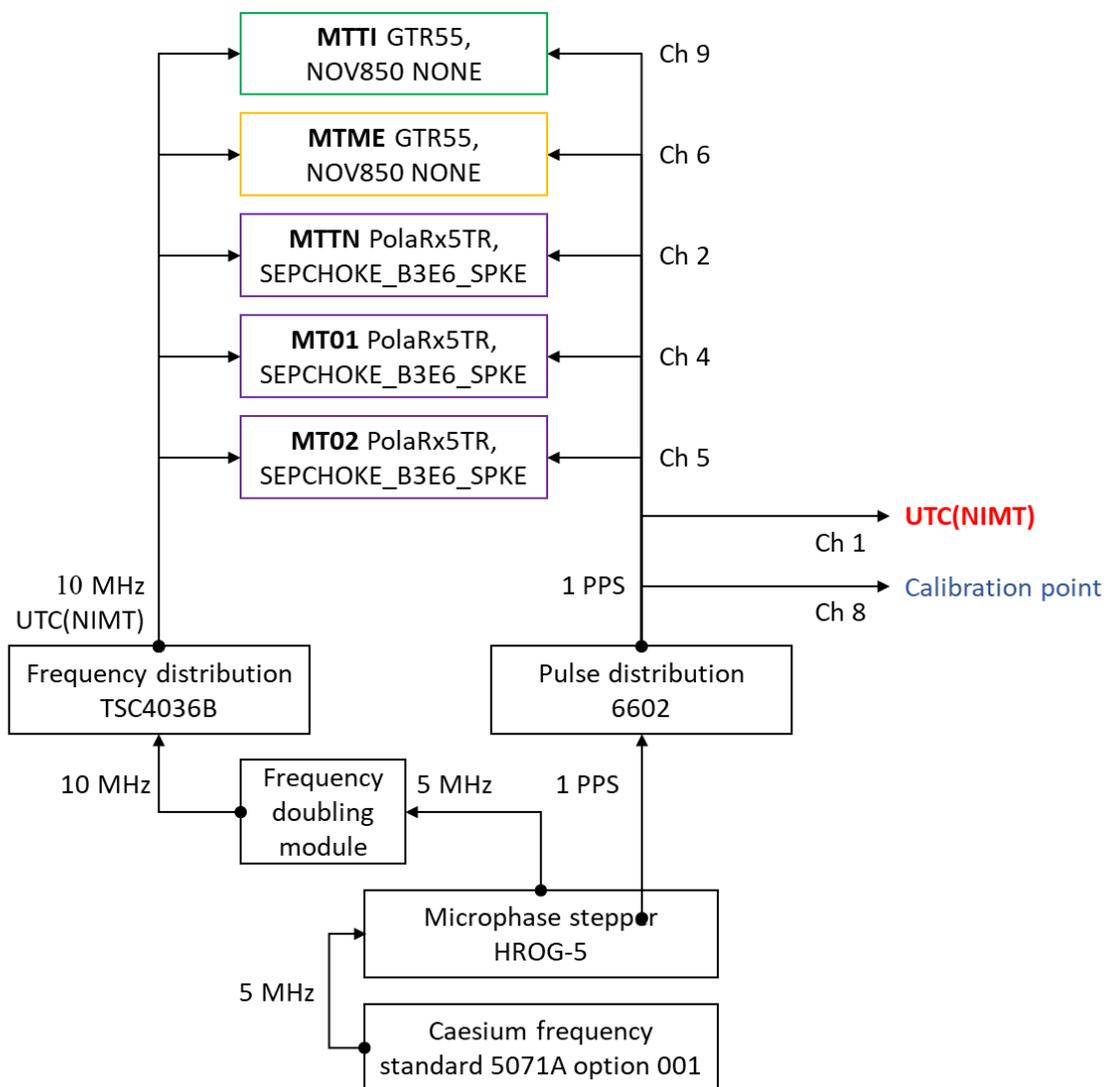
- REF point is PPSIN: Mesit GTR receivers, Piktime TTS3, Polarx5 with autocompesation mode activated
- REF point is PPSOUT: Septentrio Polarx3, Polarx4, Polarx5 Polarx5 with no autocompesation mode activated. (For all Septentrio receivers PPSOUT must be RxClock). Novatel OEM4, OEM5 or OEM6 (Please check the documentation to configure the receivers accordingly)
- REF point for TTS 4/5 receivers: Piktime TTS4, TTS5
- REF point can be the calibration point for some G1 calibration box. Please refer to the G1 instructions.

(2) For a trip with closure, not needed if the traveling equipment is used in the same set-up throughout.

Laboratory:	NIMT	
Date and hour of the beginning of measurements:	July 25, 2025, MJD 60881	
Date and hour of the end of measurements:	July 29, 2025, MJD 60885	
Information on the system		
	Local:	Travelling:
4-character BIPM code	NIMT__	TLM2
• Receiver maker and type: Receiver serial number:	Pik Time TTS-5 1027	Septentrio 4701426
1 PPS trigger level /V:	1.0 V	-
• Antenna cable maker and type: Phase stabilised cable (Y/N):	Andrew Helix FSJ Y	CFD-300
Length outside the building /m:	Length outside the building 25 m (total length is 46 m)	35
• Antenna maker and type: Antenna serial number:	JAVAD RinGantG5T RA 10041	Septentrio, PolaRx5TR 4701426
Temperature (if stabilised) /°C		
Measured delays /ns (if needed fill box "Additional Information" below)		
	Local:	Travelling:
• Delay from local UTC to receiver 1 PPS-in:	19.60 ns	15.49 ns (Local UTC to calibration point)
Delay from 1 PPS-in to internal Reference (if different):	-4.65 ³	-
• Antenna cable delay:	185.68 ns	-
Splitter delay (if any):	-	-
Additional cable delay (if any):	-	-
Data used for the generation of CGGTTS files		
• INT DLY (GPS) /ns:	48,17	
• INT DLY (GLONASS) /ns:	67,32	
• CAB DLY /ns:	185,68	
• REF DLY /ns:	4,170	
• Coordinates reference frame:	ITRF	
Latitude or X /m:	+1702150,8743	
Longitude or Y /m:	+4483774,5549	
Height or Z /m:	+4191194,0365	
General information		
• Rise time of the local UTC pulse:	4.0	
• Is the laboratory air conditioned:	Yes	
Set temperature value and uncertainty:	23 ± 1°C	
Set humidity value and uncertainty:	50% ±15%	

³ The delay from UTC(UZ) to UZ__ 1 PPS-in is 19.60 ns. The phase difference between UZ__ 1 PPS-in and the 10 MHz-in is 37.02 ns. UZ__'s actual REF DLY is 14.95 ns, a value calculated by the internal operating software (TTS-5) within UZ__.

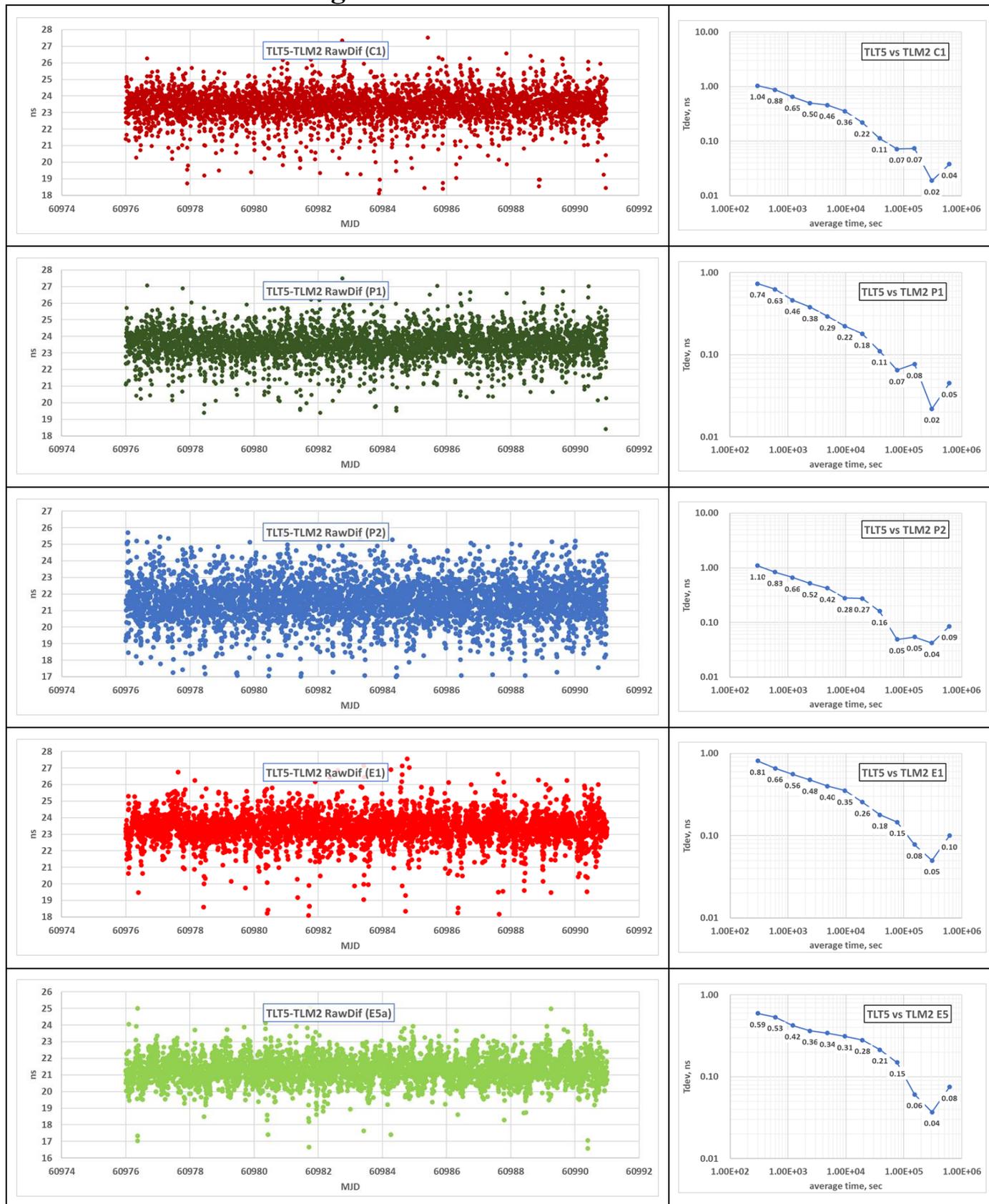
Diagram of the experiment set-up:

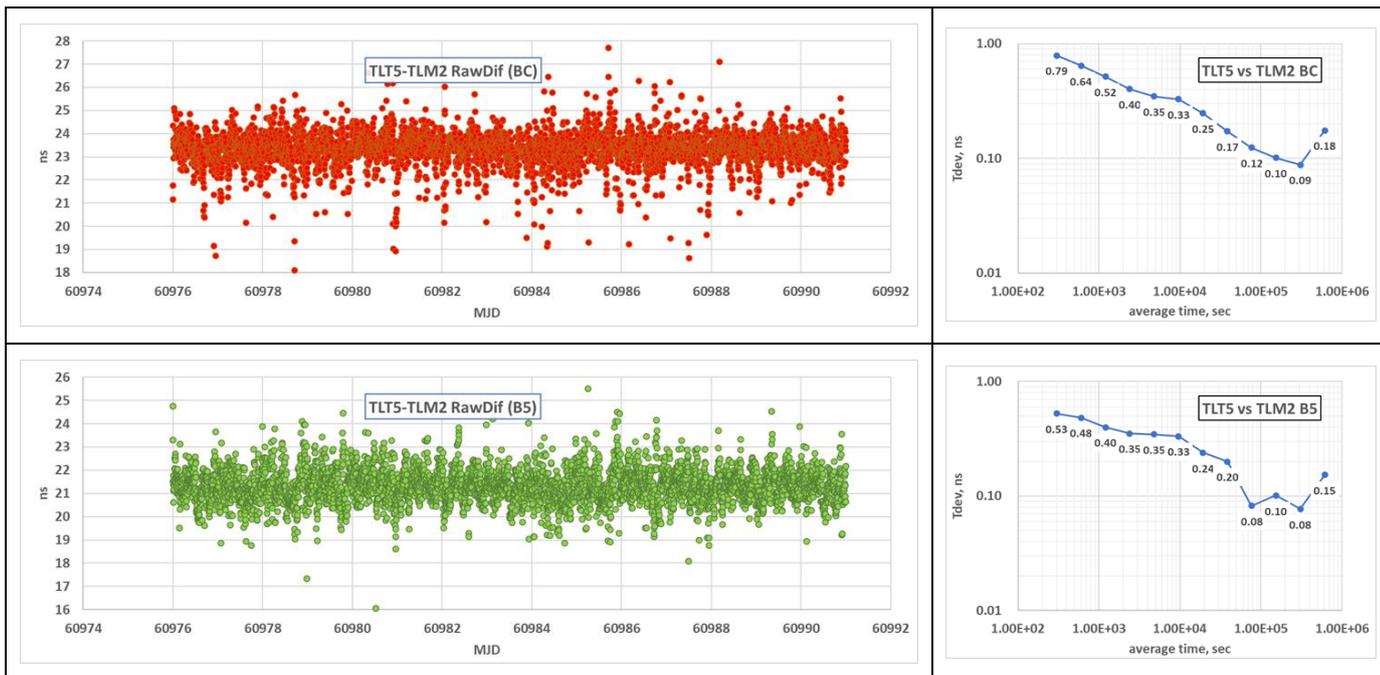


Log of Events / Additional Information:

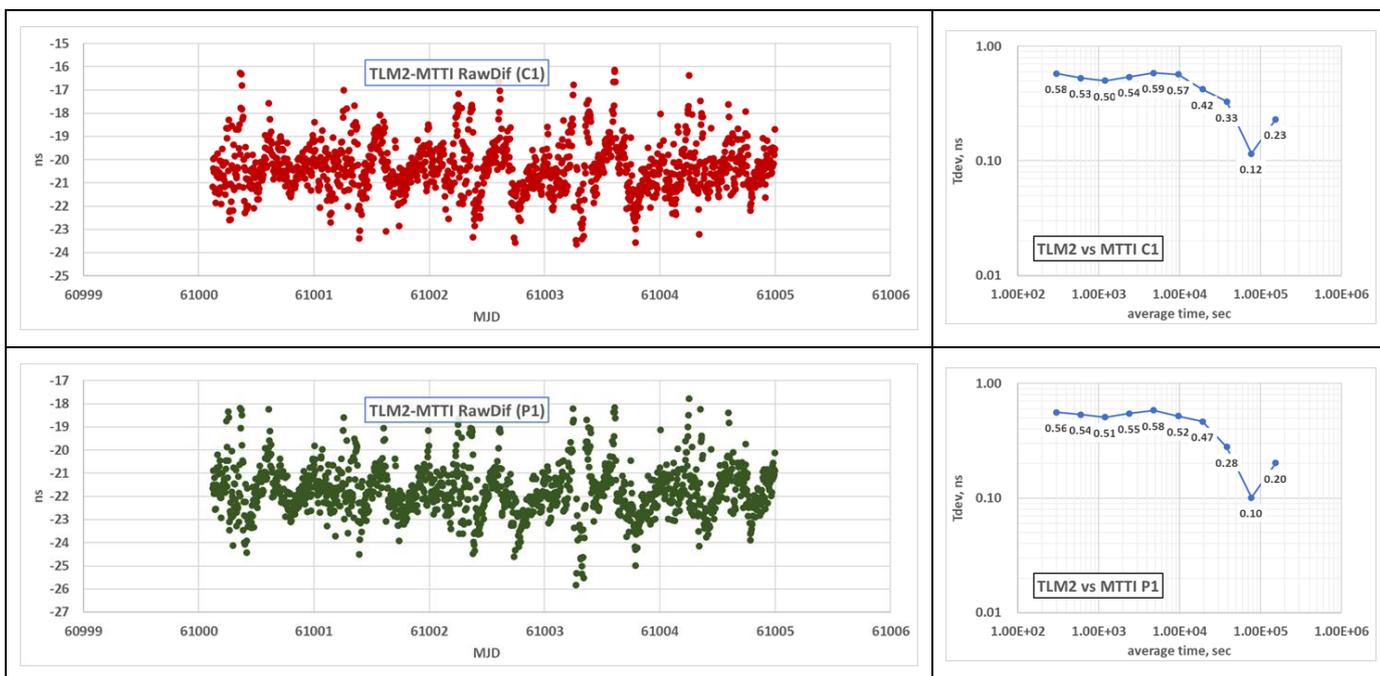
Annex B: Plots of raw data and Tdev analysis

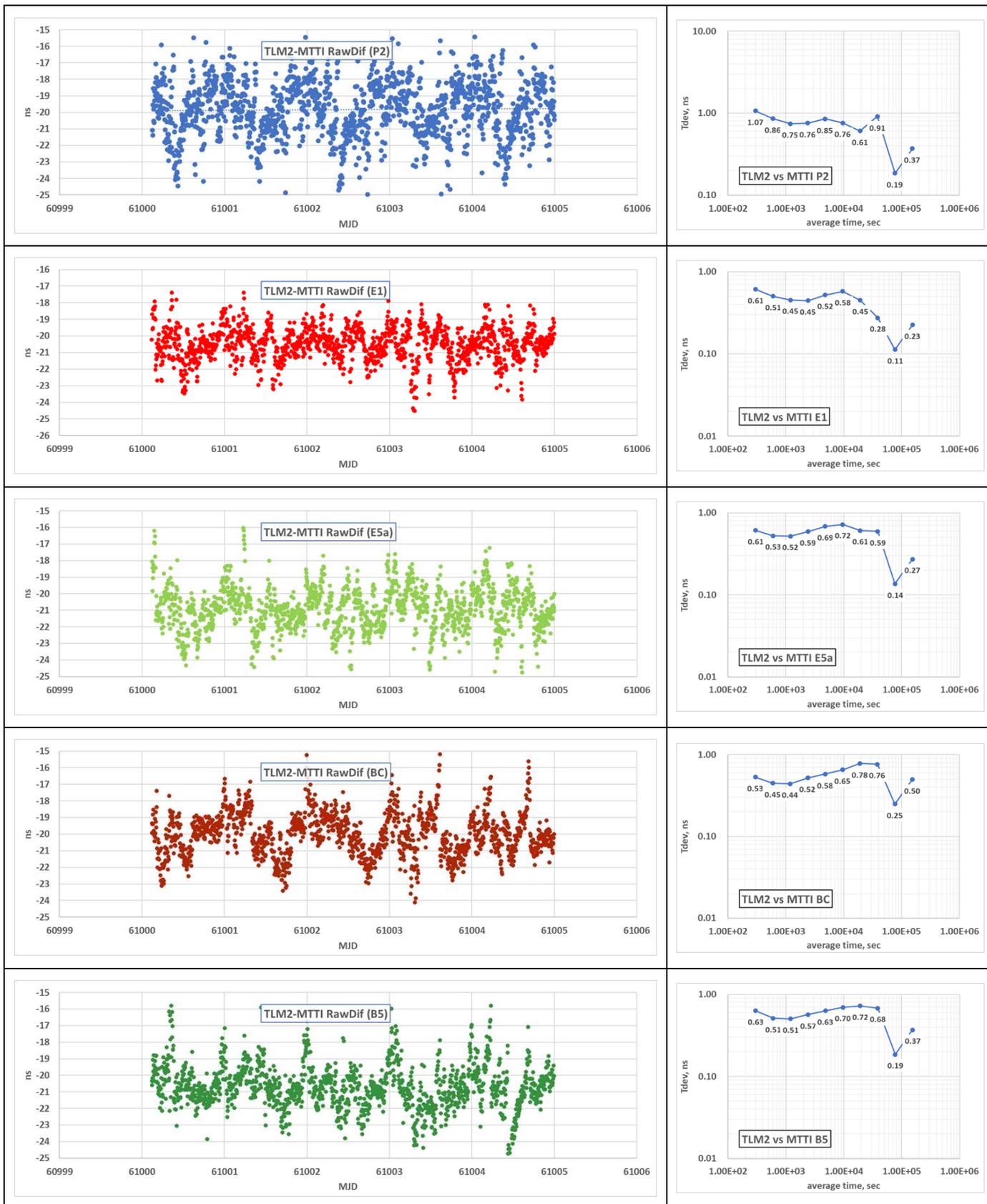
B.1 reference vs. traveling



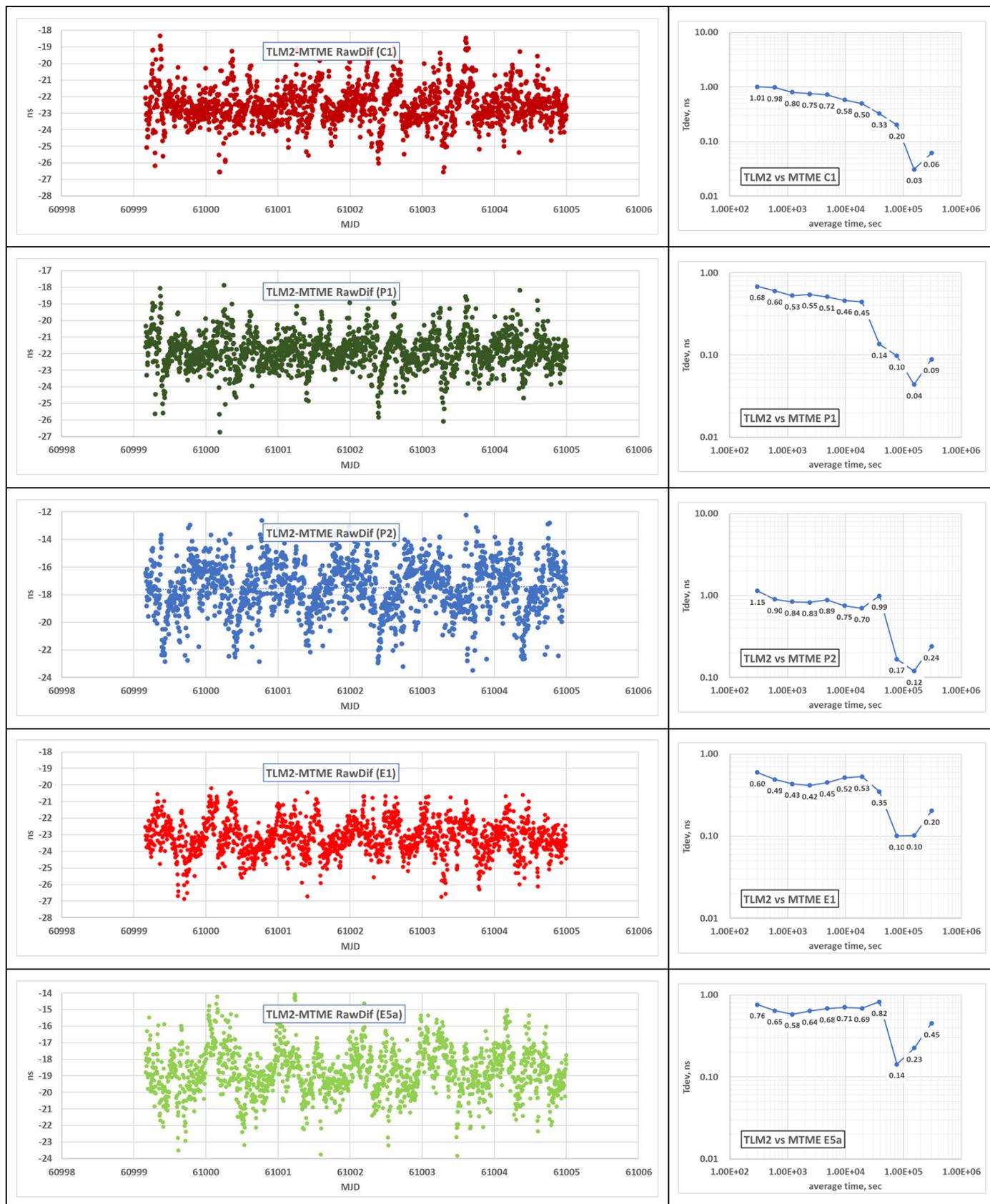


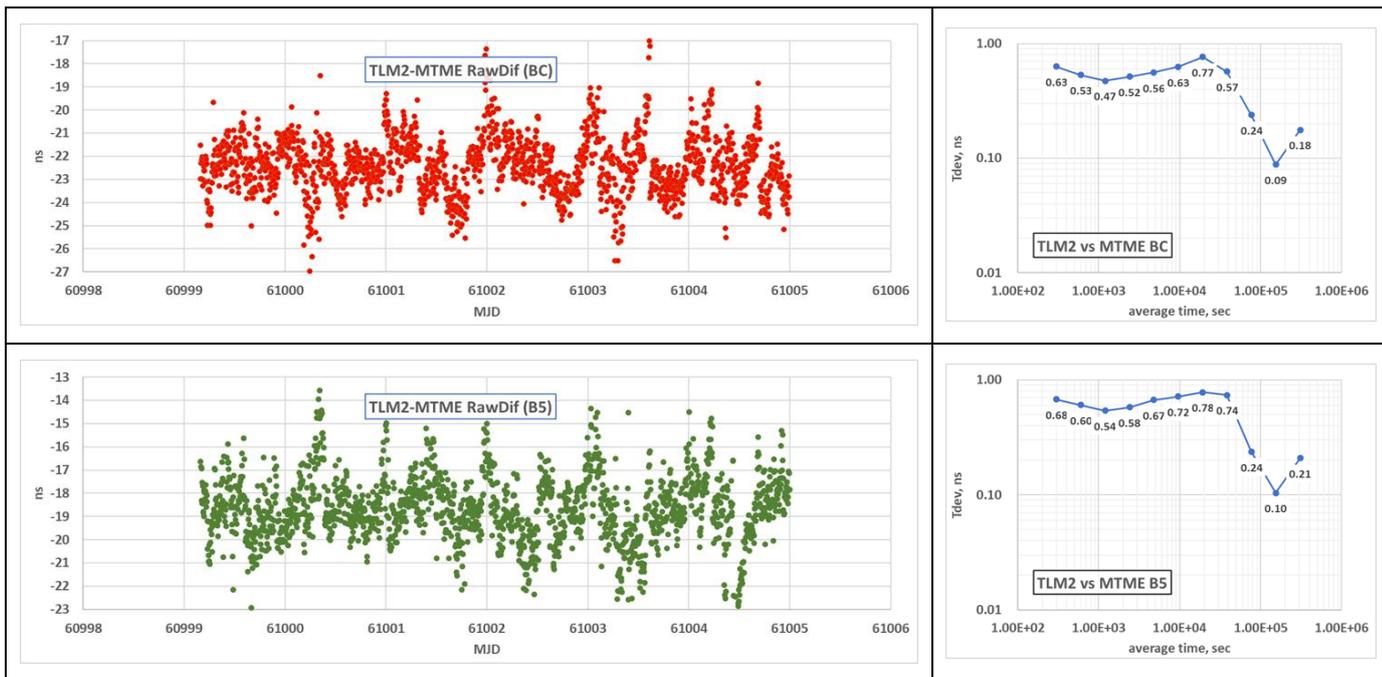
B.2 traveling vs. visited, MTTI



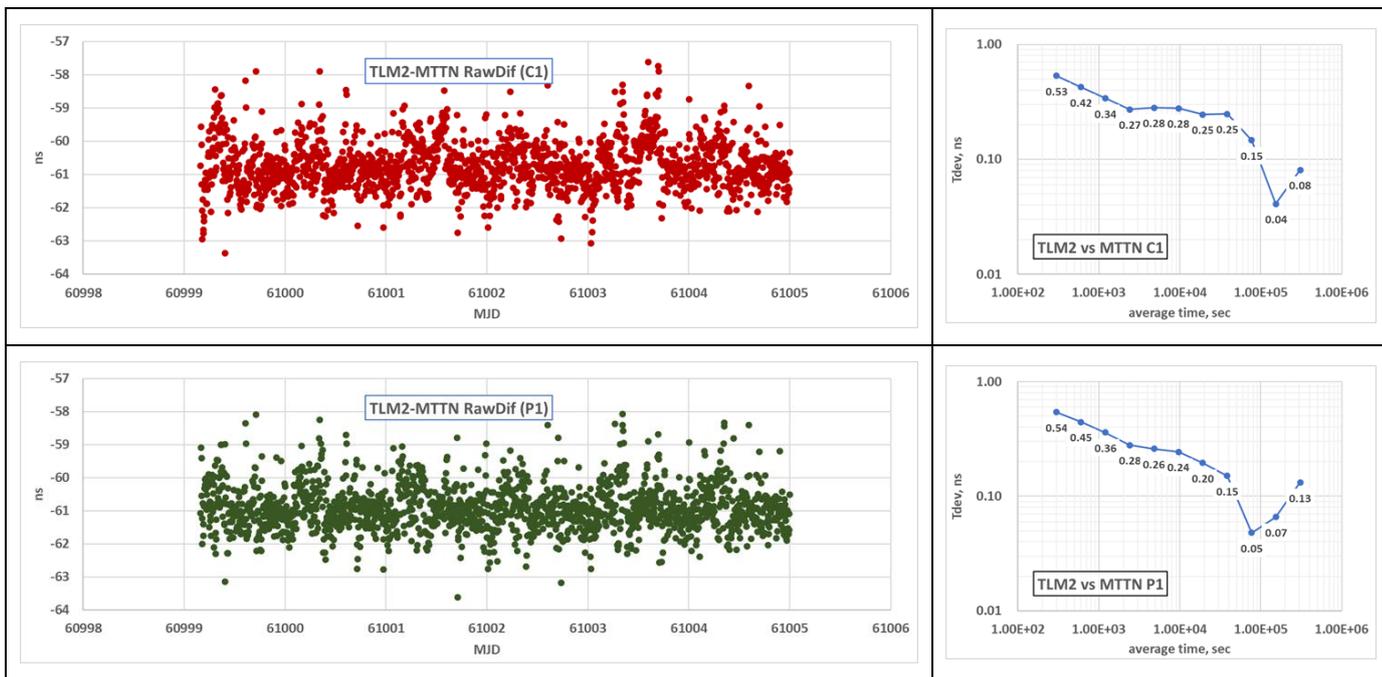


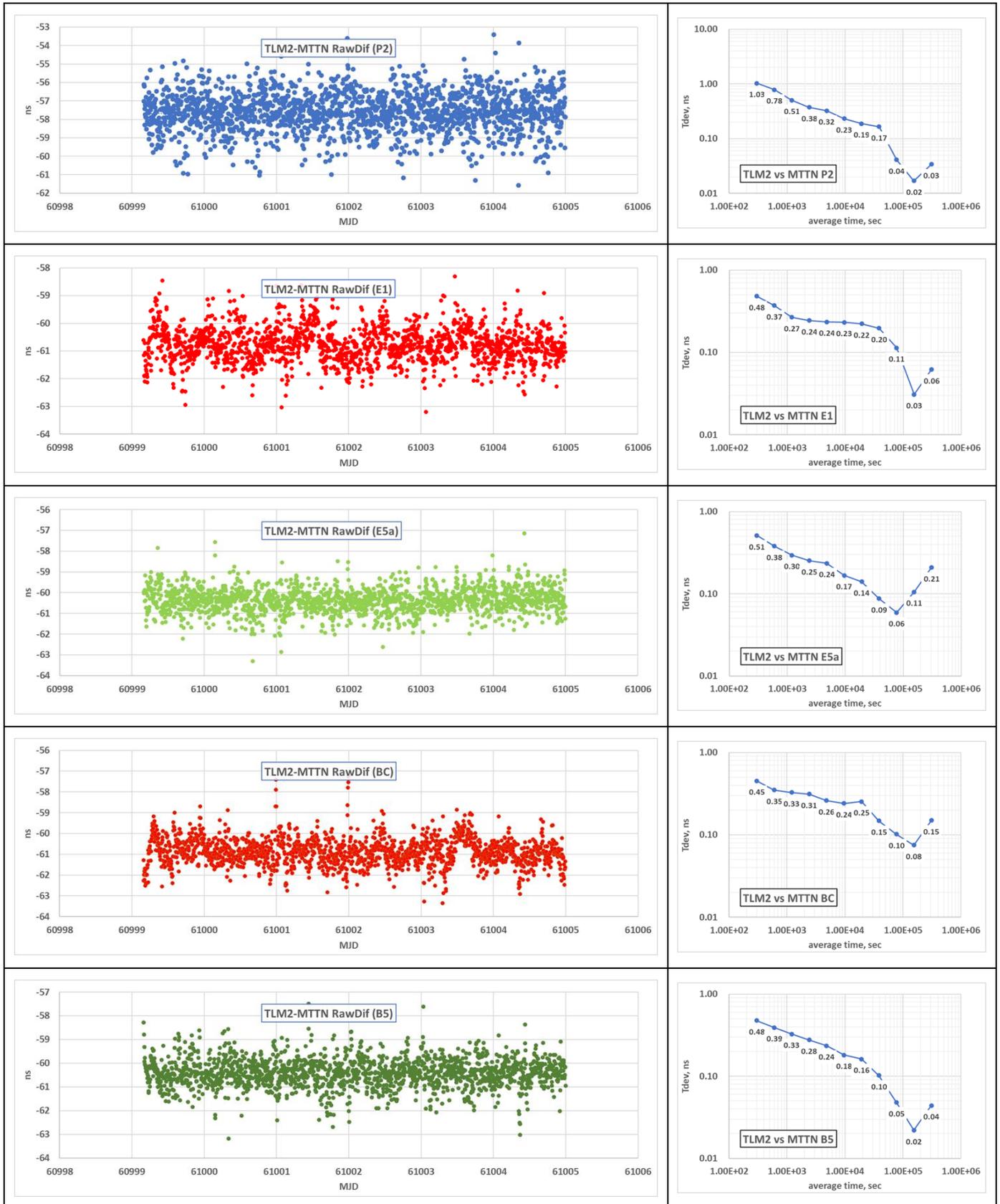
B.3 traveling vs. visited, MTME



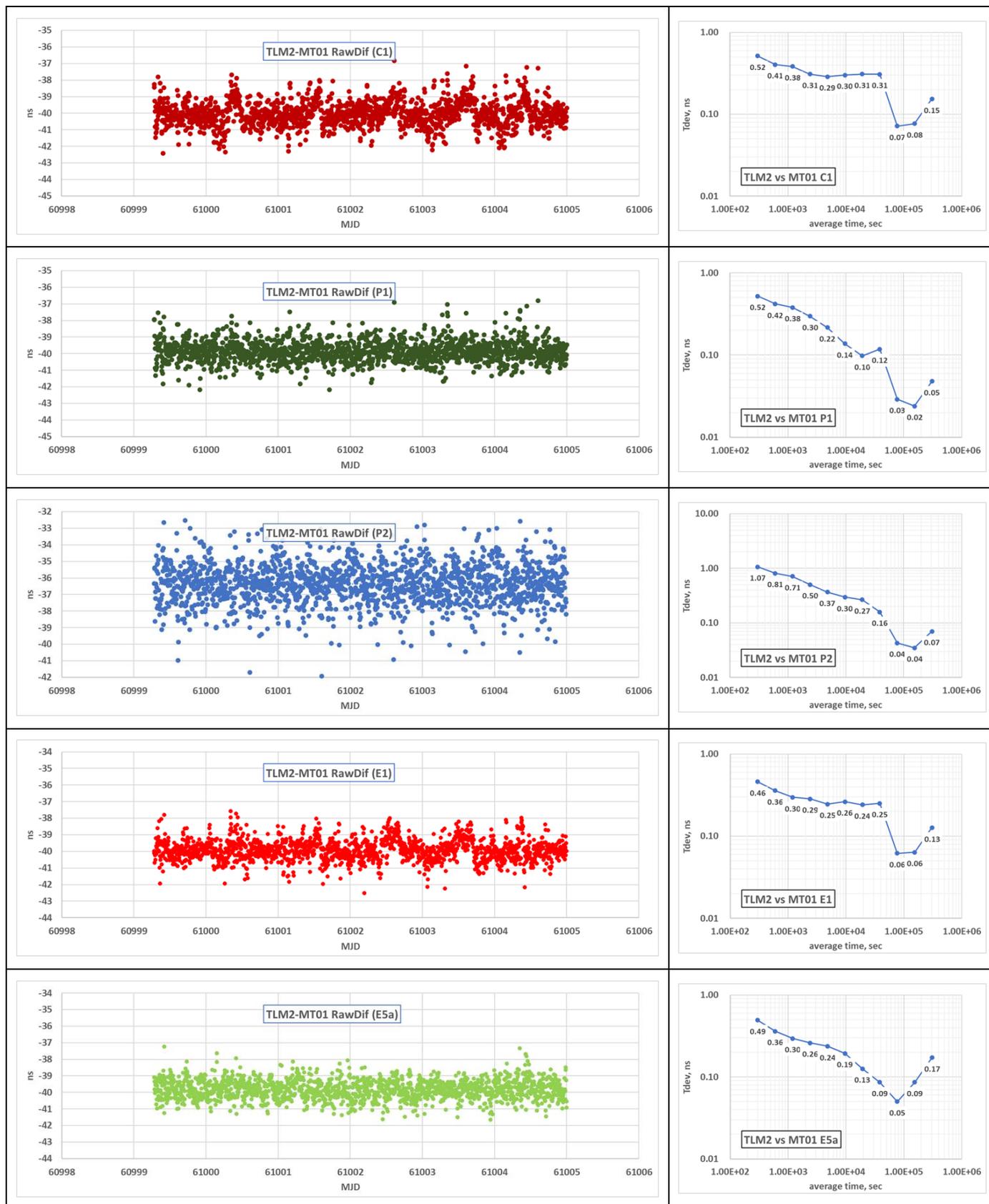


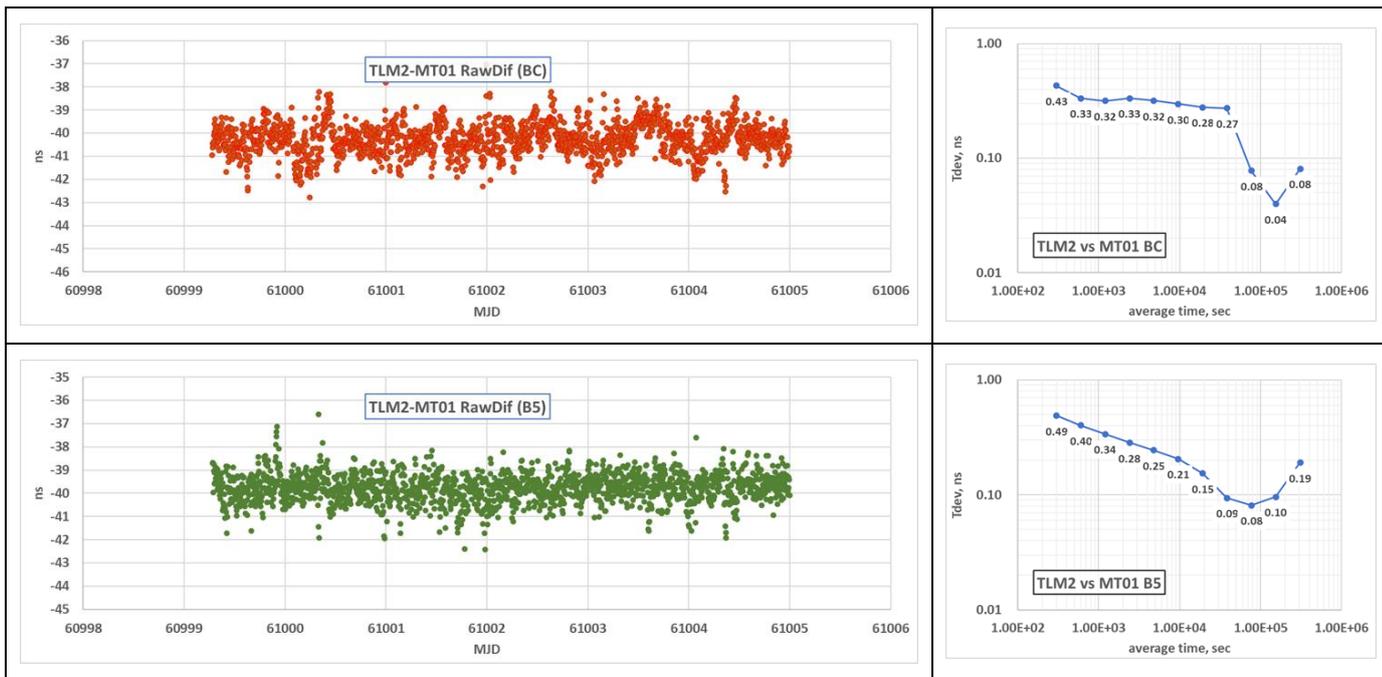
B.4 traveling vs. visited, MTTN



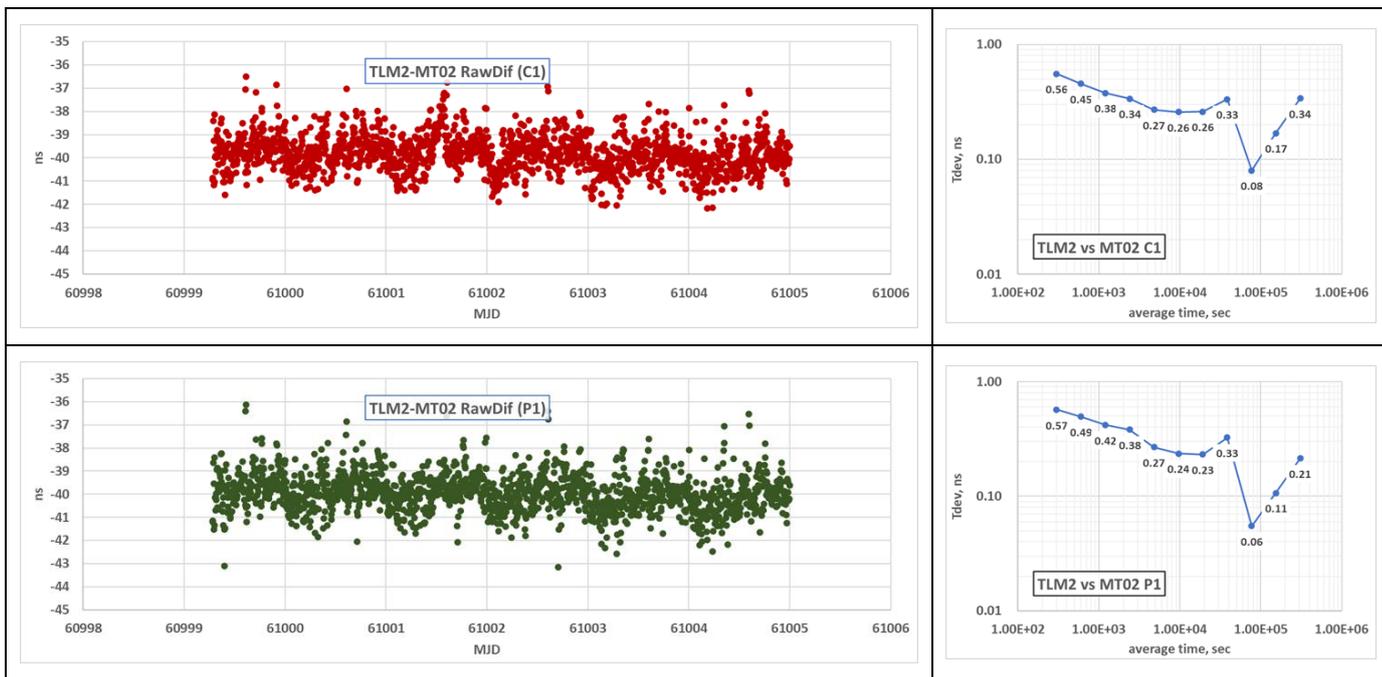


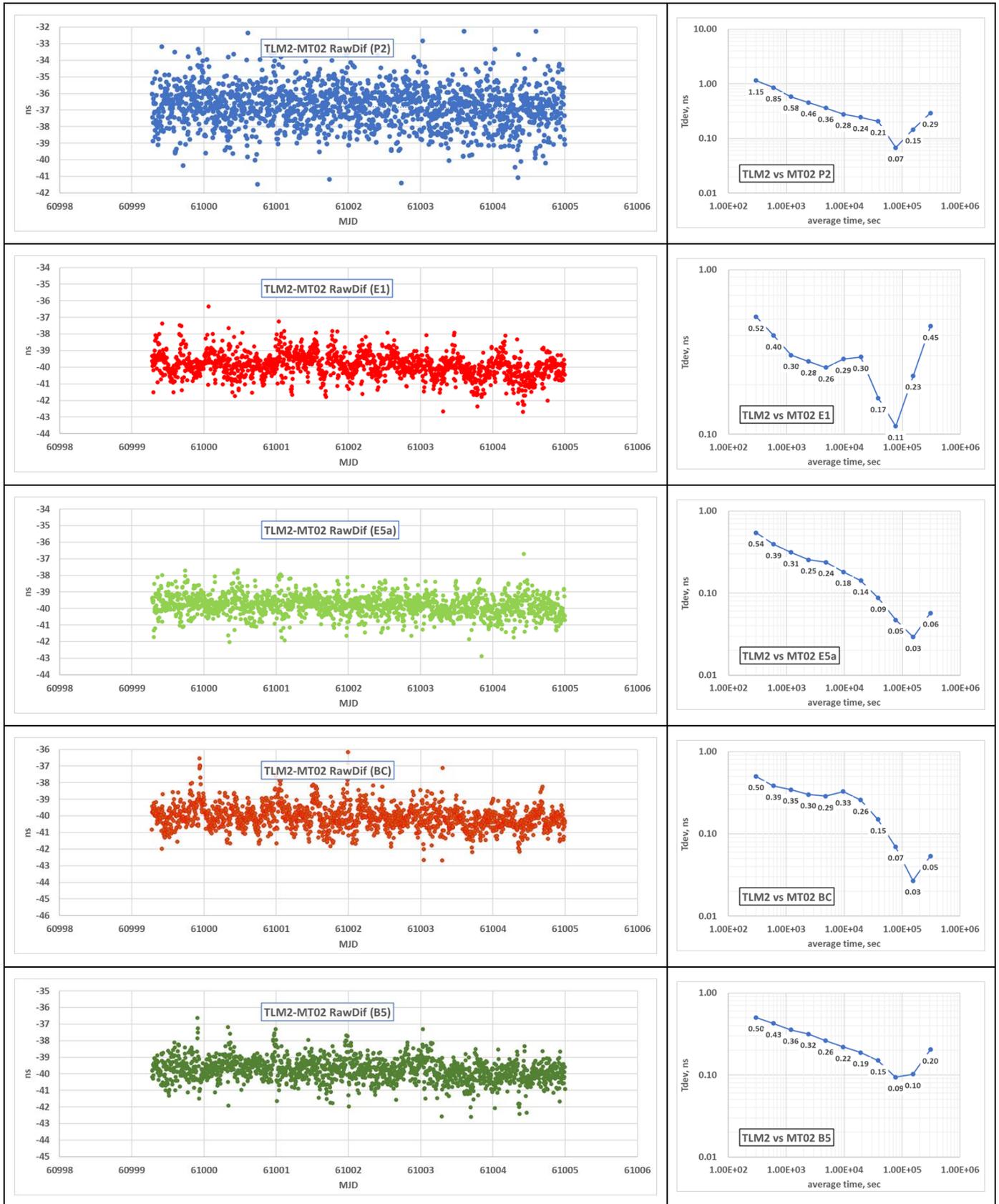
B.5 traveling vs. visited, MT01



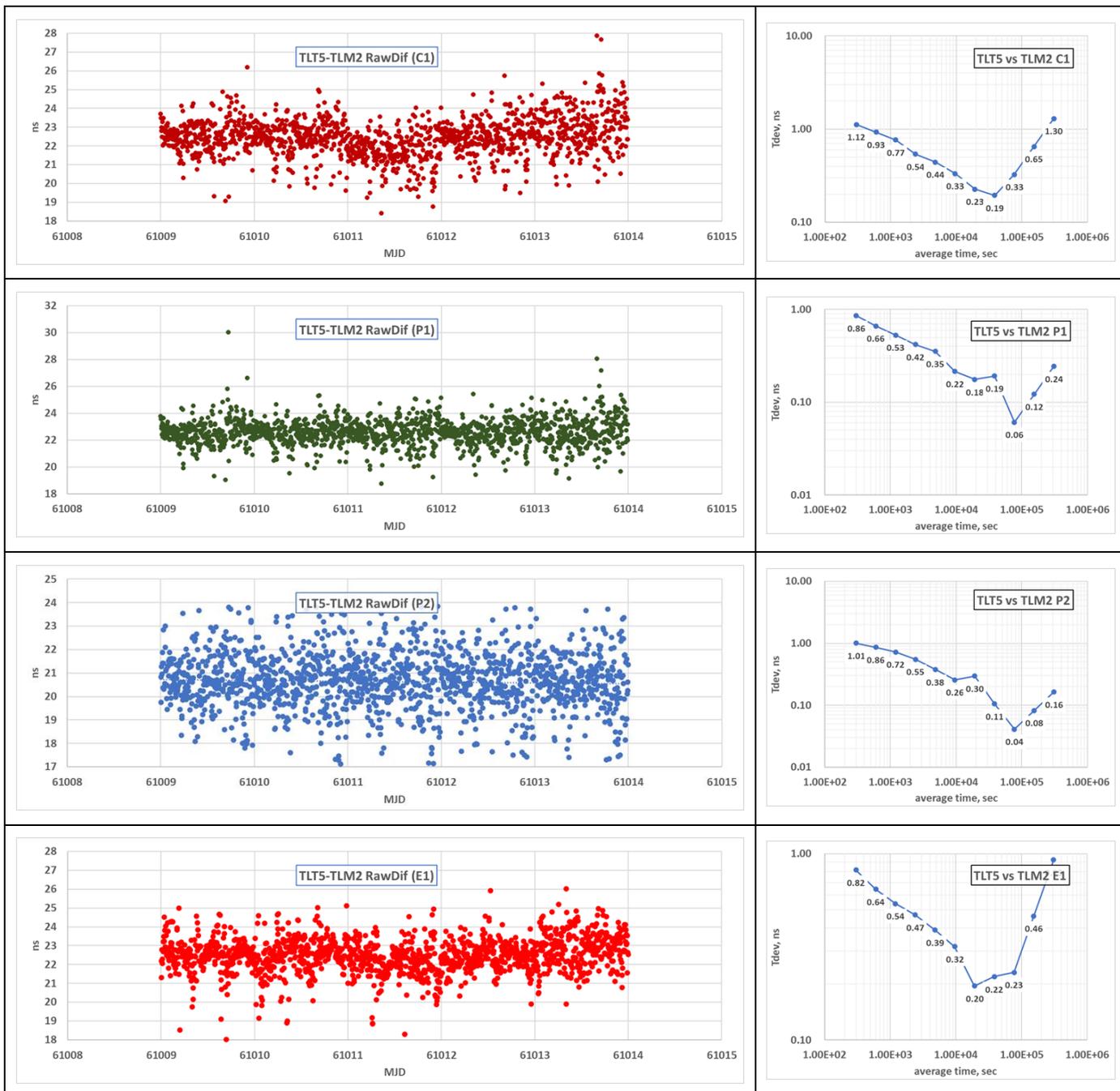


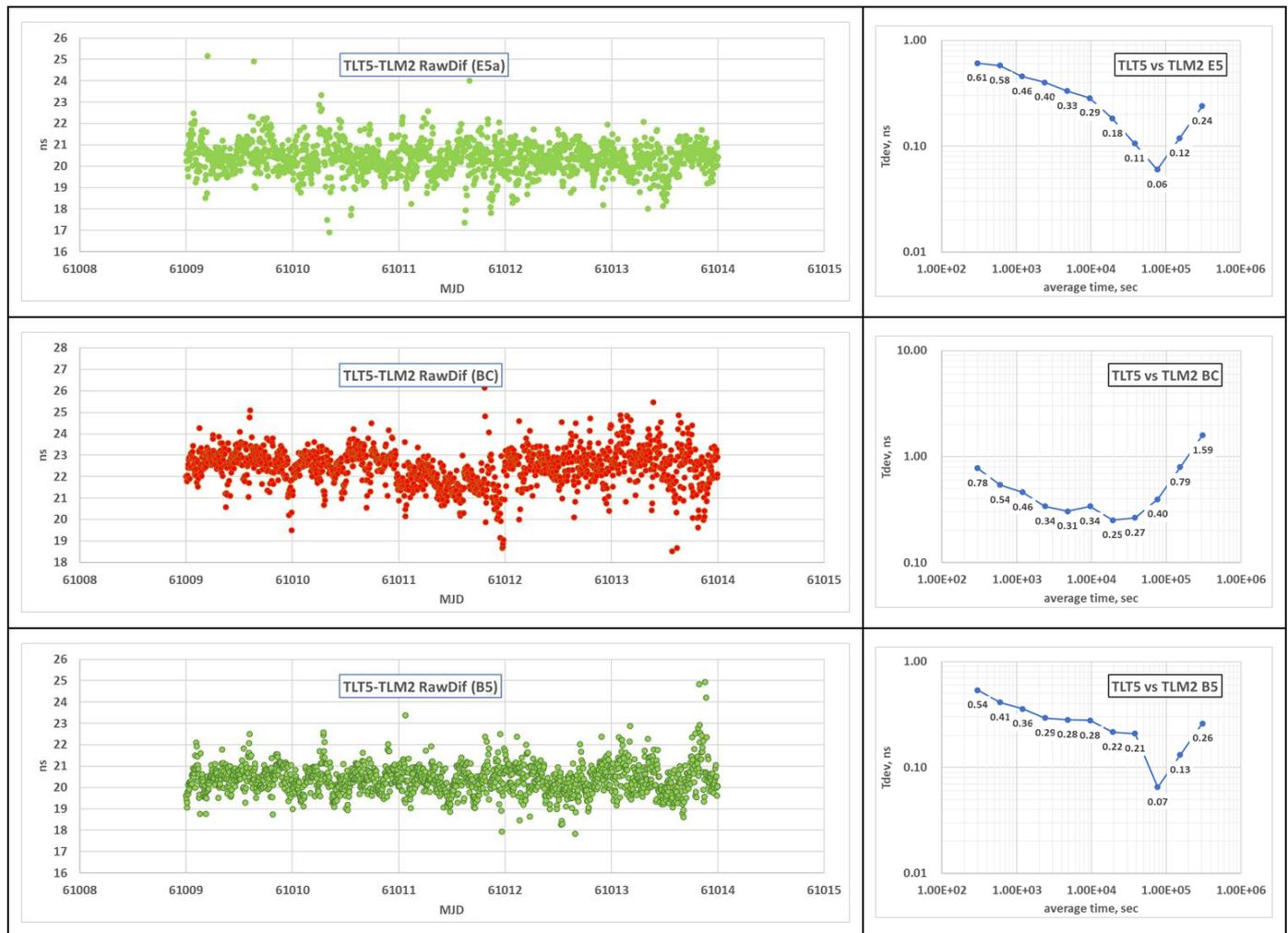
B.6 traveling vs. visited, MT02





B.3 reference vs. traveling, closure





Reference

- [1] BIPM “2022 Group 1 GPS calibration trip”,
ftp://ftp2.bipm.fr/pub/tai/publication/gnss-calibration/group1/1001-2022
- [2] BIPM guidelines for GNSS calibration, V4.0, 05/08/2021
- [3] https://webtai.bipm.org/ftp/pub/tai/publication/time-calibration/Current/1013-2018_GPSP3C1_NIMT_V1-0.pdf
- [4] https://webtai.bipm.org/ftp/pub/tai/publication/time-calibration/Current/1201-2019_GPSP3C1_NIMT-TC_V1-0.pdf
- [5] BIPM guidelines Annex3 “Procedure for computing raw difference of GNSS code measurements for geodetic receivers”, V3.2, 12/07/2021
- [6] W. Lewandowski, C. Thomas, 1991, “GPS Time transfers,” Proc. IEEE, Vol. 79, No. 7, 991-1000
- [7] G. Petit et al. BIPM TM212, Nov. 2012
- [8] J. Kouba, P. Heroux, 2002, “Precise Point Positioning Using IGS Orbit and Clock Products,” GPS Solutions, Vol 5, No. 2, 12-28

- [9] P. Defraigne and G. Petit, “CGGTTS-Version 2E: an extended standard for GNSS time transfer”,
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