# Internal delay calibration at NAOJ

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CAL-ID: 1012-2022

## 1 Introduction

NAOJ and NICT performed their first G2 calibration campaign with the NICT traveling receiver at NAOJ. The period of the calibration at NAOJ was from October 22, 2021 to February 20, 2022. Table 1 shows the receivers and antennas used for the calibration.

Table 1: List of receivers and antennas.

| *System* | *Receiver* | *Antenna* | *Remark* |
|---|---|---|---|
| NC4S | Septentrio PolaRx4 TR Pro | AeroAntenna AT1675-120SW | Master |
| NC5S | Septentrio PolaRx5 TR | NovAtel GPS-703-GGG-MV | Backup |
| NC5C | Septentrio PolaRx5 TR | NovAtel GPS-703-GGG | Traveling |
| NAT2 | TFS Timetrace I | Trimble PN57860-10 | |

We performed a common clock measurement based on "BIPM guidelines for GNSS calibration" [1] and calculated the common clock differences (CCDs) from RINEX files with the NICT receivers, and CGGTTS files with the NAOJ receiver. "concerto v4" (c4) was used as the analysis software [2], and "RTKLIB" software [3] was used to determinted the anntena positions of the traveling receiver.

The internal delays of the NICT reference and traveling receivers were calibrated by BIPM [4] as shown in Table 2.

Table 2: Internal delays of the reference receivers (all values in ns).

| *Sys.* | *Date* | *REF* | *CAB* | *C1* | *P1* | *P2* | $U_{CAL}(C1))$ |
|---|---|---|---|---|---|---|---|
| NC4S | 2021.11 | 314.1 | | 278.6 | 277.4 | 276.8 | 1.5 |
| NC5S | 2021.11 | 265.4 | | 395.7 | 393.4 | 392.6 | 1.5 |

The internal delays of the NAOJ receiver with respect to the NICT reference receivers were calculated from the values in Tables 2 and 8, and Table 3 shows the results of these calculations. The reference delay (REFDLY) of the NAT2 receiver is defined with a value of 0.0 ns though

Table 3: Internal delays of the NAOJ receiver with CCTF header values (all values in ns).

| *Sys.* | *Ref.* | *REF* | *CAB* | $\Delta C1$ | $\Delta P1$ | $\Delta P2$ |
|---|---|---|---|---|---|---|
| NAT2 | Ave. | 241.9 | 170.8 | 218.0 | – | – |
| | NC4S | | | 218.03 | | |
| | NC5S | | | 217.91 | | |

the common-clock calculation was performed with a value of 241.9 ns. The value of -16.1 ns as internal delay (INTDLY) is also included in this calculation. In addition, the cable delay is ambiguous though it is used a value of 170.8 ns for CCDs calculation. The differences of true values and CGGTTS header values are described in the information sheet in page 12.

The final calibration resutls are shown in Table 4 with equation (1).

$$INTDLY = 218.0 \text{ ns} + (-16.1 \text{ ns}) + 170.8 \text{ ns} - 241.9 \text{ ns} \tag{1}$$

We estimated the uncertainty of this calibration using equation (2).

Table 4: Final internal delays of the NAOJ receiver (all values in ns).

| *Sys.* | *REF* | *SYS* | $U_{CAL}$ |
|---|---|---|---|
| NAT2 | 0.0 | 130.8 | 2.7 |

$$U_{CAL} = \sqrt{U_{ref}^2 + U_{cal}^2} \tag{2}$$

Where $U_{ref}$ is the uncertainty of the reference receiver, given in Table 2, and $U_{cal}$ is the total uncertainty of this calibration, given in Table 9.

## 2 Results of raw data processing

Table 5 shows the average CCDs between the traveling receiver and each reference or target receiver, and Figures 1 to 5 show raw plots and the time deviation of each CCD. We used single difference observations of each code (C1, P1, and P2) between receivers, and solved the receiver clock offsets of every observation epoch. The raw plots show the estimated CCDs as receiver clock offsets.

## 3 Calibration results

Table 6 shows the ΔSYSDLY values for the traveling receiver with respect to the reference receivers. These values were calculated using equation (3).

$$\Delta\text{SYSDLY}_{A-B} = \text{CCD}_{A-B} + \text{REFDLY}_A - \text{REFDLY}_B \tag{3}$$

Table 5: Summary of the raw calibration results (all values in ns).

| *Pair* | *Date* | *CCD (C1)* | $U_a$ | *CCD (P1)* | $U_a$ | *CCD (P2)* | $U_a$ |
|---|---|---|---|---|---|---|---|
| NC5C - NC4S | 59509 - 59525 | -72.766 | 0.2 | -73.783 | 0.2 | -75.965 | 0.2 |
| NC5C - NC5S | 59509 - 59525 | -251.464 | 0.1 | -251.495 | 0.1 | -253.651 | 0.1 |
| NC5C - NAT2 | 59534 - 59558 | -89.905 | 1.0 | - | | - | |
| NC5C - NC4S | 59614 - 59630 | -86.682 | 0.2 | -87.687 | 0.2 | -89.621 | 0.2 |
| NC5C - NC5S | 59614 - 59630 | -251.928 | 0.1 | -251.911 | 0.1 | -253.987 | 0.2 |

Table 6: Computed ΔSYSDLY values for the traveling systems with respect to reference receivers. (all values in ns)

| *Pair* | *No* | $REF_T$ | $REF_R$ | *C1 (ns)* | | *P1 (ns)* | | *P2 (ns)* | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | *CCD* | ΔSYS | *CCD* | ΔSYS | *CCD* | ΔSYS |
| NC5C - NC4S | 1 | 287.30 | 303.20 | -72.77 | -88.67 | -73.78 | -89.68 | -75.97 | -91.87 |
| NC5C - NC4S | 2 | 311.20 | 315.60 | -86.68 | -91.08 | -87.69 | -92.09 | -89.62 | -94.02 |
| | | *Misclosure* | | | 2.42 | | 2.40 | | 2.16 |
| | | *Mean* | | | -89.87 | | -90.88 | | -92.94 |
| NC5C - NC5S | 1 | 287.30 | 242.60 | -251.46 | -206.76 | -251.50 | -206.80 | -253.65 | -208.95 |
| NC5C - NC5S | 2 | 311.20 | 266.70 | -251.93 | -207.43 | -251.91 | -207.41 | -253.99 | -209.49 |
| | | *Misclosure* | | | 0.66 | | 0.62 | | 0.54 |
| | | *Mean* | | | -207.10 | | -207.10 | | -209.22 |

"No" in Table 6 indicates the measurement period at NICT, where No. 1 denotes preliminary measurements and No. 2 denotes closure measurements.

Table 7 shows the ΔSYSDLY values for the NAOJ receivers with respect to the traveling receiver. *Note* (∗1): Timetrace I with the $\mathrm{REFDLY}_V$ value introduced a-priori in the CGGTTS

Table 7: Computed ΔSYSDLY values for the visited system with respect to the traveling system (all values in ns).

| *Pair* | $REF_T$ | $REF_V$ | *C1 (ns)* | |
|---|---|---|---|---|
| | | | *CCD* | ΔSYS |
| NC5C - NAT2 | 56.60 | ∗1 | -85.91 | -29.31 |

header.

Table 8 shows the ΔINTDLY values for the NAOJ receiver with respect to the reference receivers. ΔSYSDLY in Table 8 was obtained from equation (4) and ΔINTDLY was obtained from equation (5).

$$\Delta\mathrm{SYSDLY}_{V-R} = \Delta\mathrm{SYSDLY}_{T-R} - \Delta\mathrm{SYSDLY}_{T-V} \quad (4)$$

$$\Delta\mathrm{INTDLY}_{V-R} = \Delta\mathrm{SYSDLY}_{V-R} - \mathrm{CABDLY}_V + \mathrm{CABDLY}_R \quad (5)$$

*Note* (∗2): Timetrace I with $\mathrm{CABDLY}_V$ value introduced a-priori in the CGGTTS header.

Table 8: Computed ΔINTDLY values for the visited systems with respect to the reference receivers (all values in ns).

| *Pair* | $CAB_V$ | $CAB_R$ | *C1 (ns)* | |
|---|---|---|---|---|
| | | | ΔSYS | ΔINT |
| NAT2 - NC4S | ∗2 | 0.0 | -60.57 | -60.57 |
| NAT2 - NC5S | ∗2 | 0.0 | -177.79 | -177.79 |

# 4 Uncertainty estimation

Table 9 shows the uncertainty of the calibration. The method of estimating the uncertainty is the same as that in [5].

Table 9: Uncertainty contributions. Values P3 are computed as $P1 + 1.545x(P1 - P2)$

| *Uncertainty* | *Value C1/P1 (ns)* | *Value P2 (ns)* | *Value P1 - P2 (ns)* | *Value P3 (ns)* | *Description* |
|---|---|---|---|---|---|
| $u_a(T-R)$ | 0.20 | 0.20 | 0.28 | | CCD (traveling - reference) |
| $u_a(T-V)$ | 1.00 | 0.00 | 1.00 | | CCD (traveling - visited) |
| $u_a$ | 1.02 | 0.20 | 1.04 | 1.90 | |
| Misclosure | | | | | |
| $u_{b,1}$ | 1.77 | 1.57 | 1.68 | 3.13 | Observed misclosure |
| Systematic components related to CCD | | | | | |
| $u_{b,11}$ | 0.05 | 0.05 | 0.05 | | Position error at reference |
| $u_{b,12}$ | 0.05 | 0.05 | 0.05 | | Position error at visited |
| $u_{b,13}$ | 0.30 | 0.30 | 0.42 | | Multipath at reference |
| $u_{b,14}$ | 0.30 | 0.30 | 0.42 | | Multipath at visited |
| Link from the traveling system to the local UTC(k) | | | | | |
| $u_{b,21}$ | 0.50 | 0.50 | 0.00 | | $\text{REFDLY}_T$ (at reference) |
| $u_{b,22}$ | 0.50 | 0.50 | 0.00 | | $\text{REFDLY}_T$ (at visited) |
| $u_{b,TOT}$ | 0.83 | 0.83 | 0.60 | 1.25 | |
| Link from the reference system to its local UTC(k) | | | | | |
| $u_{b,31}$ | 0.50 | 0.50 | 0.00 | | $\text{REFDLY}_R$ |
| Link from the visited system to its local UTC(k) | | | | | |
| $u_{b,32}$ | 0.50 | 0.50 | 0.00 | | $\text{REFDLY}_V$ |
| $u_{b,SYS}$ | 2.31 | 1.92 | 2.06 | 3.94 | |
| $u_{CAL}$ | | | | 3.94 | |

# Revision history

**Revision 0.1** Draft version.

**Revision 1.0** Initial version.

**Revision 1.1** Assign calibration id, and fix the missing of the SYSDLY in Table 4.

## References


[1] BIPM guidelines for GNSS calibration V4.0 05/08/2021.

[2] T.Gotoh, et al, Proc. 21th EFTF and IFCS, pp.1188—1193, 2007.

[3] http://www.rtklib.com/, online

[4] 2020 Group 1 GNSS calibration trip (Cal_Id 1001-2020), v1.2, 2021

[5] "4.4 Uncertainty estimation", Annex 4 Template for the calibration report, BIPM Guidelines for GNSS equipment calibration.

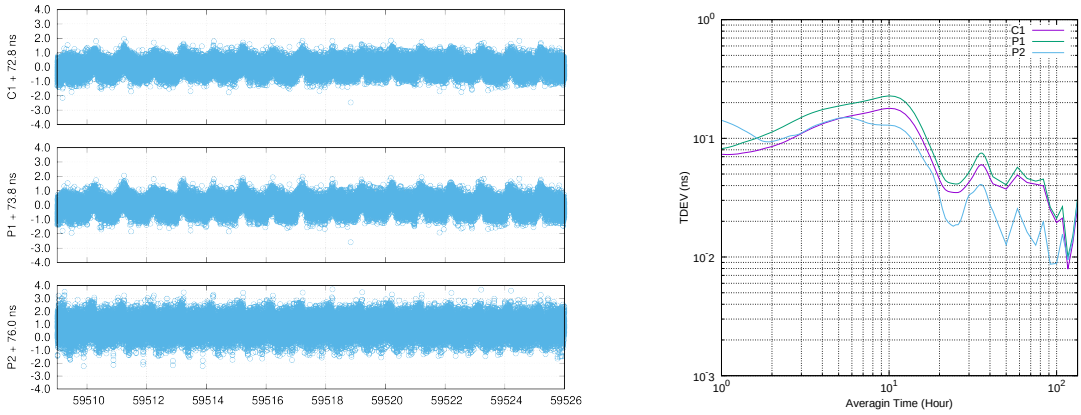




Figure 1: Common clock differences between NC5C and NC4S (preliminary).

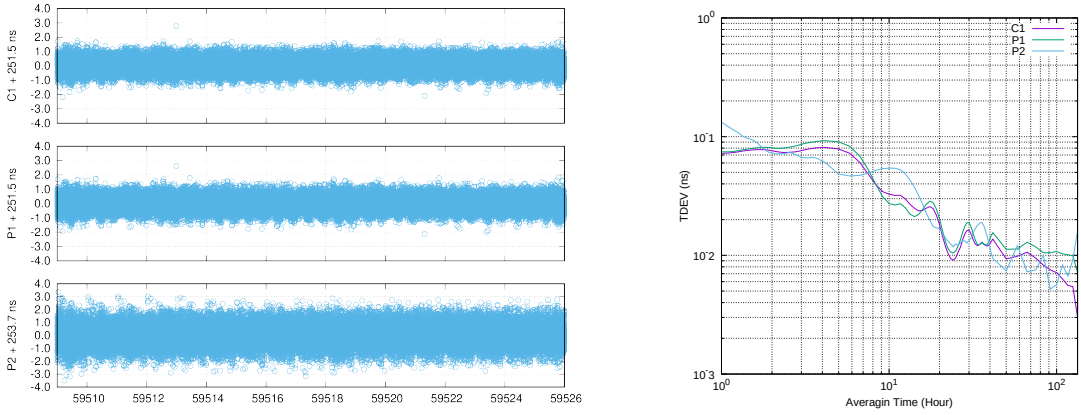



Figure 2: Common clock differences between NC5C and NC5S (preliminary).

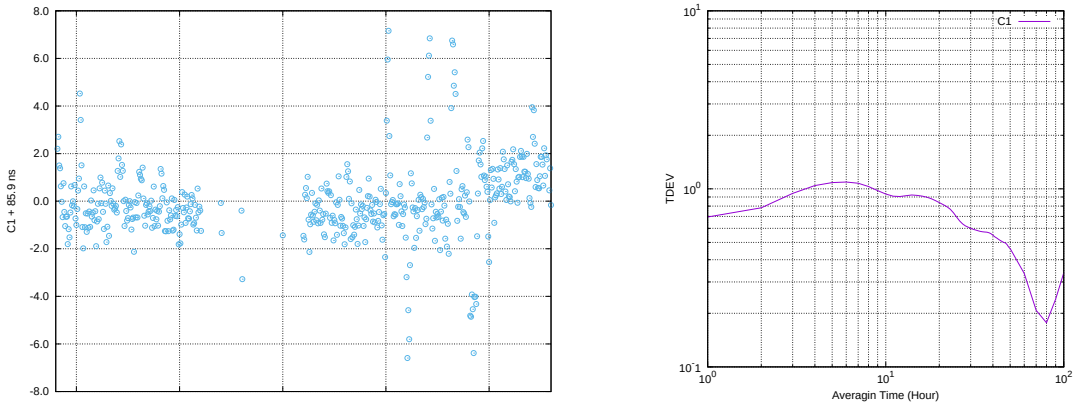



Figure 3: Common clock differences between NC5C and NAT2.

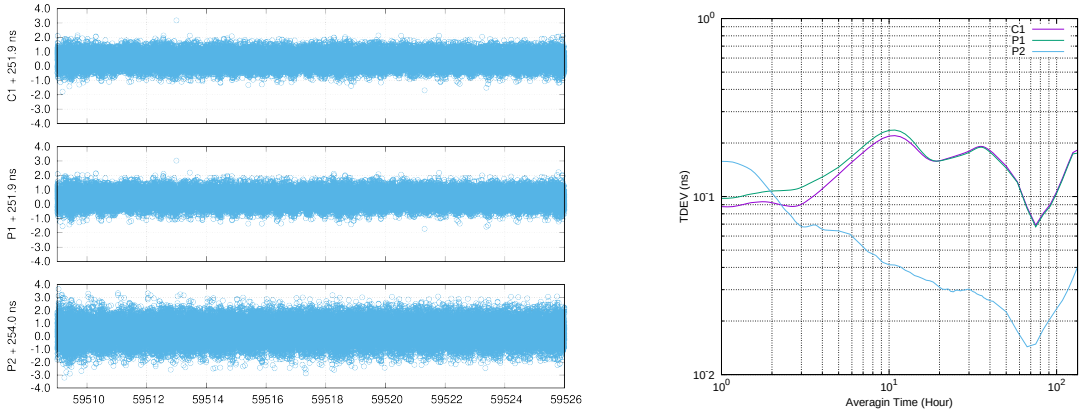



Figure 4: Common clock differences between NC5C and NC4S (closure).

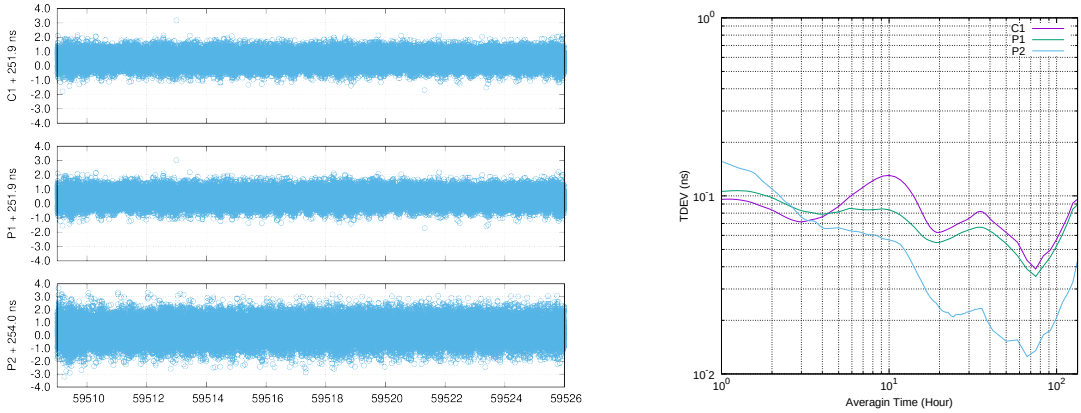



Figure 5: Common clock differences between NC5C and NC4S (closure).

# Annex A - Information Sheet

(to be repeated for each calibrated system)

| | |
|---|---|
| Laboratory: | National Institute of Information and Communication Technology |
| Date and hour of the beginning of measurements: | **22/10/2021** |
| Date and hour of the end of measurements: | **07/11/2021** |

## Information on the system

| | **Local:** | **Travelling:** |
|---|---|---|
| 4-character BIPM code | NC4S | NC5C |
| • Receiver maker and type:<br>Receiver serial number: | Septentrio PolaRx4 TR Pro<br>S/N: 3102252 | Septentrio PolaRx5 TR<br>S/N: 4701466 |
| 1 PPS trigger level /V: | | |
| • Antenna cable maker and type:<br>Phase stabilised cable (Y/N): | FUJIKURA 8D-SFA-LITE<br>Phase stabilized: No | FUJIKURA 5D-SFA-LITE<br>Phase stabilized: No |
| Length outside the building /m: | | |
| • Antenna maker and type:<br>Antenna serial number: | AeroAntenna AT1675-120SW<br>S/N: 5411 | NovAtel GPS-703-GGG<br>NEG14320005 |
| 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: | 166.1 ns | 239.4 ns |
| Delay from 1 PPS-in to internal Reference (if different):<br>(see section 2 for details) | 137.1 ns<br>(166.1 + 137.1 = 303.2 ns) | 47.9 ns<br>(239.4 + 47.9 = 287.3 ns) |
| • Antenna cable delay: | | 157.5 ns |
| Splitter delay (if any): | | |
| Additional cable delay (if any): | | |

## Data used for the generation of CGGTTS files

| | |
|---|---|
| • INT DLY (GPS) /ns: | 278.6 ns (C1), 277.4 ns (P1), 276.8 ns (P2) |
| • INT DLY (Galileo) /ns: | |
| • INT DLY (GLONASS) /ns: | |
| • CAB DLY /ns: | |
| • REF DLY /ns: | 303.3 ns |
| • Coordinates reference frame: | |
| Latitude or X /m: | -3942091.42 m |
| Longitude or Y /m: | 3368261.97 m |
| Height or Z /m: | 3701993.35 m |

## General information

| | |
|---|---|
| • Rise time of the local UTC pulse: | |
| • Is the laboratory air conditioned: | Yes |
| Set temperature value and uncertainty: | 24 degree C |
| Set humidity value and uncertainty: | 40 % |

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

# Annex A - Information Sheet

(to be repeated for each calibrated system)

| | |
|---|---|
| Laboratory: | National Institute of Information and Communication Technology |
| Date and hour of the beginning of measurements: | **22/10/2021** |
| Date and hour of the end of measurements: | **07/11/2021** |

## Information on the system

| | **Local:** | **Travelling:** |
|---|---|---|
| 4-character BIPM code | NC5S | NC5C |
| • Receiver maker and type:<br>Receiver serial number: | Septentrio PolaRx5 TR<br>S/N: 4701293 | Septentrio PolaRx5 TR<br>S/N: 4701466 |
| 1 PPS trigger level /V: | | |
| • Antenna cable maker and type:<br>Phase stabilised cable (Y/N): | FUJIKURA 8D-SFA-LITE<br>Phase stabilized: No | FUJIKURA 5D-SFA-LITE<br>Phase stabilized: No |
| Length outside the building /m: | | |
| • Antenna maker and type:<br>Antenna serial number: | NovAtel GPS-703-GGG-MV<br>NMFV16270013R | NovAtel GPS-703-GGG<br>NEG14320005 |
| 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: | 210.0 ns | 239.4 ns |
| Delay from 1 PPS-in to internal Reference (if different):<br>(see section 2 for details) | 32.6 ns<br>(210.0 + 32.6 = 242.6 ns) | 47.9 ns<br>(239.4 + 47.9 = 287.3 ns) |
| • Antenna cable delay: | | 157.5 ns |
| Splitter delay (if any): | | |
| Additional cable delay (if any): | | |

## Data used for the generation of CGGTTS files

| | |
|---|---|
| • INT DLY (GPS) /ns: | 393.4 ns (P1), 392.6 ns (P2) |
| • INT DLY (Galileo) /ns: | |
| • INT DLY (GLONASS) /ns: | |
| • CAB DLY /ns: | |
| • REF DLY /ns: | 242.6 ns |
| • Coordinates reference frame: | |
| Latitude or X /m: | -3942090.07 m |
| Longitude or Y /m: | 3368263.35 m |
| Height or Z /m: | 3701993.60 m |

## General information

| | |
|---|---|
| • Rise time of the local UTC pulse: | |
| • Is the laboratory air conditioned: | Yes |
| Set temperature value and uncertainty: | 24 degree C |
| Set humidity value and uncertainty: | 40 % |

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

# Annex A - Information Sheet

(to be repeated for each calibrated system)

| | |
|---|---|
| Laboratory: | National Institute of Information and Communication Technology |
| Date and hour of the beginning of measurements: | **04/02/2022** |
| Date and hour of the end of measurements: | **20/02/2022** |

## Information on the system

| | **Local:** | **Travelling:** |
|---|---|---|
| 4-character BIPM code | NC4S | NC5C |
| • Receiver maker and type:<br>Receiver serial number: | Septentrio PolaRx4 TR Pro<br>S/N: 3102252 | Septentrio PolaRx5 TR<br>S/N: 4701466 |
| 1 PPS trigger level /V: | | |
| • Antenna cable maker and type:<br>Phase stabilised cable (Y/N): | FUJIKURA 8D-SFA-LITE<br>Phase stabilized: No | FUJIKURA 5D-SFA-LITE<br>Phase stabilized: No |
| Length outside the building /m: | | |
| • Antenna maker and type:<br>Antenna serial number: | AeroAntenna AT1675-120SW<br>S/N: 5411 | NovAtel GPS-703-GGG<br>NEG14320005 |
| 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: | 167.9 ns | 264.2 ns |
| Delay from 1 PPS-in to internal Reference (if different):<br>(see section 2 for details) | 147.7 ns<br>(167.9 + 147.7 = 315.6 ns) | 47.0 ns<br>(264.2 + 47.0 = 311.2 ns) |
| • Antenna cable delay: | | 157.5 ns |
| Splitter delay (if any): | | |
| Additional cable delay (if any): | | |

## Data used for the generation of CGGTTS files

| | |
|---|---|
| • INT DLY (GPS) /ns: | 278.6 ns (C1), 277.4 ns (P1), 276.8 ns (P2) |
| • INT DLY (Galileo) /ns: | |
| • INT DLY (GLONASS) /ns: | |
| • CAB DLY /ns: | |
| • REF DLY /ns: | 314.1 ns |
| • Coordinates reference frame: | |
| Latitude or X /m: | -3942091.42 m |
| Longitude or Y /m: | 3368261.97 m |
| Height or Z /m: | 3701993.35 m |

## General information

| | |
|---|---|
| • Rise time of the local UTC pulse: | |
| • Is the laboratory air conditioned: | Yes |
| Set temperature value and uncertainty: | 24 degree C |
| Set humidity value and uncertainty: | 40 % |

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

# Annex A - Information Sheet

(to be repeated for each calibrated system)

| | |
|---|---|
| Laboratory: | National Institute of Information and Communication Technology |
| Date and hour of the beginning of measurements: | **04/02/2022** |
| Date and hour of the end of measurements: | **20/02/2022** |

## Information on the system

| | **Local:** | **Travelling:** |
|---|---|---|
| 4-character BIPM code | NC5S | NC5C |
| • Receiver maker and type:<br>Receiver serial number: | Septentrio PolaRx5 TR<br>S/N: 4701293 | Septentrio PolaRx5 TR<br>S/N: 4701466 |
| 1 PPS trigger level /V: | | |
| • Antenna cable maker and type:<br>Phase stabilised cable (Y/N): | FUJIKURA 8D-SFA-LITE<br>Phase stabilized: No | FUJIKURA 5D-SFA-LITE<br>Phase stabilized: No |
| Length outside the building /m: | | |
| • Antenna maker and type:<br>Antenna serial number: | NovAtel GPS-703-GGG-MV<br>NMFV16270013R | NovAtel GPS-703-GGG<br>NEG14320005 |
| 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: | 210.0 ns | 264.2 ns |
| Delay from 1 PPS-in to internal Reference (if different):<br>(see section 2 for details) | 56.7 ns<br>(210.0 + 56.7 = 266.7 ns) | 47.0 ns<br>(264.2 + 47.0 = 311.2 ns) |
| • Antenna cable delay: | | 157.5 ns |
| Splitter delay (if any): | | |
| Additional cable delay (if any): | | |

## Data used for the generation of CGGTTS files

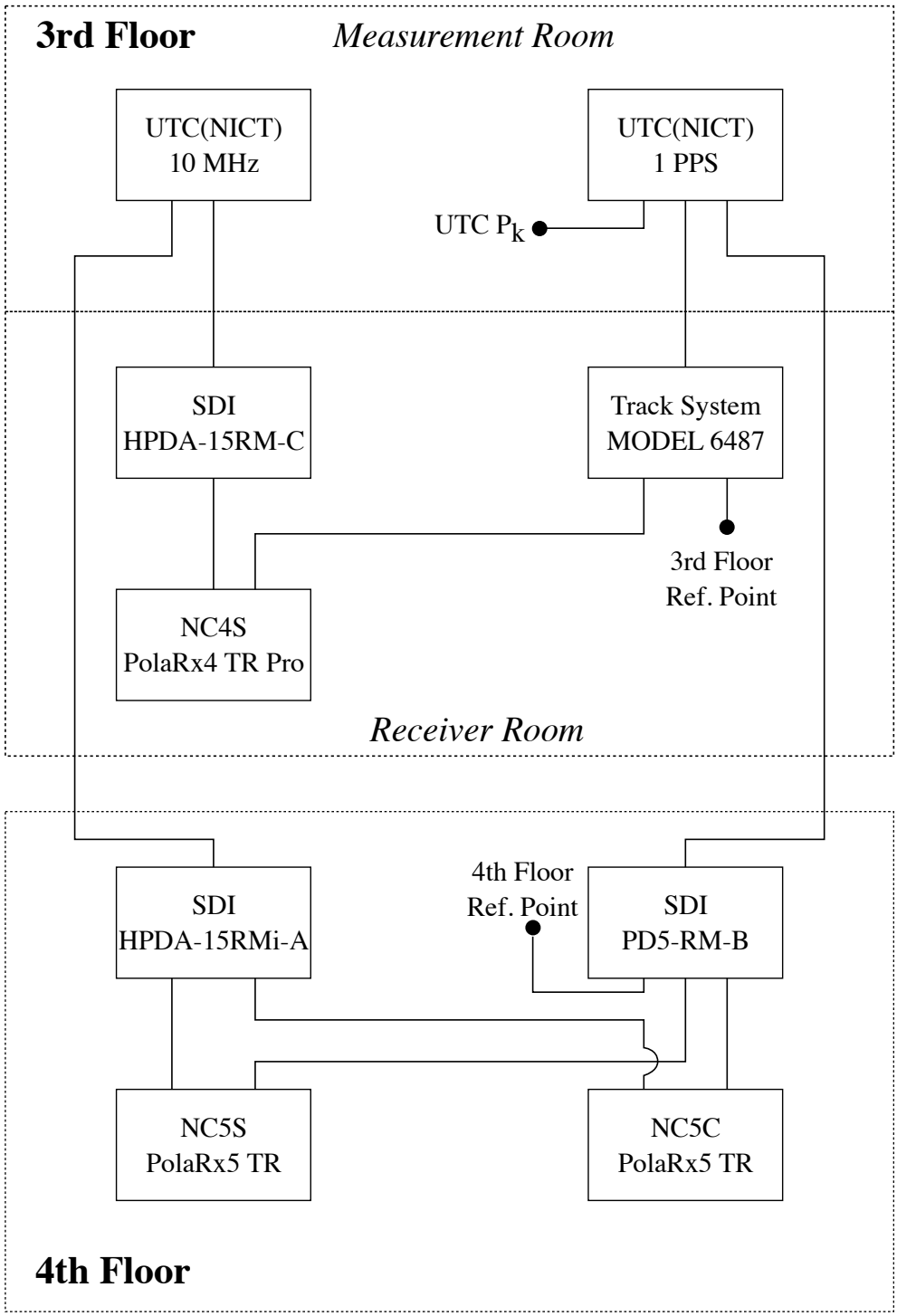
| | |
|---|---|
| • INT DLY (GPS) /ns: | 393.4 ns (P1), 392.6 ns (P2) |
| • INT DLY (Galileo) /ns: | |
| • INT DLY (GLONASS) /ns: | |
| • CAB DLY /ns: | |
| • REF DLY /ns: | 265.4 ns |
| • Coordinates reference frame: | |
| Latitude or X /m: | -3942090.07 m |
| Longitude or Y /m: | 3368263.35 m |
| Height or Z /m: | 3701993.60 m |

## General information

| | |
|---|---|
| • Rise time of the local UTC pulse: | |
| • Is the laboratory air conditioned: | Yes |
| Set temperature value and uncertainty: | 24 degree C |
| Set humidity value and uncertainty: | 40 % |

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

# Diagram of the experiment set-up:



# Annex A - Information Sheet

(to be repeated for each calibrated system)

| | |
|---|---|
| Laboratory: | National Astronomical Observatory of Japan |
| Date and hour of the beginning of measurements: | November 16, 2021 00:30 UT |
| Date and hour of the end of measurements: | December 10, 2021 01:30 UT |

## Information on the system

| | **Local:** | **Travelling:** |
|---|---|---|
| 4-character BIPM code | NAO | NC5C |
| • Receiver maker and type:<br>Receiver serial number: | Time and Frequency Solutions<br>Timetrace I SN 154 | Septentrio PolaRx5 TR<br>SN 4701466 |
| 1 PPS trigger level /V: | | |
| • Antenna cable maker and type:<br>Phase stabilised cable (Y/N): | <br>No | FUJIKURA 5D-SFA-LITE<br>No |
| Length outside the building /m: | 10m | 25m |
| • Antenna maker and type:<br>Antenna serial number: | Trimble PN57860-10<br>SN 29860047 | NovAtel GPS-703-GGG<br>NEG14320005 |
| 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: | 0.0 | 12.4 ns |
| Delay from 1 PPS-in to internal Reference (if different):<br>(see section 2 for details) | | 44.2 ns<br>(12.4 + 44.2 = 56.6 ns) |
| • Antenna cable delay: | 170.8ns (correctly 130.8ns) | 157.5 ns |
| Splitter delay (if any): | | |
| Additional cable delay (if any): | | |

## Data used for the generation of CGGTTS files

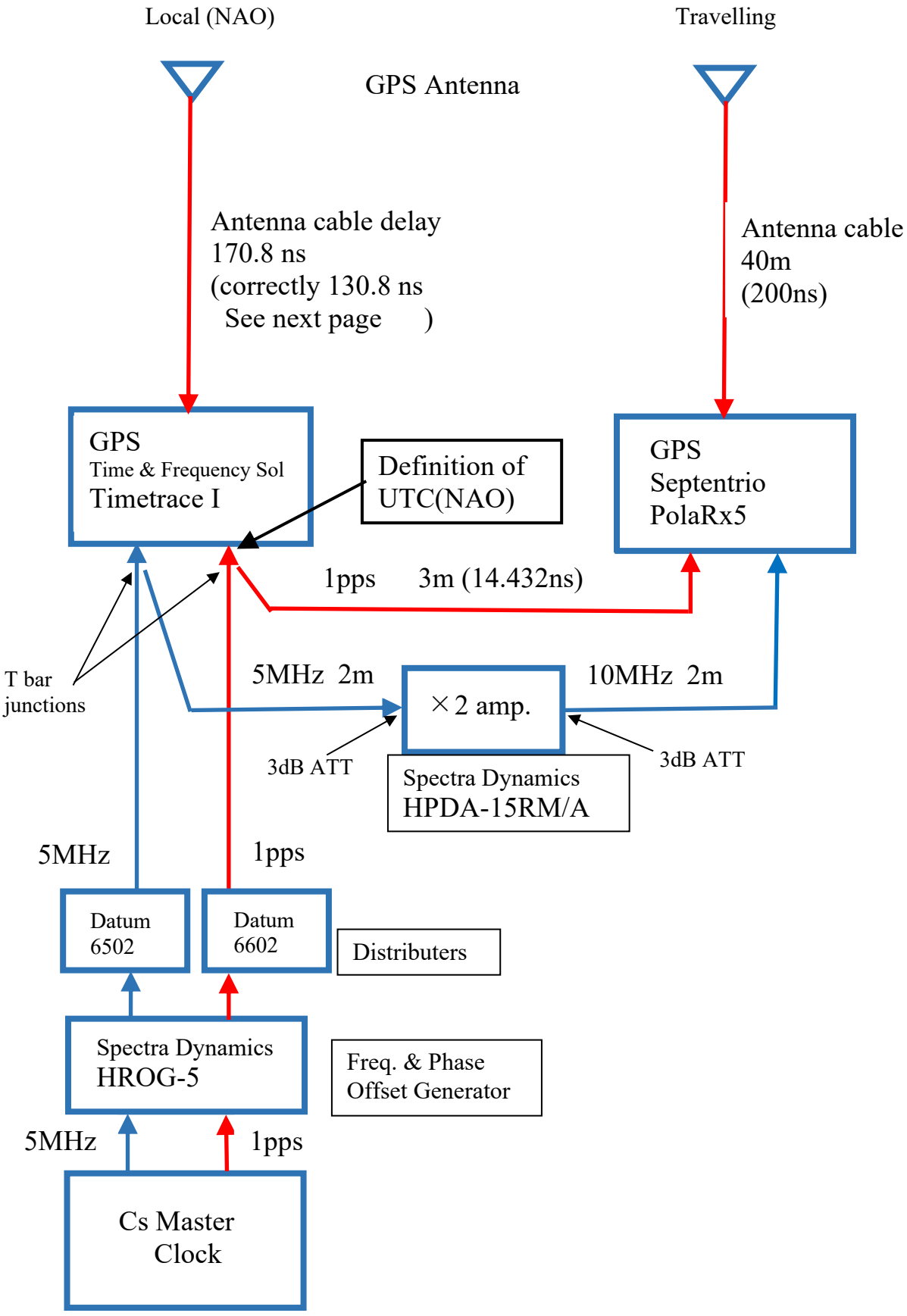
| | |
|---|---|
| • INT DLY (GPS) /ns: | -16.1 ns |
| • INT DLY (Galileo) /ns: | - |
| • INT DLY (GLONASS) /ns: | - |
| • CAB DLY /ns: | 170.8 |
| • REF DLY /ns: | 241.9 ns |
| • Coordinates reference frame: | GRS80 |
| Latitude or X /m: | 39.1350999 N |
| Longitude or Y /m: | 141.1335140 E |
| Height or Z /m: | 113.79 m |

## General information

| | |
|---|---|
| • Rise time of the local UTC pulse: | - |
| • Is the laboratory air conditioned: | Yes |
| Set temperature value and uncertainty: | 24.00 ± 0.05 ℃ |
| Set humidity value and uncertainty: | 50.0 ± 0.5 % |

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

## Diagram of the experiment set-up:



# Log of Events / Additional Information :

We adopt antenna cable delay of 170.8ns. It is not correct. We replace the GPS antenna and cable in December 2020. At that time, we did not measure the cable delay. We used the same cable delay value. The cable length differs 8m and we consider that the value is 40ns larger than the real cable delay. The cable delay might be 130.8ns. Thus our GPS observation result might be 40ns delay.