

# Calibration Report for PolaRx5TR-3046630 + SEPCHOKE\_B3E6-5460

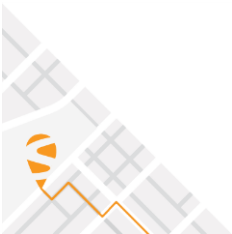
**Receiver:** PolaRx5TR sn#3046630  
**Antenna:** SEPCHOKE\_B3E6 sn#5460  
**Cable:** RG213, 40 meters

**Calibration date:** February 11, 2019

## Calibration results:

Delay	GPS P1 (ns)	GPS P2 (ns)	Uncertainty (ns)
<b>SYSDLY</b>	<b>232.12</b>	<b>232.78</b>	<b>1</b>
<b>CABDLY</b>	<b>204.41</b>	<b>204.41</b>	<b>0.5</b>
<b>INTDLY</b>	<b>27.71</b>	<b>28.37</b>	<b>1.1</b>

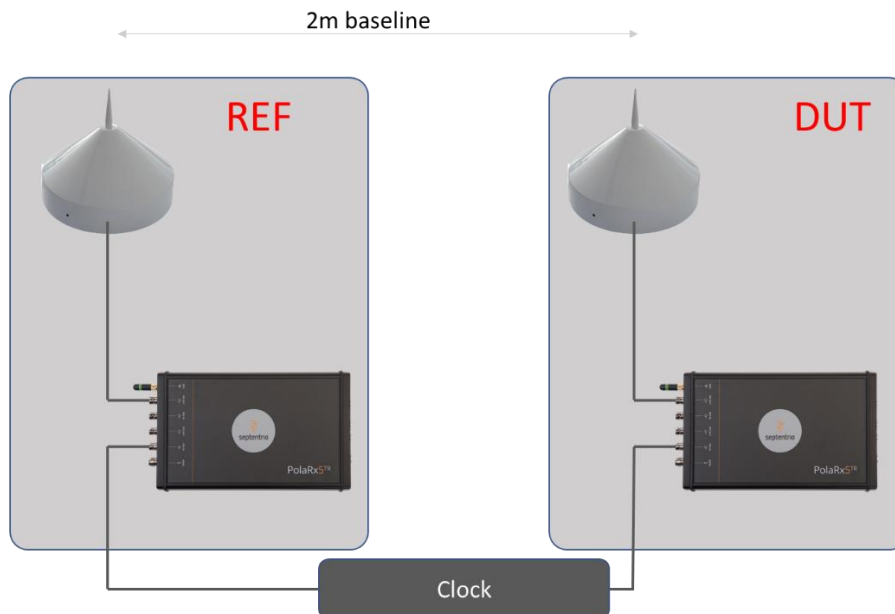
SYSDLY is the sum of the delays in the antenna, antenna cable and receiver. CABDLY is the delay in the antenna cable, and INTDLY is the delay in the antenna and receiver.  
 $INTDLY = SYSDLY - CABDLY$ .



## Calibration Procedure

Septentrio maintains a calibrated reference station (REF station) at its head office in Leuven, Belgium. The REF station consists in a receiver, antenna and cable that have been calibrated by an independent time laboratory. The details of this reference calibration and its traceability to the BIPM are provided in the “REF Station Calibration” section below.

The calibration of a new station (referred to as DUT, “Device Under Test”) is performed against the REF station. The DUT station is installed in a common clock setup with the REF station, with a short baseline between the REF and the DUT antennas (<2m distance), as illustrated below.



The total delay in the DUT antenna, cable and receiver ( $SYSDLY_{DUT}$ ) is obtained from the difference between the pseudoranges measured by the DUT and REF receivers (corrected for the baseline between the two antennas), using the following formula:

$$SYSDLY_{DUT} = \frac{\langle P_{DUT} - P_{REF} \rangle}{\Delta P} + \frac{REFDLY_{DUT} - REFDLY_{REF}}{\Delta R} + SYSDLY_{REF}$$

Where:

- $\Delta P$  is the difference between the DUT and REF pseudoranges, corrected for the antenna baseline and averaged over all satellites over a period of two days.
- $\Delta R$  is the time difference between the measurement latching instant of the two receivers.  $\Delta R$  is obtained by measuring the delay between the REF and the DUT PPSout pulses with an oscilloscope. For this measurement, the PPSout of both receivers are configured to be synchronous with the measurement latching.

- $\text{SYSDLY}_{\text{REF}}$  is the delay of the REF station, as calibrated by the time laboratory: 157.15ns for P1 and 174.76ns for P2. See details in the “REF Station Calibration” section below.

The measured delays and their uncertainties are listed in the table below.

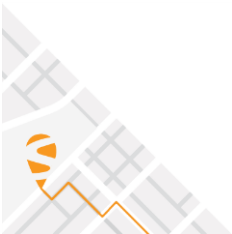
Quantity	P1 (ns)	P2 (ns)	Uncertainty (ns -1 $\sigma$ )
$\Delta P$	73.85	76.90	0.5
$\Delta R$	1.12	1.12	0.3
$\text{SYSDLY}_{\text{REF}}$	157.15	154.76	0.72
<b><math>\text{SYSDLY}_{\text{DUT}}</math></b>	<b>232.12</b>	<b>232.78</b>	<b>0.93</b>

The cable delay, including the delay in the TNC to N-type adaptor at the antenna side, has been measured using a vector network analyzer:

Quantity	Delay (ns)	Uncertainty (ns -1 $\sigma$ )
<b><math>\text{CABDLY}_{\text{DUT}}</math></b>	<b>204.41</b>	<b>0.5</b>

$\text{INTDLY}$  is the difference between  $\text{SYSDLY}$  and  $\text{CABDLY}$ . It is the sum of the signal delay in the antenna and receiver:

Quantity	P1 (ns)	P2 (ns)	Uncertainty (ns -1 $\sigma$ )
<b><math>\text{INTDLY}_{\text{DUT}}</math></b>	<b>27.71</b>	<b>28.37</b>	<b>1.1</b>




## REF Station Calibration

The REF station consists of the following elements:

- Receiver: PolaRx5TR sn#3021113
- Antenna: SEPCHOKE-B3E6 sn#5020
- Cable: RG213 25 meter.

These elements have been calibrated by the Royal Observatory of Belgium (ROB) in October 2017. Calibration was organized by installing the REF station in a common clock setup at the ROB for a duration of 1 week.

This calibration determined the receiver+antenna+cable delay (SYSDLY) applicable to the GPS P1 and P2 signals in the REF station. A copy of the frontpage of the calibration report is provided below for reference.



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### CALIBRATION REPORT

Station : SEPT  
Located in : Leuven (Septentrio) but calibrated in Brussels at the Royal Observatory of Belgium, avenue Circulaire, 3 – B-1180 Brussels  
Receiver : Septentrio POLARX5-TR SN 3021113  
Antenna : SEPCHOKE-B3E6 SN 5020

Date of Issue: October 30, 2017.

Author: Pascale Defraigne (ORB)

FINAL RESULTS		
	GPS P1	GPS P2
Delay (ns)	157.15	154.76
1 $\sigma$ uncertainty (ns)	0.72	0.70

The reference station for this calibration was BRUX, a Septentrio PolaRx4 receiver located in ROB. This receiver was relatively calibrated by the Observatoire de Paris in the frame of

a G2 calibration campaign during spring 2017, with calibration ID 1018-2017 (report available at <ftp://ftp2.bipm.org/pub/tai/publication/gnss-calibration/group2/2017/1018-2017/>).

Table 1 presents a summary of the equipment used for the REF calibration at ROB.

	BRUX	Septentrio REF station
<b>Receiver</b>	PolaRx4TR PRO sn#3001376	PolaRx5TR sn#3021113
<b>Antenna</b>	JAVRINGANT_DM sn#00464	SPECHOKE_B3E6 sn#5020
<b>X coordinate (m)</b>	4027881.71	4027862.26
<b>Y coordinate (m)</b>	306998.73	307028.09
<b>Z coordinate (m)</b>	4919499.37	4919508.61
<b>REFDLY (ns)</b>	149.77	91.31
<b>CABDLY (ns)</b>	237.00	126.72

The position of the phase centers of both antennas have been determined using the PPP Software tool named Atomium\_PPP and developed at the ROB.

The REFDLY corresponds to the difference between the internal clock of the receiver and the laboratory reference which was UTC(ORB) in this case. It has been measured using a Time Interval Counter (TIC) with a trigger at 1V using the double-weighing method.

CABDLY corresponds to the antenna cable delay. It was measured using an Anritsu site master s332E which is an extension of a usual scalar network analyzer especially designed for cable analysis and endowed with frequency domain reflectometry (FDR) capabilities.

