

Multipath test report in Urban Canyon with Spirent

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Revision History

Version	Change contents	Date
0	Initial release	2023.04.13

Intoroduction

In Global Navigation Satellite Systems (GNSS), the overcoming of multipath is one of the most important aims in the current GNSS receiver technology. GNSS signals are subject to various errors and distortions from multipath interference which can significantly affect the accuracy and reliability of position measurements. Multipath interference is a major source of error in GNSS measurements, caused by the reflection, refraction, and diffraction of signals from the satellite to the receiver. Multipath signals can arrive at the receiver with a delay and phase shift relative to the direct line-of-sight or non-line-of-sight signal, leading to errors in the timing solutions. In this report, we present the results of various GNSS receivers for the multipath test that was conducted to evaluate the performance cooperating with the Spirent™ simulator.

Purpose

The purpose of this report is to present the results of a GNSS multipath test that was performed with the Spirent™ simulator based on the mutually agreed **SOW0195** between Furuno and Spirent to assess the impact of multipath interference on the accuracy and reliability of timing measurements. Furuno asked Spirent to confirm the effectiveness of anti-multipath algorithm, "Dynamic Satellite Selection™ (DSS)".

The test was conducted under controlled conditions using several commercial receivers which are available in the current market and the Spirent simulator equipped with the multipath simulation feature. The results of this test can be used to inform how the multipath can impact the timing accuracy, as well as to inform the selection of a suitable receiver to mitigate the multipath interference.



1 PPS time error measurements tests (SOW0195)

for Furuno

Spirent Professional Services



As per SOW0195 Issue 1-01 [5], the customer's DUT was tested under strong multipath conditions in the San Francisco scene and the logs, and csv files, for all the tests have been provided. The simulated position was the following:

- Lat: 37.79013
- Lon: - 122.400792583
- Alt (Orthometric): 80.763 m

The customer's DUT was tested under the following 3 test cases:

- An initial 12hour open-sky run (with no Multipath) to set the baseline for the unit.
- A 12hour run with the DSS algorithm turned off and Multipath turned on
- A 12hour run with the DSS algorithm turned on and Multipath turned on

As for the rest of the timing receivers, the tests were the following:

- A 12hour Open Sky run (Multipath off)
- A 12hour run with Multipath on

Notes:

1. For the multipath runs, it was made sure always 1 LOS signal was available to the receiver, without any NLOS signals allocated to it.
2. For each LOS, two NLOS signals were simulated.

The actual simulated scene can be found in the Figures below:

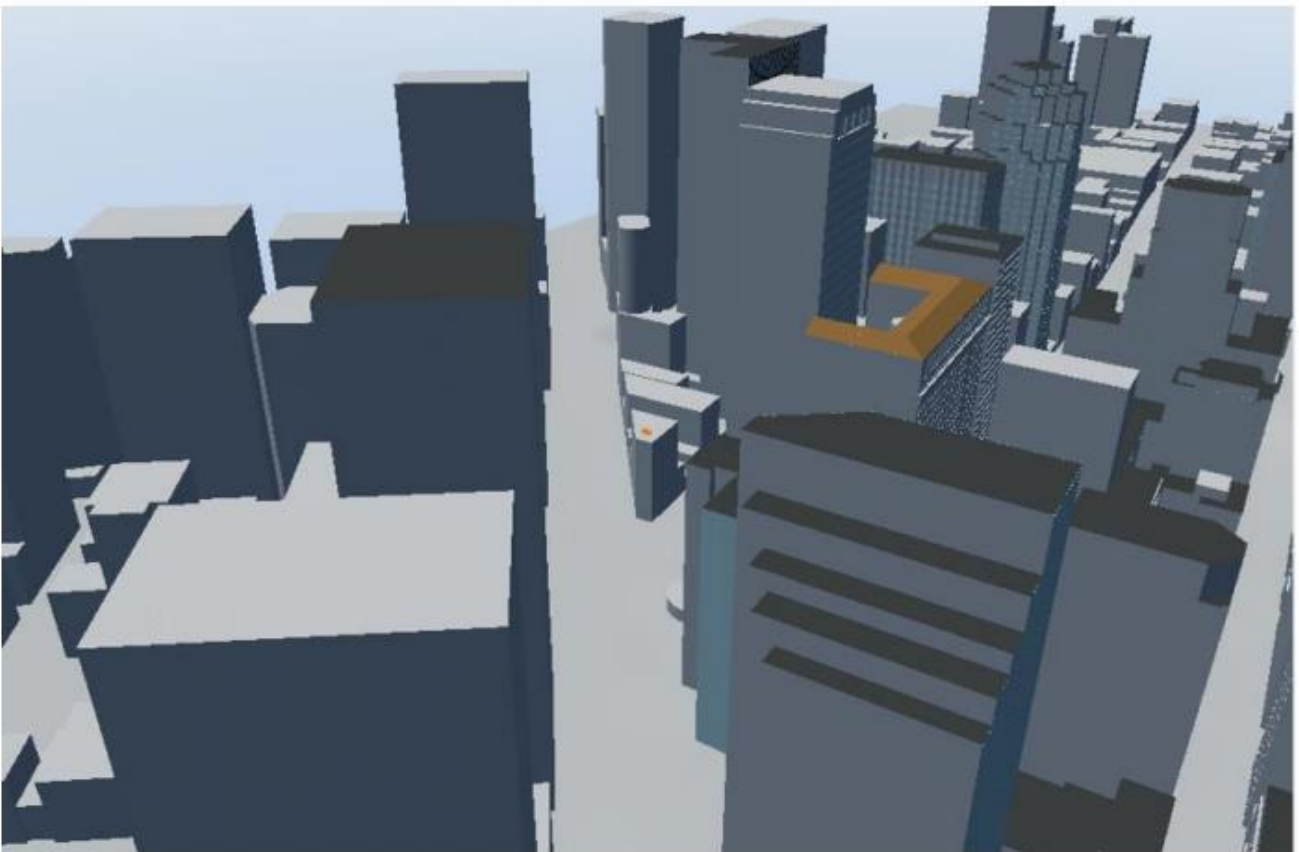


Figure 1: simulated scene (no MP applied)

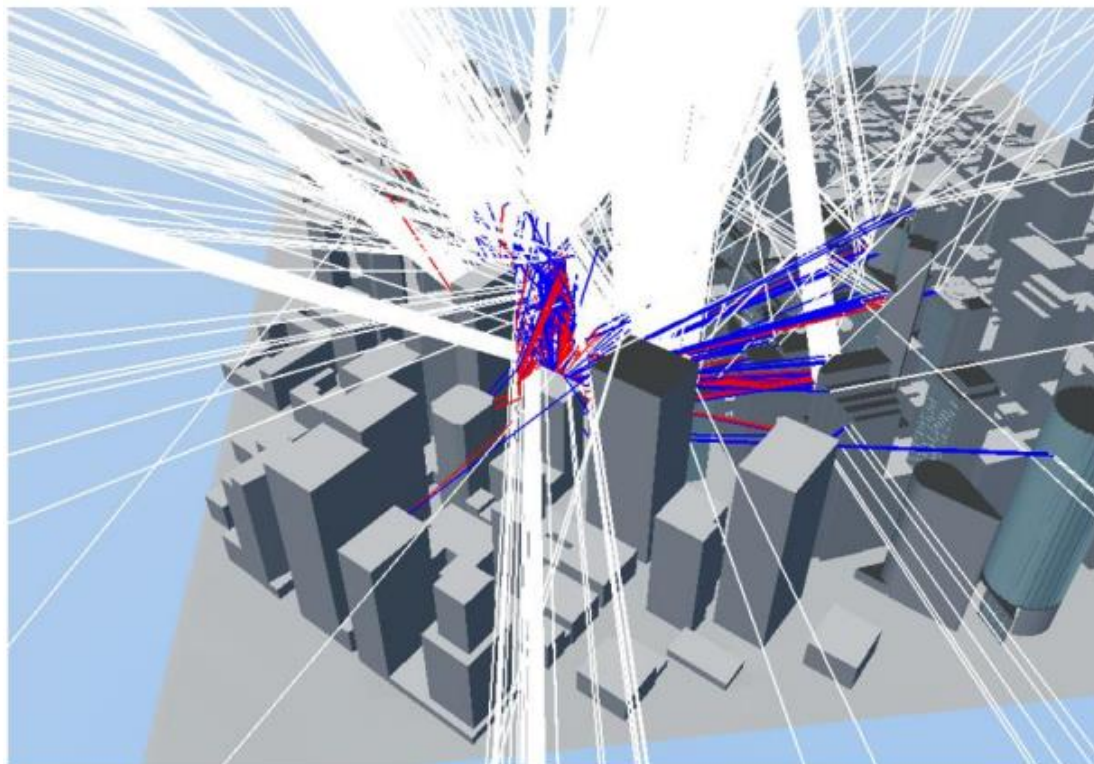


Figure 2: simulated scene (with applied MP¹)

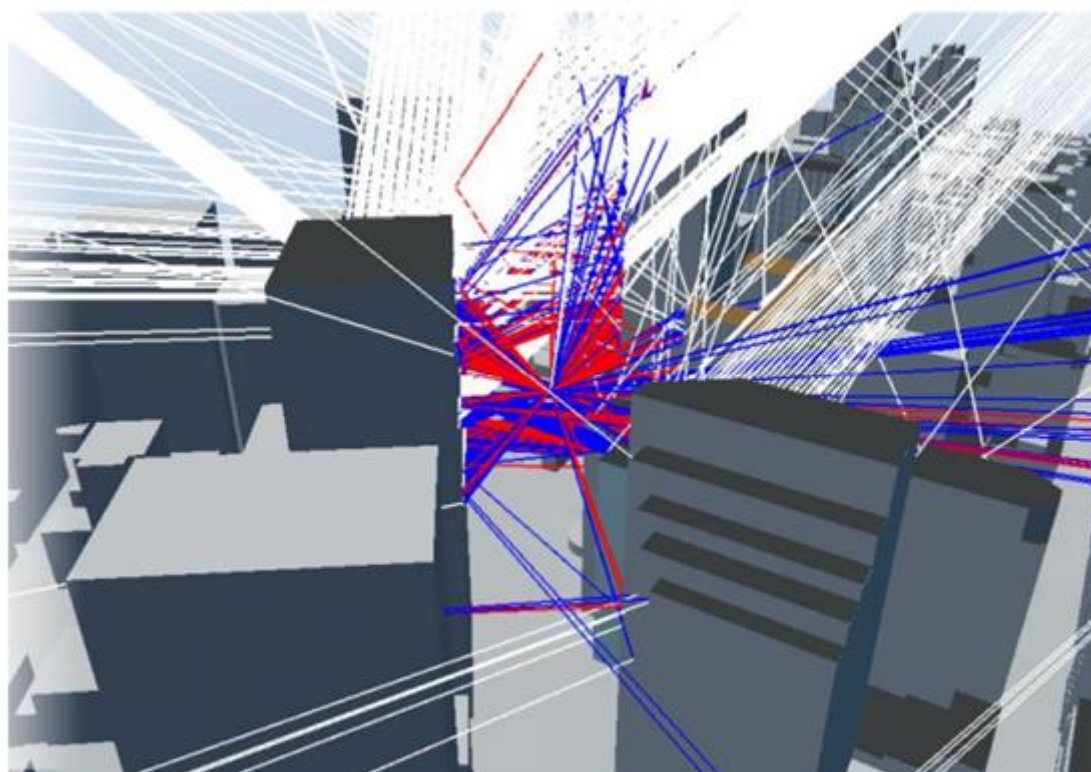
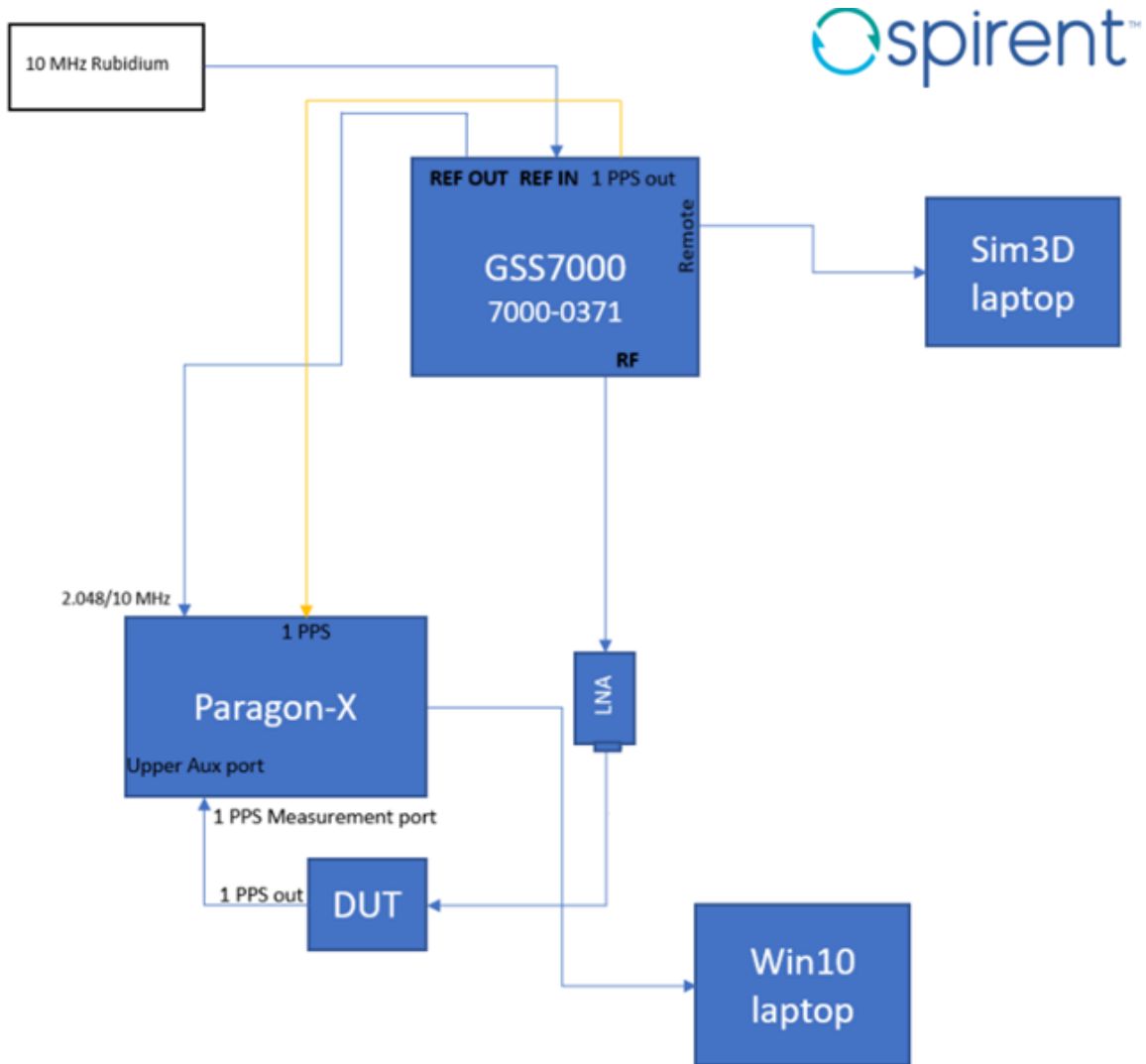


Figure 3: simulated scene - close-up (with applied MP)

¹ The white rays represent the Line of Sight (LOS) signals, the blue rays the diffracted signals and the red rays the reflected signals.

For all the tests, the position was provided manually in order to reduce the testing time. The set-up used is the one shown in the Figure below.

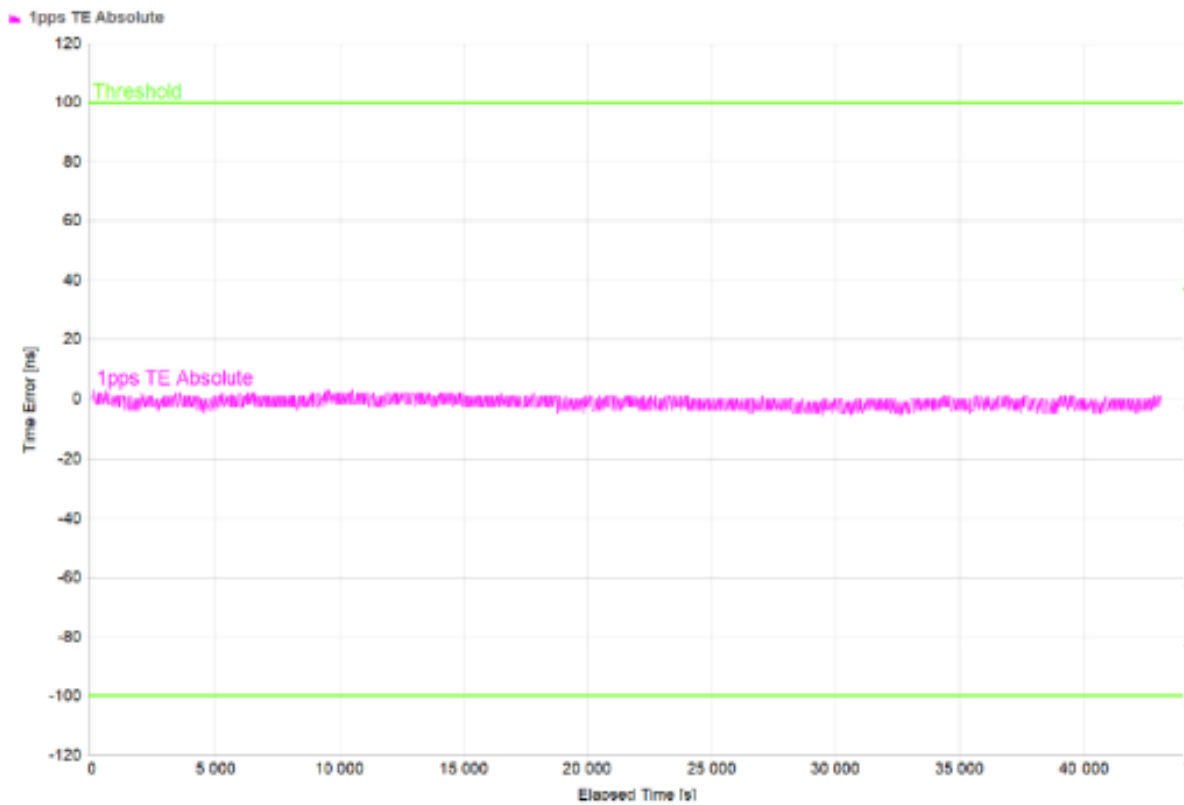


Below test result is to measure with Furuno's GT-88 Single GNSS receiver under the open sky view as a base reference.



Time Error Analysis

Offset Removal Applied	Off
Zero Offset	1 ns



Mean [ns]	-1.345
Min [ns]	-6
Max [ns]	3
Max-Min [ns]	9

Followed three test results are to measure with Furuno's GT-88 Single GNSS receiver under the urban canyon environment with many multipath signals.



Time Error Analysis

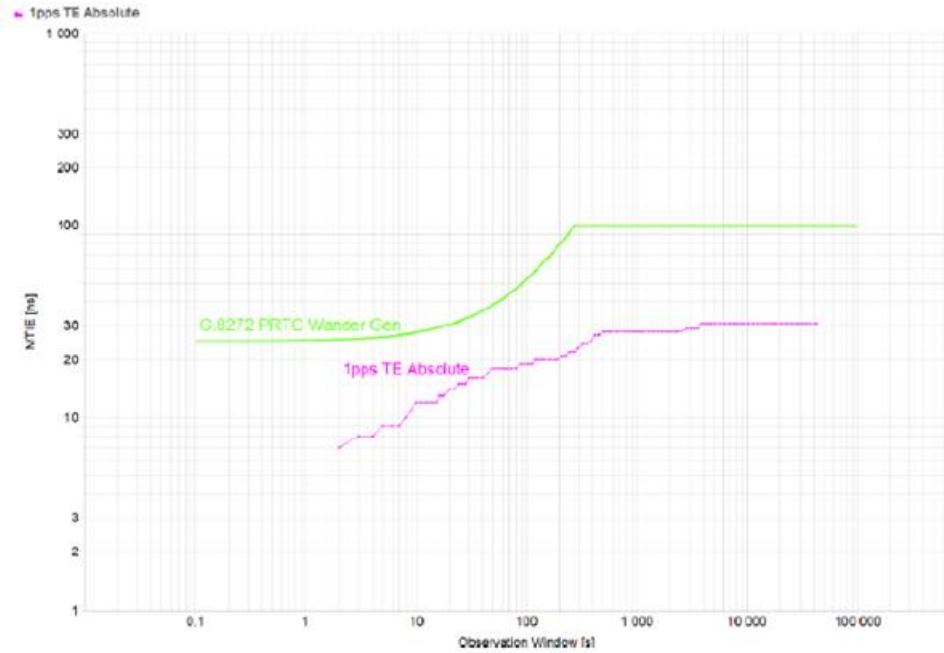
Offset Removal Applied	Off
Zero Offset	-2 ns



Mean [ns]	-0.387
Min [ns]	-23
Max [ns]	8
Max-Min [ns]	31



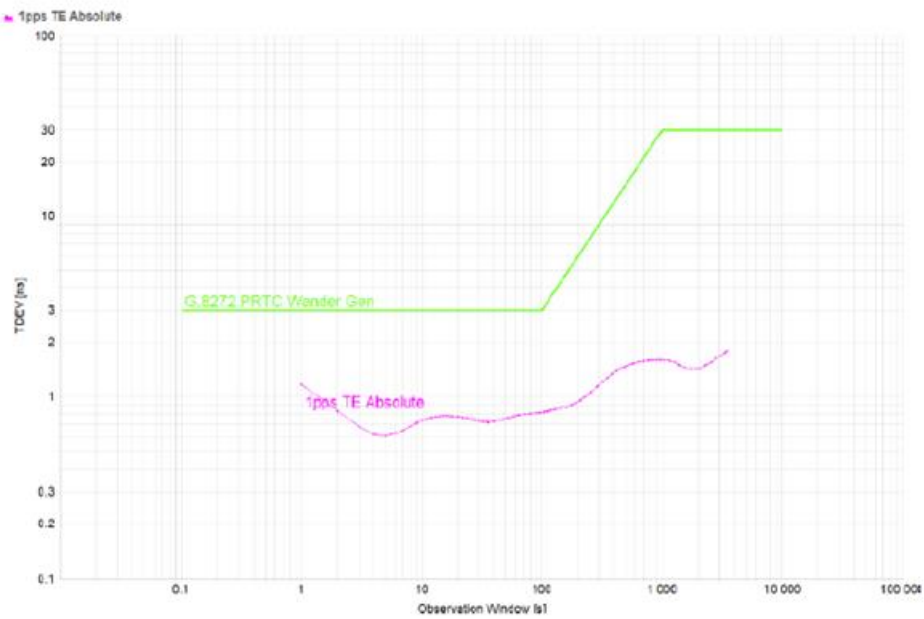
MTIE Analysis



Min [ns]	7
Max [ns]	31
Max-Min [ns]	24



TDEV Analysis



Min [ns]	0.603
Max [ns]	1.791
Max-Min [ns]	1.188

Followed three test results are to measure the PRTC(Not Furuno Product) configured as a Single GNSS receiver under the urban canyon environment with many multipath signals.



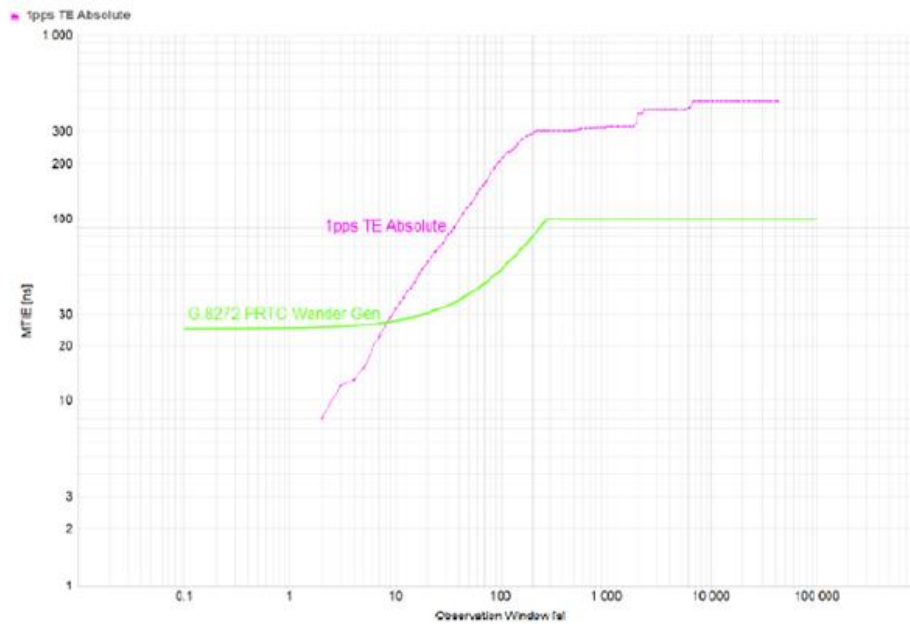
Offset Removal Applied	Off
Zero Offset	-20 ns



Mean [ns]	-24.056
Min [ns]	-326
Max [ns]	112
Max-Min [ns]	438



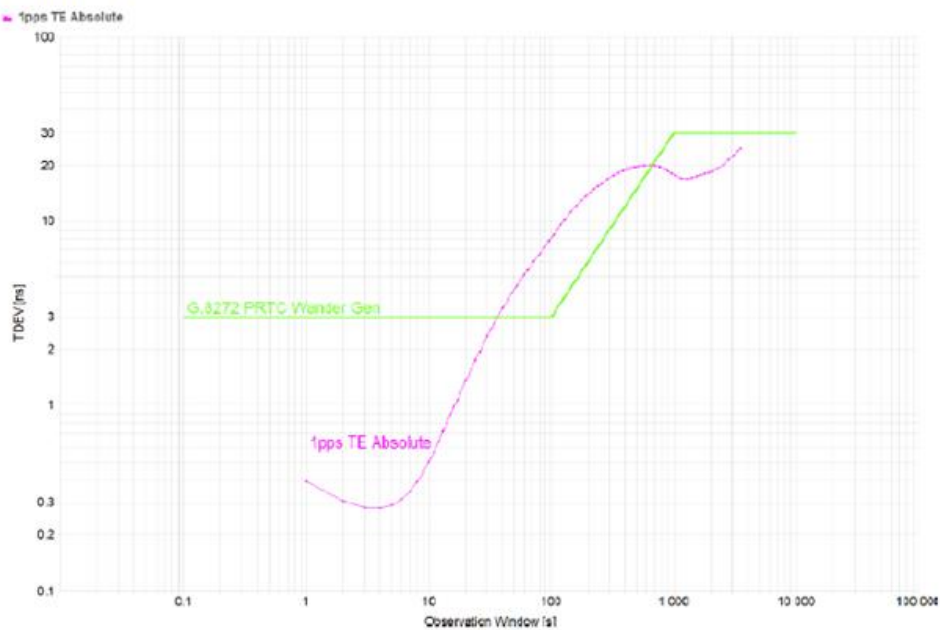
MTIE Analysis



Min [ns]	8
Max [ns]	438
Max-Min [ns]	430



TDEV Analysis



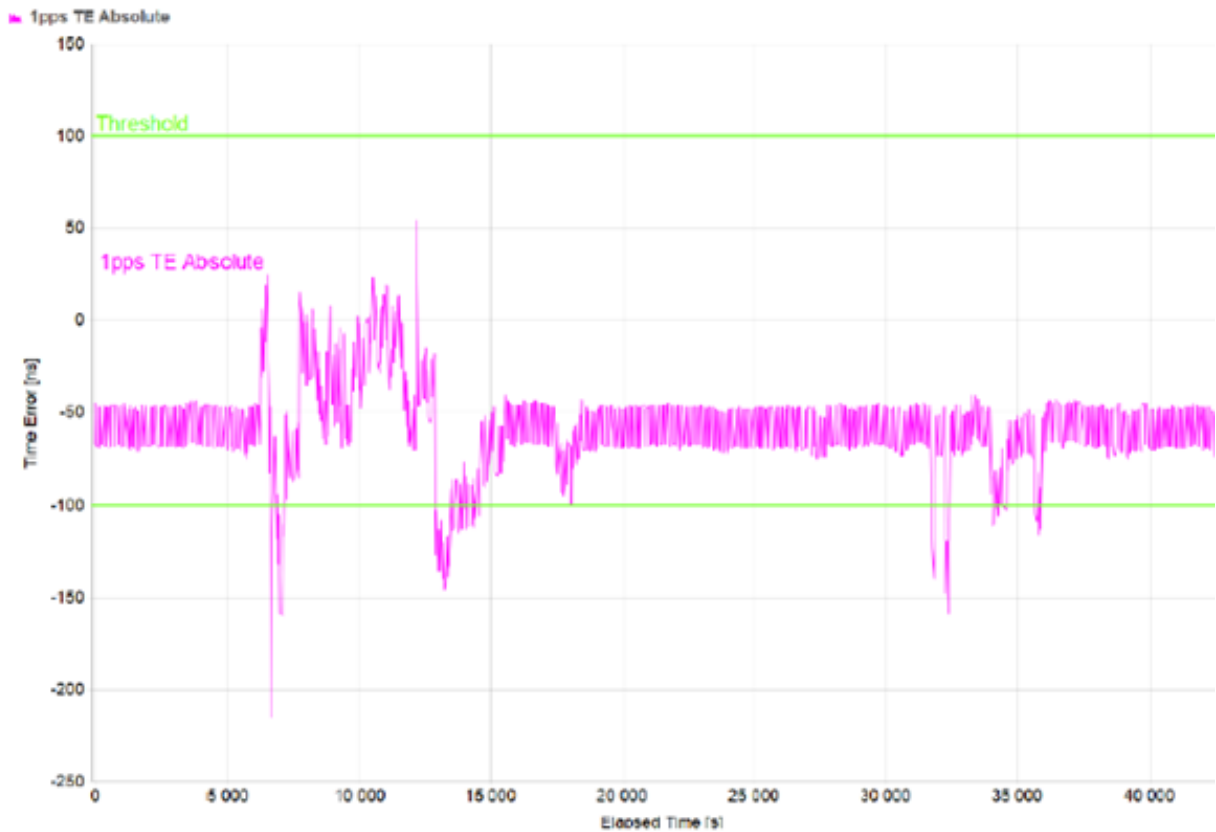
Min [ns]	0.279
Max [ns]	24.798
Max-Min [ns]	24.519

Followed three test results are to measure one commercial single band GNSS receiver(Not Furuno Product) under the urban canyon environment with many multipath signals.



Time Error Analysis

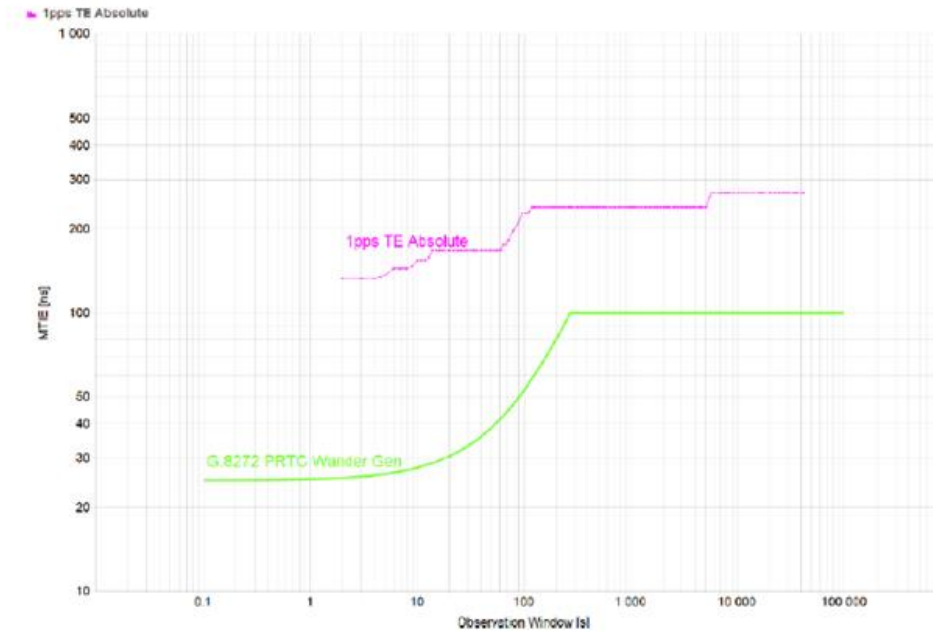
Offset Removal Applied	Off
Zero Offset	-67 ns



Mean [ns]	-58.37
Min [ns]	-215
Max [ns]	54
Max-Min [ns]	269



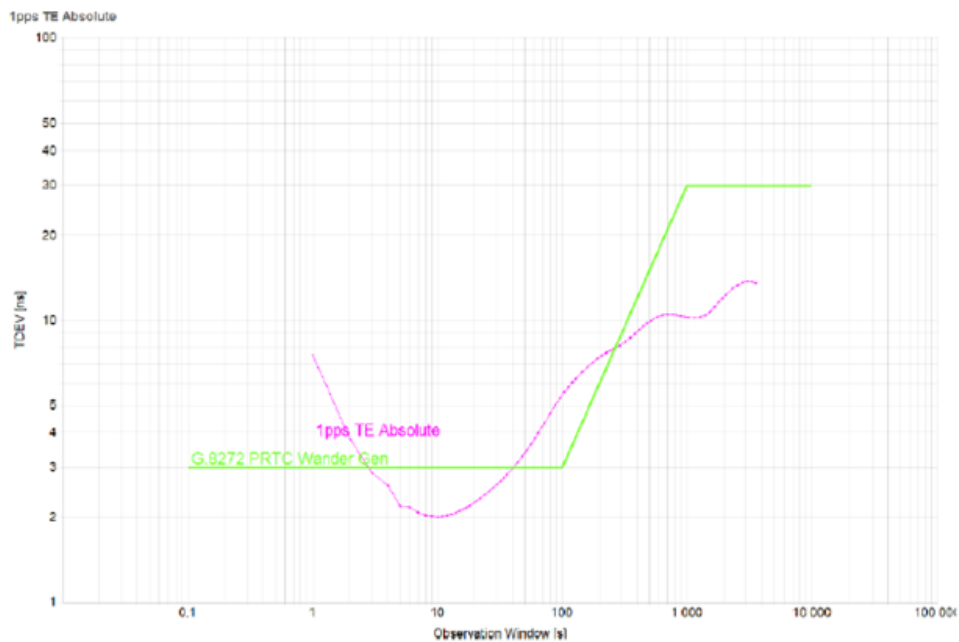
MTIE Analysis



Min [ns]	133
Max [ns]	269
Max-Min [ns]	136



TDEV Analysis



Min [ns]	2.005
Max [ns]	13.785
Max-Min [ns]	11.781

Followed three test results are to measure one commercial Dual band GNSS receiver(Not Furuno Product) under the urban canyon environment with many multipath signals.



Time Error Analysis

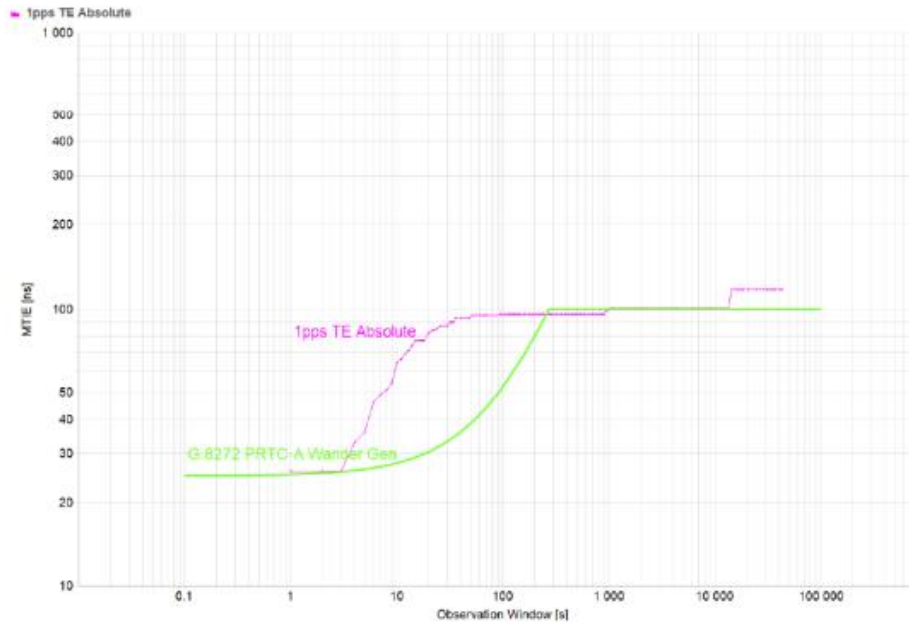
Offset Removal Applied	Off
Zero Offset	-49 ns



Mean [ns]	-49.041
Min [ns]	-139
Max [ns]	-21
Max-Min [ns]	118



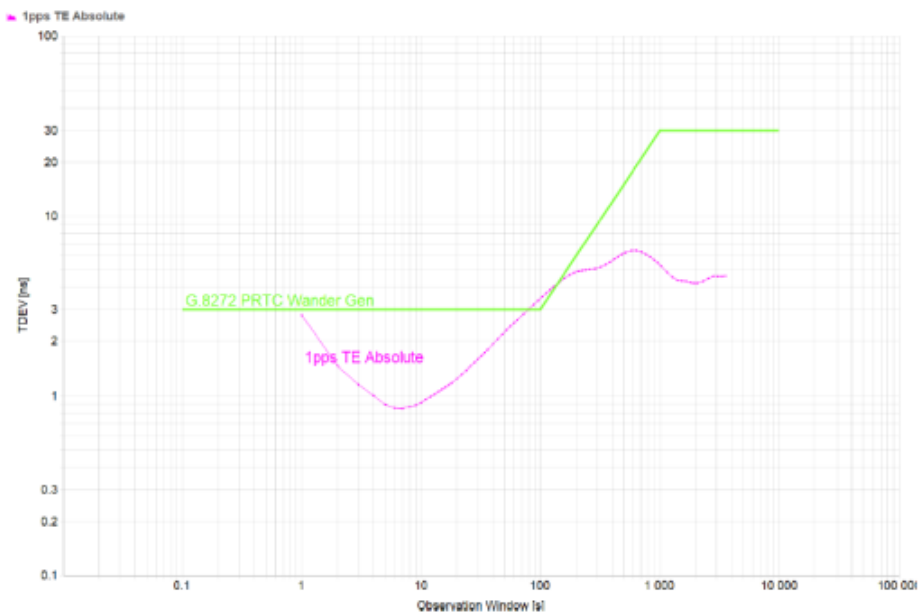
MTIE Analysis



Min	26 ns
Max	118 ns
Max-Min	92 ns



TDEV Analysis



Min [ns]	0.85
Max [ns]	6.384
Max-Min [ns]	5.534

Test Summary

In an urban canyon environment with many skyscrapers, it is difficult for a GNSS receiver to receive only direct signals from satellites. In such an environment, it is inevitable that multipath reception will degrade the accuracy of position and timing.

The "Dynamic Satellite Selection™ (DSS)" algorithm was developed to solve such problems.

DSS discriminates signals that have deteriorated due to multipath from among multiple received signals, and reduces the influence of such signals on calculations, thereby suppressing deterioration of position and time accuracy.

Based on this test report, the Furuno GNSS receiver, GT-88, with the DSS algorithm can provide better accuracy performance in a multipath environment such as an urban canyon.

This raises the prospect of being able to perform highly accurate time synchronization in various installation situations and is expected to contribute greatly to efficient antenna installation and further growth in the range of applications of time synchronization.

The Furuno timing product equipped with the "Dynamic Satellite Selection™ (DSS)" algorithm is as follows.

- Dual Band L1 + L5
 - **GT-100** timing module.
- Single Band L1 only
 - **GT-90/9001** timing module
 - **GT-88** timing module.
 - **GF-8801/8802/8803/8804/8805** timing module