NovAtel's Waypoint® Near Real Time

Performance Analysis—January 2019

Abstract

With the activation of a TerraStar Near-Real-Time (NRT) license within Waypoint post-processing software, TerraStar precise satellite clock and orbit products may be downloaded with an approximate latency of only 15 minutes. This facilitates Precise Point Positioning (PPP) and Tightly Coupled (TC) PPP in applications that require a quick turnaround, without sacrificing performance as compared to using common correction services with significantly longer latency.

The objective of this testing is to compare static and kinematic PPP performance with TerraStar NRT products with performance achieved using common correction services. Static testing demonstrates base station coordinate determination accuracy, and aerial survey testing demonstrates kinematic PPP accuracy with respect to a reference solution.

Introduction

Who is TerraStar?

TerraStar owns, operates, maintains and controls a global network of GNSS reference stations and the associated infrastructure to ensure maximum operational reliability of its augmentation services for precise positioning. With a long history in satellite-based correction services, TerraStar provides seamless delivery of trusted corrections for demanding applications.

How does Waypoint with TerraStar work?

With the activation of a Waypoint NRT license, Waypoint software will default to downloading TerraStar NRT data whenever precise satellite clock and orbit products are required. A single file is downloaded for the project time range containing precise, high rate, multi-constellation data.

NRT Enhancements over Common Correction Services

- Fast availability (~15-minute latency)
- High reliability and redundancy
- Multi-constellation (GPS, GLONASS, BeiDou, Galileo, QZSS) support
- High rate corrections (good for low noise kinematic trajectories)

Static PPP Performance Evaluation

Test Description

Eighty GNSS (GPS, GLONASS, Galileo) permanently operating reference stations from the Continuously Operating Reference Station (CORS) network were used to test static PPP accuracy as a function of occupation length. The stations used in this test were chosen based on their data quality and completeness over a 24-hour period (June 01, 2018). The National Geodetic Survey (NGS) provides published positions and station velocities, which were used to compute PPP processing errors.

A map of the stations used is shown below, with a good distribution within the continental USA and Mexico, as well as stations in the US Virgin Islands and Bermuda.

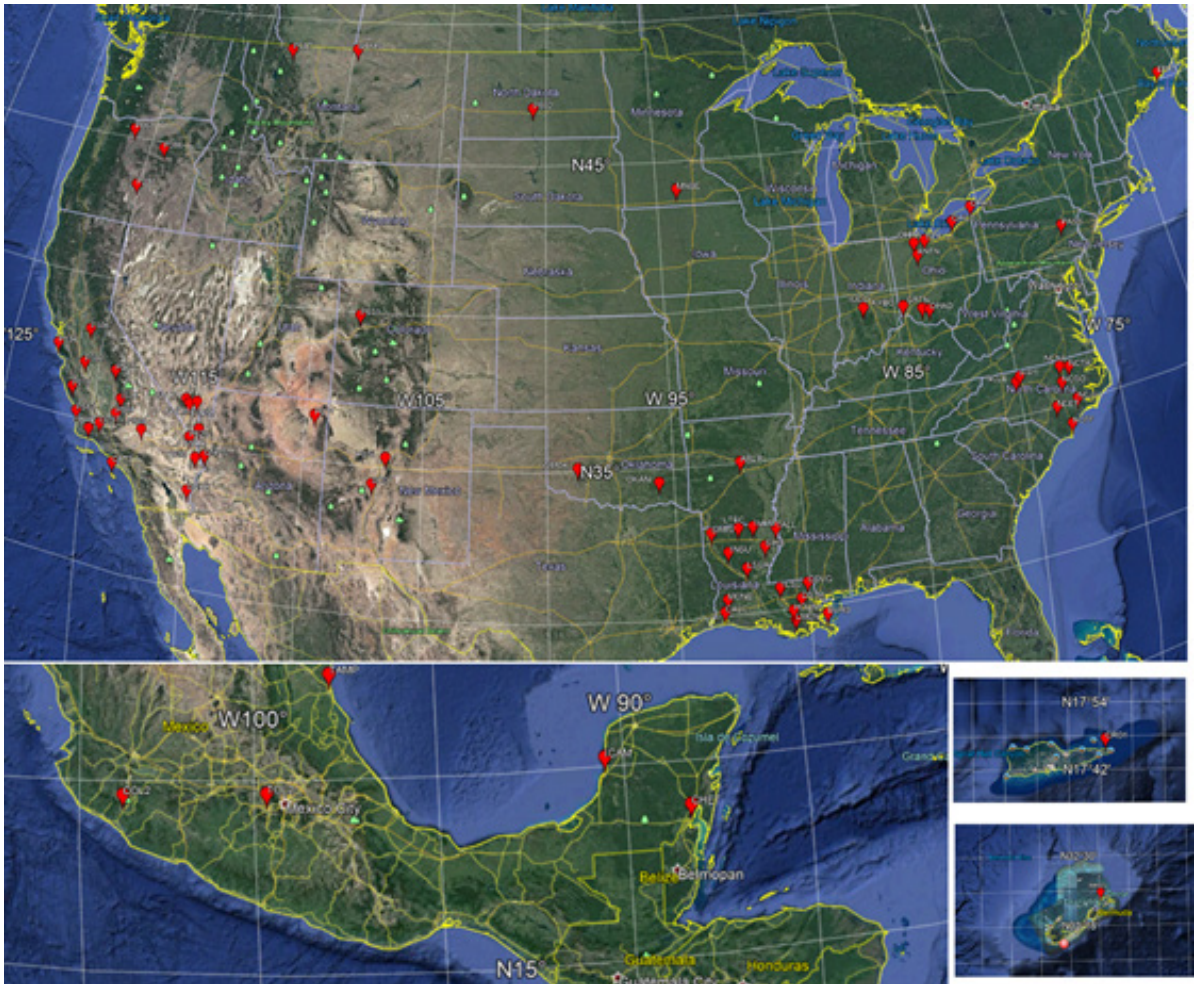

Figure 1: Permanently Operating Reference Stations used in Static PPP Testing. Map data: Google, Image Landsat/Copernicus. Data SIO, NOAA, U.S. Navy, NGA, GEBCO.

Each 24-hour dataset was processed using occupation times from 15 minutes to 24 hours. Multiple equally-spaced processing runs were done on the shorter occupation lengths to help ensure many samples with a high variability in satellite geometry were represented in the results. In total, 3040 processing runs were used to generate results for each set of precise satellite clock and orbit products tested. Processing and analysis were automated with the Waypoint Software Developers Kit (SDK).

Results are presented using both TerraStar NRT precise products and final precise products from the International GNSS Service (IGS). The IGS final products are widely considered the gold-standard for accuracy and reliability, although these products have a 12-18 day latency.

Static PPP Results

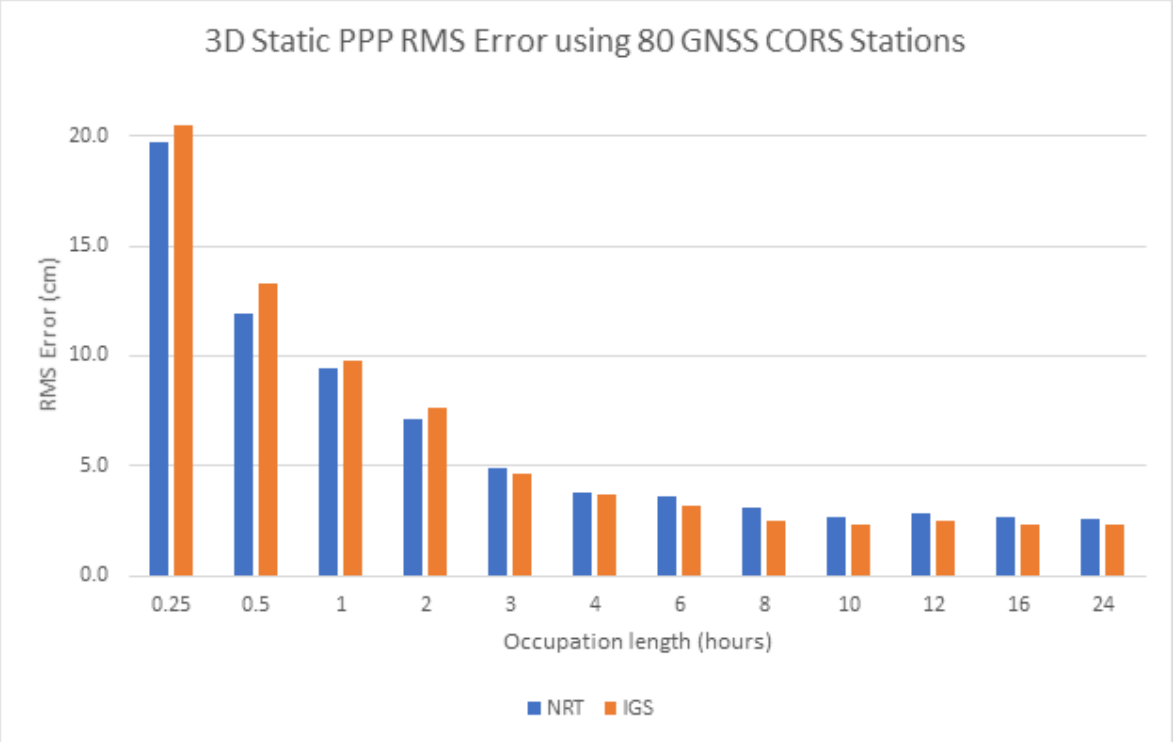

Figure 2: 3D Static PPP RMS Error Using 80 GNSS CORS Stations

Table 1: Horizontal and Vertical Static PPP RMS Error Using 80 GNSS CORS Stations

	NRT RMS Errors (cm)		IGS RMS Errors (cm)	
Length (hours)	**Hz**	**Vt**	**Hz**	**Vt**
0.25	10.5	16.7	11.7	16.8
0.5	7.8	9.0	8.2	10.5
1	6.9	6.5	7.1	6.7
2	5.5	4.5	5.9	4.8
3	3.1	3.8	3.1	3.4
4	2.3	3.0	2.5	2.7
6	2.2	2.9	1.9	2.6
8	1.8	2.5	1.4	2.1
10	1.4	2.3	1.4	1.9
12	1.4	2.5	1.3	2.1
16	1.1	2.4	1.1	2.0
24	1.1	2.3	1.2	2.0

Kinematic PPP Performance Evaluation

Test Description

Four aerial surveys collected by Leica Geosystems AG were used to evaluate kinematic PPP performance. All surveys used one or more local base stations to generate a GPS+GLONASS fixed integer reference trajectory. Two of the surveys were large-scale, multi-base projects with over 3.5 hours of data collected and flight lines of 67 km or longer. The remaining two surveys were shorter in duration and scale (8-10 km flight lines), requiring only a single base station. Maps of the processed trajectories are shown below.

Figure 3: Flights 1 to 4 (Top to bottom, left to right). Map data: Google, Image Landsat/Copernicus. Data SIO, NOAA, U.S. Navy, NGA, GEBCO

After establishing a fixed integer differential reference solution, PPP trajectories were processed using TerraStar NRT precise products as well as rapid and final precise products from the Center for Orbit Determination in Europe (CODE).

The rapid CODE products have an approximate 18-hour latency, while the final products have a 2-week latency. Both rapid and final products contain GPS and GLONASS data. The rapid CODE precise clock is provided at a 30-second rate while the final CODE precise clock is provided at a 5-second rate. High rate precise satellite clock data is desirable for computing low noise kinematic trajectories. TerraStar NRT precise products provide precise satellite clock corrections at a 5-second rate.

Test Results

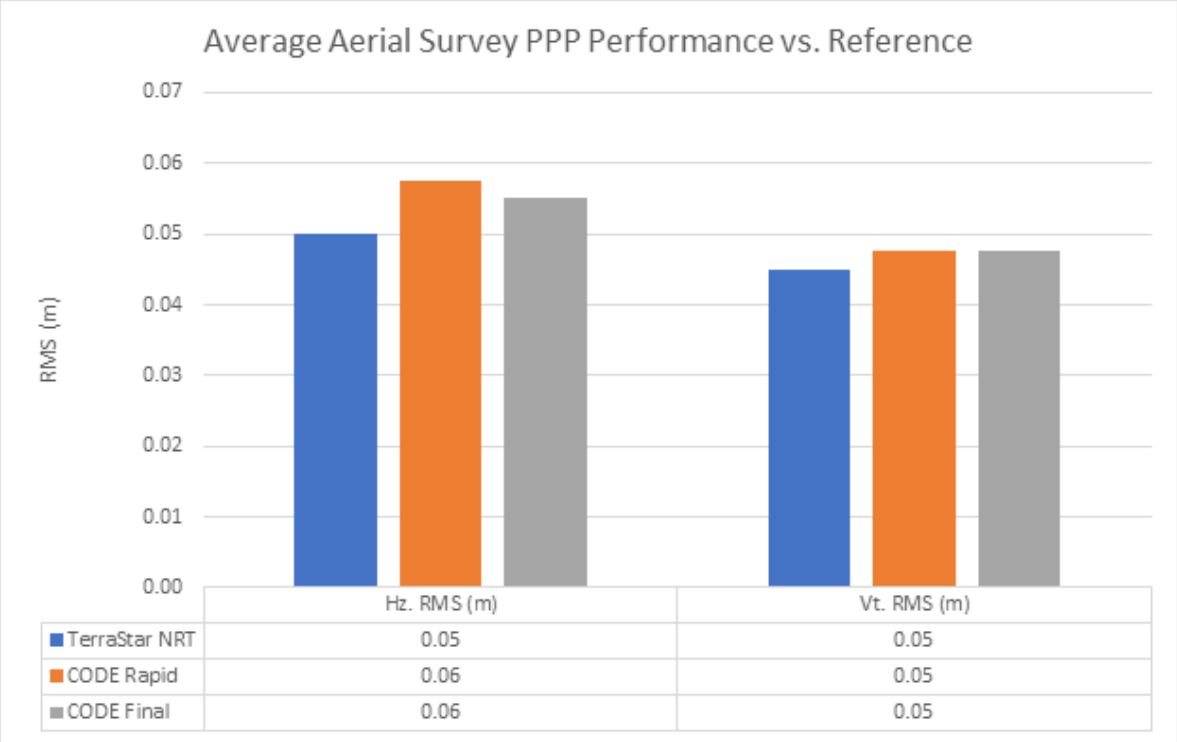

Figure 4: Average Aerial Survey PPP Performance vs. Reference

Table 2: Aerial Survey PPP Performance vs. Reference

	NRT		CODE Rapid		CODE Final	
	Hz. RMS (m)	**Vt. RMS (m)**	**Hz. RMS (m)**	**Vt. RMS (m)**	**Hz. RMS (m)**	**Vt. RMS (m)**
Flight 01	0.08	0.04	0.07	0.05	0.07	0.05
Flight 02	0.05	0.03	0.07	0.03	0.06	0.04
Flight 03	0.04	0.05	0.05	0.06	0.05	0.05
Flight 04	0.03	0.06	0.04	0.05	0.04	0.05

Conclusion

IGS currently lists the accuracy of their final precise orbit and clock products to be ~2.5 cm (RMS) and ~20 ps (SDev) respectively (see http://www.igs.org/products for more information). Static PPP testing showed similar performance using either the IGS final precise products or TerraStar NRT products. Achieving similar static post-processing accuracy using precise products that have only a 15-minute latency as compared to using precise products that have a 12-18 day latency is remarkable, and shows how an NRT subscription can add value to applications that require base station coordinate determination as quickly as possible after data collection.

Kinematic testing also showed similar PPP performance regardless of whether TerraStar NRT precise products were used or alternatives with significantly longer latency from CODE. These results also show how an NRT subscription can be invaluable that to a user whose application demands a quick turnaround without sacrificing the quality of results delivered.

TerraStar NRT precise products offer several advantages to common correction services, including fast availability (~15-minute latency), high reliability and redundancy, support for all constellations (GPS, GLONASS, Galileo, BeiDou, QZSS), and high rate corrections. This makes these products well suited to kinematic processing in demanding applications.

Acknowledgements

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For more information on the NovAtel range of Waypoint software, please visit:

https://www.novatel.com/support/info/view/software

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