Waypoint®
Base Station Coordinate Determination Using Precise Point Positioning

Performance Analysis–April 2014

ABSTRACT

This paper demonstrates GrafNav's static Precise Point Positioning (PPP) performance as a function of time using occupations ranging from 30 minutes to 24 hours.

The results were generated from 36,000 processing runs using data from 1,000 permanently operating reference stations operating within the USA. These stations use a variety of GNSS equipment. Results show that the PPP method can be used as a base station coordinate check or even for coordinate determination.

INTRODUCTION

Precise Point Positioning (PPP)

PPP is a method of autonomous GNSS positioning that uses dual frequency data from one GNSS receiver along with precise satellite clock and ephemeris data. A number of government agencies provide clock and orbit correction data with approximate "next day" latency.

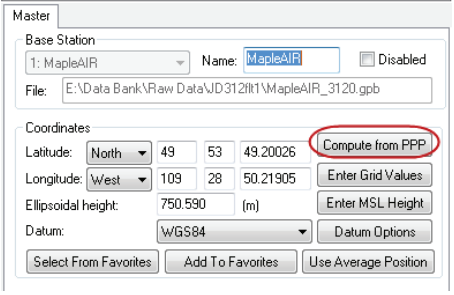
One application of PPP is to check or determine base station coordinates. Fixed, local base stations are used as part of a post-processing workflow in many applications such as aerial survey or mobile mapping. Depending on the quality of the receiver and duration of the occupation, PPP can provide cm level accuracy and is thus a powerful means of checking, or possibly even surveying, station location.

Beginning in GrafNav 8.50 access to PPP for checking or surveying base station positions is accessible from the Master Coordinate dialogue using the *Compute from PPP* button.

This feature processes the base station data using GrafNav's PPP engine and reports the horizontal and vertical difference between the entered and processed positions.

The purpose of this paper is to provide a better understanding of the accuracies achievable using this mode of positioning.

Figure 1: Master Coordinates



Continually Operating Reference Station (CORS) Network

The National Geodetic Survey (NGS) manages the CORS network. This network consists of approximately 1,970 actively logging stations, each with a published coordinate and velocity.

DATA PROCESSING

CORS data used

One day of data, collected on October 01, 2012, was downloaded from 1000 CORS stations using the Download Service Data Utility built into GrafNav. All stations had a full 24 hours of data available and were not afflicted with any unusual data quality issues, such as complete losses of carrier phase lock. All data sets are thus good examples of typical base station data collected under open skies.

A variety of GNSS equipment was in use at the stations. In total, 22 different GNSS receivers and 49 different GNSS antennas was used in the 1,000 stations included.

GrafNav Software Developer's Kit

Waypoint's Software Developer's Kit (SDK) allows GrafNav's processing capabilities to be integrated in customized or automated applications using either .NET/C# or Win32/C++ interfaces. To generate the results for this paper, version 8.50 of the GrafNav SDK was used to automate all 36,000 processing runs, using data from 1,000 different CORS stations.

Occupation Lengths Tested

In order to characterize PPP performance over a 24 hour period, sixteen different occupation lengths were tested. The start processing time of the sessions were spread evenly over the 24-hour period in order to provide a good distribution of conditions (number of satellites and geometry) for each site.

Using 1000 stations widely distributed over the continental USA and Alaska ensures variations in satellite geometry, helping to ensure the results are representative of typical performance. In total, 36,000 processing runs were performed in order to demonstrate PPP performance over a 24-hour period.

Processing and Error Analysis

No optimizations were performed for individual sites or occupation lengths and all data was processed using GrafNav's default options. This was done to isolate the effect of session length on PPP.

The error of each processing run was calculated by comparing GrafNav's final post-processed position to the published coordinates. Note that CORS provides NAD83 (2011) epoch 2010.0 coordinates. However as all data used in this test was collected on October 01 2012 (2012.75), published CORS velocities were applied to adjust the published positions to this date prior to computing the error.

Test Results

Figure 2: Horizontal PPP Errors for Session Length

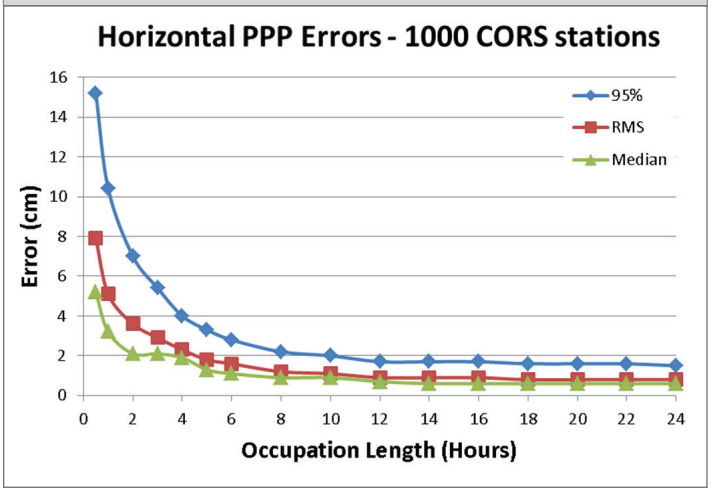
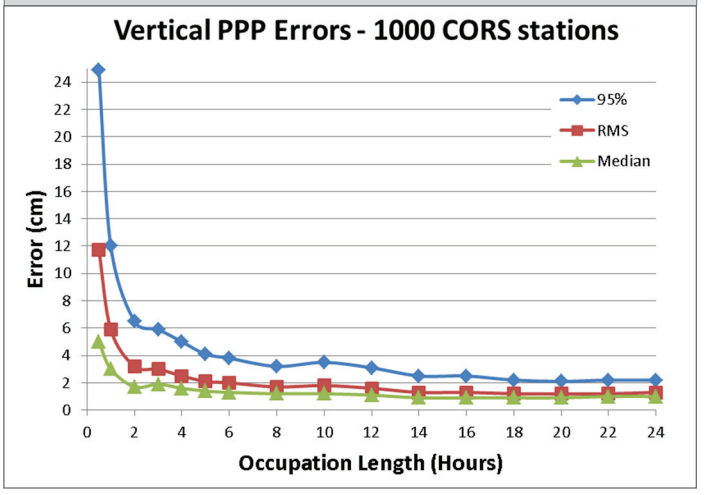


Figure 3: Vertical PPP Errors for Session Length



Results show that short occupations of less than 30 minutes are limited to decimeter-level accuracy. However even this level of accuracy can be helpful in finding certain types of errors, such as data entry or datum errors.

PPP accuracy improves with time and centimeter level results are possible provided sufficient occupation time. For example, 95% of results were within a horizontal accuracy of 2.0 cm and 3.5 cm vertically using 10 hours of data or more. For RMS errors, 2 cm accuracy was achieved both horizontally and vertically with only five hours of data.

The results also show that after eight hours of data collection, the rate of improvement slows considerably. After 14 hours of data collection, only minor improvements are achieved with longer occupation times.

CONCLUSION

The goal of this paper is to provide an understanding of static PPP performance as a function of occupation length. The number of CORS stations used in this test (1000), the wide geographic distribution of the sites, the diversity of GNSS receivers and antennas used, and the total number of processing runs performed (36,000) help assure that these results are comprehensive and representative of typical performance.

The results show that PPP is an effective means of checking or surveying base station coordinates.

For more information about Waypoint software, please visit:

www.novatel.com/products/software/

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