



# Trimble ProPoint Engine - Next Generation Centimeter Positioning and Orientation



Superior performance under challenging GNSS environments, with groundbreaking measurement management that leverages the latest developments in GNSS and Inertial sensor fusion.

## INTRODUCTION

In 1992, Trimble® released the world's first commercial GPS (Global Positioning System) receiver capable of performing centimeter accurate Real Time Kinematic (RTK) positioning. Although this first generation system required the user to position the rover over a known location to initialize the system, it was revolutionary for land surveyors enabling topographic mapping, stakeout and

as-built surveys in real-time.

Follow-on applications such as construction machine control and agriculture resulted in positioning engines that have delivered rapid on-the-fly initializations and high update rate, low latency positions. This technical bulletin provides an overview of the Trimble ProPoint™ Engine, the fifth generation RTK/RTX precision positioning engine, engineered to provide positions and orientation from the fusion of GNSS signals, worldwide correction services and measurement data from a variety of sensors.

## SYSTEM ARCHITECTURE

### **Support for the latest constellations and frequencies**

The space segment of the world's Global Navigation Satellite System (GNSS) is







Trimble has released receiver platforms with upgraded processors and the latest Trimble Maxwell 7 GNSS ASIC (Application-Specific Integrated Circuit). This allows positions to be delivered to control systems with minimal latency while also reducing overall power consumption.

## BENEFITS OF TRIMBLE PROPOINT ENGINE

To understand the advantages of including the ProPoint Positioning Engine in your application we shall review the key value drivers in terms of accuracy, availability and integrity.

Many position systems can provide some of these attributes but we believe that ticking all the boxes will deliver the positioning and orientation necessary to make your product truly successful. In head-to-head testing with the previous generation RTK/RTX engine in challenging GNSS environments such as near and among trees, and built environments, the Trimble ProPoint Engine performed at least 30 percent better across a variety of factors, including time to achieve centimeter precision levels, position accuracy and measurement reliability.

### Accuracy

Open sky guidance and control applications have been benefiting from the centimeter accuracy of RTK for over 20 years. Unfortunately most real world autonomous applications operate in challenging environments where satellite line of sight can be impaired. Trees, buildings, bridges and other obstacles both block and reflect incoming signals. The Trimble ProPoint Engine in GNSS only mode with its flexible signal management and optimal single filter approach delivers centimeter-level accuracy results under tree canopy where at best decimeter level accuracies could be obtained in the past. For

applications where most of the sky is blocked, the integration of IMU measurements into the engine offers the best solution. The ProPoint Engine tightly integrates the available GNSS and IMU measurements delivering centimeter-level accuracy and orientation during these events.

The latency of the computed results is also an important factor in autonomous vehicle control. A position may be very accurate but if it is delayed then it has little value to system performance and safety. The ProPoint engine produces positions and orientations with less than 20 milliseconds latency at update rates up to 100Hz.

### Availability

It has long been a goal as a company to deliver centimeter precision for everyone everywhere. Allowing our customers to operate in more difficult environments expands the variety of potential applications and a better return on investment for the end user of the technology.

ProPoint in GNSS only and GNSS/INS modes deliver centimeter-level accuracy in denser tree canopy and high rise urban environments where historical engines would struggle. Both on-road and off-road vehicles operating close to buildings or under bridges continue to achieve close to 100% availability of position and orientation.

Users in RTK mode benefit from the integrated xFill technology to allow continued operation when the correction source is lost. This boosts availability over that achieved by RTK users that are not leveraging PPP technology to bridge loss of corrections from the local base.

### Integrity

Providing accurate precision estimates is critical to centimeter-level control of autonomous machines. Applications depend on these horizontal and vertical indicators to know when



to trust the position and orientation information. An incorrect estimate can result in damage to end-product, equipment or at worst personnel.

Considerable testing of ProPoint in a variety of environments around the world has resulted in estimates that accurately reflect the precisions. ProPoint precision computation benefits from improved noise models and the ability to adapt these models to the current environment.

## PROVEN PERFORMANCE

In order to evaluate the capabilities of Trimble ProPoint, it was essential to conduct field tests which would closely approximate the types of challenges encountered by customers in the field on a day-to-day basis. To this end, Trimble carried out an extensive testing campaign, employing several different test courses around the world, each comprising different environments characterized by common GNSS obstacles such as trees and buildings. Below are examples from GNSS only and GNSS/INS RTK tests carried out to compare the previous generation engine with the ProPoint engine. Similar results are obtained in RTX modes.

### GNSS Performance

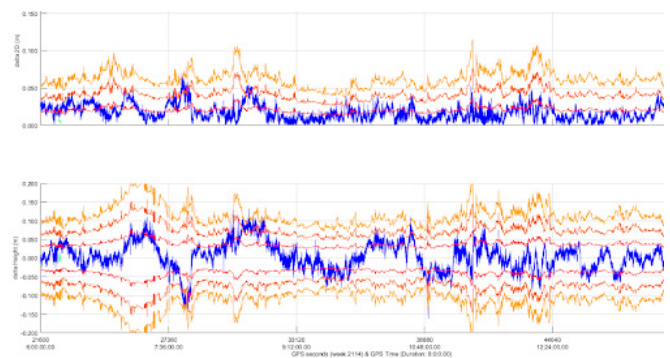
The Trimble ProPoint Engine provides superior GNSS-only performance in hostile environments. Looking at RTK data from a stationary 19km baseline with the rover in a suburban environment (5m away from a 2 story building with trees in the vicinity) an improvement is seen in both the magnitude of position errors and in the estimation of position errors. In each set of plots the top axis gives the position error in the horizontal while the bottom axis gives the vertical position error.

The blue lines indicate the position error from the known coordinate for the survey point. The Trimble ProPoint Engine produces a more accurate and precise solution than the previous

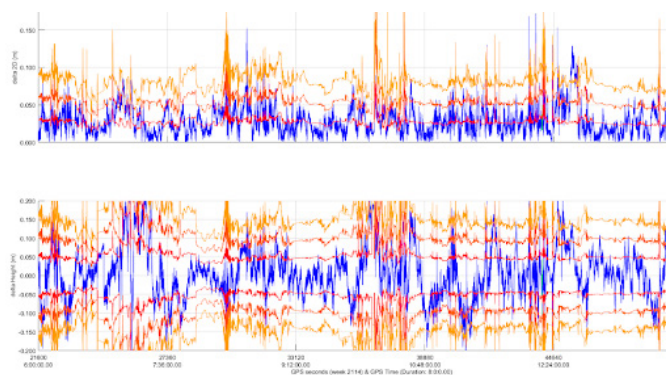
generation RTK engine.

The red/orange lines indicate the 1-sigma, 2-sigma & 3-sigma errors estimates output by the receiver in real-time. These can be seen to have dramatically improved with the Trimble ProPoint Engine, better estimating the actual position error in these harsh conditions. The error estimates are also less erratic. This will help users better gauge in real-time whether or not the position solution meets their accuracy requirements.

**Trimble ProPoint Engine positioning**



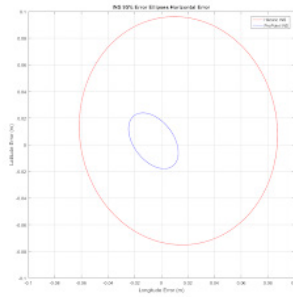
**Previous generation RTK positioning**



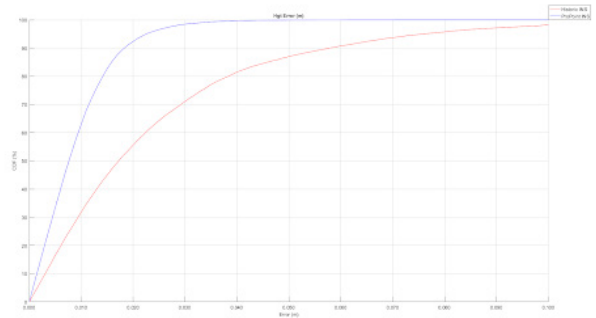


## GNSS/INS Performance

The following results are from an analysis of a 13 km suburban environment drive with the system running in GNSS/INS(RTK), which starts near the base station and ranges out to about 9 km away from the base station. A significant improvement is seen in the 95% error ellipses of the horizontal positioning, shown for ProPoint in blue. This is the difference between the real-time GNSS/INS positions and a high-accuracy, post-processed truth trajectory using an Applanix POSLV system (high end IMU system).



Similar improvements are seen in the vertical performance. Looking at the Cumulative Distribution Function plot of the error in the height component clear improvements are seen. With the previous generation GNSS/INS engine 95% of the heights (the 95 percentile) fell within 78mm of truth, now with the Trimble ProPoint Engine 95% of the heights fall within 23mm of truth.



## CONCLUSIONS

Trimble's ProPoint Engine is an investment in the future, ready to fuse present and future GNSS measurements with Inertial and sensor data to deliver premium performance in the toughest of environments. When accuracy, availability and integrity are key requirements for your autonomous application then ProPoint is the ideal choice.

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