# NovAtel's

# GL1DE™ Technology

Precise thinking



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# NovAtel's **GL1DE** Technology

## Latest Update

This white paper has been updated with information and test results for the latest release of NovAtel **GL1DE** technology. Updates are annotated with double asterisks and new text is colored blue.

## Abstract


***GL1DE** provides a relative pseudorange/delta-phase filter enhancement for the NovAtel OEMV firmware. Three sets of **GL1DE** test results are presented in this paper. The first test results are based on version 3.400 firmware, running on a FlexPak-V1 receiver. The second set of test results is on a SMART-V1 receiver, also with 3.400 firmware.*

***NEW The third set of test results is based on version 3.620 firmware, which has an improved smoothing algorithm. Testing shows **GL1DE** provides superior pass-to-pass performance for applications where relative positioning is important. The proven performance confirms that in clear sky conditions, the **GL1DE** filter provides a tight, smooth, and consistent output.***


## Introduction

**GL1DE** offers users of autonomous L1 code positioning modes, with superior positioning stability, previously only available with carrier phase solutions. Importantly, this technology is provided on all NovAtel OEMV cards and OEMV-based receivers.

## Methodology

Resources for this paper were provided by NovAtel Inc.

## **GL1DE** Overview

**GL1DE** optimally combines L1 code and phase data to produce a positioning solution well-suited for applications such as agricultural guidance, where pass-to-pass repeatability is critical. Using **GL1DE**, users will see significantly fewer positioning jumps, with less than 1cm (typical) difference in position from one epoch to the next (see Figures 4 and 5). **GL1DE** technology works with single point, SBAS, and OmniSTAR VBS, and mitigates position jumps caused by switching between these modes. Pass-to-pass accuracies of 50 cm or better are achievable even in areas where wide area correction services are not available. **GL1DE** also works with CDGPS, the Canadian correction service supported only by NovAtel receivers.

While the PDP (Pseudorange/Delta-Phase) filter optimizes a solution in varied conditions, the **GL1DE** filter design works ideally in clear sky conditions where the user needs a tight, smooth, and consistent output.

The PDP filter takes advantage of the accurate accumulated delta range (carrier phase) measurements to smooth the inherent noise in the least squares solution. It also uses a Kalman filter with a velocity and delta position model to bridge through times where fewer than four satellites are available. It essentially offers a solution which follows the least squares solution, but with short-term smoothing and bridging through brief satellite outages.

The **GL1DE** filter uses most of the same algorithms as the PDP filter, but optimizes them for relative positioning. By making very heavy use of the carrier phase observation, emphasis is placed on maintaining the error as constant as possible over 15-20 minutes. **GL1DE** has a very smooth error, but may have an overall larger absolute error than the PDP filter.

For more information on the PDP filter, refer to the application note on the NovAtel website at http://www.novatel.com/Documents/Bulletins/apn038.pdf.

## Tests

To compare **GL1DE** with standard positioning options, we used a NovAtel FlexPak-V1 receiver with a GPS-702-GGL antenna mounted on a vehicle traveling east to west at speeds of 5 to 12 km/hour. In subsequent tests, vehicle speeds were varied to test **GL1DE** boundary conditions. We collected approximately 2 hours of data. See Figures 1, 2 and 3.

**Test Vehicle and Antennas**

We also tested **GL1DE** using a SMART-V1. The test uses approximately 2 hours of post-processed GPS+INS data to demonstrate positioning stability with a lower quality patch antenna. Antennas with integrated GPS, an L-band receiver and a rugged form offer high-level L1 GPS capability that can be used in a variety of environments, including benign and foliated. See Figures 4 and 5.

GPS+INS data was used to create a "truth" trajectory, against which the FlexPak-V1 and SMART-V1 solutions were compared. The FlexPak-V1 used the same antenna as the GPS+INS equipment, and a lever-arm correction was applied to the GPS+INS trajectory to create a trajectory for the SMART-V1.

****NEW** The third set of tests used firmware version 3.620 running on a SMART-AG receiver. For comparison, we tested version 3.500 on a SMART-V1G receiver, and a competitor's product. Post data collection, NMEA GGA logs were extracted from the competitor's system and compared against NovAtel logs. As in the previous test setup, a GPS+INS data set was post-processed to generate "truth" trajectories for each of the SMART antennas. The results, shown in Figure 6, demonstrate a smoother position solution compared with earlier firmware and with the competitor's product. As noted, this performance is particularly beneficial for agricultural customers and applications, where pass-to-pass accuracy and small position variance from epoch to epoch are critical.**

# Test Results with NovAtel's FlexPak-V1 Receiver

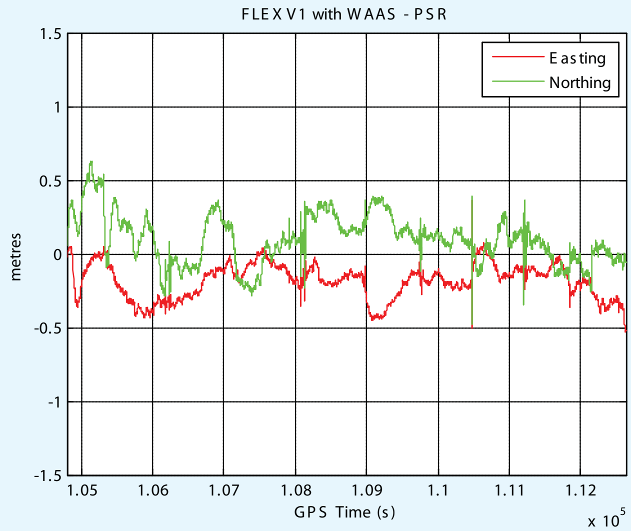


Figure 1: Least Squares Solution

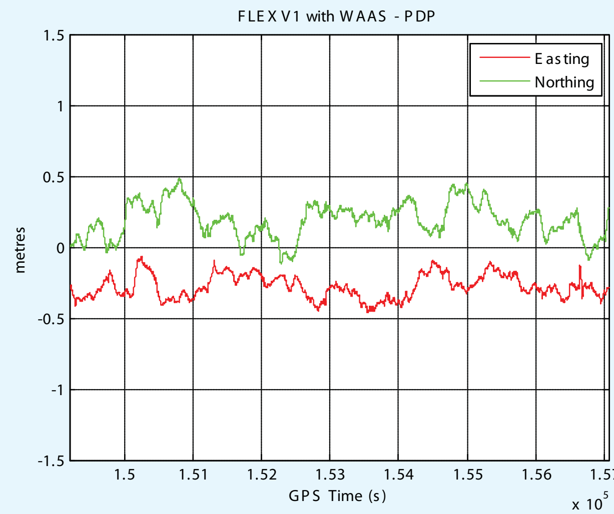


Figure 2: PDP Solution

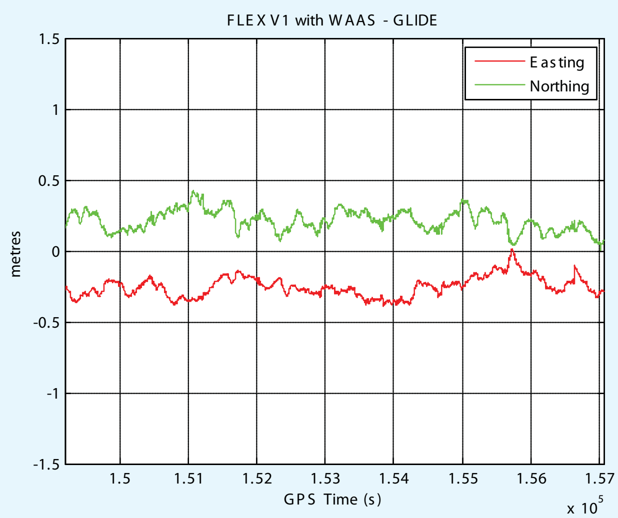


Figure 3: **GL1DE** Solution

# Test Results

## FlexPak-V1 receiver with a GPS-702-GGL antenna

Figure 1 shows the results of the least squares solution. This solution uses only pseudorange measurements and has no smoothing between epochs. Therefore, it tends to be noisy, especially in high multi-path or poor satellite coverage conditions. However, it offers independent position computations from epoch to epoch. This can be useful for users who want to know the absolute position of every epoch without time correlation from a dynamics model.

Figure 2 shows the PDP solution. The PDP solution optimizes the absolute positioning accuracy of the GPS code observation and leverages the excellent relative stability of the GPS carrier phase and Doppler observations. By optimally combining these satellite signal observations, the solution stability is improved over a traditional code-only positioning algorithm. This solution is much less noisy than the least-squares pseudorange (PSR) solution in Figure 1 but is still noisy in places.

The **GL1DE** solution in Figure 3 produces a very smooth solution with a consistent relative position, without compromising absolute position accuracy. There should be less than 1cm (typical) difference from epoch to epoch using **GL1DE**.

## Test Results

### SMART-V1 receiver

The pseudorange least squares solution using the SMART-V1 receiver in Figure 4 is noisier than the same style of positioning using the FlexPak-V1 with the GPS-702-GGL shown in Figure 1 on the previous page. This is mainly due to the use of a patch antenna that has a significantly smaller ground plane and makes the receiver more susceptible to code multipath.

There is a dramatic improvement in the position quality for the SMART-V1 using **GL1DE** (see Figure 5). The phase is much less affected by multipath and the results show good repeatability with SBAS (WAAS).


**SMART-V1 Receiver**

## Test Results with NovAtel's SMART-V1 Receiver

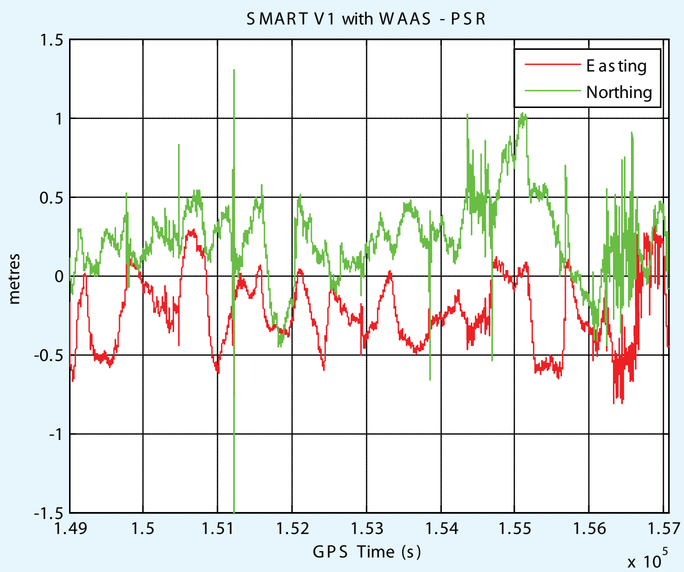


Figure 4: Least Squares Solution

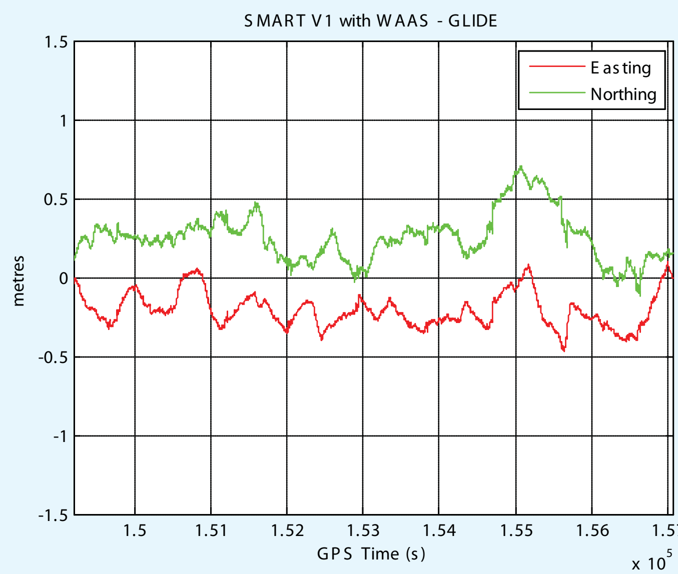


Figure 5: **GL1DE** Solution

## **NEW Test Results with OEMV Firmware Version 3.620 **

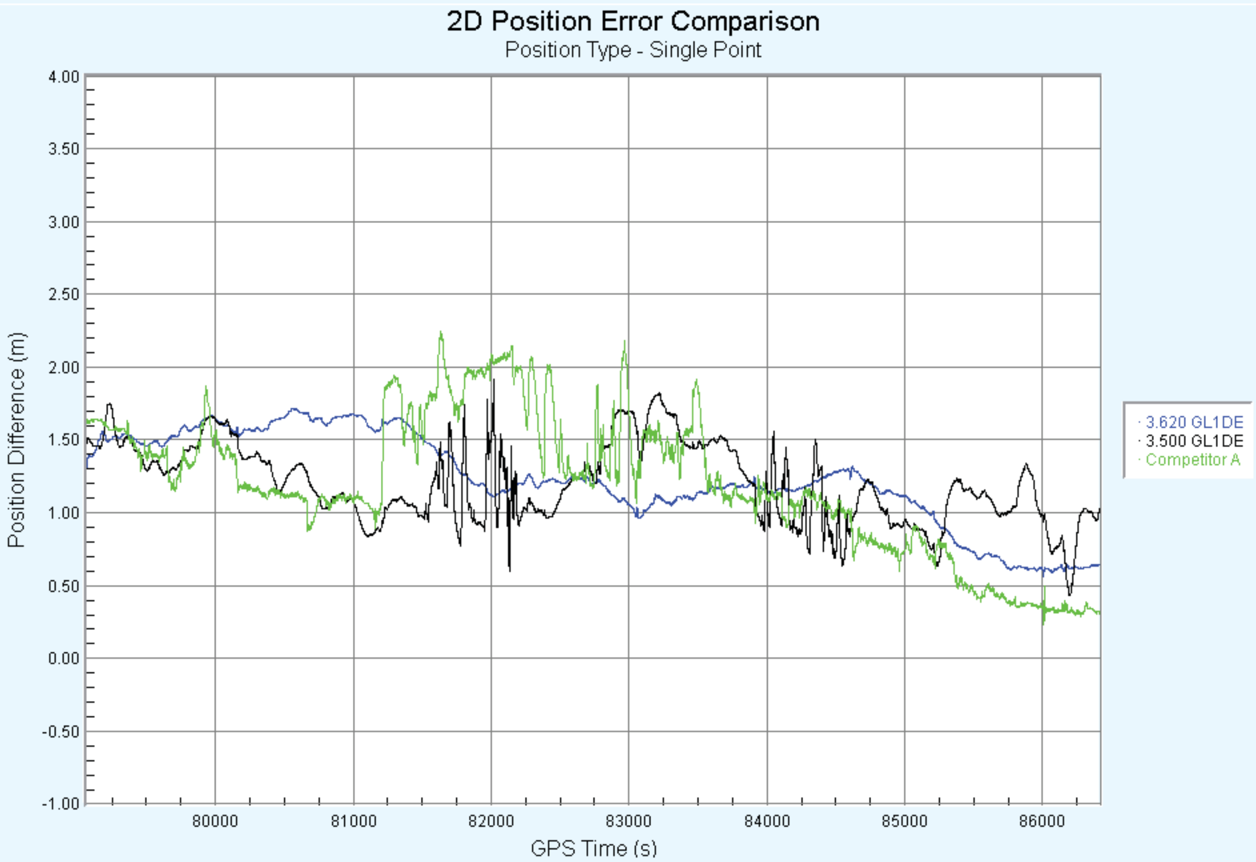


Figure 6: Firmware Version 3.620

## **NEW Test Results

### Firmware Version 3.620

Figure 6 shows the results from tests done to compare **GL1DE** performance from firmware version 3.620 with firmware version 3.500 and a product obtained from an industry competitor. The competitor's product uses its own proprietary position smoothing algorithm.

All tests were conducted in parallel on the test van using a single-point position type. It can be seen from the position error plot in Figure 6 that the solution output from firmware version 3.620 is much smoother than those from firmware version 3.500 and the competitor's product. In the case of firmware version 3.620, there were far fewer position error spikes, which will result in smoother operations.**

**Optimize Operating Efficiency with GL1DE technology**

## Conclusion

The new **GL1DE** filter efficiently combines information from the L1 code and L1 phase measurements into a high-quality Position-Velocity-Time (PVT) solution. **GL1DE** does not obtain its position smoothness through dynamics modeling. Dynamics modelling can often lead to positioning errors associated with a change in vehicle direction. **GL1DE** includes settings for a purely dynamic mode, as well as an “auto” mode, where the filtering parameters are automatically adjusted as vehicle velocity varies between stationary and dynamic states.

**GL1DE** is particularly helpful in improving single-frequency positioning for products with limited space for a ground plane. One such example of a product would be a small smart antenna. Generally, a smart antenna of that size would be more susceptible to multipath (reflected) signals. Multipath signals tend to induce time-varying biases and increase the measurement noise on the L1 pseudorange measurements. The carrier phase measurements are much less susceptible to the effects of multipath and, when used in the **GL1DE** filter, provide the stability required for a smooth position.

****NEW** Further **GL1DE** enhancements (using firmware version 3.620) demonstrate a smoother position solution. This is particularly beneficial for agricultural customers and applications, where pass-to-pass accuracy and small position variances from epoch to epoch are critical to operations.****

The **GL1DE** filter works in all code-positioning modes, with or without a wide area corrections service, and gives optimal pass-to-pass performance for relative positioning applications.

For more information visit: http://www.novatel.com.