Z-Blade Technology

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Increased Productivity in Harsh Environments with Spectra Precision Z-Blade Technology

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Abstract

Today, land surveyors are looking for ways to be more productive and efficient when investing in new and often expensive equipment. In 2011 Spectra Precision introduced the unique Z-Blade positioning technology which allows surveyors to be more productive by enabling them to work with GNSS in places where it was previously impossible or inefficient, such as dense tree canopy or urban areas. This new technology has been implemented in several Spectra Precision products such as the ProMark 800, ProMark 220 and ProFlex 800 GNSS receivers. This paper describes how Z-Blade technology increases positioning availability in difficult environments and how its performance compares to products which lack the Z-Blade capability.

INTRODUCTION

It can be challenging or even impossible for surveyors to work with GNSS equipment in cities where high buildings create urban canyons, or in forests with dense tree canopy. Nevertheless these are places where surveyors have to work more and more often, and they would like to use their GNSS equipment in these environments just as they do in other, less difficult, conditions. Clearly GNSS equipment which allows surveying in all environments is of considerably more value than equipment that works only in the open.

Spectra Precision responded to this need by developing the Z-Blade positioning technology which is currently available in a range of GNSS receivers. This unique technology carefully optimizes the combining and data processing of signals from the different GNSS systems. The resulting “GNSS-centric” approach brings independence from the GPS system and allows any combination of GNSS satellite signals to be used together. The Z-Blade GNSS-centric technology increases RTK position availability in obstructed areas where satellite visibility is limited, which in turn enables surveyors to work more productively and efficiently. The unique Z-Blade approach has clear advantages over conventional “GPS-centric” GNSS solutions.

Z-BLADE TECHNOLOGY

Z-Blade is a (patent pending) GNSS-centric positioning technology developed by Spectra Precision, based on many years of GNSS experience and know-how, and the strong understanding that the future of GNSS receivers lies in making better use of all GNSS satellite signals, without unnecessary reliance on GPS satellite signals alone.

Most manufacturers of precision GNSS equipment present their products as GNSS receivers. Some prove this by demonstrating how they track and use signals other than GPS. Others demonstrate the improved performance (position accuracy, availability or reliability) that extra GNSS satellites bring. And all of them conclude that GLONASS, Galileo or Beidou provide valuable augmentations to the GPS system. But their approach is “GPS-centric”, in the sense that signals from satellite constellations other than GPS are used only in addition to GPS signals, and where a minimum of 4, 5 or 6 GPS satellites are required for any position calculations.

The underlying premise of the Z-Blade GNSS-centric technology is relatively simple. It assumes that each satellite available in the sky is equal to any other, and that satellite signals can be used interchangeably for position calculations. In this approach, there is no underlying reliance on GPS signals, and indeed RTK positioning is possible with no GPS satellites whatsoever. This approach increases the potential satellite availability significantly, and even in areas where many satellites are not visible due to obstacles, there is a high likelihood of sufficient remaining GNSS satellites to calculate a position and fix RTK.

Figure 1 illustrates this difference between a GPS-centric approach and the GNSS-centric (Z-Blade) approach.

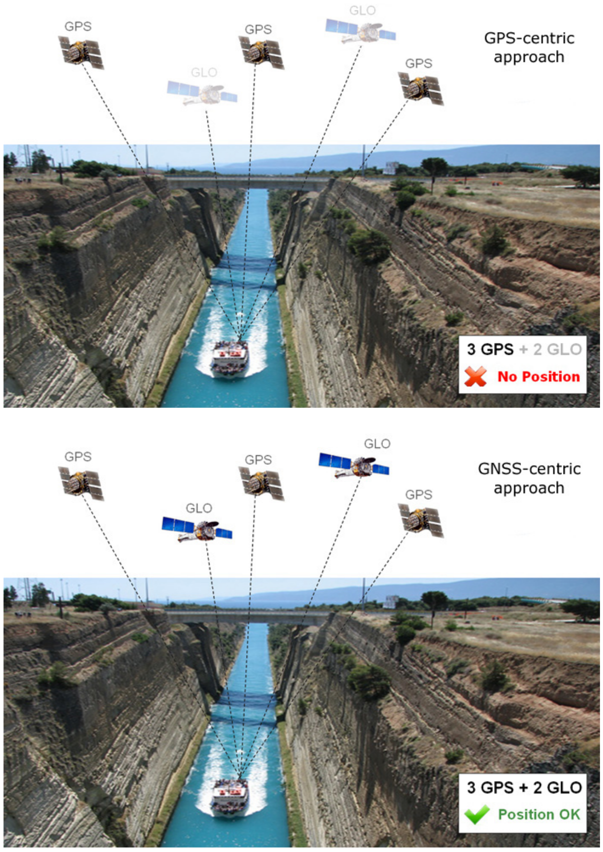

Figure 1: Most GNSS receivers today are GPS-centric (top). If there are not enough GPS satellites, then no position can be calculated. But with the Z-Blade GNSS-centric approach (bottom) – GLONASS and GPS satellites are treated equally – and with 5 satellites positions can therefore be calculated.

The difference between these two pictures above is quite clear. The first presents the standard GPS-centric approach, which is used by most of the GNSS receivers available on the market today. If there are insufficient visible GPS satellites (e.g. only three GPS satellites) then no position can be calculated, even if several other GNSS (e.g. GLONASS) satellites are visible. The second picture presents the Z-Blade GNSS-centric approach. In this approach all available satellites are considered as equal to each other. There is no requirement to have a minimal number of GPS satellites; provided the total number of all available satellites is sufficient, RTK positioning is possible.

As a result, a GNSS-centric receiver provides positions in many situations where GPS-centric receivers cannot do so.

But Z-Blade technology is not only about a GNSS-centric approach for enhanced position. Z-Blade also includes features designed to improve GNSS equipment performance while working in RTK networks such as VRS, FKP or MAC, or while working with individual physical base stations.

Even if signal reception conditions are good (typically in an open sky environment), there are many potential problems when working with RTK networks. For example, network geometry is often sub-optimal and there is the so-called "GLONASS bias issue" (clock bias handling in GLONASS measurements is specific to each GNSS equipment manufacturer). Failure to correctly address these issues may result in long time-to-first-fix or even an inability to get RTK fixed positions at all.

The Z-Blade technology is specially tuned for optimal operation in networks, regardless of the base station manufacturer(s). Z-Blade's special network processing engine automatically adjusts position computations accordingly to the type of network, the specific base station types, etc. and in doing so it mitigates potential issues related to GLONASS biases.

BENEFITS TO THE SURVEYOR

The Z-Blade GNSS-centric technology brings a number of important advantages to land surveyors.

First of all, it enables them to work in obstructed areas, where previously GNSS usability was very limited or even impossible. Thanks to Z-Blade's ability to use all of the available satellite signals, and to calculate positions without relying on a minimum number of GPS signals, Z-Blade users benefit from an expanded GNSS operating environment.

Z-Blade also provides benefit in situations where GPS signals may be available, but due to external interference (e.g. strong jamming on GPS L1/L2 bands), these signals may not be suitable for position computation. Such a case is not an obstacle for Z-Blade capable receiver, which continues to output positions as long as signals from other GNSS systems (e.g. GLONASS) are available.

Furthermore, the GNSS-centric capability brings an additional and unique ability to compute positions using only one specific GNSS (non-GPS) system. Z-Blade makes it possible for a GNSS receiver to operate in a GLONASS-only mode or a Beidou-only mode when required. Although this is not a typical operating mode for a surveyor, the ability may be of importance for Governmental customers who require an assurance that their equipment can be used during a GPS outage or denial of service. Single-constellation operation is also of interest to some research applications.

In addition, a GNSS-centric receiver allows selection of the preferred position datum and time reference. For instance, Russian governmental organizations may prefer to get positions on the Russian PZ-90.02 datum and raw data tagged to GLONASS time, whether or not GLONASS signals are tracked.

Finally, thanks to improvements in RTK processing, the Z-Blade technology provides shorter time-to-first-fix and better position availability in networks, regardless of the network equipment manufacturer.

In summary, we can list the following Z-Blade benefits and advantages to surveyors:

- Position computation in harsh, obstructed environments where satellite visibility is poor
- Position computation even in the presence of GPS L1/L2 in-band jamming
- GLONASS-only mode, Beidou-only or Galileo-only modes for specific applications
- Fast and robust RTK fixes even on long-range baselines including VRS, MAC and FKP networks
- Optimal operation with 3rd party base stations

COMPARATIVE TESTS

In order to demonstrate the advantages of Z-Blade technology, we conducted extensive tests of the Z-Blade-enabled ProMark 220 compared against a receiver from a similar product class, which uses a traditional GPS-centric technology.

As GNSS-centric benefits are particularly apparent in heavily obstructed conditions, we chose a test site where surveyors would typically find it very difficult to work productively, see Figure 2.

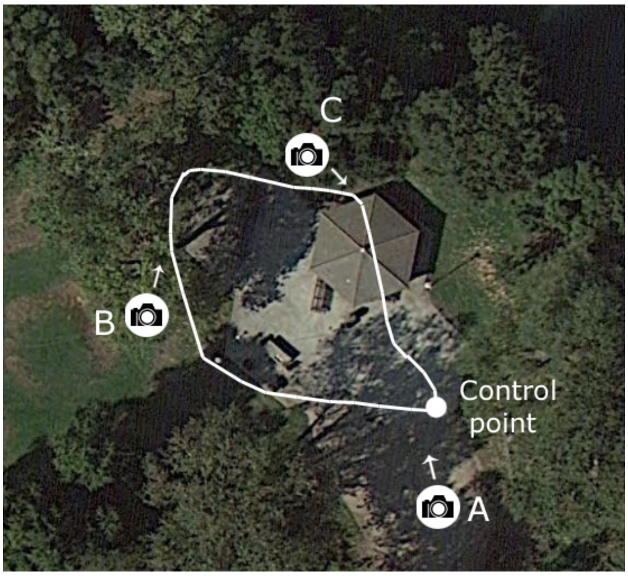

Figure 2: Overview of the testing area and testing track.

This whole area is heavily shaded, either adjacent to or beneath tree canopy. Moreover, to complicate the test scenario, part of the testing track passes under a summer house with a metallic roof, which completely blocks reception of GNSS signals. The track follows the path shown in Figure 2, while Figures 3 and 4 present the test equipment and the environment at points A, B and C.

Figure 3: Test set-up over the control point (Point A).

Both the ProMark 220 and the competitive product were used with their own-brand external antennas mounted on a single rod, as shown in Figure 5.
The tests were made using a typical stop-and-go routine, starting from the control point (A), walking through the track (point B and C), returning to the control point (A), and stopping there for couple of minutes.

Figure 4: Point B (top) and Point C (bottom) of the testing track.

Fifteen consecutive loops were done to ensure statistical significance. During the tests, both units were receiving a GPS/GLONASS RTCM-3 corrections stream from the same base, located 1.3 km from the test site.

Two tests were conducted, with two different bases: first a Spectra Precision ProMark 800 receiver was used as a base, then a receiver from the manufacturer of the competitive product was used in a second set of tests. This approach allowed us to measure the impact of the base receiver on the comparative test results and to ensure that the tests were not biased by the specific base receiver brand.

Figure 5: ProMark 220 and the competitive product fixed on the same rod, each using its own brand antenna.

Tests with the Spectra Precision base receiver

Figure 6 shows fixed RTK positions only, while Figure 7 shows both fixed and float positions. In both cases, testing was conducted using the ProMark 800 as a base for both rover units. Blue dots indicate ProMark 220 positions, while yellow dots indicate positions from the competitive product. In Figure 7, Darker color dots indicate fixed RTK positions, while lighter color dots indicate float positions.

ProMark 220 achieved 54% fixed RTK positions (out of the total number of epochs), while the competitive product achieved only 25% fixed RTK positions.

Additionally, ProMark 220 computed fixed RTK positions under heavy canopy where the competitive product's yield of fixed RTK positions was zero!

Figure 6: Fixed RTK positions only – ProMark 220 in blue (top) and competitive product in yellow (bottom), when ProMark 800 used as a base.

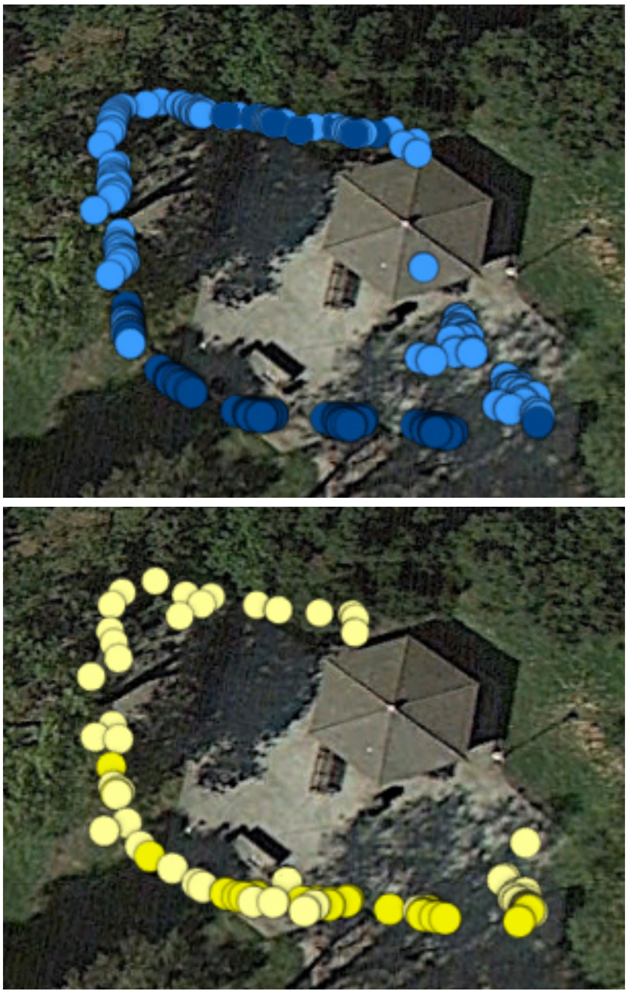

Figure 7: Fixed and Float positions – ProMark 220 in blue (top) and competitive product in yellow (bottom), when ProMark 800 used as a base.

The difference in yield between ProMark 220 and the competitive product is clearly seen. Thanks to Z-Blade technology, ProMark 220 provides much higher yield of both fixed and float positions, as quantified in Table 1.

	ProMark 220 (Z-Blade)	Competitive product
Total epochs	**1688**	**1632**
Fixed epochs	**908** *(54%)*	**411** *(25%)*
Float epochs	**644** *(38%)*	**164** *(10%)*

Table 1: Results, when using ProMark 800 base.

Based on the Table 1 data, we can conclude the following:

- ProMark 220 showed much better availability of fixed RTK positions: 2 x more fixed positions than the competitive product

- ProMark 220 achieved almost 3 x more fixed and float epochs that the competitive product

Tests with the competitive brand base receiver

Figures 8 and 9 present test data from the case where the competitive brand receiver was used as a base for both rover units. Again, blue dots represent positions computed by the ProMark 220 while yellow dots represent positions from the competitive product, while darker dots indicate fixed RTK positions, and lighter dots indicate float positions.

The difference in yield is much more significant when we take into account both fixed and float positions. In this case ProMark 220 clearly outperforms the competitive product, even though the competitive brand base receiver is used for these tests.

This test also provides clear evidence of the Z-Blade technology's capability to work efficiently even with 3rd party base equipment.

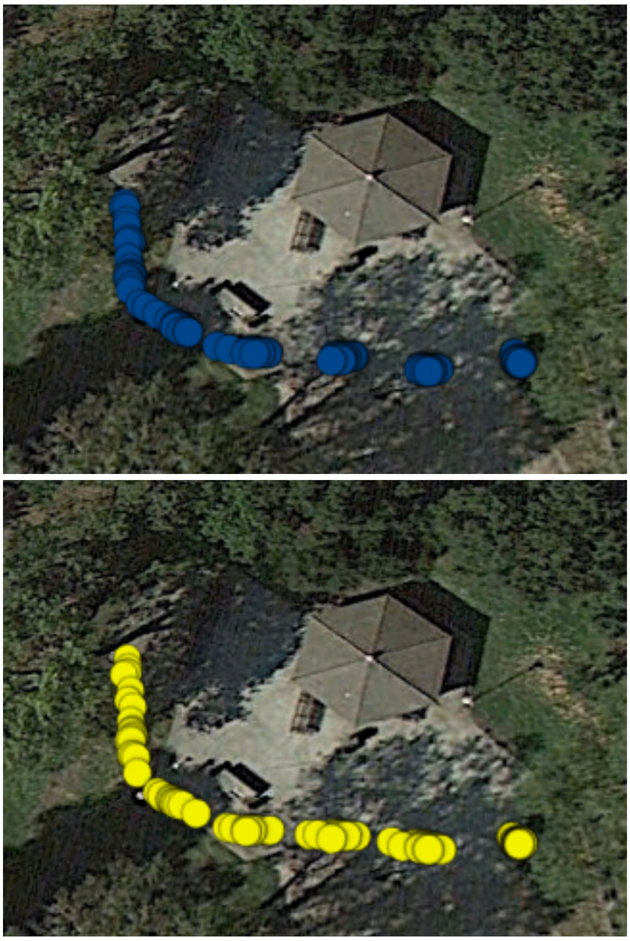

Figure 8: Fixed RTK positions – ProMark 220 in blue (top) and competitive product in yellow (bottom), when a competitive brand base is used.

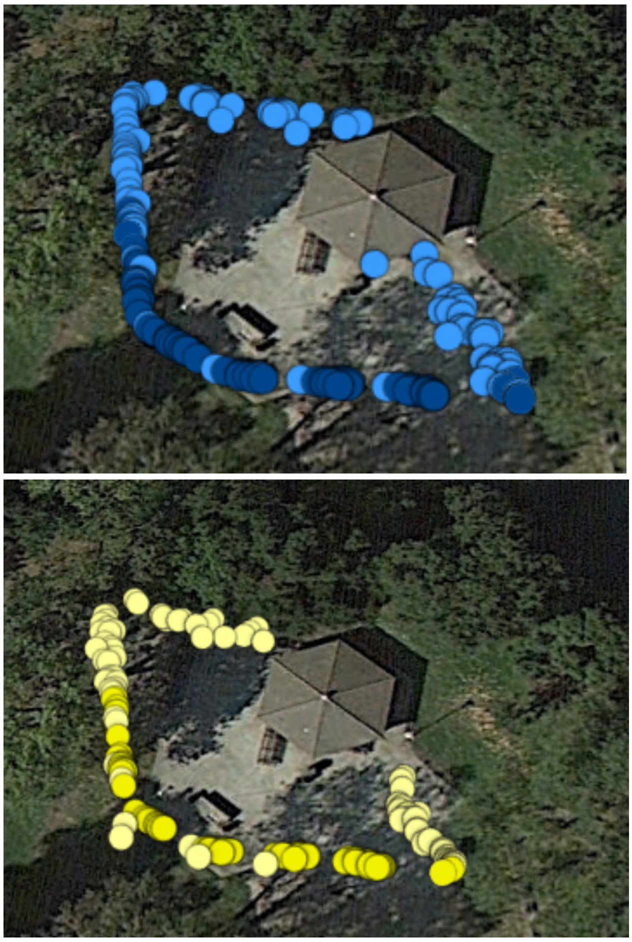

Figure 9: Fixed RTK and float positions – ProMark 220 in blue (top) and competitive product in yellow (bottom), when a competitive brand base is used.

Although the difference in fixed RTK yield between ProMark 220 and the competitive product is less visible in this case, still it represents 50% of the total number of epochs for ProMark 220, and only 44% for the competitive product, as per Table 2.

	ProMark 220 (Z-Blade)	Competitive product
Total epochs	**1367**	**1351**
Fixed epochs	**686** *(50%)*	**595** *(44%)*
Float epochs	**511** *(37%)*	**340** *(25%)*

Table 2: Results, when using competitive brand base.

Based on the data illustrated in Table 2, we can conclude the following:

- ProMark 220 continues to show better availability of fixed RTK positions (about 15% more)

- ProMark 220 continues to show much better availability of fixed and float epochs that the competitive product (almost 30% more)

CONCLUSION

Today surveyors are looking to benefit from the new GNSS systems, such as GLONASS, Beidou and Galileo. Spectra Precision is the first GNSS positioning equipment provider to treat these new GNSS signals as having equal value to GPS signals in positioning computations. The GNSS-centric Z-Blade technology is currently shipping in our ProMark 800, ProFlex 800 and ProMark 220 receivers.

The Z-Blade GNSS-centric approach allows surveyors to get fixed RTK positions in heavily obstructed areas where older GPS-centric products are less efficient and productive. Z-Blade technology also ensures shorter time-to-first fix (even for longer baselines) and optimal operation with base stations from other manufacturers.

Z-Blade products help to keep surveyors working in challenging environments, and minimize the locations where it's necessary to employ alternative surveying tools (for example, optical instruments). This unique technology enables surveyors to increase their accuracy, efficiency and productivity, thus maximizing the value of their GNSS equipment investment.

To learn more about Spectra Precision Z-Blade technology and how Spectra Precision GNSS solutions can help you and your business, please contact your local Spectra Precision reseller.

To locate your nearest Spectra Precision authorized distribution partner, visit our website at www.spectraprecision.com