

# Nexteq Precise Low-cost GPS/GIS Handhelds

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## BIOGRAPHY

Dr. Yufeng Zhang is the VP of Engineering for Nexteq Navigation. Since joining the company in 2007, Dr. Zhang has led the development of Nexteq's Freedom GNSS technologies, PAS and PAD GNSS receivers and T-series GPS/GIS handhelds. Dr. Zhang has also been a post doctoral fellow at the University of Calgary and a systems engineer at Huawei Technology. Dr. Zhang received his PhD degree from the Beijing Institute of Technology in 2001 with a focus on GPS/INS integration.

Suen Lee has a Masters degree in Geomatics Engineering and has consulted for several companies regarding GPS and wireless tracking. Currently he is a Geomatics engineer at Nexteq Navigation.

Chang Chen has more than a decade of software development and testing experience and is currently an application engineer at Nexteq Navigation.

## ABSTRACT

This paper will introduce Nexteq Navigation's recently released T-series GPS/GIS handhelds. Equipped with Nexteq Freedom technologies, Nexteq T-series products are the price/performance leaders in the GPS/GIS handheld market. The T5 handheld is the only handheld with foot level positioning accuracy while using only a single frequency GPS board, thereby offering a significant cost advantage versus dual frequency products handhelds which are currently used for foot level applications. Similarly, the T6 handheld offers sub-meter positioning accuracy while using only a consumer grade GPS chipset, and also offering significant cost advantages versus existing handhelds with comparable accuracy.

Nexteq Freedom technology will be first reviewed in this paper; the T5 and T6 positioning performance will be then investigated; additional details of the T-series handhelds will be introduced and their effectiveness for GIS data collection will be stressed.

## INTRODUCTION

Driven by the conflicting requirements of cost and accuracy, GNSS product development has been diverging into two primary streams of GNSS products in the past decade: precision and consumer GNSS products. Precision GNSS product development has focused on achieving the highest accuracy and integrity, resulting in complicated and expensive technologies such as differential technology and augmentation systems which limit their use to only specialized markets. On the other hand, consumer mass market GNSS product development is dominated by cost and availability of a position solution even in harsh conditions. This has resulted in tiny and inexpensive GNSS chipsets but only capable of several to tens of meters accuracy. This divergence leaves a sizeable market that is underserved by the two main GNSS product streams, especially for GIS data collection. GIS data collection projects generally desire simple logistics, foot level or sub-meter level accuracy, and have cost restrictions. These requirements are difficult to achieve based on current GNSS technologies; foot level accuracy can only be accomplished by expensive dual-frequency PPP [Gao 2006; Kouba and Héroux 2001] or complicated RTK systems. Low cost consumer GNSS based GIS data collectors can only obtain several meters positioning accuracy, which does not satisfy many GIS project requirements.

As described in papers for ION 2008 and 2009, Nexteq has developed Freedom, a precise GNSS technology capable of dramatically improving positioning accuracy [Zhang et al. 2008; Zhang et al. 2009]. Freedom innovation includes novel processing and integration of measurements from GNSS products and augmentation information from systems such as Satellite-Based Augmentation System (SBAS). Unlike other precise positioning techniques, Nexteq Freedom only requires free SBAS corrections which are available in real-time over North America, Western Europe and East Asia, to achieve foot or sub-foot accuracy with stand alone GNSS receivers. This enables GIS data collectors with less expensive professional single frequency GPS chipsets to satisfy foot level GIS requirements. Freedom can also be used with consumer grade GPS chipsets; sub-meter GIS handhelds can also be created using only consumer grade GPS chipsets. Consumer GPS products focus on low-cost and high-sensitivity results in greater multipath effects,

frequent cycle slips and unpredictable receiver clock jerks. Nexteq Freedom has been modified to better reject erroneous measurements and maximize the use of available information to achieve the best possible positioning accuracy.

Nexteq Freedom technology has been successfully incorporated into its T-series of GPS/GIS data acquisition handheld. These are PDA-size handhelds that integrate single frequency professional GPS or consumer mass market GPS chipsets with a compact internal antenna and advanced data connectivity capabilities. Fully integrated with a powerful processor, touchscreen LCD display, microSD slot, camera, microphone and Bluetooth, the handhelds have been extensively tested in real world environments. In typical urban environments where most GIS data collection is done, the T5 with SBAS coverage is able to provide 30 to 40 cm horizontal positioning accuracy and the T6 provides sub-meter horizontal positioning accuracy. This is a significant improvement over competing GPS/GIS handhelds which can only provide sub-meter accuracy with a professional GPS chipset while those with a consumer grade GPS chipset only achieve accuracy of 3 ~ 5 m. Such high accuracy is usually obtainable only by using precision GPS products with subscription based correction services. The T-series' ability to output precise position solution in real-time without a need to use a local base station or a subscription based correction service offers a cost-effective and efficient solution for GIS data acquisition.

This paper will first briefly describe Nexteq Freedom technology; Nexteq T-series handhelds will then be presented and their typical positioning performance will be demonstrated through several test results. Finally how T-series handhelds facilitate GIS data collection will be investigated.

## FREEDOM TECHNOLOGY

Nexteq Freedom technology optimally combines the use of all available GPS measurement information and freely available corrections to enable precise positioning with virtually no convergence time. Freedom technology achieves these feats with the following innovations:

- Techniques to handles the ionosphere delay for single frequency measurements
- Full use of carrier phase measurements beyond only smoothing the code measurements
- Position convergence time minimization
- Application of freely available orbit and clock resources (via SBAS or Internet)
- Advanced QC algorithm to detect large measurement errors and reduce their effect

For consumer GPS chipsets, measurements are more unstable and measurement errors are more unpredictable, so Freedom is also modified to make it more suitable for processing measurements from consumer GPS chipsets.

## PRODUCT DEVELOPMENT

Nexteq Navigation has developed its T-series GPS/GIS handhelds with Freedom technology. The T-series are PDA-size handhelds that integrate single frequency professional GPS (T5) or consumer mass market GNSS chipsets (T6) with a compact internal antenna and advanced data connectivity capabilities. Fully integrated with a powerful processor, touchscreen LCD display, microSD slot, digital camera, microphone, Bluetooth and cellular data connectivity, Nexteq T-series handhelds offer a complete solution for accurate GIS data collection.

### T5 Handheld

The T5 handheld is equipped with a professional single frequency GPS board that is paired with a high quality internal antenna. With Freedom technology, the T5 is capable of foot level positioning accuracy under SBAS coverage, and 1 meter autonomous positioning accuracy with broadcast GPS. In addition, the T5 is also supported by Nexteq post-processing software that provides 0.5 m global accuracy with collected T5 GPS data. Using the included cellular data connectivity, the T5 can also achieve 0.5 m real time positioning accuracy with the aid of Internet broadcasted GNSS corrections.



Figure 1: Nexteq T5 Handheld

The following section provides test results with the T5. The first test had a T5 set up on a control point on the roof of a building, and with SBAS tracking enabled. The test lasted 24 hours to fully cover the daily ionosphere cycle. Below is the result.

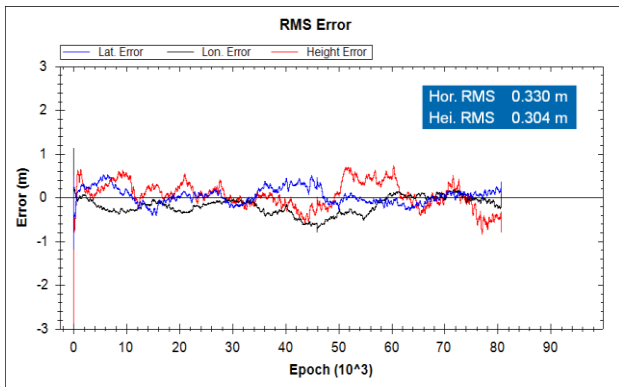


Figure 2: T5 SBAS positioning results

The 2D horizontal RMS accuracy is 33 cm, including both bias and vibration, and height RMS is 30.4 cm. Also, there was virtually no convergence time and except for the first several epochs, the positioning accuracy is the same from beginning to end. During the whole test, the positioning results were smooth with no outliers. This result indicates that T5 is the only single frequency GPS/GIS handheld on the market able to achieve foot level positioning accuracy without any correction subscriptions.

The second test was to confirm performance in regions without SBAS coverage, such as Africa and South America. This was conducted in Calgary with the T5's SBAS tracking disabled and mounted on the roof of a building. Below are the test results.

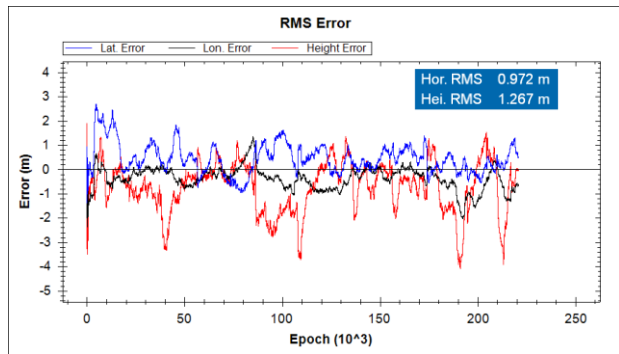


Figure 3: T5 Autonomous positioning results

It can be seen that the T5 achieves the expected performance immediately after power on with no initialization time. During the entire test, there are no position outliers. The statistics show that the T5 achieves 1 m horizontal RMS and better than 1.5 m height RMS, still excellent results for the GPS/GIS market.

For these areas outside of SBAS coverage, if sub-meter accuracy is required, Nexteq offers a post-processing package for the T5. The following results are from a 1 day data set collected by the T5.

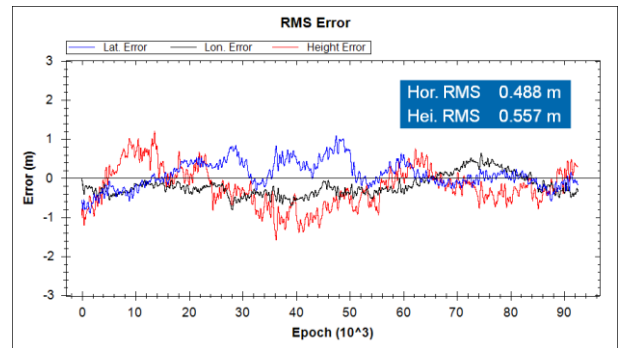


Figure 4: T5 post process positioning results

From the plot, the post-processed results are well below the sub-meter positioning accuracy threshold and have no outliers. This result is representative of the positioning accuracy of the T5 globally, even without SBAS coverage.

In the following table, the tested T5 positioning accuracy is summarized.

Table 1: T5 positioning accuracy summary

SBAS	0.4 m
Single Point	1 m
NTRIP DGPS	0.5 m
Post-Processing	
DGPS	0.2 m
Global	0.5 m
Static Surveys	
( external antenna )	5mm + 1 ppm

## T6 Handheld

T6 handheld is low cost GPS/GIS product, based on a consumer GPS chipset and a good quality internal antenna. With Freedom technology, T6 Handheld is capable of sub-meter level positioning accuracy under SBAS coverage, and better than 1.5 meter autonomous positioning accuracy. The T6 is under development and will be ready for shipment by the end of this year. Below is an image of a T6 prototype.



Figure 5: Nexteq T6 Handheld

Testing is ongoing for the T6 and selected results from a 15 hour test in Calgary are shown in the following figure.

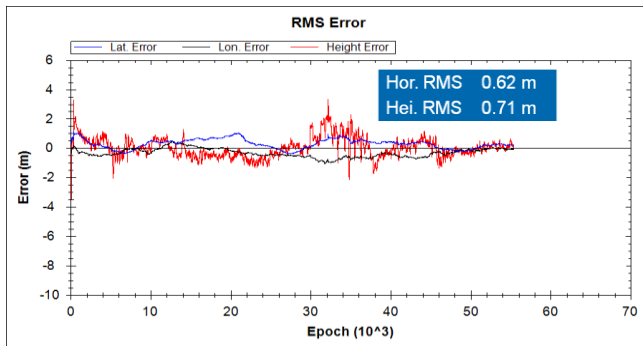


Figure 6: T6 SBAS positioning results

Even with the consumer GPS chipset, the results show that the T6 achieves smooth, instant, sub-meter positioning accuracy making it well suited for GIS data collection.

### USER FRIENDLY GIS DATA COLLECTION

A lack of accuracy can be a challenge in field work. An example of this is when there are two otherwise identical bar features located a few meters apart, such as in the following picture. With positioning accuracy of 2-5 meters, it is difficult to identify these two bars by their coordinate. The T-series handhelds with sub-meter accuracy would eliminate this ambiguity. Furthermore, if the two features are only one meter apart, then only current dual-frequency equipped GPS/GIS handhelds or the T5 can identify the correct feature.



Figure 7: Accuracy in GIS data collection

In GIS data collection, it is important that the attributes of a feature are described clearly and accurately. In most cases, this can be achieved with descriptive text and numeric values. But in some cases, it will be very difficult to describe a feature with only words like the following picture.



Figure 8: Description of complicated features

The condition of the above bridge is too complicated to be captured by a few words, generic attributes or numbers. For such features, the built-in microphone and camera of the T-series can provide more relevant information through voice and photo tagging, allowing future users of the data to clearly see the condition of the feature.

Real-time information sharing between field worker and office management team is critical for some work, especially for time-critical emergency operations like fire fighting. With the built-in cellular data connectivity, as shown in the following figure, T-series handhelds can transfer field information and conditions to the office in real-time, and help the management team make the right decision faster and field workers can act quicker based on the decisions made.



Figure 9: Real-time data sharing

To take full advantage of the positioning and hardware capabilities of the T-series handheld, a complete GIS data collection software application, named GeoInfo Mobile, has been developed. This software displays real-time location, features, vector and raster data on the T-series handheld, and collects features like points, lines and areas. Beyond data display and collection, this software also has a Navigation function, which could help field workers easily navigate to target locations.

An office tools software package named GeoInfo Office was also developed to manage the projects and data of GeoInfo Mobile and the T-series handheld. GeoInfo Office is also able to import and export data from industry standard formats such as ESRI SHP, Auto CAD DXF and MapInfo MIF, enabling the T-series handhelds to integrate with existing GPS/GIS infrastructure.

## CONCLUSIONS

As introduced in this paper, Nexteq T-series GPS/GIS handheld products offer:

- Outstanding positioning performance, 30-50 cm for T5 professional GPS/GIS handheld and sub-meter for T6 consumer GPS/GIS handheld
- Fully featured hardware and software for more effective and efficient GIS data collection
- Complete GIS data collection software, compatible with industry standard
- Simple, cost-effective and user friendly

## REFERENCES

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