ashtech

MobileMapper™ 100

White Paper

A Breakthrough in Handheld Accuracy

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Abstract

In the continuously developing GIS market, new users and market segments are currently emerging, with more and more demanding requirements.

Customers are primarily asking for better accuracy. In network management applications such as water distribution, telecommunications or electricity, sub-meter accuracy is just not enough.

Extended position availability is also becoming a strong requirement. Being unable to run GIS projects in obstructed areas because of a lack of reliable positions due to adverse reception conditions is simply unacceptable.

In parallel, as the number of specific GIS applications increases, customers are asking for more processing power, higher-quality screens and truly “handheld-operated” receivers.

In 2010, Ashtech introduced the **MobileMapper® 100** to meet all these new requirements.

The MobileMapper 100 comes in a lightweight, compact, ruggedized, Windows® Mobile handheld platform. It is fitted with a powerful processor, a large full daylight-compatible color touch screen, a cellular modem and Bluetooth. **Above all, MobileMapper 100 offers an incredibly high level of accuracy using its internal antenna**.

This White Paper details the level of accuracy that can be expected from the MobileMapper 100 in various situations. The results of comparative tests are also provided making the MobileMapper 100 a new reference standard for all GIS professionals.

Introduction

In many specific GIS market segments, there is a growing need for more accuracy.

One way of meeting this requirement is to offer post-processing capabilities. In that respect, Ashtech offers very efficient and cost-effective software products.

However, more and more users want the required level of accuracy to be available right in the field, that is, in real time. This technically requires implementing professional GNSS techologies together with adequate connectivity.

Over the years, Ashtech has developed a proven real-time GNSS technology, already available in its high-end survey receivers from the ProMark™ and ProFlex™ series.

Ashtech has also been working on solving the many issues raised by the “handheld” dilemma. How to combine high-end GNSS with a cost-efficient and compact handheld platform while optimizing performance and keeping the platform a truly “handheld” product for field use?

Today the combination of a smart phone-like architecture with Ashtech technology leads to the resolution of this dilemma: MobileMapper 100 is the Ashtech product embodying this demand.

With MobileMapper 100, the latest state-of-the-art Ashtech technology is now available on a handheld device, combining an internal high-grade GNSS antenna with powerful processing capabilities.

The result is that MobileMapper 100 can achieve amazing accuracy with its internal antenna, from meter down to centimeter level, depending on configuration and environment.

With this technology, meter accuracy is achieved in standalone mode, sub-meter accuracy in SBAS DGPS and decimeter accuracy in Flying RTK using corrections from a single base or a base network. For short baselines, the receiver can ultimately provide centimeter-level accuracy in open sky, with high availability.

The Technical Challenges

Designing a handheld receiver capable of delivering decimetric, and even centimetric accuracy, from its sole internal antenna implies that every effort is made to overcome the inevitable degradation of the GNSS signal received.

The main factors that are responsible for signal degradation are listed below:

- *Loss of Signal-to-Noise ratio*. The noise level at the internal antenna input is naturally higher than that observed with an external high-grade antenna.
- *Internal interference*. Embedded electronic devices, such as GSM and BlueTooth, are an additional source of noise and interference for the GNSS signal received.
- *Errors & biases due to multipaths*. Embedding a GNSS antenna into a handheld receiver has a strong impact on the dimensions the antenna may have. The direct consequence of a smaller antenna is a higher level of errors and biases due to multipaths.
- *Obstruction due to human body.* Truly "handheld" use of the receiver means the internal antenna is used very close to the operator's body, potentially resulting in more satellites masked and more reflected signals observed at the antenna input.

Ashtech has been using its long experience to cope with these major technical challenges:

- The choice was made to move from GPS to GPS + GLONASS so that a higher quantity of tracked signals and satellites may best compensate for the lesser quality of raw data.
- The internal antenna was designed with special care for maximum performance.
- Putting together various communication devices and GNSS reception circuitry in a limited space has been done several times by Ashtech. MobileMapper 100 has benefited from Ashtech's latest innovations in that domain.
- The proven BLADE technology was integrated to minimize multipath errors and obstruction due to the close presence of a human body.

A new hardware design and new software algorithms were also implemented to give MobileMapper 100 the incredible level of performance measured in the field:

- New powerful signal search & acquisition section.
- Patented Ashtech “Strobe™ Correlator” mitigation technique tuned for the internal antenna.
- Data received from SBAS not only include SBAS corrections but also SBAS pseudo-ranges & carrier phase measurements, which in addition to GPS observables are used in the position computation process.
- Replacement of conventional Float RTK with Ashtech Flying RTK algorithms. Flying RTK can achieve decimetric accuracy, using corrections from bases several hundred kilometers distant from MobileMapper 100 users.
- Ashtech BLADE RTK algorithms adapted for superior L1-only data collection by the internal antenna.
- Various innovations related to the combined use of GPS and GLONASS in the position computation process.

Testing the GNSS Performance of MobileMapper 100

GNSS performance is a critical aspect in GIS handheld receivers. If designed around consumer-based GPS chips, receivers cannot be ranked as high-end GIS products. Only the use of professional-grade GNSS technology can actually make a difference.

MobileMapper 100 is precisely the mix of the renown Ashtech GNSS technology with a powerful and professional handheld platform. Through this successful association, MobileMapper 100 comes with really strong assets in terms of GNSS performance.

The best way to highlight MobileMapper 100's capability to better track satellites and come up with more accurate positions is to test it in adverse reception conditions. Being able to operate smoothly in those conditions is key for GIS data collection, and even more important when higher levels of accuracy are needed.

This White Paper presents a thorough assessment of the GNSS performance of the MobileMapper 100 through two different categories of tests:

- MobileMapper 100 was first tested individually with its internal antenna and in different reception configurations:
  1. Position computation, static occupation, open sky:
     - GPS only + SBAS
     - GPS + GLONASS + SBAS
  2. Area & perimeter computation, kinematic, open sky:
     - GPS only + SBAS
     - GPS + GLONASS + SBAS
     - GPS + SBAS DGPS (RTCM 2.3 corrections)
- MobileMapper 100 performance was then compared with a selection of competitive receivers, using its internal or external antenna. Four different products were benchmarked in two comparative tests:
  1. Position computation, static occupation, open sky
  2. Area computation, kinematic, heavy canopy

All the tests were conducted in real time with MobileMapper 100 run by Ashtech field software *MobileMapper Field*.

Static Tests

Test Conditions

- MobileMapper 100 mounted on a tripod and operated in a widely open area (no obstructions nearby; see *Fig. 1*).

Fig. 1. Test Site

- Internal antenna used
- Overall test duration: > 8 hours
- Position computation reset every 5 minutes (more than 100 iterations)
- Position collected unconditionally at three different times following receiver reset: at reset time (0 sec), 30 sec. after reset, and 60 sec. after reset
- Collected positions compared to “true” position collected with ProMark 500 and then post-processed.

GPS+SBAS Test Results

- Tracking mode used: GPS only + SBAS

Time of collection	Horz. Error (RMS)	Vert. Error (RMS)
+0 sec	0.8	1.37
+30 sec	0.63	0.99
+60 sec	0.62	0.95

GPS+GLONASS+SBAS Test Results

- Tracking mode used: GPS + GLONASS +SBAS

Time of collection	Horz. Error (RMS)	Vert. Error (RMS)
+0 sec	0.92	1.33
+30 sec	0.60	0.94
+60 sec	0.56	0.89

Comments

1. MobileMapper 100 is consistently sub-meter accurate.
2. In open sky conditions, GLONASS has a neutral effect on accuracy.

Test Conditions

Fig. 2. Receiver Setup

- MobileMapper 100 mounted on a half-pole and operated to measure the area and perimeter of a handball court (virtually open sky conditions; see *Fig. 2* and *Fig. 3*).

Fig. 3. Test Site, Panoramic View

- Internal antenna used
- Measured areas and perimeters compared to "true" values determined after post-processing field data collected with ProMark 500. These trues values are:
  - Area= 1475.8 m²
  - Perimeter= 157.2 m
- Area and perimeter measured 10 times
- Operator uses Ashtech *MobileMapper Field* software to log the limits of the court as an area feature (in automatic mode).
- Raw data also logged for post-processing. Raw data post-processed with Ashtech *MobileMapper Office* software using raw data collected by a nearby base station (Baseline length: 1 km)

GPS+SBAS Test Results

- Tracking mode used: GPS only + SBAS

	Error vs. True Value (Absolute)	Error vs. True Value (%)
Perimeter	2.7 m	1.72%
Area	6 m²	0.41%

GPS+GLONASS+SBAS Test Results

- Tracking mode used: GPS + GLONASS +SBAS

	Error vs. True Value (Absolute)	Error vs. True Value (%)
Perimeter	1.8 m	1.15%
Area	1.4 m²	0.09%

Testing Flying RTK

Test Conditions

- Two MobileMapper 100 are used side by side to collect the same GIS data. One is used in Flying RTK, receiving corrections via its internal modem from a base about 400 km apart, the other in conventional SBAS DGPS mode.
- A large amount of point features are logged in various environments (urban areas, shady parks, etc.) in order to have the two receivers operated in real conditions of use where satellite reception may be impaired by multipaths and obstructions.
- Both units use their internal antenna.
- Point features are logged with Ashtech *MobileMapper Field* software in both units.

Test Results

	Position error (HRMS)	Position error (VRMS)
GPS+SBAS	0.988	1.513
Flying RTK, baseline length: 400 km	0.372	1.240

These results prove that in real conditions of use, the MobileMapper 100 can achieve better than 0.5 meter horizontal accuracy in Flying RTK over long baselines. Compared to the standard SBAS DGPS mode, Flying RTK can indeed provide a significant benefit by dramatically improving the level of accuracy achieved.

MobileMapper 100 users can consider implementing accurate GIS applications with a single base station covering a fairly large region.

Moreover, due the superiority of the Ashtech algorithms in processing signals from GLONASS satellites and generating GLONASS corrections, even better operation will be obtained using an Ashtech base station, typically a ProFlex 500.

Comparative Tests

Testing a new product against the competition is always a source of useful information. Comparative tests are even more valuable when they are performed by a third party. Ashtech would like to thank the independent GIS professional who kindly returned the results of his tests for publication in this White Paper.

Two different types of comparative tests were performed:

1. **Area & Perimeter Measurements in Shaded Area** (heavy canopy; see *Fig. 4* and *Fig. 5*). The reference values for these area and perimeter had been collected earlier in the winter season, with most trees bare of leaves, based on data collected with a centimeter-accurate surveying equipment.

Fig. 4. Test Site

2. **Static Point Logging in Open Sky**. The reference value had been collected earlier with a centimeter-accurate dual-frequency surveying equipment.

Area & Perimeter Measurements in Heavily Shaded Area

Fig. 5. Heavy Canopy

The table below is a summary of all the tests made under dense foliage. For each tested receiver, the table provides the deviations of its perimeter and area measurements compared to the aforementioned reference values.

Receiver Model	Professional Competitor A	Professional Competitor B	Ashtech MobileMapper 100
Tracking mode	GPS+GLONASS	GPS+GLONASS	GPS+GLONASS
Network connection	through external cell phone	through internal cellular modem	through internal cellular modem
Antenna used	External	External	External
Max. Horizontal Error (m)	**8.4**	**7.08**	**2.15**
Mean Horizontal Error (m)	**2.64**	**2.05**	**1.02**
Area Relative Error (%)	**1.0**	**0.8**	**0.36**

Competitors A and B are also GNSS handhelds.

In the perimeter measurement test, MobileMapper 100 provides far better results than the other two competitors, both in terms of repeatability and accuracy. In extremely adverse conditions, MobileMapper 100 succeeds in limiting the maximum horizontal error to 2 m while all other receivers struggle to keep it under 8 meters.

In the area measurement test, all receivers have been able to deliver acceptable results but once again, MobileMapper 100 was the closest to the reference value, with a precision figure **up to four times better** than that of the other receivers.

These results show that in presence of multipaths, poor signal quality and fewer satellites available, MobileMapper 100 is the best in acquiring quality data and delivering reliable measurements owing to its superior reception sensitivity and satellite tracking performance.

Static Point Logging in Open Sky

The table below is a summary of all the static tests made in open sky. For each tested receiver, the table provides the deviations of the computed positions compared to the aforementioned reference value.

Receiver Model	Professional Competitor A	Professional Competitor B	Ashtech MobileMapper 100	
Tracking mode	GPS+GLONASS	GPS+GLONASS	GPS+GLONASS	
Network connection	through external cell phone	through internal cellular modem	through internal cellular modem	
Antenna used	External	External	External	**Internal**
Max. Horizontal Error (m)	2.08	0.77	**0.09**	**0.25**
Mean Horizontal Error (m)	1.73	0.67	**0.06**	**0.21**

Again, the repeatability of the MobileMapper 100 measurements is impressive, with an amazingly good figure (less than 10 cm with an external antenna). In the same conditions, the points delivered by the other professional products are eight times more scattered. When used with an external antenna, the performance of MobileMapper 100 is in fact quite close to that of a high-grade centimeter-accurate equipment.

Even with its internal antenna, MobileMapper 100 provides far better results than its competitors with their external antennas. With only 25 cm of maximum horizontal error, MobileMapper 100 is far ahead of its closest competitors which, in the same reception conditions, can only deliver metric horizontal accuracy.

Conclusion

As a handheld receiver using its sole internal antenna, MobileMapper 100 can deliver far better accuracy than its direct counterparts, including those using an external, geodetic antenna.

In view of the test results obtained, MobileMapper 100 appears as a unique product offering maximum benefit when:

- More accuracy is required
- Reception conditions are difficult
- Truly “handheld” operation is needed.

With MobileMapper 100, the level of accuracy delivered is left at the user’s choice. This means each GIS project dictates the level of accuracy required, and MobileMapper 100 will adapt, letting users choose the operating mode that best matches this requirement.

In conclusion, MobileMapper 100 is the first GIS receiver that successfully combines high level of performance, mobility, flexibility and ease of use. MobileMapper 100 is the product that all GIS professionals have been dreaming of and which is today available from the Ashtech dealer network.

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White Paper

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