ADVANCED SATELLITE TRACKING WITH TRIMBLE 360 TECHNOLOGY

WHITE PAPER

TRIMBLE SURVEY DIVISION

WESTMINSTER, COLORADO, U.S.A.

October 2012

ABSTRACT

Advancements in global navigation satellite systems (GNSS) are increasing the number of available satellites and satellite ranging signals to surveying professionals worldwide. To ensure surveyors benefit from the latest satellite positioning technology as well as protect their investment in GNSS equipment and technology, Trimble offers the next evolution in satellite tracking technology -- Trimble 360. Integrated in the Trimble R10 receiver, Trimble 360 technology supports signals from all existing and planned GNSS constellations and augmentation systems. With 440 GNSS channels, Trimble 360 technology now makes it possible for surveyors to expand the reach of their GNSS rovers into areas that were previously too obscured, such as under trees and in dense urban areas. This paper discusses how Trimble 360 technology increases productivity and delivers business confidence with a sound GNSS investment for today and long into the future.

Survey Division, 10355 Westmoor Drive, Suite #100, Westminster, CO 80021, USA

INTRODUCTION

As GPS and GLONASS modernization progresses and Galileo and Compass continue to increase the number of satellites in space, surveying professionals are presented with additional satellites and satellite ranging signals to enable them to be more productive in the field. GNSS technology has helped users to increase productivity, improve efficiency, and lower costs. The additional satellites and signals promise to take these benefits a step beyond. Measurements can be more robust as GNSS observations become even more reliable, especially in areas with limited sky visibility.

To capitalize on these advancements in GNSS technology and future-proof surveying companies' investment, Trimble 360 technology in the Trimble R10 receiver tracks all existing and planned GNSS satellite constellations, including GPS, GLONASS, Galileo, Compass, and QZSS as well as existing and planned augmentations to these GNSS constellations, including WAAS, EGNOS, MSAS, and GAGAN. Offering 440 GNSS channels, Trimble 360 technology provides consistent and reliable tracking of all available GNSS signals.

Figure 1: Trimble R10 receiver with Trimble 360 technology

GPS

GPS was developed in 1973 by the U.S. Department of Defense to provide positioning, timing, and navigation signals to the U.S. military and civilians worldwide. As of today, there are 31 active and healthy GPS satellites in space. GPS transmits three carrier frequencies—L1, L2, and L5. The L5 signal is currently only broadcast from two Block IIF satellites. The difference between the carriers is shown in Table 1.

Carrier	Frequency (MHz)	Code
L1	1575.42	C/A, P(Y), M
L2	1227.60	P(Y), L2C, M
L5	1176.45	I5, Q5

Table 1: GPS Carriers Today

With L1, L2, and L5 carriers available, it is anticipated that the capabilities of RTK systems will be significantly boosted and will thus provide more robust positioning in extreme environments. In addition, L5 signals provide a higher power level than the other carriers. As a result, acquiring and tracking signals will be easier.

Modernization plans include the L2C signal currently broadcasted from 12 satellites, the L5 signal currently broadcasted from two satellites, and the L1C signal that is part of the Block III launch. Trimble 360 technology takes advantage of all currently available GNSS signals, including the new L2C and L5 signals of Modernized GPS.

GLONASS

Russia's satellite navigation system, GLONASS, consists of 24 fully operational satellites. The major difference between GPS and GLONASS is in the signal structure - GPS uses Code Division Multiple Access (CDMA) while GLONASS uses Frequency Division Multiple Access (FDMA). In other words, each GLONASS satellite broadcasts on a slightly different

frequency but uses the same spreading code, while all GPS satellites broadcast the same frequency but use different spreading codes. Table 2 outlines the current GLONASS carriers, frequency and codes.

Carrier	Frequency (MHz)	Code
L1	1602 + 0.5625*n	C/A, P
L2	1246 + 0.4375*n	C/A, P
L3*	1207.14	L30C

Table 2: GLONASS Carriers Today

*Note: CDMA signals broadcasted by the current GLONASS-K1 satellite are not completely determined and are subject to change in the future.

Current GLONASS modernization plans look to move towards CDMA signal rather than the current FDMA signal structure. The GLONASS-K1 satellite launched in October 2011 is broadcasting a test CDMA signal on the L3 carrier. Trimble 360 technology supports the current GLONASS signals as well as the planned CDMA signal structure.

GALILEO

Europe's satellite navigation system, Galileo, aims at having a final constellation of 30 satellites. The first two operational satellites were launched in October 2011. Full completion is expected by 2019. Trimble 360 technology is capable of tracking future Galileo operational satellites and conforms to the current Open Service Signals-in-Space Interface Control Document (OS SIS ICD), Issue 1, Revision1, September 2010. Receivers based on this technology will be capable of tracking all future Open Service signals from the satellites simultaneously. The table below outlines the current Galileo carriers, frequency and code.

Carrier	Frequency (MHz)	Code
E1	1575.42	E1a, E1b, E1c,
E5	1191.795	E5a-I, E5a-Q, E5b-I, E5b-Q
E6*	1278.75	E6a, E6b, E6c

Table 3: Galileo Carriers Today

*Note: E6a is a PRS signal and E6b and E6c are CS signals so how these will be accessed has not yet been determined.

COMPASS/BEIDOU2

Compass, also known as Beidou-2, is China's satellite navigation system. The program was approved by the Chinese government in 2004 with the expectation to have a regional navigation system covering China and neighboring regions by 2012 and a system with global coverage by 2020. The final constellation will consist of 35 satellites. Current plans call for 27 medium earth orbits (MEO) satellites, five geosynchronous satellites, and three inclined geostationary orbits. Compass uses CDMA modulation techniques and is considered interoperable with other GNSS systems. Table 4 outlines the different Compass carriers today.

Carrier	Frequency (MHz)	Code
B1	1561.098	B1-I, B1-Q
B2	1207.14	B2-I, B2-Q
B3*	1268.52	B3-I, B3-Q

Table 4: Compass Carriers Today

Note: B3 band is authorized access only (military).

Trimble 360 technology tracks the B1and B2 open service signals from the Compass test satellites. Trimble products have successfully tracked all Compass satellites launched to date, including the five Compass GEOs (G1–G5), the five Compass inclined GEOs (I1–I5) and the three MEOs (M1, M3, M4). However, as of early September 2012, Compass G2 no longer transmits ICD complaint codes.

QZSS

Quasi-Zenith Satellite System (QZSS) is a Japanese regional navigation satellite system covering Asia and Oceania. The system is designed to be completely compatible with GPS, broadcasting the same navigation signals at L1, L2, and L5 as well as an augmentation correction signal (L1-SAIF) at L1 that is compatible with other SBAS systems that provides sub-meter positioning. Table 5 outlines QZSS' carriers and its frequencies and codes.

Carrier	Frequency (MHz)	Code
L1	1575.42	C/A, L1C, L1-SAIF
L2	1227.60	L2C
L5	1176.45	I5, Q5
LEX	1278.75	Short, Long

Table 5: QZSS Carriers Today

The first QZSS satellite was launched in September 2010. Based on version IS-QZSS Version 1.2, Trimble 360 technology is capable of tracking and using the measurements made from QZSS satellites.

TRIMBLE 360 TECHNOLOGY

As the most advanced satellite tracking technology, Trimble 360 ensures that surveyors can fully take advantage of the latest GNSS technology. With two state-of-the-art Trimble Maxwell™ 6 custom integrated circuits for GNSS signal processing, the Trimble R10 receiver is the first surveying receiver to offer 440 GNSS channels of all-in-view tracking. Capable of receiving carriers from multiple GNSS, (listed in Table 6), Trimble 360 technology now makes it possible for surveyors to track more satellites to provide successful positioning in difficult environments.

GNSS System	Carrier Signal
GPS	L1, L2, L5
GLONASS	L1, L2
Galileo	E1, E5
Compass	B1, B2
QZSS	L1, L2, L5, LEX

Table 6: Trimble R10 Tracking Capabilities

At the heart of the Trimble R10 receiver is the new HD-GNSS processing engine. This ground-breaking technology transcends traditional fixed/float techniques to provide a more accurate assessment of error estimates than traditional GNSS technology. Markedly reduced convergence times as well as high position and precision reliability enable surveyors to collect measurements with confidence while reducing their occupation time.

Powered by the new HD-GNSS processing engine, and containing Trimble 360 technology, the Trimble R10 receiver offers comprehensive support for all currently available and imminent satellite navigation signals, including GPS, GLONASS, Galileo, Compass, and QZSS.

BENEFITS TO THE SURVEYOR

GNSS technology has had a tremendous impact on the surveying industry. The use of GNSS for precise positioning has previously been limited to areas of good sky visibility. However, improvements in satellite tracking technology in recent years have enabled surveying professionals to operate in difficult environments with improved performance.

Trimble 360 technology offers more robust satellite tracking compared to traditional GPS surveying equipment. With 440 GNSS channels, Trimble 360 technology tracks all available GNSS signals, including all currently operational satellites from Galileo,

Compass and QZSS, and the upcoming satellites planned for these constellations as well as satellites planned for GPS and GLONASS modernization. Multiple GNSS constellations mean a surveyor can work in more difficult environments. With the additional satellites to work with, surveyors can expect greater accuracy in demanding field conditions. That also means a decrease in downtime and an increase in productivity for field crews.

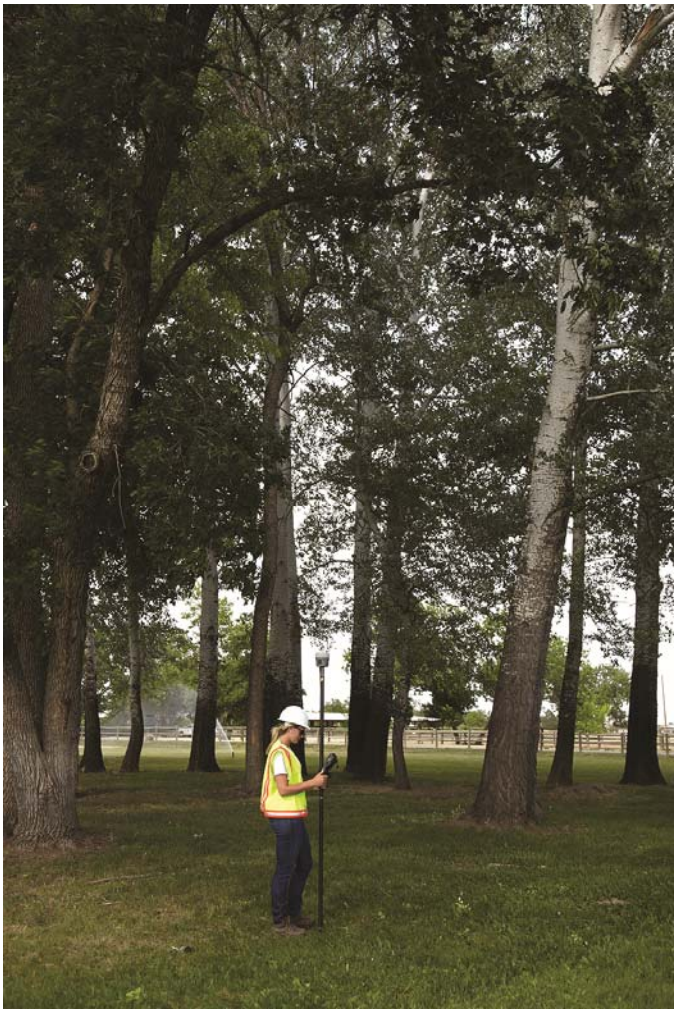

Figure 2: Trimble R10 receiver with Trimble 360 technology under tree canopy

Trimble 360 technology not only allows surveying professionals to benefit from the latest GNSS technology, it also protects surveying companies' investment in GNSS equipment and technology. Designed with the future in mind, Trimble 360 technology is optimized to receive future planned signals as the number of available satellites continues to grow. Surveying professionals can experience improved performance from their investment today and be confident that their GNSS surveying equipment is future-proof.

Figure 3: Trimble R10 receiver with Trimble 360 technology in urban area

CONCLUSION

The next decade will see many changes in the GNSS world. The coming signals that are part of GPS and GLONASS modernization and the additional Galileo, Compass, and QZSS satellites will present surveyors with opportunities for more robust satellite tracking and all the inherent benefits associated with these satellites. Trimble 360 technology in the Trimble R10 receiver can enable surveyors to utilize those benefits to increase their accuracy, efficiency, productivity, and competitiveness.

Since most surveyors use their surveying equipment for several years, companies purchasing a receiver today should take the changes in GNSS into consideration. By purchasing a receiver that is ready to receive upcoming signals without hardware upgrades, they will protect their investment for many years to come and ensure maximum accuracy and productivity through the equipment's lifetime.

To learn more about how Trimble surveying solutions can help you and your business, or to view a demonstration of the Trimble R10 receiver with Trimble 360 technology, please contact your local Trimble distribution partner. To locate your nearest Trimble authorized distribution partner, visit our website at http://www.trimble.com/locator/sales.asp.