BEYOND GNSS

ADDING MICROSENSORS AND TRIMBLE SUREPOINT TECHNOLOGY TO SURVEY ROVERS FOR ENHANCED ACCURACY AND PRODUCTIVITY

WHITE PAPER

BEYOND GNSS: ADDING MICROSENSORS AND TRIMBLE SUREPOINT TECHNOLOGY TO SURVEY ROVERS FOR ENHANCED ACCURACY AND PRODUCTIVITY

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ABSTRACT

Accurate GNSS survey measurements rely on the surveyor's ability to maintain the rover pole in a stable plumb (sometimes called "level") attitude for the duration of point collection. Surveyors spend extra time in the field trying to ensure that the rover pole is level when taking measurements. The Trimble R10 GNSS Receiver incorporates a revolutionary attitude sensing technology, called Trimble SurePoint™, to reduce the occupation time required to collect accurate survey measurements and to provide an intuitive survey workflow.

This paper will discuss how Trimble SurePoint ensures the highest level of precision and accuracy in any field condition by:

- Safeguarding against the collection of erroneous data when the rover pole is not plumb
- Measuring with increased speed and confidence using an electronic bubble (Trimble's new eBubble feature) on the data collector
- Providing additional traceability in positional data with tilt indicators incorporated into measurement records

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Trimble

BEYOND GNSS

This paper will discuss how additional sensors added to a GNSS survey receiver revolutionize survey data collection. Accurate GNSS survey measurements rely on the field operator's ability to maintain the rover pole in a stable plumb (sometimes called "level") attitude for the duration of point collection. Catering to this, surveyors spend much of their field measurement time positioning the antenna pole and maintaining it in a stable level position. After the field data collection is complete, there is no definitive record of how the operator handled the rover or whether the pole was kept plumb during measurements. The Trimble R10 GNSS Receiver goes beyond traditional GNSS support by incorporating a revolutionary attitude sensing technology, called Trimble SurePoint™, to reduce the occupation time required to collect accurate survey measurements and to provide an intuitive survey workflow.

THE TOTAL STATION ADVANTAGE

Surveyors familiar with both total stations and GNSS receivers know that both types of systems allow precision measurement but they operate very differently and offer unique benefits. Total stations are electromechanical devices that precisely measure angles and distances to determine the position of surveyed features. They require very careful setup and use their integrated electromechanical sensors to continuously monitor for any movement of the instrument. In some cases, total stations can even provide automatic error correction in response to changes in their orientation. Integrated compensators, which correct minor changes in the instrument's levelness, are particularly valuable. These devices compensate for the minor variations in the verticality of the instrument to ensure that angular measurements are accurate even if the instrument's optical aim moves slightly.

Many total stations employ complex strategies to detect and correct instrument orientation errors in real time going beyond the corrections offered by a compensator. Trimble SurePoint technology integrated within the Trimble S-Series total stations is one of the most advanced implementations of error detection and correction. Trimble SurePoint accuracy assurance goes beyond conventional compensation and allows the Trimble S-Series total stations to provide accurate measurements and remain aimed at a target to guard against sinkage, vibration, and handling that can affect an instrument after setup. If the instrument is unintentionally bumped, e.g. by pressing the trigger key with excessive force, then it will make fine adjustments to turn back to the original aimed angle. Trimble SurePoint ensures that traditional sighting errors caused by unintentional small movements of the instrument are eliminated.

Figure 1: Trimble SurePoint Technology Corrects Leveling Errors in Trimble S-Series Total Stations

SUREPOINT IN GNSS

The equivalent of a total station setup error in GNSS occurs if the antenna-bearing pole is not held plumb and stable when a measurement is taken. The positioning errors caused by this pole tilt can be quite large depending on the care with which the surveyor levels and steadies the pole. Traditionally, whether or not the pole was kept plumb and stable could only be detected in the field by the operator and there would be no stored record of the pole tilt.

Up until now, GNSS survey receivers were purely electronic devices that precisely measure ranges and time. Without integrated electromechanical angle sensors, GNSS receivers could not offer the attitude monitoring features of total stations. Because of this,

surveyors have developed procedures and techniques to reduce the possibility of pole positioning errors. Using a bipod is one of the best ways to eliminate pole attitude errors. Another technique is to occupy a point for a period of time to collect an averaged series of measurements. If the surveyor can keep the pole fairly steady to measure this series, the average position probably represents a single, vertical pole measurement well.

Figure 2: Ground positioning error increases with pole tilt

The problem with both averaged measurements and the use of bipods is they add significantly to the time required to measure a point location. One of the greatest opportunities for increasing GNSS survey productivity lies in reducing the time to get the rover pole plumb and reducing the observation time when it has to remain in a plumb orientation.

Advancements in Micro-Electro-Mechanical Systems, or MEMS, have made precise, reliable, miniature sensors available for a variety of applications. Inertial sensors based on accelerometers in particular have been miniaturized and simplified to improve their repeatability and robustness while consuming less power. The latest MEMS sensors have revolutionized everything from game controllers to space vehicles. Now, MEMS sensors are profoundly changing GNSS surveying. The Trimble SurePoint technology used in the Trimble S-Series total stations has now been integrated into the Trimble R10 GNSS receiver to create a leading-edge GNSS surveying system. Trimble SurePoint technology in the Trimble R10 GNSS receiver integrates these high quality sensors to improve GNSS point collection workflow, measurement accuracy and operator confidence.

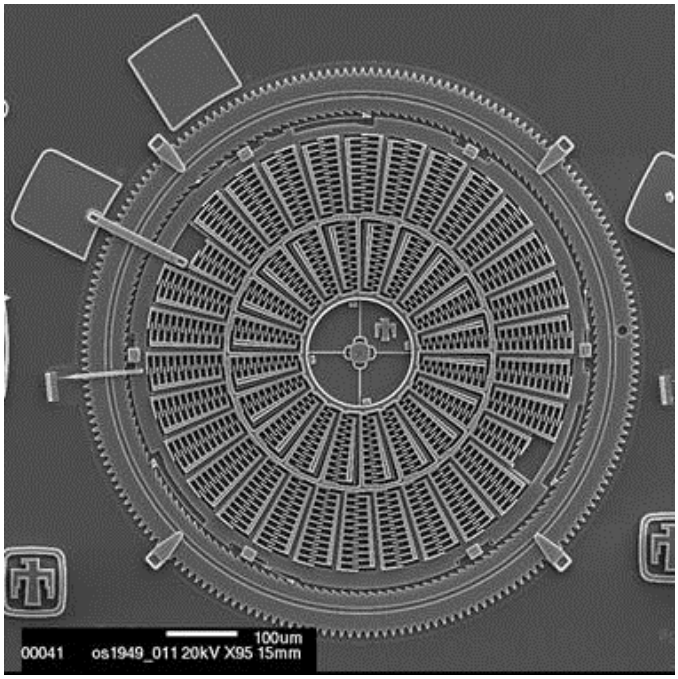

Figure 3: MEMS Torsional Ratcheting viewed at high magnification. Image Courtesy of Sandia National Laboratories, SUMMiT™ Technologies, www.mems.sandia.gov.

Therefore, Trimble SurePoint technology improves the GNSS point collection workflow in several ways:

- The need to focus on both the pole bubble and the controller screen is eliminated. Automated measurement of pole tilt allows the display to show if the pole is within tilt tolerance with a simple color change of the electronic bubble display on the controller screen.
- Beyond this display, the system also records the pole tilt associated with measurements.
- Trimble SurePoint uses pole orientation as a controlling input converting point measurement into an intuitive, flowing operation.

ELECTRONIC BUBBLE

Precision MEMS tilt sensors in the Trimble R10 allows an electronic bubble, called the eBubble, to be displayed in Trimble Access™ on the controller. Now users do not have to move their focus to the conventional bubble on the rod in order to level the pole. Instead, they can keep their focus on the Trimble Access display only and refer to the eBubble on the screen to plumb the rod. Maintaining focus on the display can greatly reduce the time required to collect point measurement data at a location.

The eBubble display also clearly indicates when the rod is plumb to within the user's defined tolerance. The eBubble will display in red when the rod is outside of the plumb tolerance setting. When the rod is within the plumb tolerance, the eBubble turns green. This quick go/no-go indication inspires user confidence and as a result, may save several minutes of pole positioning in the course of a workday.

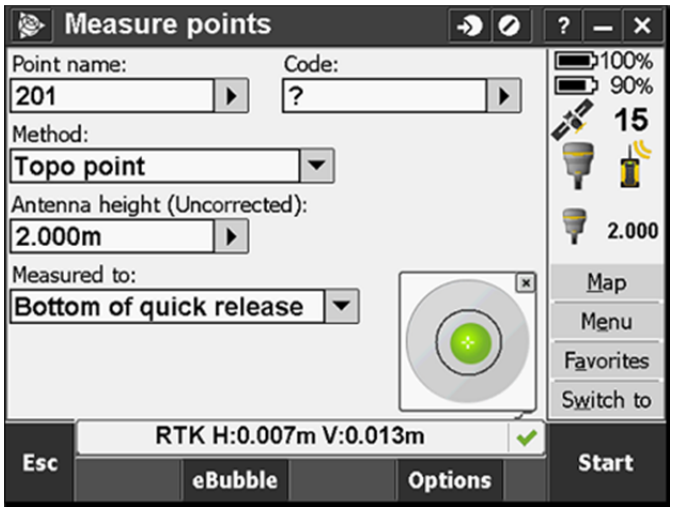

Figure 4: eBubble Display in Trimble Access

RAPID ACCURATE MEASUREMENT

Trimble SurePoint technology allows the user to collect measurements very quickly and spend less time focusing on maintaining the verticality of the pole. The integrated Trimble HD-GNSS technology in the Trimble R10 accurately determines several positions per second. This continuous rapid measurement allows the Trimble R10 to collect an averaged set of positions in a very brief time. The user usually only needs to maintain the pole in a plumb state for a couple of seconds in order to take a measurement. The intuitive eBubble with clear color indication combined with high frequency positional updates significantly speeds up the data collection process. The pole only has to be held stable for a brief moment to collect a measurement. If the pole goes out of plumb position during the measurement, the user will get a clear indication allowing him to repeat the shot if necessary. The awareness that the system is monitoring tilt and will provide warnings inspires confidence that allows the operator to hold the pole with greater stability. This confidence improves performance and increases overall productivity.

The combination of rapid measurements enabled by Trimble HD-GNSS and monitoring pole tilt easily with Trimble SurePoint reduces point measurement times by 30 to 50 percent. Topographic surveys of an area can be performed much more quickly than with a system that does not incorporate Trimble SurePoint technology. Using this productivity advantage to quickly produce a deliverable could prove to be vital in today's competitive business climate.

Figure 5: Trimble SurePoint technology enhances multi-operator surveys

Another benefit of Trimble SurePoint technology is that it reduces operator fatigue. With the Trimble R10, users spend less time maintaining the pole in a stable plumb position for each shot. Over the course of hundreds of measurements per day, the extra seconds of concentration can be very tiring. The awareness that the system is monitoring the pole tilt reduces the pressure to hold the pole in an extremely rigid manner.

In multi-operator applications such as pipeline construction surveying, one operator positions the rover pole and another operator uses the field controller to collect measurement data. In the case of a new pipeline in a deep trench, positioning the pole tip on the pipe and getting it level requires a user's full attention. Another user uses the field controller to collect the measurements. Traditionally, the controller operator could not precisely monitor the pole tilt and measurements were often made with the pole significantly out of plumb. Trimble SurePoint technology greatly improves these operations providing the field controller operator with pole tilt information including the eBubble right on the screen.

In many applications, the bipod can be left in the truck thus making the rover system easier to handle. When the weather or terrain is difficult, just reducing the amount of field time required to collect the necessary information is the ultimate in fatigue reduction.

DATA TRACEABILITY

When a GNSS rover antenna pole is plumb with a conventional bubble, there is no permanent record of the pole tilt angle when a point is measured. Any positional errors must be attributed to GNSS range measurements rather than the operator's methods and performance. With Trimble SurePoint, there is a permanent record of the rod tilt every time a measurement is stored. The tilt tolerance setting is also known and the system will warn the operator before storing points if the rod is oriented outside of that tolerance. Users can abort and re-measure if they choose not to accept the rod tilt.

The tilt angle and the distance on the ground represented by that tilt at the current antenna height are displayed with each point that is stored. This information is available in the **Review Job** menu in Trimble Access field software. Pole tilt data is stored in a JOB file and is clearly displayed in Trimble Business Center office software when positions are reviewed in that application.

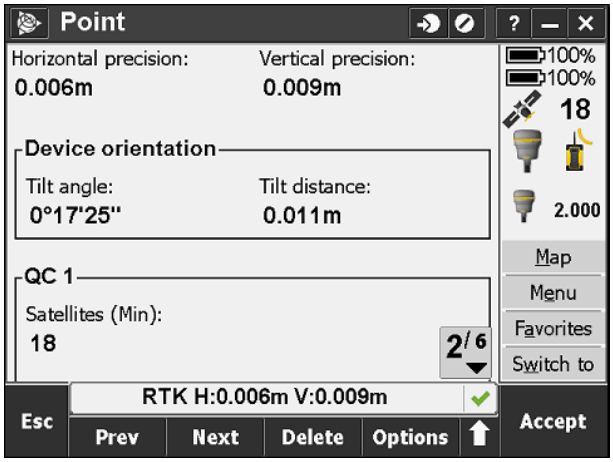

Figure 6: Review Job screen showing pole tilt records in Trimble Access

MOTION AS A CONTROL

Another exciting aspect of Trimble SurePoint technology in the Trimble R10 is that it allows receiver motion to serve as a control input. With the recent advancements in MEMS sensors, an increasing number of devices use their physical motion as a controlling input. For example, smartphones change their display orientation automatically between portrait and landscape views depending on how the user holds the phone. Video gaming systems use the motion and acceleration of controllers instead of button presses as inputs. Remotely operated vehicles use motion sensing in their control stations as well as on the vehicles themselves. And now the Trimble R10 uses its orientation as a controlling input to allow survey data collection to be even more intuitive.

Figure 7: Complex UAVs are possible due to advanced MEMS sensors. NASA Global Hawk research UAV image courtesy of NASA's Dryden Flight Research Center

In the field, the user simply selects the "**Tilt Auto-Measure**" option to survey Topographic or Rapid points then presses the **Start** button. Trimble Access provides a "**Waiting for level**" prompt on the display. At this point, the system is waiting to be brought into level. The eBubble will be tinted red when the system is not within the user defined tilt tolerance.

When the rod is plumbed to within the tilt tolerance, the eBubble turns green. If the rod is held within tolerance for a moment, the system starts measuring the point. When the auto-store tolerances are met, or the user manually stores the point, the Trimble Access prompt changes to "**Waiting to move**". When the pole is tilted more than five degrees at this stage, the system resets into "**Waiting for level**" mode and is ready to move to the next data collection location. To end the "**Tilt auto-measure**" sequence, the user must hit the **End** button.

The user can very rapidly collect a point measurement, ready the rover for the next measurement by tilting the pole more than five degrees while already moving to the next measurement location, and initiate the next measurement by plumbing the pole to within the tilt tolerance. If operating in the "**Auto-store**" mode, it is not necessary to press keys on the controller to collect point measurements. The operator gets the audible, "**Observation stored**" confirmation, tilts the rod five degrees or more while already moving to the next location, and reaches to the next observation location ready to measure another point. These physical motions are very intuitive and operators quickly acclimate to this method of control. Data collection becomes very dynamic with minimal point occupation times.

THE FUTURE BEGINS NOW

Monitoring of tilt information in the total station space has been a major advantage of these instruments for some time. Now, Trimble has introduced similar levels of advancement to the GNSS realm with the introduction of the Trimble R10 receiver.

The eBubble allows operators to maintain focus on the data collector screen. When combined with Trimble HD-GNSS technology, these features of the Trimble R10 allow rapid and accurate point measurements.

By storing the pole tilt information with the measured points in the job file, Trimble provides never before seen levels of traceability of the quality and accuracy of GNSS point measurements.

Using the physical motion of the Trimble R10 to control the field software while measuring points automates the data collection process. This allows the operator to concentrate more fully on the job at hand without having to worry about pressing the right button at the right time.

The Trimble R10 with Trimble SurePoint technology provides unprecedented speed and accuracy for all survey applications and ensures distinct productivity advantages over traditional GNSS receivers.

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 SurePoint 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.