High-Precision RTK Positioning with Calibration-Free tilt Compensation

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Key words: GNSS/GPS; Positioning; RTK, IMU, INS, Sensor fusion

SUMMARY

The rapid development of sensor fusion techniques in GNSS and IMU (inertial measurement unit) is offering a great opportunity to improve the applicability, productivity and user experience of high-precision RTK positioning. Benefiting from the tilt compensation technology that automatically adjusts pole tilt from plumb, GNSS RTK can now be applied in more restrictive situations with enhanced efficiency and flexibility. However, the conventional tilt compensation solutions are mostly sensitive to magnetic disturbances and require time-consuming on-site calibrations. In addition, the tilt compensation range is often limited to 15 degrees.

This paper presents a novel and easy-to-use tilt compensation solution of the Leica GS18 T smart antenna, which is immune to magnetic disturbances and is completely free from on-site calibrations. This invention for the surveying market was inspired by technologies that have been used in aviation and marine navigation for years. Instead of relying upon a magnetometer, an inertial navigation system (INS) utilizes precise IMU measurements, along with GNSS position and velocity estimates, to provide high-rate attitude information including pole tilt, direction of tilt and sensor heading. The internal quality control mechanisms allow an automatic start and stop of tilt compensation on the fly, which is able to cope with extreme pole dynamics such as hard shocks. Taking advantage of advanced GNSS signal tracking at low elevation angles, the IMU-based tilt compensation approach is applicable at large tilt angles of more than 30 degrees.

Based on representative data sets including various pole dynamics, the overall accuracy of 3D attitude determination is below 1.5 degrees. The GNSS and INS error components are largely uncorrelated and the total error budget of the pole tip position behaves according to the error propagation law. In comparison to the magnetometer-based approach and to conventional RTK surveying where the pole is levelled and influenced by human errors, the performance of the

proposed IMU-based tilt compensation solution is analyzed with respect to productivity, accuracy and reliability. The results from a case study of large tilt angles show that a 3D positioning accuracy of 2 cm is still achievable even when the pole is strongly tilted.