Accuracy of GNSS Observations from Three Real-Time Networks in Maryland, USA

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Key words: Engineering survey; GNSS/GPS; Positioning; Reference frames; Reference systems; Real-time kinematic; virtual reference system; master-auxiliary concept

SUMMARY

Real-time networks (RTNs) are popular for numerous types of Global Navigation Satellite System (GNSS) surveys because highly accurate geometric coordinates can be derived in seconds to minutes. Due to their accuracy and efficiency, many smart cities employ RTNs for positioning and navigation. Numerous regional, national, and international RTNs are currently available for use. For example, in Maryland of the United States, three independent RTNs are available: (1) Trimble KeyNetGPS and (2) Topcon TopNET live which both employ a virtual reference system; and (3) Leica SmartNet which uses a master-auxiliary concept. To evaluate the accuracy of these RTNs, the latest rover models from these three vendors were obtained and connected to one of the three corresponding RTNs. Then, over ten days in early 2018, a total of 486 independent network real-time kinematic (NRTK) observations of five minutes in duration were collected on nine bench marks distributed across a 4,000 square km area using the three different RTN setups. All three rovers collected both Global Positioning System (GPS) and Globalnaya Navigazionnaya Sputnikovaya Sistema (GLONASS) observables. Observations were taken by equally alternating the rovers during each visit to a mark, and repeat visits to each mark were made at different times each day. Afterwards, the resulting coordinates were differenced with adjusted coordinates derived at each bench mark from a high-accuracy, lengthy static GNSS survey campaign. The coordinate differences were similar in magnitude from each of the three RTNs, indicating that each RTN performed alike in terms of accuracy. The root-mean-square error (RMSE) of the coordinate differences was 2.3 cm horizontally and 4.5 cm in ellipsoid height at 95% confidence. The repetitive NRTK observations were also precise, with a horizontal RMSE of 2.4 cm and a vertical (ellipsoid height) RMSE of 3.4 cm at 95% confidence. Such positioning errors could be further reduced by construction and adjustment of a survey network of repeat NRTK vectors obtained at each mark. Six different survey networks were developed from the data, consisting of two to six randomly selected, repeat NRTK vectors to each bench mark. Prior to least squares adjustment of

each network, the variance-covariance matrices of the NRTK vectors needed to be scaled by variance component estimation procedures to produce realistic observational error estimates for the stochastic modeling. The average scale factor differed for the vectors from each RTN, equal to 1.4 for KeyNetGPS, 14.5 for TopNet live, and 2.2 for Leica SmartNet. When adjusting four repeat NRTK vectors per bench mark, the estimated error by formal error propagation in the adjusted coordinates was less than 1 cm horizontally and 2 cm vertically at 95% confidence at all nine bench marks in the survey network. Such small errors indicate that RTNs could be used for many geodetic, surveying, and positioning applications.