On Testing of RTK-Network Virtual Concept

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ABSTRACT

This paper deals with testing and calibrating a Real Time Kinematic (RTK) GPS network system (Trimble Terrasat). In the test net three reference stations were used situated in Southern Finland, in the cities of Lahti, Hämeenlinna and Vantaa. The distances between the reference stations are about 82 km, 84 km and 64 km. As the test net for determining the reliability, the uncertainty and the accuracy of the RTK-Network virtual concept GPS-test net of Southern Finland and the Klaukkala testfield of the Institute of Geodesy (IG) of Helsinki University of Technology (HUT) were used. The testing measurements were made together with the firm GeoTrim Oy and IG/HUT. The adjustment of the test net was made in the global coordinate system EUREF-FIN by using the three reference stations as the fixed points; the final testing and calibration results were calculated and analyzed in IG/HUT. The coordinates of the test net have been calculated by using the Bernese software and the precise ephemeris.

In the classical RTK GPS measurements one reference station is used. The effects of atmospheric refraction on the GPS radio signal restrict the use of the RTK measurements up to distances of 15 km (20 km) from the reference station to the rover. The solution for decreasing essentially the RTK relative positioining error depending on the distance of the rover from the reference station is the technique of the virtual reference station (VRS) by linking together several original reference stations for forming the RTK network. In the network a distance between the reference stations may be about 80 km. The calculation takes place in the network center: GPS data recording, the real time modeling of GPS errors among other things atmospheric errors and orbit errors of the satellites, the calculation of the virtual reference stations, the transmission of virtual data to the users, monitoring of the system and controlling the quality. It is possible to make RTK measurements rabidly and with good accuracy at the whole area of the network - even at the distance of 40 ... 45 km from the nearest physical reference station.

At the plane, in the regression analysis the value of the constant term of *(a)* varied between 17 mm ... 28 mm and the value of the relative term of *(a)* depending on the distance varied between 0.2 ppm ... 4.2 ppm. Considering also the discrepancies of the ortometric height *dH*, the corresponding values in the regression analysis of *(b)* were 25 mm ... 45 mm and 3.2 ppm 17.6 ppm. In the classical RTK GPS the distance between reference station and the rover weakens significantly the accuracy of coordinates.

For investigating the accuracy of the classical RTK GPS in detail measurements of the mapping, the RTK GPS -equipments of four different manufacturers were tested in the Otaniemi test field of IG/HUT. For transmitting the corrections to the rover the radio modem and also the GSM modem were used. Five reference stations were used; the distances between the reference points and the rover were 350 m, 2200 m, 4800 m, 12500 m and 21000 m. For determining the accuracy of the RTK mapping the discrepancies *dx*, *dy* and *dH* between the measured coordinates, the plane coordinates *x*, *y* and the ortometric height *H*, and the corresponding reference coordinates of the test field were calculated. For analyzing the accuracy, a total discrepancy of the plane coordinates, *(a)*, and a 3D-total discrepancy, *(b)*, were calculated using Pythagoras.

The Virtual Reference Stations (VRS) RTK GPS test measurements were made during September and October 2000. The test measurements included nine test points (known points) at the distance of 15 km …40 km from the nearest physical reference station, both inside and outside of their triangle. The measurements were made by Trimble/Spectra Precision Geotracer 3220 RTK system. In every test point was measured 10 independent VRS OTF fixed solutions. Always when system got fix solution then point was measured using stop&go VRS RTK mode, two 2 sec. and one 10 sec. measurements.

In the following are the means of the mean values of the coordinate discrepancies and of the total discrepancies (in millimeters) at the interpolation area and at the extrapolation area of the reference stations, i.e. the areal accuracy of the VRS RTK-Network: at the interpolation area

	MMdx	*MMdy*	*MMdH*	*MM(a)*	*MM(b)*
2 sec.	14	11	53	19	58
2 sec.	13	11	53	19	58
10 sec	. 14	12	54	19	59,

and at the extrapolation area:

	MMdx	*MMdy*	*MMdH*	*MM(a)*	*MM(b)*
2 sec.	15	7	30	15	34
2 sec.	15	9	36	19	43
10 sec	15	9	37	19	43.

The results of the regression analysis of the *(a)* values depending on the distances from the nearest reference station at the interpolation area and at the extrapolation area are as follows: *(â)* = a + b*s, were a is the constant term (in millimeter) and b is the relative term (in ppm):

at the interpolation area

2 sec.	a = 16.9 mm	+/- 8.6 mm,	b = 0.10 ppm	+/- 0.34 ppm
2 sec.	a = 17.3 mm	+/- 8.3 mm	b = 0.09 ppm	+/- 0.33 ppm
10 sec	a = 17.4 mm	+/- 8.4 mm,	b = 0.06 ppm	+/- 0.33 ppm

at the extrapolation area

2 sec.	a = 20.6 mm	+/- 2.3 mm	b = -0.06 ppm	+/- 0.08 ppm
2 sec.	a = 22.1 mm	+/- 2.4 mm	b = -0.10 ppm	+/- 0.08 ppm
10 sec	20.7 mm	+/- 0.8 mm	b = -0.06 ppm	+/- 0.03 ppm

It is possible to make VRS RTK measurements with good accuracy - even at the distance of 40 ... 45 km from the nearest physical reference station.

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