Available online www.jsaer.com

Journal of Scientific and Engineering Research, 2019, 6(11):91-95

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

"Single Cors"– An Experiment Study with Low-Cost GNSS Receiver

Ngoc Quang Vu*, Van Thinh Nguyen

Department of Surveying, University of Transport Technology, Hanoi, Vietnam
Email: quangvn@utt.edu.vn

Abstract The term *CORS* is widely used with Net RTK but it here plays a role as a single base in RTK positioning mode. This paper is an experiment of "single Cors" with the low-cost GNSS receiver. Coordinates of two national control points are determined using different CORS sites with a range of distance from five to thirty kilometers. At each national control point, its coordinates are positioned with various observations including 5, 10, 15, 20, 30, 45, 60 and 120-second observation and based on five different corsstations. Results are then compared to coordinates which are provided by a national agency (will be considered as the true values). Deviations show the dependence of the accuracy on the range of distance and the number of tracked satellites.

Keywords Net RTK, Cors, single base, RTK positioning

1. Introduction

The occurrence of GNSS technology was an evolution for establishing horizontal control networks in different classes for two past decades in Vietnam and officially became the main method for carrying out this task [1]. Evenly, this technique can be used to measure technical elevation networks for plane areas. With the layers which request a very high accuracy, static GPS measure plays a key role and of course, easily yields requested relative accuracy. However, recent two years, static GPS seems to be out of date for daily use in the surveying sector in Vietnam, especially in establishing traverse class 2 due to the appearance of continuously operating reference stations (CORS). Generally, a CORS system is operated in a unified coordinate system, normally is the WGS84 system and coordinates will then be transformed into a local coordinate system which normally is VN:2000. Three issues need to be mentioned and addressed. The first one concerns national control points. Apparently, national control points belong to different orders and were built for a long time before being approved and put into use. The GNSS technology is recorded as the main measure for establishing national control networks but it is not all. Experiencing a very long period of using, under the impact of storms, floods, natural disasters such as landslide, earthquakes, land surface subsidence, 3-D coordinates may be changed over time. Measurement is daily activities while network testing activities are periodically carried out. This leads to the difference in coordinate between real and given coordinates. The second one that needs to be mentioned is the connection between Cors sites with national control points. Normally, Corssite locations will be chosen for ensuring the stability of GNSS antenna, satellite visuality and reducing multiple path error.

Currently, two independent Cors systems are parallel existing without connection in which one is managed and operated by a national agency and the rest one is geodesy infrastructure of a private company. As mentioned in the first issue, each Cors site is connected with different horizontal and elevation national control points in separated orders with different accuracies. As a result, the unification is broken. National Cors sites have a sparse density, are mainly distributed in big cities. Constradictly, private Cors sites have a thick density, evenly distributed across provinces. The operation mode of two Cors systems is the last issue. While national Cors sites are operated as a network corsRTK, corrections transmitted to rover receivers will be calculated from several nearest Cors, private Cors sites are operating as a *single base* RTK. This paper is an experiment about *"single cors"* including limitation of distance from Cors to rover receivers, the accuracy of horizontal coordinates. It is important to impress that the cors sites here have the same role as a single base in RTK positioning mode.

2. Conventional RTK and Network RTK

Conventional RTK positioning mode requests a single base to rover receivers. Corrections will be transmitted to users via different communication methods including internal, external radio or GSM links [2]. Although single base RTKhas already been a significant progress, its accuracy is limited due to distance between two receivers. In case the base receiver has some problems with the power supply, internet connection or security [3], surveying tasks with rover receivers could not be carried out. This will be avoided in network RTK [4]. Especially, positioning results are considerably influenced by the ionosphere and troposphere bias. Distance between rover and base in conventional RTK mode normally ranges from ten to twenty kilometers [5-6].

The formation of Network RTK is to overcome the above disadvantages. The procedure of a Network RTK has four parts including Cors sites, processing center, transmitting mode and users. In principle, the more reference stations, the more redundancy in observations but it depends on the ability of processing center and normally ranges from three to five [5]. The processing center plays a key role in calculating corrections from data of reference stations. The data transmission method of two groups reference stations - processing center and processing center- users is carried out using Network Transport of RCTM via Internet protocol (Ntrip) [7]. This is open-source and can be downloaded from the Internet [8]. With network RTK, the distance between a rover and reference stations can be up to 100 Km. In a small area, the relationship between modeled distance-dependent errors and their actual values of network RTK can be seen in figure 1.

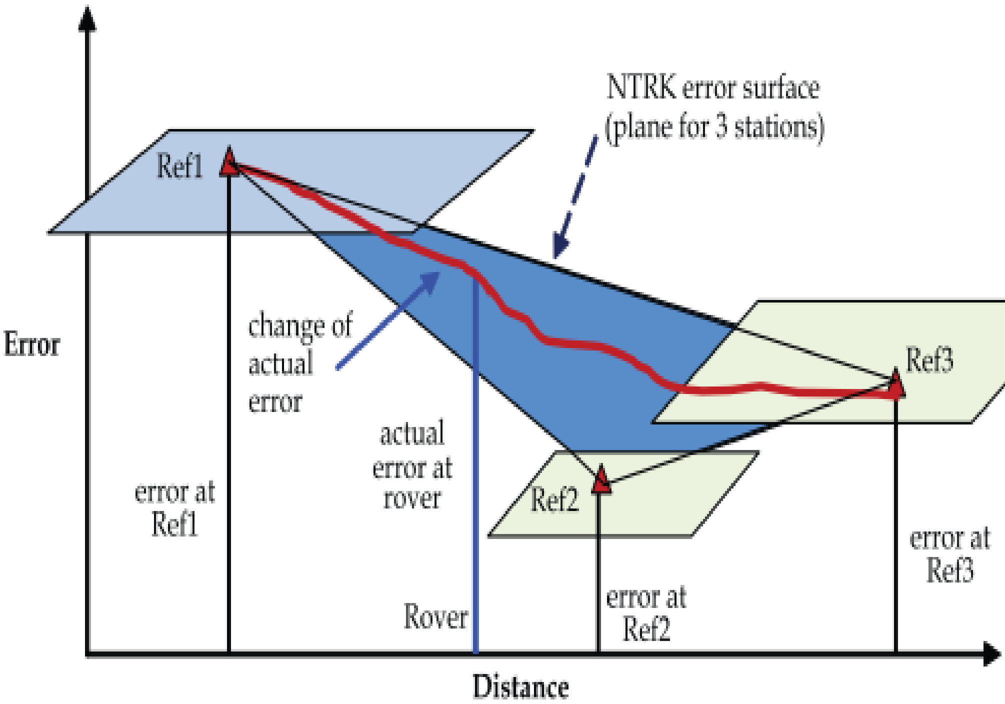

Figure 1: Relationship between errors in a small coverage area [5]

The most popular techniques for Network RTK processing were displayed in El-Mowafy [5]. Each has different advantages and disadvantages and depending on suppliers. Many options for users such as Leica's SmartNet and Trimble's VRS in Britain [9]; Leica's SmartNet and Trimble's VRS, TopNet MRS (VRS) in Ireland [10]. GNSS Cors plays the main role to modernize geodesy infrastructure in Thailand [11]. Classic-RTK and VRS-RTK were compared together in terms of *time to first fix (TTFF)*. Therefore, the average TTFF of VRS-RTK is about 8-seconds less than classic-RTK (Sun & Gibbings, 2005). Similarly, the horizontal accuracy of VRS and classic-RTK is ±20mm and ±30mm respectively.

3. Experiment Data

455, 486 are two national control points and their coordinates are provided by a national agency. HNNK, HNML, HNCM, HNGL, HYKC are five Cors. Their coordinates are determined in the local coordinates system. Coordinates of 455 and 486 will be in turn determined using coordinates of five cors with a range of observation from 5 to 120-second observation. Their relative locations can be seen in figure 2.

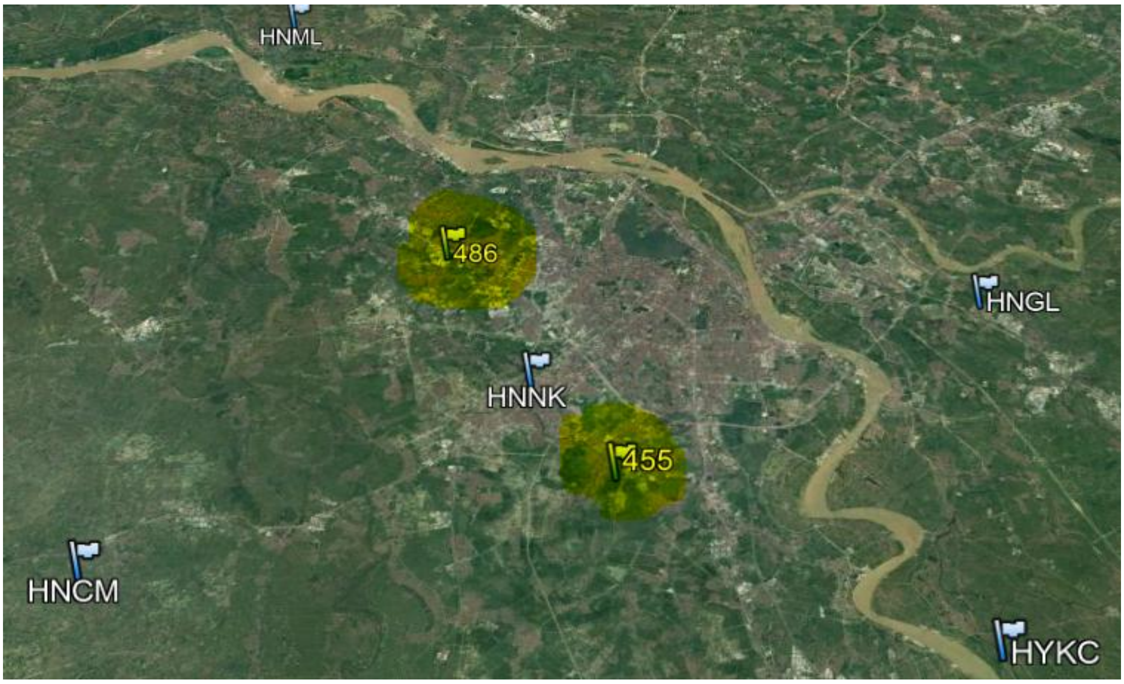

Figure 2: The relative position between corsstations and rover receivers

Specifications of cors stations can be referred to manual and downloaded from the Internet. The following is the accuracy of RTK surveying mode.

Single base < 30Km	**Network RTK**
Horizontal: 8mm + 1ppm RMS	Horizontal: 8mm + 0.5ppm RMS
Vertical: 15mm+1ppm RMS	Vertical: 15mm+0.5ppm RMS

It should be noted that the accuracy varies due to different conditions including atmospheric condition, signal multipath, observation time, signal geometry and the number of tracked satellites.

Table 1: Differences in coordinates at point 486

CORS	**Deviation**	**Time of observation**							
		5	**10**	**15**	**20**	**30**	**45**	**60**	**120**
HNNK	Dx	0.006	0.007	0.007	0.015	0.009	0.009	0.005	0.004
	Dy	-0.047	-0.044	-0.045	-0.047	-0.041	-0.040	-0.031	-0.033
HNML	Dx	-0.037	-0.039	-0.039	-0.041	-0.038	-0.039	-0.037	-0.033
	Dy	-0.025	-0.026	-0.027	-0.029	-0.033	-0.030	-0.027	-0.029
HNCM	Dx	-0.001	-0.004	0.004	-0.003	0.003	0.000	-0.004	0.001
	Dy	-0.036	-0.028	-0.029	-0.037	-0.044	-0.053	-0.054	-0.045
HNGL	Dx	-0.043	-0.044	-0.062	-0.038	-0.048	-0.048	-0.045	-0.049
	Dy	-0.046	-0.043	-0.046	-0.045	-0.048	-0.050	-0.050	-0.045
HYKC	Dx	-0.009	-0.012	-0.011	-0.012	-0.012	-0.013	-0.018	-0.024
	Dy	-0.079	-0.075	-0.083	-0.078	-0.073	-0.060	-0.062	-0.069

Table 2: Differences in coordinates at point 455

CORS	Deviation	Time of observation							
		5	10	15	20	30	45	60	120
HNNK	Dx	0.013	0.015	0.015	0.014	0.013	0.015	0.019	0.015
	Dy	-0.036	-0.035	-0.034	-0.031	-0.033	-0.036	-0.036	-0.033
HNML	Dx	-0.032	-0.036	-0.032	-0.033	-0.032	-0.029	-0.033	-0.025
	Dy	-0.026	-0.029	-0.025	-0.017	-0.017	-0.012	-0.012	-0.017
HNCM	Dx	-0.003	-0.001	0.01	0.004	0.005	0.003	0.005	0.001
	Dy	-0.025	-0.021	-0.022	-0.028	-0.027	-0.026	-0.019	-0.037
HNGL	Dx	-0.035	-0.041	-0.041	-0.036	-0.034	-0.036	-0.032	-0.026
	Dy	-0.003	0.004	0.005	-0.001	-0.003	-0.004	-0.005	0.005
HYKC	Dx	-0.004	-0.002	-0.004	-0.006	-0.008	-0.012	-0.005	-0.002
	Dy	-0.070	-0.071	-0.070	-0.065	-0.059	-0.061	-0.062	-0.059

Looking at tables 1 and 2, the first comment is that differences in X and Y coordinate of various time observations with the same cors station are not significant. However, the absolute value of the Y coordinates is almost greater than that of X coordinates except for HNML cors station at point 486 and HNML, HNGL cors stations at point 455. However, positioning results derived from various cors stations are significantly different.

Theoretically, 120-second observations will be the best. These observations are used for considering the changes in coordinate by distance. Illustrations are in figure 3, 4.

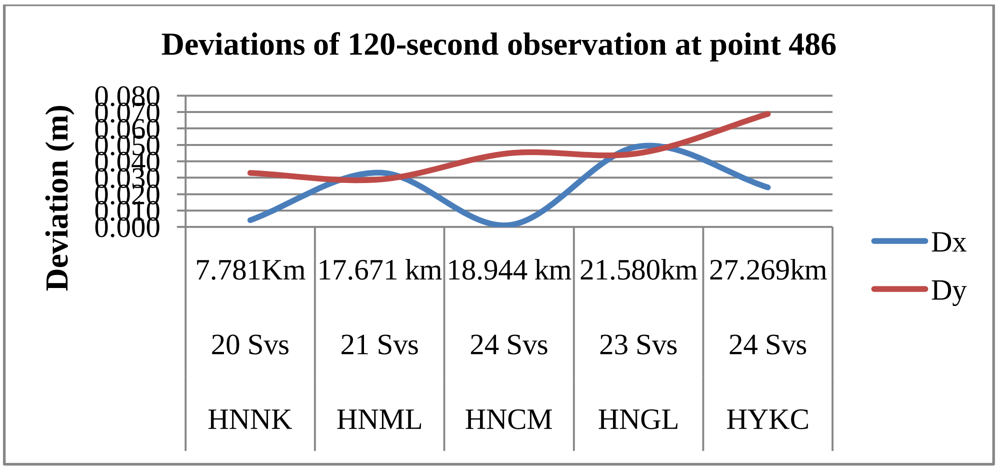

Figure 3: Deviations by distance and the number of tracked satellites at point 486

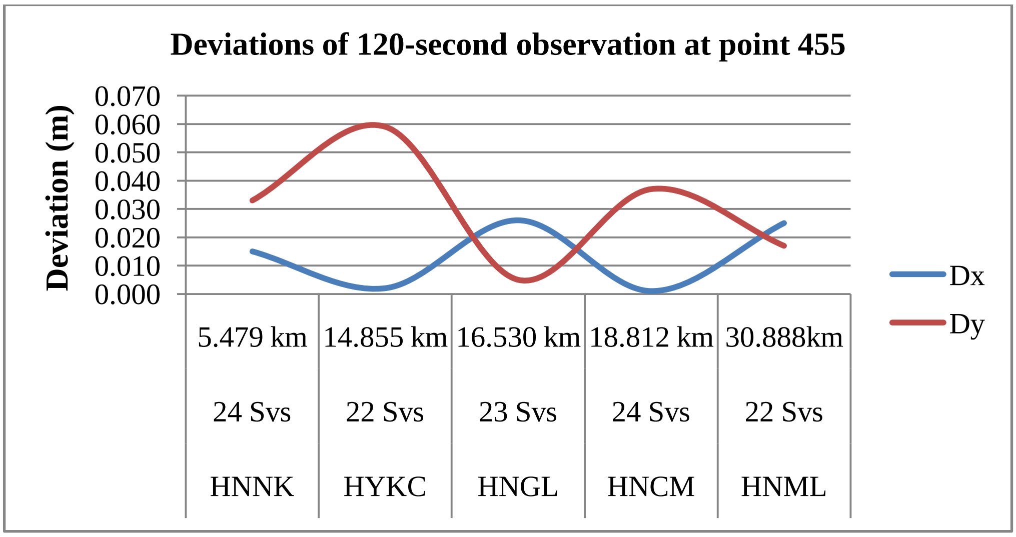

Figure 4: Deviations by distance and the number of tracked satellites at point 455

Assuming that given coordinates by the national agency of two points 486 and 455 are true values, with distance smaller than 30 kilometers, the second comment is that coordinate errors are not totally direct proportional to the distance between rover and cors station accept for y coordinate at point 486. Have a look at figure 3, for 7.781 and 18.944-kilometer distance, x coordinate deviations of point 486 are the same. Similarly, at point 455 in figure 4, the same result can be seen at 14.855 and 18.812-kilometer distance. Especially, x and y coordinate deviations for 5.749-kilometer distance are much bigger than that for18.812-kilometer distance with the same number of satellites.

4. Conclusions

Single cors seems to be good replacing for conventional positioning method. However, as the single base in RTK positioning mode, single Cors has the same limitations due to the distance, ionosphere and troposphere bias.

At the same cors, with different observations, the difference in coordinates is not significant. However, connecting to various cors stations, it makes a considerable change, even at a similar distance, and the same number of tracked satellites.

For getting a unification, the single cors system should be connected with the same order of national control points, and the first order which has the highest accuracy is the priority to increase positioning accuracy.

References

[1]. BTNMT. (2009). National technical regulation on establishment of Horizontal control network (Vietnamese).

[2]. Nedim Onur Aykut , Gülal, E., & Akpinar, B. (2015). Performance of Single Base RTK GNSS Method versus Network RTK. *Earth Sci. Res. J*, *19*(2), 135–139. https://doi.org/10.15446/esrj.v19n2.51218

[3]. Moegen, N. De, Hill, C., & Cairns, S. (2018). The Benefits and Challenges of implementing a Continuously Operating Reference Stations (CORS) GNSS Network in Emerging Countries. 2018 World Bank Conference on Land and Poverty.

[4]. Gordini, C., Kealy, A. N., Grgich, P. M., & Hale, M. J. (2006). Testing and Evaluation of a GPS CORS Network for Real Time Centimetric Positioning – The Victoria GPS net TM. International Global Navigation Satellite Systems Society IGNSS Symposium 2006.

[5]. El-Mowafy, A. (2012). Precise Real-Time Positioning Using Network RTK. Global Navigation Satellite Systems – Signal, Theory and Applications, 161–188. https://doi.org/10.5772/29502.

[6]. Frank Takac, & Werner Lienhart. (2008). Smart RTK: A Novel Method of Processing Standardised RTCM Network RTK Information for High Precision Positioning. Proceedings of ENC GNSS.

[7]. BKG (2011). Networked Transport of RTCM via Internet Protocol. 21.08.2011, Available: http://igs.bkg.bund.de/ntrip

[8]. Lenz, E. (2004). Networked Transport of RTCM via Internet Protocol (NTRIP) – Application and Benefit in Modern Surveying Systems. *FIG Working Week*, 1–11.

[9]. Edwards, S. J., Clarke, P. J., Penna, N. T., & Goebell, S. (2010). An examination of network RTK GPS services in great Britain. Survey Review, (April 2010), 107–121. https://doi.org/10.1179/003962610X12572516251529

[10]. Martin, A., & Mcgovern, E. (2012). An Evaluation of the Performance of Network RTK GNSS Services in Ireland. Knowing to Manage the Territory, Protect the Environment, Evaluate the Cultural Heritage, FIG Working Week 2012, 1–19.

[11]. Rizos, C., & Satirapod, C. (2011). Contribution of GNSS CORS infrastructure to the mission of modern geodesy and status of GNSS CORS in Thailand. Engineering Journal, 15(1), 25–42. https://doi.org/10.4186/ej.2011.15.1.25

[12]. Sun, G. O. K., & Gibbings, P. (2005). How well does the virtual reference station (VRS) system of GPS base stations perform in comparison to conventional RTK? *Journal of Spatial Science*, *50*(1), 58–73. https://doi.org/10.1080/14498596.2005.9635038