A Performance Analysis of Real Time Kinematic GNSS Services in Taiwan

Peter T.Y. SHIH, Chinese Taipei

Key words: Network RTK, PPP-RTK, Ionospheric delay

SUMMARY

Network RTK, including FKP, VRS, PRS, and MAC correction techniques, may be the most widely implemented real time kinematic services at present. In Taiwan, National Land Surveying and Mapping Center provides a VRS based system, eGNSS. The objective of eGNSS is mainly for supporting cadastral surveying, but widely applied for other applications, such as construction surveying and topographic mapping. While the number of users is growing, the frequency of reports on fails in obtaining fixed solution is also increasing. The current explanation is the activeness of ionospheric turbulence. This study documents an investigation on the relation between the I95 index and the occurrence of the fails with 10 days observation. The sampling interval is one seconds. Among the 864,000 samples, 98% were fixed. But not all the other 16,556 samples, which failed, have I95 value larger than 30.

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1. INTRODUCTION

As a part of the national spatial infrastructure, National Land Surveying and Mapping Center (NLSC), Ministry of Interior, has implemented a network of Continuously Operating Reference Stations (CORS) in Taiwan and several surrounding islands. The service of Network RTK has been tested starting in 2003 and fully operational in 2006 with selected CORSs. The service was named eGPS and renamed to eGNSS in 2014. Currently, eGNSS makes use of the signals from all four full GNSS constellations. At present, this network comprises of 90 CORS and the service area includes Taiwan, Penghu, Kinmen, and Matsu.

There are several correction techniques of Network RTK, including FKP, VRS, PRS, and MAC (El-Mowafy, 2012; Pehlivan, et al., 2019). VRS is the one implemented due to the commercial software chosen. The main purpose of eGNSS is to provide real-time positioning service for supporting cadastral surveying, but also been applied for other applications, such as construction surveying and topographic mapping. Recently, eGNSS found to be a valuable asset for the operation of unmanned aviation vehicles (UAVs). While the number of users is growing, the frequency of reports on failed in obtaining fixed solution is also increasing. The current explanation is the activeness of ionospheric turbulence. A web page, https://egnss.nlsc.gov.tw/rtkstatus.aspx, with hourly chart of I95 index (Wanninger, 2004), which is updated every hour, is made public for providing user information on why their operation failed. These I95 information are generated in post processing manner, not in real time, certainly could not be used for prediction. This study documents an investigation on the relation between the I95 index and the occurrence of the failure.

2. THE DATA AND ANALYSIS

For this study, the data were collected from a CORS operated by National Yang Ming Chiao Tung University (NYCU). The receiver is a Trimble NetR9. The antenna type is Zephyr Geodetic 2 RoHS. This station has full open sky, and installed on the roof of Engineering Building II, Kwang-Fu campus, Hsinchu. An eGNSS account was provided by NLSC for this study. The sampling rate is 1 Hz. Positioning data is recorded in NMEA-0183 GPGGA sentences. For the analysis documented in this writing, 10 days observation, from Feb. 24 (DOY 055) to March 5 (DOY 064), 2023, were used.

In the $GPGGA sentence, field 6, GPS Quality indictor, the meaning of codes is as following (https://receiverhelp.trimble.com/alloy-gnss/en-us/NMEA-0183messages_GGA.html) .

0: Fix not valid

1: GPS fix
2: Differential GPS fix (DGNSS), SBAS, OmniSTAR VBS, Beacon, RTX in GVBS mode
3: Not applicable
4: RTK Fixed, xFill
5: RTK Float, OmniSTAR XP/HP, Location RTK, RTX
6: INS Dead reckoning

In the 864,000 epochs, the occurrences of codes are listed in Table 1.

Code	Count	Percentage
1	387	0.045
2	3,007	0.35
4	847,444	98.1
5	13,162	1.523

Table 1: The occurrences of quality codes

The hourly I95 index values are shown in Figure 1. The horizontal abscissa is UTC time. While the longitude is about 121^o E, the hour Zulu is 08:00 AM local time. The daily fluctuation of I95 generally agrees with the expectation of ionospheric activeness in this area.

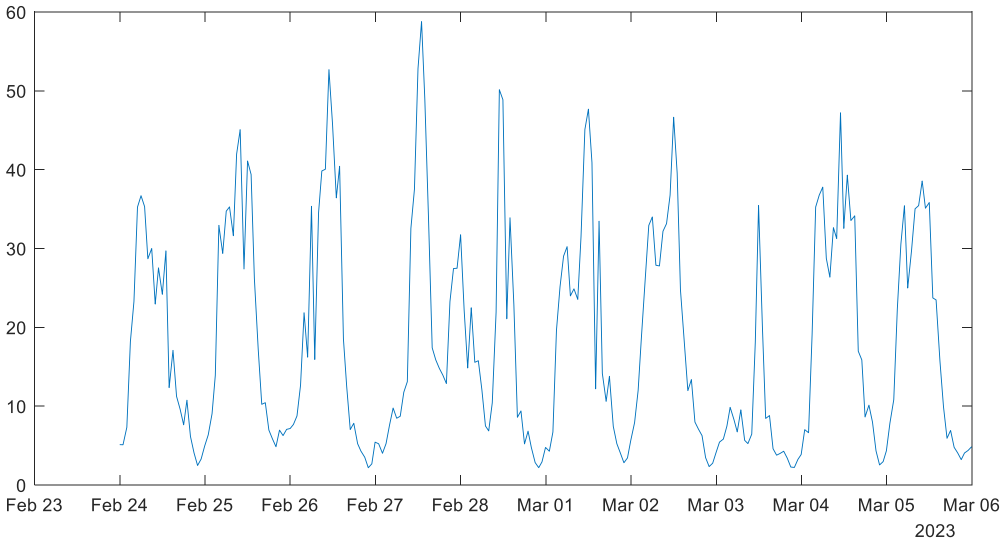

Figure 1: The I95 time series

Is the failure of fixed position caused by ionospheric effect? The instruction provided from the eGNSS web page is that the operational threshold value for I95 is 30. Higher than 30, eGNSS operation is not recommended. Checking into the data, for 387 epochs with code 1, 303 epochs has I95 value less than 30. That is, 78.3% with code 1 have I95 value lower than 30. For the 3,007 epochs with code 2, 2,555 epochs have I95 value lower than 30. For code 5, 8,001 epochs. The statistics are shown in Table 2.

Code	>30	<30
1	84	303
2	452	2,555
4	207,458	639,986
5	5,161	8,001

Table 2: The quality codes and I95

3. CONCLUDING REMARKS

From the preliminary assessment of the eGNSS service performance, the success rate of fixed positioning is about 98%. This rate is higher than the experiences of field surveyors and UAV operators. Meanwhile, failed cases may not be fully contributed from the ionospheric effects. At least, not the ionospheric effect measured with I95. Because the NYCU CORS has a full open sky view, the high success rate may be contributed from the large number of observed satellites. 93% of the epochs observed more than 10. Meanwhile, there are also 5,133 epochs with 4 to 6 satellites in total. The cause of low satellite number is currently unknown. Further investigation is needed. There are 4,338 code 5 epochs with satellites less than 10.

REFERENCES

El-Mowafy, Ahmed (2012): Precise Real-Time Positioning Using Network RTK, Global Navigation Satellite Systems: Signal, Theory and Applications, February. InTech. doi:10.5772/29502.
Pehlivan, H., Bezcioğlu, M. & Yılmaz, M. (2019): Performance of network RTK correction techniques (FKP, MAC and VRS) under limited sky view condition, International Journal of Engineering and Geosciences, 4(3), 106-114. DOI: 10.26833/ijeg.492496.
Wanninger, Lambert (2004): Ionospheric Disturbance Indices for RTK and Network RTK Positioning, Proc. ION GNSS 2004, Long Beach, CA, 2849-2854.

BIOGRAPHICAL NOTES

Peter T.Y. Shih is a Professor Emeritus at the Department of Civil Engineering of the National Yang Ming Chiao Tung University, Taiwan. He received his PhD degree from the Department of Surveying Engineering, University of New Brunswick, Canada in 1989.
His main research and teaching interests are in the fields of photogrammetry, terrain mapping, satellite positioning and navigation, and hydrography.

CONTACTS

Prof. Peter T.Y. Shih
Department of Civil Engineering
National Yang Ming Chiao Tung University
1001 Ta-Hsueh Road

Hsinchu
300093, TAIWAN
Tel. +886 3 5712121 #54940
Fax +886 3 5716257
Email: tyshih@nycu.edu.tw
Web site: https://dpwe.nycu.edu.tw/en/member/teachers/14