POSITIONING EVALUATION WITH GNSS USING REALTIME PRECISE POINT POSITIONING METHOD FOR MINING MAPING SURVEY

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ABSTRACT

Real Time Precise-Point Positioning (RT-PPP) is a relatively new method for satellite-based positioning or better known as the Global Navigation Satellite System (GNSS). RT-PPP has similarities with PPP in terms of data accuracy and precision because it was developed from the previous method called Precise Point Positioning (PPP). However, RT-PPP has an advantage in real time because it gets correction from the L-band in the Satellite Based Augmentation System (SBAS). This study aims to evaluate the RT-PPP method for mining surveys. The precision evaluation was carried out repeatedly for 7 days at specific points, while accuracy testing was compared with the static differential method at 11 points spread over the mining area. The results showed that the standard deviation of the RT-PPP method was 1.0 cm and 1.1 cm in the east and north, 3 cm in elevation. The accuracy test shows 17.5 cm for the RMSE horizontally and 6.2 cm vertically.

keyword: RT-PPP, GNSS, Accuracy, Precision, Mining

Introduction

Mining is activities with a relatively high risk of both worker safety risks and environmental risks. It is reasonable that various laws and regulations bind mining activities. The rule of law binds almost every aspect and stage of mining activities. Not only the main stages that are bound but also supporting the main stages of mining, such as mining mapping survey activities. Topography plays a vital role in mining activities, starting from planning, evaluating operations, and calculating production volumes that require accurate spatial data. The positioning method judgment becomes very important to obtain data that meet the accuracy needs and can also be available quickly.

Various high-precision positioning methods based on GNSS satellites have been widely applied in mining mapping surveys, such as static, kinematic, or real time kinematic surveys. However, mining sites generally located in remote areas often have limited infrastructure to support mapping surveys, such as Continuous Operating Reference Station (CORS) stations, reference control points, and telecommunications networks.

The method of determining the GNSS survey with Precise-Point Positioning (PPP) offers opportunities under the above limitations. The PPP method can achieve accuracy up to sub-decimeter [1]. For some jobs in mining activities, this method is sufficient. However, if a mining activity requires survey support with accurate positioning solutions in real time, PPP has not been able to fulfill it. An example of such an activity is boundary point stakeout.

This study aims to evaluate the positioning method with GNSS Realtime Precise-Point Positioning (RT-PPP) method to be applied to mining mapping surveys. Like the PPP method, RT-PPP uses observations from a single GNSS receiver, achieving accuracy up to the sub-decimeter order [2]. Using a reference base station is not required so that measurement limitation due to distance to the base station, as in the case of the differential method, can be avoided.

Methodology

This study uses two test approaches to evaluate the RT-PPP method. The first test is repeated observations at one point to get the redundancy of position measurements so that the standard deviation value or the level of accuracy of the results is obtained. The second test is observation at test points distributed in the study area to see the level of accuracy.

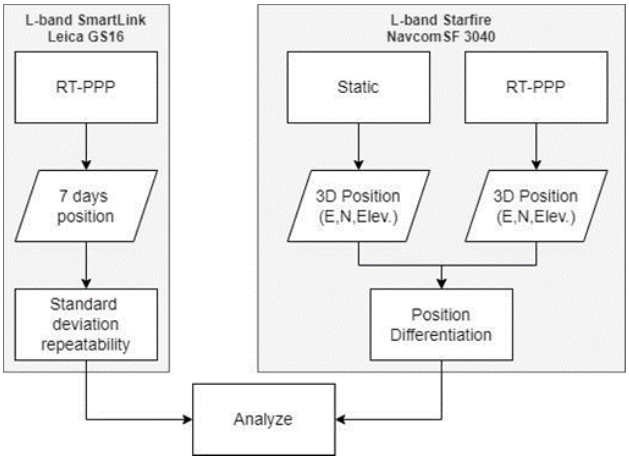

Figure 1. The procedure of testing RT-PPP method accuracy

Evaluation of Method Accuracy

The first test used 1 test point and observed the RT-PPP method with the Leica GS16 GNSS receiver. The study did not consider the length of initiation time required to achieve accuracy below 10 cm, so the accuracy value before reaching 10 cm was not recorded. The tolerance value of 10 cm is the accuracy limit, so this positioning method can be applied to most mining mapping survey activities. After the observation initiation for about 30 to 40 minutes, position recording is carried out at 1 minute intervals for approximately 3-4 hours. The observations were repeated every day for 7 days.

Evaluation Accuracy

The second test was conducted in the Paringin pit area, one of the pits at PT Adaro Indonesia's mining site in South Kalimantan. Observations were made at 11 test points in the study area using the static method with reference to the SRGI2013 and the RT-PPP method with the GNSS NavcomSF 3040 receiver. The placement of test points spread throughout the pit area is expected to represent the general characteristics of the mine pit, such as the bottom pit area.

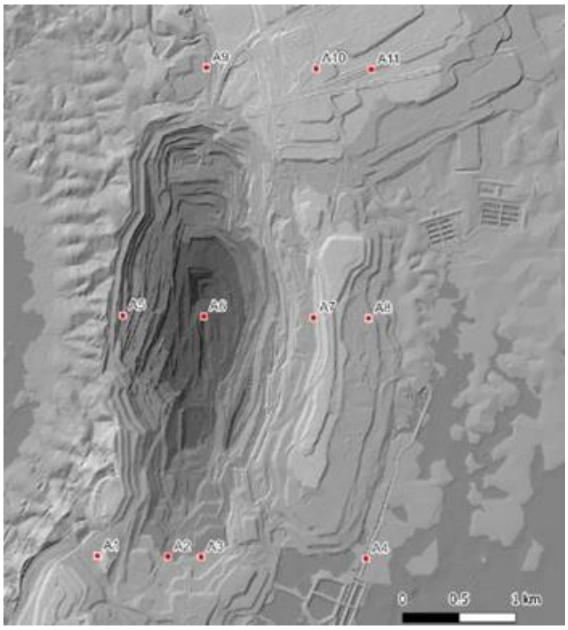

Figure 2. RT-PPP observation test points distributions

Even though the area is open, but the mask of angle is relatively high because it is in a position blocked by the mine slope wall. For GNSS NavcomSF 3040, the initialization time required to achieve accuracy below 1 decimeter is about 15 minutes.

Result and Discussion

Precision test

Position measurement with the GNSS RT-PPP method was tested at a point for 7 days, lasting about 3-4 hours. Each observation produces a reasonably consistent value for the easting, northing, and elevation components.

Table 1. Deviation standard at test point

	Easting	Northing	Elevation
Range	0.079	0.096	0.204
Std. Dev	0.010	0.011	0.030

This test is not performed at a reference point whose value is known. For this reason, the average values for easting, northing, and elevation are used as reference points to obtain deviations or errors at each position, as shown in Figure 3. The sinusoidal pattern in the measurement results, as shown in Figure 4 still needs to be studied further to explain this phenomenon.

Accuracy test

Static observations at 11 positions that referenced SRGI2013 were used as reference values for measuring the accuracy of position measurement results using the RT-PPP method. Table 2 shows the deviation at each test point. This study uses the value of Root Mean Square Error (RMSE) as a measure to assess accuracy. The RMSE of the easting component is quite large compared to the northing value, even the elevation value. It can be seen that the RMSE easting is 17.2 cm compared to the RMSE northing of 3.5 cm and the elevation accuracy is 6.2 cm. In 2D or horizontally, the accuracy of this method can reach 17.5 cm.

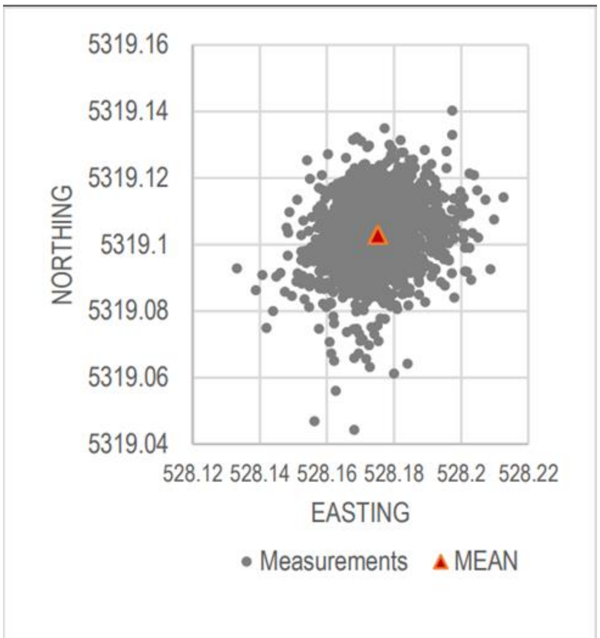

Figure 3. Distribution of observation positions

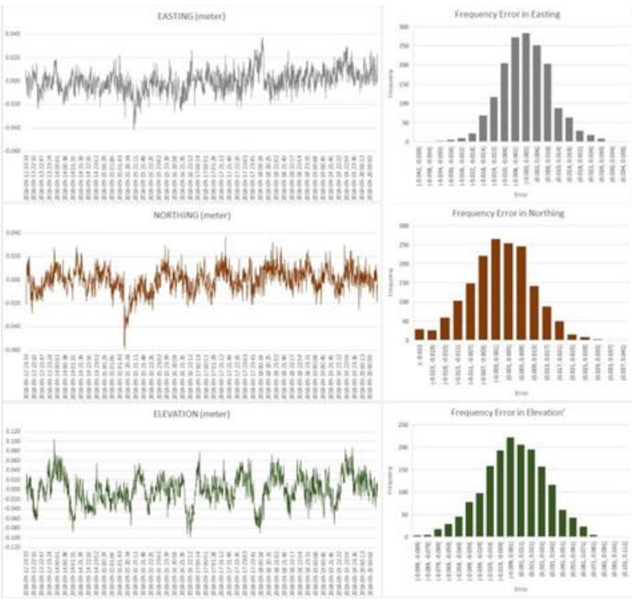

Figure 4. Error in elevation and its distribution

Mining need

According to the Decree of the Minister of Energy and Mineral Resources 1827 K/30/MEM/2018, the need for map accuracy is a scale of 1:2000 or a contour interval of 1 meter. Positioning with an accuracy below 1 meter is needed to produce an elevation accuracy of 1 meter. With the accuracy test results above, the RT-PPP method can produce up to 3 cm so that this method can meet the needs according to regulations.

Table 2. Deviation of static method and RT-PPP

No	Code	Northing	Easting	Elev.	Horizontal
1	A1	0.023	-0.244	-0.064	0.245
2	A2	0.002	-0.197	0.020	0.197
3	A3	0.035	-0.144	-0.058	0.148
4	A4	-0.003	-0.107	-0.043	0.107
5	A5	0.069	-0.127	-0.049	0.145
6	A6	-0.021	-0.111	-0.057	0.113
7	A7	0.042	-0.206	0.133	0.210
8	A8	-0.001	-0.131	-0.026	0.131
9	A9	0.040	-0.199	-0.044	0.203
10	A10	0.032	-0.202	0.010	0.205
11	A11	0.044	-0.164	0.079	0.170
Mean		0.024	-0.167	-0.009	0.170
Std. dev.		0.027	0.046	0.064	0.045
RMSE		0.035	0.172	0.062	0.175

Another regulation that regulates position accuracy is the boundary stakeout for the Mining Business License Area *(Wilayah Izin Usaha Pertambangan/WIUP).* The tolerated error for stakeout of WIUP boundary marks is 30 cm concerning SRGI2013 measurements. The results of the accuracy test with a value of 17.5 cm horizontally have met the regulations' requirements.

Conclusion

This study is intended to examine the use of the RT-PPP method for positioning in mapping surveys in mining activities. The test results show that the accuracy of the RT-PPP method is relatively consistent, so it is hoped that it can increase confidence in this method. Likewise, the accuracy value meets the requirements for map accuracy and stakeout accuracy according to regulations.

However, there are some things that need to be studied through further research. The accuracy of the easting value is sufficient compared to the northing deviation value looks like a systematic error. The opportunity to use the RT-PPP method with an accuracy below 2 cm and an accuracy below 20 cm in mining mapping surveys is also interesting to study further.

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