Analysis level of accuracy GNSS observation processing using u-blox as low-cost GPS and geodetic GPS (case study: M8T)

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Abstract. The Global Positioning System (GPS) is a satellite navigation system and positioning that is owned and managed by the United States of America. This system is also designed to provide three-dimensional position and speed and information about time, continuously throughout the world without depending on time and weather, to many people simultaneously. The GPS module undergoes system expansion on low-cost devices by producing low-cost and energy-saving devices, including being able to provide L1 satellite data equivalent to geodetic GPS. This study shows whether low-cost U-Blox GPS can be equivalent to Hi-Target V60 geodetic GPS. The test was carried out by observing the four corners of the Geomatics Engineering volleyball field and PWK ITS using the RTK method. The results of GPS observations were carried out statistical tests to see if low-cost U-Blox GPS can be equivalent to GPS Geodetic Hi-Target V60.

1. Introduction
Surveying and mapping has increasingly rapid development, especially in the fields of technology and information. People used to know conventional technology to take measurements such as the use of total stations, theodolite, EDM, waterpass, and so on. In this modern era, people know the technology that relies on satellites in the acquisition of survey and mapping activities. This technology is commonly called the Global Positioning System (GPS) or commonly called GNSS [1].

GNSS stands for Global Navigation Satellite System. GNSS is a technology used to determine the position or location (latitude, longitude, and altitude) and time in scientific units on earth. Satellites will transmit radio signals with high frequencies that contain data on the time and position that can be taken by the recipient that allows users to find out their exact location anywhere on the surface of the earth [2]. GNSS also could observe tropospheric correction and weather changes [5] and ionospheric correction [6].

The GPS module undergoes system expansion on low-cost devices by producing low-cost and energy-saving devices, including being able to provide L1 satellite data equivalent to geodetic GPS. The GPS module is available at a price of less than USD 100. This GPS module usually only provides meter level accuracy that comes from GPS code signals only, but using the concept of measurement such as geodetic can make it possible to achieve accurate positioning in the Real-Time Kinematic method. There is weakness in the low cost GPS device because at one frequency L1 so that the ionosphere correction...
and the troposphere can not be eliminated properly [3]. Low cost GPS already done for different U Blox tools and open source software [12,13].

In this study, we will analyze the results of the coordinates obtained in low-cost GPS and GPS geodetic, with statistical tests on GPS coordinate data and analyzing the results obtained.

2. Methodology

2.1. Research site

The location used as a case study in this research was in the PWK ITS volleyball court in Surabaya. This place can be seen in Figure 1. The location was chosen for accuracy pencil analyst because low cost GPS will observe rectangular shape.

![Figure 1. PWK ITS volleyball court](image)

2.2. Data collecting

2.2.1. Data collecting using Hi-Target V60

Hi-target V60 was used to collect GPS observation data at the corner of the volleyball court by using the RTK method, the CORS used in the method was BIG CORS CSBY of Surabaya City and CORS PSBY of Surabaya City Public Works Agency. The results of the coordinates obtained can be seen in table 1.

| Marked Placed | CORS CSBY NORTHING (meters) | CORS CSBY EASTING (meters) | CORS CSBY HEIGHT (meters) | CORS PSBY NORTHING (meters) | CORS PSBY EASTING (meters) | CORS PSBY HEIGHT (meters) |
|---------------|-----------------------------|----------------------------|---------------------------|-----------------------------|---------------------------|---------------------------|
| A             | 9194908.246                 | 698107.358                 | 32.062                    | 9194908.219                 | 698107.369                 | 32.046                    |
| B             | 9194915.071                 | 698101.349                 | 32.036                    | 9194915.055                 | 698101.355                 | 32.055                    |
| C             | 9194902.900                 | 698088.129                 | 32.107                    | 9194902.798                 | 698088.089                 | 32.034                    |
| D             | 9194895.985                 | 698094.131                 | 32.079                    | 9194895.967                 | 698094.148                 | 32.081                    |

2.2.2. Data collecting using U-Blox M8T

U-Blox M8T was used to collect GPS observation data at the corner of the volleyball court by using the RTK method, the CORS used in the method was BIG CORS CSBY of Surabaya City and CORS PSBY.
of Surabaya City Public Works Agency. The results of the coordinates obtained can be seen in table 2.

| Marked Placed | CORS CSBY | CORS PSBY |
|---------------|-----------|-----------|
|               | NORTHING  | EASTING   | HEIGHT    | NORTHING  | EASTING   | HEIGHT    |
|               | (meters)  | (meters)  | (meters) | (meters)  | (meters)  | (meters) |
| A              | 9194908.010 | 698107.316 | 34.452   | 9194907.997 | 698107.482 | 33.989   |
| B              | 9194915.071 | 698101.699 | 33.710   | 9194914.440 | 698100.262 | 36.372   |
| C              | 9194902.892 | 698089.320 | 33.642   | 9194902.820 | 698089.439 | 33.450   |
| D              | 9194896.006 | 698094.062 | 33.500   | 9194895.972 | 698094.243 | 33.309   |

2.3. Statistic test

Statistical tests have three types of hypotheses based on the comparability of two samples and which ones to use, depending on the sound of the sentence in the formulation of the hypothesis [8,9].

1. Test of Two Parties

The two-party test is used to see the difference or similarity of sample A with sample B, the hypothesis used is [10,11]:

\[ H_{H0}: AA1 = BB2 \text{ and } H_{H1}: AA1 \neq BB2 \]  

Parametric statistics are used to test the comparative hypothesis on an average of two samples if the data are in the form of intervals or the ratio is using the t-test. The formulation of the t-test used to test the comparative hypothesis of two independent samples is shown in the following formula.

Separate Variance

\[ t = \bar{x}_1 - \bar{x}_2 \cdot (\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2})^{-\frac{1}{2}} \]  

The t-test to be used can be selected based on the following criteria:

- If the number of sample members \( n_1 = n_2 \) and homogeneous variance (\( \sigma_1^2 = \sigma_2^2 \)), then the T Test can be used, both separated and polled variance, to find the t-table used dk (degree of confidence) which is \( dk = n_1 + n_2 - 2 \).
- If the sample \( n_1 \neq n_2 \), and homogeneous variance (\( \sigma_1^2 = \sigma_2^2 \)) can be used t-test with polled variance, the value of \( dk = n_1 + n_2 - 2 \).
- If \( n_1 = n_2 \) and the non-homogeneous variance (\( \sigma_1^2 \neq \sigma_2^2 \)) can be used both separated and polled variance with the value \( dk = n_1 - 1 \) or \( dk = n_2 - 1 \).
- If \( n_1 \neq n_2 \) and the variance is not homogeneous (\( \sigma_1^2 \neq \sigma_2^2 \)), the separate variance formula is used for this. The value of \( t \) in place of the value of t-table is calculated from the difference in the value of t-table with the value of \( dk = n_1 - 1 \) and \( dk = n_2 - 1 \), divided by two and then added by the smallest value of \( t \).

The t-test that will be used for the hypothesis is chosen based on the results of the f-test first to determine the variance of both homogeneous samples or not.

\[ F = (\text{Highest variance}) . ((\text{Lowest variance})^{-1}) \]
The f-test uses the highest and lowest variance values for each sample, which is then calculated to be the f-value and compared to f-table with the numerator “dk” (confidence degree) = \( nn1 - 1 \) and denominator = \( nn2 - 1 \), in this case the provisions apply, if f-value is smaller or equal to the value of f-table means homogeneous variance, if the f-value is greater with the value of f-table means the variance is not homogeneous. The degree of confidence using the error level of 5%.

3. Result and Discussion

3.1. Result and analysis of statistic test GPS observation data

The results obtained in GPS observations were then tested for statistics to see a comparison between GPS U-Blox and GPS Hi-Target V60. The hypothesis used is as follows:

\( HH0 = \) GPS U-Blox is equivalent to GPS Hi-Target V60 and can be used for geodetic measurements. \( HH1 = \) GPS U-Blox is not equivalent to GPS Hi-Target V60 and cannot be used for geodetic measurements

The results of the coordinate value are carried out f-test first to see whether the results are homogeneous or not, then from these results, the t-test calculation is used to test whether \( HH0 \) above is accepted or not. UBX-TGT is the result of a comparison between U-Blox and Hi-Target V60.

| Marked Placed | CORS CSBY | CORS PSBY |
|---------------|-----------|-----------|
|               | NORTHING and EASTING (meters) | HEIGHT (meters) | NORTHING and EASTING (meters) | HEIGHT (meters) |
| A             | Homogeneous | Homogeneous | Non Homogeneous | Homogeneous |
| B             | Homogeneous | Homogeneous | Non Homogeneous | Non Homogeneous |
| C             | Non Homogeneous | Homogeneous | Non Homogeneous | Non Homogeneous |
| D             | Non Homogeneous | Homogeneous | Non Homogeneous | Homogeneous |

The t-test results for coordinate values using CORS CSBY indicate that \( HH0 \) is accepted as 0 from 4 points, and the t-test results for coordinate values using CORS PSBY indicate that \( HH0 \) is accepted as 0 from 4 points, so the GPS U-Blox coordinate value parameters cannot be used as GPS observations such as GPS Hi-Target V60 [4].

GPS observations are then plotted into autocad to see the shape of the object produced from the observation. The result from using CORS CSBY can be seen in Figure 2 and result from using CORS PSBY can be seen in Figure 3.
The object with the red line is an area that is generated using GPS U-Blox, it can be seen that the results of GPS U-Blox area is smaller than the GPS Hi-Target V60, so GPS U-Blox can not be used as a GPS observations like GPS Hi-Target V60.

4. Conclusion
The conclusions obtained from the measurement results are as follows:
- Test Result The Coordinates of observations the RTK method are not accepted HH0 for the 8 samples tested.
• U-Blox cannot be used as a GPS observation when compared to Hi-Target V60 because the number of $HH0$ received is less than half the number of samples tested.

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