Comparative Analysis of Low-Cost GNSS OEM Board K706 AND BX316 (Case Study: Bulusidokare Village Sidoarjo Regency)

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Abstract. Innovations in GNSS technology have been increased rapidly with significant development in geodetic and navigation types due to its low-cost. One of the advantages of low-cost GNSS is in its price tags, which varies from the geodetic type. This study determines GNSS Tersus BX316 and Comnav K706 Oem Board's equivalent abilities compared to Stonex S800 GNSS geodetic. The post-processing and precise point positioning were used to determine the activities of RTK. In conclusion, the data obtained by BX316 are closer to those from Stonex S800.

1. Introduction

The Global Navigation Satellite System (GNSS) comprises several satellites which continuously orbit around the earth and has experienced significant growth over the past few decades. GNSS enables the users to determine their position, such as latitude, longitude, and height using code signal/pseudo-range signals. Its spectrum accuracy ranges from meters to millimetres [1, 2].

Previous study [10] has been carried out in order to improve the accuracy of GPS in land with thick density, namely by integrating GPS with IMU. This study stated that the standard deviation generated by the GPS-IMU is better than the GPS (standalone) in areas covered by density.

In another previous study [11] the low-cost K706 OEM receiver was tested for its accuracy, whether it is equivalent to the Topcon HiperPro geodetic receiver or not. As a result, the low-cost K706 has a better standard deviation compared to Topcon Hiperpro receiver, indicated by the results of K706's Horizontal and vertical RMSE which are superior to Topcon Hiperpro.

Another previous study [11], was carried out to test the accuracy equivalent of Ublox M8T low cost receiver compared to the geodetic receiver of Hi target V60. This study used the Real Time Kinematic measurement method at 4 measuring points, and then the measurement results were processed for statistical tests to find out the equivalent of the two receivers. The results obtained from this research states that Ublox M8T is not yet equivalent compared to Hi-target V60 geodetic receiver because the statistical test obtained has a bad value.

The next study [13] conducted to monitor the performance of Ublox M8t and Allystar HD9100 low-cost receivers. The coordinates of the geodetic measurement results used a TOPCON GPS receiver as a reference with SPP and RTK methods. The results obtained are...
quite good compared to the survey grade receivers. In the RTK method, the meter's accuracy can be fixed to centimetres. Rather than using GPS L1, future researchers can try to use another GPS to get a more diverse GNSS signal. Future researchers were also encouraged to use a splitter antenna for antenna sharing.

Previous experiments using Allystar HD9100 GPS with Ublox Neo M8T shows that the usage of low-cost GPS with RT method leads to an accuracy rate in cm [9]. In addition, open-source program packages for RTK applications using low-cost receivers such as RTKLIB have been developed by Takasu et al. (2009) [6]. This program supports the provision of raw data measurements, with the usage of RTK mode to improve low-cost GNSS systems for optimum accuracy.

2. Instrument Setting

The research has been carried out to measure the post-processing and precise point positioning at one point, as well as RTK observations by using three receivers, namely Stonex S800, Tersus Bx316, and Comnav K706, as described in the following subsections.

2.1. Bx316

Bx316 is a GPS module which supports the accuracy of data position capture and direction information. It has the ability to capture multi-constellation satellite data to obtain the position (GPS L1 / L2, GLONASS L1 / L2, and BeiDou B1 / B2), and output direction of the signals in real-time (RTK). For data retrieval, BX316 is supported by the ability of ethernet, USB, LVTTT, RS232, CAN, PPS, and event alerts, as well as module dimensions 108 x 54 x 12 mm and weighing 50 grams. As for data retrieval and recording, the device is compatible with the NovAtel correction protocol, supported by 384 GNSS channels and equipped with 4GB memory for storing recorded results. Bx316 also offers real-time, cost savings, precise positioning accuracy in cm, and it is flexible for various application usage such as precise navigation, surveying, and UAV. The receiver’s accuracy spreads across 1.5m and 3m to the horizontal and vertical positions using PPS (Point Positioning Single) method. Furthermore, the horizontal and vertical direction using the RTK method is 10mm + 1ppm horizontally and 15mm + 1ppm respectively [7].

2.2. S800 GNSS Receiver

Stonex S800 is a GNSS receiver for capturing data positions with high accuracy, equipped with 555 GNSS channels and able to retrieve data in multi-satellite constellations, namely GPS, GLONASS, Beidou, and Galileo. This receiver’s accuracy spread across 2.5mm + 1ppm and 5mm + 1ppm to horizontal and vertical positions using static methods. Furthermore, horizontal and vertical direction using the RTK method is 8mm + 1ppm horizontally and 15mm + 1ppm respectively. The Stonex S800 has 8GB memory and weighs 1.2 kg with dimensions of 146 mm x 146 mm x 76 mm [5].
2.3. K706
The K706 is a GPS module that supports high accuracy of data positioning with 352 GNSS channels and supports multi-constellation satellite data collection such as GPS L1 / L2, BeiDou B1 / B2, GLONASS L1 / L2, Galileo, and QZSS. This receiver’s accuracy spreads across 8mm + 1ppm and 15mm + 1ppm to the horizontal and vertical positions using the static method. Furthermore, the horizontal and vertical direction using the RTK method is 2.5mm + 1ppm horizontally and 5mm + 1ppm, respectively. K706 weighs 26.6 grams with dimensions of 71mm x 46 mm x 9 mm [3].

2.4. Antenna
AT330 geodetic is a GNSS antenna consisting of multiple satellite constellations such as GPS L1, L2, L5, GLONASS L1, L2, and BeiDou B1, B2, B3. It has a high benefit and provides a wide beam good signal tracking performance even when the satellite is at a low altitude. Furthermore, it has a ± 2mm Phase Center Accuracy. [3]

3. Experiments and Results

3.1 Experiments
The test configuration instrument used to carry out this research is shown in Figure 1, with data obtained from the Stonex S800 receiver. Furthermore, BX316 and K706 receivers connected to the dual-frequency GNSS CNTAT330 antenna mounted on the roof to obtain a good view of the sky. A geodetic antenna has been used to suppress multipath [8], while GNSS signal from the antenna has been divided into 2 Receivers, namely BX316 and K706, using a simple antenna divider. Internet services were used to link the receivers to CORS stations via NTRIP 1 sec data. CSBY Station which is one of the GNSS CORS stations located in the center of the Surabaya region and maintained by the Geospatial Information Agency (BIG) has been used as a reference station with the
baseline length close to 13 km from the reference point. GNSS data has been recorded for every second using RTKLIB setting on Personal Computer (PC). RTKLIB is a software library for extracting raw GNSS signal data measurements [5]. A relative static position reduced the reference point position with dual-frequency of L1 + L2 using Stonex S800 for 24 hours. The results coordinates are shown in Table 1.

**Table 1.** The coordinates of CSBY and Stonex S800

| Station Name | Latitude       | Longitude       | Ellipsoid Height |
|--------------|----------------|-----------------|------------------|
| CSBY         | 7° 20' 03.6043" S | 112° 43' 27.7142" E | 51.253 m         |
| Stonex S800  | 7° 27' 27.6747" S | 112° 43' 44.1041" E | 36.6840 m        |

Observations were conducted using RTK and PPP methods to test data accuracy from BX316 and K706. The results of the two methods will be explained in the following subsections.

**3.2. Differential Static, Real-Time Kinematic and Precise Point Positioning**

In this study, static observations were carried out for 12 hours using NTRIP. Real-time and observational raw data results have been processed using BX316 and K706 as shown in table 2.

**Table 2.** Mean and standard deviation of differential static, real-time kinematic, and precise point positioning for receiver BX316 and K706.

| Receiver | Northing (m) | Easting (m) | Height (m) | Mean | Std. Deviation | Mean | Std. Deviation | Mean | Std. Deviation |
|----------|--------------|-------------|------------|------|----------------|------|----------------|------|----------------|
| BX 316   | 9175281,199  | 690796,8177 | 36,829     | 9175281,194 | 0,0022 | 690796,804 | 0,013 | 35,069 | 0,0193 |
| K706     | 9175281,177  | 690796,793  | 36,867     | 9175281,186 | 0,0017 | 690796,816 | 0,0082 | 35,090 | 0,0184 |

**Figure 2:** The location of CSBY (CORS_SURABAYA)
3.3. Satellite recording data
Satellite recording has been performed for 11 hours with BX316 and K706 receivers to obtain the numbers recorded by both satellites.

![Figure 3: Number of satellites captured by BX316 (blue) and K706 (yellow) receivers](image)

The results of satellite recording for 11 hours using the CORS CSBY method at intervals of one second showed that the BX316 obtained 12 to 20 satellite signals, while the K706 obtained 19 to 25.

3.4. Accuracy Test
Accuracy tests were performed using BX316 and K706 receivers based on the reference point from the data produced by Stonex S800. The accuracy test of the two receivers was conducted using the RTK and PPP methods.

![Figure 4: Precision accuracy of RTK method using K706 (yellow) and a BX316 (blue) receiver](image)

From the accuracy testing results using RTK method, it has been found that the data taken using the K706 receiver are closer to the reference point than BX316.

![Figure 5: Precision accuracy of PPP method using K706 (yellow) and BX316 (blue) receiver](image)

From the results of accuracy testing using PPP method, it has been found that the data taken using the K706 receiver are closer to the reference point than BX316.
4. Conclusion

The conducted test showed that BX316 and K706 receivers can be used to measure high-accuracy objects. Furthermore, these low-cost receivers produce accuracy in centimetres and millimetres using RTK and static methods.

Based on the results of data recording satellite for 11 hours simultaneously, K706 receiver obtained 19 to 25 satellite signals, while BX316 receiver obtained 12 to 20 signals. Therefore, it can be concluded that the capability of the K706 receiver is higher than BX316.

The result of a data accuracy test using RTK and PPP showed that the BX316 receiver is closer to the reference point compared to K706. Therefore, BX316 receiver offers more accurate data recording capability compared to K706.

5. References

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