The utilization of mobile base station in cadastre surveying

Achmad Setiawan¹²³, Arief Syaifullah¹, Kusmiarto¹

¹ National Land College (STPN Yogyakrta), Tata Bumi Street No. 5, Sleman Regency, Yogyakarta, Indonesia. 
² Nusa Laut Street No. 20, Blitar City, East Java, Indonesia. 
³ nawaiites.achmad@gmail.com.

Abstract. A baseline is one of the problems in the Continously Operating Reference Stations (CORS) utilization using the Real Time Kinematic-Networked Transport RTCM via InternetProtocol (RTK-NTRIP) method. A long baseline becomes a constraint to solving ambiguity resolution. It causes correction loss and the receivers need a long time to receive a fixed solution. Therefore, a base station can be installed closer to the measurement site, so it is movable and not permanent. It is called a mobile base station, which makes the baseline shorter. The purpose of this paper is to evaluate the level of efficiency and precision from the utilization of mobile base station. The same samples were measured twice from the two different stations: the base station and the mobile base station. The results show that the average observation duration using the mobile base station is 1.27 minutes, while directly from the base station is 10.73 minutes. The mobile base station can improve the measurement efficiency by 11.84%. The lateral difference is 0.026-0.168 metres for agricultural area and 0.025-0.153 metres for residential area. The difference of land parcels area stay within the allowable tolerance of ± 0.5√L.

Keywords: Cadastre, CORS, Baseline, Mobile Base Station.

1. Introduction

Land parcels measurement methods using Global Navigation Satellite System (GNSS) technology are growing fast. One of the examples is Real Time Kinematic-Networked Transport RTCM via InternetProtocol (RTK-NTRIP) method. A long baseline becomes a constraint to solving ambiguity resolution. It causes correction loss and the receivers need a long time to receive a fixed solution. Therefore, a base station can be installed closer to the measurement site, so it is movable and not permanent. It is called a mobile base station, which makes the baseline shorter. The purpose of this paper is to evaluate the level of efficiency and precision from the utilization of mobile base station. The same samples were measured twice from the two different stations: the base station and the mobile base station. The results show that the average observation duration using the mobile base station is 1.27 minutes, while directly from the base station is 10.73 minutes. The mobile base station can improve the measurement efficiency by 11.84%. The lateral difference is 0.026-0.168 metres for agricultural area and 0.025-0.153 metres for residential area. The difference of land parcels area stay within the allowable tolerance of ± 0.5√L.

Keywords: Cadastre, CORS, Baseline, Mobile Base Station.
The closest base station plays a role as a master station. There is no requirement for the master station to be the closest reference station to the rover as it is simply used for data transmissions and does not play a special role in correction computations. This enables compatibility for one-way and two-way communications receivers. In broadcast mode (one-way), the master station is predetermined by the network while in automatic mode (two-way), the master station is chosen as the reference station closest to the rover[3]. In addition to its real time, CORS can also be used for post processing using Receiver Independent Exchange Format (RINEX) format data which is recorded and stored on each base station.

The speed and stability of internet connection is very important to support NTRIP communication system. A weak and slow internet connection can delay the process of transmitting data corrections from the base station to the rover. The problem on the internet connection can decrease the efficiency of observation time. In fact, on the blank spot area of the internet connection, the real time kinematic NTRIP (RTK NTRIP) using JRSP is unable to perform.

In East Java, the base stations are installed on the land office’s rooftop. However, there are still several land offices which are not equipped with the base station yet, so it is a problem in the cadastral surveying using CORS, especially the land offices with large administrative areas. The problem is related to the location of the land parcels. The measurement of the land parcels using CORS which are located far away from the base station makes a long baseline. Differential positioning system is greatly affected by the length of the baseline: the shortest baseline results in better accuracy[4]. A long baseline makes the rover receive corrections from the base station slowly. The long distance is a problem in solving ambiguity resolution and it causes data lost when it is sent from the base station to the rover[5]. In consequence, the rover takes a long time to get fixed solution and land cadastre surveying becomes inefficient.

**Figure 1.** Closer Control Point Mechanism. The right sketch use a long baseline for measurement. It makes a long time observation and has to use dual-frequency receiver. On the left sketch, a baseline is shortened by installing/building the control point near the survey location. The control point in this paper is the base station while the installed control point is the mobile base station.

The problem can be solved by shortening the baseline as shown in Figure 1. The baseline is shortened by installing the base station closer to the measuring site. This base station is called the mobile base station because it can be installed anywhere (but still in the internet connection coverage area) and be built easily closer to the measuring site. In the other words, it is not installed permanently on somewhere or building rooftop. The mobile base station is set up using a geodetic GPS receiver. The fixed coordinate is measured through static positioning and calculated by post-processing method. The GPS receiver is connected to server by the modem. The modem has functions as a network data communications system and sends the corrections using Networked Transport of RTCM rover via the Internet Protocol (NTRIP) to the rover, so that the mobile base station can
produce more accurate data efficiently. This paper is focussed on the level of efficiency and precision from the utilization of mobile base station.

2. Method
In this method is divided into two parts, i.e. materials and procedure.

2.1. Materials
To install the mobile base station, below are some of the equipments or instruments needed:
1. Geodetic GPS receiver as mobile base station (Trimble NetR9 Geospatial).
2. Rover (JAVAD TRIUMPH- VS and Leica Viva NetRover GS08).
3. Blitar City Land Office’s Base Station.
4. Information Geospatial Agency’s (Badan Informasi Geospasial) base station site Malang City.
5. Handphone for tethering.
6. GSM card (Telkomsel).
7. Laptop.
8. Accu.
9. Modem.

The Trimble NetR9 was chosen because of the RJ45 jack. It was the reason why the mobile base station used in this research can connect to the server and the other base stations in the network. The RJ45 connects to the modem as data communication system over the internet.

There are two brands of rover: JAVAD and Leica. The JAVAD is used to observe the samples whereas the Leica is used for log data static-positioning. The reason why Leica is used is because when post-processing using LGO, the data does not need to be converted.

Some sets of software are also needed to process and calculate the data, i.e :
1. Leica Geo Office for post-processing.
2. Justin Link to download data from the rover (JAVAD TRIUMPH- VS) to laptop.
3. AutoCAD Map 3D 2012 to plot the coordinates and calculate the area parcels.
4. Leica Spider.
5. Microsoft Office Excel 2007 for statistical calculation.

2.2. Procedure
There were three stages in this research: Pre-survey, Survey, and Data Processing.
1. Pre-Survey
   a. Pre-survey consisted of some preparations, i.e. the instruments, creating a pre-survey work map (Figure 2), observing and writing down the observation duration. The duration counted from the rover connect to NTRIP server until get fixed solution using RTK-NTRIP method.
   b. The instruments were JAVAD TRIUMH- VS, handphone/modem, work map, and observation form. The handphone/modem was used for tethering as system communication data and correction for RTK-NTRIP. JAVAD TRIUMH- VS has wi-fi feature.
   c. The points were spread into four quadrant. Each quadrant was divided to several ranges i.e. 5 km, 15 km, and 20 km from Blitar City Land Office’s Base Station.

The RTK-NTRIP method was used to measure every point and to obtain the slowest time to get fixed solution. Then, the mobile base station was utilized in the selected point or range which had the longest duration to receive the fixed solution. The mobile base station construction is shown in Figure 3.
Figure 2. The Pre-Survey Work Map. The points spread into several radius in four quadrants and as the origin is “BPN Kota Blitar”. R 5.3 represents the point of 5 km radius in quadrant III. Meanwhile, R 10.1 represents the point of 10 km radius in quadrant I. Etc.

Figure 3. The Mobile Base Station, Installed on point open-view-sky location. Used Trimble NetR9 Geospatial. Connected to laptop for configured, modem for streamed data, and accu for power supply.

2. Survey
In this stage, each sample was measured twice: using the mobile base station and without the mobile base station. The first survey using the mobile base station needed some equipment:

a. Trimble NetR9 Geospatial as mobile base station, Leica Viva NetRover GS08 as mobile base station’s coordinate data logger, LGO software for post-processing, modem, laptop, accu
b. JAVAD TRIUMPH-VS as rover.
c. The mobile base station was installed in the quadrant and radius which had the longest duration to fixed solution according to the pre-survey results. The distribution of samples were plotted in survey work map as shown in Figure 4.
d. The coordinate of mobile base station was measured on 8th April 2017 through static positioning using Leica NetRover. The measurement time was approximately one hour.
e. The coordinate of mobile base station was differential-GNSS-measurement to the BIG’s base station site Malang City, so raw data from the Leica NetRover and BIG’s base station site Malang City were downloaded to the laptop and calculated by post-processing method.
f. Then, the antenna was replaced with the Trimble’s antenna. The mobile base station was set from antenna, NetR9, laptop, modem, and accu as power supply.
g. The function of modem was to connect the mobile base station to the NTRIP server and stream corrections via NTRIP to the rover.

h. The laptop was used to configure the Trimble receiver through web interface, input the coordinate (X,Y,Z) of mobile base station, and also to configure it to the Leica GNSS Spider as shown in Figure 5. According to the Leica GNSS Spider, the site has to receive at least five satellites before it can stream corrections.

i. Afterwards, the mobile base station was ready to stream data corrections. Then, the rover could start to observe the samples. The samples were 22 points spread out into four quadrant as shown in Figure 4.

j. The first observation which took place on 8th April 2017, the samples were observed by using the mobile base station as NTRIP caster.

**Figure 4.** The Survey Work Map: Distribution of Samples. The points were conditioned in radius < 3 km from mobile base station. Spread into the four quadrants. Located in the ideal obstruction for GNSS survey.

**Figure 5.** Configuring Through A Web Browser. 192.168.1.3 is NetR9’s IP. “NTRIPCaster http://” was filled with NTRIPServer IP. Insert the password. Then, mobile base station is integrated.
Meanwhile, on the second survey, the mobile base station was switched off (without the mobile base station), the needed equipment ranged as following:

a. Blitar City Land Office’s Base Station.
b. JAVAD TRIUMPH-VS as rover.
c. During the observation which took place on 11th April 2017, the samples were observed again without the mobile base station. The Blitar City Land Office’s Base Station played role as NTRIP caster. In this section, the mobile base station was switched off (deactivated).
d. The same samples were measured again.

3. Data Processing

The data were processed with some software, there were Microsoft Excel 2007, AutoCAD Map 3D 2012, and Justin Link.

a. The coordinates from 22 sample points were downloaded to laptop by using Justin Link. There were two kinds of coordinates: coordinates using the mobile base station and coordinates without the mobile base station.
b. The coordinates were plotted to AutoCAD Map 3D 2012.
c. The coordinates difference data were input to Microsoft Excel and calculated with \( \sqrt{(\Delta X^2 + \Delta Y^2)} \) formula. These differences were between coordinates using the mobile base station (MBS) and without the mobile base station (BS).
d. The duration data were input and calculated by using Microsoft Excel.
e. The statistic test used Data Analysis Tools menu in Microsoft Excel.

The research method applied was comparative experiment with quantitative approach. Comparative experiment means that the experiment includes data comparison from the same samples over the different treatments. The reason why quantitative approach was chosen was because the data would be processed statistically. In addition, the sampling technique is called purposive sampling, which is a sampling technique in which the researcher relies on his or her own judgment when choosing members of population to participate in the study.

Each sample was measured twice: first, measured using mobile base station; second, measured without mobile base station (used Blitar City Land Office’s Base Station), and then compared to each other. The framework is presented in Figure 6.

![Figure 6. The Framework. The samples were measured by using base station and mobile base station. The methods was RTK-NTRIP. The results were duration and coordinates. Both of them were compared and tested by statistic test.](image)

3. Result and Discussion

3.1. The Difference of Observation Duration

The samples location were chosen in radius approximately 17 km (18.790 km to be more precise) from Blitar City Land Office’s Base Station. Based on Table 1 below, this distance had the longest time observation, i.e. 630 seconds. It was caused by the long baseline. The long baseline had an effect on the ambiguity resolution, because satellites’ signal had to pass the thick atmosphere before it was...
received by the rover. It also affected the corrections-delay. Therefore, the baseline was shortened by installing the mobile base station in this location.

**Table 1. The Observation Duration.**

| Point | Baseline (km) | Quadrant | Duration (second) |
|-------|---------------|----------|-------------------|
| R5.1  | 5.399         | I        | 60                |
| R10.1 | 8.987         | I        | 60                |
| R5.4  | 5.756         | IV       | 240               |
| R10.4 | 9.596         | IV       | 60                |
| R10.3 | 7.058         | III      | 240               |
| R5.3  | 5.149         | III      | 120               |
| 1     | 4.816         | III      | 60                |
| R5.2  | 6.914         | II       | 60                |
| R15.2 | 15.633        | II       | 60                |
| R20.2 | 18.790        | II       | 630               |

The mobile base station was installed on 8th April 2017 at 09:00-13:00 WIB (Waktu Indonesia Bagian Barat/ Western Indonesian Time. It is time zone division that exist in Indonesia which is 7 hours ahead of Coordinated Universal Time). Through static positioning method, the coordinate was measured by using Leica NetRover GS08 and processed by using Leica Geo Office 7.0.0.0. The coordinate is $8^\circ08'32,39534"$ S; $112^\circ19'08,91440"$ E; 225,4412 metres above ellipsoid.

Each sample was measured twice, i.e. using the mobile base station (MBS) and without the mobile base station (BS). The observation of samples using mobile base station was done on 8th April 2017 at 14:15 – 17:01 WIB and in this section, the mobile base station plays a role as a master station. Then, the observation without mobile base station was done on 11th April 2017 at 14:30 – 16:45 WIB. This time window was chosen to obtain the same ionosphere condition as in the previous observation when using mobile base station.

The duration of observation using the mobile base station (Table 2) and without the mobile base station (Table 3) was compared. The aim was to obtain the difference observation duration at the same point of each quadrant. The observation duration using mobile base station was faster than that without the mobile base station as shown in Figure 7.

![Figure 7. Diagram of Duration Difference. MBS was measured by mobile base station, while BS was not. MBS needed short time to get fixed solution rather than BS needed. The biggest difference was in quadrant III.](image)
Table 2. The Observation Duration Using Mobile Base Station.

| Quadrant | Point | Baseline (km) | Duration (second) |
|----------|-------|---------------|-------------------|
| I        | 1C    | 3.909         | 60                |
| I        | 1C1   | 3.909         | 60                |
| I        | 1C2   | 3.909         | 60                |
| I        | 1C3   | 3.909         | 60                |
| I        | 1C4   | 3.909         | 60                |
| I        | 1C5   | 3.909         | 60                |
| II       | 1A    | 3.358         | 120               |
| II       | 1A1   | 3.358         | 60                |
| II       | 1A2   | 3.358         | 60                |
| II       | 1A3   | 3.358         | 60                |
| III      | b     | 2.525         | 60                |
| III      | C1    | 2.525         | 60                |
| III      | D     | 2.525         | 60                |
| III      | E     | 2.525         | 120               |
| III      | F     | 2.525         | 60                |
| III      | F1    | 2.525         | 120               |
| IV       | 1B    | 3.118         | 60                |
| IV       | 1B1   | 3.118         | 60                |
| IV       | 1B2   | 3.118         | 60                |
| IV       | 1B3   | 3.118         | 180               |
| IV       | 1B4   | 3.118         | 120               |
| IV       | 1B5   | 3.118         | 60                |
Table 3. The Observation Duration Without Mobile Base Station.

| Quadrant | Point     | Baseline (km) | Duration (second) |
|----------|-----------|---------------|-------------------|
| I        | Sawah b1  | 17.157        | 60                |
| I        | Sawah b2  | 17.157        | 60                |
| I        | Sawah b3  | 17.157        | 60                |
| I        | Sawah b4  | 17.157        | 60                |
| I        | Sawah b5  | 17.157        | 120               |
| I        | Sawah b6  | 17.157        | 60                |
| I        | Sawah b7  | 17.157        | 60                |
| I        | Sawah b8  | 17.157        | 60                |
| I        | Sawah b9  | 17.157        | 60                |
| II       | Bola 1    | 16.227        | 1980              |
| II       | Bola 2    | 16.227        | 540               |
| II       | Bola 3    | 16.227        | 420               |
| II       | Bola 4    | 16.227        | 1800              |
| III      | Voli 7    | 15.481        | 720               |
| III      | Voli 2    | 15.481        | 720               |
| III      | Voli 3    | 15.481        | 720               |
| III      | Voli 4    | 15.481        | 720               |
| III      | Voli 5    | 15.481        | 720               |
| III      | Voli 6    | 15.481        | 720               |
| IV       | Sawah a1  | 15.794        | 600               |
| IV       | Sawah a2  | 15.794        | 600               |
| IV       | Sawah a3  | 15.794        | 600               |
| IV       | Sawah a4  | 15.794        | 600               |
| IV       | Sawah a5  | 15.794        | 600               |
| IV       | Sawah a6  | 15.794        | 600               |

A large duration difference took place in quadrant II, which was caused by the long baseline and the day time environment. Meanwhile, a small duration difference took place in quadrant I, which was caused by the ionospheric effects.

The ionosphere affect the observation duration. At 14.30 WIB, the ionosphere condition is not stable yet as the effect from the sun wave to the ionosphere. Meanwhile, at 16.00 WIB the ionosphere condition is stable because the distance between the sun and the ionosphere is far, so the effect of sun wave decreases.

The ionosphere condition can look at The Network Online Visualisation of Accuracy (NOVA) Maps. The NOVA Maps are some features of Leica Spider QC which can visualize in real time the ionosphere and troposphere conditions and the problems in a network. The NOVA can provide...
quality control to the user with this color gradations. It enables users to visualize the spatial and temporal quality of single base and network RTK positioning over their network. Real time maps show the distribution of residual ionosphere and troposphere/orbit error enabling users to monitor the network status and identify problem areas in the network. Network users can view the maps over the web to get assurance on the quality of the corrections provided by the network and to decide between using nearest site and network RTK corrections for the specific location of their survey. The visualization of NOVA Maps on 11th April 2017 at 14:40 WIB is shown in Figure 8.

Table 4. t-Test for The Difference of Observation Duration.

|                      | Duration of MBS | Duration of BS |
|----------------------|----------------|---------------|
| Mean                 | 1.272727273    | 9.909090909   |
| Variance             | 0.303030303    | 68.18181818   |
| Observations         | 22             | 22            |
| Pearson Correlation  | 0.288571429    |               |
| Hypothesized Mean    | 0              |               |
| df                   | 21             |               |
| t Stat               | -4.991447925   |               |
| P(T<=t) one-tail     | 3.05802E-05    |               |
| t Critical one-tail  | 1.720742871    |               |
| P(T<=t) two-tail     | 6.11605E-05    |               |
| t Critical two-tail  | 2.079613837    |               |

Table 4 shows that the observation duration between using the mobile base station and without mobile base station is significantly different. The observation duration using mobile base station is faster than that directly from base station.

Figure 8. The Ionosphere Condition on 11 April 2017 at 14:40 WIB. The blue area is ideal radius for measurement. The green area is still secure too. The yellow area indicates the ionosphere effect has begun to appear. The red area is not ideal for measurement, because the effect of the ionosphere
is great. As a result, the measurement on red areas will be difficult to get fixed solutions. So, avoid measurements at 11:00 am to 02:00 pm (local time).

3.2. The Coordinates Difference
Each sample was measured twice: using the mobile base station and without mobile base station (directly from base station). The measurement used the same rover (JAVAD Triumph-VS). The measurement using mobile base station is a short baseline, while the measurement directly from the base station is a long baseline. The mobile base station functions to shorten the baseline. A GPS baseline is formed by two GPS receivers, which is installed in each point (each end point) of the measured line. They collect data from the same GPS satellites at the same time. The duration of observations varies based on the the baseline length and the accuracy needed. It is measured typically an hour or more. When the data from both points is later combined, the difference in position (Latitude, Longitude and Height) between the two points is calculated with special software. Many of the uncertainties of GPS positioning are minimized in these calculations because the distortions in the observations are similar at each end of the baseline and cancel out. The accuracy obtained from this method depends on the duration of the observations, but is typically about 1 part per million (1 millimetre per kilometre), so a difference in position can be measured over 30 kilometres with an uncertainty of about 30 mm, or about 100 mm over 100 kilometres[6].
Table 5. The List of Coordinates.

| Point     | MBS Coordinate | BS Coordinate |
|-----------|----------------|---------------|
|           | X              | Y             | X              | Y             |
| 1C/a      | 181147.062     | 603450.441    | 181147.063     | 603450.470    |
| 1C1/a6    | 181121.986     | 603453.390    | 181121.960     | 603453.392    |
| 1C2/a7    | 181095.176     | 603455.966    | 181095.206     | 603456.030    |
| 1C3/a8    | 181094.259     | 603432.638    | 181094.204     | 603432.651    |
| 1C4/a9    | 181117.360     | 603432.119    | 181117.309     | 603432.035    |
| 1C5/a10   | 181141.808     | 603429.104    | 181141.804     | 603429.078    |
| 1A/2a3    | 178174.113     | 596920.462    | 178174.017     | 596920.523    |
| 1A1/2a2   | 178165.305     | 596918.011    | 178165.351     | 596918.002    |
| 1A2/2a1   | 178162.603     | 596934.045    | 178162.619     | 596934.109    |
| 1A3/2a    | 178171.983     | 596936.551    | 178172.010     | 596936.560    |
| F1/3.a    | 178012.835     | 598240.430    | 178012.895     | 598240.391    |
| b3/a1     | 178001.668     | 598245.385    | 178001.644     | 598245.449    |
| C1/3.a2   | 177989.596     | 598249.953    | 177989.593     | 598249.800    |
| D/3.a3    | 177982.623     | 598233.554    | 177982.612     | 598233.577    |
| E/3.a4    | 177995.453     | 598227.866    | 177995.479     | 598227.807    |
| F/3.a5    | 178007.257     | 598225.003    | 178007.291     | 598224.867    |
| 1B/a      | 179698.514     | 602788.595    | 179698.650     | 602788.424    |
| 1B1/a5    | 179675.266     | 602795.565    | 179675.227     | 602795.681    |
| 1B2/a4    | 179678.360     | 602808.662    | 179678.424     | 602808.763    |
| 1B3/a3    | 179680.360     | 602831.768    | 179680.442     | 602831.632    |
| 1B4/a2    | 179707.070     | 602826.157    | 179707.174     | 602826.134    |
| 1B5/a1    | 179701.907     | 602803.191    | 179702.014     | 602803.320    |

Based on the coordinates list above, the value of lateral difference can be calculated by using formula $\sqrt{(\Delta X^2 + \Delta Y^2)}$. 


Table 6. The Coordinates Difference.

| Point | ΔX (m) | ΔY (m) | Lateral (m) | Tolerance (m) | Accept/Reject |
|-------|--------|--------|-------------|---------------|---------------|
| 1C    | -0.001 | -0.029 | 0.029       | 0.250         | Accept        |
| 1C1   | 0.026  | -0.002 | 0.026       | 0.250         | Accept        |
| 1C2   | -0.030 | -0.064 | 0.071       | 0.250         | Accept        |
| 1C3   | 0.055  | -0.013 | 0.057       | 0.250         | Accept        |
| 1C4   | 0.051  | 0.084  | 0.098       | 0.250         | Accept        |
| 1C5   | 0.004  | 0.026  | 0.026       | 0.250         | Accept        |
| 1A    | 0.096  | -0.061 | 0.114       | 0.100         | Reject        |
| 1A1   | -0.046 | 0.009  | 0.047       | 0.100         | Accept        |
| 1A2   | -0.016 | -0.064 | 0.066       | 0.100         | Accept        |
| 1A3   | -0.027 | -0.009 | 0.028       | 0.100         | Accept        |
| F1    | -0.060 | 0.039  | 0.072       | 0.100         | Accept        |
| b     | 0.024  | -0.064 | 0.068       | 0.100         | Accept        |
| C1    | 0.003  | 0.153  | 0.153       | 0.100         | Reject        |
| D     | 0.011  | -0.023 | 0.025       | 0.100         | Accept        |
| E     | -0.026 | 0.059  | 0.064       | 0.100         | Accept        |
| F     | -0.034 | 0.136  | 0.140       | 0.100         | Reject        |
| 1B    | -0.136 | 0.171  | 0.218       | 0.250         | Accept        |
| 1B1   | 0.039  | -0.116 | 0.122       | 0.250         | Accept        |
| 1B2   | -0.064 | -0.101 | 0.120       | 0.250         | Accept        |
| 1B3   | -0.082 | 0.136  | 0.159       | 0.250         | Accept        |
| 1B4   | -0.104 | 0.023  | 0.107       | 0.250         | Accept        |
| 1B5   | -0.107 | -0.129 | 0.168       | 0.250         | Accept        |

There are two classifications for tolerance: tolerance by 0.250 m for agricultural area and tolerance by 0.100 m for residential area. This rule is regulated by The Technical Instruction of PMNA/KBPN No. 3/1997 (Petunjuk Teknis PMNA/KBPN 3/1997). There are three rejected-points, i.e. 1A, C1, and F. It was caused by an unstable surveyor when holding the pole between the first measurement and the second measurement on the same point.

To test the precision level, the statistic test for each classification was conducted.
Table 7. t Test for Agricultural Area.

|                | Difference of X | Difference of Y |
|----------------|-----------------|-----------------|
| Average of ΔX  | -0.029          | Average of ΔY   | -0.001          |
| α              | 0.05            | α               | 0.05            |
| Df             | 11              | df              | 11              |
| SD             | 0.06754         | SD              | 0.09601         |
| μ₀             | 0               | μ₀              | 0               |
| t table        | 2.20099         | t table         | 2.20099         |
| t test         | -1.49178        | t test          | -0.04209        |

Table 8. t Test for Residential Area.

|                | Difference of X | Difference of Y |
|----------------|-----------------|-----------------|
| Average of ΔX  | -0.007          | Average of ΔY   | 0.018           |
| α              | 0.05            | α               | 0.05            |
| Df             | 9               | df              | 9               |
| SD             | 0.04459         | SD              | 0.0792          |
| μ₀             | 0               | μ₀              | 0               |
| t table        | 2.26216         | t table         | 2.26216         |
| t test         | -0.5319         | t test          | -0.69877        |

The α represents the significance level and it is the probability of rejecting the null hypothesis in a statistical test when it is true. The null hypothesis means it is not significant difference between coordinates using mobile base station and without mobile base station. So, not significant means precise. The null hypothesis is true if t test < t table. The μ₀ is the expected value of difference.

Table 7 and Table 8 show that every t test value is smaller than t table. Statistically, the coordinates from utilizing of mobile base station were precise.

3.3. The Land Parcels Area Difference

This research used 7 (seven) land parcels which were formed by 22 points of samples. The land parcels were spread into four quadrants (with the origin in the mobile base station point). The distance between the 22 points of samples and the mobile base station ranged between 2.5 km to 4 km. Meanwhile, the distance between those sample points and Blitar City Land Office’s Base Station ranged between 15.7 km to 17.1 km.

Table 9. The Land Parcels Area.

| Point  | Area (m²) | ΔL  | Tolerance |
|--------|-----------|-----|-----------|
|        | MBS       | BS  |           |
| Parcel 1 | 542  | 545 | -3 | ± 11.656 |
| Parcel 2 | 560  | 562 | -2 | ± 11.842 |
| Parcel 3 | 152  | 150 | +2 | ± 6.144 |
| Parcel 4 | 212  | 214 | -2 | ± 7.297 |
| Parcel 5 | 244  | 244 |  0 | ± 7.810 |
| Parcel 6 | 344  | 349 | -5 | ± 9.307 |
| Parcel 7 | 598  | 594 | +4 | ± 12.206 |

The ΔL is the area differences between measurement using mobile base station (MBS) and without mobile base station (BS). The tolerance is regulated in The Technical Instruction of PMNA/KBPN No. 3/1997 by ± 0.5√L. Table 9 shows that the area differences (ΔL) stay within the allowable tolerance of ± 0.5√L.
4. Conclusions
The research results presented in this paper clearly show that the average observation duration without mobile base station is 10.73 minutes and can be accelerated to 1.27 minutes when using mobile base station. So, the utilization of mobile base station accelerates the duration by 11.84% and still allows a precise coordinates or insignificant difference with the coordinates measured directly from the base station (without mobile base station). The measured land parcels area also stay within the tolerance by The Technical Instruction of PMNA/KBPN No. 3/1997. Avoiding the observation at 11:00-14:00 local time can also accelerate the duration because in the GNSS, an ideal ionosphere condition is required, as shown in Figure 9.

![Figure 9. The Ideal Ionosphere Condition. The Network Online Visualisation of Accuracy (NOVA). The NOVA is a feature of Leica Spider QC which can visualize in real time the ionosphere and troposphere conditions and the problems in a network. NOVA can provide quality control to user. The color gradations on the NOVA make it easy for the user to decide to use the nearest site with the measurement location to get the best correction at specific times and locations. The quality of the correction can be either network corrections or single reference station corrections (nearest site).](image)

The utilization of mobile base station has some limitations. There are the receiver antenna specifications, power supply, and internet connection. First, the receiver antenna specifications for mobile base station is not the same as the chokering specifications on the land office’s base station. The effect is the mobile base station need more time to ambiguity fixing before it can stream the corrections. Second, the power supply is needed for switch on the laptop and modem. Last, the mobile base station can only work in the area with internet connection. The reason is RTK-NTRIP can only work in area with internet connection.

5. Acknowledgments
We would like to acknowledge that the instruments were provided by The Ministry of Agraria dan Tata Ruang/Badan Pertanahan Nasional (ATR/BPN) East Java Province Regional Office, Blitar City Land Office, and Pamekasan Regency Land Office.
6. Appendices

Appendix A. The Observation Time of Pre-Survey

| Point | Baseline (km) | Quadrant | Clock Observation |
|-------|---------------|----------|-------------------|
|       |               |          | Start/Connect     | Stand alone | Float | Fixed |
| R5.1a | 5.399         | I        | 07:50             | 07:50       | 07:50 | 07:50 |
| R5.1b | -             | -        | -                 | -           | -     | 07:54 |
| R5.1c | 8.04          | I        | 08:04             | 08:04       | 08:05 | 08:05 |
| R5.1d | -             | -        | -                 | -           | -     | 08:13 |
| R5.1e | -             | -        | -                 | -           | -     | 08:16 |
| R10.1a| 8.987         | I        | 8:54              | 8:54        | 8:55  | 8:55  |
| R10.1b| -             | -        | -                 | -           | -     | 8:59  |
| R10.1c| -             | -        | -                 | -           | -     | 9:02  |
| R10.1d| -             | -        | -                 | -           | -     | 9:06  |
| R10.1e| -             | -        | -                 | -           | -     | 9:09  |
| R10.1f| -             | -        | -                 | -           | -     | 09:12 |
| R5.4a | 5.756         | IV       | 09:53             | 09:54       | 09:54 | -     |
|       |               |          | 09:56             | 09:57       | -     | 09:57 |
| R5.4b | IV            | -        | -                 | -           | -     | 10:02 |
| R5.4c | IV            | -        | -                 | -           | -     | 10:06 |
| R5.4d | IV            | -        | -                 | -           | -     | 10:09 |
| R10.4a| 9.596         | IV       | 10:45             | 10:45       | 10:45 | 10:45 |
|       |               |          | -                 | -           | 10:46 | 10:55 |
|       |               |          | -                 | -           | 10:56 | -     |
| R10.4b| IV            | -        | -                 | -           | -     | 11:00 |
| R10.4b1|            | -       | -                 | -           | -     | 11:15 |
| R10.3 | 7.058         | III      | 15:39             | 15:40       | 15:40 | 15:43 |
|       |               |          | 15:44             | 15:44       | 15:44 | 15:45 |
| R5.3a | 5.149         | III      | 16:10             | 16:10       | 16:11 | 16:12 |
| R5.3b | III           | -        | -                 | -           | -     | 16:15 |
| R5.3c | III           | -        | -                 | -           | -     | 16:18 |
| R5.3d | III           | -        | -                 | -           | -     | 16:21 |
| 1     | 4.816         | III      | 16:39             | 16:39       | 16:39 | 16:40 |
| 2     | III           | -        | -                 | -           | -     | 16:45 |
| Quadrant | Point | Baseline (km) | Clock Observation | Duration (minute) | Latency (ms) |
|----------|-------|---------------|-------------------|------------------|-------------|
|          |       |               | Start/Connect     | Stand alone      | Fixed       |               |
| I        | 1C    | 3.909         | 16:54             | 16:54            | 16:55       | 1             |
|          | 1C1   |               | 16:57             |                  | 16:57       | 1             |
|          | 1C2   |               |                   |                  | 16:58       | 1             |
|          | 1C3   |               | 16:59             |                  | 16:59       | 1             |
|          | 1C4   |               |                   |                  | 17:00       | 1             |
|          | 1C5   |               |                   |                  | 17:01       | 1             |
|          | 1A    |               | 15:23             | 15:23            | 15:25       | 2             |
|          | 1A1   |               |                   |                  | 15:26       | 1             |
|          | 1A2   |               |                   |                  | 15:27       | 1             |
|          | 1A3   |               |                   |                  | 15:28       | 1             |
|          | b     |               | 14:15             | 14:15            | 14:15       | 1             |
|          | C1    |               |                   |                  | 14:28       | 1             |
|          | D     | 2.525         |                   |                  | 14:33       | 1             |
|          | E     |               |                   |                  | 14:35       | 2             |
|          | F     |               |                   |                  | 14:36       | 1             |
|          | F1    |               |                   |                  | 14:38       | 2             |
|          | 1B    |               | 16:13             | 16:13            | 16:14       | 1             |
|          | 1B1   |               |                   |                  | 16:15       | 1             |
|          | 1B2   |               | 16:16             | 16:19            | 16:20       | 1             |
| IV       |       | 3.118         | 16:16             | 16:19            | 16:20       | 1             |

**Appendix B. The Observation Time By Using The Mobile Base Station (MBS)**
### Appendix C. The Observation Time Without The Mobile Base Station (BS)

| Quadrant | Point         | Baseline (km) | Start/Connect | Stand alone | Float | Fixed | Duration (minute) | Latency (ms) |
|----------|---------------|---------------|---------------|-------------|-------|-------|-------------------|--------------|
| I        | Sawah b1      | 17.157        | 16:30         | 16:30       | 16:30 | 16:30 | 1                 | 1            |
|          | Sawah b2      |               | 16:31         | 16:31       | 16:32 | 16:32 | 1                 | 1            |
|          | Sawah b3      |               |               |             | 16:33 |       | 1                 |              |
|          | Sawah b4      |               |               | 16:34       | 16:34 | 16:34 | 1                 |              |
|          | Sawah b5      | 17.157        |               |             |       |       | 16:36             | 2            |
|          | Sawah b6      |               | 16:36         | 16:36       |       |       | 1                 |              |
|          | Sawah b7      |               |               |             |       |       | 16:37             | 1            |
|          | Sawah b8      |               |               |             |       |       | 16:38             | 1            |
|          | Sawah b9      |               |               |             |       |       | 16:39             | 1            |
|          | Bola 1        |               | 14:38         | 14:38       | 14:39 |       | 15:12             | 33           |
| II       | Bola 2        | 16.227        | 15:04         | 15:13       |       |       | 15:13             | 45           |
|          | Bola 3        |               | 15:07         | 15:14       |       |       | 15:14             |              |
|          | Bola 4        |               | 15:09         | 15:09       |       |       | 15:09             | 30           |
|          | Voli 7        | 15:22         | 15:22         | 15:22       |       |       | 15:22             | 12           |
|          | Voli 2        |               |               |             | 15:37 |       | 15:37             | 12           |
|          | Voli 3        |               |               |             | 15:37 |       | 15:37             | 12           |
| III      | Voli 4        | 16.481        |               |             | 15:38 |       | 15:38             | 12           |
|          | Voli 5        |               |               |             | 15:39 |       | 15:39             | 12           |
|          | Voli 6        |               |               |             | 15:39 |       | 15:39             | 12           |
|          | Sawah a1      | 16.01         | 16:01         | 16:02       | 16:11 |       | 16:11             | 10           |
|          | Sawah a2      |               |               |             |       |       | 16:12             | 10           |
|          | Sawah a3      |               |               |             |       |       | 16:13             | 10           |
|          | Sawah a4      | 15.794        |               |             | 16:15 |       | 16:15             | 10           |
|          | Sawah a5      |               |               |             | 16:16 |       | 16:16             | 10           |
|          | Sawah a6      |               |               |             | 16:18 |       | 16:18             | 10           |
7. References

[1] Asia Geospatial Forum, 17-19 October 2011, GNSS-RTK Network Technology Impact Assessment for Land Surveying at Badan Pertanahan Nasional Republik Indonesia (BPN RI) : A Report, Hotel Mulia Senaya, Jakarta, Indonesia, p 1.

[2] Yusup, A., Othman, R., Musliman, I.A., Han, W.O., 2012. ISKANDARnet CORS Network Integrity Monitoring, Jurnal Teknologi (Sciences and Engineering) eISSN 2180–3722, 71:4 (2014): 11-19, p 13.

[3] What is a CORS Network?, http://www.sage.unsw.edu.au/currentstudents/ug/projects/Gowans/Thesis/What_is_it.html (accessed Aug 6, 2017).

[4] Abidin, H.Z., 2000, Penentuan Posisi Dengan GPS Dan Aplikasinya, PT. Pradnya Paramita: Jakarta, p 96.

[5] Hafiz, E.G., Awaluddin, M., Yuwono, B.D., 2014, Analisis Pengaruh Panjang Baseline Terhadap Ketelitian Pengukuran Situasi Dengan Menggunakan GNSS Metode RTK-NTRIP (Studi Kasus: Semarang, Kab. Kendal dan Boyolali), Geodesi Undip Journal, Vol. 3, No. 1, (ISSN : 2337-845X): 315-331, pp 316-317.

[6] The Intergovernmental Committee on Surveying and Mapping (ICSM), Surveying for Mapping-Section 4, Surveying Using GPS and Conclusion, http://www.icsm.gov.au/mapping/surveying4.html and icsm@ga.gov.au (accessed February 7, 2017).