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EFFICIENCY OF PUBLIC TRANSPORTATION USING GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS)

Riza Putera[1], Anisa Santoso[2], Irene Sondang[3], Oky Pratama [4] Garrin Nandhito[5] and Esty Suyanti[6]

[1,2,3,6] School of Strategic and Global Studies, Graduate Program, Universitas Indonesia, Indonesia;
[4]Departement of Geography, Faculty of Mathematic and Natural Science, Universitas Indonesia,
[5]Infomation Technology, Faculty of Engineering, Universitas Islam Negeri Syarif Hudayatulloh, Indonesia;
Indonesia

*Corresponding Author, Received: 18 June 2016, Revised: 10 August 2016, Accepted: 30 Nov 2016

ABSTRACT: Motor vehicles are one of the biggest air pollution contributor in the city. Pollution getting worsened by poor public transport system in the city that caused lack of public services. In order to minimize the impact, so the focus not only by reducing the quantity of vehicles but also by managing the use of motor vehicles becomes more efficient. Through Global Satellite Navigation System (GNSS) as precise navigation tool, the patterns of transport system such as distance, duration, number of vehicle can be estimated accurately and more efficient. This research applied GNSS in the public transportation at Universitas Indonesia. Mode of transportation which we used in this research is campus buses or "Bis Kuning". We used quantitative experimental integrated with Geographic Information Systems (GIS). The results are GNSS can predict the patterns of campus buses, from the patterns we tried to connect with users of Bis Kuning satisfaction.

Keywords: GNSS, public transportation, Universitas Indonesia, Campus Bus

1. INTRODUCTION

Urban dynamics and mobility have bad consequences such as environmental degradation that eventually matters to health issue [1]. As a developing country, cities in Indonesia deals with growth and environmental degradation at once. The condition in Jakarta, the capital city itself has been rated one of the worst polluted in Asia. It rated 43 from the World Health Organizations in their 2013 report. Research have also showed that around 58 percent of reported public health issues in Jakarta itself have been traced to ailing level of air quality in the city [2]. It needs a better solution in urban transportation if city want to increase the quality of environment and health.

The use of public transportation is one of the best answer for solving the urban transportation issues. However, it does need to be re-examined whether it operate efficient or not in accordance to better impact not only for the services changes to urban residents but also for urban environment.

The role of technology in this sense becomes crucial as it not only facilitates these changes, but also makes managing issues such as mobility, distance to service distribution much faster and more effective [3]. The assumption is the more effective, the more satisfied of passengers and the lesser of pollution on the local environment, in the end the better of life quality at urban area. Hence, technology intervention could make mobility predictable precisely that impact to the punctuality and less pollute to the environment.

Nowadays the using of navigation technology is very common. GPS as one of Global Navigation Satellite System (GNSS) is known as the most popular navigation technology that used by public, in Indonesia. The accessible and open source navigation system like Google Map and Waze are using GPS. However, the open public GPS has limitation. GPS is not too precise if we compare with the real location. In GPS operation, it is between 3 to 10 meters' deviation if we compare the map and real location. The measurements with real time kinetic (RTK) GNSS also become a solution to predict the mobility. Based on the experimental study, measurements with RTK have much higher accuracy [4].

Therefore, Tokyo University developed GNSS-RTK using the QZSS satellite to make accurate navigation. It could predict the mobile location with only 2-3 cm deviation to the real condition. This navigation system applied in Jakarta, Indonesia cooperated with Multidisciplinary Study background in Universitas Indonesia. Due to the limitations coverage of the system, we would like to explore this system to pinpoint the urgent of urban issues which are transportation sector. In this research case, through technology methods like GNSS –RTK we like to know the mobility of public transport as depicted on the bus trip at campus.

Universitas Indonesia (UI) is chosen to be area of study because it has similar characteristics, especially

for urban transportation systems. UI transportation system integrated by train, buses, bicycle and motorcycle. Among all modes, campus buses are the most used by students. So we considered public buses to be an object of observation.

2. METHODOLOGY

In order to explain pattern of public transport, in this research we did several techniques to collect data.

2.1 Campus as City Miniature

Universitas Indonesia (UI) is chosen as a simulative miniature to test the mapping of transportation pattern. With regards to contextual similarity, a chosen suitable city miniature should have similar characteristics to a city. Both need to be similar in terms of being a center of resources while at the same time having society members as supplier of demands that require constant supply of resources. UI Campus in Depok is one of the biggest campus in Indonesia, with 320 hectare consist of 25 % are built area and the other 75% are green area. Figure 2 shows the campus area of Universitas Indonesia.

Since they have 11 faculties, the infrastructure and facilities in this campus are complete enough to meet the activities more than 30.000 inhabitants in this campus. This particular distribution of land use and infrastructure represents similar characteristics that can be found in a big city. Based on those data, UI campus could be the representation of city life.

In particular, of transportation sector, this campus has public transport named “Bikun” stand for “Bis Kuning” or yellow campus buses in english. It is most popular transportation in Universitas Indonesia. This campus bus is very important to support the movement from one faculty to others or another point of interest in campus. Therefore, this research aims to utilize the frameworks of university campus as a simulated miniature for a city.

2.2 Integrating GNSS RTK and GIS

Device that we used as a Rover is *U-Blox EVK-M8T Evaluation Kit* (and *U-Center* as its supporting software). We attached U-Blox to the campus bus along to track its movement. This device produces .ubx data that contain the track movement from campus bus.

After we got the. ubx data, we used *RTKLIB ver.2.4.2 p11* software to process the data. With *RTKCONV*, we converted the .ubx data into .obs data (observation from the rover). And then, we have to download the raw data (T02) and navigation data (.P) from the *Trimble* base station as the correction data. But we have to convert the .T02 data with *Convert to RINEX* to get the observation data (.o).

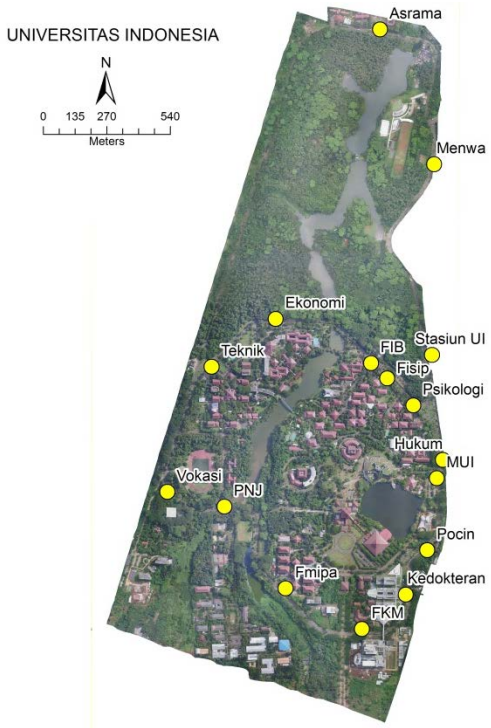

Fig 2. Bus Station at Universitas Indonesia

With *RTKPOST*, we processed the observation data (.obs) from the rover, observation data (.o) from the base station, and navigation data (.P) with the kinematic configuration to get the position data (.pos). This position data (.pos) is more accurate and precise. We can use and convert this data as needed, for example, excel extension (.xlsx), keyhole markup manguage (.kml), shapefile (.shp), etc.

2.3 Using Observation and Questionnaire

Using observation and interview with questionnaire, we like to complete the big picture of public transportation mechanism in UI campus. Statistical review is important to optimize the spatial data form the GNSS. An observation leads us to determine the characteristic campus bus trip. We have 4 variables to look forward such as: number and location of bus stops, number passengers, headways, lay overtime.

In general, we observed the trip characteristics based on two-time sequence; first is busy hour and the other is less busy hour. We assumed there are differences pattern in that two-time sequence. So we divide into 4-time phase consist of: 1) Morning-less busy hour 09.00-12.00, 2), Noon- less busy hour 12.00-14.00, 3) Noon –busy hour 14.00-16.00, 4) Afternoon-Busy Hour. 16.00-18.00,

Meanwhile the structural interview by questionnaire lead us to find out the user satisfactory about campus bus services as public transportation in campus. We used random purposive sampling with

total 70 respondents that spread along the bus stop. We asked 12 closed question to the campus bus users. This structural open ended question become a benchmark for the user satisfactory

At the processing phase, we used descriptive statistic to analyze the data. By using SPSS and Microsoft excel we did a modest statistic processing to describe a characteristic of campus bus trip.

3. RESULT

This research is defining in two results consist of the spatial analysis and the characteristic of campus bus trip pattern.

3.1 Spatial Analysis of Public Transport Mobility

The data show us that there are differences between before and after correction. Still, we divided the data collecting using GNSS RTK by two sequence of time: busy hour and less busy hour. Busy hour needs 33 minute for each trip compere with 22 minute in less busy hour.

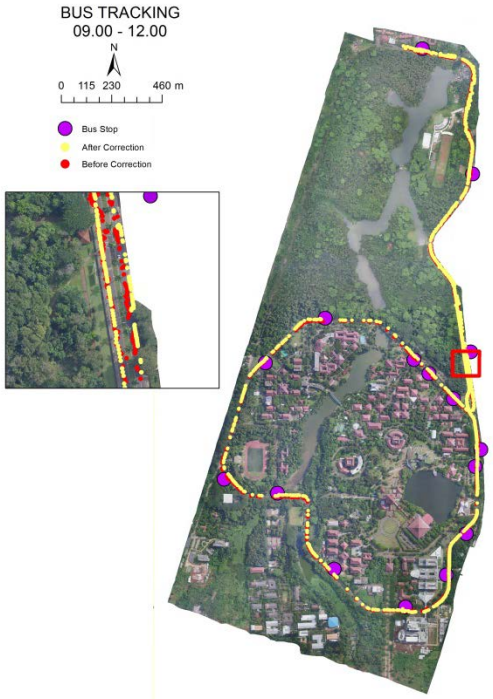

Fig 3. Mobility pattern of Morning Less Busy Hour

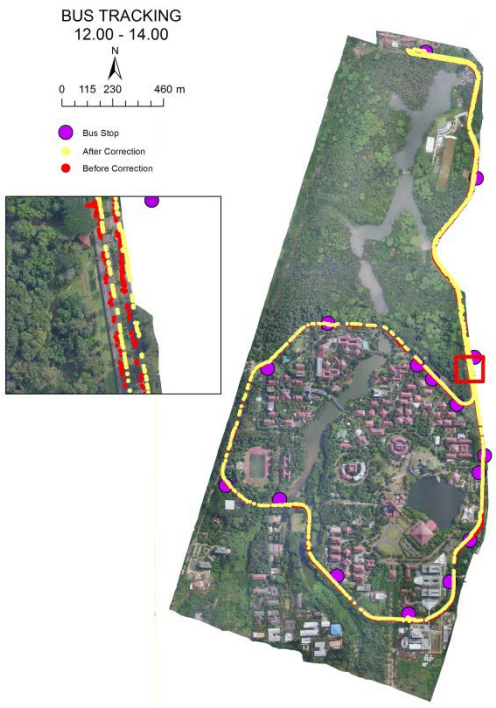

Fig 4. Mobility pattern of Noon Less Busy Hour

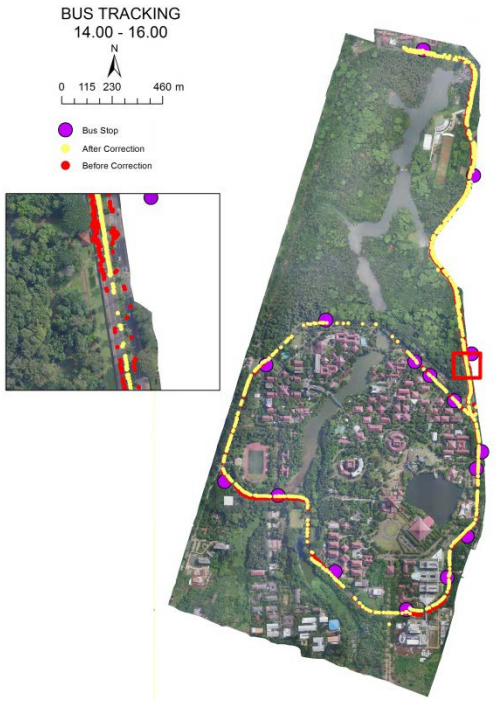

Fig 5. Mobility pattern of Noon Busy Hour

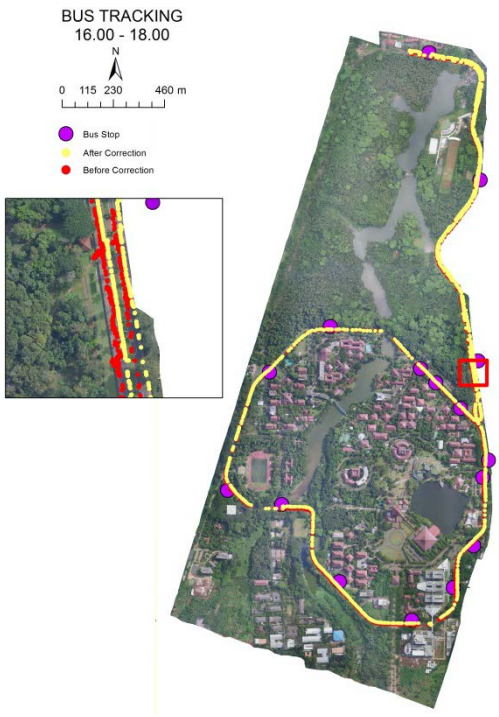

Fig.6 Mobility pattern of Afternoon Busy Hour

From the figure 3-6, after correction dot which the yellow dot more precise at the road route, meanwhile the red ones are slightly away, too close to the vegetation edge.

Moreover, if we could see the spatial pattern of the real time kinematic result so we could know where the campus bus/campus busses decrease the speed. The first red circle shows us, the dot is pile up at one location, so it means the bus slower or even stop. It is a bus stop namely Stasiun Universita Indonesia (Universitas Indonesia station), which are the biggest bus stop at campus. Then, the second red circle show the dot also pile up, but there is bus stop surround it. It was the main gate of campus and usually has congestion on it.

If we compare the busy hour pattern and less busy hour pattern we could see, the pile up not much more than the less busy pattern.

Campus bus mobility could monitor by GNSS-RTK. It helps us to predict where the position of campus bus at the real time. Real time Kinematic system with precisely makes us know whether the campus bus has obstacle or not. It predicts from the speed of the campus bus movements from one point to other points.

Limitation of this testing using GNSS-RTK is the sky view that is disrupted by the vegetation cover, so it makes the signal and the track is sometimes on and off. From the survey we known that the sky view is very important to have the clearer signal and data, based on the map dots that are scrambled not to regularly. It is because the poor signal that is stunted by the vegetation cover likes leafs, tree branches and so on.

3.2 Estimated Pattern of Campus Bus Trip as Public Transportation

The infrastructure to support public transport like CAMPUS BUS at campus UI already developed. Based on our data campus UI has 16 bus stop in each faculty and another point of interest (Figure 2). To serve the mobility on campus, Universitas Indonesia has 12 unit of campus bus. The service of CAMPUS BUS comprises two routes the blue ones and the red ones. Actually, it still the same route but with difference sequence of bus stop (Figure 2).

By our observation at 6-time phase, we found there is different between pattern of busy hour and less busy hour, as shown in the figure 4. The average total number passengers in one-day trip of CAMPUS BUS normally around 64 peoples in less busy hour and increase 100 % to busy hour become 120 or even 160 peoples for each trip.

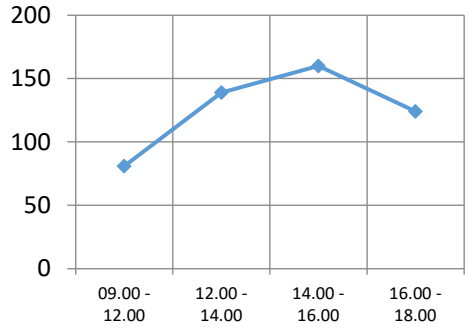

Fig.7. Number of total Average Passengers

Most of passengers rose in the Stasiun UI bus stop (123 passengers), followed by FT bus stop (84 passengers). From the observation data, it shows that the busiest bus stop that stops the bus stop of UI station, FT, and Pocin (Pondok Cina Bus Station).

Average time stops at every stop on the red route is 17.5 seconds and 20.14 seconds for blue route. The average time to stop the longest contained in Pocin bus stop, both the blue route and the red route. The average time in a round of campus bus's trip is 28 minutes on the red route and 29 minutes for the blue route. The longest time there in the afternoon rush hour (note: the normal path).

Table 1. Headways time (minutes).

Route	Less Busy Morning	Less Busy Noon	Busy Noon	Busy Evening	Average
Blue	5	6	5	7	5.75
Red	6	5	5	5	5.25

Campus bus time headways between the two most recently occurred at rush hour afternoon and evening hours for the blue route. The time headways between two campus bus longest occurred in leisure hours in the morning to the blue route (table 1).

Table 2. Number of road barriers.

U-Turn	Speed Bump	Intersection
14	21	11
14	18	8

Barriers are most distributed along the Gerbatama-UI station bus stop. That is due to many vehicles that lined to enter UI campus. Also, a lot of vehicles dropping off passengers at the station UI or motorcycle line that waiting for passengers at the UI station bus stop. The number of road barriers are shown in the table 2.

Meanwhile, based from our data collecting that show about user satisfaction. Overall the user is satisfying enough, but not too optimize (Figure 5).

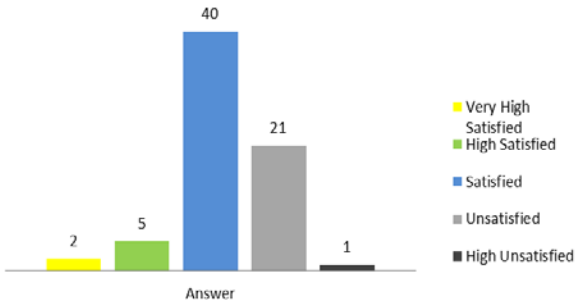

Fig.8 CAMPUS BUS service rank.

Moreover, if we talk about services, the waiting time is very important. The CAMPUS BUS arrival as public transport at campus less punctual and do not have a regular pattern. Based on the survey form the questionnaire, the respondents said more than 5 minutes to have the CAMPUS BUS in each bus stop (Figure 6). The universities already have the bus schedule, but it seems blurry when in operational phase.

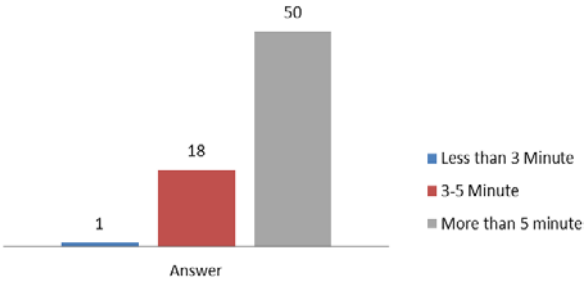

Fig.9 Campus Bus time arrival.

4. CONCLUSION

Research shows several characteristics that built the pattern of Campus Bus system. Total of passengers is quite influenced by the time, on the another hand, bus movement sometimes was disturbed by several factors like characteristics of bus stop and road barriers. As a result, customer satisfaction from campus buses services is not as well as expectation because most of people gave negative comments related with services performance.

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