Mapping Unsafety Driving Zone on Trans Semarang Corridor VI to Improve Public Transport Service

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Abstract. The concept of sustainable transportation has become an agenda for urban areas in both developed and developing countries. One of the implementations in realizing the concept of sustainable transportation is the development of mass public transportation facilities. Bus Rapid Transit (BRT) is one of the modes considered suitable for developing cities such as Semarang named Trans Semarang. To ensure the sustainability of the BRT, good planning and operation and maintenance are required. In the operation of BRT safety driving behaviour is believed to make the BRT safe and reliable for passenger. This research is intended to know the behaviour of the driver in operating the BRT. From driver’s behaviour and onboard survey can be classified the level safety driving the operation of BRT in Semarang. Safety driving level assessment was conducted on a sample of the BRT fleet. The analysis is done by making the level of safety driving divided into high, medium and low. At medium and low level, it can be said unsafety driving and conducted analysis of the cause. Furthermore, spatial analysis is done to map the areas that have low levels. From the mapping results can be concluded which areas have medium and low safety driving level and what causes it. From these conclusions, recommendations for BRT performance improvement can be formulated.

Keywords: BRT, safety driving, sustainable transportation.

1. Introduction

With all their activities, residents in urban areas need a certain amount of space which then leads to the need for transportation facilities to fulfill their mobility between spatial areas, both inner city space and its interaction with wider regional spaces. The higher mobility demands should be balanced with the increase of transport supply to prevent negative externalities, but in reality, urban transport problems are still commonly found in developing countries. Indonesia as one of the developing countries has transportation problems such as high number of traffic accidents, which one of them is caused by the high number of private vehicle usage. The number of traffic accidents in Indonesia in 2015 reached 98.9 thousand cases which increased by 3.19% from the previous year [1]. To solve urban transportation problems, it is necessary to develop a sustainable transportation system which can maintain the health and safety of people and their environment, in a ways that economic progress can continue and the balance of society will meet. Sustainable transportation is an important component of sustainable development because transportation is a prerequisite for development in general [2]. Sustainable transportation as part of sustainable development is generally developed through three conditions: improving the economic welfare of the community, minimizing the impact of development on the
environment, and sustainability of resources. This is in line with the objective of sustainable transport to ensure that environmental, social, and economic considerations are taken into account in decision-making regarding transport activities [3].

The high number of private vehicle use can be reduced, one of them is by increasing the use of public transportation, but in reality there are still many people who prefer to use private vehicles. Indonesia is a country with high motorcycle usage. In 2016 it was noted that in Indonesia there are 105.2 million units of motorcycle and 14.6 million units of cars, while the number of public transportation is only 2.5 million units [1]. The role of public transport in Indonesia is still relatively low, on average 23%, whereas in developed countries the role of public transportation is more than 50%, even public transportation in Singapore reaches 60% and in Hong Kong reaches 90%.

Bus Rapid Transit in Semarang (Trans Semarang) was launched by the Government on May 2, 2009. Until the 9th year of the operation, there are still some cases of accidents indicating that BRT still has not supported the concept of sustainable transportation. One of them can be seen in the corridor VI Undip (Diponegoro University) – Unnes (National Semarang University) corridor which is an additional corridor and was launched in March 2017. This route serve the south corridor Semarang city that growth rapidly caused by extended urban fringe [4]. Less than 2 weeks after the launching, there were 2 cases of accidents that cause fleet damage and injury to some passengers. Based on data and interview from the Public Works Department (DPU) of Semarang officer, several road segments passed by corridor VI have a width of 3-5 meters ranging from road Semeru Raya to Taman Siswa in Unnes. Based on data and interview from Planning Board, corridor VI routes have different elevation levels and pass several steep inclines and derivatives, for example in the derivatives on the Gombel Lama road and on the road of Dewi Sartika. Wide road conditions that tend to be narrow and over steep terrain may increase the risk of accidents so that driving should pay more attention of the way they drive. Corridor VI routes through various types of land use ranging from education to trade in services that will lead to the rise and pull of travel and affect the volume of traffic around it. Traffic conditions such as volumes may affect driving behavior, in addition to the activities in the surrounding land uses should be a safety consideration because BRT could endanger people on the move on land along the corridor VI route and also endanger other road users.

To reduce the risk of traffic accidents and create security for all road users in realizing sustainable transportation it is necessary to apply the concept of Safety Driving by BRT drivers. Safety Driving is driving behavior by applying some rules or indicators to improve security during driving both for our self and for others by reducing the risk of traffic accidents. Safety Driving is one way to achieve sustainable transportation especially in the social field with the aim of minimizing the number of injured and casualties caused by traffic accidents [5][6][7]. Based on the interview with BLU Trans Semarang as a stakeholder, it is known that there has never been any training given specifically to BRT corridor VI drivers including on safe driving rules, so driving behavior may be the cause of the traffic accidents. It is importance to know the typology of safety driving. The purpose of this research is to mapping the level of Safety Driving on Trans Semarang Corridor VI to Improve Public Transport Services.

2. Data and Methods

Safety Driving is driving behavior by applying some rules or indicators to create security while driving both for you and for others by reducing the risk of traffic accidents. Each person's driving style describes their actual driving action. Drivers can exercise their free will even when affected by some conditions such as roads and congestion, so that the driver's dynamic behavior is reflected through how they act in vehicle controls such as gearshift, brake, and steering vehicles [8]. Driving safely should be noted and implemented by each driver to keep traffic smooth and minimize the risk of accidents. In fact on the highway, there are unruly drivers in obeying traffic rules and increasing the risk of accidents that can hurt other drivers. One of the driver behaviors at risk in many ways is aggressive driving. According to Tasca L [9] aggressive driving is an unsafe driving behavior that can increase the risk of accidents
and be done consciously or deliberately because it is triggered by impatience, annoyance, or effort to save time. Approaches that can be applied to reduce the risk of loss from aggressive driving is by raising awareness, knowledge, and ability by applying the concept of Safety Driving during driving.

Safety Driving is not just about driving skills or behavior, but it can also be influenced by the driving nature of the driver at the workplace and the vehicle being steered. Safety Driving leads more to safety efforts while driving on the road and makes the road safer for everyone who use it [10]. The benefits of Safety Driving are to improve safety and comfort for drivers and passengers by reducing accident risk and maintaining the sustainability of BRT fleet by minimizing the risk of damage. Sustainable transportation can be realized through the application of Safety Driving.

The first rule on Safety Driving is to focus on the road during driving, which is not driving while doing things that can shift focus such as eating, using a cell phone, watching television, and listening to music / radio. It is noted that drivers who have a hand-held / mobile phone call during driving are causing higher violation significantly such as passing speed limits and not complying with signs. Drivers who are not focus on traffic in front of them can also increase the risk of accidents. In addition to unfocused drivers, traffic accidents are also frequent due to a sudden braking that usually culminates in a successive accident, so braking is also an indicator that must be considered in Safety Driving. Drivers who brake suddenly can risk rear-end collisions. In relation to these indicators, to prevent sudden braking the driver needs to keep a safe distance with the vehicle in front of them. If the driver gives space or distance of several meters, the BRT will have sufficient space and time to slow down especially when there was a vehicle in front of them stopped abruptly. This will reduce the risk of accidents that can arise if BRT braking abruptly. The safe distance is usually adjusted to the speed of the vehicle. Based on the calculations from the and the calculations of the Traffic Corps of the Republic of Indonesia issued in the Practical Guide Book, the distance to be maintained by vehicles adjusts to the pace. At a speed of 30 km / h then the driver must keep a safe distance of 15 meters, then for speed 40 km / h safe distance 26 meters with the vehicle in front, for speed 50 km / h safe distance of 35 meters, and for speed 60 km / h the safe distance of 45 meters.

One of the causes of the highest accident is the speed that exceeds the limit, so that on the Safety Driving there are rules for driving with attention of speed to not exceed the maximum limit. Driving below the speed limit can improve safety for yourself as well as for others. Based on Government Regulation No. 79 of 2013 on Traffic and Road Transport Networks, the highest speed limit for urban areas is 50 km / h. Rules that also must be done in the application of Safety Driving is to turn signal light while driving. If you want to turn or change the lane the driver must reduce the speed of the vehicle and give a mark or information by turning on the lights a few seconds earlier or at least 100 feet before turning, so that the vehicle behind can know the movement and minimize the occurrence of traffic accidents. Paying attention to and complying with traffic signs, traffic lights, pedestrian crossing lights and marking lines while driving is also a form of Safety Driving application. The rules are appropriate to be applied in Indonesia due to traffic lights and traffic light violations, including the most frequent form of offenses by motor vehicle users in Indonesia. Parking or stopping where on the right place is also one of the rules in Safety Driving, with the aim to not causing traffic problems. The location of the dismissal made by the driver when they want to load and unload the passengers can be observed, whether it is at the proper place or in a less appropriate place.

Drivers are considered to support the Safety Driving concept while running 7 indicators during operation. Safety Driving level can be different depending on how the behavior of each driver to Safety Driving indicators. Differences in driver behavior on applying Safety Driving rules or indicators are certainly influenced by factors that cause the driver to take a decision while driving. According to [11] individual decision-making and behavior is determined by personal characteristics (eg motivation and ability) and extrinsic conditions (eg, opportunities for action) [11]. Individual characteristics may also include emotional levels that affect higher speed changes [12]. Extrinsic conditions are conditions on the road or traffic that can affect the decision of the driver in driving.
The method of analysis used in this study is descriptive statistical analysis method based on data that has been collected both primary and secondary data. Observations were made on 16 BRT corridor VI drivers using checklists and assessments performed on each segment or bus stops of a total of 26 stops based on 7 Safety Driving indicators as illustrated in Table 1:

**Table 1. Safety Driving Indicators**

| Indicator                                      | Description                                                                                       | Sources                      |
|------------------------------------------------|--------------------------------------------------------------------------------------------------|------------------------------|
| Focus on the road while driving               | Not driving while eating, using a cell phone, watching tv, chatting, or doing anything else that can interfere with driving concentration | OSHA, 2011; RTA, 2012; AT&T, 2015; MDOR, 2107 |
| Safe Distance between Vehicles                | Provide space or safe distance with the vehicle in front to minimize the risk of accidents or collisions. The distance is adjusted to the speed of the vehicle. 30 km / h = 15 meters 40 km / h = 26 meters 50 km / h = 35 meters 60 km / h = 45 meters | RTA, 2012; AT&T, 2015; MDOR, 2107 |
| Speed Limit                                   | Drive at a steady pace and pay attention not to exceed 50 km / h speed limit                       | HSA dan RSA, 2012; AT&T, 2015; MDOR, 2107 |
| Turn signal light and reduce speed when turning| Make sure to always turn on the vehicle's signal lights a few seconds before turning or at a distance of 100 feet and also reduce the speed when going to turn or changing the lane | RTA, 2012; HSA dan RSA, 2012; MDOR, 2107; DHSMV, 2017; DMVNV, 2016 |
| Not braking abruptly                          | Not braking abruptly to reduce the risk of back collision                                          | DMVNV, 2016; DHSMV, 2017 |
| Traffic signs and rules                       | Driver must pay attention and obey traffic signs, traffic lights, pedestrian crossing lights, and line marks when driving | DMVNV, 2016; DMV, 2017 |
| Parking and stopping location                 | Make sure the vehicle is parked or stops where it should have been (legal) such as BRT stop at the bus stop, with the purpose to not causing traffic problems | DMVNV, 2016; DHSMV, 2017 |

*Source: OSHA, 2011; RTA, 2012; AT&T, 2015; MDOR, 2107; HSA dan RSA, 2012; DHSMV, 2017; DMVNV, 2016; DMV, 2017*
The analytical method used is descriptive quantitative with the analysis tool or method of measurement using Guttman scale to provide an assessment of Safety Driving indicators based on observations using checklists for 'Yes' being scored 1 and for 'No' answers given a score of 0. The smallest score is obtained from the number of subjects multiplied by the smallest scale and the largest score is obtained from the number of subjects multiplied by the largest scale. Categorization by referring to the measuring instrument aims to score results and Safety Driving level can be seen in general. The maximum and minimum score obtained with reference to the measuring instrument:

- Minimum score is 0 with the assumption that all drivers do not apply Safety Driving indicator on a segment / stop stop, so the driver gets a score of 0 x 7 (Each Indicator) x 16 (Number of Driver) = 0
- The maximum score of 112 is assumed that all drivers apply Safety Driving indicator on a segment / stop stops, so the driver gets a score of 1 x 7 (Each indicator) x 16 (Number of Driver) = 112

According to [13], the determination of the number of categories can be made according to the desired level of differentiation but first the limits must be set based on the standard deviation unit and taking into account the range of maximal numbers. Safety Driving level categorization will be made into 3 groups that is high, medium, and low based on normal curve distribution by dividing data using standard deviation formula that is as follows (see Table 2):

**Table 2. Range for 3 Level of Category**

| Range                  | Level of Category |
|------------------------|-------------------|
| \( X \geq (\mu+1\sigma) \) | High              |
| \((\mu-1\sigma) \leq X < (\mu+1\sigma)\) | medium            |
| \( X < (\mu-1\sigma) \) | Low               |

*Source: Azwar (2012; 2003)*

- The hypothetical mean is obtained from the maximum score minus the minimum score and divided by 2, so the hypothetical mean is \( \frac{((112-0))}{2} = 56 \)
- Standard deviation obtained from the maximum score minus the minimum score and divided by 6, so that the standard deviation is obtained \( \frac{((112-0))}{6} = 19 \)

Based on the maximum score data, minimum score, hypothetical mean, and standard deviation then the category of Safety Driving level can be seen Table 3:

**Table 3. Category of Safety Driving Level**

| Level of Category | Score |
|-------------------|-------|
| High              | \( X \geq 75 \) |
| Medium            | \( 37 \leq X < 75 \) |
| Low               | \( X < 37 \) |

*Source: analysis, 2018*

Based on the results of data processing that has been done by researchers based on the results of observation it will get the total score on each segment or stop. Total score is then compared with table 4 so that will get the level of Safety Driving for each stop / segment. From this level, it can be seen any indicator that the number of violations by the driver is still high on every segment and overall in corridor VI.
3. Result and Discussion

Sustainability in the operation of BRT can be realized if Safety Driving indicators are implemented by the driver during operation. Based on the literature, 7 indicators have been obtained and it will be used in assessing the level of Safety Driving which is focus on the road while driving by not doing things that can interfere with concentration such as chatting and watching tv, not braking abruptly, obey signs and traffic rules, parking and stop on the legal places, keep a safe distance with other vehicles, not over the speed limit of 50 km / h, and turn on the signal lights and reduce the speed when going to turn. Based on 7 Safety Driving indicators, the assessment will be conducted on each driver of a total of 16 drivers. Assessment on each driver will be done at each stop of BRT from a total of 26 stop points along the corridor VI. If the driver runs an indicator then given a score of 1 and if the driver violates the indicator it will be scored 0. Based on the assessment will get the total score on each segment along with its Safety Driving level. Based on the results of observation and data processing, the following is the total score along with the level of Safety Driving on each segment compared to the score category in Table 4 below:

| Stop/Segmen | Score | Safety Driving Level |
|-------------|-------|----------------------|
| H1          | 68    | Medium               |
| H2          | 78    | High                 |
| H3          | 78    | High                 |
| H4          | 61    | Medium               |
| H5          | 81    | High                 |
| H6          | 68    | Medium               |
| H7          | 89    | High                 |
| H8          | 72    | Medium               |
| H9          | 63    | Medium               |
| H10         | 79    | High                 |
| H11         | 70    | Medium               |
| H12         | 84    | High                 |
| H13         | 64    | Medium               |
| H14         | 64    | Medium               |
| H15         | 68    | Medium               |
| H16         | 57    | Medium               |
| H17         | 60    | Medium               |
| H18         | 58    | Medium               |
| H19         | 68    | Medium               |
| H20         | 77    | High                 |
| H21         | 82    | High                 |
| H22         | 87    | High                 |
| H23         | 55    | Medium               |
| H24         | 68    | Medium               |
| H25         | 79    | High                 |
| H26         | 73    | Medium               |
To make it easier in understanding the results in table 6 it will be displayed in the form of maps on Figure 1. The map will be displayed as a route map of BRT Corridor VI. Routes connecting the driving environment level at each stop or segment of stops. The level of eco driving described on the map is a different color. To know more clearly seen in this map in Figure 1.

From the Figure 1 and table 5 it can be seen that on 16 segment or stop the safety driving level is medium, while on the rest of the segment the safety driving level is high. It shows that in all segments or along the corridor VI the driver has implementing the Safety Driving indicator, but in the segment with the medium level is still need to be improved again by referring to the violation of indicator that is still done by the driver. Based on the Safety Driving level of each segment, it will be seen in the segment with the results are, what indicators are still often violated by the driver. These indicators are how to brake, park and stop location, safe distance between vehicles, traffic signs and rules, speed limits, and signal light and speed reductions when turns.

Figure 1. Level of Safety Driving Corridor VI BRT Semarang
4. Conclusion

Based on the analysis that has been done conclusions can be made to describe in brief the results of the study. Assessment of the way of driving shows the result that the level of Safety Driving at most bus stops or segments in corridor VI has a medium level of Safety Driving. This indicates that the concept of Safety Driving on corridor VI has been done by the drivers but still lacking or violations are still committed by drivers related to Safety Driving indicators. Violations occur in signal and speed at turns, speed limits, signs and traffic rules, and focus while driving are entirely influenced by internal factors. This means that violations occur because of decisions that are influenced by the attitude or condition of each driver and no traffic conditions that cause the driver to commit an offense. For violations on parking and stopping indicators, and braking indicators influenced by internal factors and external factors. Based on the identification that can be done for the distance indicator, obtained the result that the violation occurred because of external factors. External factors is the condition of traffic that causes the driver to violate the indicator.

Previous studies related to BRT provide more information on BRT's performance and services from the passenger side as the recipient of the service. From the results of this study can be known the operation of BRT corridor VI which seen from the side of the driver with reference to the concept and indicator Safety Driving is also related to the concept of sustainable transportation. The level of Safety Driving at BRT corridor VI belonging to the medium category indicates that the BRT operation is in line with the concept of sustainable transportation especially in social aspect. It also shows that transportation needs can be fulfilled without causing negative impact on social aspect that is related to public safety and comfort. The result of interview with Trans Semarang BLU shows that the driver of BRT corridor VI has never received training on previous Safety Driving concept. Expertise or knowledge about safe driving is also not a requirement in the driver's reception. Apart from these conditions, the average corridor VI driver who has experience working as a driver of public transport and city bus for 3 to 5 years has been able to operate the BRT safely proven through the Safety Driving level which is classified on the medium level. In BRT Corridor VI which is in the medium category violations of Safety Driving indicator are still conducted by the driver, so that driver performance improvement need to be done with reference to factors influencing driving behavior that is internal factor and external factor.

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6. References

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