Finding alternative ways of minimising the impacts of local problems in using micro simulation software

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1 Introduction

A study by Gwilliam (2003) indicated that urban transportation problems in developing countries are different from the developed countries. This is especially true in terms of traffic management. Two prominent causes are the lack of sufficient planning and implementation skills, and the lack of attention devoted by the local government to traffic management. This means that developing countries are far behind the developed countries in term of transport systems.

Modelling activities in developing countries seem to be more difficult than developed countries due to several factors related to local contexts. Aldian (2005) suggested that little attempt has been devoted to accommodating local features of the study area in developing countries, such as culture, travel behaviour and economic condition into the modelling process. Some distinctive features such as public transport condition, petrol price and motorcycle growth rate are some of the main concerns. The majority of developing countries, including Indonesia, are likely experiencing the same problems related to the urban transport systems.

Travel demand increases along with the urbanisation rate increases which could increase twice as quickly as in the United States (Morichi, 2005) and even higher compared to the countries in Europe. Due to the increases, it has caused difficulties in modelling and analysing their transport systems in developing countries compared to in developed countries where the system has been well-established, particularly when the modelling and analysis is undertaken using micro simulation instead of micro analytical traffic analysis software. Hence, the application of micro simulation traffic analysis and modelling software which have been successful in developed countries could generate different results when used in developing countries.

Meanwhile, there are various ways in modelling being classified as "analytical" and "simulation" methods. Various forms of traffic analysis and modelling software based on the two methods at different levels are now commercially available. For example, TRIPS can be considered as macro analytical software. FREQ, PASSER and TRANSYT7F are the examples of macro simulation software. Further, aaSIDRA is widely used micro analytical signal evaluation software. Among many micro simulation software, VISSIM, CORSIM and PARAMICS are widely used (Dowling *et al*., 2002), CUBE Dynasim is one of them and it is used in this research.

The use of microscopic traffic simulation plays major roles in the analysis and evaluation of transport systems. Due to its ability to model and analyse a transport system based on vehicle characteristics and operation conditions. It can simulate the interactions between users in transport systems. Therefore, microscopic traffic simulators can be considered as the most appropriate tool in analysing transport operations (Barcelo *et al*., 2002). It can reproduce a significant satisfactory on accuracy and capture the interactive impacts among traffic elements in a system which analytical models are unable to do. Besides, it can generate outputs which present the variations of particular transport system parameters.

For example, it can produce the average travel speed and its variations so that the profile of the speed within certain periods of time can be observed (Lehmuskoski and Nittymäki, 1999). Hence, through a simulation model the practitioners are able to estimate the likely outcomes in the system after some alternatives applied. Therefore, the best scheme among the proposed plans can be selected appropriately (Gomes *et al*. 2003).

The capability of a traffic simulator to accommodate traffic planners/engineers needs must be equipped with the ability to generate accurate and precise outputs. Furthermore, the software must have a tool that can be used to input the data and calibrate the model based on local conditions. Dowling *et al*. (2004) explained that the calibration process is important since the appropriate model parameters can be selected according to the local traffic operation conditions. Then, some of the data which is required to be calibrated are, for example, traffic volumes, average travel speeds, travel times and average delays. In addition, the driver reaction time towards the traffic environment, kinetic factors (such as acceleration and deceleration), and driver's aggressiveness could reduce the level of accuracy of the model, and hence may require to be calibrated.

The main aim of this paper is to provide an illustration of problems and findings related to the application of CUBE Dynasim, in modelling and analysing a signalized intersection located in Indonesia. The efforts to minimize the impacts of local conditions will also be discussed. Another case in Adelaide, South Australia is used as a reference for software performance. The research applied aaSIDRA, a micro analytical traffic software.

CUBE Dynasim is an event-based software with stochastic and dynamics outputs. It has tools which can be used to model the real transport system including the application of Intelligent Transport System (ITS) facility, for instance, actuated traffic signals. It is a multimodal traffic simulator software and able to import data from CAD, GIS and other databases as well as other traffic analysis programs. This micro simulation software also has tools to calibrate or adjust the traffic parameters based on the local traffic data.

On the other hand, aaSIDRA is a micro analytical traffic software which has been used in more than 80 countries, predominantly in the USA and Australia. It has the ability to analyse intersections for up to 8 legs with options of two-way, one-way approach or one-way exit. In addition, it can calibrate the analysis based on local conditions and compatible with the Highway Capacity Manual (HCM), for example the signal as well as the road conditions. Moreover, it can determine the optimum cycle time which is unable for micro simulation software to perform. aaSIDRA can take into account the impact of on-street parking and bus stopping in the system, but only for on-street parking and bus stopping which is located on the approaching lane.

2 Discussion of model outputs

2.1 Local traffic figures and research limitation

This study only involves one signalised intersection in Padang CBD, West Sumatra, as a test case. It is a-four leg intersection and controlled with pre-timed signal. It is an intersection between Sudirman St and Agus Salim St as shown in Figure 1. There are only three approaches namely Sudirman St, Agus Salim St and Bagindo Aziz Chan St on the East, South and West approach respectively. The North approach, in this case Pasar St, is an exit only and a one-way road. The data has been collected by undertaking traffic surveys including traffic volumes and distributions, signal timings, bus headways and on-street parking.

The vehicle composition can be classified into three types namely passenger car, motor cycle and heavy vehicle. Figure 2 depicts the vehicle type and public transport composition. Based on transport modes, it is classified as private car and public transport. The public transport is sub-classified as bus and paratransit. Paratransit is a minibus with 12-14 seats operated as public transport called “Angkot” (Joewono and Kubota, 2005). It can be seen that motorcycle has the highest percentage ranging from 54 to 64 per cent. For the public transport, minibus has a higher percentage than bus. The impacts of these two findings will be further discussed later. The discussion will also involve the findings of former research by Yaldi and Yue (2006) and Yaldi *et al*. (2007a; b), concentrating on the traffic flow only.

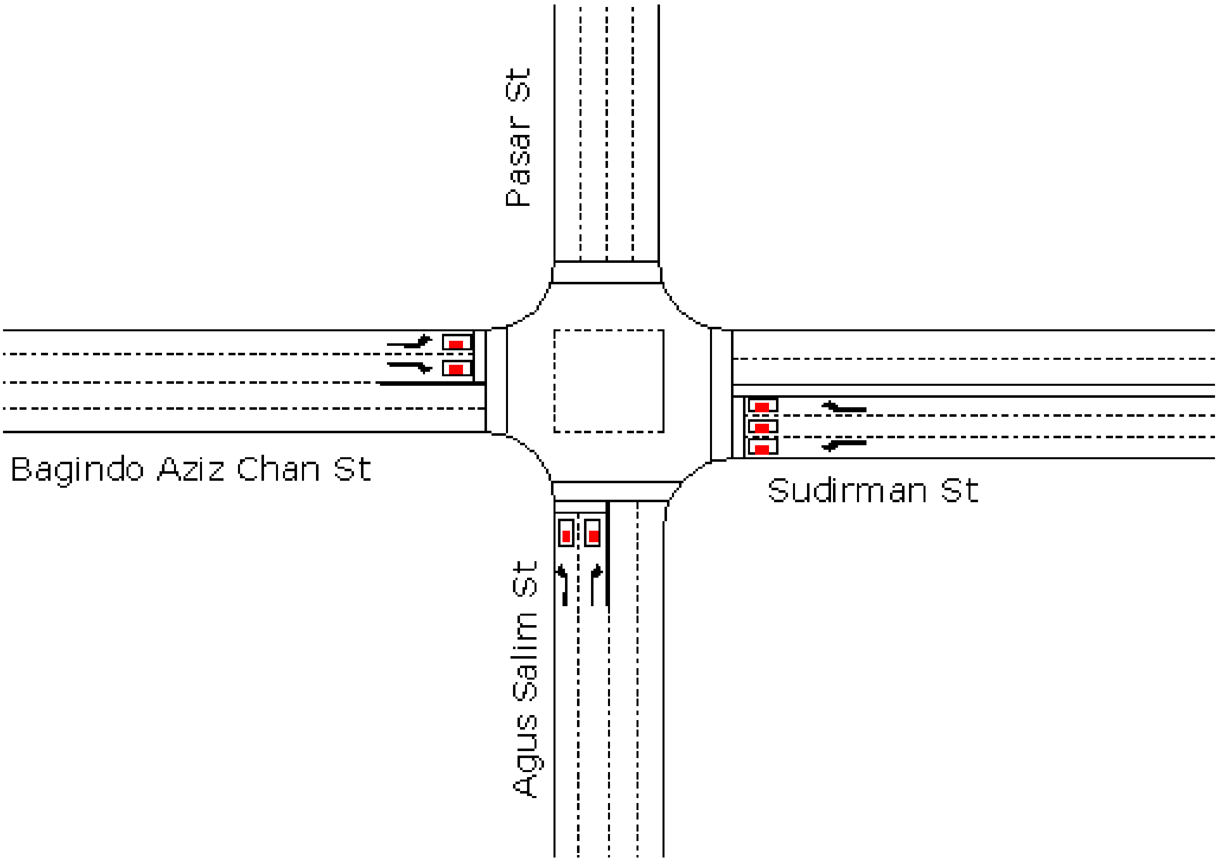

Figure 1 – Intersection layout

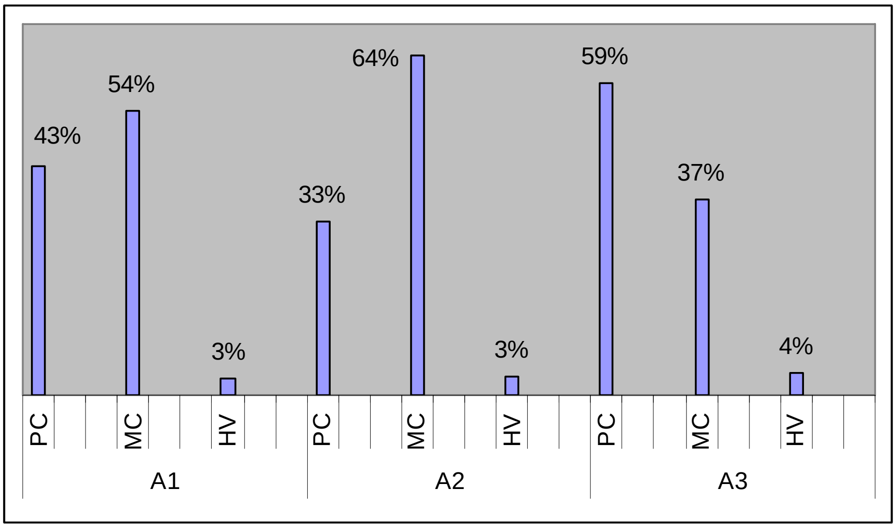

Figure 2 – Average percentage of traffic distribution

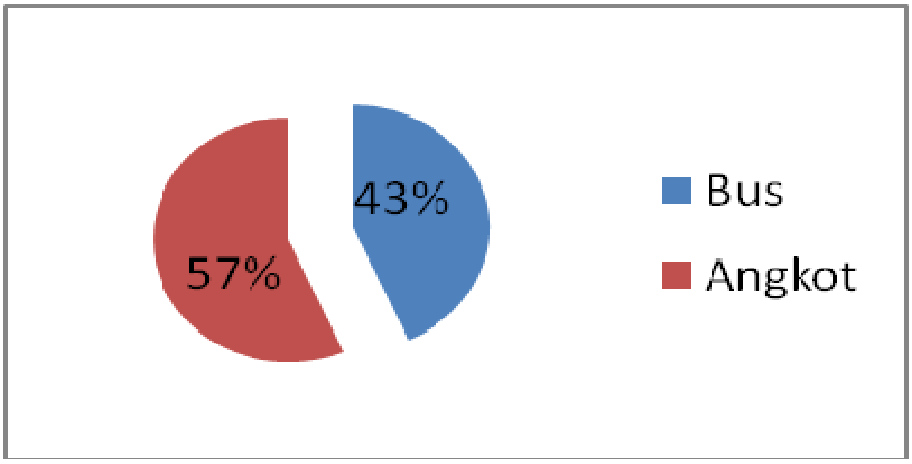

Figure 3 – Average percentage public transport composition

A study in modelling and analysing a signalised intersection was conducted by Yaldi and Yue (2006). It involved a signalised intersection located in Adelaide, South Australia. A comparison of CUBE Dynasim and aaSIDRA in modelling and analysing a signalised intersection was undertaken. Despite some minor differences, both methods generated nearly the same outputs as the real data.

Another study involving a signalised intersection located in Padang-Indonesia, generated some major differences in the outputs compared to the real data (Yaldi *et al*., 2007a; b). The study also used CUBE Dynasim as micro simulation and aaSIDRA as micro analytical modelling and analysis software. aaSIDRA generated the same outputs as real data, in this case traffic flow. CUBE Dynasim outputs have major differences compared to real data.

Some limitations are applied in this research on the purpose to focus on issues discussed before. They include, for example, the vulnerable road users; including non-motorised transport modes have been ignored. The adjacent minor junctions were also ignored. The transport modes are categorised into three categories, namely Passenger Car (PC), Heavy Vehicle (HV) and Motorcycles (MC). The study used Manual Kapasitas Jalan Indonesia (MKJI), the Indonesian Highway Capacity Manual. According to MKJI (1996), a motorcycle can be converted into passenger car unit by multiplying them with 0.2 while a passenger car-size public transport/minibus converted into heavy vehicles by multiplying them with 1.3. The conversions were undertaken before entering the data into both software packages.

2.2 Research findings

One of the aims of micro simulation modelling and analysis is to evaluate traffic movement during a definite period of time. The impact of every intervention such as public transport stopping, traffic signals and crossing pedestrians to the traffic flow can be investigated. The traffic pattern during certain periods of time can be reported.

Both CUBE Dynasim and aaSIDRA intersection models were developed after all necessary data have been collected. All required data used in both models are the same, including the traffic volume and compostion, intersection geometry and signal phases and timings. The model used in this study is the same as model used by Yaldi *et al*., (2007a; b). The difference is in the research reported here includes public transport and motorcycle data. Those data are modified into passenger car unit, updated and then used in this study. There are three bus stops included in the intersection model. One bus stop located on Bagindo Aziz Chan approach. There is also one bus stop on Bagindo Aziz Chan exit. Another one is on the Sudirman approach. There is no bus stop located on Agus Salim approach. The results of the modelling and analysis will be discussed below.

In CUBE Dynasim, the traffic flow is defined as an instant flow. The instant flow for each lane from a certain origin and destination can be collected by setting up data collector on the simulation objects. After running the model, the instant flow for each lane is generated by CUBE Dynasim. The proximity of the simulation outputs to the real data is determined by the number of simulation undertaken in the analysis. In this study, 30-time runs are used. CUBE Dynasim produces the simulation results in two types of statistical outputs which are tables and graphs.

Figure 4 illustrates the exiting traffic flow fluctuation at the intersection from each direction. Like other micro simulation analysis software, CUBE Dynasim can generate the output as small as one second interval. The output in this research is set to be reported for intervals of 15-minutes and one-hour. The simulation time is 60 minutes.

It can be seen that more motorists travelled to the western area than others. The lowest was to the southern area. This time series-volume illustrates a different figure compared to the real data (see Figure 5). The figure demonstrates that the highest exiting flow is on the Bagindo Aziz Chan approach or east approach.

However, the real data has the highest exiting flow on the Sudirman approach or west approach. CUBE Dynasim generated only 737 vehicles per hour or 14 per cent lower (see Table 1). In contrast, aaSIDRA calculates that the degree of saturation (X) of each lane on Bagindo Aziz Chan approach is much lower than one, or, the capacity is much higher than the demand (see Figure 6). Therefore, aaSIDRA could have resulted in outputs close to the real conditions of the intersection. Another study conducted by Yaldi *et al*. (2007a; b) has indicated that aaSIDRA generated closer output to the actual data than CUBE Dynasim.

The difference between CUBE Dynasim flow to the real data and aaSIDRA output is likely to be caused by the high number of public transport (PT) arrival rate with relatively high average stop time, the number and type of lane discipline, the attitudes of the local motorist on the road, public transport types, and motorcycle numbers.

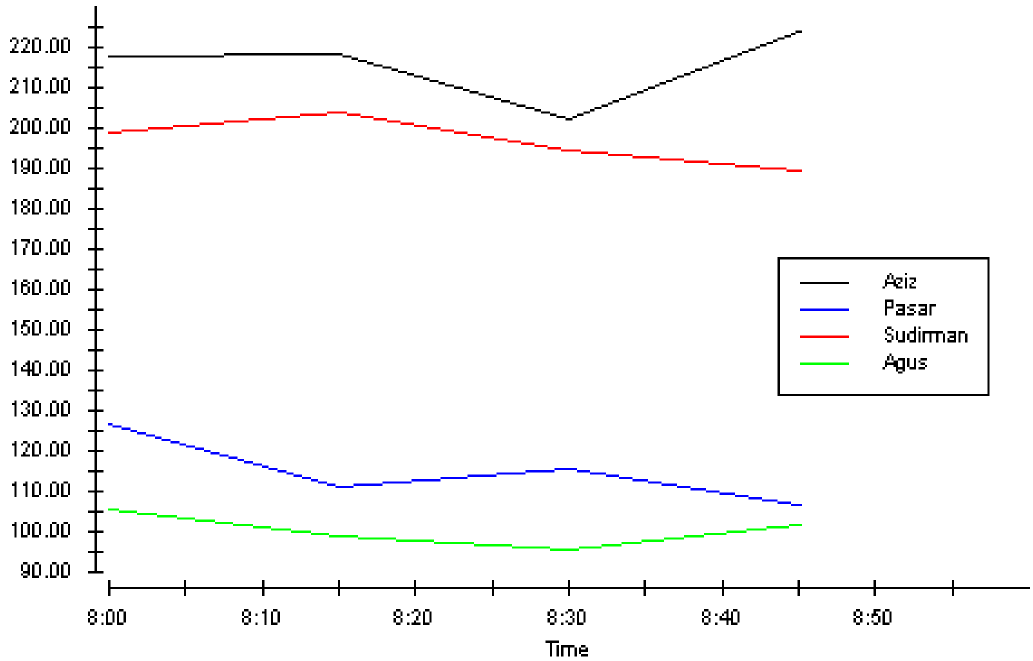

Figure 4 – CUBE Dynasim's exiting flow

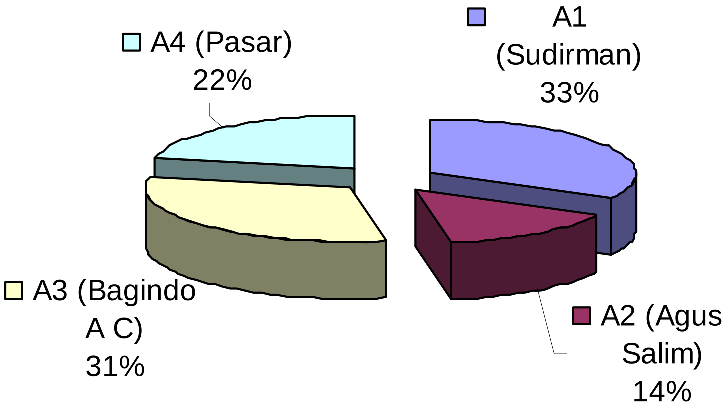

Figure 5 – Intersection real data of exiting flow

As micro analytical analysis software, aaSIDRA takes into account the impact of public transport stop frequencies only on the approaching lanes. Furthermore, it does not explicitly consider the stop time of public transport. From aaSIDRA analysis, it was found that the degree of saturation flows of all lanes at the intersection is less than 1 (see Figure 6). It means that the intersection still has spare capacity, or, the traffic volume is lower than the capacity of the intersection. Based on observations at the intersection, the traffic flow was fairly stable or match with the aaSIDRA outputs.

CUBE Dynasim is a micro simulation modelling and analysis software. It generates traffic movement at the intersection by generating two and three dimension of animations. The impact of public transport arrivals and stop times can be observed. For example, there is a long queue of public transports on the most left lane of Bagindo Aziz Chan approach as illustrated by Figure 7. The long queue is formed since the public transport stop time is higher as well as its arrival rate. It could reach up to 405 seconds (or equal to about 6.5 minutes for the stop time), while the arrival rate is 123. It is common for a public transport in the study area to stop for an extremely long or short time.

Table 1 – CUBE Dynasim lane flow, field data and the differences

	Traffic flow (vehicles/h)		
Lane category	*CUBE Dynasim*	*Field data*	*Difference*
Sudirman approach			
LT	367	363	1.1%
TH1	337	352	-4.3%
TH2	327	352	-7.1%
RT	94	93	1.1%
Total	*1130*	*1160*	*-2.6%*
Agus Salim approach			
LT	216	219	-1.4%
TH	79	81	-2.5%
RT	576	642	-10.3%
Total	*874*	*942*	*-7.2%*
Bagindo Aziz Chan approach			
LT	380	465	-18.3%
TH	300	335	-10.4%
RT	65	66	-1.5%
Total	*737*	*866*	*-14.9%*

Left Turn (LT), Through (TH), Right Turn (RT)

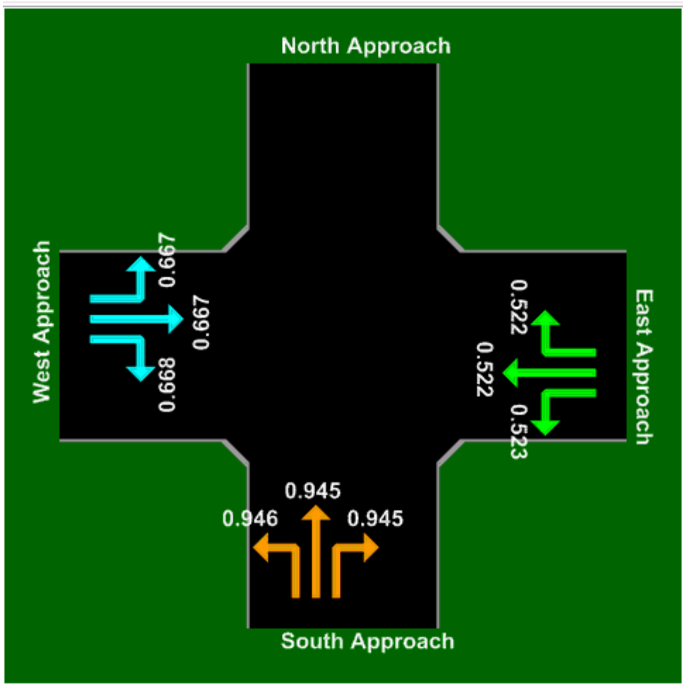

Figure 6 – Degree of saturation generated by aaSIDRA

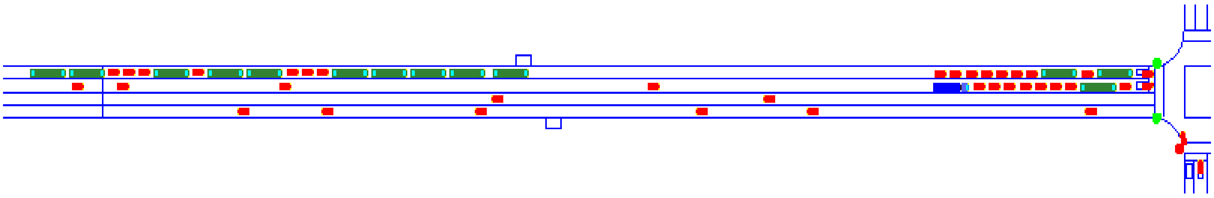

Figure 7 – PT queuing on left lane of Bagindo Aziz Chan approach

This could block the movement of other road users, including the other public transport vehicles behind and hence the traffic flow, particularly left turn and through vehicles, decreased. Besides, the available lanes on this approach are shared lanes. Therefore, some vehicles with destinations Pasar and Sudirman approaches are blocked. This situation could occur when there is a high number of public transport arrival and high stop time. Nonetheless, the vehicles behind the queuing public transport should change lanes quickly and proceed to their destinations as normally happened in the real situation.

A study conducted by Yaldi and Yue (2006) has demonstrated that both aaSIDRA and CUBE Dynasim generated approximately the same results to the real data investigated. That study was conducted in Adelaide, South Australia. In that study, the maximum stop time of PT was 44 seconds or less than one minute. In addition, there were only 8 PT arrivals and majority of lanes were not shared lanes. Therefore, it can be assumed that, high number of arrivals and maximum stop time could reduce the intersection capacity of CUBE Dynasim model.

To investigate this case, the CUBE Dynasim model was modified by maintaining the number of PT arrivals but reducing the stop time in increments of 10 per cent. The purpose is simply to seek the impact of various stop time to the approach and exiting flow of Bagindo Aziz Chan and Sudirman approach. The aaSIDRA model was not modified, since it only considers the frequency of bus stops.

Figures 7, 8 and 9 present the traffic flows on Sudirman, Agus Salim and Bagindo Aziz Chan approaches respectively. It can be seen that the traffic flow slightly fluctuated; however, the variation is relatively small, increasing by about one per cent. Hence, the length of stop time could affect the traffic flow in CUBE Dynasim model only; however, it is not significant.

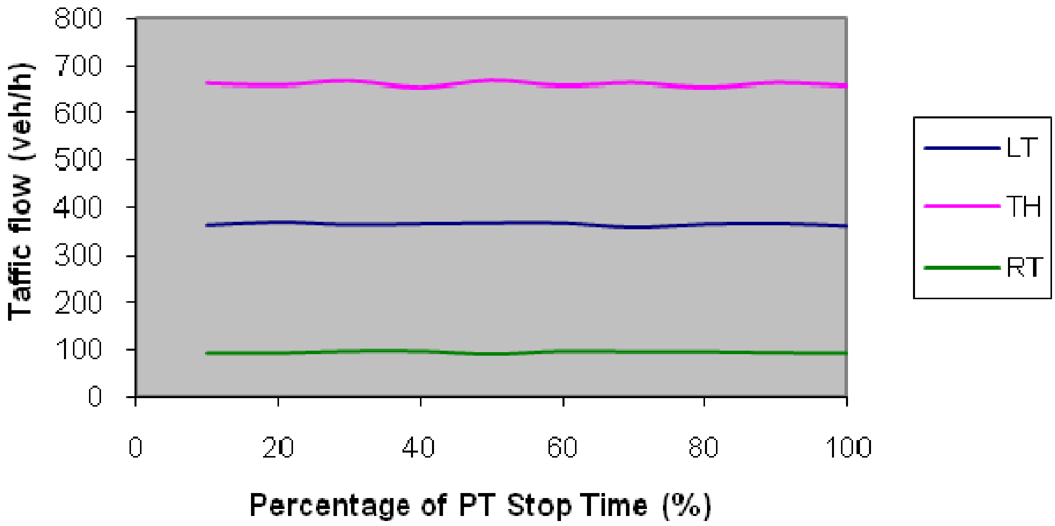

Figure 8 – Traffic flow on Sudirman approach with PT stop time reduction

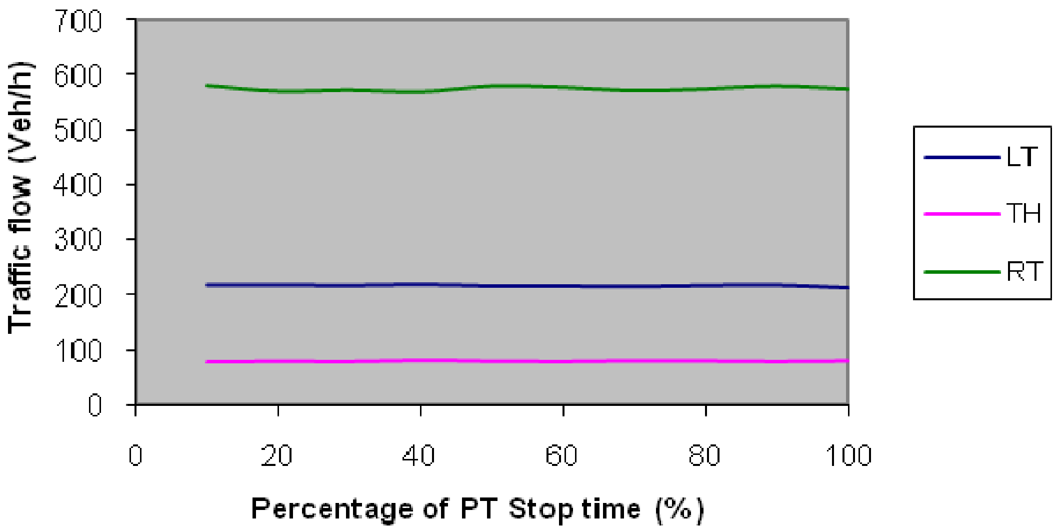

Figure 9 – Traffic flow on Agus Salim approach with PT stop time reduction

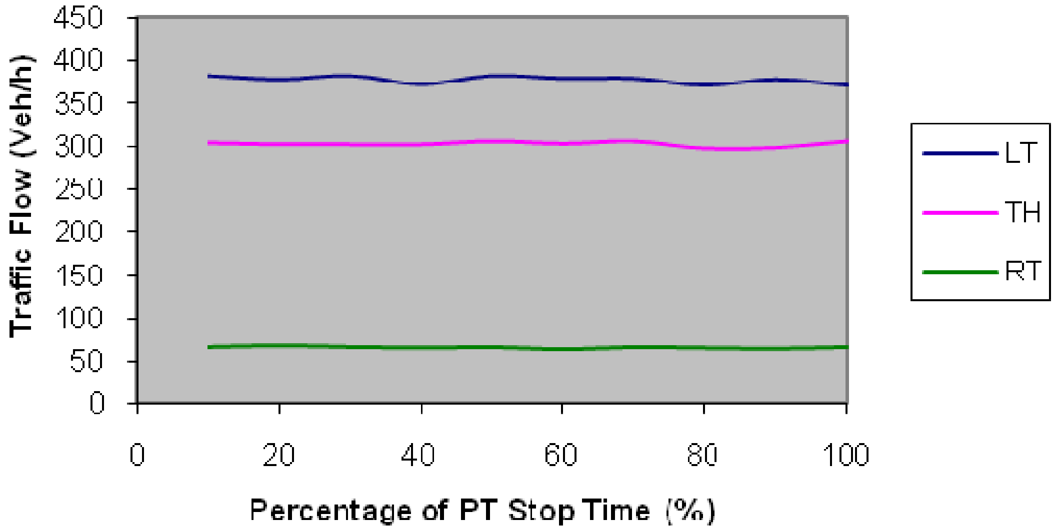

Figure 10 – Traffic flow on Bagindo Aziz Chan approach with PT stop time reduction

Another attempt to investigate this case is by reducing the PT arrival rates on all approaches. The PT arrival rate is set to be 30, 40, 50, 60, 70, 80, 90 and 100 per cent of the real data. The modification is applied in both aaSIDRA and CUBE Dynasim models. The PT stop time remains the same as the original data. The purpose is to investigate the proximity of CUBE Dynasim results to the real data and aaSIDRA results. Furthermore, the investigation will highlight the Bagindo Aziz Chan and Sudirman approaches only, particularly the left and through lanes of Bagindo Aziz Chan approach and through lane of Sudirman approach. Special treatment will be undertaken on the Agus Salim approach. It is due to the differences between CUBE Dynasim flow and the real data are predominantly on those lanes. The results are depicted by Figures 10, 11 and 12.

Figures 11 and 12 demonstrate that CUBE Dynasim generates almost the same lane flow on Bagindo Aziz Chan approach than before even though the PT arrival is reduced. The line on the graph tends to be flat and to intersect with the real data when the PT arrival reduction is 100 per cent, or, there is no PT arrival in the model. Meanwhile, aaSIDRA generated the lane capacity which increases sharply when the PT arrival is reduced. It occurs on both left and through lanes of Bagindo Aziz Chan approach as well as on through lane of Sudirman approach (see Figures 10, 11 and 12). Thus, it can be assumed that, the higher the PT arrival rate, the bigger the deviation of the traffic flow generated by CUBE Dynasim to the real data and aaSIDRA outputs. CUBE Dynasim model would generate the same lane flow to the real data when the PT arrival rate is zero.

The last attempt is by modifying the CUBE Dynasim once more. As discussed above, the CUBE Dynasim was modified on the basis of stop time and PT arrival by 10 per cent incrementally. There were no significant changes related to the traffic flow on all approaches. Hence, it could be assumed that PT stop time and arrival rate could reduce the approach flow significantly. CUBE Dynasim generated the same approach flow as real data when PT was removed from the model.

However, the Sudirman approach flow tends to increase until the PT stop time equals to 50 per cent of the original data. It was 1126 vehicles per hour. In the mean time, CUBE Dynasim also generated 1126 vehicles per hour on the Sudirman approach when the PT arrival was reduced 30 per cent and it is the same as the real data. It may relate to the type and number of lane available on this approach. The Left and right lanes are shared lanes. In addition, the right lane is also a short lane. The competition in using road space is higher. Each road users would compete in a limited space and time to reach their destination. Therefore, it is possible for CUBE Dynasim to generate the same Sudirman approach flow as the real data when the PT stop time is reduced by 50 per cent and there is only 30 per cent of PT arrival in the model as there would be lower number of vehicles in the network. Besides, the PT would stop to serve the passengers is a shorter time and hence it could cross the intersection quicker and reduce the blockages. However, it remained constant on other approach. Even though there was an increasing flow on the Bagindo Aziz Chan approach, it was still below the real data. The increase was ended when the PT stop time reduction reached 50 per cent.

Based on these findings, the CUBE Dynasim is modified for a third time. The PT stop time is taken as 50 per cent of the original data while the PT arrival is reduced by 10 per cent incrementally. The purpose is to investigate the traffic flow generated by CUBE Dynasim when the PT stop equals to 50 per cent of the real data. It also sees what would happen to the traffic flow at the intersection, particularly on Sudirman approach when the PT stop time is only 50 per cent of the real data with a various PT arrival rates. It is expected that shorter stop time could enhance the capacity. Further, the point at which the approach flow reaches the same level as the real data could be found. The results are given in Figures 13, 14 and 15.

The traffic flows on all approaches were seen to be fluctuating in the CUBE Dynasim model. There is an increasing flow on the Sudirman approach, however it tends to decrease when the PT arrival is about 55 per cent of the real data as shown by Figure 14. On the other hand, the approach flow on the other approaches remains the same as before as illustrated by Figure 15 and Figure 16.

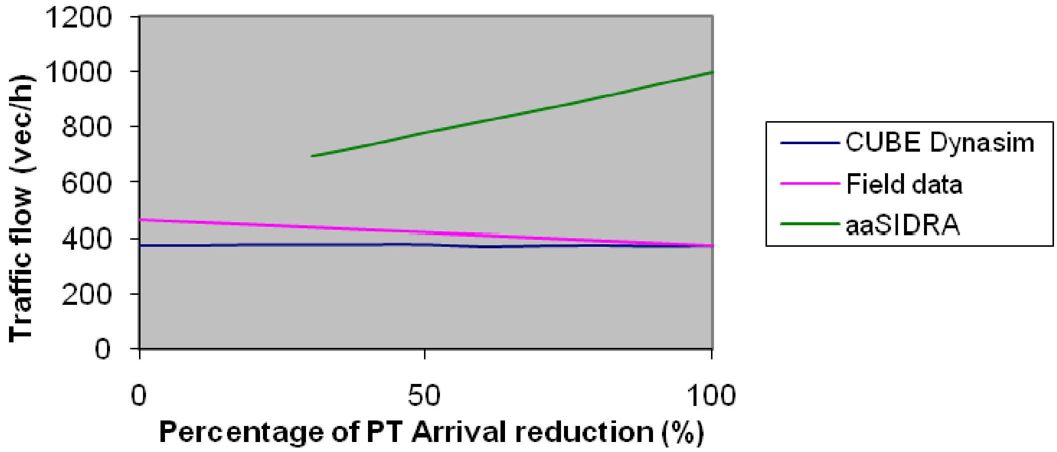

Figure 11 – Bagindo Aziz Chan left turn flow with various PT arrival rate reductions

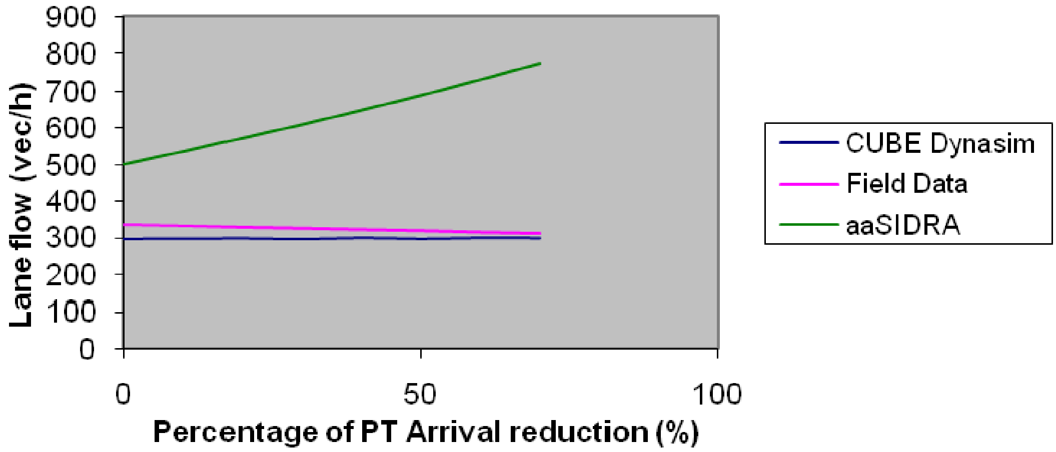

Figure 12 – Bagindo Aziz Chan through lane flow with various PT arrival rate reductions

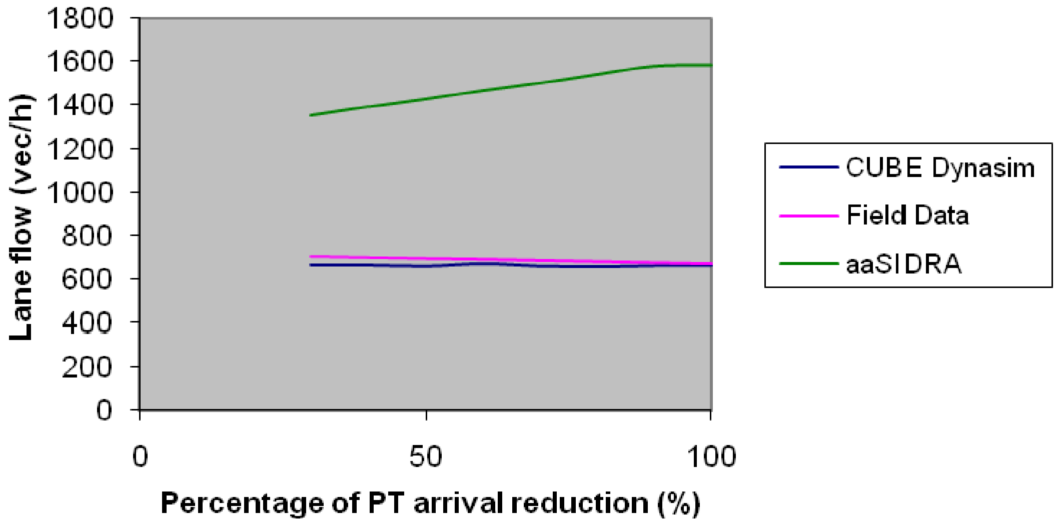

Figure 13 – Sudirman through lane flow with various PT arrival rate reductions

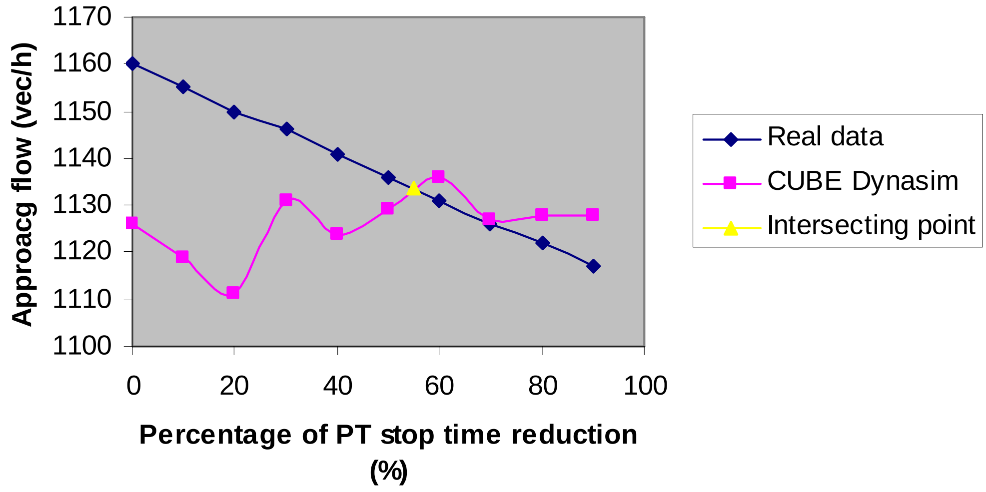

Figure 14 – Sudirman approach flow with 50% reduction of PT arrival rate

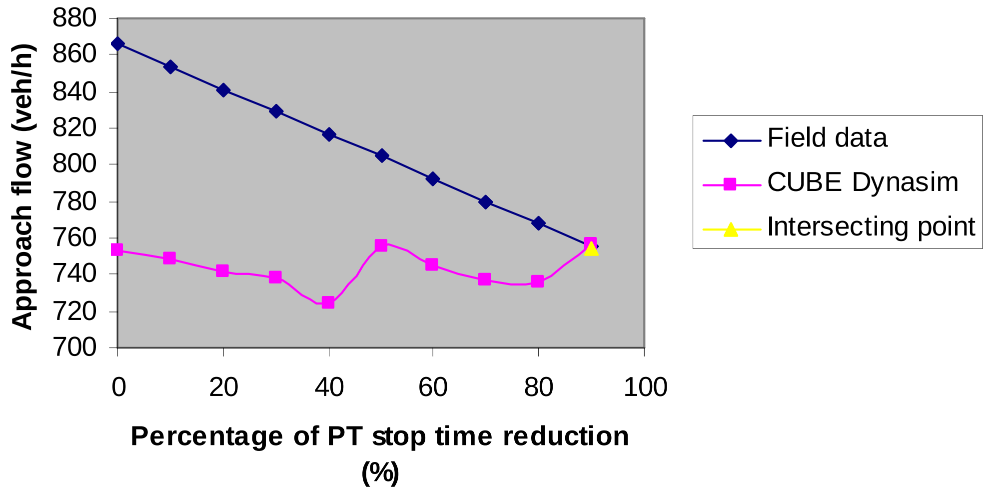

Figure 15 – Bagindo Aziz Chan approach flow with 50% reduction of PT arrival rate

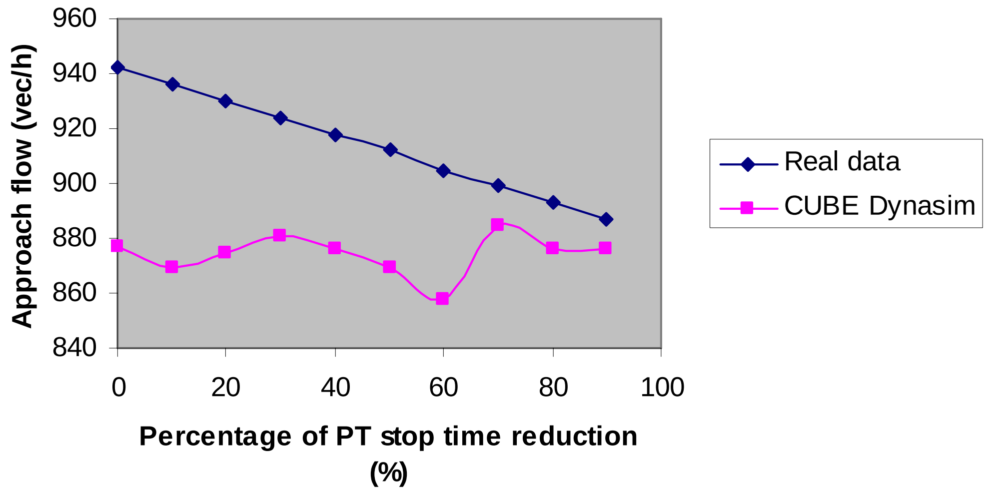

Figure 16 – Agus Salim approach flow with 50% reduction of PT arrival rate

Based on the first, second and the third modifications, the CUBE Dynasim could not generate the approach flow at the same number of the real data due to several factors, specifically: the high stop time and PT arrival rates. Besides, the majority of lanes are shared lanes. As micro simulation software, CUBE Dynasim takes into account all events occurred during the simulation. For example, the motorists following behind a public transport vehicle would change lanes quickly. Then, it would overtake that public transport vehicle when they perceive the public transport vehicle would stop as happened in the real situation.

However, the acceleration and the reaction time factors embedded in the CUBE Dynasim software seems lower compared to the real local motorists' aggressiveness. As discussed above, CUBE Dynasim would generate the same traffic flow as the real data when the PT arrival rate is zero. It began to generate lower traffic flow when the stop time reaches 50 per cent and the public transport arrival rate equals to 30 per cent of the original data. In other word, the aggressiveness of the motorists in CUBE Dynasim model is likely to be lower than in real life, particularly when it compared with the local motorists' behaviour.

Thus, it generated lesser flow when there were more interruptions in the system. With those percentages, the motorists still could travel at the intersection which is the same as the real situation. Yet, when the stop time is higher than 50 per cent and the PT arrival rate is more than 30 per cent of the original data, CUBE Dynasim produced lesser traffic flow compared to the real one. Therefore, the differences could be caused by some simulation factors such as the reaction time, acceleration and deceleration and driver aggressiveness factors built in the CUBE Dynasim software.

2.3 Alternative approaches

As described in section 2.1, public transport has two types based on vehicle size, namely bus and mini bus (angkot) that has the same size as a passenger car. This type of public transport is not likely to exist in developed countries. The percentage of minibuses which is higher than bus with a margin of 14 per cent could have dominant contribution to the traffic condition. All minibuses turn left to the Pasar approach as the final destination.

Due to software limitation and simplification of the model, a minibus was converted to a bus-size according to the local code by using a converting factor of 1.3. (Yaldi *et al*., 2007a).

In order to improve the outputs of CUBE Dynasim, another approach is proposed called as scenario 1. The ratio of minibus and bus capacity in carrying passengers is used instead of 1.3. During peak time, one bus can carry up to 35 passengers. It is common for a bus to be overloaded during peak time in the study area.

Since the maximum number of passengers that a minibus can carry is 14 passengers, the ratio factor is 2.5 (35/14). The modification is applied on Bagindo Aziz Chan approach as minibuses and buses only serve that approach. Thus, the number of public transport in the simulation model is updated. In additions, another two scenarios are applied to the simulation.

Motorcycles are an important transport mode in Indonesia, perhaps for other developing countries too. Its percentage could be much higher than other modes of transport. Figure 2 depicts the percentage of motorcycles and other transport modes in the study area. Motorcycle is usually converted to passenger car based on local code by using a factor of 0.2. In addition, CUBE Dynasim does not have a facility to model motorcycle. The modification of motorcycle converting factor is called Scenario 2. A value of 0.1 is used instead of 0.2 due to the characteristic of the local riders which is usually very aggressive.

Unlike other motorised modes, motorcycles can stand not only in between two consecutive cars, but also beside two parallel cars. Based on the observation at the intersection, with the space required by a car on a queue, six motorcycles can stand there, while another four stand in the left and right side of two parallel cars. Therefore, it is assumed that one passenger car is approximately equal to ten motorcycles. This modification is expected to improve the results on all approaches. The last scenario is Scenario 3, a combination of Scenario 1 and Scenario 2. The total impacts the modification 1 and 2 toward all approaches can be seen through the last scenario.

The result of scenario 1, 2 and 3 are reported in Tables 2, 3 and 4. According to Table 2, the results for other approaches remain the same with some minor changes in the lane flow. However, the total flow on the Bagindo Aziz Chan approach is more than 4 per cent higher compared to before the modification. The improvement is mainly contributed by the left lane. It is likely contributed by minibus as they use it before turning left to Pasar.

The second modification was expected to improve the simulation results as the amount of traffic is reduced. In contrast, it generated strange figures. The percentage of differences between total flow of real data and CUBE Dynasim outputs were slightly higher than before the modification. It is less than 2 per cent for Agus Salim approach, while for approaches is below 1 per cent. The last scenario shows the same pattern as the second one. The percentage difference between real data and simulation results is the same for Sudirman and Agus Salim approach. It is slightly higher than for Bagindo Aziz Chan approach.

3 Conclusions and recommendations

3.1 Conclusions

Despite its successful use in developed countries, micro simulation models seem to be not as successful as micro analytical models when applied in developing counties. A case study conducted in Padang-Indonesia mainly involving the use of CUBE Dynasim indicates that some local features could reduce the accuracy of simulation performance. The difference between real data and the simulation outputs show quite high percentage of differences. It is presumed that the differences are due to several factors, namely the conditions of local public transport including high arrival rate and stop time, the existence of paratransit/minibus, and high number of motorcycles.

Some modifications involving the PT arrival rate and stop time, and the method of converting a paratransit to a bus-sized and a motorcycle to a passenger car unit have been undertaken. The modifications are aimed at minimizing the differences between simulation model outputs toward the actual data. Therefore, modifications are only undertaken on CUBE Dynasim model. Despite some minor improvement in the simulation model outputs, major differences still exists. Modification in the PT arrival rate and stop time, and their combinations only slightly improved the simulation output. Next modification is the method of paratransit size conversion to the regular public transport size (scenario 1) and the conversion method of the motorcycle to passenger car (scenario 2) while the last attempt is a combination of scenario 1 and 2. Scenario one gave better results than other scenarios, however, the improvement was minor only.

3.2 Recommendations

Further study should involve the use of different micro simulation software that has better facility or tools in modelling public transport, motorcycle and road users' aggressiveness such as PARAMICS or AIMSUN. Another approach in dealing with local features, such as public transport and transport mode conditions could improve the quality of simulation model.

Table 2 – CUBE Dynasim lane flow, field data and the differences with scenario 1

Lane category	*Traffic flow (veh/h)* *CUBE Dynasim*	*Field data*	*Difference*	*Lane category*	*Traffic flow (veh/h)* *CUBE Dynasim*	*Field data*	*Difference*
Sudirman approach				**Bagindo Aziz Chan approach**			
LT	364	363	0.3%	LT	373	422	-11.6%
TH1	338	352	-4.0%	TH	298	334	-10. 8%
TH2	329	352	-6.5%	RT	64	66	-3.0%
RT	93	93	0.0%	*Total*	*735*	*823*	*-10.7%*
Total	*1124*	*1160*	*-3.1%*				
Agus Salim approach							
LT	215	219	-1.8%				
TH	80	81	-1.2%				
RT	577	642	-10.1%				
Total	*871*	*942*	*-7.4%*				

Table 3 – CUBE Dynasim lane flow, field data and the differences with scenario 2

Lane category	*Traffic flow (veh/h)* *CUBE Dynasim*	*Field data*	*Difference*	*Lane category*	*Traffic flow (veh/h)* *CUBE Dynasim*	*Field data*	*Difference*
Sudirman approach				**Bagindo Aziz Chan approach**			
LT	344	338	1.7%	LT	367	457	-19.7%
TH1	308	318	-3.1%	TH	267	303	-11.9%
TH2	283	317	-10.6%	RT	58	59	-1.7%
RT	79	78	1.3%	*Total*	*692*	*819*	*-15.5%*
Total	*1014*	*1051*	*-3.5%*				
Agus Salim approach							
LT	180	184	-2.0%				
TH	63	64	-1.6%				
RT	500	571	-12.5%				
Total	743	819	-9.3%				

Table 4 – CUBE Dynasim lane flow, field data and the differences with scenario 3

Lane category	*Traffic flow (veh/h)* *CUBE Dynasim*	*Field data*	*Difference*	*Lane category*	*Traffic flow (veh/h)* *CUBE Dynasim*	*Field data*	*Difference*
Sudirman approach				**Bagindo Aziz Chan approach**			
LT	344	338	1.7%	LT	367	414	-11.5%
TH1	308	318	-3.1%	TH	267	303	-12.0%
TH2	283	317	-10.6%	RT	58	59	-2.0%
RT	79	78	1.4%	*Total*	*691*	*776*	*-11.0%*
Total	*1014*	*1051*	*-3.5%*				
Agus Salim approach							
LT	180	184	-2.0%				
TH	63	64	-1.6%				
RT	500	571	-12.5%				
Total	*743*	*819*	*-9.3%*				

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