The use of CUBE Dynasim and aaSIDRA in analyzing a signalized intersection

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1 Introduction

The use of microscopic traffic simulation plays major roles in the analysis and evaluation of transport systems. It is due to its ability to model and analyze a transport system based on each vehicle properties and operations. It can model the interaction between vehicles in the systems and between vehicles and the infrastructure as well. Therefore, microscopic traffic simulators can be considered as the best tool in analyzing transport operation (Barcelo et al. 2000). It can reproduce a significant level of accuracy and capture the interactive impacts among transport elements in a system. Besides, it can generate outputs which show the variations of particular transport system parameter.

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

However, the capability of traffic simulator to accommodate traffic planners/engineers needs in modeling and analyzing a transport system must be equipped with its ability to generate remarkable, accurate and precise outputs. Furthermore, the software must have a tool that can be used to input the data to calibrate the model based on local conditions. Dowling et al. (2004) explained that calibration process is important since the appropriate model parameters can be selected according to the local traffic operation conditions. Some of data which is required to be validated are, for examples, traffic volumes, average travel speeds, travel times and average delays. In addition, the driver reaction time toward its traffic environment, kinetics factors such as acceleration and deceleration, and driver aggressiveness could reduce the level of accuracy of the model, and hence it may require to be calibrated too.

The main aim of this paper is to compare aaSIDRA and CUBE Dynasim in analyzing a signalized intersection. 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 multimodal traffic simulator software and able to import file or data from CAD, GIS and other databases as well as other traffic analysis programs. This micro simulation software also has some tools to calibrate or adjust the traffic parameters based on the local traffic data.

On the other hand, aaSIDRA is micro analytical traffic software and has been used in more than 80 countries, predominantly in the USA and Australia. It has the ability to analyze an intersection with up to 8 legs with options of two-way road, 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 count the impact of on-street parking and bus stopping on the system, however, it is only for on-street parking and bus stopping which is located on the approach lane. Therefore, this could be a weaknesses of aaSIDRA compared to CUBE Dynasim.

To undertake this minor research, an intersection located in Adelaide CBD was chosen. It is a four-leg signalized intersection and has three phases. The data are quoted from Transport System Center, UniSA. Some minor surveys were undertaken, for instances, signal timing, bus headways and pedestrian number surveys. Then, a comparison has been made addressing the ability of each software in modeling the intersection as well as the output generated by the two software. The output comparison will focus on the traffic flow, travel speed and queue.

The layout of the intersection can be seen in figure 1. It is the intersection between Pulteney St and South Tce. It has four legs and currently operates under “Masterlink” mode. It is located on the South of Adelaide CBD. The intersection has vehicle detectors embedded in each lane and operated by Sydney Coordinated Adaptive Traffic System (SCATS). The intersection has a bicycle lane on the Pulteney St (South approach); however, it is eliminated in the modeling and analysis processes. Then, every approach, except the North approach, has one shared lane with various lengths. The intersection is also equipped with pedestrian crossing buttons on all legs. It was selected since the majority of the input data required for modeling has been already collected by SCATS. Some minor traffic surveys will still need to be conducted, for instance, an on-street parking survey as well as public transport headways or arrival frequency. Meanwhile, the optimum cycle time was obtained by using aaSIDRA. The result is then used in both aaSIDRA and CUBE Dynasim models. Hence, the signal plan for both models is identical.

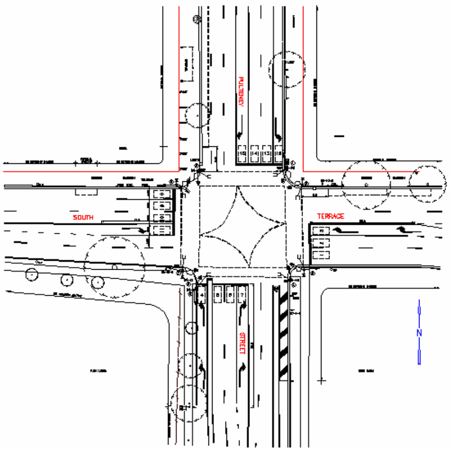


Figure 1 The intersection layout

2 Output comparison

2.1 Traffic flow

In CUBE Dynasim, the traffic flow is named as instant flow. The instant flow for each lane from a certain origin and destination can be collected by setting up the 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, 10-time runs are used. CUBE Dynasim produces the simulation results in two kinds of statistical outputs which are tables and graphs. Figure 2 illustrates the exiting traffic flow at the intersection for each direction. Like other micro simulation traffic 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 an interval of 900 seconds or 15-minute interval and one-hour interval. The simulation time is 60 minutes.

It can be seen from figure 2 that the highest number of exiting traffic flow is on the North approach or the traffic which is going to inside the city (the first line from the top on the graph). It is followed by West, East and South respectively. This result is match with the real situation on the site where in morning peak there is more traffic approaching the city compared to other directions. Furthermore, the graph shows that the traffic flow trend for every 15 minutes tends to fluctuate which micro analytical traffic software unable to display. In the first 15-minute period, number of vehicles to North and South increase then it decreases in the next period before increasing again. Then, it seems that the traffic flow tends to level up again in the last 15-minute period. In the mean time, the traffic flow to East and West shows the opposite trend. The statistical output in form of table for exiting traffic flow outputs is reported in table 1.

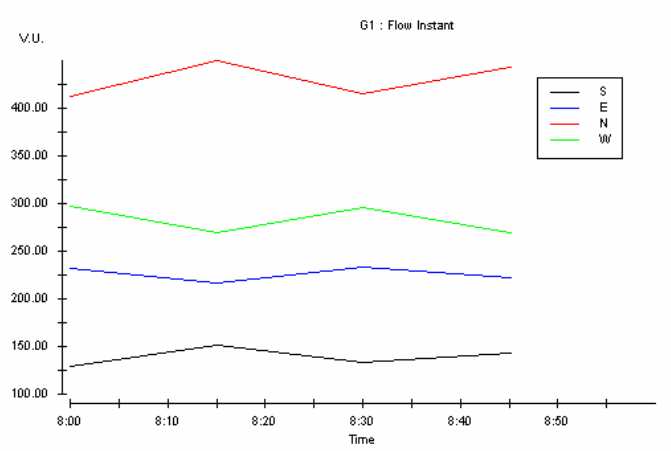


Figure 2 CUBE Dynasim exiting demand flow profile

Table 1 CUBE Dynasim traffic flow statistics output for each approach (15-minute interval)

Statistical parameter	Output			
	East (E)	North (N)	South (S)	West (W)
Mean	227	430	140	282
Standard deviation	14.89	19.10	17.05	19.72
Confidence interval	4.01	5.15	4.60	5.32
Maximum	258	465	179	333
Minimum	199	390	105	233
Percentile 25	216	417	127	271
Percentile 50	227	428	139	281
Percentile 75	240	448	151	296

Table 2 CUBE Dynasim traffic flow output for each approach (15-minute interval)

Approach	Volume (veh/15')			
	15'	30'	45'	60'
East (E)	234	220	234	221
North (N)	414	442	419	447
South (S)	128	156	127	148
West (W)	295	269	293	272

Table 3 CUBE Dynasim approach and exit flow output for each approach (60-minute interval)

	Flow (veh/h)			
	E	N	S	W
Approaching flow	1124	778	1552	868
Exiting flow	909	1704	565	1129

CUBE Dynasim released different number of vehicle in every 15-minute interval as can be seen in table 2. Meanwhile, aaSIDRA generates approach, circulating and exiting flows as shown by figure 3. Compared to the same outputs produces by CUBE Dynasim as reported in table 3, the difference is almost insignificant. For example, aaSIDRA generates the approach flow for 60-minutes period on the north approach as 790 vehicles and CUBE Dynasim's is 778 vehicles. Then, the exiting flow on the west approach is 1140 vehicles given by aaSIDRA. For this approach, CUBE Dynasim calculated the exiting as 1129 vehicles.

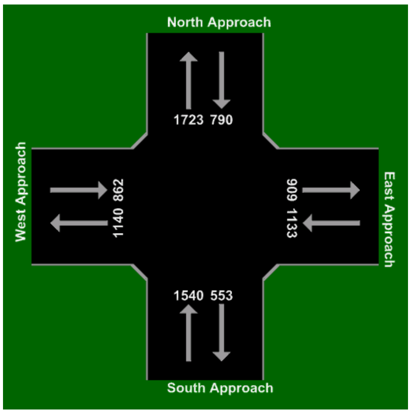


Figure 3 aaSIDRA approaching, circulating and exiting flow

aaSIDRA demand flow lane by lane and its comparison with CUBE Dynasim is shown in table 4. Data on E3 row for aaSIDRA column is including the excess flow from back of right turn lane (E4). Its number is 78 vehicles. The differences vary and the highest one is in the east approach right turn lane (E4). CUBE Dynasim releases more vehicles compared to aaSIDRA. It would cause CUBE Dynasim has a shorter queue on that lane compared to aaSIDRA model. Moreover, the difference of total approaching and exiting flow for each lane between aaSIDRA and CUBE Dynasim is reported in table 5 and 6. The highest difference of approaching flow, for example, is 4.05 percent on north approach while the lowest is 0.5 percent on south approach. Then, it can be seen that CUBE Dynasim as a micro simulation traffic modeling and analysis software released less vehicles than aaSIDRA. Then, it can be assumed that aaSIDRA as micro analytical traffic modeling and analysis software will generate higher lane capacity than CUBE Dynasim.

Table 4 The differences of lane by lane approaching traffic flow generated by aaSIDRA and CUBE Dynasim

Approach number	Volume (v/h)		Difference (%)
	aaSIDRA	CUBE Dynasim	
E1	5	4	20
E2	474	528	-11.39
E3	482*	347	28.00
E4	173	246	-42.19
N12	227	233	-2.6
N13	243	275	-13
N14	243	202	16.9
N15	77	68	11.7
S4	190	190	0
S5	638	660	-3.4
S6	638	616	3.45
S7	87	88	-1.14
W8	204	205	-0.49
W9	298	302	-1.3
W10	298	297	0.33
W11	63	63	0
Total	4340	4324	0.37

Table 5 The differences of approaching traffic flow generated by CUBE Dynasim and aaSIDRA data for 60-minute interval

	Flow (veh/h)			
	E	N	S	W
CUBE Dynasim	1143	758	1548	847
aaSIDRA	1133	790	1540	862
Difference	-0.9	+4.05	-0.5	1.7

Table 6 The differences of exiting traffic flow generated by CUBE Dynasim and aaSIDRA data for 60-minute interval

	Flow (veh/h)			
	E	N	S	W
CUBE Dynasim	904.9	1719.30	558	1133.10
aaSIDRA	909	1723	553	1140
Difference	+0.45	+0.21	-0.9	+0.6

2. 2 Travel speed

There are two kinds of travel speed output generated by CUBE Dynasim. Those are the maximum and the average speed. To collect travel speed output, data collector is installed in every lane in each approach as shown by figure 4. The Origin and destination for each vehicle's traveling on the model together with the data collector numbering and uses is given in table 7. One of the advantages of CUBE Dynasim is that the travel speed profile can be seen within certain interval, for example 15-minute interval as reported on table 8 and 9. Further, the travel speed graph is divided into two groups. The first group consists of south and north approaches and the second group comprises east and west approach. The aim of this grouping is to simplify the graph so that the travel speed for each lane can be seen clearly.

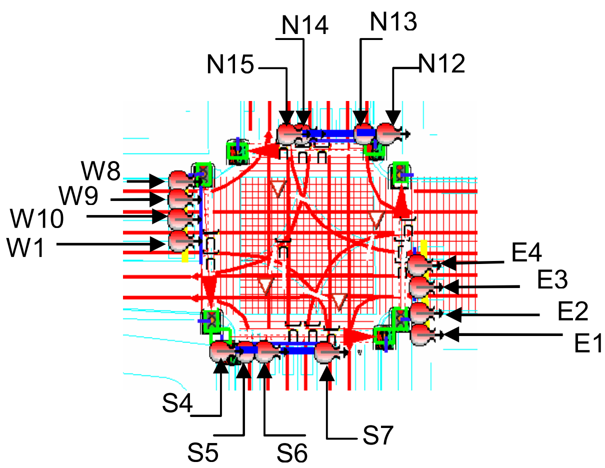
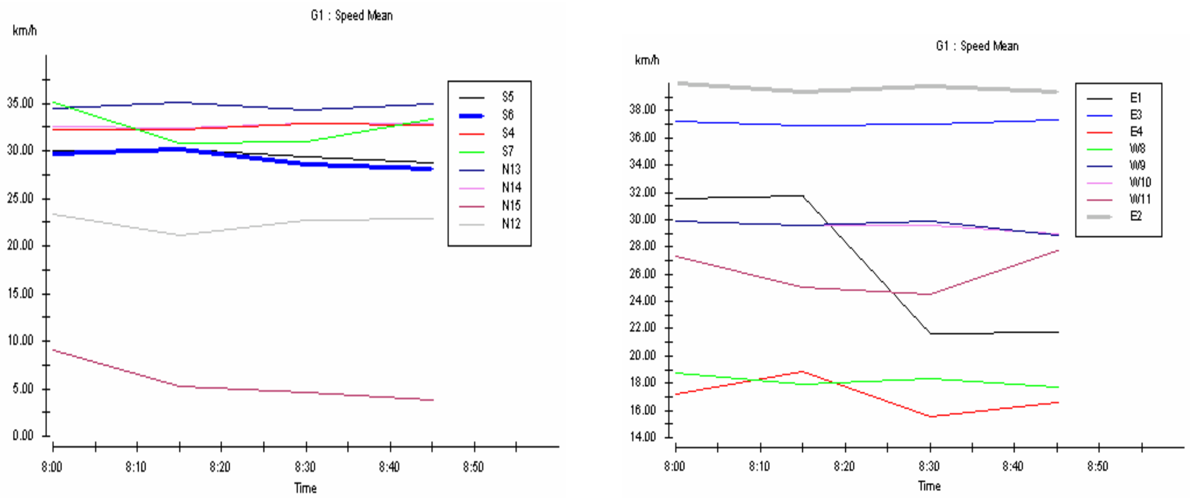


Figure 4 Data collector location for measuring travel speed

The average travel speed during the simulation for each lane in the south and north approach is displayed in figure 5(a). The mean travel speed for most lanes is above 30 km/h except right and left turn lane on the north approach. There is a bus stop on left turn lane of the north approach which might reduce the travel speed along that lane. Meanwhile, since there are a high number of vehicles approaching the city from south approach in the morning peak period, the vehicle whose destination is west must wait an acceptable gap so that it can make a right turn safely. This will cause the vehicle on the right turn lane to wait and queue and reduce their speed when traveling on this lane.

Meanwhile, the average travel speed on right turn lane of east approach is lower than average travel speed of other lanes in the same approach as can be seen in figure 5(b). It could be caused by the traffic and road condition as well as the time allocated on each phase. This right turn lane is a short lane and the length is 25 m. it can be occupied by approximately 4 to 5 passenger cars. When it is fully occupied, the vehicle which is going to the city must queue on the through lanes and it is often blocked behind the vehicles on the through lane. Therefore, the average travel speed is drop since the vehicle cannot move even though the signal is green.



(a) (b)

Figure 5 **CUBE Dynasim average travel speed profile on (a) north and south; and (b) west and east approach**

Table 7 **Data collector numbering and uses**

Data collector number	use			
	Flow		Speed	
	O	D	O	D
E1	E	S	E1	S
E2	E	W	E2	W
E3	E	W	E3	W
E4	E	N	E4	N
N12	N	E	N12	E
N13	N	S	N13	S
N14	N	S	N14	S
N15	N	W	N15	W
S4	S	W	S4	W
S5	S	N	S5	N
S6	S	N	S6	N
S7	S	E	S7	E
W8	W	N	W8	N
W9	W	E	W9	E
W10	W	E	W10	E
W11	W	S	W11	S

Table 8 CUBE Dynasim maximum travel speed profile output on each approach

Lane number	Maximum travel speed (km/h)			
	15’	30’	45’	60’
E1	32.29	33.68	30.65	36.22
E2	57.53	57.76	57.59	57.24
E3	58.08	57.70	57.93	57.47
E4	51.60	54.71	53.81	53.69
N12	46.80	47.64	47.08	48.76
N13	48.81	48.53	48.76	48.42
N14	48.91	48.31	48.94	48.34
N15	22.26	15.32	9.24	12.56
S4	57.07	57.26	57.22	56.80
S5	56.13	55.65	54.65	55.24
S6	56.29	56.37	55.36	55.44
S7	54.07	55.35	52.20	55.75
W8	47.05	47.54	47.35	46.90
W9	47.88	46.69	47.20	47.73
W10	49.21	48.77	48.86	48.25
W11	44.40	43.33	44.03	41.44

Table 9 CUBE Dynasim mean travel speed profile output on each approach

Lane number	Mean travel speed (km/h)			
	15’	30’	45’	60’
E1	31.55	32.84	26.90	34.62
E2	39.98	40.70	39.60	40.64
E3	36.69	38.37	37.14	37.47
E4	16.87	18.60	16.45	14.90
N12	24.48	21.98	24.32	22.57
N13	34.81	34.77	33.64	34.64
N14	33.78	33.05	33.51	32.37
N15	8.85	4.77	2.25	3.50
S4	33.06	31.06	31.90	31.25
S5	30.70	29.75	29.24	29.34
S6	30.45	28.8	28.55	28.84
S7	29.89	33.06	30.79	30.87
W8	18.30	19.43	17.06	18.11
W9	29.15	28.79	28.76	28.81
W10	29.98	29.94	29.19	29.11
W11	26.75	25.87	22.73	26.27

The average travel speed generates by aaSIDRA is given on figure 7 while table 10 shows the average speed on the intersection produced by CUBE Dynasim. Lane by lane maximum and average travel speed generated by CUBE Dynasim are reported on table 10 and 11.

Table 10 CUBE Dynasim travel speed profile output for each lane (60-minute interval)

Lane number	Maximum Speed (k/h)	Lane number	Maximum Speed (k/h)
E1	51.07	S4	58.51
E2	58.80	S5	57.46
E3	58.83	S6	57.49
E4	56.82	S7	57.38
N12	49.45	W8	48.97
N13	49.69	W9	48.86
N14	49.80	W10	49.98
N15	28.43	W11	46.22

Table 11 CUBE Dynasim average travel speed output for each lane (60-minute interval)

Lane number	Average speed (km/h)	Lane number	Average speed (km/h)
E1	40.83	S4	31.76
E2	40.20	S5	29.69
E3	37.37	S6	29.09
E4	16.41	S7	31.01
N12	23.12	W8	18.08
N13	34.47	W9	28.86
N14	32.90	W10	29.54
N15	4.71	W11	24.98

All of speeds counted by CUBE Dynasim, except right turn lanes of north and east approach, are nearly the same with aaSIDRA results (see table 10 and 11). Because the differences between travel speeds on right turn lanes of north and east approach are big, special treatment has been attempted.

To investigate this case, traffic demand in aaSIDRA model on left and through lanes of south approach is modified. For example, number of vehicles approaching from left and through lanes resulted from CUBE Dynasim is 190 and 1276 v/h respectively while from aaSIDRA is 185 and 1268 v/h. CUBE Dynasim released 13 vehicles higher than aaSIDRA. This number would cause fewer vehicles from north to travel to west in CUBE Dynasim model. Then, 190 and 1276 v/h was used instead of 185 and 1268 v/h. The result is slightly different. For instance, the right turn lane travel speed was 18.9 km/h. After the modification it is slightly lower than before modification, which is 18.8 km/h. Another attempt has been done to figure out this case by modifying the CUBE Dynasim model. The speed limit on the north approach, in this case right turn lane only, from 50 to 60 km/h. the results are mostly all of approaching flow decreased. On right turn lane of north approach, it decreased from 68 to 67 v/h, however, it increased for 10 v/h on the through lane. Then, the speed limit is decreased to 40 k/h. CUBE Dynasim produces nearly the same trend as aaSIDRA when the speed is increased except the vehicle number traveling on the right turn lane of north approach. It has 2 vehicles higher than at 50 k/h speed. Therefore, it can be presumed that modification in speed does not affect the approach flows and the right turn lane travel speed of north approach will remain the same.

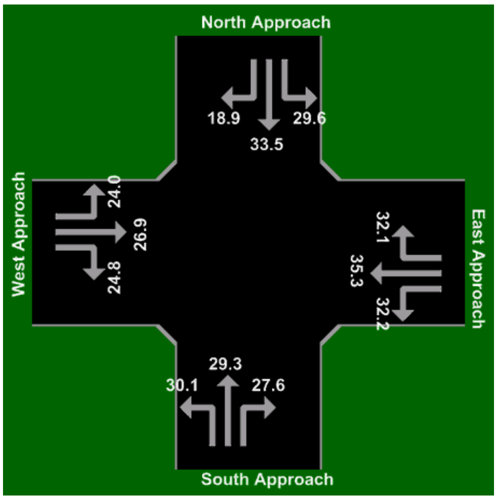


Figure 7 aaSIDRA average travel speed

Last attempt was observing the animation movie. Some findings from the observation are, the reaction time and driver aggressiveness is likely low. Mostly all of vehicles in the animation movie need more than two seconds to start moving. For example, during all red time, the motorist would have opportunities to make right turn as in the real life. Nevertheless, the vehicles often require longer than two seconds in making decision and finishing its turning movement.

Furthermore, CUBE Dynasim gives higher average speeds on the east approach than aaSIDRA, except on the right turn lane. CUBE Dynasim calculates the average travel speed on the right turn lane as 16.41 km/h while aaSIDRA estimated the same travel speed as 32.1 km/h. The difference could be caused by the simulation factor such as reaction time, driver aggressiveness and acceleration & deceleration factor built in CUBE Dynasim software. Besides, CUBE Dynasim will calculate the effect of any events occurred during the simulation. For example, vehicles from the right turn lane on the north approach might use the inter-green time to move to its destination. This condition will interrupt the vehicle from right turn lane on the east approach. It will wait and give priority to the vehicle that is still moving at the end of green period or during inter-green time from north to west as it could be happened in the real situation. The effect of this situation is counted by CUBE Dynasim.

2.3 Queue

To collect queuing data, there are two methods that can be used. First, it can be done by installing a set of stages and data collectors at the entrance of each lane. This Stage is a dimensionless simulation object created in the logical mode. When the lane is fully occupied, the incoming vehicles will stop on stage until the queue is discharge. Therefore, to collect the number of vehicles on queue, the data collector must be set on the stage. However, it could be used only when all lanes are through lanes. The second way to collect number of queuing vehicle is by doing direct observation on the animation movie generated by CUBE Dynasim. In this method, number of vehicles on the queue can be counted for every cycle time. This method takes longer time and more errors could occur but number of vehicles queuing on the short lanes can be computed. Since there are short lanes on this analysis, the latter method is then used.

Table 12 Vehicle length and speed (source: Citilabs (2004) p 39)

Vehicle	Length (m)	Maximum speed (km/h)		
		Minimum	Average	Maximum
Pedestrian	0.5	3	5	7
Bicycle	1.8	30	35	40
Passenger car	4.1	80	100	115
Heavy truck	12	70	80	90
Bus standard	12	75	80	85
Bus articulated	18	75	80	85

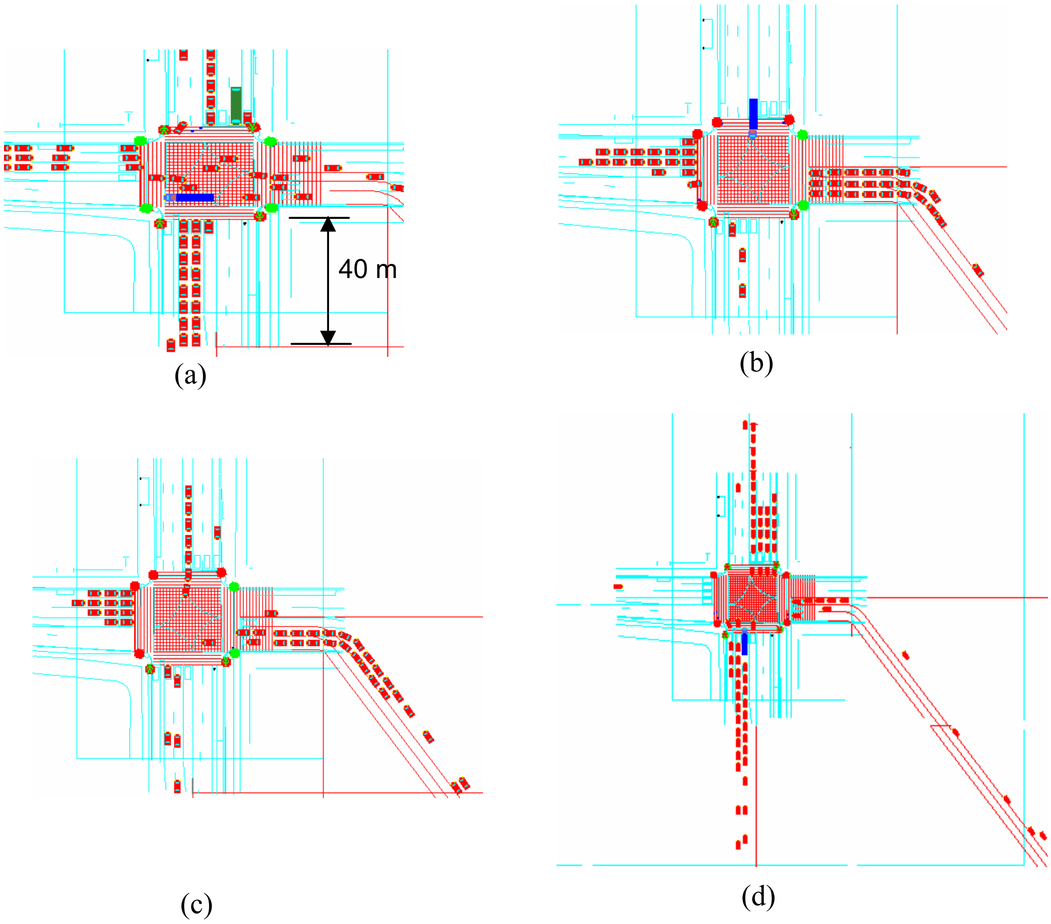
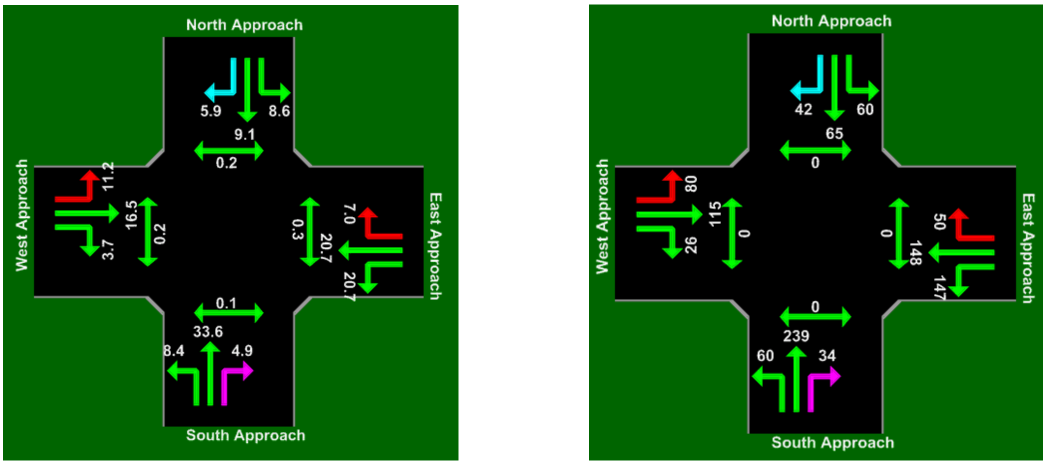


Figure 9 CUBE Dynasim queue length estimation

Like aaSIDRA, CUBE Dynasim generates number of vehicle on the queue. However, it does not generate queue distance. Based on the animation movie generated by CUBE Dynasim, for road length of 40 meters can be occupied by 8 passenger cars on the queue (See figure 9 (a)). The distance between passenger cars from center to center is about 5.1 m. The standard length of vehicles used in CUBE Dynasim is shown on table 12. Then, the spacing between two consecutive passenger cars is 5.1 minus 4.1 divided by two and it is equal to 0.5. Compared to aaSIDRA, CUBE Dynasim uses a shorter queue space required for one passenger cars which is 7 m while it is 13 meters for a heavy vehicle.

Only the maximum number of vehicle on the queue resulted from direct observation on the animation movie is considered in this study. The queue is counted based on the back of queue condition. The last vehicle that joins the back of the queue is the last vehicle that departs at the end of the saturated part of green time or the available gap interval. From the observation is found that the longest queue is on the south approach lane number 6 and followed by lane number 5 with 31 and 27 passenger cars on the queue respectively. They both are through lanes. It is a normal situation for a morning peak analysis where a high number of people go to the city for mainly working and studying. Then, there are also long queues on the east approach lanes with destination of west and north areas. It is due to the traffic volume which is the second largest is coming from this approach. The maximum numbers of vehicles on the queue are 20 and 19 on lane 2 and 3 respectively. They are also through lanes.

It can be seen in figure 9 (b) that long queue exists on the through lanes of east approach. However, the queue not only consists of vehicles which are going to the west, but also to the CBD or to the north. It illustrates by figure 9 (c) where longer queue is located on the closest through lane to the right turn lane. Then, as in the morning more people go to the city than other destinations, long queues also occurred on south approach as shown in figure 9 (d). It also depicts long queue on the right turn lane of north approach. Vehicles on this lane must wait acceptable gaps before travel to the west. Since the number of vehicles from the south is high in the morning peak, this queue is seldom fully discharged.



(a) (b)

Figure 10 aaSIDRA queue length

Meanwhile, aaSIDRA longest queue is along through lanes on south approach followed by through lane on east and west approach respectively as can be seen on figure 10 (a). There are 33.6, 20.7 and 16.5 vehicles on each lane or equals to 239 and 148 meter each (see figure 10 (b)). In mean time, the queue data from CUBE Dynasim shows that the longest queue is on lanes S6 and S7 with 27 and 31 vehicles on the queue. It is followed by lanes E3 and E2 with 20 and 19 vehicles on the queue while lanes W9 and W10 on the west approach have 12 and 13 vehicles each on the queue. It is estimated that CUBE Dynasim uses a shorter queue space for PC compared to aaSIDRA. It is about 5.1 m for one PC while aaSIDRA uses 7 m for a light vehicle. Based on these results, CUBE Dynasim queue outputs are close to the aaSIDRA but the queue distance is shorter as CUBE Dynasim uses shorter queue space for a PC.

3 Conclusion and recommendation

3.1 Conclusion

After modeling, analyzing and comparing using aaSIDRA and CUBE Dynasim models, the conclusions relate to the aim and objective of the study can be drawn. As mentioned in the first chapter of this research, the objective of this study is to explore the differences between the two software in modeling and analyzing a transport system. The conclusions are as follows:

1. CUBE Dynasim and aaSIDRA generates demand traffic flows results which is match with the real condition. Approach, circulating and exiting flows generated by aaSIDRA compared to the same outputs produces by CUBE Dynasim mostly the same. The highest difference of approach flow is +4.05 which is on the north approach. The lowest difference is 0 which is on the south approach. Meanwhile, aaSIDRA generates lower exiting flow on the south approach which is about 0.9 percent. But, it is 0.6 higher in the west approach.

   Meanwhile, the demand flows on each lane between aaSIDRA and CUBE Dynasim model vary. The difference is major on east approach which is the highest one is on the right turn lane. It is 42.19 percent. The difference is also big n the through and right turn lanes of north approach. The highest one is 16.9 percent on the through lane. This is caused by the characteristic of CUBE Dynasim which releases the vehicles randomly while aaSIDRA is not. CUBE Dynasim releases different number of vehicles for each lane of through lane, while aaSIDRA releases them with the same number. For example, it is 275 and 202 v/h for N13 and N14 of CUBE Dynasim model. aaSIDRA's is 243 v/h each. The total demand flow for that lane is 477 and 486 v/h for CUBE Dynasim and aaSIDRA model respectively. Thus, the difference becomes much lower which is 1.89 percent.

2. Travel speed outputs for both models are close each others. For example, travel speed on through lane of south approach is 29.69 and 29.3 k/h for CUBE Dynasim and aaSIDRA model respectively. Then, it is 24.98 and 24.8 k/h on the right turn lane of west approach. However, the speed on the right turn lane for both of north and east approach has major differences between CUBE Dynasim and aaSIDRA model. CUBE Dynasim generates 4.71 k/h on the north appraoch's turn lane while is 16.41 k/h on the east approach's right turn lane. On the other hand, aaSIDRA generates 18.9 and 32.1 k/h for the same lanes.

   Some attempts have been done to threat this case. Firstly, since aaSIDRA has higher demand volume from the south direction compared CUBE Dynasim, this might cause that problem. Therefore, the demand flow on this approach of aaSIDRA model was modified to the same data of CUBE Dynasim. The result is almost the same than before modification. The only change is the travel speed on the right turn lane of north approach slightly decreases from 18.9 to18.8 k/h.

   Then, the second attempt was modifying the speed limit of CUBE Dynasim model. It was increased from 50 to 60 km/h and also decreased to 40 km/h. the results of the modification are the same. Mostly all of approach demand flow decreases. Therefore, it is presumed that speed limit modification does not give impacts to the approach flows and the right turn lane travel speed of north approach will remain the same.

   The last attempt was observing the simulation movie generated by CUBE Dynasim. Based on the observation, it was found that CUBE Dynasim the reaction time and driver aggressiveness is likely low. Nearly all of vehicles in the intersection require more than two seconds starting moving. As example, the motorist would have opportunities to make right turn during all red time as in the real life. Nonetheless, the vehicles seem need longer than 2 seconds making decision and finishing its turning movement. Unfortunately, CUBE Dynasim does not have facilities or tools so that the user can modify reaction time as well as acceleration and deceleration factors.

3. The last comparison is queue. Both models have the same pattern of queue. For example, the longest queue is on the through lane of south approach. However, the number of vehicle on the queue is 31 for CUBE Dynasim. It is 34 for aaSIDRA or 8.8 percent higher. Long queue also occurred on the through lane of east approach. CUBE Dynasim's queue is 20 PC while aaSIDRA's is 21 or 4.7 percent higher. Then the next long queue occurred on the through lane of west approach. It is 13 and 17 vehicles on the queue for CUBE Dynasim and aaSIDRA model respectively.

   However, the number of vehicle queuing on the right turn lane of north approach has a major difference between the two models. CUBE Dynasim has 14 vehicles on the queue while aaSIDRA has only 6 vehicles. This has the trend with the average travel speed of both model and may have positive correlation. As CUBE Dynasim's average travel speed is much lower than aaSIDRA's, the CUBE Dynasim's queue becomes longer than aaSIDRA's.

3.2 Recommendation

The results of this study have indicated that CUBE Dynasim and aaSIDRA model has few differences but the majorities are nearly the same. The differences are likely caused by some default values in CUBE Dynasim software which cannot be modified at present version or probably by the number of the analysed intersection which was only one signalized intersection. For example, CUBE Dynasim does not have tools or facilities to specify or modify the reaction time, acceleration and deceleration factors. In other micro simulation program, for instance, PARAMICS, the user can modify or specify such data. Therefore, it will give better results if the user can input those parameters in CUBE Dynasim model. Further, the capacity of CUBE Dynasim software used in this research is limited. This causes part of model cannot be modeled. For example, the coordination factors of the intersection with others could not be applied in this study. It will result in more accurate output if they are also used in the study. Moreover, the intersection modeled and analyzed in this study may have few changes in its geometry features. As example, the on-street parking between 8-9 am, which the time interval used in the study, is banned. It could be allowed in the future. The impact can be analyzed as a future work of the study. In addition, the impact of road closure on the intersection also can be modeled and analyzed.

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