

Evaluating the Performance of Traffic Flow using SIDRA for Roundabouts in Ipoh, Perak

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ABSTRACT

Due to rapid development and urbanisation, the traffic systems in Perak are developing and continuously growing in numbers. Evaluation of junction concerning capacity and safety is very important since it is directly related to delay, level of service, accident, operation cost and environmental issues. Traffic congestion happens due to delay and reduction of average speed during AM Peak hours at two roundabouts. This study aims to improve the traffic flow by determining the LOS at two different roundabouts. A traffic study was conducted at “Bulatan Bahagia” and “Bulatan Sultan Iskandar” in Ipoh. Sidra 5.0 application was used as an alternative to Highway Capacity Manual to analyze the junction and LOS performances. This analysis was carried out using SIDRA Software 5.0 to determine the LOS at “Bulatan Bahagia” and “Bulatan Sultan Iskandar” in Ipoh. This study provides recommendations to improve the roundabout performance. The result shows the improvement in the level of service from LOS F to LOS B and from LOS F to LOS D. The percentages of reduction for delay were 2 % and 5% respectively. The finding shows that speed on road has a direct correlation with traffic congestion. The speed improves up to 57 % and 20 %. The analysis indicates that Sidra application utilisation gives the best alternative design for intersections and improve the LOS due to sustainable traffic demand on both upstream and downstream roundabouts.

Keywords: Sidra Application 5.0; roundabout; level of service; delay; speed

INTRODUCTION

An evaluation of junction concerning capacity and safety is very important since it is directly related to delay, level of service, accident, operation cost, and environmental issues. For more than three decades modern roundabouts have been used successfully throughout the world as a junction control device (Berhanu 2004). Level of Service (LOS) is defined as a measurement of the operational condition within a traffic stream, generally in terms of travel time, speed, freedom, traffic interruptions, comfort and convenience (HCM, 2000). It is important to obtain information on existing traffic volume along with a road network to determine whether the road can withstand the road load and services.

Highway traffic congestion is one of the major problems that challenge developed countries around the world. As a result of traffic congestion at intersections in Malaysia, delays and long queues were observed repeatedly during peak hours due to the poor strategies of the road network (Ali, Reşatoğlua & Tozan 2018; Albraka 2014). If the traffic volume exceeds the required level, then traffic congestion would occur and consequently, the smoothness of movement and traffic safety will be affected. When the traffic movement is disrupted, the speed of traffic flow will

be affected. Thus, the volume of traffic is a measurement used to assess the state of congestion before any necessary action is taken to resolve the problem. Measuring the volume of traffic can be done in several ways within an appointed period hand (Arasan 2010).

Sidra Intersection is a traffic engineering software package used for analyses and optimizes intersection (junction), estimate network capacity, the performance of level of service (LOS) and analysis, determine network timing calculations by traffic design, operations and planning professional (Thejas 2020). Sidra Intersection is a micro-analytical traffic evaluation tool that employs lane-by-lane and vehicle drive cycle models (Al-Omari 2007). It can be used to compare alternative treatments of individual intersections and networks of intersections (Ismail & Mokhtar 2018).

Sidra Intersection allows the modelling of separate Movement Classes (Akcelik 2003). The movement classes are light vehicles, heavy vehicles, buses, bicycles, large trucks, light rail/trams and six user classes with different vehicle characteristics. These movements can be allocated to different lanes, lane segments and signal phases (Chakravorty 2017).

STUDY AREA

Selecting and identifying the study area were very challenging due to traffic congestions at peak hours. Road inventories and detailed peak hour traffic volume of the study areas were conducted as shown in Figure 1: Proposed Study Area 1: ‘Bulatan Bahagia’, a three-arm multi-lane roundabout and Figure 2: Proposed Study Area 2 ‘Bulatan Sultan Iskandar’, a four-arm multi-lane roundabout.

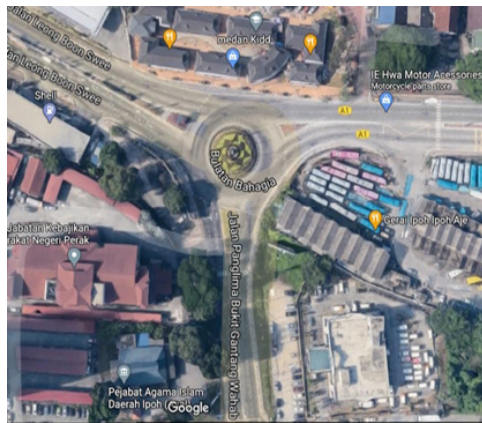


FIGURE 1. Proposed Study Area “Bulatan Bahagia”.



FIGURE 2. Proposed Study Area “Bulatan Sultan Iskandar”.

METHODOLOGY

The methodology of this study is divided into four major steps. There are data collection, data analysis using Sidra Software 5.0, enhanced outcomes and findings. A traffic volume study was conducted at the proposed areas to obtain data inputs for SIDRA 5.0 software. The variables were collected from the traffic study, traffic count, phase movement of intersection and queue length. The data collected was expanded and analysed. The substantial numbers of data inputs in the first phase were required for LOS analysis and to determine the value based on Highway Capacity Manual (HCM) process as shown in Figure 3: LOS Operational Framework (Akçelik 2017; TRB 2016). Data collected was analysed using Sidra 5.0 Software, to determine LOS, average delay time and average speed (Essa et al. 2017) as shown in Figure 4.

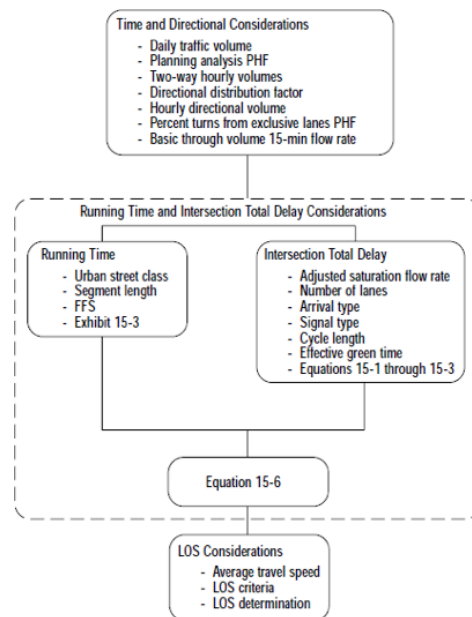


FIGURE 3. LOS Operational Framework. (TRB 2016)

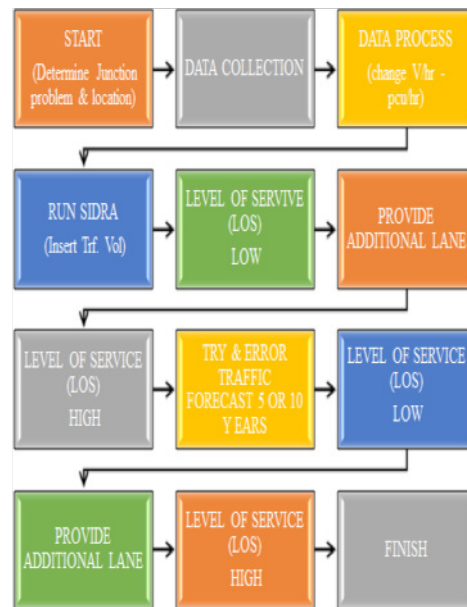


FIGURE 4. LOS Operational using SIDRA

DATA COLLECTION

The data of the study was collected for an hour, that was from 7.00 a.m. to 8.00 a.m. at ‘Bulatan Bahagia and Bulatan Sultan Iskandar’. These areas were considered as potential AM Peak hours (Tukiar, Zainuddin & Rasid 2018). A total of eight observers carried out manual counting at their assigned positions along Jalan Tun Abdul Razak, Jalan Leong Boon Swee and Jalan Panglima Bukit Gantang Wahab as shown in Figure 5. Layout Plan at ‘Bulatan Bahagia’ with Traffic Flow Values in pcu/hr. All traffic movements were recorded and divided into several compositions of cars, heavy vehicles, buses, motorcycles and bicycles.

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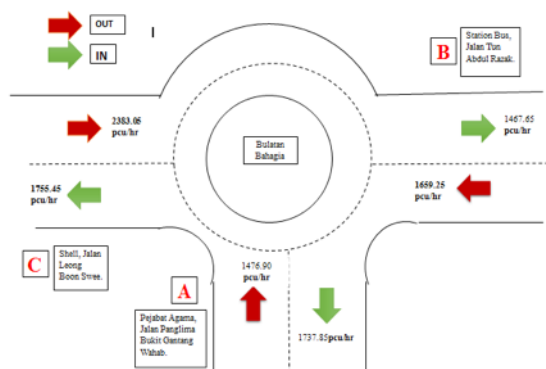


FIGURE 5. Layout plan at Bulatan Bahagia with Traffic Flow pcu/hr.

A total of eight observers carried out manual counting at their assigned positions along with Jalan Raja Ashman Shah, Jalan Raja Musa Aziz (In) and Jalan Raja Musa Aziz (out) as shown in Figure 6, Layout Plan at ‘Bulatan Sultan Iskandar’ with Traffic Flow Values in pcu/hr. All traffic movements were recorded and divided to several compositions of cars, heavy vehicles, buses, motorcycles and bicycles.

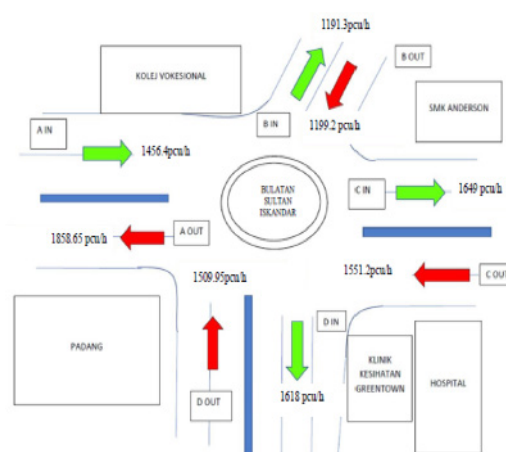


FIGURE 6. Layout Plan at Bulatan Sultan Iskandar with Traffic Flow Values in pcu/hr.

RESULT AND DISCUSSION

DATA ANALYSIS USING SIDRA 5.0

The collected data was used as input for SIDRA 5.0 software. The results obtained show the LOS which were used as the measurement for the factors that affect the speed and delay time, traffic interruptions, manoeuvre freedom, safety, driving ease and convenience. The concept of LOS is utilized in the intersection’s capacity analysis. Figure 7 and Figure 8 show the Movement Summary for ‘Bulatan Bahagia’ and ‘Bulatan Sultan Iskandar’. The results obtained from SIDRA show LOS, Average Delay and Average speed for ‘Bulatan Bahagia’ and ‘Bulatan Sultan Iskandar’ as shown in Table 1: Existing Data of Level of Service (LOS) in the study areas.

MOVEMENT SUMMARY

Site: New Site - 1

CADANGAN KAJIAN LALULINTAS DI BULATAN BAHAGIA BERDEKATAN MEDAN KIDD Roundabout

Movement Performance - Vehicles											
Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Sain v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Dari Balai polis, Jalan Panglima Bukit Gantang Wahab											
2	L	824	0.0	0.335	5.8	LOS A	3.0	21.1	0.63	0.53	48.7
1	T	699	0.0	0.587	12.7	LOS B	7.1	49.8	0.81	0.78	44.0
Approach		1523	0.0	0.587	9.0	LOS B	7.1	49.8	0.71	0.65	46.4
North East: Dari Medan Kidd, Jalan Tun Abdul Razak											
6	L	856	0.0	1.716	661.2	LOS F	236.1	1652.6	1.00	8.19	3.1
26	R	856	0.0	2.161	1072.2	LOS F	303.1	2121.9	1.00	8.34	2.1
Approach		1712	0.0	2.162	866.7	LOS F	303.1	2121.9	1.00	8.26	2.5
North West: Dari Shell, Jalan Leong Boon Swee											
27	L	1128	0.0	1.312	301.5	LOS F	189.8	1328.9	1.00	6.29	6.5
3	R	1329	0.0	0.871	35.0	LOS D	21.5	150.3	1.00	1.42	31.5
Approach		2458	0.0	1.312	157.4	LOS F	189.8	1328.9	1.00	3.66	11.6
All Vehicles		5693	0.0	2.162	330.9	LOS F	303.1	2121.9	0.92	4.24	6.1

FIGURE 7. Movement Summary from SIDRA at ‘Bulatan Bahagia’

MOVEMENT SUMMARY

Site: 1 [New Site - 1]

Cardangan Memperbaiki Bulatan Sultan Iskandar
Site Category (None)
Roundabout

Movement Performance - Vehicles												
Move ID	Turn	Total VEH	Demand Flows HV %	Opp. Sats. sat	Average Delay sec	Level of Service	95% Stack of Queue Vehicles veh	Queue Distance m	Prop. Queue	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: Lebu Cator (Kolej Vokasional)												
1b	L3	15	36.0	0.200	13.8	LOS B	0.9	9.5	0.67	0.92	0.87	47.0
2	T1	27	64.0	0.200	15.9	LOS B	0.9	9.5	0.67	0.92	0.87	48.9
Approach		42	53.9	0.200	15.1	LOS B	0.9	9.5	0.67	0.92	0.87	48.2
East: Jalan Raja Musa Aziz (Highway)												
4	L2	52	2.0	0.055	5.5	LOS A	0.2	1.7	0.58	0.64	0.58	53.8
4a	L1	2541	98.0	2.051	934.5	LOS F	497.2	6404.1	1.00	15.40	33.73	3.7
Approach		2593	96.1	2.051	935.5	LOS F	497.2	6404.1	0.99	15.10	33.07	3.7
North: Jalan Raja Musa Aziz (Dataran)												
7	L2	493	42.0	0.451	7.0	LOS A	2.4	22.8	0.64	0.80	0.71	52.6
8	T1	670	58.0	0.487	9.1	LOS A	2.5	26.2	0.69	0.86	0.85	53.5
Approach		1163	51.2	0.487	8.2	LOS A	2.5	26.2	0.67	0.83	0.79	53.0
SouthWest: Jalan Raja Ashman (Hospital)												
30a	L1	974	46.6	0.675	5.9	LOS A	8.3	85.5	0.27	0.43	0.27	54.1
32a	R1	765	44.0	0.326	8.7	LOS A	2.1	20.5	0.20	0.54	0.20	52.3
Approach		1739	50.7	0.675	5.9	LOS A	8.3	85.5	0.27	0.43	0.27	54.1
All Vehicles		5538	72.1	2.051	441.7	LOS F	497.2	6404.1	0.69	7.39	15.74	7.4

FIGURE 8. Movement Summary from SIDRA for Bulatan Sultan Iskandar.

TABLE 1. Existing Data of Level of Service (LOS) at study the area.

Study Area	LOS	Average Delay (sec)	Average Speed (Km/h)
1 <i>Bulatan Bahagia</i>			
<i>Jalan Panglima Bukit Gantang</i>	B	9.0	46.4
<i>Jalan Tun Abdul Razak</i>	F	866.7	2.5
<i>Jalan Leong Boon Swee</i>	F	157.4	11.6
2 <i>Bulatan Sultan Iskandar</i>			
Lebu Cator (South)	B	15.1	48.2
Jalan Raja Musa Aziz (East)	F	935.5	3.7
Jalan Raja Musa Aziz (North)	A	8.2	53.0
Jalan Raja Ashman (South)	A	5.9	54.1

Table 1 shows the average value of LOS, delay and speed of traffic study area. The LOS value for both 'Bulatan Bahagia' and 'Bulatan Sultan Iskandar', is F. Both roundabouts need to be upgraded to improve traffic congestion and traffic situation. The good value of LOS is in the range of C and D. The value of F in LOS shows that traffic jams, all the vehicles are in the situation of forced flow, speeds and volume can drop to zero. Stop pages can occur for a long period.

RESULT AFTER IMPROVEMENT

Sidra output shows that LOS for 'Bulatan Bahagia' and 'Bulatan Sultan Iskandar' is F. Both roundabouts need improving SIDRA results. It can be attained by broadening the shoulder of the intersection, adding an acceleration lane, adding a deceleration lane and adjusting the signalise intersection by adjusting the cycle time (Akcelik & Associates 2010).

MOVEMENT SUMMARY

Site: New Site - 1

New Site
Roundabout

Movement Performance - Vehicles											
Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Pejabat Agama, Jalan Panglima Bukit Gantang Wahab											
1	L	824	0.0	0.444	4.3	NA ^a	NA ^a	NA ^a	NA ^a	0.39	53.6
3	R	699	0.0	0.435	13.0	LOS B	3.3	22.9	0.75	0.89	44.3
Approach		1523	0.0	0.444	8.3	LOS B	3.3	22.9	0.35	0.62	48.8
North East: Stesen Bas, Jalan Tun Abdul Razak											
24	L	856	0.0	0.461	4.3	NA ^a	NA ^a	NA ^a	NA ^a	0.39	53.6
26	R	856	0.0	0.710	19.3	LOS B	6.9	48.4	0.92	1.10	40.3
Approach		1712	0.0	0.710	11.8	LOS B	6.9	48.4	0.46	0.74	45.8
North West: Shell, Jalan Leong Boon Swee											
27	L	1128	0.0	0.608	5.3	NA ^a	NA ^a	NA ^a	NA ^a	0.46	52.4
29	R	1329	0.0	0.720	15.0	LOS B	7.8	54.4	0.83	1.05	43.2
Approach		2458	0.0	0.720	10.6	LOS B	7.8	54.4	0.45	0.78	46.8
All Vehicles		5693	0.0	0.720	10.3	LOS B	7.8	54.4	0.43	0.72	47.0

FIGURE 9. Movement Summary from SIDRA at ‘Bulatan Bahagia’ after improvement

Adding 2.6 m to Acceleration Lane and 2.6 m to Deceleration Lane using SIDRA software 5.0 at ‘Bulatan Bahagia’ for all the three arms increase the average LOS for all the arms from LOS F to LOS B as shown in Figure 10: Upgraded Acceleration Lane and Deceleration Lane at ‘Bulatan Bahagia’.

Adding signalized intersection at roundabout for all the four arms using SIDRA software 5.0 at ‘Bulatan Sultan Iskandar’ increase the average LOS for all the arms from LOS F to LOS C as shown in Figure 12: Upgraded signalised intersection at ‘Bulatan Sultan Iskandar’.

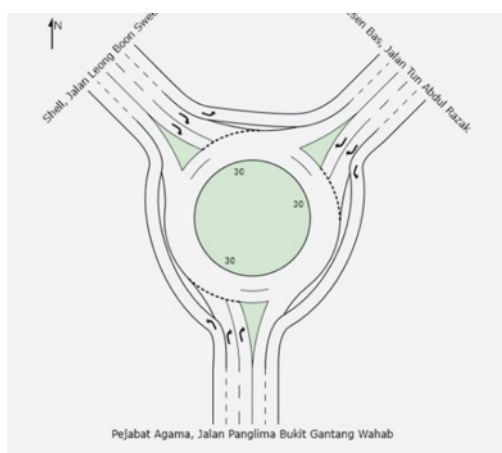


FIGURE 10. Upgraded Acceleration Lane and Deceleration Lane at Bulatan Bahagia.

Figure 11 show the movement summary from SIDRA at ‘Bulatan Sultan Iskandar’ after improvement. Adding signalised intersection at roundabout for all the four arms using SIDRA software 5.0 at ‘Bulatan Sultan Iskandar’

increase the average LOS for all the arms from LOS F to LOS C as shown in Figure 12: Upgraded signalised intersection at ‘Bulatan Sultan Iskandar’.

MOVEMENT SUMMARY

Site: 1 [New Site - 1]

Cadangan Memperbaiki Bulatan Sultan Iskandar
Site Category: (None)
Roundabout Metering

Movement Performance - Vehicles												
Mov ID	Turn	Demand Flows Total (veh/h)	HV %	Req Satn veh	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: Lebuh Cator (Kolej Vokasional)												
1b	L3	15	36.0	0.042	5.2	LOS A	0.1	1.1	0.33	0.51	0.33	53.4
2	T1	27	64.0	0.042	5.2	LOS A	0.1	1.1	0.33	0.51	0.33	55.8
Approach		42	53.9	0.042	5.2	LOS A	0.1	1.1	0.33	0.51	0.33	54.9
East: Jalan Raja Musa Aziz (Highway)												
4	L2	52	2.0	0.207	12.6	LOS B	1.0	7.4	0.92	0.95	0.92	49.4
4a	L1	2541	98.0	1.080	40.5	LOS D	0.0	0.0	0.00	0.00	0.00	26.5
Approach		2593	96.1	1.080	39.9	LOS D	1.0	7.4	0.02	0.02	0.02	26.8
North: Jalan Raja Musa Aziz (Bandar)												
7	L2	493	42.0	0.436	5.9	LOS A	1.9	17.7	0.57	0.70	0.53	53.3
8	T1	670	56.0	0.554	6.4	LOS A	1.5	15.6	0.57	0.61	0.63	54.4
Approach		1163	51.2	0.436	6.2	LOS A	1.9	17.7	0.57	0.66	0.53	53.9
SouthWest: Jalan Raja Ashman Shah (Hospital)												
30a	L1	974	56.0	0.367	5.5	LOS A	0.2	2.1	0.06	0.34	0.06	56.9
32a	R1	765	44.0	0.306	8.5	LOS A	0.2	1.5	0.06	0.59	0.06	52.8
Approach		1739	50.7	0.367	5.7	LOS A	0.2	2.1	0.06	0.45	0.06	55.0
All Vehicles		5536	72.1	1.080	21.8	LOS C	1.9	17.7	0.15	0.29	0.15	36.8

FIGURE 11. Movement Summary from SIDRA at 'Bulatan Sultan Iskandar' after improvement

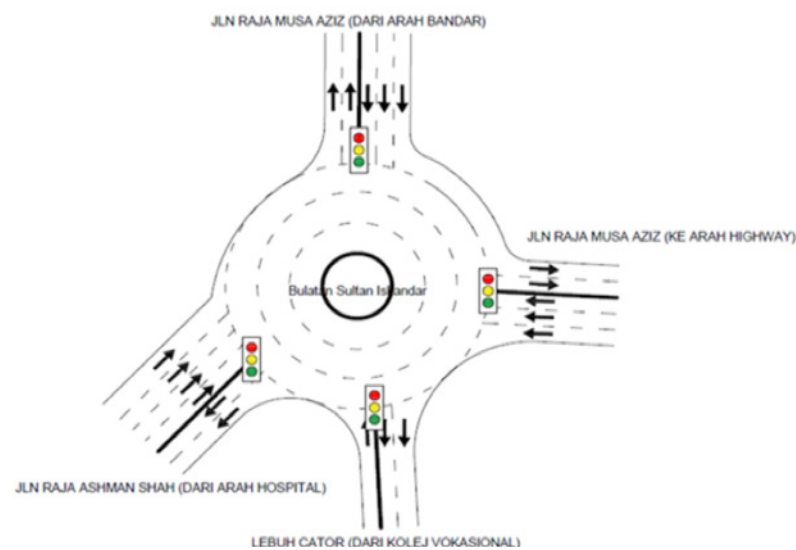


FIGURE 12. Upgraded signalised intersection at 'Bulatan Sultan Iskandar'.

TABLE 2. Data Comparison at Study Area

Study Area	Before Improvement			After Improvement		
	LOS	Delay (sec)	Speed (Km/h)	LOS	Delay (sec)	Speed (Km/h)
<i>Bulatan Bahagia</i>						
<i>Jalan Panglima Bukit Gantang</i>	B	9.0	46.4	B	8.3	48.8
<i>Jalan Tun Abdul Razak</i>	F	866.7	2.5	B	11.5	45.8
<i>Jalan Leong Boon Swee</i>	F	157.4	11.6	B	10.6	46.8
<i>Bulatan Sultan Iskandar</i>						
Lebuh Cator (South)	B	15.1	48.2	A	5.2	54.9
Jalan Raja Musa Aziz (East)	F	935.5	3.7	D	39.9	26.8
Jalan Raja Musa Aziz (North)	A	8.2	53.0	A	6.2	53.9
Jalan Raja Ashman (South)	A	5.9	54.1	A	5.7	55.0

DISCUSSION

The results of reduction percentage (%) of the study, before and after optimization of SIDRA 5.0 revealed the value of total delay, travel speed and level of service. The acceleration lane and deceleration lane were upgraded at 'Bulatan Bahagia' after applying SIDRA Software 5.0. An improvement was seen that was LOS improved from LOS F to LOS B. That is the average delay improved from 866.7 sec to 11.5 sec and the average speed increased from 2.5km/h to 45.8 km/h. On the other hand, the roundabout was upgraded with signalized intersection for 'Bulatan Sultan Iskandar' after applying SIDRA Software 5.0. An improvement was seen that was LOS improved from LOS F to LOS D. That is the average delay improved from 935.5 sec to 39.9 sec and average speed increased from 3.7 km/h to 26.8 km/h. The percentage reduction of delay was 2 % and 5% respectively. It also shows that the speed on road is in direct correlation with traffic congestion. The speed on the roads managed to improve up to 57 % and 20 %.

CONCLUSION

The utilization of SIDRA software is much easier compared to flip through (TRB 2016), ATJ JKR, Malaysia Standard and other manuals. It was easier to attain a basic understanding of traffic study, volume, capacity, Level of Service (LOS), speed and delay using Sidra Software 5.0. Improvements of traffic signal coordination at the roundabout and additional lanes can be planned and suggested easily by improving the LOS, increasing travel speed and reducing delays. A study was done at AM Peak hour and both roundabouts were unable to obtain a huge volume of traffic flow at rush hours. These roundabouts need additional new lanes and traffic lights to reduce the congestion by improving delay and speed.

ACKNOWLEDGEMENT

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DECLARATION OF COMPETING INTEREST

None

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