Intersection Analysis by aaSIDRA Software for Computer Simulation to Optimize the Traffic Flow

Ali Ahmed Mohammed
Office Reconstruction & Projects, Ministry of Higher Education & Scientific Research /Baghdad
E-mail: aliam812004@yahoo.com

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ABSTRACT

Computer simulation is important for the analysis of freeways and urban streets systems. Through simulation, Transportation specialists can study the formation and dissipation of congestion on roadways. The Roundabout (Bandar Baru Bangi) and intersection The National University of Malaysia (UKM) are two major causes that have a significant effect on travel time, delay, level of service, stop and degree of saturation. The aim of this paper is to analysation and rationalization the traffic flow of the intersection and roundabout to provide useful information for engineers to design the roads with the shortest travel time and reducing the congestion in roundabout and intersection.

The data required for the study were mainly collected through video filming technique .Also the calculation and assessment are constructed with the aaSIDRA software.

Keywords: roundabout, intersection, simulation, optimization, aaSIDRA**.**

تحليل تقاطع بواسطة المحاكاة بالحاسوب برنامج اسدرا لتحسين سير المرور

الخلاصة

المحاكاة بالحاسوب مهمة لتحليل الطرق السريعة وانظمة الشوارع الحضرية .من خلال المحاكاة , اختصاصيوا النقل يمكن ان يدرسوا التشكيل وانقشاع الازدحام على الطرق .

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الدوار(بندر بارو بانكي) والتقاطع (الجامعة الوطنية الماليزية) سببان رئيسيان لهما تاثير على زمن الرحلة ,التأخير ,مستوى الخدمات ,التوقف, ودرجة الاشباع . ان هدف هذه الورقة هو للتحليل وترشيد انسيابية سير مرور التقاطع والدوار لتزويد المعلومات المفيدة للمهندسين لتصميم الطرق بمدة الرحلة الاقصر وتقليل من الازدحام في الدوار والتقاطع .
البيانات التي تطلبت للدراسة جمعت بشكل رئيس من خلال تقنية تصوير الفيديو. كذلك الحساب والتقييم مبني على اساس برامج الاسدرا .

INTRODUCTION

Traffic flows are made up of individual drivers and vehicles interacting with each other and with the physical elements of the roadway and its general environment [1]. Because both driver behavior and vehicle characteristics vary, individual vehicles within the traffic flow do not behave in exactly the same manner. Further, no two traffic flows will behave in exactly the same way, in similar circumstances, because driver behavior varies with local characteristics and driving habits. Dealing with traffic, therefore, involves an element of Variability. The problem with car-dependence on societies lies with its large impact on the environment [12].

A flow of water through channels and pipes of defined characteristics will behave in an entirely predictable fashion, in accord with the laws of hydraulics and fluid flow[4]. A given flow of traffic through streets and highways of defined characteristics will vary with both time and location. The critical task of a traffic engineer is to control and manage these conflicts in a manner that ensures safety and provides for efficient movement through the intersection and roundabout for both motorists and pedestrians.

The use of microscopic traffic simulation plays major roles in the analysis and evaluation of transport systems. It is due to its ability to analyze a transport system based on each vehicle properties and operations. It can analyze the interaction between vehicles in the systems and between vehicles and the infrastructure as well. Therefore, microscopic traffic simulators can be considered as a suitable tool in analyzing various transport operations [8]. 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 parameters [9]. 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 evaluated. Hence, through a simulation analysis the practitioners are able to estimate the likely outcomes in the system after some alternative changes are applied. Therefore, the best scheme among the proposed planes can be selected accordingly [5]. Urban freeways are becoming more congested due to higher demands and the delays due to incidents are amplified as the system approaches or exceed capacity.

Travel time can be used to quantify conditions between widely spaced detectors, even when the local, point-based measurements are not representative of the entire segment.

Roundabouts represent an emerging traffic control approach in the US that imposes behavioral changes on drivers [11]. They often require drivers to decelerate from, and reaccelerate to, highway speeds, and can involve one or multiple stops. One concern about congested roundabouts is that vehicle emissions will increase because of the occurrence of excessive delays, queue formation and speed change cycles for approaching traffic. These occurrences could have a significant impact on congestion and air quality in the surrounding urban area. [6].

LITERATURE REVIEW

The software used for data analysis is aaSIDRA, Version 1.0. The Australian Road Research Board (ARRB), Transport Research Limited, developed the aaSIDRA package as an aid for design and evaluation of intersections such as signalized intersections; roundabouts, two-way stop control, and yield-sign control intersections [1, 2, and 3].

In a roundabout performance evaluation study conducted by using aaSIDRA they found that: the main aaSIDRA is (**A**kcelik &**A**ssociates **S**ignalized **I**ntersection **D**esign and **R**esearch **A**id) [8].

In evaluating and computing the performance of intersection controls there are some advantages that the aaSIDRA model has over any other software model. The aaSIDRA method emphasizes the consistency of capacity and performance analysis methods for roundabouts, sign-controlled, and signalized intersections through the use of an integrated modeling framework. This software provides reliable estimates of geometric delays and related slowdown effects for the various intersection types. Strength of aaSIDRA is that it is based on the US Highway Capacity Manual (HCM) as well as Australian Road Research Board (ARRB) research results. Therefore aaSIDRA provides the same level of service (LOS) criteria for roundabouts and traffic signals under the assumption that the performance of roundabouts is expected to be close to that of traffic signals for a wide range of flow conditions[4,13].

The software is for use as an aid for design and evaluation of the following intersection types: Signalized intersections (fixed / pre timed and actuated), Roundabouts, Two-way stop sign control, Give-way (yield) sign-control.

aaSIDRA has been a valuable technology transfer tool based on extensive research carried out in Australia and elsewhere (especially the US research towards the Highway Capacity Manual)[15]. It has been developed continuously in response to from practicing traffic engineers and planners. This feedback has improved the methods used in aaSIDRA and expanded its functionality to cover range problems.

aaSIDRA now uses one of the most advanced methodologies of any traffic design package[16]. We can use aaSIDRA to Obtain estimates of capacity and performance characteristics such as delay, queue length, stop rate as well as operating cost, fuel consumption and pollution emissions for all intersection types, analyze many design alternatives to optimize the intersection design, signal phasing and timing specifying different strategies for optimization, determine signal timing (fixed-time/pre timed and actuated) for any intersection geometry allowing for simple as complex phasing arrangements, Carry out a design life analysis to assess impact of traffic growth, Carry out a parameter sensitivity analysis for optimization, evaluation and geometric design purposes, design intersection geometry including lane use arrangements taking advantage of the unique lane-by-lane analysis method of aaSIDRA,[8] Design short lane lengths (turn bays, lanes with parking upstream, and loss of a lane at the exit side),analyze effects of heavy vehicles on intersection performance, analyze complicated cases of shared lanes, opposed turns (e.g. permissive and protected phases, slip lanes, turn on red),Handel intersection with more than 4 legs, analyze oversaturated condition making use of aaSIDRA`s time-dependent delay, queue length and stop rate formulae[9,11].

In using aaSIDRA can prepare data and inspect output with ease due to the graphical nature of aaSIDRA input and output, specify data at intersection , approach road , lane and movement levels, obtain output including capacity, timing and performance results reported for individual lanes, individual movement (or lane group), movement groupings (such as vehicles and pedestrians), control the amount of output by selection individual output tables, with options for summery and full output, In your reports , present your data and results in picture and graphs form, Compare alternative (gap-acceptance and "empirical") capacity estimation methods for roundabouts, calculate annual sums of statistics such as operating cost, Fuel consumption, Emissions, total person delay, stops and so on, and present demonstrated benefits of alternative intersection in a more powerful way, carry out sensitivity analyses to evaluate the impact of changes on parameters representing intersection geometry and driver behavior, Calibrate the parameters of the operating cost model for your local conditions allowing for factors such as the value of time and resource cost of fuel[1,6].

Performance Index (PI) is a measure which combines several other performance statistics, and therefore can be used as a basis for choosing between various designs options (the best design is the one which gives the smallest value of PI). The equation of the Performance Index is defined as:

$$PI = Tu + w_1*D + w_2*K*H/3600 + w_3*N' \quad \ldots(1)$$

$$Tu = qa*tu \quad \ldots(2)$$

Degree of saturation (x) is defined as the ratio of demand flow to capacity, x = qa /Q (also known as volume/capacity, v/c, ratio). The movement degree of saturation is the largest degree of saturation for any lane of the movement. If there is no lane under-utilization, the degrees of saturation for all lanes and the movement (lane group) . Movements in shared lanes will have the same degree of saturation except in the case of de facto exclusive lanes. The approach degree of saturation is the largest x value for any movement (or any lane) in the approach, and the intersection degree of saturation is the largest x value for any approach.

That the colour code used for movements in the Degree of Saturation screen of GOSID (Graphical Output System for Intersection Design) is based on the following values irrespective of the LOS (level of service) Definition or the intersection type as shown table 1.[13.15]. The colour code used for movements and approaches in the Delay & LOS screen of GOSID is based on the LOS values given in Table 2[3].

DATA SPECIFIC TO ROUNDABOUTS

Definitions of inscribed diameter, central island diameter, circulating road width, and entry lane width relevant to a subject approach are shown in Figure 11. The Roundabout Data screens for the intersection and approaches contain the same parameters [5]. In the Intersection Data screen, the parameters shown in Table 3 are specified for the intersection as a whole. When a data item is updated in the Intersection data screen for roundabouts, the values of these parameters for individual approaches are updated automatically. These values can be reset in the Approach data screen for roundabouts [3,4]. Different parameter settings for individual approach roads are useful in the cases of extra circulating lanes and oval shaped roundabouts. Normally, it is sufficient to specify roundabout data in the Intersection Data screen only. The data shown in Table 3. As well as the parameters calculated by aaSIDRA (inscribed diameter, number of entry lanes, average lane width, proportion of bunched vehicles, critical gap, follow-up headway, etc.) as shown table 3.

Central Island Diameter And Circulating Road Width

The roundabout analysis method will use the inscribed diameter of the roundabout (Di) which is calculated from the central island diameter (Dc) and circulating road width (wc) through [2]:

$$Di = Dc + 2\ Wc \qquad \ldots(3)$$

D_i, D_c and w_c are in meters. The inscribed diameter is measured to the middle of the give-way line of the approach road in order to get the relevant measure for oval roundabouts. The central island diameter is measured accordingly [1,8].

NUMBER OF CIRCULATING LANES

The number of circulating lanes (nc) is related to the circulating road width (wc) according to the results in Table (4). When a value of (wc) is typed in, the corresponding nc will be calculated and displayed automatically (when Enter key is pressed). However, the user can specify a different value of (nc) which does not follow the relationship given in Table 4. When the number of approach lanes is changed in the Intersection screen, the number of circulating lanes for roundabouts (data for all approaches) will be set to the same value as shown table (4) [2,9 and11].

RESEARCH METHODOLOGY

Study Area

Among all the areas in Kajang and Bangi, our group has selected the intersection near The National University of Malaysia (UKM), and roundabout at Bandar Baru Bangi. The main reason why we choose this intersection and roundabout is that it links the road that leads to Kajang, Bangi, Bandar Baru Bangi and also The National University of Malaysia (UKM). In other words, this intersection and roundabout is one of the main intersections and roundabout that we can find it links to Bangi industrial area, to Kajang, Bangi toll, and also to UKM. As the result of the nearest landmark is the UKM, we have called our case study's intersection and roundabout 'UKM Intersection and Bandar Baru Bangi Roundabout. The north side of the intersection and roundabout is the way to Bandar Baru Bangi and Bangi toll. The south side is the way to UKM. From the east side is Bangi[12]. The west side has a Kajang. Therefore, this intersection and roundabout is used by many vehicles and sometimes, especially peak hours, this intersection and roundabout is quite congested. A study of this intersection and roundabout will help us deepen our understanding towards this intersection and roundabout by analyzing it, we may be able to optimize the traffic flow in this intersection [12]. Figure 1 below shows the plan view of the intersection and roundabout.

Data Collection (Traffic Surveys)

The study consists of eight main activities as shown in Figure 3. The main activities are data collection, determination of phasing sequences, determination of optimum cycle. In this phase the data was visually collected from the videotapes. All the videotapes were studied visually to extract the traffic volumes and turning movements for the analysis. Every vehicle coming from all the approaches for a period of 15 minutes was recorded on pre-prepared data collection sheets. Hourly counts were used as input data for analysis using aaSIDRA.

Experimental Results for Optimum Cycle Time

Calculation the optimum common cycle time ,green time split for each intersection and offset time by Assume Amber for all =3 ,all red time = 1_{sec} , speed =36 km/h ,h=2 $_{sec}$,loss=2 $_{sec}$ as shown Table (5)

Optimum Cycle Time.

The maximum cycle time will be 120 seconds .The Webster a formula is given as follows.

$$C_o = \frac{1.5L + 5}{1 - \sum y} \qquad \ldots(4)$$

Saturated Flow=1800*2=3600 pcu/h.
L= 4 directions (4 sec) = 16 $_{sec}$
C_0 = 1.5*16 +5/ (1- 0.573) = 68 $_{sec}$
Cycle time = effective green time + Amber time + All red
Amber for all = 3*4 =12 $_{sec}$
All red = 1*4 =4 $_{sec}$
Effective green time = 68 - (4+12) =50
= 52 sec as shown table 6, 7
C_0 = 1.5*16 +5/ (1- 0.529) = 62 $_{sec}$
Will choose the largest cycle time to confirm as a cycle time for all intersections
C_0 = 68 $_{Sec}$ Amber for all = 3*4 =12 $_{sec}$ All red = 1*4 =4 $_{sec}$ Effective green time = 62 - (4+12) =50 $_{sec}$, = 46 sec as shown table 8

Offset Time.

Queue length is one the parameters required to determine the suitable offset time in a network of signalized intersections. As the queue becomes longer at the downstream intersection, the offset time becomes shorter [7] as given in equation (4). The reduction in
Offset time is mainly to clear the queued vehicles before the platoon of vehicles from the Upstream intersection arrive at the stop line as shown the figure 4,5

$$T_{ideal} = \frac{L}{S} - \left(Qh + Loss \right) \qquad \ldots(5)$$

$$T_{ideal} = \frac{900}{10m/\sec} - \left(15*2 + 2 \right)$$

Absolute offset = 58 sec

RESULTS

To analyze and try to optimize the traffic flow of the intersection and roundabout between the Kajang and Bangi, The data are collected from videotapes for the peak periods manually in 15-minute periods, and hourly data was then input to the aaSIDRA software for analysis. The data analysis was done separately for the AM and PM hourly volumes but the procedure followed was the same for both sets of data. This was done to see whether the results differed due to the differences in before and after traffic volumes for both AM and PM traffic counts, as there was more traffic during the PM period than during the AM period.

There are several items that they are used for the roundabout and intersection such as Delay and Loss, Queue, Stops, Degree of saturation, geometry. In the following part this paper tries to analysis the data and optimizes the result with each other to find out what is the best choice for the roads.

INTERSECTION ANALYSIS SOFTWARE FOR KAJANG(UKM)

After collecting and input the data in the aaSIDRA the software analysis the current situation for roundabout and intersection for the intersection in front of the University Kebangsaan Malaysia (UKM) which has a high flow and the traffic jam and long queue will happen around the main gate of the university which make a long queue and heavy delay time over the traffic light that are shown in figure (6), (7).Regarding to the table 10,11 there are some items that are shown the impact of the intersections on the traffic such as Intersection Level of Service, Average intersection delay, Degree of saturation, Practical Spare Capacity (lowest), Total vehicle capacity, all lanes (veh/h), Total vehicle delay (veh-h/h and some more items. From the above tables it’s obvious that having the intersection is good because the Intersection Level of Service (LOS) is(C), regarding the effects of various types of movements on aaSIDRA results all movements except dummy and slave movements are considered when determining the intersection degree of saturation (largest degree of saturation for any movement), Performance Index (PI) in this case is 67.28 %. For the Delay and LOS rating is Acceptable and the level D in two legs and level C in others approaches as shown the figure 8,9 and 10.

ROUNDABOUT ANALYSIS SOFTWARE FOR BANDAR BARU BANGI

The table 12, 13 there are some items that are shown the impact of the roundabout and intersections on the traffic such as Intersection Level of Service, Average intersection delay, Degree of saturation and some more items. From the tables it’s obvious that having the roundabout is better than the intersection is very good result for analyzing the roundabout starting delay, stops, queues, capacities, flows. Based on the data analyzing from aaSIDRA, it is concluded generally that the direction, which begins from the north to the south (Bandar Baru Bangi Roundabout), has the best value for all consideration in aaSIDRA analysis than the others. The Roundabout Level of Service (LOS) is (B) it no change the cycle time and don’t add any lane in this roundabout Shown the results and description about roundabout as shown the figure 11,12,13 and 14 .

CONCLUSIONS

The aaSIDRA method emphasizes the consistency of capacity and performance analysis methods for roundabouts, sign-controlled, and signalized intersections through the use of an integrated modeling framework. Two main intersections are selected and analysis by the aaSIDRA software and then it is replaced by roundabout and analysis again. The results are shown that the roundabout it is better condition than intersection in UKM and Bandar Baru Bangi area. The next target for this study to analyse and rationalize the intersection and roundabout and the effect of that in the real situation and find out the impact of the increasing rationalization on the vicinity intersection and roundabout. A case study performance of a theoretical intersections with that of the existing traffic signal shows a significant rationalization in terms of stops, queue length and level of service and improvement to the cycle time and reduce into shorter time, To make the turn right lane become longer and more capacity of the leg, change the phasing sequences, using intelligent traffic control system.

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List of Symbols		
Symbols	**Description**	**Units**
C_0	Optimum cycle time in second	
D	Total delay due to traffic interruption	(veh-h/h)
H	Total number of stops	(veh/h)
Red	Bad	
h	Discharge head way	sec / veh
K	Stop penalty	
L	Lost time in one cycle which includes all read time and starts up delay	

Loss	Loss time associated with vehicle starting from rest at the first downstream signal (2_{sec})	
N'	Sum of the average queue length values for all lanes of the movement	
Q	Number of vehicles queued per lane in number of Vehicle	
qa	The arrival (demand) flow rate	
S	Vehicle speed	m per sec
$T_{(ideal)}$	Ideal offset	sec
Tu	Total uninterrupted travel time	(veh-h/h)
tu	The uninterrupted travel time	
w_1	Delay weight	
w_2	Stop weight	
w_3	Queue weight	
Y	Summation of critical flow ration with saturation Flows at all approaches.	

Table (1): Movements of the Degree of Saturation screen of GOSID.

Colour code	Rating	Degree of Saturation
Green	Very Good	Up to 0.75
Blue	Good	0.75 to 0.90
Magenta	Acceptable	0.90 to 0.95
Red	Bad	Above 0.95

Table (2): movements and approaches in the Delay & LOS screen of GOSID.

Colour code	Rating	LOS
Green	Very Good	A or B
Blue	Good	C
Magenta	Acceptable	D
Red	Bad	E or F

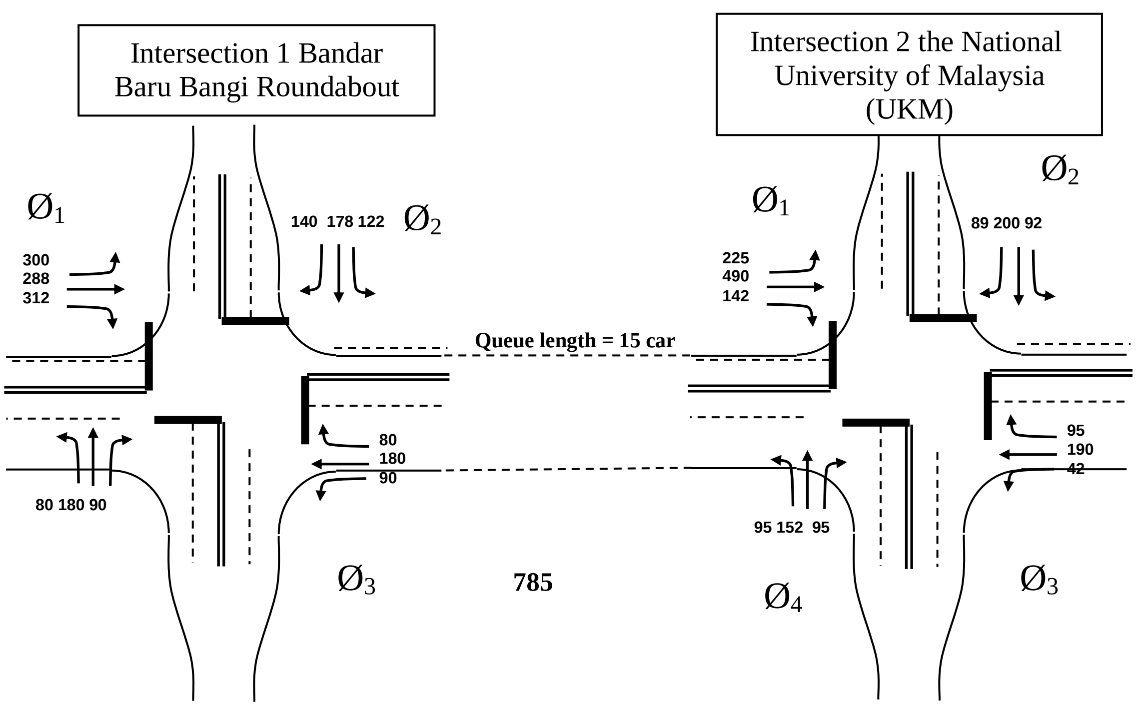
Table (3): Roundabout data in aaSIDRA.

	Range	Default
Central island diameter, D_c	4 – 250 m	20 m
Circulating road width, w_c	5 – 20 m	10 m
Number of circulating lanes, n_c	1 – 6	2
Extra bunching for approaches	– 50 to + 50 %	0

Table (4): The relationship between the circulating road widths (wc) and the number of circulating lanes (nc) [2].

Circulating Road Width wc (meters)	Number of Circulating Lanes (nc)
$4 \le wc < 10$	1
$10 \le wc < 15$	2
$15 \le wc < 20$	3

Figure (1): Plan Views of Bandar Baru Bangi Roundabout and UKM Intersection.



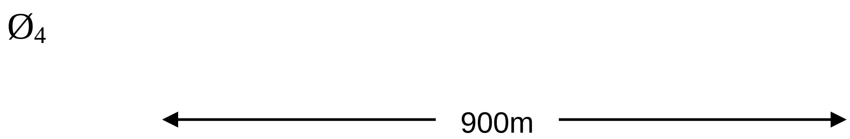


Figure (2): An illustration of two signalized intersections and Roundabout.

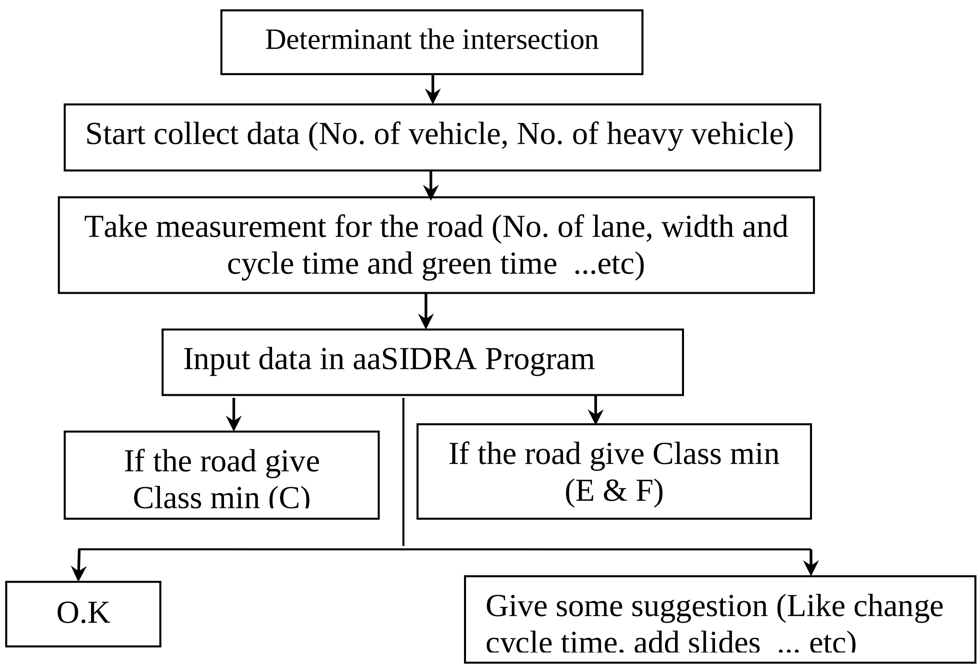


Figure (3): Flow chart showing the Main Procedure analysis.

Table (5): Estimate the effective green time in Intersection1 Roundabout Bandar Baru Bangi.

Phase	Left	Straight	Right	Total Actual Flow (a)	Saturated Flow pcu/h (v)	Y=a/v
Ø1	300	288	312	900	3600	0.25
Ø2	140	178	122	440	3600	0.123
Ø3	87	121	122	330	3600	0.092
Ø4	94	168	128	390	3600	0.108
						Y=0.573

Table (6): Classification of effective green for each intersection.

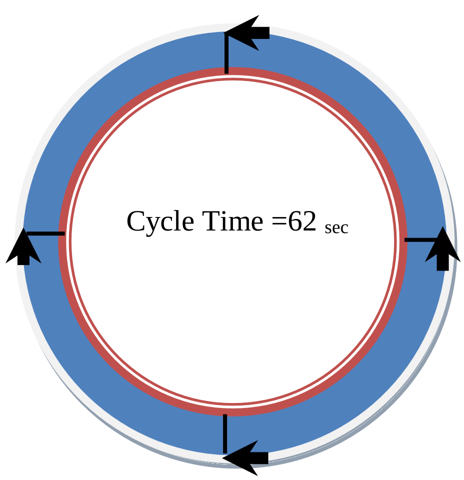
Phase	Y=a/v	Effective green time (sec)
Ø1	0.25	22
Ø2	0.123	11
Ø3	0.092	9
Ø4	0.108	10
	Y=0.573	52

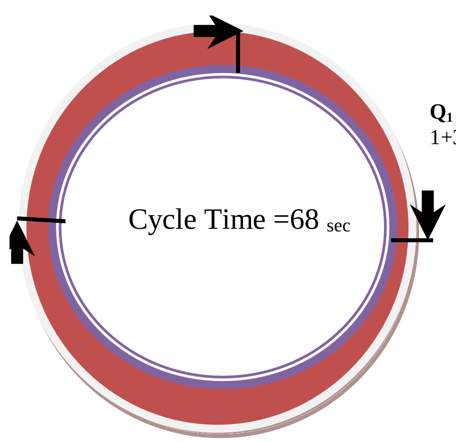
Table (7): Estimate the effective green time in Intersection2 (UKM).

Phase	Left	Straight	Right	Total Actual Flow (a)	Saturated Flow pcu/h (v)	Y=a/v
Ø1	225	490	142	857	3600	0.238
Ø2	89	200	92	381	3600	0.105
Ø3	95	190	42	327	3600	0.091
Ø4	95	152	95	342	3600	0.095
						Y=0.529

Table (8): Classification of effective green for each intersection.

Phase	Y=a/v	Effective green time (sec)
Ø1	0.238	21
Ø2	0.105	9
Ø3	0.091	8
Ø4	0.095	8
	Y=0.529	46





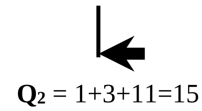


Figure (4). Signal Controller Setting.

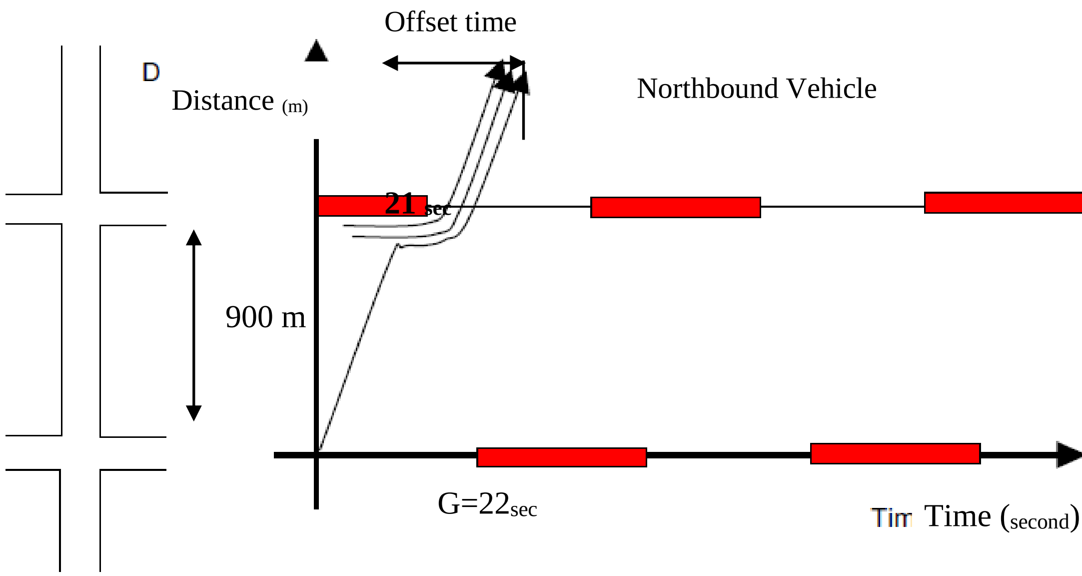


Figure (5): A Times-Space diagram for two intersections.

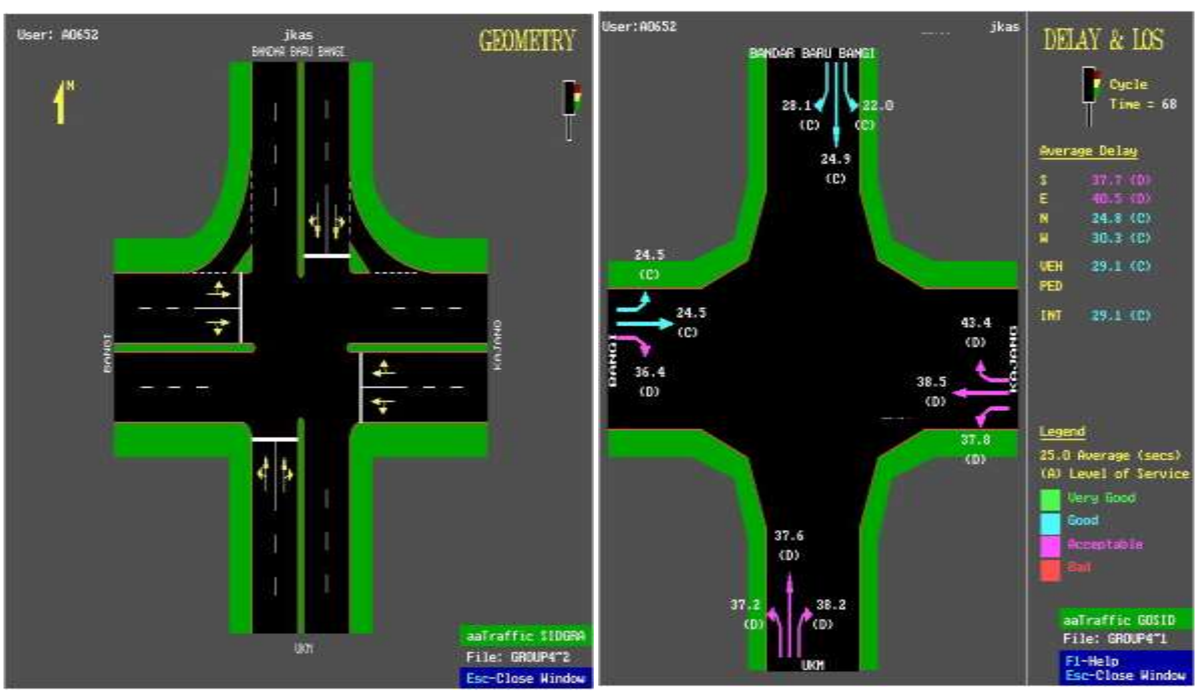


Figure 6: Intersection road UKM (main road)

Figure 7: Description delay and

- **Table (11) Parameters Used in Cost Calculations.**

Intersection Parameters	
Cycle Time:	= 68
Intersection Level of Service	= C
Worst movement Level of Service	= D
Average intersection delay (s)	= 29.1
Largest average movement delay (s)	= 43.4
Largest back of queue, 95% (m)	= 73
Performance Index	= 67.28
Degree of saturation (highest)	= 0.609
Practical Spare Capacity (lowest)	= 48 %
Total vehicle capacity, all lanes (veh/h)	= 2776
Total vehicle flow (veh/h)	= 1375
Total person flow (pers/h)	= 2063
Total vehicle delay (veh-h/h)	= 11.13
Total person delay (pers-h/h)	= 16.70
Total effective vehicle stops (veh/h)	= 1051
Total effective person stops (pers/h)	= 1577
Total vehicle travel (veh-km/h)	= 1581.0
Total cost ($/h)	= 967.92
Total fuel (L/h)	= 160.4
Total CO2 (kg/h)	= 401.04

Parameters	Results
Pump price of fuel ($/L)	= 0.850
Fuel resource cost factor	= 0.50
Ratio of running cost to fuel cost	= 5.0
Average income ($/h)	= 20.00
Time value factor	= 0.60
Average occupancy (persons/veh)	= 1.5
Light vehicle mass (kg)	= 1200
Heavy vehicle mass (kg)	= 8000

Level of Service (LOS).

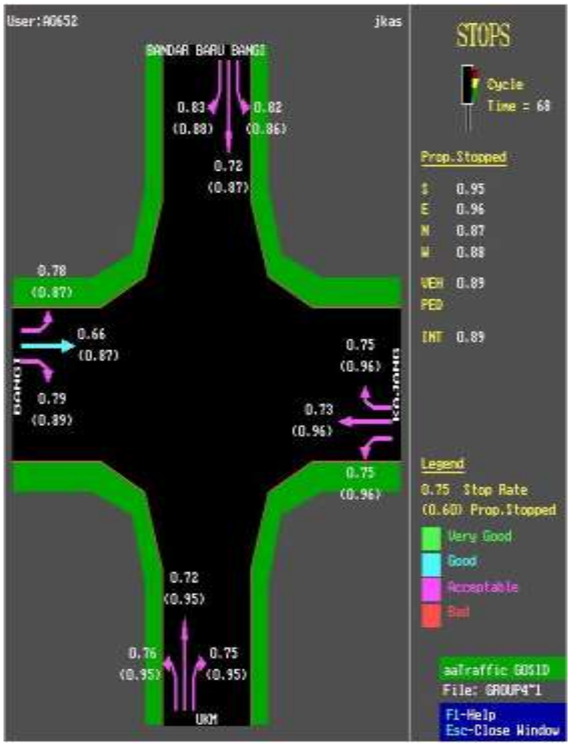
Table(10) Result For Case Study 1(UKM).

Table (12) Result for case study 2(Bangi).

Intersection Parameters Roundabout	
Cycle Time:	= 68
Intersection Level of Service	= B
Worst movement Level of Service	= B
Average intersection delay (s)	= 12.6
Largest average movement delay (s)	= 13.7
Largest back of queue, 95% (m)	= 40
Performance Index	= 122.57
Degree of saturation (highest)	= 0.645
Practical Spare Capacity (lowest)	= 32 %
Total vehicle capacity, all lanes (veh/h)	= 9038
Total vehicle flow (veh/h)	= 3937
Total person flow (pers/h)	= 5906
Total vehicle delay (veh-h/h)	= 13.73
Total person delay (pers-h/h)	= 20.59
Total effective vehicle stops (veh/h)	= 3149
Total effective person stops (pers/h)	= 4723
Total vehicle travel (veh-km/h)	= 4827.1
Total cost ($/h)	= 2568.74
Total fuel (L/h)	= 451.7
Total CO2 (kg/h)	= 1129.22

Table (13) Parameters Used in Cost Calculations.

Parameters	Results
Pump price of fuel ($/L)	= 0.850
Fuel resource cost factor	= 0.50
Ratio of running cost to fuel cost	= 5.0
Average income ($/h)	= 20.00
Time value factor	= 0.60
Average occupancy (persons/veh)	= 1.5
Light vehicle mass (kg)	= 1200
Heavy vehicle mass (kg)	= 8000



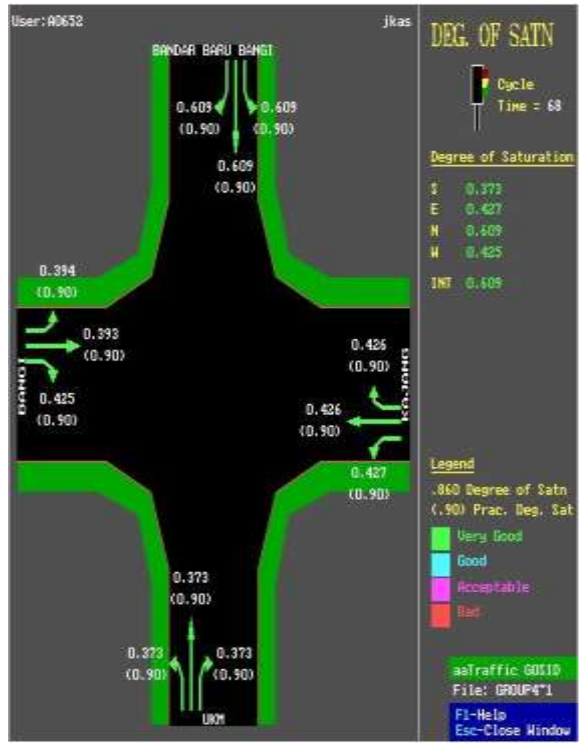


Figure (8): Description of Stops. **Figure (9): Description Degree of saturation**

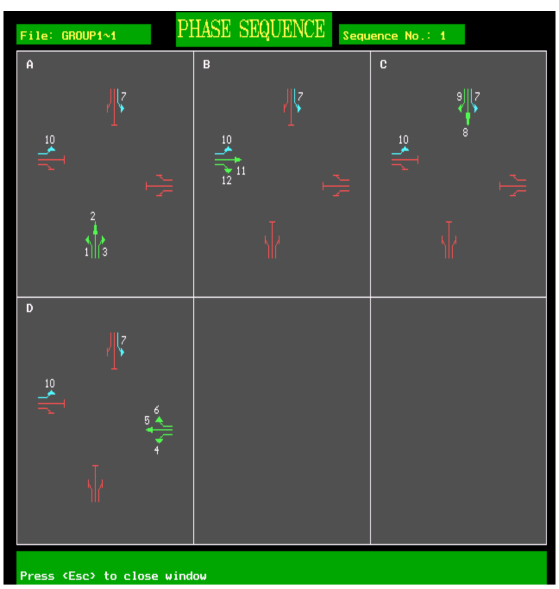


Figure 10: The Phase Sequence Analysis at the Intersection

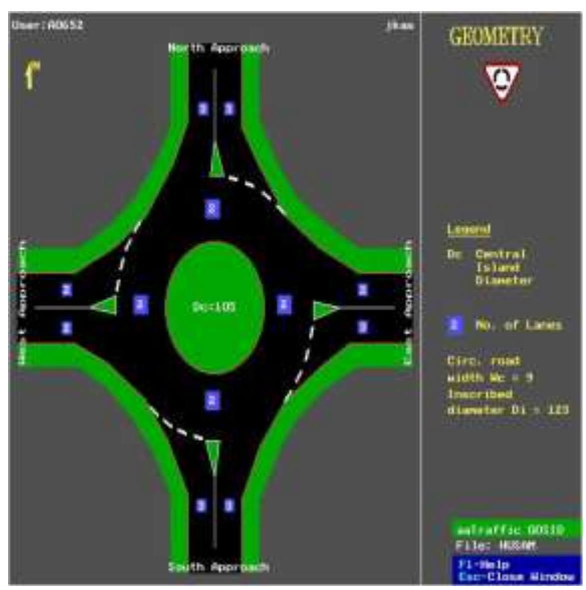


Figure11: Roundabout road Bandar Baru Bangi (main road)

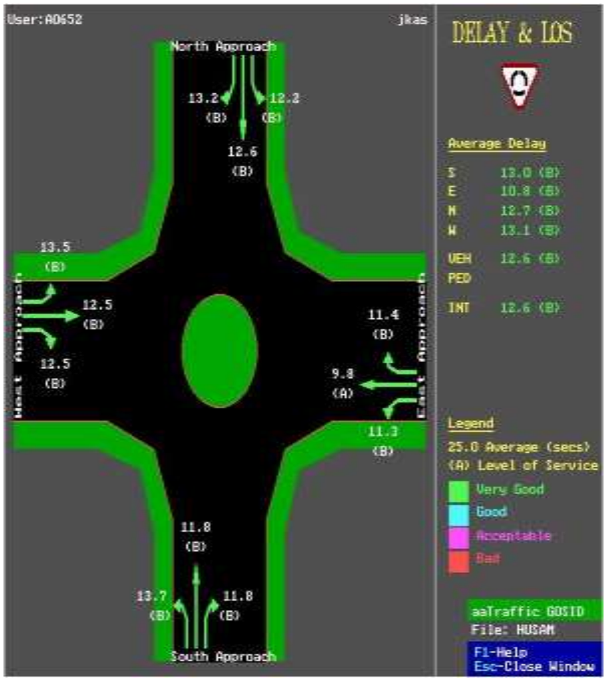


Figure (12): Description delay and Level of Service (LOS)

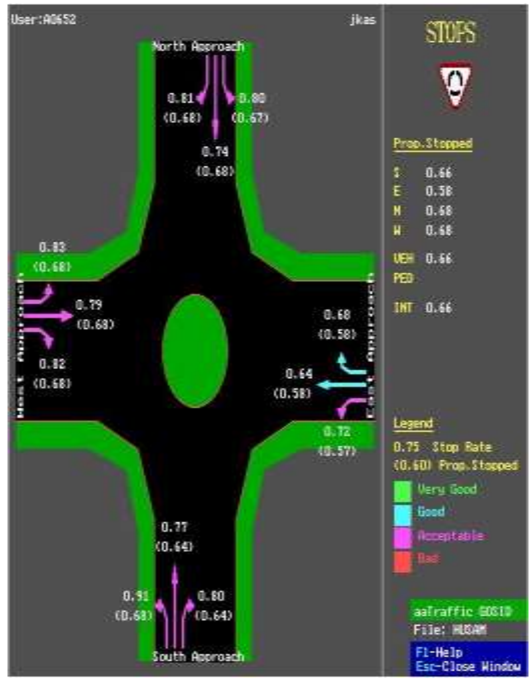


Figure (13): Description of Stops

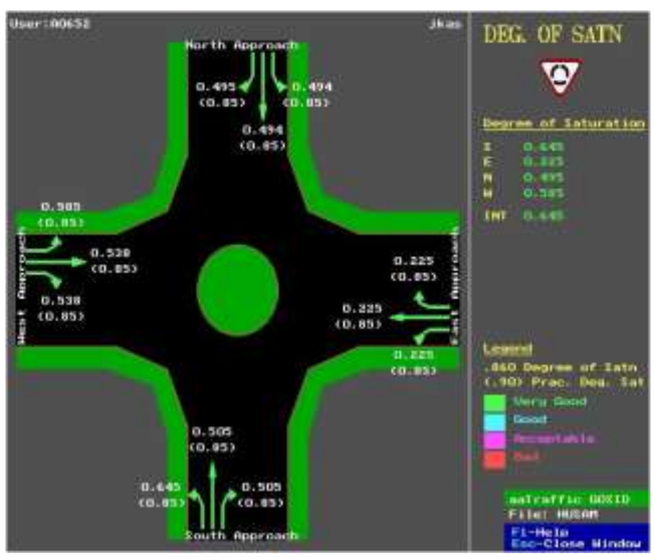


Figure (14): Description degree of saturation