COMPARISON OF A ROUNDABOUT MODEL USING AASIDRA AND PARAMICS

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ABSTRACT

Roundabout is a very popular traffic management tool in Australia for Secondary Arterial road to Local Streets. Design and analysis of Roundabout operation has been an issue for both traffic engineering practitioners and researchers until the aaSIDRA, the most popular analytical based software has evolved. Though it has the best performance among analytical models, it is not free from limitations in comparison with microscopic simulation models (i.e. PARAMICS). On the other hand microscopic simulation models tend to ignore capacity, the most widely used concept in traffic engineering practice. The reason behind is that, micro simulation models are based on different modelling paradigm (car following, queuing, acceleration etc). So it is often advised by researchers to calibrate microscopic simulation models using analytical models output data in the absence of real data. But to reflect the actual environment (unique geometry, public transport modelling*)* or adjacent effects, microscopic simulation model calibration can be also used to calibrate analytical models, which is one of the objectives of this study. Video observation has been conducted to collect approximate O/D pattern and queue length. Model calibration parameters were systematically changed to assess their impact on the results with respect to field observations. The conclusion of this study suggests about the comparability of some of the performances and parameters for both models. At the recommendation stage, some issues have been raised in improving the comparability through better calibrations.

Keywords: aaSIDRA, analytical model, PARAMICS, microscopic simulation model.

1. INTRODUCTION

Recent years have witnessed a genuine interest in the Australian states in using modern roundabouts as an effective and safer options as intersection control. Most of the roundabouts in Australia, especially in suburban areas, are installed because the following warrants i.e. speed calming, safety performance enhancement, improved traffic flow, less delay etc. But to satisfy the warrants it is of utmost importance to design and analyse roundabout models properly before implementation on site as a structure. The word ‘properly’ signifies as the best representation of the real observation in the virtual environment satisfying all the expected traffic operating outcomes.

Models available for roundabout analysis and design can be broadly classified into two groups: (1) analytical models; and (2) microscopic simulation models. Analytical models are also familiar as macroscopic models as these models represent isolated places (Stanek and Milam, 2005).

Analytical models are based on empirical observations that relate the roundabout capacity to traffic characteristics and roundabout geometry. In other words analytical models are based on gap acceptance theories that attempt to predict capacity on the basis of acceptable gaps and vehicle move up times at priority intersections.

In the U.S., a survey conducted by Jacquemart in 1998, showed that aaSIDRA was one of the most commonly used analytical roundabout analysis procedures. aaSIDRA was developed primarily for Australian operating conditions but has been expanded to include the UK regression equations as well as various gap acceptance models. Much of the information contained in the FHWA Report –Roundabouts, an Information Guide was based on analysis using aaSIDRA.

While analytical-type models are quite useful in the design and analysis of roundabouts, their major limitation lies in treating the roundabout as an isolated intersection. Attempts to account for platooning come mainly through the use of adjustment factors.

Microscopic simulation models allow the roundabout to be treated as a part of a system (i.e. network). They offer additional advantages, including realistic modelling of vehicle arrival and departures, the ability to study the spatial extent of queues, and more refined estimation of fuel consumption and emissions. Microscopic simulation models, however, must be calibrated first against field data or against other validated analytical models to ensure accuracy. This crucial step of calibration is unfortunately often neglected. Therefore the scope of this study is set to bridge a gap by considering lack of specific approaches for calibration of microscopic simulation models using reliable and calibrated analytical models.

For this purpose the operational as well as performance indicating parameters has been compared through altering a fixed set of influencing parameters for both the aaSIDRA and Paramics models. The influencing parameters are i.e. global minimum gap (paramics), link reaction factor (paramics), follow up headway (aaSIDRA), lane utilization ratio (aaSIDRA), queue space (aaSIDRA) etc. The performance / operational output parameters those have been compared are i.e. capacity, queue length, negotiation speed, circulatory flow and approach delay.

This study considers the calibration of both analytical (aaSIDRA) and microsimulation (Paramics) model for a roundabout situated at the intersection of Smart road and Reservoir road in Modbury in South Australia. Both the roads are collector roads and having a volume of about 3000 veh/day (Smart Rd) and 8700 veh/day (Reservoir Rd). Smart Road is connected with North-East-Road which is a major arterial road and reservoir road is a connector road between two major arterial roads, one is Grand-Junction Road and the other is North-East Road. The notable features of this area are i.e. nearby shopping centre entrance, international residence, hospital and very close intersection etc.

2. METHODOLOGY

Analytical model and microsimulation models have different paradigm in development and analysis procedures. In this research, aaSIDRA model has been done in a typical way through the input steps and the limited of geometric/functional parameter calibrations. On the other hand, Paramics model is developed in a more comprehensive way than aaSIDRA, and FHWA procedure has been followed. Some limitations have been observed for both the models while doing different types of detailing. These limitations will be discussed in later section of this paper.

For comparison of roundabout approach capacity, indirect method has been used to represent capacity from a microsimulation model, i.e. artificial continuous queuing condition has been imposed on the target approach keeping the condition same for other approaches.

For speeds, it has been assumed that speed in the circulatory links in paramics model can be compared with the negotiation speeds of aaSIDRA model. It has been assumed that the vehicles at the circulatory links remain in negotiation speeds. Again for the calculation of the negotiation speeds, the average of the three circulatory link speeds which can be traversed by a vehicle has been considered. In this case, the link just right to the first circulatory link in front of any approach is not considered. The basic reason behind this is that u-turning movements are not very frequent at this intersection.

As an example, the negotiation speed for approach 1 is the average speed of the circulatory speeds in links 3, 4 and 1 (refer to Figure 1). Circulatory link 2 is ignored in the calculation. In developing Paramics model, the average negotiation speeds from aaSIDRA has been used to form a similar input environment. The roundabout approach delay in this instance has been assessed by adding the total stop-line delay to the deceleration delay resulted in the approach delay. The deceleration delay has been assumed to be half of the acceleration/deceleration delay (Gagnon et al., 2008).

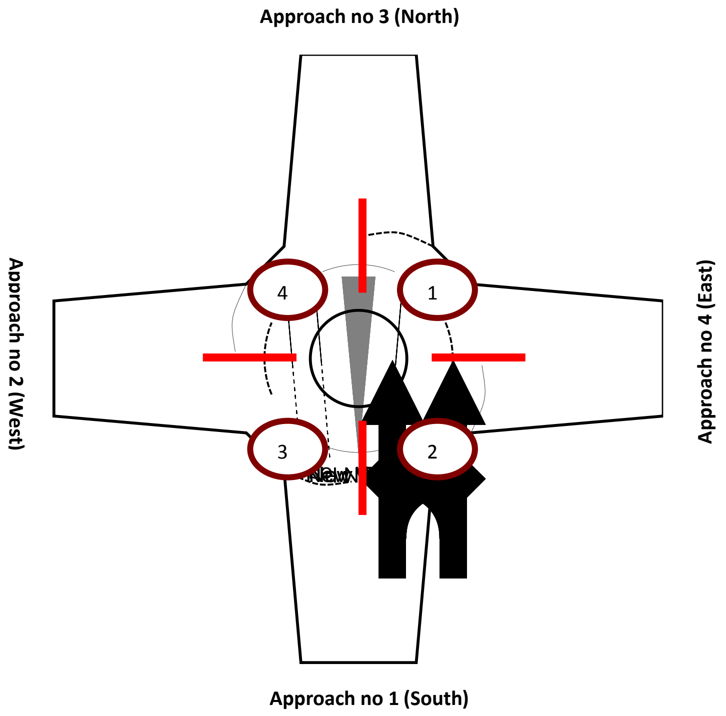

Figure 1 Roundabout Circulation Movements

For the circulatory flow calculations, only the circulatory links ahead of the considering approach has been taken into consideration. Therefore, it can be seen in Figure 1, to determine the circulating flow for the southern approach used in Paramics, the average flow in circulating link sections 2 and 3 has been used as a normal flow condition. While in aaSIDRA, the circulating flow values are provided for each movement associated with each lane, i.e. approache one has 2 lanes with 2 movements in each lane. As the opposing circulating flows for all movement of a specific approach are same so the total circulating flow can be calculated as 2 times of the opposing flow for a single movement. For queue length, maximum queue length in terms of meters and number of vehicle has been compared.

3. COMPARISONS

From Table 1, it can be seen that the southern approach has the maximum capacity of 1858veh/h in aaSIDRA, and for Paramics, the eastern approach has the maximum capacity of 1883veh/h. If the total capacity and total circulatory flow is compared then a very favourable match could be achieved.

From Table 1, it is also obvious that approach capacity and circulatory/opposing flow values for both paramics and aaSIDRA models are close and comparable to each other. The precision of the total capacity and total circulatory flows indicate the degree of success in the calibration effort. So, the capacity and circulatory flow can then have two common calibration parameters which can be shared by both models. It is to note that capacity is a performance parameter and circulatory/opposing flow is a gap acceptance parameter.

Table: 1 Capacity Comparison for Normal Demand Condition.

	aaSIDRA		Paramics	
Approach no	Approach Capacity (Summation of lane Capacities) (veh/hr)	Circulating flow (pcu/hr)	Approach Capacity (Summation of lane wise stop line counts) (veh/hr)	Circulating flow (pcu/hr)
1 (South)	1858	766	1879	953
2 (West)	1520	1422	1544	1160
3 (North)	1616	1502	1735	1186
4 (East)	1766	846	1883	985
Total	**6760**	4536	**7041**	4284

Table 2 represents the capacity comparison for both models and in the condition of demand being doubled (the result shown in the table is after recalibration of the aaSIDRA). When the demand increases the capacity decreases in other way. AS aaSIDRA model has been calibrated for 100% demand condition and the gap acceptance parameter has been altered to match Paramics simulation output, the parameters become user defined or constant. So those parameters need to be altered again to match the calibration condition.

After a few attempts, it has been found that, if the gap acceptance parameters are set as to be calculated by the program, a very good match with the paramics output is not unexpected.

From Table 2, it can be seen that the circulatory/exiting flow changes with the changes of gap acceptance parameters. But though the total opposing flow increased due to lowering the gap acceptance parameters, the total intersection capacity has been increasing too. This phenomenon can be described as that due to redistribution of flow values the overall capacity has been increased.

Table: 2 Capacity Comparisons for Doubling Demand Condition.

	aaSIDRA		**Paramics**	
Approach no	Approach Capacity (Summation of lane Capacities) (veh/hr)	Circulating flow (pcu/hr)	Approach Capacity (Summation of lane wise stop line counts) (veh/hr)	Circulating flow (pcu/hr)
1 (South)	1416	1624	1437	1791
2 (West)	720	2630	938	2036
3 (North)	1003	2374	1126	2068
4 (East)	1269	1544	1360	1823
Total	**4408**	8172	**4861**	7718

In this instance, both of the circulatory flows and capacity values are quite comparable. Moreover the comparison of the parameters for both 100% and 200% demand condition depict the validity of the calibration effort (conditional) as well as reliability of the parameters as common potential for mutual calibration.

Table 3 shows the maximum queue lengths generated from running both the models. It can be seen that the maximum queue length in Paramics is in the west approach at the value of 32.5m, and in aaSIDRA it is in the southern approach (32m). The minimum lengths are in the northern approach for both of the models. Paramics and aaSIDRA performed a very close match in the southern approach; the least match is in the western approach. In general, as shown in Table 3, the differences in the maximum queue lengths for both of the models are not significant.

Table 3: Comparison of Maximum Queue Length.

Approach number	**Maximum Queue Length**			
	aaSIDRA		**Paramics**	
	(m)	**(veh)**	**(m)**	**(veh)**
1 (South)	32	4.5	32.5	5
2 (West)	22	2.0	35.5	5
3 (North)	13	1.8	19.4	2
4 (East)	16	2.2	19.9	2

Another factor, which is considered as an important parameter in aaSIDRA is the negotiation speed. According to the aaSIDRA model specifications, the speed of the vehicles negotiating the roundabout, in other words, moving through the circular links (in Paramics), can be defined as the negotiation speed.

It is evidenced in Table 4 that the negotiation speeds from aaSIDRA and Paramics in circulatory links are comfortably comparable within the range of 4 - 5 km/h. Another notable characteristic of the negotiation speed is that this type of speed doesn't depend upon the demand condition. There is no traffic volume parameters presented in the negotiation speed formula in aaSIDRA model. From the result by Paramics, it can be seen that the speeds in circular links actually don not depend on the demand conditions. Another notable reason behind the difference in the average circular link speed is that, in aaSIDRA, the negotiation speed consists of some portion of approach speed, which appears after the transition from cruise speed to negotiation speed. While for Paramics, only circular link speeds has been taken into account as the negotiation speed.

Table 4 Comparison of Average Negotiation Speeds

Approach number	**Average Negotiation Speed from aaSIDRA (km/h)**		**Average Negotiation Speed from Paramics (km/h)**	
	100% demand	200% demand	100% demand	200% demand
1 (South)	34.733	34.67	39.51	38.52
2 (West)	34.7	34.53	38.73	38.42
3 (North)	34.43	34.33	40.66	40.46
4 (East)	34.7	34.47	38.63	38.89

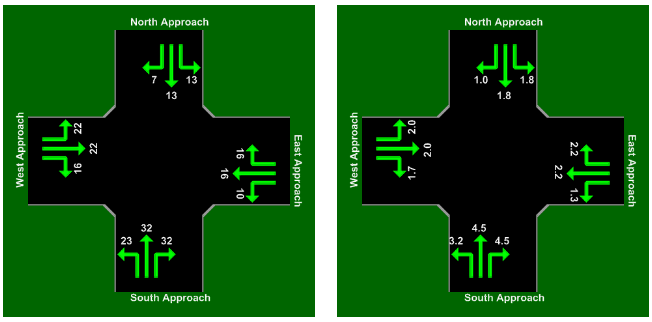

Figure 2 aaSIDRA Queue Length in Metres and Number of Vehicles

Figure 2 represents aaSIDRA output on delay situation for all 4 approaches, with the left part shows the queue in metres and right part in number of vehicles.

Delay is always one of the most important performance measurements in evaluating intersection. The models' outputs on link delay for Paramics and approach delay for aaSIDRA are listed in Table 5. It is clear that for all approaches, aaSIDRA produced higher delays than that for Paramics.

Table 5: Comparison of Approach Delay.

Approach number	Delay	
	aaSIDRA (approach delay = stop line delay + ½ of acceleration-deceleration delay) s/v	**Paramics (Sum of link delays) in seconds**
1 (South)	11.55	7.8
2 (West)	11.7	9.6
3 (North)	9.85	8.9
4 (East)	10.1	7.8

Before the comparison, it should be noted that for Paramics the link delay calculation includes of all links (both directions in one approach) has been taken into account. The differences in delay values may have originated due to the following reasons:

- During model development, Paramics uses graphical input process with which nodes have been located according to the street network overlay so the approach links may become a little shorter or longer than expected. As Paramics model calculates link DELAY following the free flow time parameter which is a function of link length, in this case a smaller than expected link delay may have been generated.
- The approach followed to calculate the approach delay value used in aaSIDRA may need some more actuation.

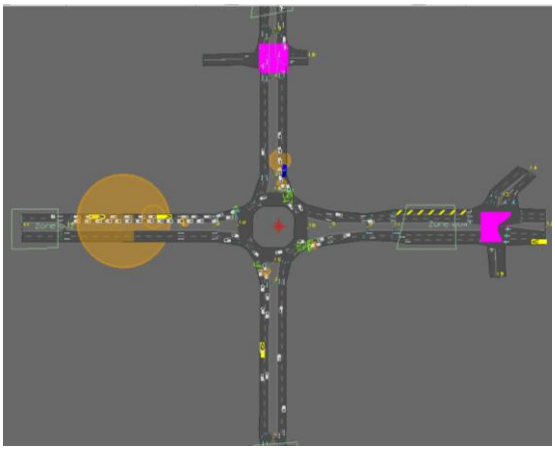

Figure 3 Vehicles Queuing in Paramics

Figure 3 demonstrates one of the running phase screens of Paramics, which shows the queue situations for all roundabout approaches. It can be seen that the west approach experiencing the maximum queue length. This process could help modellers in observing the performance of the model.

The maximum delay for both of the models is in the western approach which is 11.7 seconds /vehicle for aaSIDRA and 9.6 seconds for Paramics respectively. Largest difference is in the southern approach. Models generated the minimum delays for different approaches .i.e. for paramics it is both southern and eastern approach and for aaSIDRA it is the northern approach.

4. CONCLUSIONS

As mentioned earlier that analytical and microsimulation models have different base paradigms. But directly or indirectly both the models tend to evolve as effective performance evaluation tool. The conclusions are as follows:

- The parameters first compared are capacity and circulating flow/exiting flows. It is found that for the data collected, the capacity values from both the models are almost the same. The circulatory flows are also within an acceptable range (apparently). There has been another comparison for the same parameters with the same input data but with doubled demand values. In this case the capacity values have been found quite different though the circulatory flow values are almost the same apart from the northern approach. So to minimise the differences between capacity values, aaSIDRA gap acceptance parameters should be calibrated and then the capacity values are quite comparable. The circulatory flow for the northern approach has been found within allowable range too.
- A very important and effective intersection performance parameter of queue length has been the next parameter considered in the model comparison process. It has been found that the queue length from Paramics output are larger than that from aaSIDRA. Though the difference is not significant, for more accuracy peak hour conditions, more detailed calibration should be conducted, such as gap acceptance.
- It has been found that aaSIDRA tends to demonstrate higher delay values than that measured by Paramics. The highest difference has been found in the southern approach.
- Although aaSIDRA and Paramics used different techniques describing speeds, it found that the negotiation speeds are quite similar with some minor differences
- As the negotiation speed in aaSIDRA does not depend on traffic volume/trip distribution conditions, there is a negligible change in the negotiation speed. So it can be concluded that the changing in circular link driver behaviour will change the negotiation speed as well as other parameters associated with the negotiation speed. In the newer version of aaSIDRA, the roundabout geometric parameters, i.e. turning radius, superelevation etc. can be altered to match the negotiation speed. In this instance, link speed, target headway factor as pertinent of driver aggressiveness, change in Z coordinates of nodes to provide superelevation etc. may be recommended to achieve more accuracy.

As mentioned in the comparisons section, the differences between the queue lengths determined by aaSIDRA are not significantly lower than the generated values in Paramics. When at the doubled demand condition, the queue length has been found unmatched between the two models. Another important source of this difference is the releasing percentage of heavy vehicles in both models.

In aaSIDRA, a percentage or total number of heavy vehicles according to turning distribution is adopted; it is different from that in Paramics. This phenomenon largely contributes to the differences because lengths/reactions of heavy vehicles are more than cars/light vehicles which can change the queue lengths significantly. There are scheduled vehicles such as public transports, number of busses and their trip distributions have been considered in Paramics; while aaSIDRA does not have this function. All these could be the reasons behind the different results generated by the two models.

It is recommended more calibrations for more sites should be conducted to look for the best calibration parameters under different traffic conditions.

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