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Evaluating Innovated Intersection Treatments and Quantifying their Benefits Over the Conventional Intersection Designs

By

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DECLARATION

I certify that this thesis:

1. does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any university.
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Print name of Principal Supervisor......Dr.Nicholas Holyoak..

Date.........................28-05-2024.............................

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EXECUTIVE SUMMARY

This thesis investigates the critical issues of road safety and traffic congestion at signalized intersections in Adelaide, with a focus on the Greenhill Rd-Goodwood Rd intersection, one of the city's busiest intersections. The study explores the potential benefits of Partial Continuous Flow Intersections (CFI) to mitigate these problems, aiming to reduce average delays, improve the level of service (LOS), lower emissions, and decrease fuel consumption and vehicle cost.

Chapter 1 introduces the problem, highlighting the significance of intersection congestion in urban traffic delays and accidents. It explains the need for innovative solutions in metropolitan areas like Adelaide, where right-turn accidents at signalized intersections are prevalent.

Chapter 2 reviews the literature on intersection designs and traffic management systems, particularly the Sydney Coordinated Adaptive Traffic System (SCATS). This chapter establishes the foundation for understanding the current traffic challenges and the potential benefits of implementing CFIs.

Chapter 3 outlines the methodology, detailing the use of SIDRA and AIMSUN software for simulating and evaluating the CFI design. The chapter describes the data collection process, including the analysis of SCATS vehicle count data and on-site surveys during peak traffic hours.

Chapter 4 presents the results and discussion, demonstrating significant reductions in average delays with the CFI design. For instance, PM peak delays on Goodwood Rd North were reduced from 273.2 seconds to 29.5 seconds. The chapter also shows improvements in LOS, reductions in fuel consumption, and lower CO_2 emissions. Emphasizing the positive impact of CFIs on traffic flow and safety. It acknowledges limitations such as the reliance on simulation data and suggests areas for future research.

Chapter 5 conclusion, summarizing the main findings and their implications for urban traffic management. The study confirms that CFIs can effectively enhance intersection efficiency and safety, offering valuable insights for transportation engineering and urban planning.

Overall, this thesis contributes to the field by providing evidence on the benefits of innovative intersection designs, supporting their application to improve urban mobility and reduce traffic-related issues.

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1. INTRODUCTION

1.1 Project Background

Intersections are critical components of an efficient and safe transportation system, significantly impacting traffic flow and congestion management, limiting the network's overall capacity. According to researcher YU, WANG and GONG primarily intersection congestion done by the traffic delays and accidents, contributed to over a third of urban road traffic delays and accounted for 50% of traffic accidents (Yu, 2013).

The issue of road safety and traffic congestion in South Australia is increasing day by day, particularly at signalised junctions where right-turn accidents are common. South Australia has 1.2 million residents and has a serious concern about road safety because traffic accidents account for 80% of injuries. This trend is particularly happening in metropolitan areas like Adelaide, where city driving characterized by many intersections, high traffic volumes, increase the number of collisions, especially during right-turn movements.

The intersection of Greenhill Rd-Goodwood Rd is in top 40 busiest intersection in Adelaide with 69,400 vehicles/day (Home | Data.SA). It also spots where a lot of crashes happen. From the Crash report of government of South Australia (2018-2022) there were 107 crashes happened (Home | Data.SA). The cost of accidents around 12.5 million dollars. The method to find the cost of accidents are shown in social cost of crashes (Bureau of Infrastructure and Transport Research Economic, 2022). Cost Since accidents happen and people require medical attention, emergency services must respond, and vehicles and signals need to be fixed. Therefore, crashes creating impact not just on road but also in community.

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Figure 1: Existing Intersection of Greenhill Rd-Goodwood Rd

To overcome the problem of crashes, average delay, intersection safety and efficiency this research project proposes the evaluation of an innovative intersection design known as Partial Continuous Flow Intersections (CFI). A continuous flow intersection is an innovative intersection that allows vehicles to travel more efficiently through an intersection. CFI enhances safety and increases traffic flow through intersections by allowing Right-turning traffic and through-traffic to move simultaneously. CFI offer unique feature such as right-turn crossover, reduction in average delay, improve the environment by reducing emission and fuel consumption, aimed at reducing conflict points and improving traffic flow. The characteristics of these new intersection designs are the relocation of some vehicle movements from their usual stop line location to some other secondary locations. One example of such design can be seen in the figure 2.

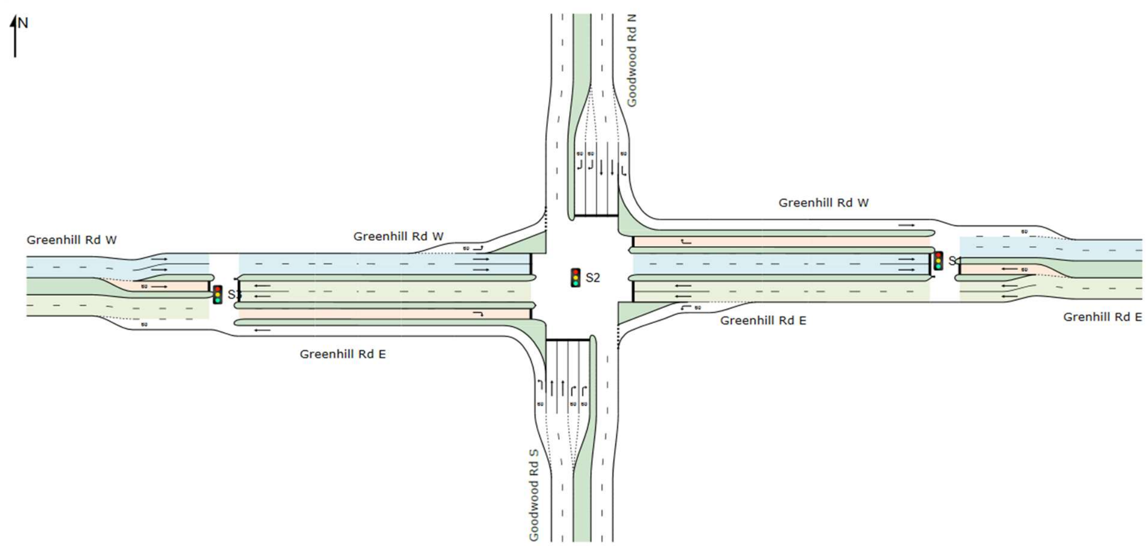

Figure 2: Partial CFI Design on Greenhill Rd-Goodwood Rd

1.2 Project Aim

This research focuses on the development and evaluation of a new innovative intersection design known as Continuous Flow Intersections (CFI) using SIDRA and AIMSUN software. The primary objective is to compare the benefits of CFI against existing intersection configurations. In this research, one of the busiest and accidental prone intersection selected and developed in software and compare the results. The aim of this study is established before the undertaken study and described below-

- The aims of this research are to evaluate and developed one of the innovated intersection designs called “**Partial Continuous Flow Intersections” (CFI)** on some of the Adelaide’s busiest intersections and their performance compared to the existing intersection.
- Possible savings in the vehicle accidents will be calculated using current Australian crash costs for different crash types.
- The study aims to archive minimum 15% reduction in Average delay during AM peak and PM peak.
- In this design Key intersection performance indicators, such as Average delays, level of service, emissions, Fuel cost, Vehicle cost etc. will be used in the interaction performance for comparison.

The main aim of this research is to reducing Average delay, emission, fuel cost, improving the level of service (LOS), and it can be archived through sated aim and results in the thesis.

1.3 Report Structure

Chapter 1 is the introduction. It provides general background of the thesis.

Chapter 2 is literature review, provides the finding of research.

Chapter 3 is methodology. It provides step by step guide on data collection, Data analysis, modelling in SIDRA. Furthermore, model developed in AIMSUN software to demonstrate the movement of vehicles in new design.

Chapter 4 is results and discussion. It represented the results of SIDRA software. In this section, existing intersection results compare with new intersection. Key parameters including average delay, level of service, emissions, fuel costs, and vehicle cost etc. examined.

Chapter 5 is conclusion. It concludes the all-research work and also provides the future work on Continuous flow intersection.

2. LITERATURE REVIEW

The literature review aims to highlights the significance of this research, which focuses on developing an innovative design known as the partial continuous flow intersection (CFI) and comparing its benefits with those of conventional designs. The Greenhill Rd-Goodwood Rd intersection has been selected as the case study for this research. Furthermore, this literature review emphasizes the importance of this study and justifies it by presenting existing research on CFIs. The findings highlighted in this review are crucial for advancing new, innovative intersection designs.

2.1 Traffic Congestion

In Adelaide the traffic increase day by day. A study conducts by department of transport and regional service according to them in Adelaide car traffic increases by 18% every year (Department of trasport and regional service). Traffic congestion on main roads is becoming increasingly common for drivers, particularly in central business district (CBD) areas. This growing issue significantly impacts daily commuting and overall urban mobility, highlighting the need for innovative solutions to manage and alleviate traffic flow (urban transport crowding and congestion). Australia's national urban arterial roads have historically provided a high level of service for all road users, including commuters, business travellers, freight vehicles, and public transport. However, in recent years, increasing traffic volumes have caused many urban at-grade arterial roads to reach capacity. This growing congestion is expected to worsen in the future, with traffic volumes projected to rise further. (COUNCIL OF AUSTRALIAN).

When travel demand surpassing road capacity, traffic congestion is most commonly defined. From the perspective of delay-travel time, congestion happens when a high vehicle density disrupts the regular flow of traffic, increasing the journey time. Additionally, congestion can be defined by the increased cost to road users due to the disruption of normal traffic flow. (Afrin). The reduction in delay can also help to reduce the emission and fuel cost and social cost.

2.2 Emission and fuel consumption

Fuel consumption and emissions are another important factor for traffic signals. Growth in traffic is directly related to the fuel and environmental issues. Transport network system is the third largest emission producer in Australia, with emissions from transport increasing nearly 60% since 1990. (Transport emissions). In Adelaide, traffic increase on year 18% from 2002 to 2020. As a result, the traffic in Adelaide city increases by 33% in coming years. It is simple fact that if traffic increase then emission will increase (Department of trasport and regional service). Fuel consumption traffic system can be reduced by increasing fuel economy, giving alternative innovated intersection design, and optimizing traffic control measurement. Fuel consumption depends on vehicle type, road geometry, traffic control efficiency. (Liao, 1998). According to Sangjun Park and Hesham Rakha they perform simulations using the INTEGRATION and VISSIM tools. It was discovered that CFIs enhance operations, resulting in fuel savings and a reduction in emissions. Energy savings were calculated using the VISSIM and INTEGRATION models, providing results of 5% and 11%, respectively. It is expected that emissions will decrease by 1% to 6% (Park, 2010).

2.3 Simulation Modelling

SIDRA is a software programme that is frequently used in transportation planning and traffic engineering to analyse the operation of road networks and intersections. "SIDRA Intersection" is the term for the product created by Akcelik & Associates Pty Ltd.

SIDRA Intersection is a microanalytical traffic evaluation tool used to aid in designing and evaluating intersection. Department of infrastructure and transport also using this software for evaluating intersections. According to a researcher Seonyeong Cheong, Saed Rahwanji, and Gang-Len Chang they developed CFI design in SIDRA to check the results of intersection how intersection performed. According to them It is worth mentioning that CFIs have been said to cut down on traffic delays by 64% and wait times by 61% during rush hours (Cheong, 2008). Analysing traffic in software offers many advantages such as showing average delays, eliminate the need conduct on-site, evaluation of traffic flow, evaluating peak and non-peak conditions. (Dia 2011).

2.4 SCATS (Sydney Coordinated Adaptive Traffic System)

Sydney Coordinated Adaptive Traffic System (SCATS) is an advanced traffic management tool used to control and coordinate signals at intersection. This system is developed by Roads and Maritime Services (RMS) of New South Wales, Australia. SCATS system is based on algorithm and collect real time data from the signals. In this research, the Sydney Coordinated Adaptive Traffic System (SCATS) count data is utilized for vehicle counting purposes in the modelling process.

SCATS system collects real time data from various sources such as loop detectors in road surface, video camera and some other sensor. Based on real time data SCATS automatically adjust the timing of traffic signal to optimise traffic flow and reduce congestion. SCATS managed traffic flow more efficiently, SCATS can contribute to improved road safety by reducing collision at intersection. SCATS adopt change traffic conditions in real-time, responding to incidents, special events, and fluctuations in traffic volume.

2.5 Previous study on Continuous Flow Intersection.

2.5.1 Average delay

Dr. P. Vedagiri and Shikhar Daydar claim that in order to understand how CFI reduces traffic in Indian towns, computer simulations are used. The statistics indicated that both NFI and CFI experienced longer delays as traffic volumes increased, but that NFI's rate of delay growth was significantly higher than CFI's. This showed that the CFI was more effective than the NFI, which in every case had average delays that were 30% to 60% shorter. (Vedagiri, 2012). Using VISSIM software, Michael D. Fontaine compares the CFI with regular at-grade modifications and a Single Point Urban Interchange (SPUI) in Norfolk, Virginia, considering the expected amount of traffic during peak hours in 2030. According to the findings, it may reduce delays by up to 50% at a cost that was only 10% more than that of conventional techniques. (Fontaine, 2009).

2.5.2 Ecological benefits

Energy conservation and reducing emissions in transportation have become very important as urban traffic congestion increases. Continuous Flow Intersections (CFIs) can make traditional intersections more efficient, especially when there is a lot of left-turn traffic. CFIs eliminate the need for a separate left-turn signal phase, reducing traffic delays by shortening the signal cycle and making better use of the intersection's space and time. According to Na WU, Yating LIU CFI reduce the length of the lines was reduced by over 41%, while energy and pollution emissions were reduced by nearly 8%. (Wu, N., & Liu, Y. (2023).

3. METHODOLOGY

3.1 Data Collection

Data Collection task performed using SCATS count from flinders data base and conducting site visit. In this database flinders student have a access of intersection drawing, phasing and timing of signals, lane configuration and many more.

3.1.1 SCATS Count

Flinders university developed a comprehensive SCATS Database offering students access to data from over 600 traffic signals for conducting traffic analyses. SCATS count of TS067 intersection which is Greenhill Rd-Goodwood Rd intersection already available. The SCATS Operation sheet data serves as the operational blueprint for traffic signals, providing crucial insights into signal phasing, turning movement operations, and phase percentages during peak periods. These operational parameters were meticulously analysed to inform the modelling of traffic signals at each intersection.

furthermore, the SCATS vehicle count dataset furnishes detailed traffic counts at 5-minute intervals for the year 2017 at each intersection. This dataset is derived from detectors positioned in every lane, which activate upon vehicle passage. These detectors serve as invaluable tools for capturing real-time traffic flow. The data of SCATS count 2017 for site TS067 is shown below-

Site: 67 Wednesday, 15 November 2017 Traffic Flow filename:WESTAD_20171115.

On Wednesday, 15 November 2017
Approach: Approach 1, Detector(s): 1-18

	00:	01:	02:	03:	04:	05:	06:	07:	08:	09:	10:	11:
:05	28	8	4	4	12	38	110	236	344	363	244	282
:10	33	13	10	9	14	50	143	326	399	392	327	332
:15	22	12	11	10	12	38	121	298	362	382	274	278
:20	24	17	6	5	9	53	149	327	431	397	273	277
:25	21	8	6	8	19	67	154	329	349	357	257	263
:30	18	7	2	9	16	61	182	383	392	412	273	319
:35	15	5	5	12	31	59	173	359	359	329	251	280
:40	8	9	6	9	26	102	209	383	396	349	253	317
:45	22	9	15	14	32	98	229	431	354	304	220	296
:50	17	16	11	8	41	119	276	466	330	336	306	356
:55	11	12	7	11	38	93	206	393	338	254	258	323
:60	14	8	2	12	42	89	251	428	401	326	272	320
Hourly Total	233	124	85	111	292	867	2203	4359	4455	4201	3208	3643

AM Total: 23781 AM peak 4750 07:45 - 08:45

	12:	13:	14:	15:	16:	17:	18:	19:	20:	21:	22:	23:
:05	319	345	266	310	384	358	365	193	149	133	146	61
:10	307	325	263	362	369	454	396	235	175	133	128	56
:15	312	320	308	335	391	421	327	226	170	160	119	58
:20	330	321	319	360	495	462	341	185	144	127	87	57
:25	315	350	293	348	417	411	270	206	158	126	116	53
:30	337	376	307	358	453	425	315	192	148	140	118	49
:35	291	382	322	368	400	367	279	183	164	128	73	40
:40	319	376	320	385	439	412	248	171	145	144	73	33
:45	328	332	319	389	410	428	249	197	155	118	80	27
:50	314	337	353	378	453	406	188	186	186	160	63	32
:55	364	286	312	373	386	381	225	193	134	113	73	36
:60	359	271	333	372	444	424	244	182	111	115	64	-
Hourly Total	3895	4021	3715	4338	5041	4949	3447	2349	1839	1597	1140	502

PM Total: 36833 PM peak 5130 16:15 - 17:15

Figure 3: SCATS count for Greenhill Rd-Goodwood Rd intersection.

3.1.2 Site Survey

For calculating real-time vehicle count of the intersection, two peak time taken AM peak and PM peak. Based on the SCATS count 2017 time period for AM peak is 8:00 to 9:00 in the morning and for PM peak 4:00 to 5:00 in the evening. The reason behind choosing this time because in this time frame the greatest number of vehicles passing.

To gather data, we installed video cameras and recorded footage during both the morning (AM) and evening (PM) peak hours. Each approach to the intersection was thoroughly filmed for one hour during these peak periods. This approach ensured comprehensive coverage of traffic flow from all directions, enabling detailed analysis of vehicle movements, any congestion patterns.

Figure 4: Site Survey on Goodwood Rd

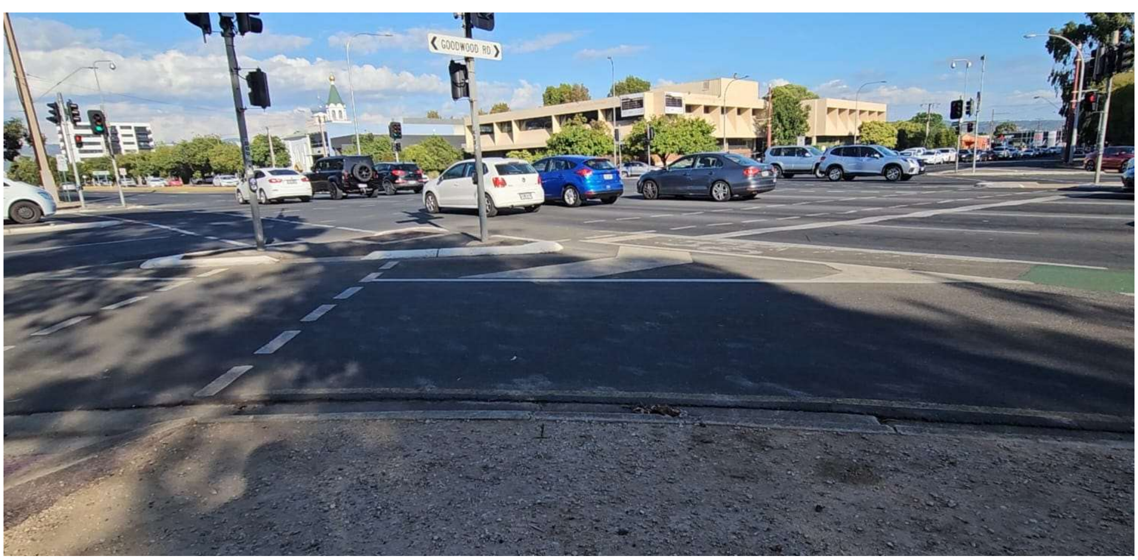

Figure 5: Site Survey on Greenhill Rd

3.2 Data Analysis

In-depth data analysis conducted in this study revealed significant findings. Through SCATS count data examination, it was observed that the morning (AM) peak hours, specifically from 8 to 9 AM, and the evening (PM) peak hours, from 4 to 5 PM, experienced the highest volume of vehicle traffic. This information is visually represented in Figure 3. During the AM peak, a total of 4750 vehicles were recorded passing through the intersection, while during the PM peak, the count reached 5130 vehicles, resulting in a combined total of vehicle passages.

The on-site survey further supplemented our data collection efforts, providing additional vehicle count details as presented in Table 1 and Table 2. These tables offer a comprehensive overview of the observed vehicle counts at the intersection. In real-time data analysis, it was determined that during the morning (AM) peak period, 5396 vehicles passed through the intersection, while during the evening (PM) peak period, 5459 vehicles approached the intersection.

Table 1: Real-time count AM peak 8:00 to 9:00 AM

TS067	8 to 9	AM					
		Turns	**Detector**	**Count**	**Car (95%)**	**Truck (5%)**	**Total**
					0.95	0.05	
	Goodwood North	Straight	2,3	257	244.15	12.85	619
		Right	4	44	41.8	2.2	
		Left		318	302.1	15.9	
		Bus lane	1	3			
	Greenhill East	Straight	14,15,16	1341	1273.95	67.05	1740
		Right	17,18	170	161.5	8.5	
		Left		229	217.55	11.45	
	Goodwood South	Straight	5,6	571	542.45	28.55	1444
		Right	7,8	667	633.65	33.35	
		Left		206	195.7	10.3	
	Greenhill West	Straight	9,10,11	1423	1351.85	71.15	1593
		Right	12,13	158	150.1	7.9	
		Left		12	11.4	0.6	

Table 2: Table 1: Real-time count PM peak 4:00 to 5:00 AM

TS067	4 to 5	PM					
		Turns	**Detector**	**Count**	**Car (95%)**	**Truck (5%)**	**Total**
					0.95	0.05	
	Goodwood North	Straight	2,3	661	627.95	33.05	1069
		Right	4	22	20.9	1.1	
		Left		378	7.6	0.4	
		Bus Lane	1	8			
	Greenhill East	Straight	14,15,16	1384	1314.8	69.2	1890
		Right	17,18	180	171	9	
		Left		326	309.7	16.3	
	Goodwood South	Straight	5,6	421	399.95	21.05	935
		Right	7,8	390	370.5	19.5	
		Left		124	117.8	6.2	
	Greenhill West	Straight	9,10,11	1249	1186.55	62.45	1565
		Right	12,13	300	285	15	
		Left		16	15.2	0.8	

3.3 SIDRA Modelling

Intersections, priority junctions, and signalised intersections are only a few of the features that SIDRA provides for modelling different kinds of intersections. To simulate and assess the operational effectiveness of intersections, users can input factors including traffic volumes, signal timings, lane configurations, and geometric design features.

In SIDRA modelling, two peak traffic periods, morning (AM) and evening (PM), are selected. The initial step involves creating the existing model for the Greenhill Rd-Goodwood Rd intersection, concentrating on both AM and PM peak times. Subsequently, a future scenario is developed for 10-years ahead to assess the potential worsening of traffic flow conditions. Following this analysis, a partial continuous flow system is designed exclusively for Greenhill Road during both peak periods. Refer Appendices for all SIDRA model figures.

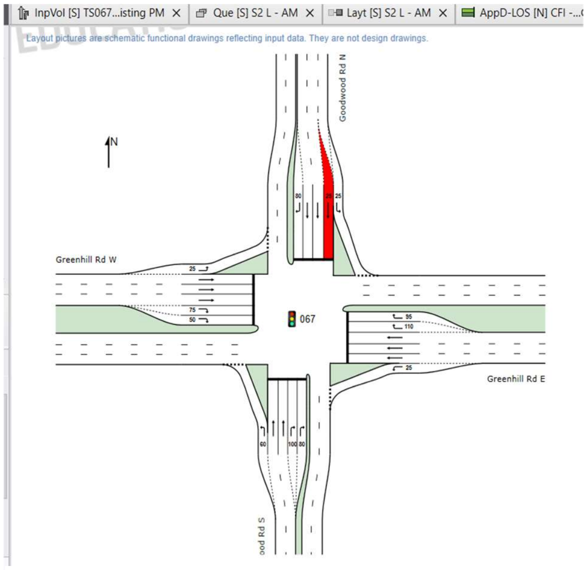

Figure 6: Existing Intersection

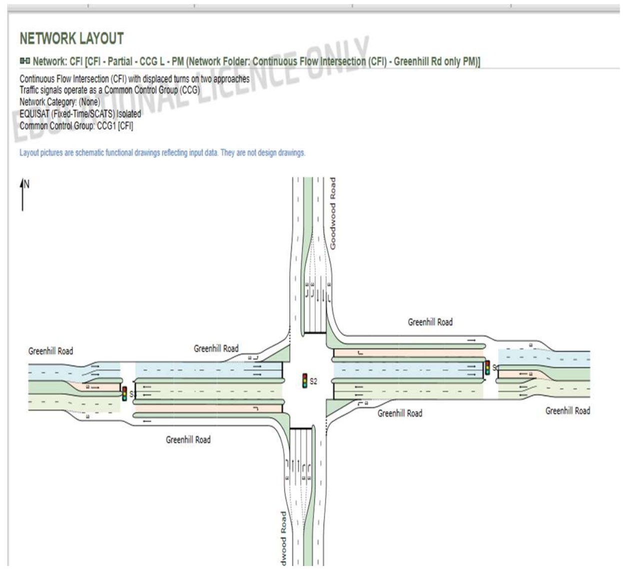

Figure 7: Partial continuous flow intersection design at Greenhill-Goodwood Rd

3.3.1 Intersection geometry

The geometry of the Greenhill Rd-Goodwood Rd intersection, as provided by the Flinders database, is showing in Figure 8. All parameters such as the site name, lane configurations, leg geometry, approach distances, and other crucial details are represented in the drawing, which is then inputted into the intersection dialog box within the SIDRA software for modelling. Refer to Appendices for an illustration of this dialog box.

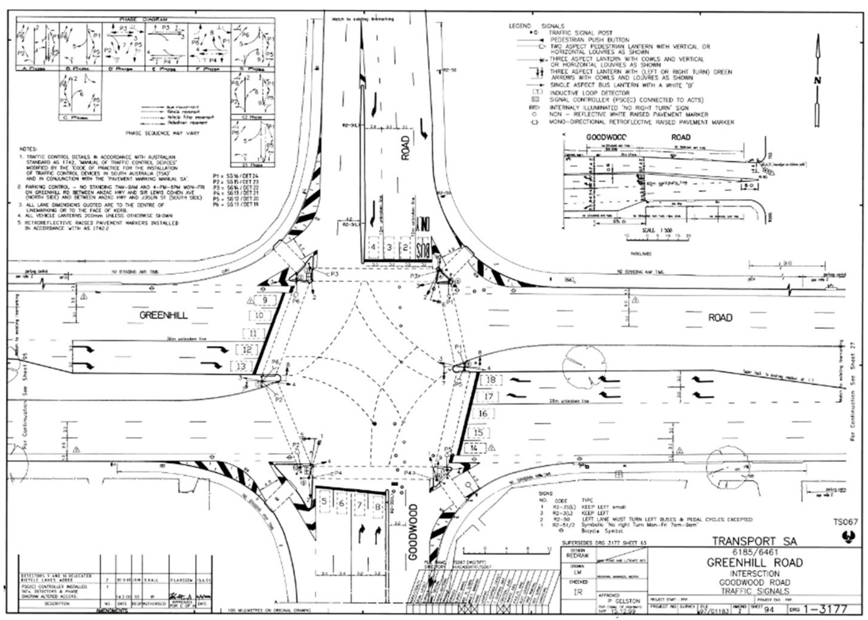

Figure 8: Intersection Drawing

3.3.2 Traffic Volume

For traffic count analysis, SCATS data serves as our primary reference, representing information from 2017. However, we also integrate real-time data to capture the current traffic scenario. Both real-time and SCATS count data are detailed in Table 1 and in Figure 3, within our data collection and Data analysis. Refer Appendices for SIDRA volume box.

3.3.3 Phasing and Timing

Utilizing the phasing and timing data obtained from the SCATS system, we constructed the existing model in SIDRA. Refer Appendices phasing summary for specific movements in each phase and the green, the inter-green time.

3.4 AIMSUN Modelling

A software called AIMSUN is used to model and simulate transportation systems, such as public transportation networks, roadways, motorways, and city streets. The simulation of individual vehicle and traveller behaviour inside a network facilitates extensive analysis of traffic flow, congestion, emissions, and other performance parameters for transportation engineers, planners, and researchers.

A decision was made to develop a model in AIMSUN to better understand how the traffic pattern operates within the new intersection design. The objective was to closely observe areas where traffic congestion occurs, enabling informed adjustments as necessary. The simulation model, which showcases these findings, was presented during the results seminar. For further details, please refer to Figure 9.

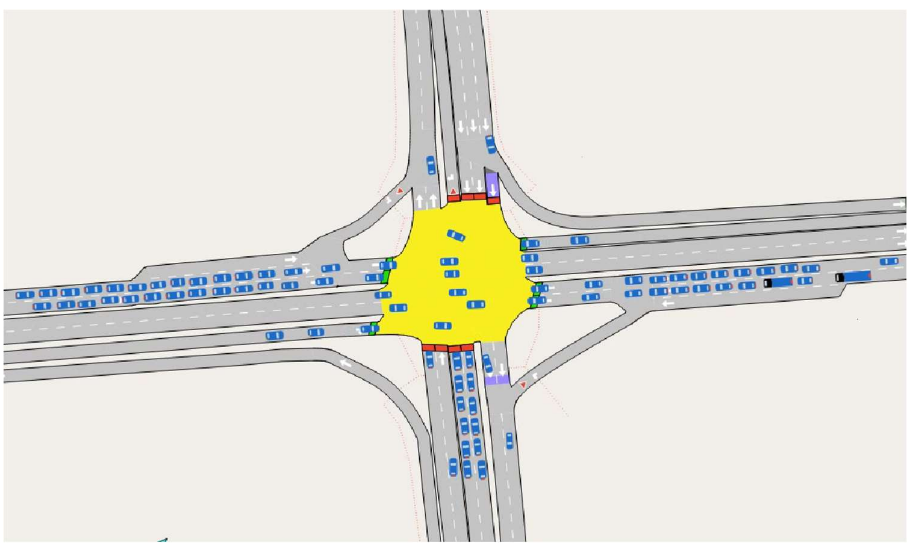

Figure 9: AIMSUN model on Partial continuous flow intersection.

3.5 Calibration and validation

Calibration is a crucial step in traffic modelling that involves adjusting the model parameters to closely replicate real-world traffic conditions. Using of SIDRA, the calibration depends on Collect real-time data on traffic volumes, delays, and queue lengths at the intersection under study. This data provides the baseline for calibration. So, we developed an initial traffic model in SIDRA using the collected data. This model serves as the starting point for calibration. Adjust various parameters within the SIDRA model, such as saturation flow rates, lane capacities, and signal timings, to align the model's outputs with observed real-world data. Specifically, queue lengths observed in real-time are used to tweak the model until the simulated queue lengths match the observed ones. The goal of calibration is to create a model that not only matches traffic volumes but also accurately represents other key traffic behaviours, such as delays and queue lengths. (Tactical Adelaide Model (TAM), 2022)

Validation involves ensuring that the calibrated model reliably predicts traffic conditions under different scenarios. For this project, validation was performed using criteria from the Tactical Adelaide Model (TAM) Guidelines. A key metric used in the validation process is the GEH statistic. According to the TAM Guidelines, a GEH value of less than 5 is generally acceptable for hourly volumes, and a GEH value of less than 10 is acceptable for daily volumes. However, for a highly reliable model, a GEH value of less than 3 for all approaches is desirable. The criteria of GEH value for validation shown in Figure 10. (Tactical Adelaide Model (TAM), 2022)

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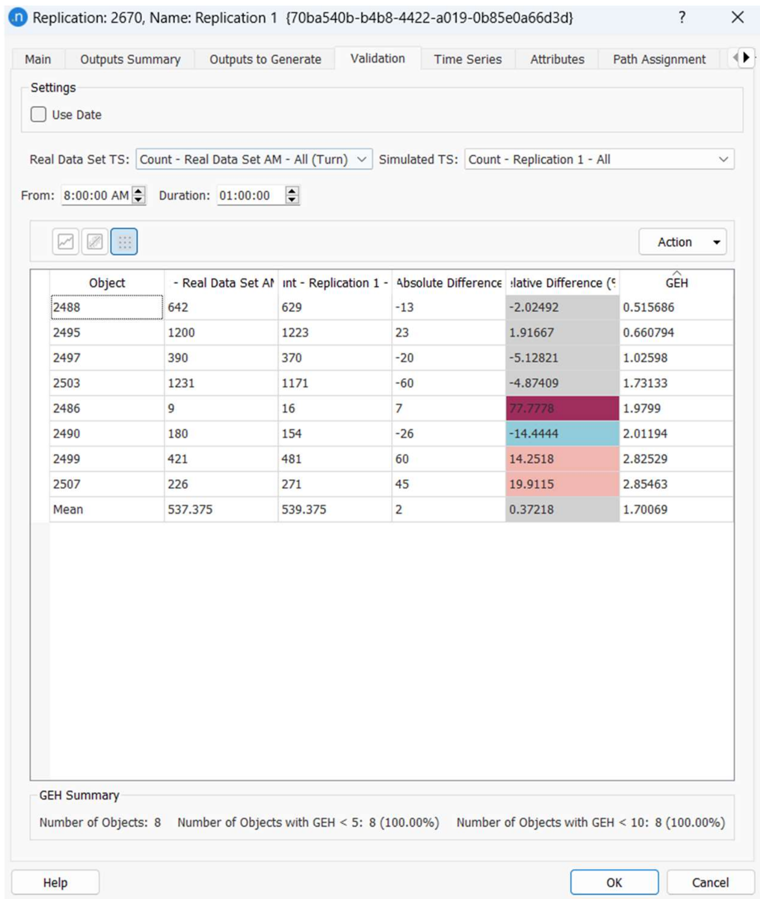
Figure 10: GEH criteria for validation.

Figure 11 shows the GEH values for all approaches at the intersection. In our new innovative design, all GEH values are less than 3, which complies with the TAM guidelines. This indicates that our model is validated and accurately represents real-world traffic conditions. Achieving a GEH value of less than 3 for all approaches confirms that the model is well-calibrated and validated, providing confidence in its predictive capabilities for evaluating the performance of the Partial Continuous Flow Intersection (CFI) design.



Object	- Real Data Set AI	ınt - Replication 1 -	Absolute Difference	ılative Difference ('	GEH
2488	642	629	-13	-2.02492	0.515686
2495	1200	1223	23	1.91667	0.660794
2497	390	370	-20	-5.12821	1.02598
2503	1231	1171	-60	-4.87409	1.73133
2486	9	16	7	77.7778	1.9799
2490	180	154	-26	-14.4444	2.01194
2499	421	481	60	14.2518	2.82529
2507	226	271	45	19.9115	2.85463
Mean	537.375	539.375	2	0.37218	1.70069

Figure 11: GEH value for all approach.

4. RESULT AND DISCUSSION

This research evaluated the partial continuous flow design at the Greenhill Rd and Goodwood Rd intersection in SIDRA software. The existing intersection performed poorly in SIDRA, showing high average delays, low levels of service (LOS), high fuel consumption, increased CO2 emissions, and elevated vehicle costs. After implementing the continuous flow intersection (CFI) design, the performance of the intersection showed significant improvement in this area.

4.1 Average delay

The extra time that a car or pedestrian needs to travel in comparison to the base journey time is quantified as delay. SIDRA software provides delay time in seconds by predicting traffic congestion. By using the exact number of vehicle volumes, this tool is capable of simulating and analysing delays accurately. The analysis of average delay is shown in Figure 12.

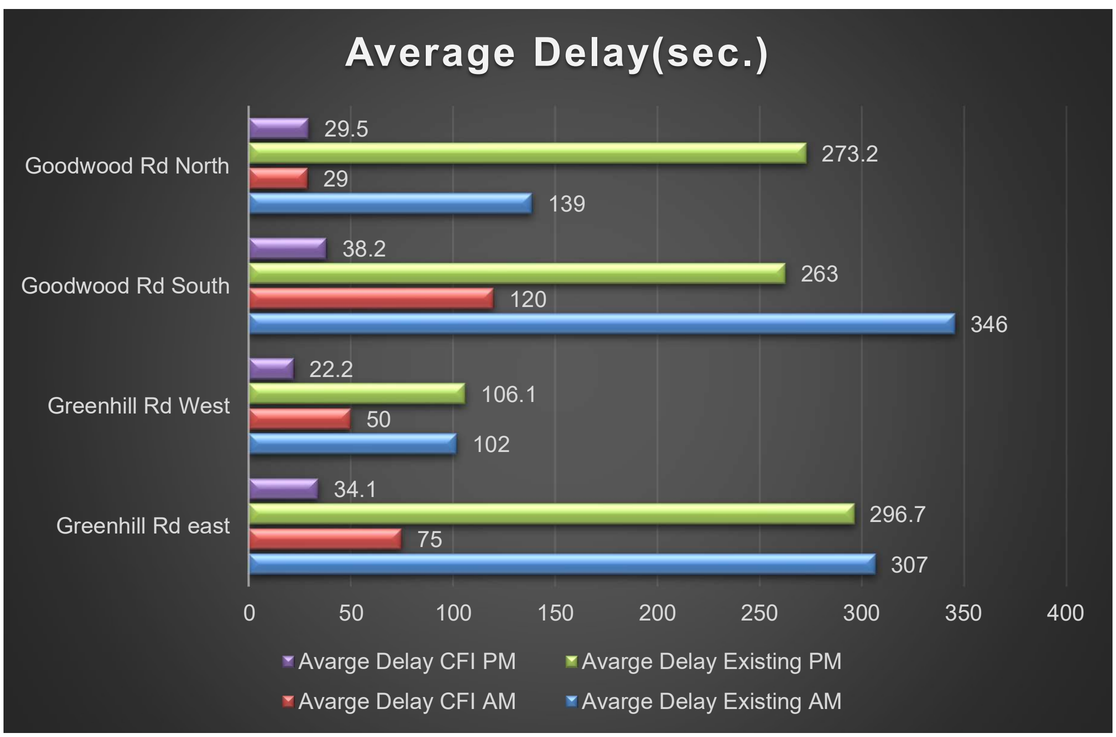


Figure 12: Comparison of average delay.

Key Observations:

- **Goodwood Rd North:** The CFI design significantly reduces the average delay in both AM and PM peaks, with PM delays reduced from 273.2 seconds to 29.5 seconds and AM delays from 139 seconds to 29 seconds.

- **Goodwood Rd South:** The average delay in the PM peak is reduced from 263 seconds to 38.2 seconds, and in the AM peak from 346 seconds to 120 seconds with the CFI design.

- **Greenhill Rd West:** There is a notable decrease in PM peak delays from 106.1 seconds to 22.2 seconds and AM peak delays from 102 seconds to 50 seconds.

- **Greenhill Rd East:** The PM peak delays drop from 296.7 seconds to 34.1 seconds, and the AM peak delays decrease from 307 seconds to 75 seconds with the implementation of the CFI design.

4.2 LOS (Level of Service)

An indicator of how well traffic is operating on a specific road, traffic lane, approach, intersection, route, or network based on metrics including travel time index, density, speed, congestion coefficient, delay, and degree of saturation during a specific flow period. On an A to F scale, where LOS A denotes the best operating conditions and LOS F the worst, this offers a quantitative stratification of a performance measure or measures that represent quality of service. The criteria of LOS shown in figure 13. (Department of infrastructure and Transport)

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Figure 13: Criteria of LOS (Traffic modelling guideline)

Table 3 presents the results of the Level of Service (LOS). The current LOS at the intersection is rated as ‘F’, indicating poor performance. However, with the introduction of Continuous Flow Intersection (CFI), there has been an improvement in the LOS from ‘F’ to E and D. The improved LOS results are also displayed in Table 3.

Table 3: Result of LOS

	Existing AM	CFI AM	Existing PM	CFI PM
Greenhill Rd east	LOS F	LOS E	LOS F	LOS D
Greenhill Rd West	LOS F	LOS E	LOS F	LOS D
Goodwood Rd South	LOS F	LOS E	LOS F	LOS D
Goodwood Rd North	LOS F	LOS E	LOS F	LOS D

4.3 Fuel Cost

For the purpose of traffic management design, operations, and planning, it is helpful to estimate operating costs, fuel consumption, and pollutant emissions while assessing intersection and mid-block traffic situations. From the results (figure 14) Continuous Flow Intersections (CFI) are generally more fuel-efficient than existing intersections. Specifically, Greenhill Rd East and West show a marked decrease in fuel consumption with CFI, while Goodwood Rd South and North also improved efficiency.

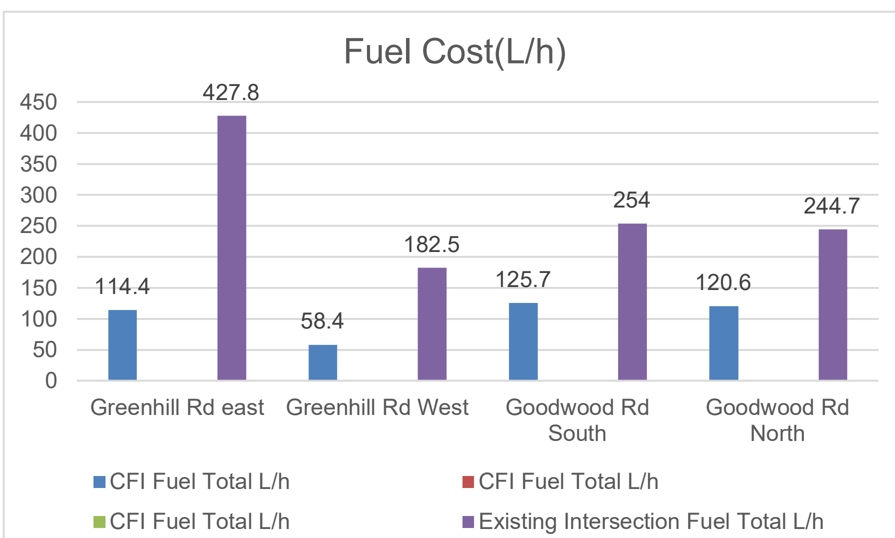

Figure 14: Result of Fuel Cost

4.4 Emission Cost

Traffic congestion and the resulting average delays can lead to environmental challenges. Increasing fuel consumption due to delays can have adverse effects on the economy. Furthermore, vehicles stuck in traffic emit CO2, which is harmful to human health. However, Continuous Flow Intersections (CFIs) have the potential to mitigate these issues by reducing CO2 emissions. The effectiveness of CFIs in reducing CO2 emissions is demonstrated in Figure 15. We can see 70% reduction in emission cost.

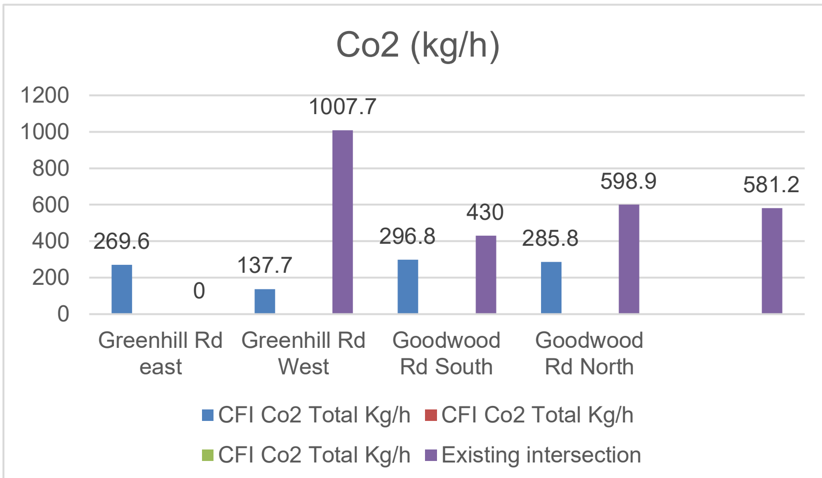

Figure 15: Results of Co2 emission.

4.5 Vehicle Cost

This research also focuses on reducing vehicle costs through the use of SIDRA analysis. SIDRA software calculates operating costs, which represent vehicle running expenses, including the resource cost of fuel, as well as costs for tires, oil, repairs, and maintenance. An increase in traffic congestion further escalates these annual expenditures. From the figure as we can see significant reduction in vehicle operating cost. We can see 80% reduction in vehicle cost.

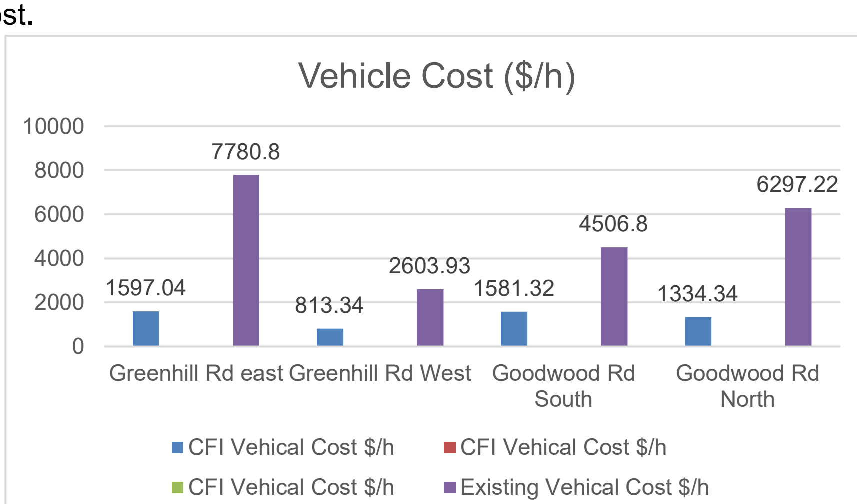

Figure 16: Results of vehicle cost.

5. CONCLUSION

This research aimed to address the significant issues of road safety and traffic congestion at signalized intersections in Adelaide, particularly focusing on the implementation and evaluation of Partial Continuous Flow Intersections (CFI) at the Greenhill Rd-Goodwood Rd intersection. The primary objectives were to reduce average delays, improve the level of service (LOS), lower emissions and fuel consumption, and ultimately enhance traffic flow and safety.

Key findings from the study indicate that the CFI design substantially reduces traffic delays across all directions during both AM and PM peak periods. Specifically, the implementation of CFI led to reductions in delays from 273.2 seconds to 29.5 seconds on Goodwood Rd North during PM peak and from 307 seconds to 82 seconds on Greenhill Rd East during AM peak. These significant improvements resulted in the intersection's LOS improving from a failing grade of 'F' to more acceptable levels of 'D' and 'E'. This advancement signifies better operational conditions and traffic flow.

Moreover, CFI demonstrated 70% to 80% reduction in fuel consumption and CO_2 emissions, contributing positively to environmental sustainability. This is particularly crucial in urban settings where traffic congestion exacerbates pollution and fuel usage. The economic implications are also notable, as reduced congestion directly correlates with lower vehicle operating costs, encompassing fuel, maintenance, and repair expenses.

The research highlights the substantial benefits of CFI in terms of enhancing intersection efficiency and safety, supporting the notion that innovative intersection designs can effectively mitigate common urban traffic challenges. However, it is essential to acknowledge the limitations of this study, including the reliance on simulation data, which may not entirely capture the complexities of real-world traffic scenarios.

In conclusion, this study contributes to the field of transportation engineering by providing empirical evidence on the efficacy of CFI in improving traffic conditions at one of Adelaide's busiest intersections. The findings underscore the potential for broader application of such designs in urban areas facing similar traffic issues, paving the way for future research and practical implementations to enhance urban mobility and road safety.

6. FUTURE WORK

This research has focused on the implementation of a Partial Continuous Flow Intersection (CFI) at the Greenhill Rd-Goodwood Rd intersection. For future work, full design can be developed on this intersection. Additionally, the current study focused on specific peak times, such as AM peak and PM peak, but future study could expand by analysing a broader range of traffic scenarios, including different times of day and varying traffic conditions, to better understand the intersection’s performance under diverse circumstances. this research considered the impact of cars and heavy vehicles, future studies could incorporate a higher proportion of electric vehicles. This would provide insights into how increased usage of electric vehicles affects traffic flow, emissions, and overall intersection performance.

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8. APPENDICES

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Figure 17: Intersection layout.

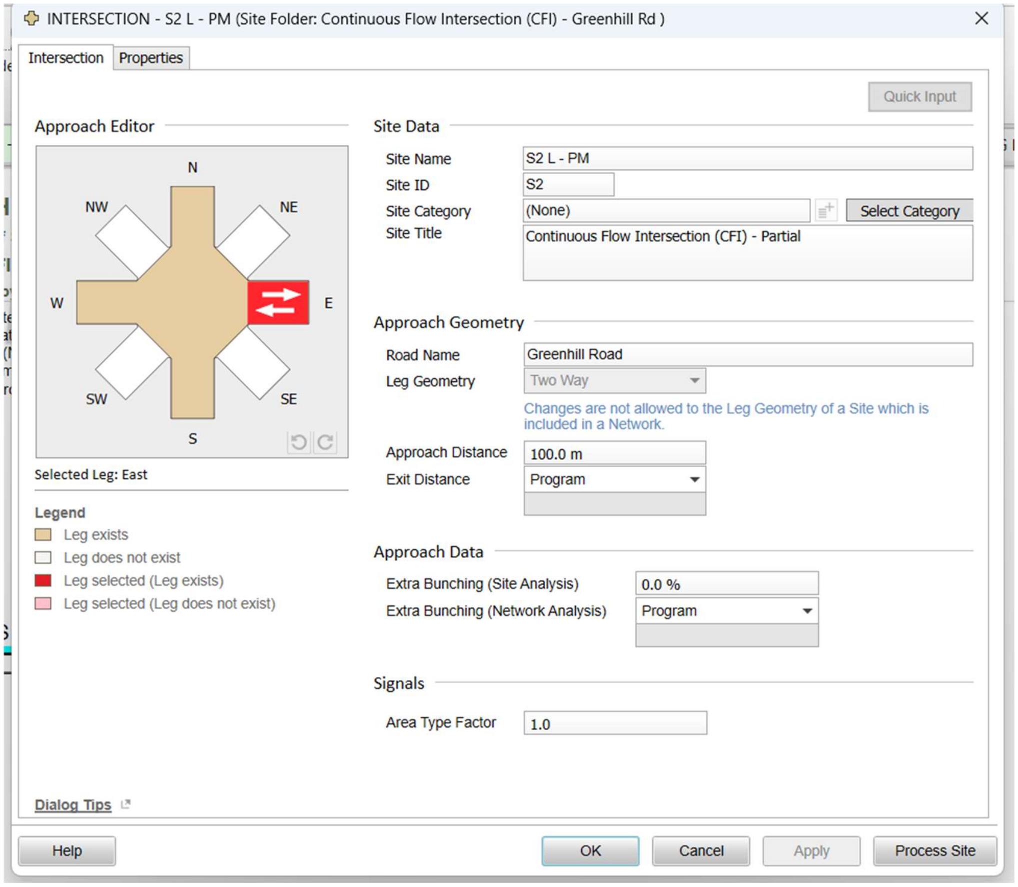

Figure 18: Intersection Parameter dialogue box.

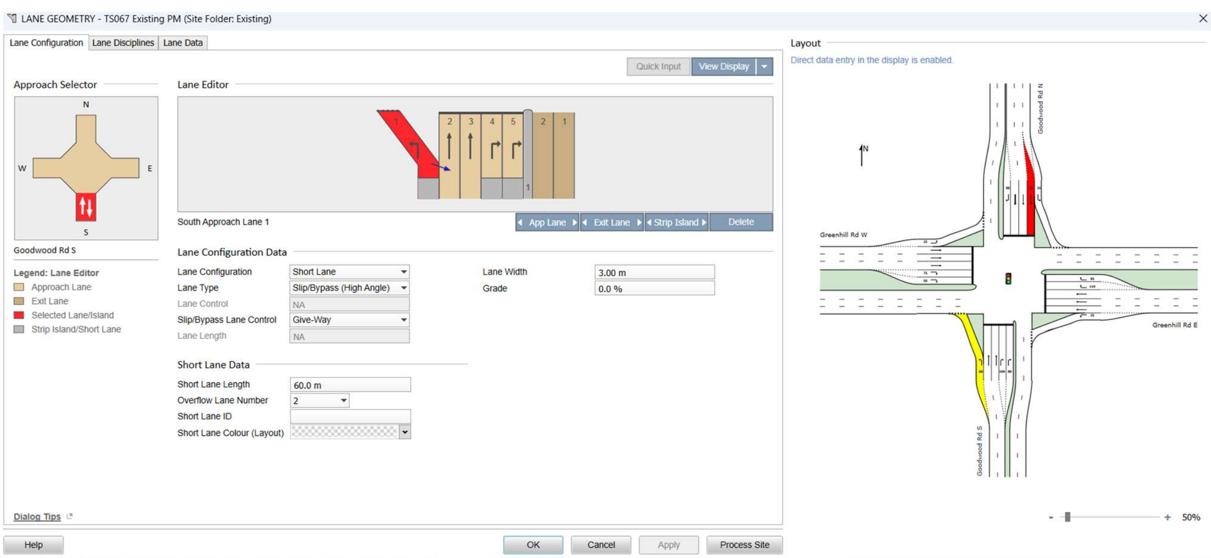

Figure 19: Lane geometry dialogue box.

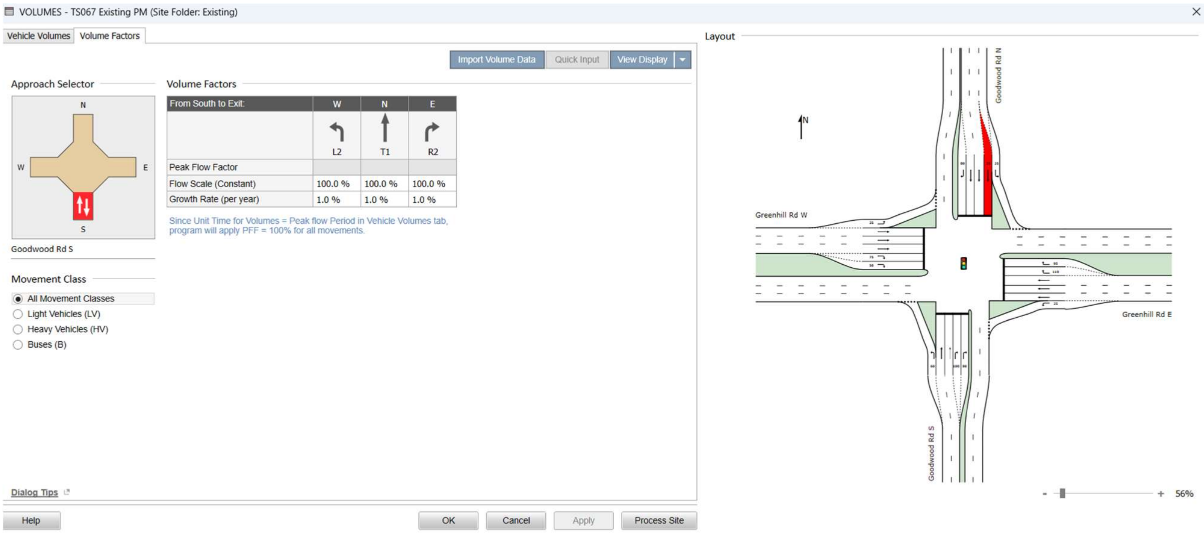

Figure 20: Traffic Volume dialogue box.

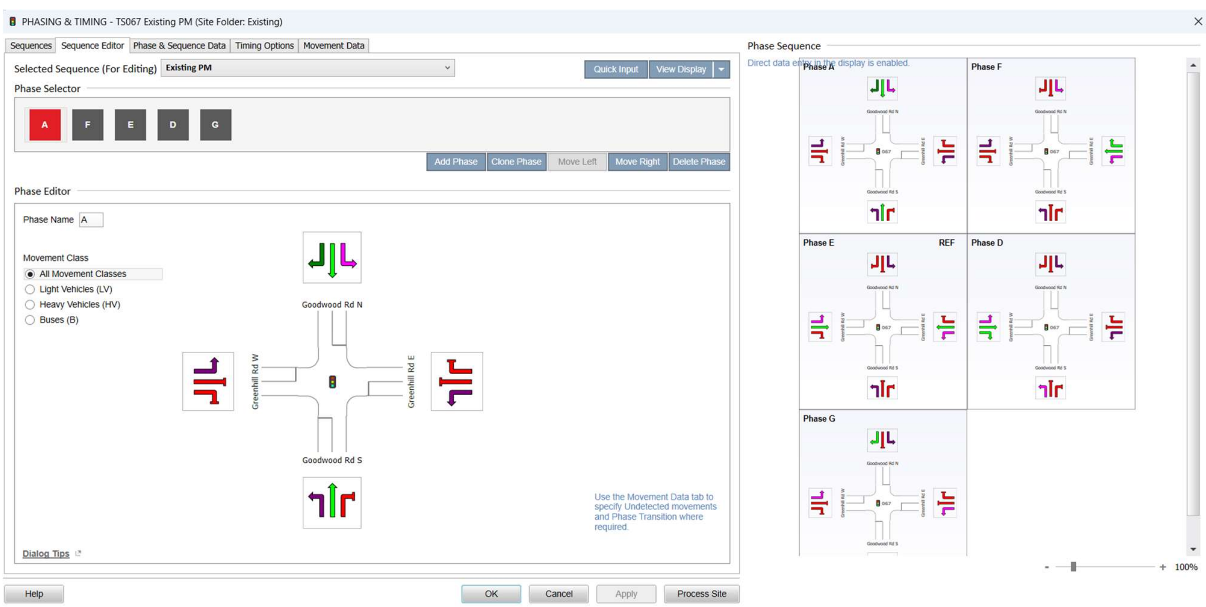

Figure 21: Phasing and Timing dialogue Box.

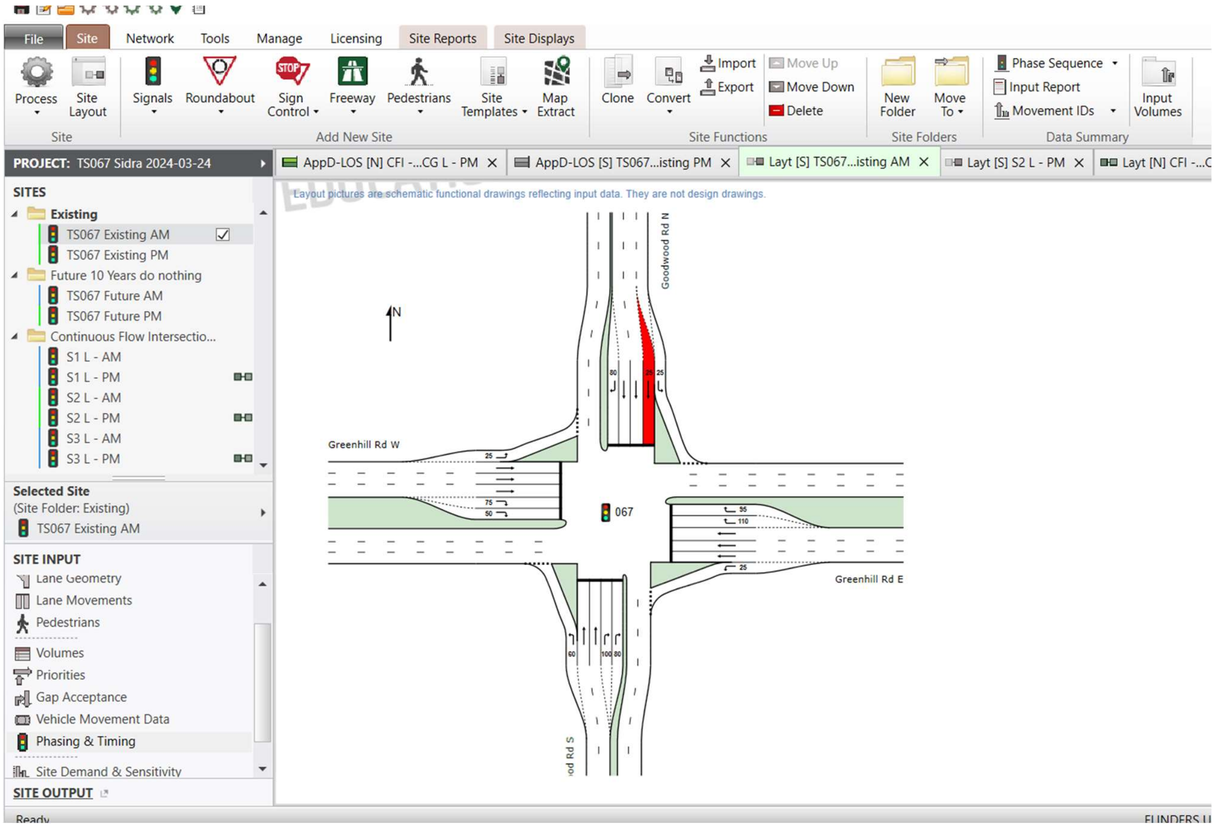

Figure 22:Existing Intersection Model

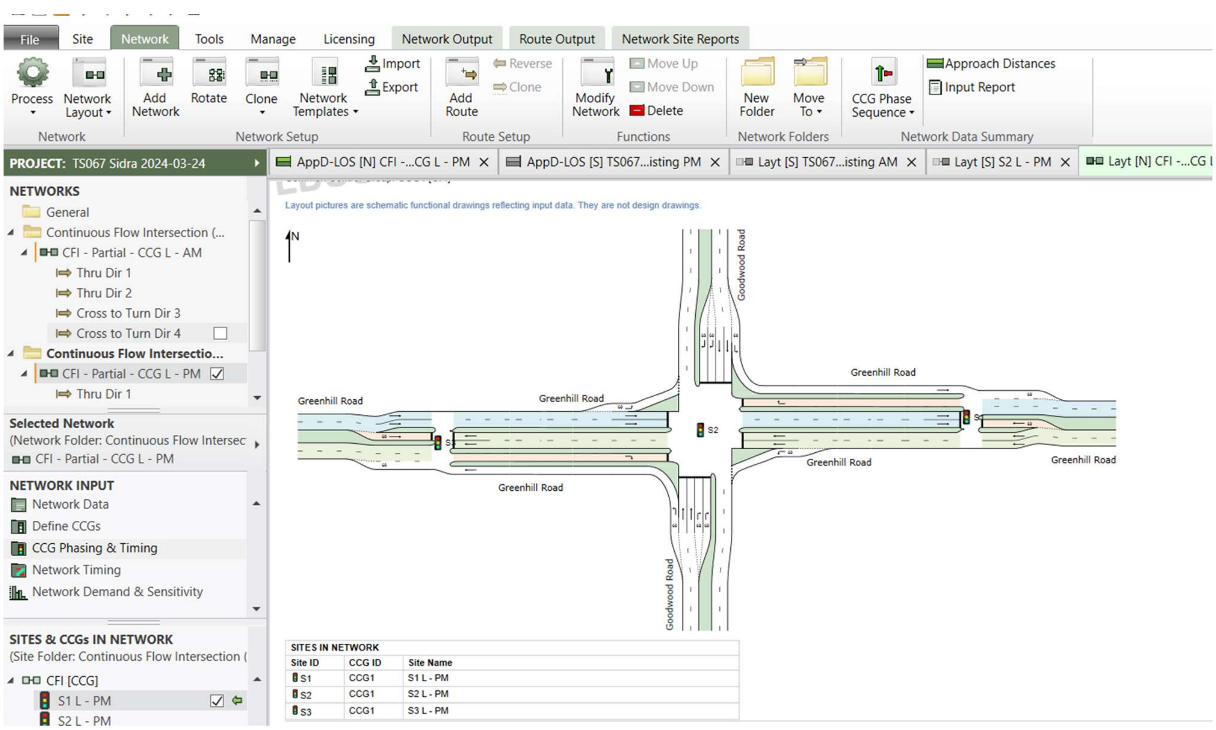

Figure 23: Partial Continuous Flow Intersection

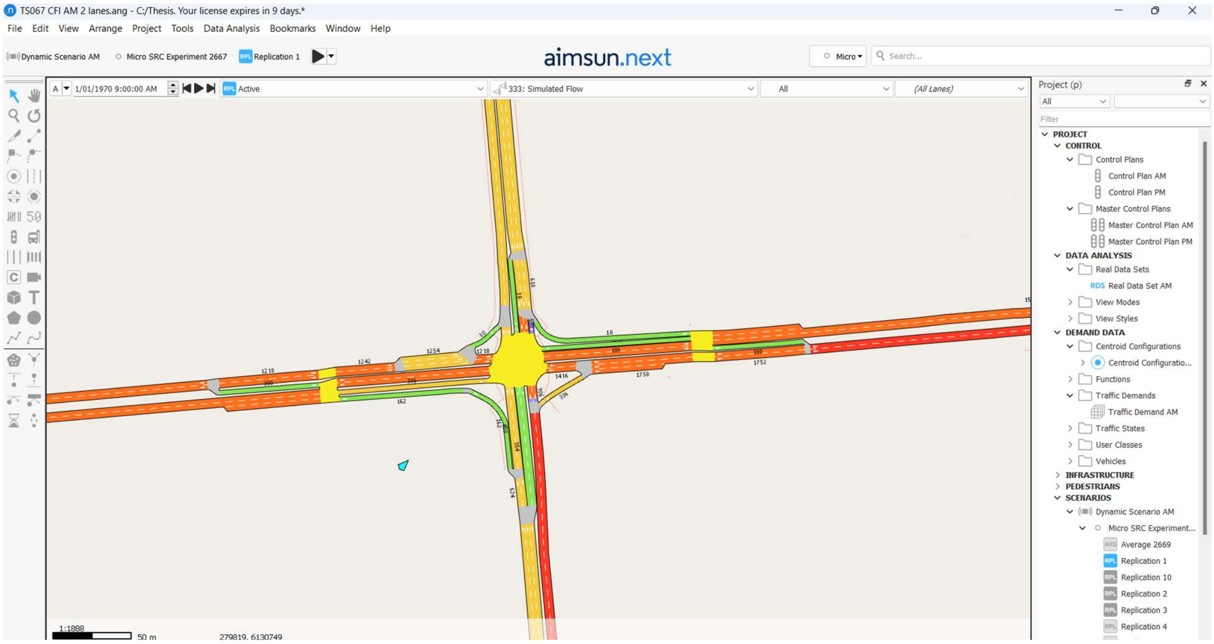

Figure 24: AIMSUN Model

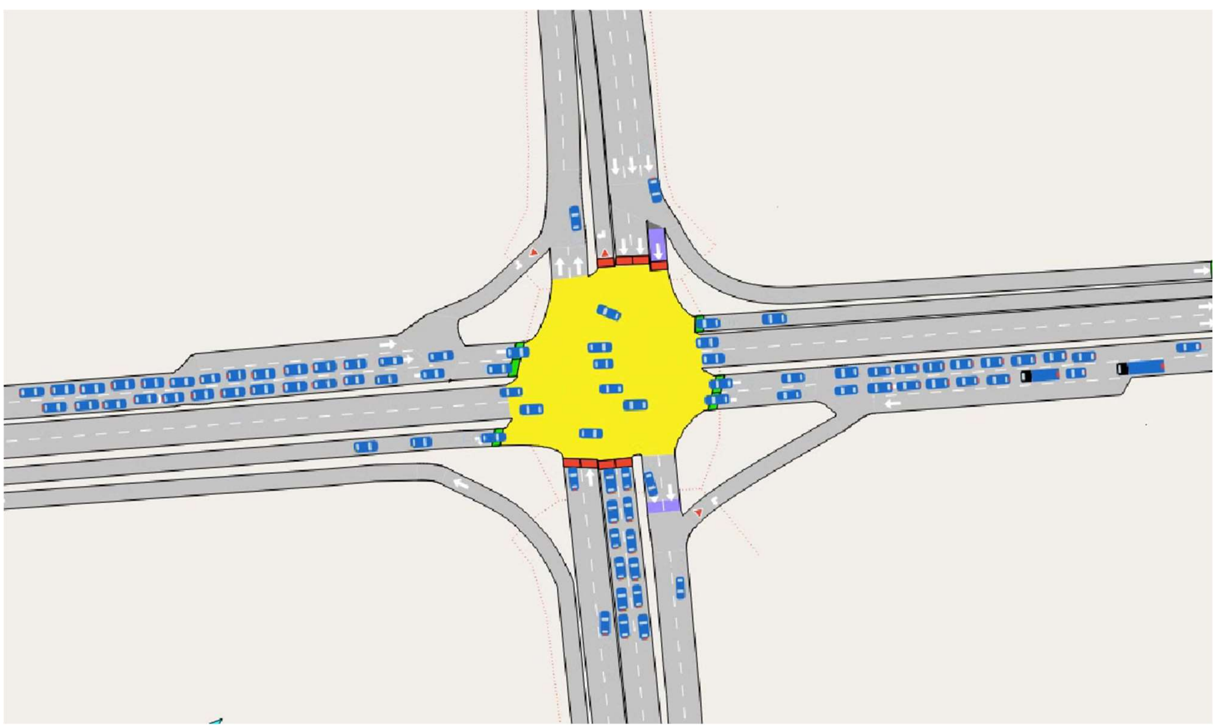

Figure 25: Traffic Simulation