CHAPTER 1

TRAFFIC FLOW AND SAFETY ANALYSIS OF TAMAN MELEWAR INTERSECTION

*Mohamed Abdulrahman Al-Maqtari[1] & Basil David Daniel[2]**

[1-2] Faculty of Civil Engineering and Built Environment,
Universiti Tun Hussein Onn Malaysia, Batu Pahat, 86400, Malaysia.
*Corresponding Email: basil@uthm.edu.my

1.1 INTRODUCTION

The rapid population and economic expansion in Malaysian cities over the past two decades have led to a significant increase in private automobile ownership. Almost every household in Malaysia now owns at least one private automobile, considering it a necessity due to the ease of acquiring a vehicle [1]. However, this surge in the number of registered cars has created transportation challenges, particularly in metropolitan areas, where congestion has become a significant issue [2].

Signalized intersections, known for their complex traffic movements and constantly changing traffic lights, are considered hazardous areas within the road network [3]. The primary cause of traffic congestion on roads is overcrowding, where an excessive number of vehicles saturate the route, disrupting the flow of traffic [4]. This congestion hinders the movement of vehicles, affecting the daily routines of road users. The ability to manage the flow of traffic at intersections and other sites is an essential part of today's transportation infrastructure [5]. Fixed-time control is a common traffic signal system that operates on a predetermined schedule, but it may not be suitable for high traffic areas or complex intersections as it does not adjust to changing conditions [6].

The escalating number of motorists in Malaysia, as indicated by the increase in registered vehicles, has further exacerbated traffic congestion, particularly at signalized intersections. This situation is prevalent in major cities and emerging nations, including Malaysia. The average daily traffic (ADT) in the Parit Raja area alone reached approximately forty-three thousand in 2017[7]. This will in turn lead to the increasing number of vehicles which has led to traffic congestion at the Taman Melewar intersection. The record shows that the Taman Melewar intersection along with the rest of federal road 50 are common places for accidents [8].

Ensuring the safety of motorists and cyclists at signalized intersections is of utmost importance. In particular, when duration of the yellow signal phase is misleading drivers and riders. This poses a significant risk when the signal turns red, leading to departing vehicles still crossing the intersection [9]. Furthermore, the conflict points between vehicles entering Jalan Parit Sempadan and those exiting Institut Latihan Kementerian Kesihatan Malaysia creates safety concerns due to high-speed traffic and limited sight distance.

Additionally, the disobedience of traffic rules by motorcyclists and cyclists, including running red lights, poses a serious safety issue [10]. Although traffic signals and right-of-way signs aim to manage critical intersection conflicts, drivers who disregard these rules can cause potential conflicts and accidents.

This study aims to improve the signalized staggered intersection at the Taman Melewar location. To achieve this goal, the study has outlined specific objectives, including analyzing the level of service at the intersection using the SIDRA intersection software and investigating the safety of motorists and cyclists through a conflict-based study based on the FHWA-IP-88-027 Manual [11]. By addressing these objectives, the study aims to enhance traffic flow and ensure the safety of road users at the Taman Melewar intersection.

1.2 METHODOLOGY

This section discusses the methodology employed in a study focused on determining the Level of Service (LOS) and conducting a safety analysis at a signalised intersection in Taman Melewar, known for experiencing traffic congestion during peak hours. Due to limited equipment and time constraints, data collection for the study is performed manually. The following information needs to be gathered from the site for analysis using SIDRA software:

1.2.1 GEOMETRY OF THE INTERSECTION AND LANE GEOMETRY

Measurements and records of intersection dimensions, including lane number, lane width, and physical features such as medians or turn lanes.

1.2.2 PEAK HOUR

Determination of the time of day when traffic volumes are highest at the intersection. Data for the volume of traffic in each leg of the intersection is collected from 7:00 am to 9:00 am for in 15 minutes intervals, then the peak hour is chosen for the highest 4 intervals.

1.2.3 TRAFFIC COUNT

Counting the number of vehicles passing through the intersection from each direction during the peak hour to establish a baseline measure of traffic volume.

1.2.4 PERCENTAGE OF TRUCKS IN EACH DIRECTION

Determination of the proportion of trucks in the traffic mix, considering their larger size and weight, which can impact the LOS.

1.2.5 IDENTIFYING PRIORITY MOVEMENT

Determination of which movements at the intersection have priority, such as left turns or through movements, as this can influence traffic flow and LOS

1.2.6 PHASING SEQUENCE OF THE INTERSECTION

Identification of the order in which traffic signals at the intersection change, along with the duration of each phase, as this can impact traffic flow and LOS.

1.2.7 Recording Yellow time, All-red Time, and Cycle Time and Speed Limit

Record the durations of the yellow light warning, the all-red interval, and the overall cycle time for the traffic signals at the intersection. Also, Recording the posted speed limit on the approach streets to the intersection, as higher speeds can affect the LOS by increasing the time required for vehicles to stop or slow down at the intersection.

1.2.8 ANALYSIS USING SIDRA INTERSECTION 9

After manual data collection, SIDRA Intersection Software 9 is used for data analysis. This software allows for the analysis of various delay statistics at signalised intersections, including total volume, number of stopped vehicles, total delay, Degree of saturation, and the Level of service of the intersection.

1.2.9 SAFETY ANALYSIS USING CONFLICT-BASED

STUDY

The process of collecting data for safety analysis at signalized intersections involves several key steps. Here is a summary of the data collection process

1.2.9.1 SITE PREPARATION

Before heading to the study location, all necessary equipment and materials has to be gathered including observation protocols, a survey timetable, a map of the area, contact information, identification card, mechanical count board, tablet, pencils, stopwatch, camera, data collection forms, and safety vests. It's important to have the Observer's Manual for reference.

1.2.9.2 ARRIVAL AT THE STUDY LOCATION

The approach legs to be used for conflict observation and the total number of lanes are identified. Observation points are chosen to ensure an unobstructed view of the crossing and traffic flow. The observer is typically positioned 10-30 feet from the intersection on the right side of the approaching roadway, maintaining visibility without disrupting passing motorists. Data collection forms are filled out, and watches and stopwatches are synchronized.

1.2.9.3 CONDUCTING THE SURVEY

The survey is conducted over two separate days, each lasting one hour. Data related to conflicts at signalized intersections is collected using two observers. The observation begins by counting traffic conflicts from a designated approach leg. After 20 minutes, the count is recorded, and the observer moves to the opposite approach leg for a second count. This process is repeated with the two observers alternating between adjacent approaches every twenty minutes.

1.2.9.4 THE CONFLICT FORM

A recommended form is provided for recording traffic conflicts, including an approach-leg numbering system. Separate forms are created for each approach leg, and the results from the counting board are transferred into the corresponding columns of the form.

1.2.9.5 COLLECTING OTHER DATA

In addition to traffic conflict counts, other site data is collected. This may include determining the signal timing at the intersection, taking photographs of the junction from the driver's perspective, and documenting on-site observations of operational and safety issues at the intersection. The site sketch includes posted speed limits, intersection geometry, signs, signals, pavement markings, driveways, landmarks, and street names.

1.2.9.6 IDENTIFYING TYPES OF CONFLICTS IN EACH DIRECTION OF TRAFFIC FLOW

After the survey, it is important to identify common types of conflicts in each direction of traffic flow and analyze the causes behind these conflicts. Since repeated conflicts signify a problem in the intersection design and discuss recommendations based on the observed conflicts.

1.3 RESULTS AND DISCUSSION

The efficacy of the site location was examined based on data collected during peak hours. The data was calibrated and adjusted using the Signalised Intersection Design and Research Aid Software (SIDRA) Version 9.0 and tabulated using Microsoft Excel. The safety of the intersection for cyclists and motorists was also evaluated through a conflict-based study.

1.3.1 IDENTIFYING PEAK HOUR

The bar chart in Figure 1.1 represents the volume of vehicle traffic at the Taman Melewar intersection in Batu Pahat during the morning period. The peak hour is recorded between 7:30 a.m. and 8:30 a.m., the chart shows a peak reading of 922 vehicles passing through the intersection. This high volume is primarily due to the intersection's important role as the main road link to various destinations, such as workplaces, markets, schools, and the city center. However, between 8:00 a.m. and 9:00 a.m., there is a decrease in vehicle volume compared to the previous hour, likely because a significant number of vehicles had already passed through the intersection during the initial hour.

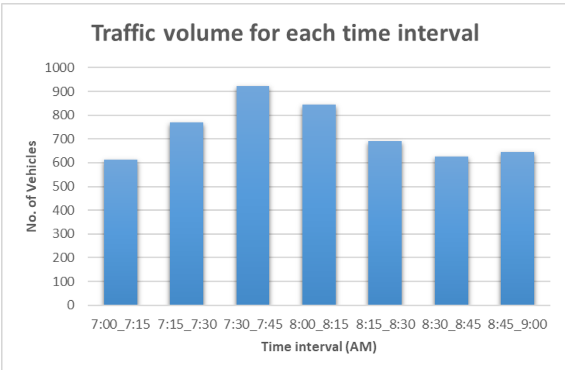

Figure 1.1: Traffic volume per 15 minutes time interval

1.3.2 PERCENTAGE OF VEHICLES BY CLASS AT THE INTERSECTION

The analysis of the pie chart in Figure 1.2, representing the vehicles passing through the Taman Melewar intersection, reveals that cars account for the majority, with a percentage of 62%, followed by motorcycles at 28%. Other vehicle types, such as lorries of various weights and buses, have lower usage percentages compared to cars and motorcycles.

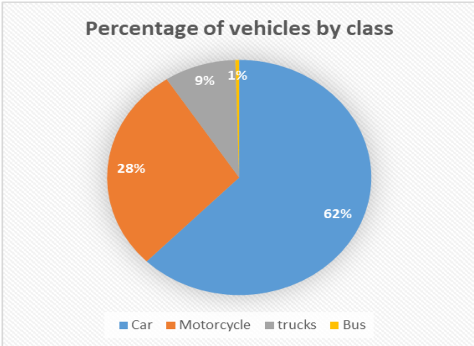

Figure 1.2: Percentage of vehicles passing through the intersection by class

1.3.3 LEVEL OF SERVICE OF INTERSECTION ON 28/5/2023

Based on the observations and analysis conducted at the Parit Raja intersection during the morning peak hour on 28/5/2023, the overall Level of Service (LOS) was classified as D, indicating severe traffic congestion. Specifically, the traffic from Batu Parit Raja to Batu Pahat showed a LOS D service level, while the movement from Batu Pahat to Parit Raja exhibited a slightly improved service level of LOS C. Both lanes in the secondary road experienced significant congestion, with a service level of LOS F as shown in Figure 1.3.

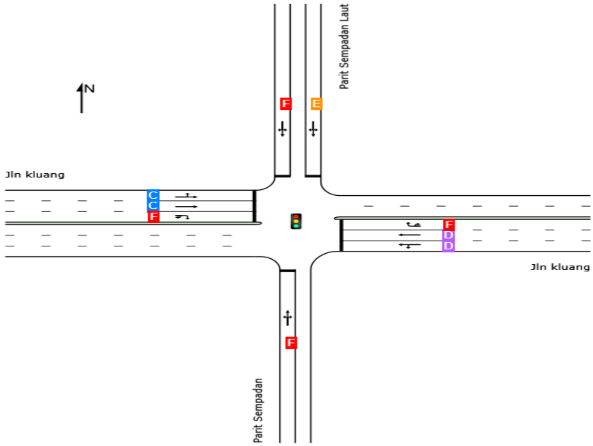

Figure 1.3: LOS of the Intersection Per Lane

The degree of saturation shown in Figure 1.4, which ranged between 0.6 and 0.7, indicates a moderate level of congestion rather than excessively high levels. However, the observed delays at the intersection are between 80 to 100 seconds, which raises concerns. These delays could be due to inadequate signal timing, insufficient capacity, or inefficient traffic management strategies.

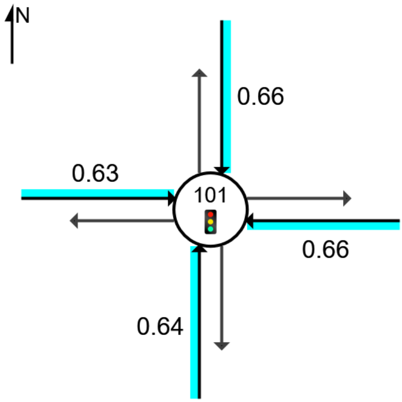

Figure 1.4: Degree of saturation in the intersection on the first day

1.3.4 LEVEL OF SERVICE OF INTERSECTION ON 29/5/2023

The morning traffic conditions at the Parit Raja intersection shown in Figure 1.5 were classified as Level of Service (LOS) E, indicating severe congestion. The study revealed significant traffic congestion at the Taman Melewar intersection, with LOS D for traffic from Batu Parit Raja to Batu Pahat and LOS F for both lanes in the secondary road. Overall, the analysis highlights severe congestion at both intersections during the morning period.

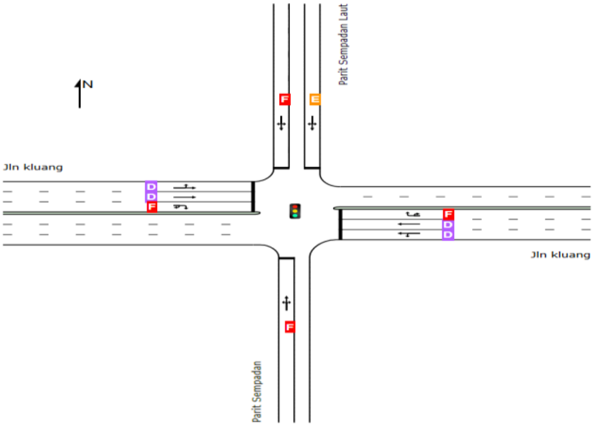

Figure 1.5: LOS of the Intersection Per Lane

The intersection is experiencing high levels of saturation as shown Figure 1.6, indicating significant congestion. The saturation levels range between 0.8 and 0.9, suggesting that the intersection is approaching or already operating at near-capacity traffic conditions. This congestion leads to severe delays and longer queues, necessitating prompt action to maintain smoother and more efficient vehicle movement.

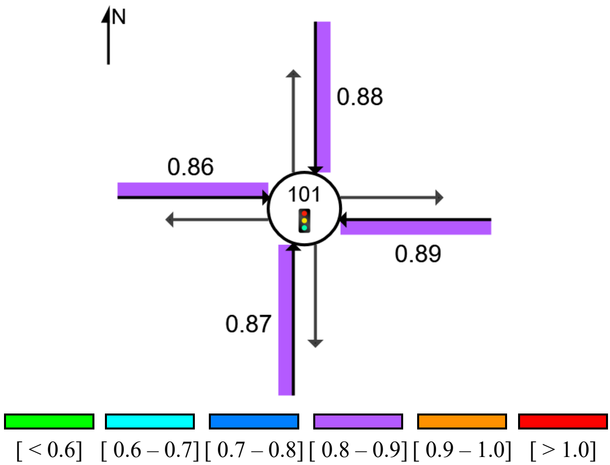

Figure 1.6: Degree of saturation of the intersection on the first day

1.3.5 SAFETY STUDY

The safety study conducted on the traffic flow at the intersection has revealed critical insights into the prevailing challenges and risks faced by motorists and cyclists alike. The analysis of northbound, southbound, westbound, and eastbound traffic has brought to light numerous violations and conflicts that demand immediate attention to mitigate potential accidents and injuries

1.3.5.1 NORTHBOUND TRAFFIC ANALYSIS

In the northbound traffic, 15 mild violations were recorded for opposing right-turn conflicts involving motorists. This indicates a concerning trend of drivers disregarding traffic rules and posing a potential safety risk. Additionally, four serious violations for red-light running were observed, highlighting the importance of enforcing traffic signal compliance. These violations can lead to severe accidents and injuries. It is crucial to address these violations promptly through increased enforcement, driver education programs, and engineering modifications to improve intersection safety for both motorists and cyclists.

1.3.5.2 SOUTHBOUND TRAFFIC ANALYSIS

Similar to the northbound traffic, the southbound traffic also exhibited conflicts related to opposing right-turn maneuvers by motorists. A total of 16 mild violations were recorded, indicating a recurring issue that needs attention. Furthermore, nine serious conflicts involving right turns in the same direction were observed, posing a high risk of collision. These conflicts highlight the need for improved signage, lane markings, and driver awareness programs to promote safer right-turn movements. Additionally, six cases of mild conflicts of rear-end collisions emphasize the importance of maintaining a safe following distance and promoting defensive driving practices among motorists.

1.3.5.3 WESTBOUND TRAFFIC ANALYSIS

The westbound traffic analysis revealed 11 cases of mild line changes and three serious cases of line changes involving both motorists and cyclists. These conflicts suggest a potential lack of lane discipline and driver awareness, leading to unsafe maneuvers. Moreover, 12 serious conflicts of red-light running and three mild conflicts were recorded, further indicating the need for improved signal timing, visibility, and driver compliance. The high number of serious conflicts demands urgent attention to prevent severe accidents involving both motorists and cyclists. Additionally, the presence of nine mild cases of rear-end collisions emphasizes the importance of driver education programs and maintaining appropriate following distances. At the time of recording the data, a motorcycle slid on the road due to wet road conditions and cracks in the pavements.

1.3.5.4 EASTBOUND TRAFFIC ANALYSIS

The eastbound traffic analysis, involving both motorists and cyclists, revealed several violations and conflicts. One motorist was observed without a helmet, which is a clear violation of safety regulations and poses a risk to the individual's well-being. Stricter enforcement and awareness initiatives should be implemented to ensure compliance with safety measures. Additionally, two drivers weaving in the lanes and four speeding motor vehicles were recorded, highlighting the prevalence of aggressive driving behaviours. These violations pose a significant risk to both motorists and cyclists and necessitate increased law enforcement and targeted driver education campaigns. There were also several minor incidents, including two minor rear-end collisions, seven minor lane-change conflicts, and six serious red-light running conflicts. All the above emphasizes the importance of promoting safe driving practices and enhancing driver awareness among both motorists and cyclists.

1.4 CONCLUSION

In conclusion, the study found that the Taman Melewar intersection had a Level of Service (LOS) D on the first day and LOS E on the second day, indicating unstable traffic flow and congestion during morning periods. The average control delay reached up to 118 seconds, contributing to the intersection's instability. The study recommended optimizing traffic signal timings, implementing intelligent transportation systems, and improving intersection geometry to improve traffic flow

Violations of traffic rules, aggressive driving behaviors, and safety concerns for cyclists and motorists were observed. For safety, recommendations included increased enforcement and public awareness, intersection design modifications, driver education and training, and continuous monitoring and evaluation. The study acknowledged limitations in manual traffic conflict analysis and suggested exploring automated data extraction methods and conducting a more extended data collection period.

BIBLIOGRAPHY

[1] Abdelfatah, A. S., Shah, M. Z. & Puan, O. C. (2015). Evaluating the Sustainability of Traffic Growth in Malaysia, J. Traffic Logist. Eng., vol. 3, no. 1, 2015, doi: 10.12720/jtle.3.1.6-11.

[2] Suthanaya, P. A. & Upadiana, N. (2019). Traffic management of Udayana University Sudirman campus intersection using Vissim software. MATEC Web Conf., vol. 276, p. 03006, doi: 10.1051/matecconf/201927603006.

[3] Kidando, E., Kitali, A. E., Boniphace Kutela, Mahyar Ghorbanzadeh, Alican Karaer, Mohammadreza Koloushani, Moses, R., Eren Erman Ozguven, & Sando, T. (2021, Jan). Prediction of vehicle occupants injury at signalized intersections using real-time traffic and signal data. Accid. Anal. Prev., vol. 149. doi: 10.1016/j.aap.2020.105869.

[4] Thammasaroj, P. & Jinsart, W. (2019, Dec). Effects of overcrowded traffic and road construction activities in bangkok on PM2.5, PM10 and heavy metal composition. EnvironmentAsia, vol. 12, no. Special Issue, pp. 28–35, doi: 10.14456/ea.2019.60.

[5] Sirohi, D., Kumar, N. & Rana, P. S. (2020, March 1). Convolutional neural networks for 5G-enabled Intelligent Transportation System: A systematic review. Computer Communications, vol. 153. Elsevier B.V., pp. 459–498,. doi: 10.1016/j.comcom.2020.01.058.

[6] Mittal, U., Chawla, P. & Kumar, A. (2022). Smart traffic light management system for heavy vehicles. Autonomous and Connected Heavy Vehicle Technology, Elsevier, pp. 225–244. doi: 10.1016/B978-0-323-90592-3.00013-6.

[7] Sutandi, A. C. & Pinem, R. D. A. (2017). The Application of Road Lighting Standard Towards Sustainable Transportation in Large Cities in Indonesia. in Procedia Engineering, Elsevier Ltd, pp. 1463–1471. doi: 10.1016/j.proeng.2017.01.471.

[8] Prasetijo, J., Musa, W. Z., Mohd Jawi, Z., Zainal, Z. F., Hamid, N. B., Subramaniyan, A., Siang, A. J. L. M., Anting, N., & Mohd Hafzi Md, I. (2020). Vehicle road accident prediction model along federal road FT050 Kluang-A/Hitam-B/Pahat route using excess zero data. in IOP Conference Series: Materials Science and Engineering, IOP Publishing, p. 12144.

[9] Sanchez, C., Xu, P., Bonnifait, P. & Armand, A. (2022). Integrity Management of the Reachable Space with Lane Grid Maps. IEEE Trans. Intell. Veh.,

[10] Zhang, Y., Yan, X. & Li, X. (2021, Feb). Effect of warning message on driver's stop/go decision and red-light-running behaviors under fog condition. Accid. Anal. Prev., vol. 150, , doi: 10.1016/j.aap.2020.105906.

[11] Parker, M. R., Zee,C. V. & Parker, M. R. (1988). Traffic Conflict Techniques for Safety and Operations: Engineer's Guide. United States. Department of Transportation. Federal Highway Administration.