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Case Study: Performance Analysis of Intersection Along Federal Route Ft23 in Bandar Tangkak Using Sidra Intersection 9.1

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Abstract

The study analyzed the performance of selected intersections along Federal Route FT23 in Bandar Tangkak using SIDRA Intersection 9.1 software. The objectives were to identify peak hours along Federal Route FT23 in Bandar Tangkak, analyze the performance of selected intersections along the route, and recommend intervention to improve the performance of intersections. The volume of vehicles, including turning movements, were manually counted and collected. The result showed that severe congestion took place during peak hours (7:00 a.m. - 8:00 a.m. and 5:00 p.m. - 6:00 p.m.), with average Level of Service (LOS) ratings between E and F. The factors of this problem included poor road geometry, lack of turning lanes, and inefficient signal timing. The study recommends optimizing traffic signals, adding flyovers, and improving public transport.

1. Introduction

In many Malaysian emerging cities, urbanization and the sharp rise in private car ownership have made traffic congestion much worse, especially at signalized junctions that serve as hubs for local transportation systems. Federal Route FT23 is a vital arterial route that facilitates the daily flow of institutional, commercial, and residential traffic in Bandar Tangkak, Johor. Particularly during peak commute times when road capacity is most constrained, the consistent increase in land use activities along this route has led to a discernible increase in travel delays, increased fuel consumption, and general inefficiencies in road utilization [1], [2], [3].

Considering these circumstances, traffic flow, road safety, and user happiness are all significantly influenced by the operational performance of junctions. Long lines, protracted wait times, and irritated drivers are inevitable problems at crossings that are not properly maintained or built to handle growing traffic numbers [4], [5], [6]. Traffic engineers therefore frequently use performance indicators like average vehicle delay, queue length, degree of saturation, and Level of Service (LOS) to assess and enhance these intersections efficiently. These indicators offer a thorough grasp of intersection capacity and functionality under various demand conditions [7], [8].

Among the many tools available for such evaluations, SIDRA Intersection software has been widely recognized for its ability to model and simulate traffic conditions with high precision using real-world parameters such as lane geometry, traffic volume, and signal timing [2], [9], [10]. Because of its analytical capabilities, practitioners may compare different designs or signal plans, evaluate the efficacy of suggested

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solutions, and pinpoint specific performance flaws. Additionally, SIDRA's modelling capabilities are particularly useful for assessing overloaded crossings, forecasting delays in travel times, and proposing signal-based or physical changes that might increase throughput [9], [6].

Numerous traffic engineering studies indicate that intersections with low LOS ratings frequently have design flaws like insufficient space between stop lines and conflict points, fixed-timed signals that don't react to real-time traffic flow, and a lack of exclusive turning lanes. Research has shown that to address these problems, enhancements such as adaptive signal control systems, appropriate channelization, optimized signal phase arrangements, and even small geometric redesigns can greatly lower average delays, boost throughput, and improve an intersection's overall safety and effectiveness [3], [11], [12], [8]. To make sure that any implemented solution is in line with the intersection's unique demand and traffic behavior, additional influencing factors like the distribution of vehicle classes— including cars, motorcycles, and heavy vehicles—and directional travel patterns must be considered [7], [12], [13].

The objectives of this are to identify traffic peak hours along Federal Route FT23 in Bandar Tangkak, analyze the performance of selected intersections along the route, and recommend intervention to improve the performance of intersections. This research uses SIDRA Intersection 9.1 to evaluate the operational effectiveness of a few chosen junctions in Bandar Tangkak in response to the difficulties seen along Federal Route FT23. To identify major bottlenecks, ascertain the Level of Service at each junction, and suggest appropriate short-term and long-term improvements, this research will manually count traffic volumes and observe turning movements during the busiest peak hours. In order to facilitate more effective and sustainable urban mobility as the town grows, the research's findings are meant to help local planners and authorities make well-informed decisions about lane configuration improvements, traffic signal modifications, and infrastructure upgrades [5], [6].

2. Project Method and Implementation

2.1 Site Location

This project was carried out along Federal Route FT23 in Bandar Tangkak, Johor, which is one of the main federal roads in the area. The reason this route was chosen is because it has several busy intersections and is often used by different types of road users, especially during peak hours. The intersections are located within a semi-urban area that includes residential zones, schools, shops, and government buildings. These conditions make the road a good case study for analyzing traffic performance.

The study area location is shown in Fig. 1. Five intersections of Jalan Muar along Federal Route FT23 have been chosen for this study, which is Jalan Naib Long, Jalan Sialang/Jalan Solok (INT 2), Jalan Ong Siong/Jalan Hospital (INT 3), Jalan Cenderawasih (INT 4) and Jalan Bekoh (INT 5). However, Jalan Naib long, which was supposed to be the first location, had to be excluded. This was because there was ongoing construction work along the road. So, the team decided not to include that intersection. These intersections were chosen because they had different types of vehicle movement and traffic conditions. This made it easier to study and compare their performance. This location was suitable because it included signalized and unsignalized intersections, as well as pedestrian activity, which helped make the traffic analysis more complete.

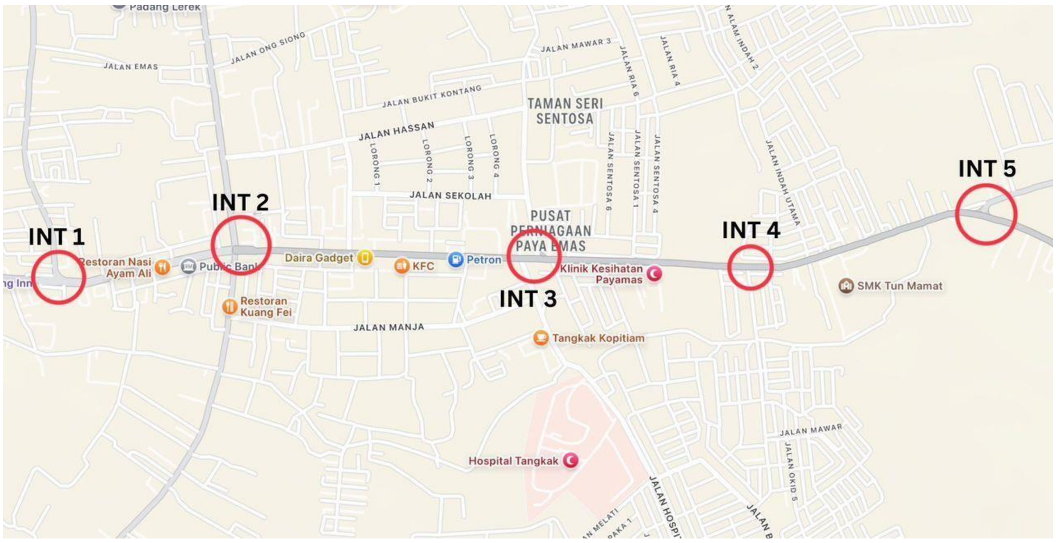


Fig. 1 *Study area location*

2.2 Data Collection using CountCam

To collect the turning movement data, this project used a system called CountCam, which is a video-based tool that records vehicle movements. It was chosen because it's more efficient and accurate compared to manual counting [12]. The camera was placed at a high position to capture a clear view of all the vehicle movements at each intersection [7], [8]. The recordings were done during two peak periods, which are morning peak (7:00 a.m. to 8:00 a.m.) and evening peak (5:00 p.m. to 6:00 p.m.) as shown in Fig. 2.

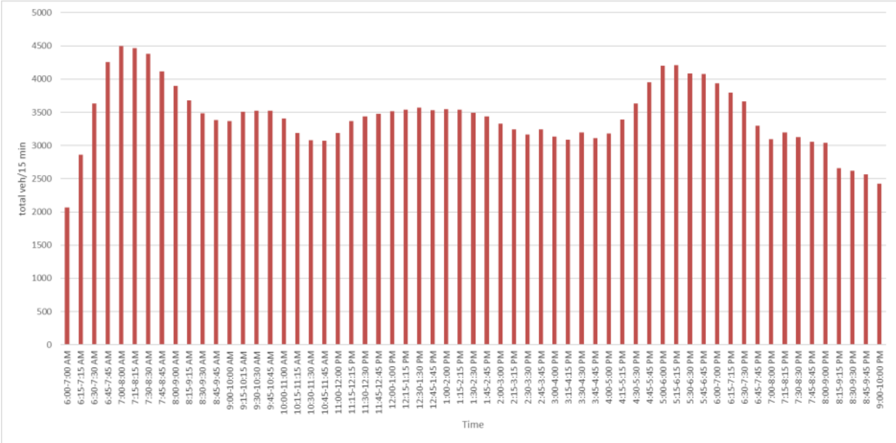


Fig. 2 *Time series graph*

After the video was recorded, the footage was reviewed manually by group members. From there, the number of vehicles was counted and categorized into four types of vehicle classification as shown in Table 1. The process of vehicle counting was conducted using CountCam 3+ as shown in Fig. 3.

Each vehicle movement, turning left, going straight or turning right was recorded for all directions. The use of CountCam made it easier to avoid missing any vehicles since the footage could be replayed multiple times if needed. It also helped reduce human error during data collection [3], [14].

Table 1 *Class and type of vehicle* [4]

Class	Type of vehicle
1	Motorcycles
3	Cars
	Vans & Medium /truck
5	Heavy Trucks & Buses

2.3 Data analysis using Sidra Intersection 9.1

Once all the vehicle counts were completed, the data was analyzed using Sidra Intersection 9.1 software used for traffic performance evaluation [2], [9]. The software helped simulate how traffic moves through each intersection and provided useful results to identify which junction had congestion issues [3]. Several details were needed for each intersection like, number of lanes, width of each approach and type of vehicle for every direction [4], [12].

All this information was combined with the vehicle counts and entered Sidra. The software then generated several performance results, including Level of Service (LOS) rated from A to F based on performance, Degree of Saturation (DoS) to see how busy the intersection is, average delay, queue length and traffic capacity. These results helped the team to see which intersections were working well and which ones had high delays or long queues [2]. Based on this, the team could suggest where improvements might be needed.

3. Methodology

The methodologies will include areas such as the location of study, methods to collect the data and methods analyses the data. Fig. 4 shows a flowchart of our overall methodologies. This flowchart shows the steps taken throughout the study to reach the project objectives. It started with a literature review, where related studies were read to get a better understanding of the topic. After that, a site visit was carried out at Federal Route FT23 in Bandar Tangkak to observe the actual road conditions. Then, data collection was done by focusing on vehicle movements and how road users behaved at the intersections. The data collected was analyzed using SIDRA 9.1 to evaluate how the traffic was performing. After that, time-based analysis was done to identify any trends and to see how efficient the intersections were. Once all the findings were reviewed, a discussion and recommendation section were written to suggest possible improvements. Finally, the study ended with a conclusion that summarized the results.

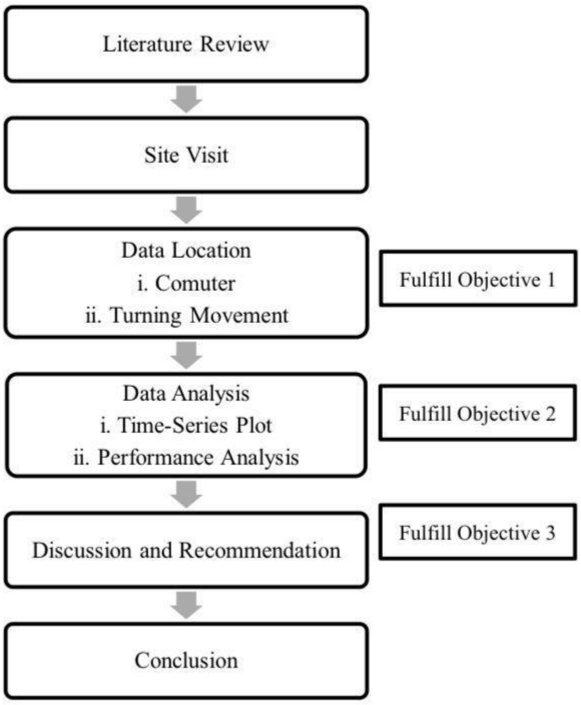


Fig. 4 *Flowchart of overall methodology*

4. Results and Discussion

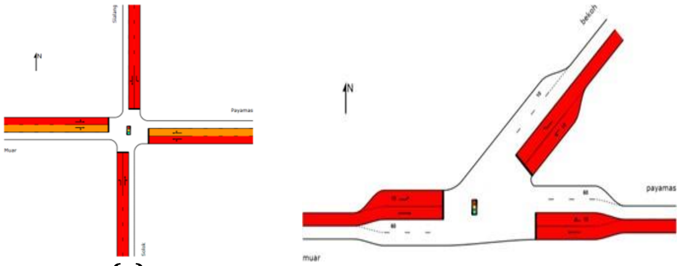
4.1 Findings from Traffic Inspection Using SIDRA

SIDRA Intersection 9.1 is a software program made for analyzing the performance of both signalized and unsignalized intersections. It was used to evaluate the intersections along Federal Route FT23 in Bandar Tangkak in this study. In addition to modeling traffic flow, SIDRA combined specific details including fuel usage, vehicle delay, queue length, and saturation level [1], [14], [10]. Using real-world information including vehicle volumes, turning movements, road geometry, and signal timing, the users can examine intersection performance. SIDRA was used to evaluate performance and simulate traffic behavior by entering movement data and field observations. Before being implemented in the real world, different traffic management techniques and infrastructure changes can also be tested in SIDRA's simulation software.

2.3 Discussion

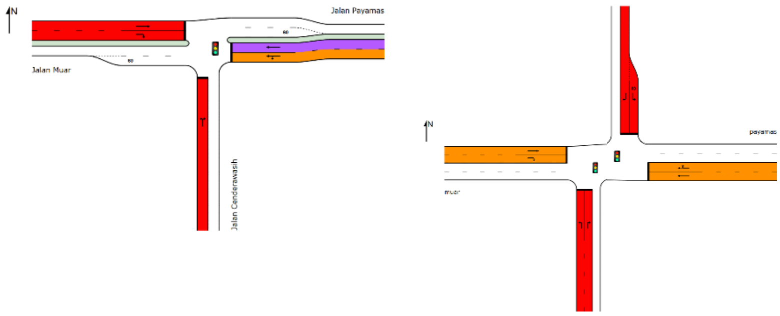
The analysis of intersections from SIDRA along Federal Route FT23 shows critical patterns in traffic behavior. The analysis focused on four major intersections to examine their performance both during morning and evening peak hours through collected data of traffic volume, turning movement counts and the road geometry. The results demonstrate that the intersections are under the Level of Service (LOS), E and F during the peak hours. Jalan Solok / Jalan Sialang and Jalan Bekoh produce the critical and worst performance, with Level of Service (LOS) rated F and values of Degree of Saturation (DoS) exceeding 1.4 as shown in Fig. 5. This reveals that traffic flow at these intersections exceeds their capacity and design limit. This resulted in long queues and increased users' travel time as they had to wait through multiple cycles to clear the congestion. Jalan Bekoh shows that the intersection performance during morning peak hour is rated F, while the evening peak hour is rated E.

However, intersections such as Jalan Cenderawasih and Jalan Ong Siong / Jalan Hospital showed a lower and better performance analysis, with some of the directions rated E or D as shown in Fig. 6, revealing that traffic conditions are inconsistent across approaches or times of day. Jalan Ong Siong / Jalan Hospital is a staggered junction with different distribution of green time among the four phases and resulting in inefficient signal control.



(a) (b)

Fig. 5 LOS at *(a) Jalan Solok / Jalan Sialang; (b) Jalan Bekoh*



(a) (b)

Fig. 6 *LOS at (a) Jalan Cenderawasih; (b) Jalan Ong Siong / Jalan Hospital*

Another observation is that the evening peak hours (5:00 p.m. - 6:00 p.m.) present worse traffic conditions than morning peak hours (7:00 a.m. - 8:00 a.m.), due to overload flows from residential, commercial, and community areas from the school nearby. Other factors that could cause the congestion might be insufficient turning lanes and a skewed junction. While other intersections can be improved through better signal timing or a new design upgrade.

In general, this study aims to highlight the importance of providing solutions to the specific conditions at each intersection. Congestion and delay problems can be solved with short-term changes and long-term changes to infrastructure improvements and better traffic management strategies. Minor operational improvements such as signal retiming or lane addition may provide short-term solutions, upgrades in intersection geometry, signal technology, and modern infrastructure are essential for sustainable improvement. Moreover, continuous traffic monitoring and performance analysis using tools like SIDRA should be commonly used to ensure that any suggested solutions remain effective under evolving traffic conditions.

5. Conclusion

SIDRA Intersection 9.1 was used in this study to evaluate the performance of important intersections along Federal Route FT23 in Bandar Tangkak. Most intersections were running at Level of Service E or F during peak hours, indicating significant traffic congestion, according to the report. High traffic loads, poor signal timing, inappropriate lane distribution, and geometric constraints are the primary causes of subpar performance. Several recommendations were made considering these findings, including creating dedicated lanes for vehicle types, optimizing signal timing, and considering long-term infrastructure upgrades like flyovers. These actions are intended to improve road safety, decrease delays, and increase traffic flow. The findings offer useful information to help local authorities put into practice sustainable and efficient traffic management plans to support Bandar Tangkak's explosive growth.

6. Recommendations

Based on the study along Federal Route FT23 in Bandar Tangkak, to improve the traffic flow at an intersection, several recommendations have been produced to reduce congestion, especially during peak hours. It is advised to synchronize green time for through traffic at all signalized intersections to get a green wave, so that delays can be reduced and increased flow efficiency [14], [11], [15]. Additionally, adding flyovers or viaducts at intersections is recommended as a long-term solution to eliminate bottlenecks and ensure smooth traffic flow, although it involves high costs. Finally, adding and improving public transportation can also reduce congestion. For example, increase the number of buses and upgrade the bus stops.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Ainii Amirra Asmuni, Husna Haneena S. Mohd Rafee, Izzati Syazwani Abd Halim, Mohd Erwan Sanik;* ***data collection:*** *Ainii Amirra Asmuni, Husna Haneena S. Mohd Rafee, Izzati Syazwani Abd Halim;* ***analysis and interpretation of results:*** *Ainii Amirra Asmuni, Husna Haneena S. Mohd Rafee, Izzati Syazwani Abd Halim, Mohd Erwan Sanik ;* ***draft manuscript preparation:*** *Ainii Amirra Asmuni, Husna Haneena S. Mohd Rafee, Izzati Syazwani Abd Halim, Mohd Erwan Sanik. All authors reviewed the results and approved the final version of the manuscript.*

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