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SIMULATION OF A RAILROAD INTERSECTION USING PTV VISSIM: A CASE STUDY OF THE ABDURAHMAN SALEH-GARUDA RAILROAD INTERSECTION IN THE CITY OF BANDUNG

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ABSTRACT

According to Numbeo's 2023 data, Bandung City has a traffic index of 201.26 and a Time Index of 43.68 minutes, with motorcycles and private cars being the primary modes of transportation. While it fares better than Jakarta, there is a need for transportation improvement. Abdurahman Saleh Street experiences severe congestion as it connects arterial roads, railway lines, and Husein Sastranegara Airport. The government is planning to construct the Abdurahman Saleh Flyover to reduce congestion, enhance safety, and support the Jakarta Bandung highspeed railway (KCJB). This study aims to understand the performance before and after the Abdurahman Saleh-Garuda Flyover using PTV VISSIM, with the hope of providing valuable recommendations for Bandung. The research is based on traffic flow data encompassing various vehicle types on Abdurahman Saleh Street in Bandung. This data includes a survey conducted by the Bandung City Transportation Agency in 2020, with an average vehicle flow of 8,008 vehicles per hour from both directions, dominated by motorcycles (62%) while buses (0.5%). Train schedule data from PT. Kereta Api Indonesia (PT. KAI) is also crucial to identify the train movement patterns at this intersection. There are three scenarios in the modeling: Existing, Do Nothing (no changes), and Do Something (with the flyover). Vehicle growth projections are used in both Do Nothing and Do Something scenarios. The modeling results indicate that with the construction of the flyover (Do Something), Queue Length decreases by 81%, vehicle delay decreases by 49%, and the level of service improves to 'C'. This highlights the benefits of constructing the flyover in addressing congestion and improving transportation services on Abdurahman Saleh Street. Although the flyover construction can enhance the intersection's service quality, this improvement is not yet significant. Therefore, it is essential to remember that improving transportation quality must also be accompanied by efforts to promote the use of public transportation and reduce private vehicle usage. This is necessary to ensure better transportation quality, which is a crucial aspect of the economic and social movement of the community.

Keywords: PTV VISSIM, Traffic Model, Interchange, Railroad Crossing.

INTRODUCTION

Data obtained from Numbeo, a cost of living and transportation quality database, in 2023 reveals that Bandung City has a traffic index of 201.26 and a Time Index of 43.68 minutes. In this database, motorcycles and private cars are the most commonly used modes of transportation for commuting to work or school. While these values are better than those of Jakarta, which has a traffic index of 250.39 and a time index of 52.22 minutes, there is room for improvement to enhance transportation performance and the movement of the population in Bandung City. For comparison, Vienna, Austria,

holds the top rank with a traffic index of 73.34 and a time index of 22.79 minutes (Numbeo, 2023). One of the improvements that must be made is in the infrastructure of the roads themselves.

Abdurahman Saleh Street in Bandung is one of the main roads facing serious traffic issues. This intersection connects Abdurahman Saleh Street, an arterial road, with a railway line frequently used by long-distance and commuter trains. Additionally, this road serves as one of the access routes to Husein Sastranegara International Airport. Unfortunately, the conditions around this road are already congested, and widening the road is not feasible. Consequently, the increasing number of railway vehicles on this stretch causes regular traffic congestion, negatively impacting transportation performance.

Traffic congestion on Abdurahman Saleh Street in Bandung has been a major concern in recent years. The rising congestion levels disrupt the mobility of residents and economic activities in the area. Furthermore, the existing railway crossings have become accident-prone spots, leading to physical injuries and even fatalities. Hence, the government of Bandung City's plan to construct the Abdurahman Saleh Flyover is a crucial initiative to address these issues (Humas Kota Bandung, 2023). By closing the existing railway crossing and directing all vehicle movements onto the flyover, it is hoped that traffic congestion will be reduced, and safety at the railway crossing will improve. Additionally, this construction will facilitate the operation of the Jakarta-Bandung High-Speed Train Feeder (KCJB), enhancing connectivity between Padalarang and Bandung stations while minimizing potential conflicts between road traffic and the railway line that was previously at grade with Abdurahman Saleh Street.

Thus, this project will not only provide a solution to the congestion and safety risks at the railway crossing but will also support the development of more efficient and sustainable mass transportation infrastructure, such as the Jakarta-Bandung High-Speed Train Feeder (KCJB). It is expected to have a positive impact on improving population mobility, supporting economic growth, and creating a safer and more efficient transportation environment in Bandung City.

Figure 1 Abdurahman Saleh-Garuda Railroad Intersection Source: Google Maps, 2023

The construction of a railroad interchange crossing at Abdurahman Saleh Street can bring significant benefits to transportation performance. Research conducted by Li et al has shown that the impact of railroad interchange crossings built in major cities in China has had a positive effect on reducing congestion, travel time, and traffic accident rates (Li, Zhang, & Wang, 2020). The research results indicate that interchange significantly reduces vehicle travel delays and traffic density in densely populated areas, leading to a decrease in traffic accidents.

Previous studies have highlighted various approaches to improving transportation performance in different regions of Indonesia. For example, research conducted in Bandar Lampung resulted in a significant 45.58% reduction in travel time using an underpass model (Hutapea, Herianto, & Siregar, 2021). On the other hand, research in Kendal, Indonesia, emphasized the need for geometric changes from a 2/2UD ratio to 4/2D to accommodate the high frequency of approximately 200 train passages per day, using the Greenshields model and shockwave method (Yusyadiputra, Hermawanto, Pudjianto, & Yulipriyono, 2014). However, road widening is not a suitable solution for improving transportation performance on Abdurahman Saleh Street due to limited available land in that stretch.

Previous studies underscore the importance of finding effective and efficient solutions to address transportation problems, especially in areas with land constraints like Abdurahman Saleh Street. As technology advances and our understanding of transportation issues improves, innovative approaches are required, such as the use of interchange models or appropriate geometric changes, to enhance transportation performance without sacrificing valuable land. Therefore, further research considering various aspects and region-specific factors can be a crucial step in addressing transportation challenges in the future.

In the context of urban infrastructure development, traffic modeling using PTV VISSIM can assist in making informed decisions for railroad interchange construction. Simulation studies for railroad interchanges in different locations have shown that this approach can provide a more comprehensive view of its effects on traffic and help identify the best scenarios to optimize traffic performance (Rahayu, P, & Setiawan, 2022). The use of traffic simulation software like PTV VISSIM has become a standard in academic research to model the impact of transportation infrastructure development. Research by Chandra et al. used PTV VISSIM to predict the effects of railroad interchange construction on heavily trafficked roads and identify optimal design alternatives (Chandra, Rahman, & Putra, 2021).

Although the application of PTV VISSIM in traffic engineering is widespread, modeling of railroad interchange crossings using this software is still relatively rare. An example of the use of PTV VISSIM was applied to determine the appropriate traffic engineering on flyovers and highways conducted by recent studies (Yulianto, 2019) (Fabianova, Michalik, Janekova, & Fabian, 2020). Therefore, the PTV VISSIM modeling approach will be employed in traffic engineering for the construction of a railroad interchange crossing on Abdurahman Saleh Street.

Abdurahman Saleh Street in Bandung has been facing a serious issue of chronic traffic congestion. The root causes of this congestion include high vehicle intensity, one of the routes to Husein Sastranegara International Airport, the densely populated conditions surrounding the road, bottlenecks from the north, and slowdowns due to public transportation. With the construction of the Abdurahman Saleh-Garuda flyover above the railway tracks, it is hypothesized that it will alleviate congestion and improve transportation performance. This research will be modeled using PTV VISSIM software to assess transportation performance before and after the flyover is built. It is hoped that this study will provide suggestions and recommendations to optimize traffic performance and offer suitable proposals for the construction of the flyover in the future. Additionally, this research is expected to deliver significant benefits to the community and stakeholders involved.

LITERATURE REVIEW

Traffic Generation

This research using the simple formula to estimate vehicle volume in the future plan year. Referring to the formula formulated in the PUPR Journal, the growth formula is as follows (Iskandar, 1998):

$$Pn = P_0(1+i)^n$$

Pn : Number of vehicles in the plan year

P0 : Number of vehicles in the year of observation

i : Interest (%)

n : Plan year – observation year

PTV VISSIM

PTV VISSIM is a crucial software tool for microscopic traffic modeling. Developed by PTV (Planung Transport Verkehr AG), this software was first launched in 1992 in Karlsruhe, Germany. One of the primary advantages of PTV VISSIM is its ability to simulate various types of traffic vehicles, including cars, freight transport, buses, LRT (Light Rail Transit), trams, motorcycles, and even pedestrians (Fabianova, Michalik, Janekova, & Fabian, 2020). To conduct accurate simulations, this software requires several essential pieces of data, such as base maps, road networks, vehicle volumes, vehicle types, vehicle distribution directions, vehicle speeds, and information about cycle times.

The use of PTV VISSIM is not limited to traffic analysis but is also highly beneficial in urban transportation system planning. With its highly detailed microscopic modeling capability, PTV VISSIM can generate realistic simulations of traffic flow, travel times, and density levels in specific areas, such as the railway crossing on Abdurahman Saleh Street. Through various analyses and virtual experiments, modeling with PTV VISSIM enables planners and policymakers to project future traffic conditions and plan necessary actions to optimize the transportation system's performance during operation.

In an era of increasingly complex infrastructure planning and development, PTV VISSIM has become an invaluable tool. It not only aids in understanding traffic behavior and identifying potential issues but also provides powerful insights for stakeholders to make informed decisions in developing efficient and sustainable transportation systems. With accurate data and simulations that closely resemble reality, PTV VISSIM is an essential tool in effective urban traffic planning and management.

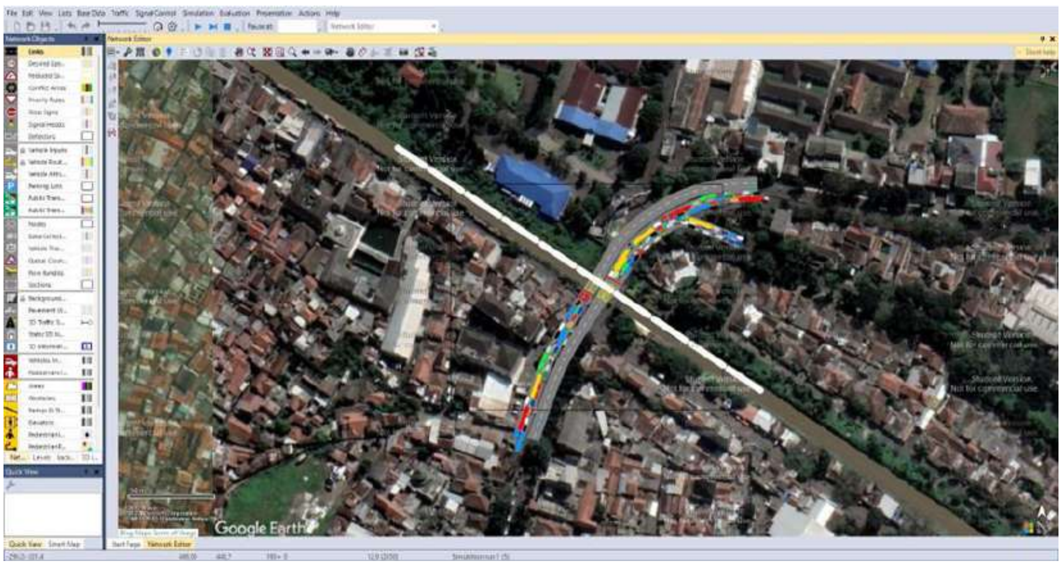

Figure 2 Simulation process in PTV VISSIM

The steps for using PTV VISSIM in traffic modeling can be explained as follows (Nagel & Pieck, 2015):

1. **Data Preparation:** Gather the necessary field data for modeling, including vehicle traffic volume, average speeds, vehicle movement patterns, and other relevant data. Ensure that this data is accurate and representative of the area being modeled.
2. **Network Creation:** Create a road network that includes the railroad interchange crossing. Define vehicle lanes, intersection positions, and road geometry characteristics.
3. **Simulation Design:** Determine the simulation scenarios you want to run, such as simulation time, initial traffic conditions, and variations of other factors to be tested.
4. **Vehicle Configuration:** Set vehicle attributes, such as vehicle types, maximum speeds, and driver types. This allows the simulation to represent various types of vehicles.
5. **Control Device Placement:** Add traffic signals, warning signs, and other control devices at the railroad interchange crossing. Set signal timings and control device policies according to the desired traffic conditions.
6. **Simulation:** Run the simulation with PTV VISSIM based on the configurations and scenarios set earlier. Observe and record traffic outcomes during the simulation.
7. **Results Analysis:** After the simulation is completed, analyze the results by comparing simulation data with

field data or desired performance targets. Evaluate the performance of the railroad interchange crossing and identify improvements or changes that may be needed.

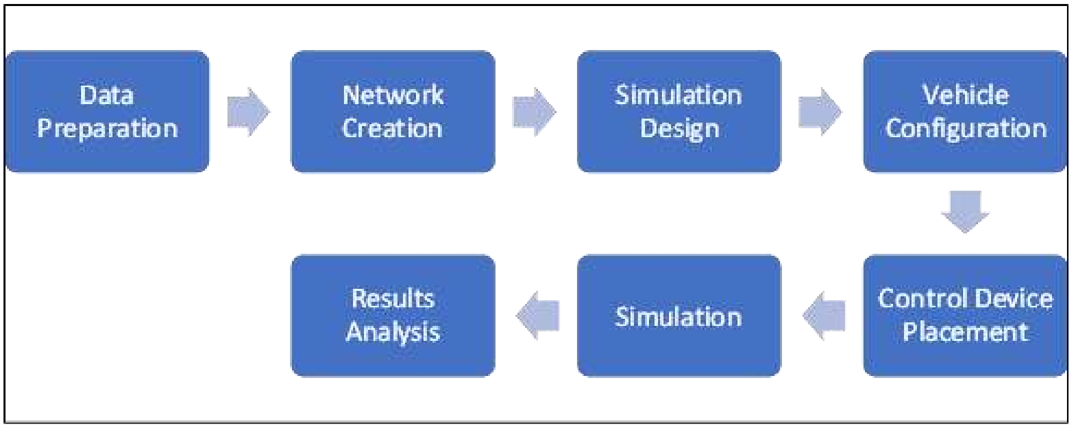

Figure 3 VISSIM PTV Modeling Steps

Railway Crossing

A railroad crossing is a point where a railway track intersects a road, allowing vehicles and pedestrians to cross the tracks. This crossing can become a potential accident-prone spot if not managed properly. A literature review highlights the importance of safety at railroad crossings (Sugiarto, Wijaya, & Pratama, 2019). The research discusses various factors contributing to accidents at railroad crossings, including driver behavior, environmental conditions, and infrastructure. The study's findings provide crucial insights for planners and policymakers in identifying risks and designing preventive measures to enhance safety at railroad crossings.

Figure 4 Railway Crossing

In this modeling, we will specifically discuss how to model a railroad crossing in PTV VISSIM. This configuration includes control devices such as traffic signals. In PTV VISSIM modeling, signal settings can be adjusted based on time or signal detectors. In the context of a railroad crossing, signal settings are done using signal detectors.

A signal detector is a tool that can provide instructions to change signals when specific vehicles pass through it. Signal detectors are divided into signal in and signal out. In this case, signal detectors are set to receive instructions from train vehicles. The instructions from the signal detector are then relayed to the signal heads installed on the road. So, when a train passes the signal detector, vehicles on the road will come to a stop because they receive a red signal on the road. This red signal will remain in place until the end of the train passes the signal detector out, and then the vehicles can resume moving.

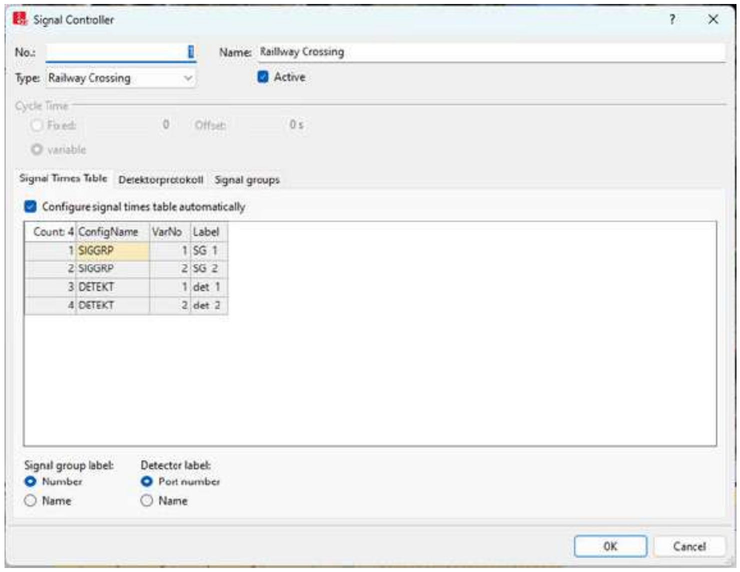

Figure 5 Signal Controller Settings

After determining the positions of the signal head and signal detector, the next step is to configure signal control. This is done to ensure that the system operates as explained earlier and becomes a signal system at the intersection. After adding the signal controller, configure the signal timetable to align with the desired control logic. Then, set up signal groups, taking into account the lane types and signal timing logic according to the desired model.

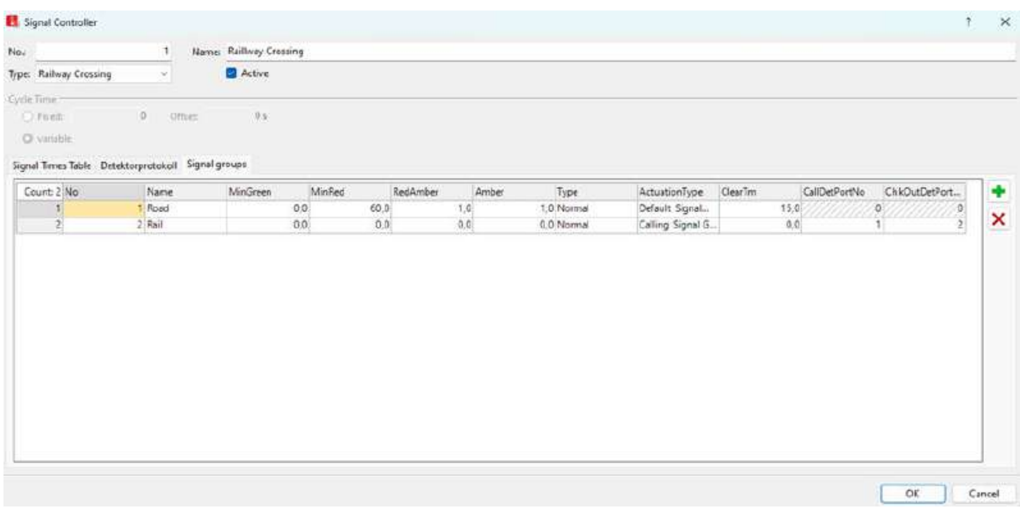

Figure 6 Signal Group Settings

Interchange

An interchange is a point where a roadway intersects a railroad track without alignment at a single level. The research examines the performance of an interchange using microscopic analysis (Abdullah, Hanum, & Nurhani, 2020). This study analyzes vehicle movements, delay times, and traffic density levels at the intersection. The research results provide valuable information about the performance of interchanges and offer input for more efficient and safe infrastructure improvements and developments. This study serves as a relevant reference for transportation planners aiming to optimize the performance of interchanges and enhance traffic flow and safety.

In the context of traffic modeling, it is important to understand the type of intersection being tested because various types of intersections have different characteristics. In this research, the modeling focus is on interchanges, which often play a crucial role in traffic planning and analysis. In the PTV VISSIM software, the creation of interchanges is controlled using the levels tool. Essentially, the line level is positioned at the base with coordinates at z = 0. However, to model an interchange, researchers can adjust the level to the desired z-coordinate height. This measurement is in meters and takes into account positive (above the surface) or negative (below the surface) signs. For example, in the case of modeling a flyover or overpass, the z-coordinate value will be higher than the base level. Conversely, if modeling an underpass, the z-coordinate value must be lower than the base level. Knowledge of level adjustments is crucial in conducting accurate and adequate modeling for traffic analysis at interchanges.

Figure 7 Differences in line levels in VISSIM

A good understanding of level settings in modeling interchanges provides a strong foundation for researchers and practitioners to accurately model real-world conditions in the field. This enables them to accurately depict complex and diverse road infrastructure situations, such as flyovers and underpasses. Furthermore, the use of appropriate levels ensures that traffic simulations reflect actual conditions, allowing the analysis results obtained to be used for the planning, improvement, and development of road infrastructure that is more effective and efficient.

Level of Service

Several important factors serve as the basis for assessing road service levels. These factors include traffic volume, road capacity, and vehicle speed. In transportation literature, the reference commonly used to measure road service levels is the Highway Capacity Manual. This manual classifies road service levels into six classes, with Class A representing the best conditions and Class F indicating the worst conditions (Transportation Research Board, 2000). Each class reflects traffic flow and vehicle speed situations in general. Good road performance has a road service level greater than 4, falling between 1-3 (Romadhona & Artistika, 2020).

Table 1 Information on the level of service at intersections and roads

Level of Service		Information
1	A	Free flow, free speed
2	B	Steady flow, limited starting speed
3	C	The flow is stable, but the speed and motion of the vehicle is controlled
4	D	Flow is unstable, speed decreases

5	E	Unstable flow, vehicles get stuck
6	F	Blocked flow, low speed

Source: Transportation Research Board, 2000

In modeling with VISSIM software, road service level calculations are automatically performed by the program based on the data input into the model. This results in evaluations that are directly derived from the calculations carried out by the software. The outcomes of these evaluations provide a clear insight into road performance, which can be used as a basis for making decisions regarding improvements and changes in the transportation system.

METHOD

Study Location

This research focuses on transportation analysis on Abdurahman Saleh Road, located in Bandung, Indonesia. This road segment holds significant importance as one of the main access routes to Husein Sastranegara International Airport, serving air transportation in the region. However, the main challenge in the surrounding area is heavy traffic congestion that doesn't allow for conventional road widening. Therefore, the proposed solution in this research is to adopt the concept of an interchange. Specifically, this intersection focuses on the junction between Abdurahman Saleh Road and the railroad track, and the aim of this research is to investigate the potential improvement in transportation performance by applying an interchange model to the existing conditions at the site.

This approach becomes relevant given the importance of maintaining accessibility to the airport and addressing congestion in the surrounding area. Considering the limitations of the available land, this research contributes to formulating possible alternative solutions to enhance the capacity and efficiency of transportation on Abdurahman Saleh Road. Furthermore, the results of this research can also provide valuable insights for the development of similar transportation infrastructure in other urban areas facing similar challenges in maintaining connectivity and the mobility of both people and goods.

Figure 8 Satellite image of the Abdurahman Saleh-Garuda intersection Source: Google Earth, 2023

Analytical Method

In this research, the applied analysis is an integral part of the methodology used. A deep understanding of traffic behavior and its impact on the roadway is crucial to achieving the research objectives. Therefore, the analysis is conducted using specialized modeling software, namely PTV VISSIM. This research involves the collection of diverse data, including background maps, vehicle counts, vehicle types, time data, and traffic signal information. These data serve as the basis for conducting simulations that allow for up to 5 iterations. From the results of these simulations, several key parameters such as the level of service, queue length, and vehicle delay can be measured. To obtain more representative results, the average value from the 5 iterations is taken as the primary reference in the analysis.

The findings of this research are not only valuable for understanding and optimizing traffic in a specific context but also provide valuable insights for decision-makers in the fields of transportation planning and road infrastructure development. Rigorous analysis methods and accurate modeling are the key factors in producing reliable and relevant results for the general public and stakeholders involved in transportation system planning and management.

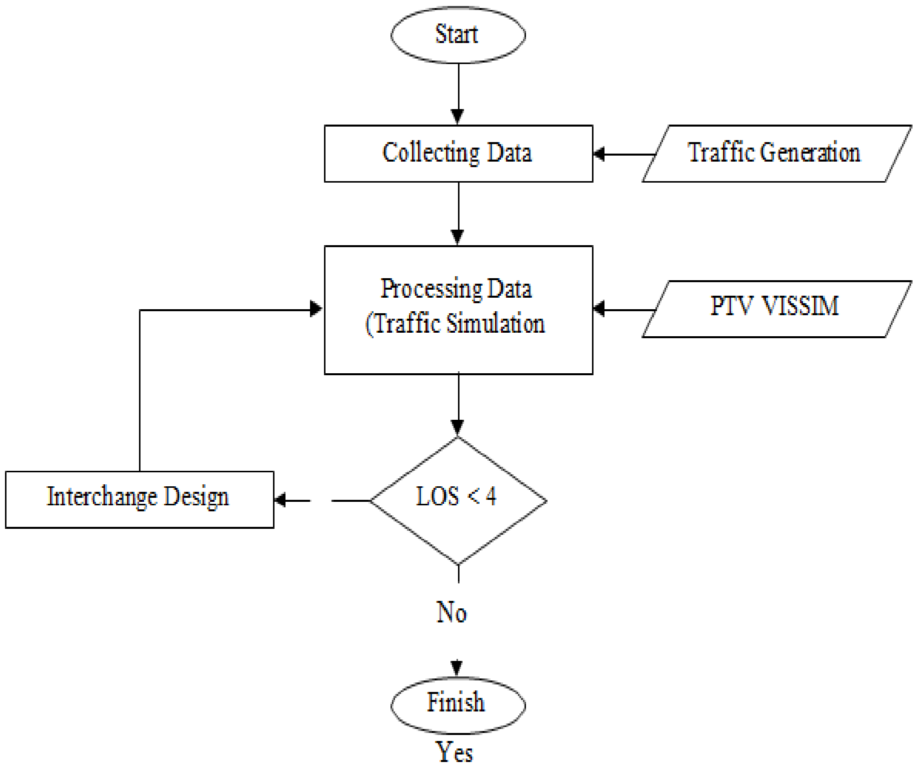

Figure 9 Flow Diagram

RESULTS AND DISCUSSION

Traffic Flow

This research is based on traffic flow data that encompasses various types of vehicles, such as passenger cars (LV), public transport (LV), buses (LHV), trucks (HV), and motorcycles (MC). The traffic flow data was obtained through a survey conducted by the Bandung City Transportation Agency in 2020. The survey results revealed that the average traffic flow through Abdurahman Saleh Street reached 8,008 vehicles per hour from both directions. Characterization of vehicle types showed that motorcycles (MC) were the most dominant type, accounting for 62% of the total traffic flow, while buses (LHV) were the least prevalent, comprising only 0.5% of the total traffic flow (Dinas Perhubungan Kota Bandung, 2020).

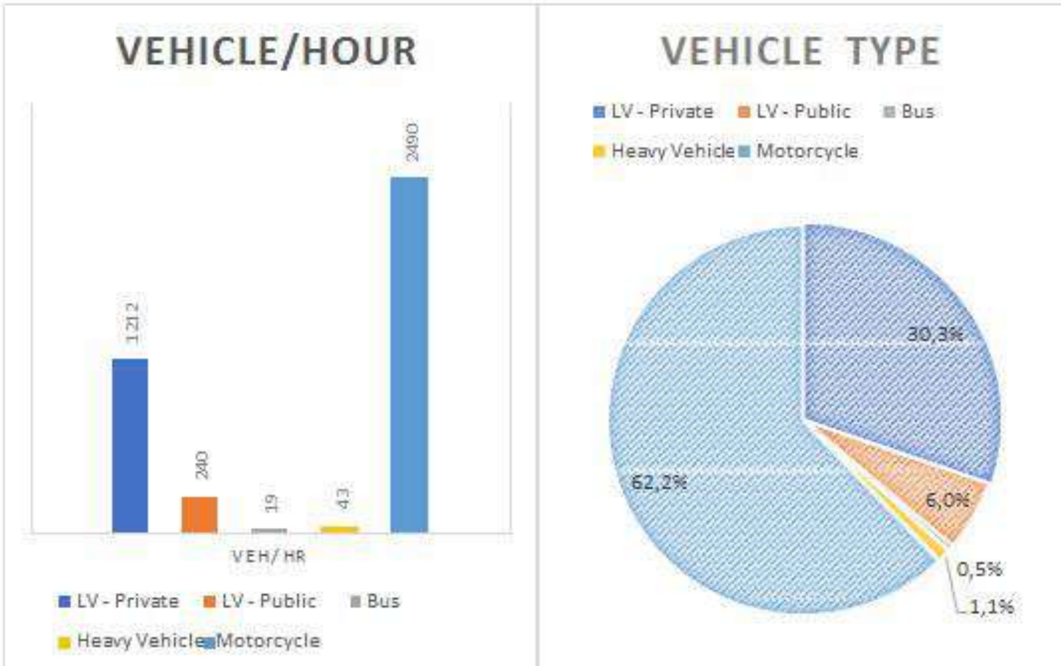

Figure 10 Traffic Flow and Percentage of vehicle types passing through Abdurahman Saleh Street Source: Dinas Perhubungan Kota Bandung, 2020

Train Schedule

Information about the train schedules that pass through the Abdurahman Saleh - Garuda Intersection is a crucial factor in understanding and analyzing traffic in that area. Data on train schedules can be obtained through PT. Kereta Api Indonesia (PT. KAI), especially the Bandung Operational Region (Daerah Operasi II Bandung). In this context, it is known that there are a total of 32 train trips in one day for each track, and this pattern also applies to the opposite direction of travel.

Table 2 DAOP II Bandung Train Schedule which passes through Garuda Railroad

No	Train	Station		Departure / day
		Origin	Destination	
1	KA Argo Parahyangan	Bandung	Gambir	10
2	KA Cikuray	Garut	Pasar Senen	1
3	KA Ciremai	Bandung	Tawang	2
4	KA Harina	Bandung	Pasarturi	1
5	Ekonomi Lokal	Cicalengka	Padalarang	18
	Total			**32**

Source: PT. Kereta Api Indonesia, 2023

Data regarding train schedules is of significant value in identifying the patterns and intensity of train movements passing through the intersection. This information also provides insights into the potential impact on road traffic and serves as a basis for developing accurate modeling models to optimize traffic flow and reduce congestion in the area. Furthermore, this train schedule data is also crucial for traffic safety efforts, at-grade intersection management, and better transportation infrastructure planning in the future.

PTV VISSIM Modeling

To address this issue, modeling was conducted using PTV VISSIM software. This modeling aims to design solutions that can reduce traffic congestion in the area. There are three scenarios evaluated in this modeling: the Existing scenario, Do Nothing, and Do Something.

The Existing scenario represents the traffic flow at the time of the study, reflecting the conditions and situation at the intersection as it currently exists in the field. The purpose of this modeling is to understand how the existing situation looks when viewed in the model. Additionally, calibration and adjustment of driving behavior were also performed to approach real-world conditions in the model.

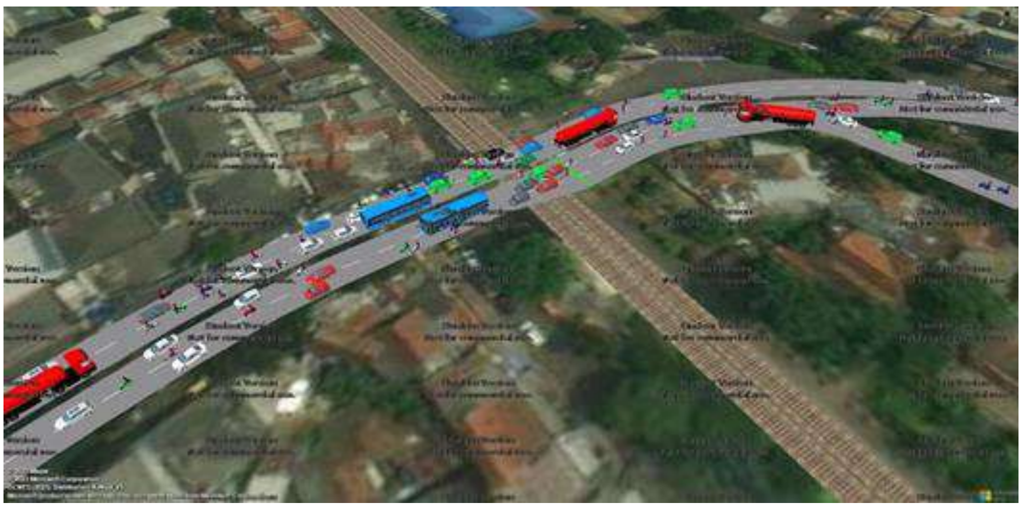

Figure 11 Existing Model of the Abdurahman Saleh-Garuda Intersection

Using the calculation formulated by PUPR, a simple projection for the number of vehicles passing through Abdurahman Saleh Road and the railway line can be obtained. In this simple projection, the growth rate is assumed to be 5%. The projection is used to determine the number of vehicles that need to be included in the Do Nothing and Do Something modeling.

Table 3 Number of Vehicles/hours

	Year	
Vehicle Type	**2023**	**2033**
	Veh/hr	**Veh/hr**
LV - Private	1403	2286
LV - Public	278	453
Bus	22	35
Heavy Vehicle	50	82
Motorcycle	2882	4695
Train	16	26

The Do Nothing scenario involves projecting the estimated traffic flow for the planning year, which is 2033. The year 2033, which is 10 years from the existing model, is considered as the medium-term planning for development. This scenario still uses the same intersection conditions and traffic policies as the existing conditions. The purpose of this modeling is to determine the conditions in the planning year if the intersection situation remains unchanged.

Figure 12 Do Something Model Abdurahman Saleh – Garuda Interchange

The Do Something scenario in this modeling is an approach that considers the projected traffic flow for the year 2033, with a planned interchange situation using a flyover. In this modeling, the flyover is designed using a configuration of 4 lanes, 2 directions, and undivided (4/2 UD). This design takes into account the high volume of vehicles assumed to pass through the Abdurahman Saleh road section and the availability of land.

Simulation Results

After the modeling is conducted, the simulation outputs include Queue Length, Vehicle Delay, and Level of Service. These parameters can be used as considerations when implementing traffic policies in the field. The construction of the interchange can reveal how much benefit and change it provides compared to having no construction at all.

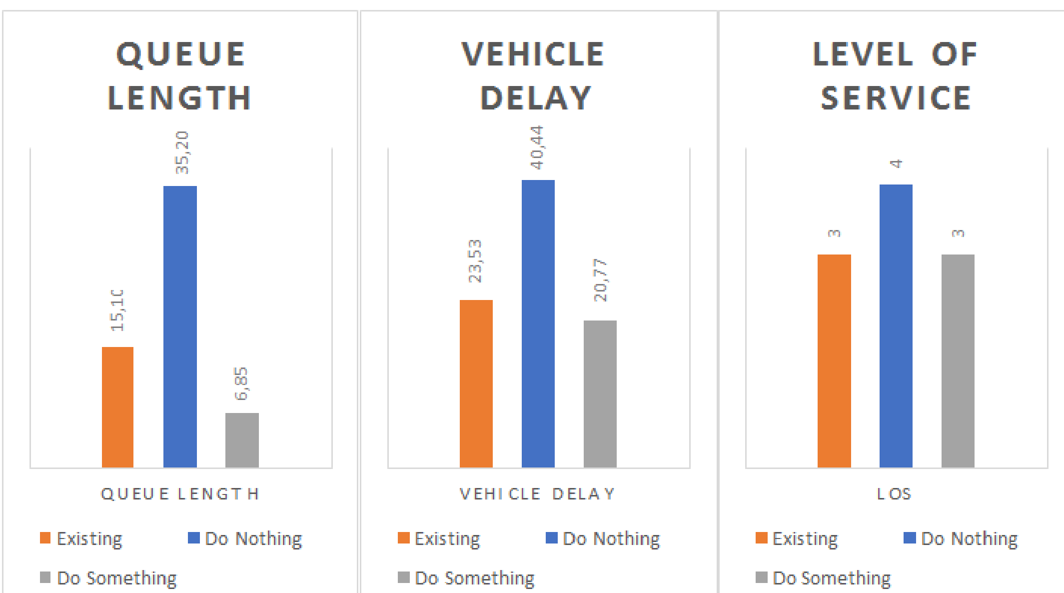

Figure 13 Queue Length, Vehicle Delay, and Level of Service

Queue Length is defined as the length of vehicle queues generated per time interval. The Queue Length results show the existing condition at 15.10 meters. With the increasing number of vehicles but no changes in geometry or traffic signals, the Queue Length changes to 35.20 meters, doubling its value.

By constructing an interchange in the form of a flyover, the change in Queue Length can be minimized to 6.85 meters. This change is reduced by 81% compared to the "Do Nothing" condition.

Vehicle delay is defined as the actual travel time delay compared to the ideal travel time that should occur. The Vehicle delay result for the existing condition is already at 25.33 seconds. If no changes are made in 2033, the vehicle delay increases to 40.44 seconds. With the construction of the flyover, the vehicle delay decreases to 20.77 seconds. This means that even with the construction, there is still some vehicle delay. This change is reduced by 49% compared to the "Do Nothing" condition.

The third parameter, the level of service, is defined as the value of vehicle service level derived from the overall parameter calculation. Values 1-6 can also be defined as LOS A-F. The level of service in the existing condition is C. If no interchange is constructed, the level of service in 2033 will change to D. However, if an interchange is built, the level of service will return to C.

CONCLUSIONS

The scenarios modeled include the existing condition during the year of the study, a "do nothing" scenario with the projected number of vehicles for the year 2033, and a "do something" scenario with a flyover configuration of 4 lanes 2 ways undivided (4/2 UD) and the projected number of vehicles for the year 2033. The modeling results using PTV VISSIM show that the Queue Length for the existing condition is 15.10 meters, for "do nothing" it's 35.20 meters, and for "do something" it's 6.85 meters. The Vehicle delay for the existing condition is 25.33 seconds, for "do nothing" it becomes 40.44 seconds, and for "do something" it changes to 20.77 seconds. The Level of service for the existing condition is C, for "do nothing" it changes to D, and for "do something" it becomes C.

This means that the existing condition based on the model at the Abdurahman Saleh – Garuda intersection already shows a low level of service. The operation of the Jakarta-Bandung High-Speed Train (KCJB) feeder, which passes through the railway that intersects with Jalan Abdurahman Saleh, will increase the movement volume of trains and delay vehicle movement on the arterial road. In 2033, this condition further reduces the quality of service at the intersection. The construction of an interchange in the form of a flyover will improve the service quality of the interchange.

Even though the improvement in the quality of service at the intersection increases and meets the minimum required parameters with the model of the flyover development scenario, this improvement is not yet significant. The quality of transportation can also be improved by increasing the use of public transportation and reducing the use of private vehicles. Therefore, the quality of transportation, which is an important aspect of economic and social mobility, can be enhanced.

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