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Calibrating and Validation Microscopic Traffic Simulation Models VISSIM for Enhanced Highway Capacity Planning

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ABSTRACT

This research aims to calibrate and validate the VISSIM simulation model tool by comparing field data with simulation data. The ultimate goal is to evaluate traffic performance by comparing simulation results with direct observations in the field. This study uses modeling to determine a road segment's maximum flow volume. This study was conducted in Makassar, South Sulawesi, Indonesia, on Jalan Veteran Selatan. The method uses two main inputs: urban road primary capacity data from the Indonesian Highway Capacity Manual (IHCM 1997) and roadside activity data from PTV VISSIM. The GEH and MAPE have commonly used metrics for measuring the accuracy of simulation models and calibration measurements using driving behavior parameters. The research results obtained for validation measurements have met the requirements. Namely, the obtained MEPE value (7.38%) is 10% smaller than the obtained GEH value (2.032 and 3.961), which is still more than 5.00. The calibration measurements obtained the suitability of the vehicle location and intervehicle spacing in the simulation model (VISSIM) with the actual field conditions. The results obtained from using VISSIM can be reliable and helpful in designing and optimizing urban transportation systems in the future. It is essential to remember that traffic simulation with VISSIM is only a transportation decision-making and planning tool and must be combined with field observations and accurate data for adequate and efficient transportation solutions.

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1. INTRODUCTION

Urban development and transportation planning are closely intertwined, and transport planning is crucial to create sustainable, efficient, and livable cities [1, 2]. It involves evaluating the current transportation system, including road networks and public transportation, and developing new systems that meet the needs of urban residents. The ultimate goal of transport planning is to ensure the smooth flow of people and goods while reducing congestion, which can have many benefits, such as more efficient use of resources and less air pollution [3-5]. One of the biggest challenges in transport planning is the increasing traffic volume in cities worldwide. This leads to problems such as traffic congestion, longer travel times, and increased air pollution [6, 7]. While many efforts have been made to address this issue, such as improving road infrastructure and public transportation, these solutions are often insufficient to reduce traffic congestion effectively. Therefore, innovative and sustainable solutions are needed to tackle this challenge, including using intelligent transportation systems, encouraging alternative modes of transportation, and implementing policies that promote sustainable urban development [8, 9].

High congestion and traffic density levels often cause delays, accidents, and air pollution. Therefore, it is necessary to have the right strategy in traffic management to reduce the negative impacts. One of the practical tools in traffic management is the Microscopic Traffic Simulation Model. Simulation analysis heavily relies on software as the primary tool for facilitating the

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calculation process [10]. The features of four different simulation programs: AIMSUN [11], TransModeler [12], CORSIM [13], and VISSIM were analyzed by Salgado et al. [14] and Hadi et al. [15]. Although each software package has advantages, the study ultimately chose VISSIM due to its superior vehicle routing capabilities, total output, stability, and extensive supporting documents accompanied by animations [16-19]. Traffic flow simulation can be conducted at macro and micro levels. However, Habtemichael and de Picado Santos [20] focused on transportation management and found that simulation at the micro level yields more satisfactory results compared to macro simulations. At the micro level, the simulation can better capture the impact of heterogeneous traffic and produce more comprehensive and precise results. This level of detail is crucial for evaluating traffic flow scenarios, predicting traffic patterns, and making informed traffic management and planning decisions.

Using microscopic traffic simulation models such as VISSIM has revolutionized transportation planning by providing planners with a powerful tool to evaluate various scenarios and predict the impact of infrastructure changes on traffic flow. These models use advanced algorithms to simulate the behavior of individual vehicles, considering factors such as driver behavior, traffic signals, and lane changes [21]. By analyzing the simulation results, transportation planners can identify potential issues and test different solutions before making any changes to the transportation infrastructure [22].

The level of detail provided by these models allows for a comprehensive evaluation of traffic flow in urban areas. Transportation planners can use these models to optimize the timing of traffic signals, adjust road layouts, and improve public transportation systems to reduce congestion and improve accessibility. Using microscopic traffic simulation models, transportation planners can make more informed decisions, leading to a more efficient flow of people and goods, improved safety, and reduced environmental impact [23]. VISSIM, in particular, has become a widely used and well-regarded microscopic traffic simulation software program due to its ability to predict traffic flow and congestion accurately. The software includes various customizable parameters, including vehicle types, traffic signals, and lane changes, allowing for detailed traffic flow analysis at the individual vehicle level [24]. The program also allows the simulation of various scenarios, such as changes in traffic patterns, lane configurations, or signal timings, to estimate the effect of different infrastructure changes on travel movement.

VISSIM and other traffic simulation models' accuracy depends on the calibration and validation process. This process involves adjusting the model's parameters to match real-life traffic flow data and validating the calibrated model against independent traffic data to verify the model's accuracy [25]. Calibration and validation ensure that the model accurately represents actual traffic conditions, accounting for changes in traffic volume, time of day, and weather conditions. Regularly updating and maintaining calibration and validation procedures is crucial to ensure the accuracy and reliability of simulation models, as traffic conditions can change ith respect to time [26-28]. Both calibration and validation must be periodically revised to ensure that the simulation model can still accurately replicate field conditions and produce consistent results with new observation data. This ongoing process is vital in ensuring the relevance and reliability of simulation results [29].

Calibrating a microstimulator involves two sets of parameters: driving behavior parameters and travel behavior parameters. Some examples of the former are models of acceleration, lane switching, and intersections; examples of the latter are models of origin-destination flows and route selection. However, scant information is available on calibrating traffic simulation models, with most studies focusing on one aspect typically driving behavior and assuming that the rest of the limits are already known. For example, studies conducted by Zhe et al. [30], Jha et al. [31], Daigle et al. [32], and Ratrout et al. [33] only calibrate driving behavior parameters. Route selection is a crucial element in the calibration procedure. It is commonly assumed that the flows between origin and destination have been pre-established. The estimation procedures for origin-destination flows function on the premise that the assignment matrices, which represent the impact of route selection and flow propagation, have been established or are already known. The assignment matrices are paramount in comprehending and simulating the dispersion of traffic volumes among diverse paths within a transportation system. Assuming the availability of assignment matrices, the calibration procedure can prioritize the adjustment of other parameters and variables to enhance the precision and dependability of the comprehensive model [11]. Yang and Slavin [12] took a different tack by extending the origin-destination estimation process to incorporate a route choice model, but they did so assuming that the model parameters are immutable.

The model's parameters are fine-tuned during calibration by comparing the simulated and observed traffic flows. This requires making small, incremental changes to the parameters to get simulation results as close as possible to the actual data. The calibration process is not complete until validation has been performed, as this verifies the accuracy of the model and its applicability for foreseeing the results of any future changes to the infrastructure. Predictions from the calibrated model checked against data on traffic flows that were not used during calibration. The calibration and validation process is essential to the success of traffic simulation models like VISSIM [24, 34]. Adjusting the model's parameters to correspond with observed traffic volumes is known as calibration, and checking the model's accuracy by comparing predictions to external traffic measurements is known as validation. Calibration and validation check the accuracy of traffic simulation models so that transportation infrastructure decisions can be made confidently [35].

Based on the description, the research aims to calibrate and validate using the VISSIM simulation model tool by comparing field data with simulation data. The ultimate goal of the research is to evaluate traffic performance by comparing simulation results with direct observations in the field. By evaluating these results, the research can provide recommendations to improve traffic performance in the future. VISSIM model's vehicle behavior in urban transportation systems to better understand traffic performance and predict infrastructure changes' effect on traffic movement. Therefore, by calibrating and validating, the results obtained from the VISSIM can be reliable and helpful in designing and optimizing urban transportation systems in the future use.

2. MATERIALS AND METHODS

2. 1. Research Approach The research approach in this study involves a modeling method to define the determined movement volume a highway segment can handle. The method uses two main inputs, namely the primary capacity data from the Indonesian Highway Capacity Manual (IHCM 1997) [36] for urban roads and the number of roadside activities from the PTV VISSIM assistance program [37]. The study requires several data types to model, including road geometry, side barriers, and free-flow speed data. The side barrier data used in this study include roadside parking activities, vehicle activities entering and leaving the road segment, and slow vehicles. The study did not consider the influence of pedestrians in the modeling process.

This study employed a quantitative methodology based on the analysis and modeling of collected data. The study relies on existing data sources and software programs to perform the modeling process. The study results are presented in numerical values that indicate the maximum flow volume the road segment can handle.

2. 2. Location of Study This study was conducted in front of the Maricaya Market, located on Jalan Veteran Selatan, Makassar sub-district, Makassar City. Maricaya Market is a traditional market located in the heart of a densely populated settlement that serves as a local trading center.

This location was chosen for research because Maricaya Market is an important land transportation area in Makassar City. Because of its strategic location, this market is a crossroads for many transportation routes, including highways, ring roads, and other major thoroughfares. This makes it a desirable location for observing and analyzing traffic patterns and interactions between vehicles and pedestrians in congested areas.

The location was chosen to analyze the impact of market activities on road volume and travel congestion. The study was conducted for one week in July-August 2022 and included observations on weekdays and holidays. On weekdays, observations were made from Monday to Friday, while on holidays, they were held on Saturday and Sunday.

Data collection was conducted in three sessions, each at different times of the day, to capture any changes in traffic conditions. Session I was held in the morning from 6.00 to 10.00 A.M. Session II in the afternoon from 12.00 to 2.00 P.M., and Session III in the evening from 4.00 to 6.00 P.M.

The study focused on peak hours, four hours in the morning and four hours in the afternoon, to capture the highest traffic volumes and travel congestion. The research used direct observation methods to collect data, including manual traffic counting, recording travel times, measuring vehicle speeds and measuring road geometry.

This study aims to collect traffic flow data consisting of four types of vehicles, namely light vehicles, heavy vehicles, motorbikes, and non-motorized vehicles, which are obtained directly from observations and measurements in the field. The road section has 2/4D divided lanes. Observations were made on this road section because it is a busy and vital area for land transportation in Makassar City.

2. 3. Data Geometric Primary data was obtained directly from surveys of geometric road conditions. This data includes road width, number of lanes, lane width, road shoulder width, and road type. Where the observed

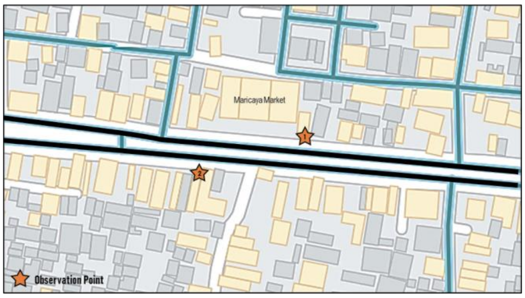

Figure 1. Test Site: Veteran Selatan Road, Makassar, South Sulawesi, Indonesia

location is at the point of the road, namely Jalan Veteran Selatan. The following is a description of the geometric conditions of the road (Table 1).

Data obtained from field observations will later be processed and analyzed to produce useful information on road capacity, traffic density, and congestion around Maricaya Market. The data from this research can assist decision-makers in traffic management in Makassar City, particularly in increasing road capacity and reducing traffic jams in busy and densely populated areas.

2. 4. Data Analysis

2. 4. 1. Traffic Volume The definition of traffic volume refers to the count of vehicles passing a particular point or line on a road cross-section. The method of traffic counting is done manually by recording vehicles in a flow that is distributed according to the type of vehicle continuously at 20-minute time intervals. The calculation of vehicle volume is determined using an equation:

$$Q = {}^{n}/_{t} \tag{1}$$

where, Q is volume of vehicles (vehicles/hour), n is the number of vehicles (vehicles) and t is observation time (hours).

2. 4. 2. Road Capacity Capacity refers to the maximum traffic volume sustained under specific conditions, including geometry, distribution of traffic directions and composition, and environmental factors, with units of PCU/hour [36]. Regarding explanations for road capacity, speed, volume, and density are related. The more vehicles on the road, the more the average speed decreases. The basic equation for determining capacity is as follows:

$$C = C_O \times FC_W \times FC_{SP} \times FC_{SF} \times FC_{CS} \tag{2}$$

Where, C is capacity (PCU/hour), Co is basic capacity for ideal conditions (PCU/hour), FCw is traffic lane width adjustment factor, FCsp is directional separation adjustment factor, FCsf is side resistance adjustment factor and FCcs is city size adjustment factor.

2. 4. 3. Degree of Saturation The degree of saturation is the traffic flow ratio (PCU/hour) to capacity (PCU/hour) and is used as a critical factor in assessing and determining the performance level of a road segment. If the Q/C Ratio exceeds 1, the traffic volume exceeds the available road capacity. This indicates the excess capacity and possible congestion. The higher the Q/C Ratio, the denser and more jammed the traffic conditions. The calculation of the degree of saturation is determined using an equation:

$$DS = {}^{Q}/_{C} \tag{3}$$

where, DS is degree of saturation, Q is traffic flow (PCU/hour) and C is capacity (PCU/hour).

TABLE 1. Road Geometric Characteristics

Road Characteristics	Observation (Existing)
Road Type	Four-lane Split or One-way Street
Type of Road Pavement	Asphalt
Road Lane Width	9 meters
Road Lane Width	3 meters
Road Shoulder Width	1 meter

2. 5. Calibration Model The purpose of calibrating driving behavior parameters is to ensure that the simulation model can accurately reproduce the field's driver behaviors. This is very important in transportation analysis and highway planning because an accurate simulation model can provide more accurate predictions about how changes in road conditions or traffic policies may affect driver behavior and traffic flow.

Calibration in VISSIM is a process of forming appropriate parameter values so that the model can replicate traffic to conditions that are as similar as possible. The method used is trial and error, which is done by comparing field observation conditions with conditions in the simulation. This simulation is accurate if the error rate between the simulation results and the observed data is relatively low. The calibration uses optimization techniques to minimize the deviation between the observed data and the simulation measurements made to match.

This calibration process is carried out by comparing empirical or field data with the simulation results of the developed mathematical model. In this case, the difference between the empirical data and the simulation results will be used to adjust the required parameter values in the model. The simulation model must first be calibrated using field data to produce accurate predictions. This can be done by collecting data from direct observations, such as measurements of speed, acceleration, head distance, and other variables related to driver and vehicle behavior on the road.

2. 6. Validation Model In VISSIM, the validation process involves comparing the results of simulations with observations to verify the accuracy of the calibration. The validation examines the traffic flow volume and the queue length. The GEH (Geoffrey E. Havers) test is a statistical method used to evaluate the accuracy of simulation models. It measures the difference between the observed and simulated values and compares it to the expected range of differences. In the following GEH [38-41], the formula has specific provisions for the resulting error values as follows:

$$GEH = \frac{\sqrt{(q\_simulated - q\_observed)^2}}{0.5 \times (q\_simulated + q\_observed)} \quad (4)$$

where q simulated is average traffic flow volume in simulation (vehicles/hour) and q_observation is traffic flow volume in the field (vehicles/hour).

The GEH test is a valuable tool for evaluating the accuracy of simulation models and can help ensure that the models are reliable and accurate for use in transportation planning and decision-making. To explain from the GEH results can be seen in Table 2.

A GEH value less than 5.00 is generally considered acceptable, indicating that the simulated values are accurate and can be used for further analysis and planning. However, a GEH value between 5.00 and 10.00 indicates a possible error or harmful data, and further investigation may be necessary. A GEH value greater than 10.00 indicates that the simulated values are significantly different from the observed values, and the model should not be used for further analysis or planning.

The Mean Absolute Percentage Error (MAPE) is a commonly used metric for measuring the accuracy of a forecast or prediction [42]. It is calculated by taking the absolute difference between the actual and predicted values, dividing that by the actual value, and multiplying by 100 to get a percentage [43]. The MAPE is then calculated as the average of these percentage errors.

$$MAPE = \frac{1}{n}\sum_{t=1}^{n}\left|\frac{At-Ft}{At}\right| \times 100\% \quad (5)$$

where n is total data, At is the observation data and Ft is simulation model data.

MAPE is a valuable metric because it provides a simple way to evaluate the accuracy of a forecast or prediction, regardless of the scale of the data or the units of measurement. Based on Lewis [44], the range of MAPE values can be interpreted into four categories (Table 3).

TABLE 2. Description of GEH Result

GEH Range	Description
GEH < 5.00	Accepted
5.00 ≤ GEH ≤ 10.00	Caution: model error or insufficient data
GEH > 10.00	Denied

TABLE 3. Description of MAPE Result

MAPE Range	Description
≤ 10%	Simulation results are very accurate
10 – 20%	Good Simulation results
20 – 50%	Simulation results are feasible (good enough)
> 50%	Inaccurate simulation results

MAPE is a method of measuring the error or accuracy of a prediction or simulation model by comparing the difference between the actual value and the normalized predicted value in the form of a percentage.

3. RESULTS AND DISCUSSIONS

3. 1. Calibration Model Driving Behavior must be adapted to conditions in the field so that the simulation results can represent conditions in the field. The parameter used for modeling validation with field conditions is the model traffic volume equal to the field traffic volume. If the results do not represent the conditions in the field, then a reset or calibration is required to suit the field. By calibrating the Driving Behavior parameters, the simulation model will be able to represent driver behavior and traffic volume following the conditions in the field so that the simulation results can be used to predict realistic traffic conditions. The Driving Behavior Parameters used in this study summarized in the following table:

The driving behavior Table shows several parameters with constant values in each simulation period. The interpretation of the calibration values for the parameters in Table 4 is as follows:

- Average Standstill Distance: The calibration value indicates that the vehicle has an average distance of 0.2 meter before stopping.
- Additional Part of Desired Safety Distance: Two calibration values are used, 0.5 and 1 meter. This indicates that the safe distance between the vehicle in front and behind is increased by a larger additional distance when travelling at higher speeds.
- Number of Observed Vehicles: In this simulation, the number of observed vehicles is 2.

TABLE 4. Calibration Model Validation

Parameter	Driving Behavior	
	Default	Changes
Average Standstill Distance	2 meters	0.2 meter
Add. Part of Desired Safety Distance	2 meters	0.5 meter
Add. Part of Desired Safety Distance	3 meters	1 meter
No. of Observed Vehicle	2.00	2.00
Lane Change Rule	Free Lane Selection	Free Lane Selection
Desired Lateral Position	1 meter	Any
Lateral Distance Driving	1 meter	0.15 meter
Lateral Distance Standing	1 meter	0.45 meter
Safety Distance Reduction Factor	0.6 meter	0.45 meter
Minimum Headway	0.5 second	0.5 second

- Lane Change Rule: The rule used in the simulation is free lane selection.
- Desired Lateral Position: The desired lateral position is any.
- Lateral Distance Driving: The lateral distance between one vehicle and another while driving is 0.15 meter.
- Lateral Distance Standing: The lateral distance between one vehicle and another while standing is 0.45 meter.
- Safety Distance Reduction Factor: The calibration value used for the safety distance reduction factor is 0.45 meter.
- Minimum Headway Time: The minimum headway time or the minimum time distance that must be maintained between vehicles is 0.5 second.

This shows that driver behavior can vary in traffic conditions, such as rush hour and off-peak. Therefore, to obtain accurate simulation results, it is necessary to calibrate these parameters based on traffic conditions according to the situation in the field (Figures 2 and 3).

The calibration Figures 2 and 3 show the difference in traffic flow behavior before and after calibration on the VISSIM software. The traffic in the simulation is observed to move steadily in a lane-by-lane manner with sufficient gaps between the vehicles before undergoing calibration. However, the traffic becomes more erratic after calibration, with frequent overtaking and closing gaps between vehicles.

This change indicates that the driving behavior in the VISSIM simulation model better represents real-world traffic conditions, where overtaking and chaos on the road are common occurrences. In a heterogeneous traffic context, where various vehicles with different speeds are on the same road, the calibration results show that the simulation model is acceptable and provides more accurate results. This way, the VISSIM simulation results can be used to plan and develop a more effective and efficient traffic system.

Figure 2. VISSIM Test: Before Calibration

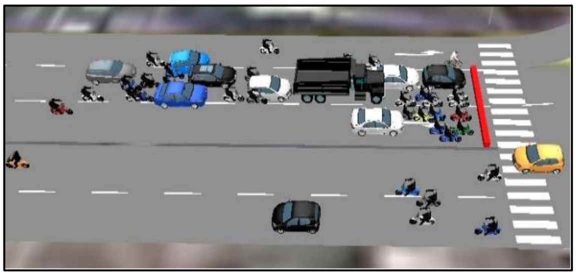

Figure 3. VISSIM Test: After Calibration

3. 2. Validation Model

Table 5 shows the validation results of the simulation models used in transportation analysis and planning. The table calculates two GEH values for two days, namely Monday and Saturday (peak hours).

Table 5 presents the validation results of the GEH test for vehicle volume per hour, comparing VISSIM and IHCM 1997. The study was conducted on two different days, namely Monday and Saturday.

The interpretation of the results shows that on Monday, there was a slight difference in vehicle volume between VISSIM and IHCM 1997, as indicated by the GEH (2.032). However, vehicle volume significantly differed on Saturday between the two models, as indicated by the higher GEH (3.961). Despite this, the GEH values for both days were below 5, indicating that the simulation model meets the desired accuracy criteria. Therefore, the simulation model is acceptable for more advanced transport planning and analysis.

The range of MAPE values (Table 6) obtained in the calibration results given is (7.38%) where these results are ≤10. This shows that the forecasting/simulation results are accurate and follow the actual field conditions. The smaller the MAPE value, the better the forecasting or simulation model's ability to predict the actual value. In this context, the MAPE values obtained indicate that the simulation model used in this study can predict actual values and is reliable for further analysis and transportation planning.

Apart from using performance evaluation metrics such as Mean Absolute Percentage Error (MAPE), validating the simulation results can also be done by comparing field conditions with simulation results. From Figures 4 and 5, it can be seen that the simulation

TABLE 5. GEH Test Validation Results (vehicle/hour)

Time	VISSIM	IHCM 1997	GEH
Monday	1707	1792	2.032
Saturday	1340	1489	3.961

TABLE 6. MAPE Test Validation Results (vehicle/hour)

Time	VISSIM	IHCM 1997	MAPE
Monday	1707	1792	2.37%
Saturday	1340	1489	5.00%
		Average	7.38%

Figure 4. VISSIM Test Condition Site

Figure 5. Existing Conditions Site

results are quite similar to the actual field conditions. This shows that the simulation model used is quite good and can represent traffic conditions in the field.

Simulation model validation is a process to check the reliability and accuracy of the model in predicting traffic behavior in the field. By doing good validation, the simulation model can be well-calibrated to be trusted in predicting traffic behavior in the field. In this case, the visualization images in Figures 4 and 5 show the suitability of the vehicle position and the distance between the vehicles in the simulation model with the actual field conditions. This proves that the simulation model has passed the validation process correctly.

By using a well-calibrated simulation model, traffic infrastructure development decisions can be taken more effectively and efficiently because the model can accurately predict traffic behavior in the field. Therefore, validation of the simulation model is essential to ensure the reliability and accuracy of the model so that decisions made based on the model can be more accurate and reduce the risk of errors in the development of traffic infrastructure.

3. 3. Comparison of Observation (IHCM 1997) and Simulation (VISSIM) Traffic volume is one of the parameters used in validating using the Geoffrey E. Havers (GEH) formula. This aims to compare whether the simulation model is appropriate or describes the traffic conditions at the observation location. Due to the limitations of the VISSIM Software in displaying simulation results, namely for 600 seconds of simulation, the volume of vehicles compared is the volume of vehicles per hour.

Figure 6 compares simulated and observed traffic volumes on Monday and Saturday afternoons. The simulated traffic volume is calculated using the VISSIM software, while the observed traffic volume is measured directly in the field. The figure shows that the traffic volume on Monday afternoon was higher than Saturday afternoon for both simulation and observation. However, there is a difference between the simulated and observed values on the two days. On Monday afternoon, the simulation value was 1707 vehicles/hour, while the observed value was 1792 vehicles/hour. On Saturday afternoon, the simulation value was 1340 vehicles/hour, while the observed value was 1489 vehicles/hour.

This shows that even though the simulated and observed values have the same trend (i.e., the traffic volume is higher on Monday afternoon), there is a numerical difference between the two. Several factors, such as inaccuracies in observational measurements or the calibration of simulation models, can cause this difference. Therefore, it is necessary to adjust or calibrate the simulation model so that the results are more accurate and can better represent field conditions.

The VISSIM procedure utilizes predetermined parameters, such as the maximum vehicle speed, the distance between vehicles, and the red time of traffic lights. The VISSIM simulation results demonstrate the traffic service level on a road or intersection. This information can be used to evaluate the performance of existing traffic and identify areas requiring improvement or modification. The VISSIM simulation results can also be used to compare the performance of different tested scenarios. The optimal and most effective scenario for increasing traffic performance can be selected by comparing the performance of the two scenarios. The initial stage calibration and validation process must be carried out with care to obtain accurate and reliable simulation results. After that, the specified parameters can be used to run VISSIM to produce accurate and reliable service-level simulation results. The Level of Service measures road performance and traffic congestion. Average speed, travel time, number of vehicles per unit of time, road capacity, traffic density, and congestion level are used to score this system. Road service is as follows:

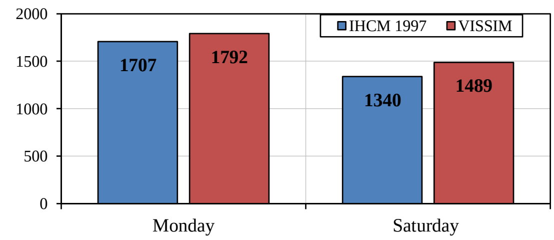

Figure 6. Comparison of Observation (IHCM 1997) and Simulation (VISSIM)

At the Level of Service, each level is denoted by a letter from A to F, with A being the best level and F being the worst level [36, 45]. At level B, traffic flow is stable with moderate vehicle volume and limited speed. The driver has sufficient freedom in choosing the speed of the vehicle. At level C, traffic flow remains stable, but the speed and movement of vehicles are controlled by traffic volume. The driver has limitations in choosing the speed of the vehicle. At level D, the traffic flow is nearly unstable, with high traffic volumes and speeds that can be tolerated but are highly influenced by flow conditions. The traffic flow is close to unstable, and almost all drivers have limited freedom in driving the vehicle.

Based on the simulation results using the VISSIM software, the level of service on Monday is D, while on Saturday, it is B (Table 7). However, there are differences in results when using the 1997 Indonesian Highway Capacity Manual (IHCM) method, which uses the degree of saturation value in categorizing service levels. Based on this calculation, the level of service on Monday afternoon is categorized as C, and on Saturday afternoon is categorized as B. This shows differences in the results of measuring the traffic service level depending on the methods and techniques used. Therefore, traffic and transportation experts need to choose the correct methods and techniques for analyzing and measuring the level of traffic services. In addition, the results of these measurements can be used to identify traffic problems and design effective solutions to improve road service levels and performance.

Several studies in Indonesia have also used VISSIM as a microscopic simulation application to evaluate the performance of a road segment. This study used VISSIM to model vehicle traffic on a road segment and evaluate traffic performance [46-53]. To compare the results of the analysis from VISSIM, the study also used the Indonesian Highway Capacity Manual (IHCM) 1997 as a comparison. The research results in several countries show that VISSIM can accurately evaluate traffic performance on a road segment. Thus, using VISSIM in traffic simulations can assist decision-makers in making more informed decisions regarding developing a better transportation system [54-58].

In the Indonesian context, which has challenges in overcoming traffic congestion, using VISSIM can assist in designing more effective and efficient transportation solutions. Using VISSIM, decision-makers can evaluate various traffic development schemes and select the most appropriate solution to address traffic problems in an area. This can help to improve the transportation system's performance in Indonesia and reduce traffic congestion, a significant problem in several big cities in Indonesia. In addition, the calibration carried out for drivers in Indonesia in this study cannot be immediately generalized to drivers in other countries. Driver behavior in each country can also vary, such as the level of discipline in following traffic rules, preparedness in dealing with emergencies, and awareness in driving. This difference may affect the driver's ability to follow the calibration model simulation results in other countries. Observations conducted in Dutch [59] and China [60] cities showed that drivers there had lower acceleration and desired speed profiles than observations in the Netherlands. Drivers in Indonesia may have experience driving on potholes or damaged roads, while drivers in other countries may not.

TABLE 7. Table of comparison of service levels resulting from IHCM 1997 and VISSIM

Time	IHCM 1997	VISSIM
Monday	D	B
Saturday	C	B

VISSIM is a traffic simulation software that models various transportation scenarios, but its accuracy can be influenced by external factors such as weather, accidents, or policy changes. Real-world traffic conditions are complex and dynamic, making it difficult to predict the impact of external factors. Therefore, it is important to exercise caution when interpreting VISSIM outcomes and to consider a range of factors, including historical data, expert insights, and real-world observations, for a comprehensive understanding of the transportation system. Traffic simulation models like VISSIM are only one tool among many for transportation planning and decision-making, and a holistic approach that considers economic, social, and environmental impacts, community needs, and priorities is necessary for effective, sustainable, and equitable transportation solutions that benefit all stakeholders.

4. CONCLUSION

Based on simulation results using VISSIM and the Indonesian Highway Capacity Manual (IHCM) 1997 method, there are differences in measuring the traffic service level. This demonstrates the importance of selecting the correct method and technique for analyzing and measuring traffic service levels. Using VISSIM as a microscopic simulation application can assist decision-makers in developing more effective and efficient transportation solutions to reduce congestion. With VISSIM, a traffic simulation is only a transportation planning and decision-making tool. The simulation results must be analyzed using data and field observations to draw more accurate and pertinent conclusions about the field situation. VISSIM must always be combined with field observations and accurate data for adequate and effective transportation solutions. VISSIM is a useful software instrument for researchers and transportation planners to evaluate road network performance, develop scenarios, and make better decisions to improve road network safety and performance.

Future research on VISSIM calibration may employ more precise techniques like drone technology to collect traffic data. Then, machine learning techniques can be used to predict simulation model parameters using historical data more accurately. The ultimate objective of this study is to improve the simulation model's ability to reflect actual traffic conditions. This research's findings can be utilized more effectively for infrastructure planning and decision-making that is more effective and efficient.

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Persian Abstract

چکیده

هدف این تحقیق کالیبراسیون و اعتبارسنجی ابزار مدل شبیه سازی VISSIM با مقایسه داده های میدانی با داده های شبیه سازی است. هدف نهایی ارزیابی عملکرد ترافیک با مقایسه نتایج شبیه سازی با مشاهدات مستقیم در میدان است. این مطالعه از مدل سازی برای تعیین حداکثر حجم جریان یک بخش جاده استفاده می کند. این مطالعه در ماکاسار، سولاوسی جنوبی، اندونزی، در جالان کهنه سرباز سلاتان انجام شد. این روش از دو ورودی اصلی استفاده می کند: داده های ظرفیت اولیه جاده های شهری از راهنمای ظرفیت بزرگراه اندونزی (IHCM 1997) و داده های فعالیت کنار جاده از PTV VISSIM. GEH و MAPE معمولاً از معیارهایی برای اندازه گیری دقت مدل های شبیه سازی و اندازه گیری های کالیبراسیون با استفاده از پارامترهای رفتار رانندگی استفاده می کنند. نتایج تحقیق به دست آمده برای اندازه گیری اعتبار، الزامات را برآورده کرده است. یعنی مقدار MEPE بدست آمده 10% (7.38%) کوچکتر از مقدار GEH بدست آمده (2.032 و 3.961) است که همچنان بیش از 5.00 است. اندازه گیری های کالیبراسیون مناسب بودن مکان وسیله نقلیه و فاصله بین خودرو را در مدل شبیه سازی (VISSIM) با شرایط میدان واقعی به دست آورد. نتایج به دست آمده از استفاده از VISSIM می تواند در طراحی و بهینه سازی سیستم های حمل و نقل شهری در آینده قابل اعتماد و کمک کننده باشد. مدل شبیه سازی ترافیک یک ابزار تصمیم گیری و برنامه ریزی است که باید با مشاهدات میدانی و داده های دقیق ترکیب شود تا راه حل های حمل ونقل کارآمد ایجاد کند.