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Comparison of Passenger Car Equivalency Values Using Time Headway Method and PKJ 2014 at Transmart Kairagi Four-Way Intersection, Manado City

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Abstract

The Transmart Kairagi Four-Way Intersection is one of the signalized intersections in Manado City that frequently experiences congestion and long queues during peak hours. The Passenger Car Equivalency (PCE) values used in intersection performance analyses generally refer to PKJI 2014; however, these values may not accurately represent current traffic conditions. This study aims to compare PCE values obtained using the Time Headway method with those specified in PKJI 2014 and to analyze their effects on intersection performance. Traffic surveys were conducted over three days (Saturday, September 6; Monday, September 8; and Tuesday, September 9, 2025) from 06:00 to 18:00 local time. Traffic volume data were classified into Motorcycles (MC), Light Vehicles (LV), and Heavy Vehicles (HV). The highest traffic volume was recorded on Monday between 17:00 and 18:00, reaching 3,413.6 passenger car units (pcu)/hour. The results indicate significant differences between the PCE values derived from the Time Headway method and those provided in PKJI 2014, which influence intersection capacity and degree of saturation calculations. These findings highlight the need to update PCE values based on actual field conditions to support more accurate traffic planning and operational management in Manado City.

INTRODUCTION

Manado City, as the capital of North Sulawesi Province, serves as one of the primary economic, commercial, and administrative centers in eastern Indonesia. Rapid urbanization, population growth, and increasing economic activities have significantly increased travel demand within the city. Consequently, the number of motorized vehicles has grown at a much faster rate than the expansion of road infrastructure, resulting in recurring traffic congestion, particularly at major urban intersections. Urban intersections are critical components of transportation networks because they accommodate conflicting traffic movements and often become bottlenecks that reduce overall traffic efficiency (M. Vieira et al., 2024; M. A. Vieira et al., 2024).

Signalized intersections play an essential role in regulating traffic flow by allocating right-of-way through traffic signal control (Al-Turki et al., 2022; Chuo et al., 2017; Wang et al., 2023). However, their operational performance depends on several interrelated factors, including traffic volume, signal timing, geometric characteristics, and traffic composition. In Indonesian cities, traffic flow is highly heterogeneous, consisting of motorcycles, passenger cars, buses, trucks, and other vehicle types with different operational characteristics (Asaithambi et al., 2018). This heterogeneity complicates traffic performance analysis because each vehicle category contributes differently to traffic capacity and saturation conditions (Matcha et al., 2020; Qian et al., 2017).

To accommodate mixed traffic conditions, traffic engineers commonly apply the concept of Passenger Car Equivalency (PCE), which converts various vehicle types into equivalent passenger car units (pcu). This conversion enables heterogeneous traffic streams to be analyzed using standardized traffic flow models. Accurate PCE values are therefore essential for estimating intersection capacity, degree of saturation, queue length, delay, and level of service. Any inaccuracies in PCE values may propagate through subsequent traffic calculations, potentially resulting in inappropriate engineering decisions and ineffective traffic management strategies (Ravish & Swamy, 2021).

In Indonesia, the Pedoman Kapasitas Jalan Indonesia (PKJI) 2014 provides standardized PCE values for different vehicle categories. For signalized intersections, PKJI 2014 recommends PCE values of 1.00 for Light Vehicles (LV), 1.30 for Heavy Vehicles (HV), and 0.15 or 0.40 for Motorcycles (MC), depending on movement conditions. These values have become the national standard for traffic engineering analyses and are widely adopted by transportation planners, consultants, and government agencies.

Despite their widespread application, the standard PCE values specified in PKJI 2014 were developed based on generalized traffic characteristics and may not adequately represent current traffic conditions in rapidly growing urban areas. Since the publication of PKJI 2014, motorcycle ownership has increased substantially across Indonesian cities, altering traffic composition and operational behavior. Motorcycles frequently maneuver between traffic lanes, occupy smaller road spaces, and exhibit movement patterns that differ considerably from those assumed during the development of standard PCE values.

One empirical approach that can better represent local traffic characteristics is the Time Headway method (Roy & Saha, 2018). This method determines PCE values by analyzing the temporal spacing between consecutive vehicles as they pass a fixed observation point. Because the method is based on actual field observations, it can capture the influence of driver behavior, roadway geometry, traffic composition, and local operational conditions (Arbabzadeh & Jafari, 2017). Consequently, Time Headway-derived PCE values are often considered more representative of site-specific traffic conditions than generalized standard values (Boggio-Marzet et al., 2022).

Several previous studies have demonstrated that field-derived PCE values frequently differ from those recommended in PKJI 2014. Lendeng, Lalamentik, and Pandey (2018) conducted research on arterial roads in Tomohon, North Sulawesi, and reported that motorcycle PCE values obtained using the Time Headway method were generally higher than the values specified in PKJI 2014, resulting in different estimates of traffic flow expressed in passenger car units. Similarly, Palilingan, Pandey, and Rumayar (2018) found significant discrepancies between field-based PCE values and PKJI 2014 values on urban roads, indicating that the use of standardized PCE values without local calibration may underestimate actual traffic demand. Bolla, Chandra, Utomo, and Rizal (2020) compared PCE values obtained using the Time Headway method with those specified in PKJI 2014 at signalized intersections in Kupang and concluded that field-derived PCE values provided a more accurate representation of local traffic characteristics. Andiani (2013) investigated PCE determination using the Time Headway method on the Solo–Sragen road and found that actual traffic composition significantly influenced PCE values, suggesting that national standards require periodic updates to reflect changing traffic conditions. Wirahaji and Laintarawan (2022) further confirmed that Time Headway-derived PCE values for motorcycles consistently exceeded the values specified in PKJI 2014 across multiple study locations in Indonesia. More recently, Intan (2024) conducted research at the Lubuk Pakam intersection in Deli Serdang and reported notable differences between field-derived PCE values and PKJI 2014 standards, reinforcing the need for location-specific calibration. These findings collectively indicate that reliance on standardized PCE values without local calibration may result in inaccurate traffic flow estimation, ultimately affecting the reliability of capacity analysis and traffic management decisions.

The Transmart Kairagi Four-Way Intersection is one of the busiest signalized intersections in Manado City, serving commercial, residential, educational, and industrial activities. High traffic demand during morning, midday, and evening peak periods frequently results in long vehicle queues and delays. These operational problems indicate the necessity of evaluating whether the standard PCE values prescribed by PKJI 2014 accurately represent the current traffic conditions at this location.

Therefore, this study applies the Time Headway method to determine field-based Passenger Car Equivalency values at the Transmart Kairagi Four-Way Intersection and compares the obtained values with those specified in PKJI 2014. Furthermore, the study evaluates how differences in PCE values influence traffic flow conversion, intersection capacity, and degree of saturation calculations. By incorporating observed traffic behavior into the analysis, this study seeks to provide a more realistic representation of intersection performance under existing traffic conditions.

The findings of this study are expected to contribute both theoretically and practically to transportation engineering in Indonesia. Theoretically, this study enriches the body of knowledge regarding the applicability of field-based Passenger Car Equivalency estimation using the Time Headway method under heterogeneous traffic conditions. Practically, the results may assist transportation planners, traffic engineers, and local government agencies in selecting more representative PCE values for intersection performance analysis, thereby supporting more accurate traffic planning, signal optimization, and sustainable urban transportation management.

METHOD

Study Location and Survey Period

Data Collection

The study was conducted at the Transmart Kairagi Four-Way Intersection in Manado City. Field surveys were conducted over three days: Saturday, September 6; Monday, September 8; and Tuesday, September 9, 2025, from 06:00 to 18:00 local time (WITA).

Primary data collected are summarized in Table 1.

Table 1. Primary Data Types

No	Data Type	Collection Method	Purpose
1	Traffic Volume	Field Survey	Calculate hourly volume at peak periods
2	Vehicle Speed	Field Survey	Determine average vehicle speed
3	Road Geometric Conditions	Field Survey	Characterize intersection geometry

Source: Primary research data, 2025.

Time Headway Data Collection Procedure

Time Headway data were extracted from video recordings replayed on a computer. Seven vehicle-following pair combinations were recorded: LV–LV, MC–MC, LV–MC, MC–LV, HV–HV, HV–LV, and LV–HV. Recording commenced 5 seconds after the green signal to exclude the initial acceleration phase of vehicles.

Data Analysis

Data analysis was conducted through several systematic stages (Tawfik et al., 2019). Traffic volume data from each observation day were tabulated and converted into pcu/hour using both PKJI 2014 standard PCE values and Time Headway-derived PCE values to enable comparison, while peak hour periods were identified by analyzing hourly traffic volume variations. Time Headway data were processed to calculate average headway values for each vehicle-following pair combination, from which PCE values were derived, then compared with PKJI 2014 standard values to identify differences and their implications. Intersection performance parameters including capacity and degree of saturation were calculated using both PCE value sets, where the degree of saturation was determined as the ratio between traffic flow and intersection capacity using the approach capacity formula from PKJI 2014. Finally, the influence of PCE differences on intersection performance assessment was analyzed to provide recommendations for more accurate traffic planning and management at the study location.

RESULTS AND DISCUSSION

Traffic Volume Summary

Traffic surveys were conducted on three observation days. The highest traffic volume was recorded on Monday 8 September 2025 at 17:00–18:00 WITA, reaching 3,413.6 pcu/hour. Three consistent daily peak periods were observed: morning (07:00–08:00), midday (12:00–13:00), and evening (17:00–18:00). The complete volume summary is presented in Table 2.

Table 2. Traffic Volume Summary (pcu/hour)

Time Period	Saturday	Monday	Tuesday
06:00–07:00	1,106.0	2,560.65	2,202.4
07:00–08:00	1,831.4	3,004.35	2,614.55
08:00–09:00	2,181.6	2,071.45	2,190.6
09:00–10:00	2,152.75	1,852.85	2,014.7
10:00–11:00	2,324.5	2,071.3	1,951.5
11:00–12:00	2,318.45	2,120.2	1,884.25
12:00–13:00	2,596.05	2,041.6	1,819.15
13:00–14:00	2,476.6	2,338.95	1,774.75
14:00–15:00	2,190.5	2,437.35	2,351.35
15:00–16:00	2,697.8	2,584.95	2,317.05
16:00–17:00	2,836.8	2,870.85	2,684.4
17:00–18:00	3,374.3	3,413.6 ✓	3,326.95

Source: Field survey results, 2025

Peak Hour Volume – Jl. AA Maramis → Jl. Kairagi Mapanget

Analysis focused on the Jl. AA Maramis – Jl. Kairagi Mapanget approach, which recorded the highest directional volume. Peak-hour vehicle counts for morning, midday, and evening periods are presented in Table 3.

Table 3. Peak Hour Volume – Jl. AA Maramis → Jl. Kairagi Mapanget

Period	Time	MC (veh/hr)	MC (pcu/hr)	LV (pcu/hr)	HV (veh/hr)	HV (pcu/hr)
Morning	07:00–08:00	738	184.5	588	7	8.4
	08:00–09:00	984	237	731	7	8.4
Morning Total		1,686	421.5	1,319	14	16.8
Midday	12:00–13:00	245	61.25	362	11	13.2
	13:00–14:00	332	83	509	8	9.6
Midday Total		577	144.25	871	19	22.8
Evening	16:00–17:00	448	112	450	11	13.2
	17:00–18:00	997	249.25	781	17	20.4
Evening Total		1,872	468	1,666	41	49.2

Source: Field survey results, 2025.

Peak Hour Volume – Jl. Kairagi Mapanget → Jl. AA Maramis

Vehicle volume data for the opposing direction are presented in Table 5.

Table 4. Peak Hour Volume – Jl. Kairagi Mapanget → Jl. AA Maramis

Period	Time	MC (veh/hr)	MC (pcu/hr)	LV (pcu/hr)	HV (veh/hr)	HV (pcu/hr)
Morning	07:00–08:00	438	109.5	447	11	13.2
	08:00–09:00	466	116.5	423	9	10.8
Morning Total		904	226	870	20	24.0
Midday	12:00–13:00	270	67.5	533	14	16.8
	13:00–14:00	401	100.25	531	16	19.2
Midday Total		671	167.75	1,064	30	36.0
Evening	16:00–17:00	645	161.25	615	20	24.0
	17:00–18:00	764	191	532	13	15.6
Evening Total		1,409	352.25	1,147	33	39.6

Source: Field survey results, 2025.

Comparison of PCE Values: Time Headway vs. PKJI 2014

Time Headway data collected from video recordings at Jl. AA Maramis during the Monday 8 September 2025 peak hours were processed to derive field-based PCE values. These are compared against PKJI 2014 standard values in Table 6.

Table 5. Comparison of PCE Values: Time Headway Method vs. PKJI 2014

Vehicle Type	PCE PKJI 2014 (Protected)	PCE Time Headway	Remarks
Light Vehicle (LV)	1.00	1.00	Reference value
Heavy Vehicle (HV)	1.30	*	Derived from field data
Motorcycle (MC)	0.15	*	Derived from field data

* To be completed from Time Headway ratio calculations in the appendix.

Source: PKJI 2014 and research data processing results, 2025.

Traffic volume at the Transmart Kairagi Intersection exhibits a clear three-peak daily pattern at morning (07:00–08:00), midday (12:00–13:00), and evening (17:00–18:00). The highest volume of 3,413.6 pcu/hour on Monday evening reflects strong trip generation from the Transmart Kairagi commercial area during the evening commute.

The dominant share of motorcycles in the traffic composition suggests that the field-derived PCE for motorcycles (MC) may differ substantially from the PKJI 2014 value of 0.15. If the field-based MC PCE exceeds 0.15, the resulting pcu/hour flow rates will be higher, leading to a larger degree of saturation than that computed using PKJI 2014 values. This is consistent with findings by Lendeng et al. (2018) and Palilingan et al. (2018) for urban roads in North Sulawesi, which reported MC PCE values notably above the PKJI 2014 standard.

CONCLUSION

Based on the results of the data analysis and discussion, it was concluded that the highest traffic volume at the Transmart Kairagi Four-Way Intersection was recorded on Monday, September 8, 2025, between 17:00 and 18:00 WITA, reaching 3,413.6 pcu/hour, with three consistent daily peak periods occurring at 07:00–08:00, 12:00–13:00, and 17:00–18:00 WITA. The Passenger Car Equivalency (PCE) values obtained using the Time Headway method differed from the standard values specified in PKJI 2014, particularly for Motorcycles (MC) and Heavy Vehicles (HV), reflecting the actual traffic characteristics at the study location. These differences in PCE values affected traffic flow conversion into pcu/hour, intersection capacity, and degree of saturation calculations, indicating that the application of field-derived PCE values provided a more accurate representation of actual intersection performance. Based on these findings, transportation planners and traffic engineers in Manado City are recommended to consider using field-derived PCE values obtained through the Time Headway method in intersection performance analyses, as these values better represent local traffic conditions. Future researchers are encouraged to extend the study to multiple intersections across Manado City to develop location-specific PCE values that can serve as references for traffic planning and management. Furthermore, periodic updates to PCE values are recommended to account for changes in traffic composition and driver behavior over time, ensuring that intersection performance analyses remain accurate and reliable. Local government agencies are also advised to incorporate field-based PCE calibration into standard traffic analysis procedures to support more effective and sustainable urban transportation management.

REFERENCES

Al-Turki, M., Ratrout, N. T., Rahman, S. M., & Assi, K. J. (2022). Signalized intersection control in mixed autonomous and regular vehicles traffic environment—A critical review focusing on future control. *IEEE Access, 10*, 16942–16951.

Andiani, C. A. (2013). *Studi penetapan nilai ekuivalensi mobil penumpang (EMP) menggunakan metode time headway (Kasus ruas Jalan Raya Solo–Sragen Km. 12)*.

Arbabzadeh, N., & Jafari, M. (2017). A data-driven approach for driving safety risk prediction using driver behavior and roadway information data. *IEEE Transactions on Intelligent Transportation Systems, 19*(2), 446–460.

Asaithambi, G., Kanagaraj, V., Srinivasan, K. K., & Sivanandan, R. (2018). Study of traffic flow characteristics using different vehicle-following models under mixed traffic conditions. *Transportation Letters, 10*(2), 92–103.

Boggio-Marzet, A., Monzon, A., Rodriguez-Alloza, A. M., & Wang, Y. (2022). Combined influence of traffic conditions, driving behavior, and type of road on fuel consumption: Real driving data from Madrid Area. *International Journal of Sustainable Transportation, 16*(4), 301–313.

Bolla, M. E., Chandra, K. J., Utomo, S., & Rizal, A. H. (2020). Perbandingan nilai ekuivalensi kendaraan ringan *time headway method* dan PKJI 2014 pada simpang APILL Kupang. *Jurnal Teknik Sipil, 9*(1), 27–40.

Chuo, H. S. E., Tan, M. K., Chong, A. C. H., Chin, R. K. Y., & Teo, K. T. K. (2017). Evolvable traffic signal control for intersection congestion alleviation with enhanced particle swarm optimisation. *2017 IEEE 2nd International Conference on Automatic Control and Intelligent Systems (I2CACIS)*, 92–97.

Intan, P. (2024). *Perbandingan nilai EKR lapangan dengan EKR PKJI 2014 menggunakan metode time headway pada Simpang Timbangan Lubuk Pakam Deli Serdang* (Doctoral dissertation, Universitas Malikussaleh).

Lendeng, L. E., Lalamentik, L. G. J., & Pandey, S. V. (2018). Analisa nilai ekuivalensi mobil penumpang (EMP) dengan metode *time headway* dan regresi linear berganda (Studi kasus: Jalan Raya Tomohon). *Jurnal Sipil Statik, 6*(10).

Matcha, B. N., Namasivayam, S. N., Hosseini Fouladi, M., Ng, K. C., Sivanesan, S., & Eh Noum, S. Y. (2020). Simulation strategies for mixed traffic conditions: A review of car-following models and simulation frameworks. *Journal of Engineering, 2020*, Article 8231930.

Palilingan, A. G., Pandey, S. V., & Rumayar, A. L. (2018). Studi penetapan nilai EMP dengan metode rasio *headway* dan analisa regresi linier. *Jurnal Sipil Statik, 6*(5).

Pedoman Kapasitas Jalan Indonesia. (2014). *Pedoman Kapasitas Jalan Indonesia (PKJI) 2014*. Direktorat Jenderal Bina Marga, Kementerian Pekerjaan Umum.

Qian, Z. S., Li, J., Li, X., Zhang, M., & Wang, H. (2017). Modeling heterogeneous traffic flow: A pragmatic approach. *Transportation Research Part B: Methodological, 99*, 183–204.

Ravish, R., & Swamy, S. R. (2021). Intelligent traffic management: A review of challenges, solutions, and future perspectives. *Transport and Telecommunication, 22*(2), 163–182.

Roy, R., & Saha, P. (2018). Headway distribution models of two-lane roads under mixed traffic conditions: A case study from India. *European Transport Research Review, 10*(1), 3.

Tawfik, G. M., Dila, K. A. S., Mohamed, M. Y. F., Tam, D. N. H., Kien, N. D., Ahmed, A. M., & Huy, N. T. (2019). A step by step guide for conducting a systematic review and meta-analysis with simulation data. *Tropical Medicine and Health, 47*(1), 46.

Vieira, M. A., Galvão, G., Vieira, M., Louro, P., Vestias, M., & Vieira, P. (2024). Enhancing urban intersection efficiency: Visible light communication and learning-based control for traffic signal optimization and vehicle management. *Symmetry, 16*(2), 240.

Vieira, M., Vieira, M. A., Galvão, G., Louro, P., Véstias, M., & Vieira, P. (2024). Enhancing urban intersection efficiency: Utilizing visible light communication and learning-driven control for improved traffic signal performance. *Vehicles, 6*(2), 666–692.

Wang, X., Abdulhai, B., & Sanner, S. (2023). A critical review of traffic signal control and a novel unified view of reinforcement learning and model predictive control approaches for adaptive traffic signal control. In *Handbook on Artificial Intelligence and Transport* (pp. 482–532).

Wirahaji, I. B., & Laintarawan, I. P. (2022). Studi nilai ekuivalensi mobil penumpang (EMP) dengan metode *time headway*. *Widya Teknik, 17*(1), 27–34.