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INTEGRATION PLANNING BETWEEN COMPONENTS OF TYPE B BUS STATION SUKOREJO

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Kendal Regency has problems with passenger bus station services in the transportation sector. Integrating components in Sukorejo Type B Bus Station includes crossing circulation patterns between people and vehicles. The crossing can cause conflicts that endanger the safety of service users. This study aimed to handle circulation conflicts through the integration of the components applied in the Sukorejo Type B Bus Station can be optimal. This study used a methodological approach such as quantitative, explanation, and planning, referring to the field results and observational surveys. This research used 135 respondents of inter-city transportation within the province (AKDP) and 147 respondents of rural transportation (ANGDES). The results showed the integration performance between the components of the Sukorejo Type B Bus Station through the Normalized Score, which got a value of -100 with good information and indicated by the total circulation distance needed to reach each bus station component in 452 meters for 342 seconds. In Bus Station Type B Sukorejo, circulation crossings caused conflict at as many as 10 points due to the pedestrian crossing activities in private vehicle parking, arrival areas, waiting areas, and public transport departures. The research value of PV2 < 108 meant the need for pedestrian facilities indicated that it was not necessary to handle circulation crossings with pedestrian facilities. It was just sufficient to provide pedestrian warning signs to cross, so that vehicle drivers could be careful in crossing each conflict point.

Keywords: integration, bus station, pedestrian

1 INTRODUCTION

Kedungsepur is one of Indonesia's largest agglomeration areas, consisting of Kendal, Demak, Ungaran, Salatiga, Semarang, and Purwodadi districts. The kendal district is traversed by a North Coast Line transportation route (PANTURA). Therefore, Kendal Regency has the potential for transportation development to accelerate regional development. Transportation cannot be separated from people's daily activities because it supports the mobility of people and goods from one place to another[1]The transportation system is integrated by each component consisting of the community, regulations and provisions, facilities, and infrastructure. [2][3] Critical infrastructure in the ongoing transportation system is the bus station. According to the Law of the Republic of Indonesia Number 22 of 2009 concerning Road Traffic and Transportation, a bus station is a public infrastructure used to regulate arrivals and departures, pick up and drop off people and goods, and transfer modes of transportation. According to Syarif et al., the bus station is useful as nodes in the transportation system used in loading and unloading passengers and goods, places for intermodal transfers, controlling traffic, and as an ending place in a journey from origin to destination. The bus station consists of a passenger and goods section. [4]The passenger section is one road transportation infrastructure that raises and lowers passengers, transfers intra and intermodal transportation, and regulates the departure and arrival of public transport. [5][6]

Kendal Regency has several problems with passenger Bus Station services, one of which is at Sukorejo Type B Bus Station. Sukorejo Type B Bus Station has a built-up area of 14,822.86 m2 and still has 12,477.14 m2 of open area. Sukorejo Type B Bus Station serves three inter-city-in-province transportation routes (AKDP) and rural transportation (Angdes). Inter-City Within Province (AKDP) transportation routes consist of Sukorejo-Magelang, Sukorejo-Semarang, and Sukorejo-Pekalongan routes. Meanwhile, the Rural Transport route (Angdes) consists of 46 (Sukorejo-Selokaton-Plantungan-Pikatan-Manggungwangu-Wadas-Gentinggunung-Getasblawong), 48 (Sukorejo-Curugsewu-Pilangsari-Manggung-Singgorojo), and 57 (Sukorejo-Depok-Pageruyung -Pucakwangi). Sukorejo Type B Bus Station can serve 48 Inter-City In-Province Transportation (AKDP) units and 165 Rural Transport routes (Angdes) daily. There is a crossing problem of circulation patterns in the integration between Bus Station components. The deduction is between the circulation of people and vehicles in private vehicle parking, the arrival, waiting, and departure areas of public transportation, so that it does not meet the security aspect of circulation. Circulation is defined as the linkage of the building inside and outside (Imany et al., 2019). According to Dina and Setiawan, circulation security avoids crossings between the flow of people and vehicles. [7]Avoiding crossing can eliminate crimes against passengers. The bus station can add the flow of vehicle movement and explanations for the division of running lanes to avoid crossings. Circulation problems at Sukorejo Type B Bus Station can cause conflicts between the flow of people and vehicles, disrupting the integration performance between Bus Station components and endangering the safety of passengers. These problems make Sukorejo Type B Bus Station not yet meet the safety aspects in the Minimum Service Standards (SPM) of the Bus Station. Safety aspects must be provided for pedestrian lanes, minimizing crossings with vehicles, and safety facilities available (signs, markings, street lighting, and fence), which were described in The Minister of Transportation

Regulation in Indonesia Number PM 40 of 2015. This regulation concerns Service Standards for Road Transport Passenger Bus Station Operation.

One of the cities that implements an integration system between nodes using the modal interaction matrix (MIM) method is Bandar Lampung City, which is an integration facility for intermodal passengers in the form of building bridges connecting stations and terminals with an Intermodal Transfer Point facility system which is very important because it is a connection point between the two types of traffic. modes of two different network types. In implementing good integration, it is necessary to calculate distance and time using MIM analysis. [8][9][10]

In integration planning, planning the integration between the components of the Sukorejo Type B Bus Station is intended to optimize the integration performance applied by handling circulation conflicts within the Bus Station. Existing facilities need to be evaluated to determine whether the integration in the Bus Station can provide continuous services for the community in using public transportation. [11]Analyzing the Modal Interaction Matrix (MIM), the integration performance is known. Due to the circulation conflict involving people and vehicles, an analysis of the need for crossing facilities is used. This study obtained results in handling circulation conflicts in the Sukorejo Type B Bus Station so that the integration between the components applied could be optimal.

2 STUDY LITERATURE

2.1 Bus Station Integration System Analysis

This analysis aimed to determine the Bus Station integration system's performance, including the linkage of facilities, infrastructure, and passengers. In addition, it is also used to analyze the circulation patterns of people and vehicles reaching the Bus Station infrastructure. According to Juniati, integration is a unification that becomes a unified whole and unanimous. [12]The modal Interaction Matrix method is used for Bus Station integration system analysis. The calculation in this method used distance data between vehicle interaction components based on the circulation of movements in the Bus Station and the distance between components expected by passengers.

The problem that often occurs related to activities at the terminal is the distance from where passengers get on and off from one mode which will then continue with another mode. From this, calculations can be carried out with the modal matrix interaction. If the calculation results for the running time are too long and the distance is too far, then it is necessary to solve problems such as the need to move points from one to another so that circulation is easier, or a mode of connection is needed such as a shuttle bus or other things.

Terminals in developed countries pay great attention to the comfort of their users. One developed country that is an example is the bus terminal in Stockholm, Sweden. The terminal facilities provided are quite good but there are still some problems, one of which is the tram which only has one lane and if there are obstacles on the route it will hamper travel and make the terminal capacity accumulate. Therefore, a calculation of fleet needs, passenger capacity, and passenger transfer vehicles from other transportation and other supporting facilities is carried out so that the capacity of the fleet and terminals can be calculated. [13][14]

Service is an activity offered by one party to another without any ownership. [4]The bus station is divided into three types based on passenger service: type A, type B, and type C. [15]Bus station type A serves public transportation for cross-border transportation and Inter-City-Inter-Provincial (AKAP) transportation combined with inter-city-in-provincial transportation services (AKDP), urban transportation, and rural transportation. Bus station type B serves public transportation for inter-city-in-province transportation (AKDP) combined with urban and rural transportation services. Type B Bus Station serve public transportation for urban or rural transportation. [16]

The components used are Bus Station facilities with links with facilities and passengers at the bus station. According to Lestari and Romadhona, infrastructure is an arrangement of certain types of transportation based on the characteristics of the traffic space. [17]Respondents conducted interviews to determine the expected distance between components. The Slovin method was used in determining the sample of respondents in this study.

$$n = \frac{N}{1+N\,x\,e^2}$$

Source: Afkar et al. [18]

Statements:

n = Sample size

e = 5% error tolerance (error tolerance; significance level)

N = Total Population

The sample size obtained is then proportioned using proportional random sampling. Proportioned was done so that all sampled members have the same opportunity according to the proportions of each population.

$$N = \frac{n}{s} \text{ x n}$$

Source: Andini et al. [19]

Statements:

N = Total sample each user

n = Total population each user

n = Total sample all users

s = Total population all users

After the distribution of samples for each population was obtained, interviews were conducted with respondents. Respondents' answers were processed using the Modal Interaction Matrix (MIM). The following are the stages of the Modal Interaction Matrix (MIM):

1. Determine the components to be used in facilities and other modes at the bus station.
2. Develop an interaction matrix to compare the interactions between components.
3. Measure the walking distance between components. This distance calculates the circulation time between components by multiplying it by the average walking speed. According to Tanan, the average walking speed is 1.32 m/s. [20]
4. Measures the walking distance between pre-defined components.

Table 1. Example of Walking Distance Value

Value	Description	Distance Value
1–2	Too bad	>100
3–4	Bad	61–100
5–6	Enough	21–60
7–8	Good	6–20
9–10	Too good	0–5

Source: Horowitz & Thompson [6]

5. Insert the value between the desired components based on the walking distance in the interaction matrix.
6. Reduce the current distance value with the desired distance value so that the negative value is obtained in the interaction matrix.
7. The Negative Value is multiplied by 100 and divided by the number of components. The results obtained can then be seen its performance in the following table. The range of normal values or what is known as the level of service is a grouping based on the results obtained and adjusted for the value group. [21]The results obtained can then be seen in the following table.

Table 2. Normal Value Range

Normal Value Range	Description
0 s/d – 50	Too good
– 51 s/d – 100	Good
– 101 s/d – 150	Enough
– 151 s/d – 200	Bad
– 201 s/d – 250	Too Bad

Source: Horowitz & Thompson,[6]

Pedestrian Facilities

This facility is placed along the road, which will increase the number of pedestrians, followed by the growth of traffic flow, and fulfill the requirements for the facility's construction. [22] These places include:

1. Industrial areas
2. Shopping mall
3. Office center
4. School
5. Bus station
6. Housing
7. Entertainment center

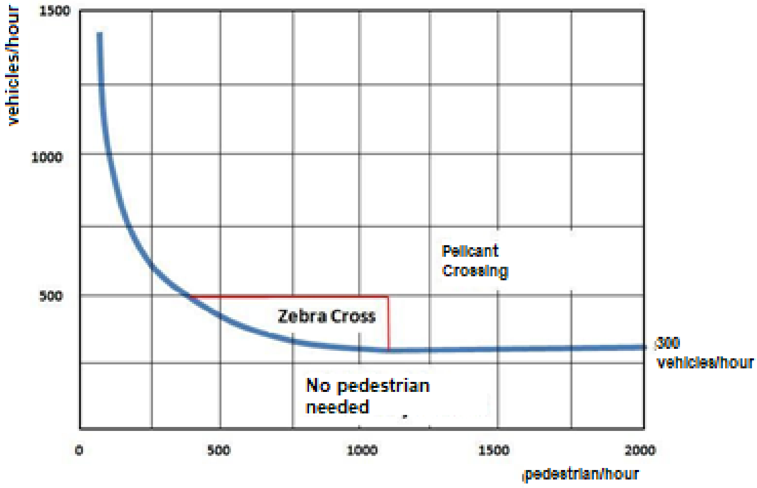
Based on the provisions of the Ministry of Public Works (1995), the need for pedestrian facilities can be determined from the flow of pedestrians crossing (P) and the flow of vehicles (V).

Table 3. Type of Crossing Facility Determination

PV^2	P	V	Initial Recommendation
$> 10^8$	50 – 1100	300 – 500	Zebra Cross (ZC)

PV^2	P	V	Initial Recommendation
> $2x10^8$	50 – 1100	400 – 750	ZC with protectors
> 10^8	50 – 1100	> 500	Pelican (P)
> 10^8	> 1100	> 500	Pelican (P)
> $2x10^8$	50 – 1100	> 700	P with protectors
> $2x10^8$	> 1100	> 400	P with protectors

Source: Public Works Department [22]



Source: Public Works Departement [22]

Fig. 1. Crossing Facilities Recommendation

3 RESEARCH METHODS

3.1 Data Collection Technique

a) Primary Data

A vehicle interaction interview in a bus station obtained primary data from surveys and field observations. It measured the distance between vehicle interaction components based on the circulation of movements that occurred in the bus station. In addition, interviews with public transport passengers at the bus station as a sample discussed the expected distance between components. The data required is the distance between the components of the bus station vehicle interaction and the distance between the components of the bus station vehicle interaction that the passengers expect.

b) Secondary Data

A bus station layout as secondary data was obtained from the Kendal Regency Transportation Office.

3.2 Bus station Integration System Analysis

This analysis required the distance between the components desired by the passenger. Therefore, it took a sample of passengers' respondents to have interviews regarding the circulation distance on foot from one component to another bus station component in the form of a value of 1-10. The greater the value chosen by the respondent, the closer the desired distance is. Determination of the sample of respondents used the Slovin method. Furthermore, it was proportioned using proportional random sampling. The proportioned sample was aimed at samples that could have the same opportunity according to the proportions of each population. The respondents in a day were 456 passengers for inter-city transportation within the province (AKDP) and 496 passengers for rural transportation (ANGDES). Furthermore, this study took a sample of 135 passengers for inter-city transportation within the province (AKDP) and 147 for rural transportation (ANGDES). After the distribution of samples for each population was obtained, the interviews' results were processed using the Modal Interaction Matrix (MIM) method. This method determined the integration performance between components and the distance and time required to reach each bus station component. [23]

3.3 Pedestrian Analysis

Sukorejo Type B Bus Station is a passenger bus station where the integration between components is based on the circulation of people. In this Type B Bus Station, there is a circulation crossing. Mapping of circulation patterns based on the relationship between activities carried out by Bus Station service users (Bus Station management, public transport operators, and passengers) and the facilities used were as follows:

a) Bus station management

Table 4. Relationship Between Bus station Management Activities and Facilities Used

Activities	Facilities Used
Enter the bus station	Bus Station entrance gate
Off from the vehicle	a. Private vehicle parking area b. Public transportation arrival area
a. Administration Depatment b. Cleaning Department c. Security Department d. Eat/drink e. Shower/self-cleaning f. Pray	a. Headroom UPTD Bus Station / Administration Room b. Information Room c. Security Room d. Food court e. Toilet *f. Mushola*
g. Get into vehicle	a. Private vehicle parking area b. Public transportation arrival area
Exit the bus station	Bus Station exit gate

Source: Nursetyo, [24]

b) Public Transportation Operators

Table 5. Relationship Between Public Transport Operator Activities and Facilities Used

Activities	Facilities Used
Enter the bus station	Bus station entrance gate
Buy the retribution ticket	Ticket counter
Drop off the passenger	Public transportation arrival area
a. Waiting in line b. Temporary break c. Eat/drink d. Shower/self-cleaning e. Pray f. Light maintenance of public transportation	a. Public transportation waiting area b. Vehicles break area c. Food court d. Toilet *e. Mushola* f. Workshop
Load the passenger	Public transportation departure area
Collected the retribution ticket	Ticket check counter
Exit thebus station	Bus station exit gate

Source: Nursetyo [25]

c) Passenger

Table 6. Relationship Between Passenger Activities and Facilities Used

Activities	Facilities Used
Passengers arrive at a bus station	a. Public transportation arrival area b. Park and ride c. Kiss and ride
a. Buy the travel ticket b. Eat/drink c. Shower/self-cleaning d. Temporary break e. Pray	a. Ticket counter b. Food court c. Toilet d. Passenger waiting area *e. Mushola*
Leave the bus station	a. Public transportation departure area b. Park and ride

Source: Nursetyo [25]

4 RESULT AND DISCUSSION

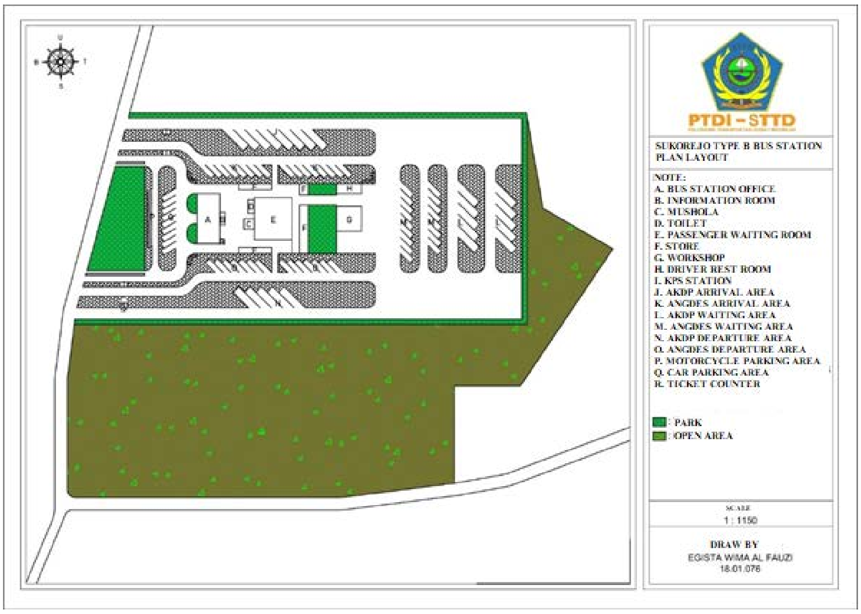
4.1 Sukorejo Type B Bus Station Facility Inventory

Sukorejo Type B Bus Station serves many loads and unloads passengers. Inter-City Transportation within the Province (AKDP) had as many as 458 passengers, and Rural Transportation (ANGDES) had as many as 496 passengers daily. The facilities available at Type B Sukorejo Bus Station to support bus station activities were as follows:

Table 7. Sukorejo Type B Bus Station Facilities

Main Facilities	Area (m^2)
Arrival Area	1728,11
Departure Area	1522,04
Public Transportation Waiting Area	1854,65
Private Vehicle Parking Area	543,02
Passengers' Waiting Area	254,00
Bus Station Office	182,00
KPS Station	6,00
Drivers' Rest Area	40,00
Ticket Counter	3,00
Information Room	10,00
Workshop	100,00
Supporting Facilities	
Mushola	17,50
Toilet	14,00
Food court	152,40
Park	1933,42
Total	**14822,86**

Source: Analysis Result



Source: Analysis Result

Fig. 2. Sukorejo Type B Bus Station Layout

The table and layout above show that the waiting area is the largest bus station facility, 1.854.65 m^2. The ticket counter is the minor bus station facility, which is 3 m^2. Based on all existing facilities, the total area of bus station Type B Sukorejo is 14.822.86 m^2.

4.2 Bus Station Integration System Analysis

The Bus Station performance measurement integration system in this study used the Modal Interaction Matrix (MIM) analysis. The components included in the matrix will be determined in the Modal Interaction Matrix (MIM). In the analysis of the Modal Interaction Matrix (MIM) using several components, namely:

Table 7. Modal Interaction Matrix (MIM) Component

No.	Integration Component
1.	Park and Ride
2.	Kiss and Ride
3.	Rural transport (Angdes)
4.	Province Inter-City Transportation (AKDP)
5.	Counter
6.	Waiting Room

Source: Analysis Result

The integration component was then calculated using the Modal Interaction Matrix (MIM) analysis. This analysis used the distance data between interaction components based on circulation and the distance between components expected by passengers. The distance between components that passengers expect was obtained from interviews with a sample of respondents using the Slovin Method.

Table 8. Interview Respondents Sample

Passengers	Total Passenger	Sample
AKDP	456	135
ANGDES	496	147

Source: Analysis Result

Based on 456 intercity-in-provincial transport passengers (AKDP), it takes a sample of 135 passengers, while from the 496 Rural Transport passengers (ANGDES), it takes a sample of 147 passengers. Data on the distance between components in the field and the distance between components expected by passengers is then calculated for the performance of the bus station integration system.

Table 9. Modal Interaction Matrix (MIM) Bus Station Type B Sukorejo

Park and Ride												
Kiss and Ride	10	10 / 0										
ANGDES	6	7 / -1	6	8 / -2								
AKDP	5	7 / -2	5	8 / -3	6	5 / 1						
Counter	8	8 / 0	8	9 / -1	8	8 / 0	7	8 / -1				
Waiting Room	6	7 / -1	6	8 / -2	10	10 / 0	9	10 / -1	8	10 / -2		**Total**
Sum of negative differences		-4		-8		1		-2		-2		-15
Modal InteractionMatrix	Park n Ride		Kiss n Ride		ANGDES		AKDP		Counter		Waiting Room	

Sumber: Hasil Analisis

Based on the Modal Interaction Matrix (MIM) of Sukorejo bus station above, the total difference in value is -15. This value, then calculated Normalized Score.

Table 10. Normalized Score in Bus Station Type B Sukorejo

Normalized Score	
n	6
Number of Cells	n(n-1)/2
	15
Normalized Score	100*Total/(Number of Cells)
	-100
Rating	**Good**

Source: Analysis Result

From the Normalized Score calculation table, Sukorejo Type B Bus Station got a value of -100 with good information. Normalized Score bus station Type B Sukorejo had a good rating, and this result was indicated by the distance and circulation time required to reach each bus station component as follows:

Table 11. Distance and Circulation Time for Bus Station Type B Sukorejo

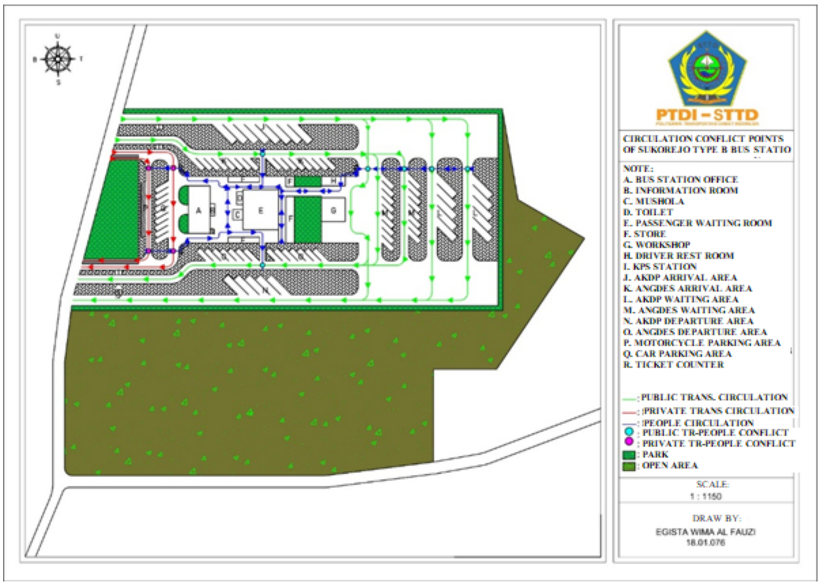
Interaction	Park n Ride		Kiss n Ride		ANGDES		AKDP		Counter		Waiting Room	
	Distance	Time	Distance	Time	Distance	Time	Distance	Time	Distance	Time	Distance	Time
Park n Ride												
Kiss n Ride	5	4										
ANGDES	44	33	42	32								
AKDP	49	37	47	36	37	28						
Counter	22	17	20	15	27	20	31	23				
Waiting Room	43	33	41	31	7	5	17	13	20	15		

Source: Anlysis Result

The longest distance was from the intercity-in-provincial (AKDP) drop-off point to the private vehicle parking area, which was 49 meters with a circulation time of 37 seconds. The total integration distance between the Sukorejo Type B Bus Station components was 452 meters with a circulation time of 342 seconds. Normalized Score, distance, and circulation time at Bus Station Type B Sukorejo were considered good in terms of integration between components by public transport passengers. Furthermore, a mapping of the circulation pattern of people and vehicles was carried out to determine whether the occurring circulation causes conflict.

4.3 Circulation Pattern Mapping

The circulation pattern of people, vehicles, and circulation conflicts occur from the relationship between activities and facilities in Bus Station Type B Sukorejo. The following were the conflict points that occurred in the Sukorejo Type B Bus Station:



Source: Analysis Results

Fig. 3. Interaction between Sukorejo Type B Bus Station Components

4.4 Pedestrian Analysis

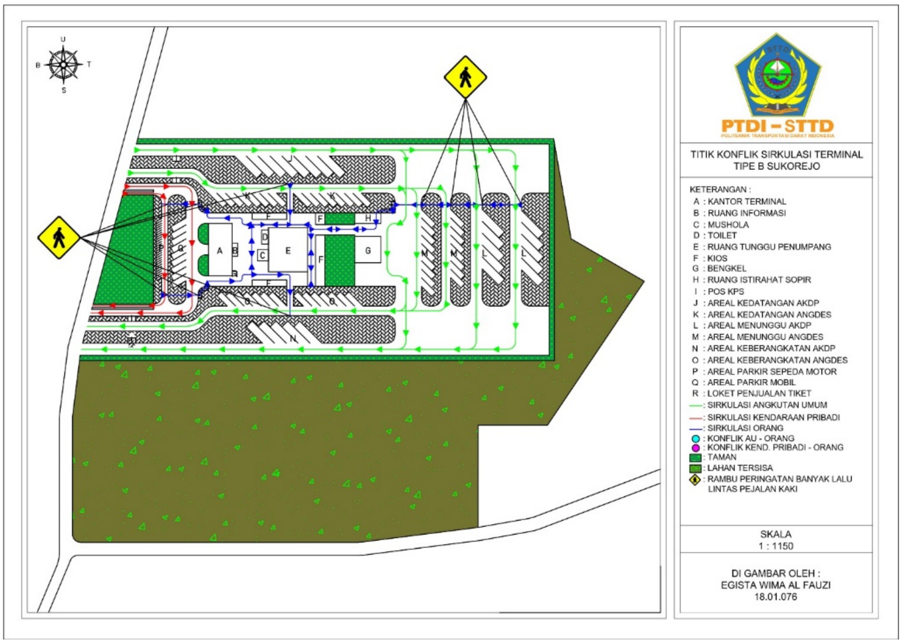
Figure 3 shows that there were six conflict points of the circulation of people with public transportation and four conflict points of the circulation of people with private vehicles. Circulation conflicts occur in private vehicle parking areas, arrival areas, departure areas, and waiting areas for public transportation. Calculation of pedestrians needed based on the flow of pedestrians crossing (P) and the flow of vehicles (V) every hour must be carried out to minimize conflicts and support safety.

Table 13. Need Calculation for Pedestrian Facilities at Bus Station Type B Sukorejo

Conflict Points	P	V	PV^2
Arrival	237	111	2920077
Departure	266	73	1417514
Private vehicles parking area	864	16	2221184
Public transportation waiting area	183	147	3954447

Source: Analysis Result

Calculating the need for pedestrian facilities is that the PV2 value at each conflict point was < 108. Based on this value, the conflict points that occurred do not need to be handled with pedestrian facilities. It was sufficient to provide warning signs for pedestrians, such as crossing signs, so that vehicle drivers can be careful in crossing each point of conflict as follows:



Source: Analysis Result

Fig. 4. Sukorejo Type B Bus Station Circulation Conflict Handling

4.5 Discussion

In large collections of multivariate time series, it is of interest to determine interactions between each pair of time series and distance. However, new methodology must be developed to determine time series interactions in settings that depart from the classical stationary linear model. [26]

From the results above, it can be seen that there are 6 components of MIM with a total sample of 135 AKDP passengers and 147 Angdes. The results of the assessment from the interviews were processed and the result was -15 with a good rating. The results of distance and time are also obtained with different results but are still in good condition. Modal matrix interaction analysis is needed in planning integration between modes, nodes and passenger movements. Through MIM analysis it can be seen whether the movement of passengers to nodes, modes and facilities is too far, close or appropriate.

5 CONCLUSIONS

Normalized Score Calculation of Bus Station Type B Sukorejo got a score of -100 with good information. Normalized Score Bus Station Type B Sukorejo was good, as indicated by the total circulation distance required to reach each bus station component along 452 meters in 342 seconds. The circulation of people and vehicles at Bus Station Type B Sukorejo was a circulation crossing that caused conflicts at as many as 10 points. These conflicts included pedestrian crossing activities in private vehicle parking, arrival, waiting, and departure areas for public transportation. From the calculation of the need for pedestrian facilities, it was known that the value of PV2 < 108.

This value indicated there was no need to handle circulation crossings with pedestrian facilities. It was sufficient to provide pedestrian warning signs, such as crossing signs, so that vehicle drivers could be careful in crossing each conflict point.

Based on the study's results, it is necessary to carry out supervision activities on the integration between the components of the Sukorejo Type B Bus Station to maintain its performance. Installing signs at each circulation crossing point indicates there is pedestrian activity.

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