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Industrial Land Use Interaction Model - Road Network to Know the Effect of Goods Vehicles on Road Performance

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Abstract**—** *Road is one of the connectivity between regions. At present, the condition of the road network in Malang area has decreased in service levels. Congestion occurs because of the increase in traffic volume. Congestion that occurs at this time is considered as a result of the high number of goods vehicles in the composition of traffic. So the Ministerial Decree No. 655 of 2016 emerged that goods vehicles did not allow to cross the Malang - Surabaya section on weekends except for certain goods vehicles. This study was prepared to find out whether vehicles contribute to congestion by using interaction models for industrial land use with road networks. The method used is the level service of road analysis and linear regression analysis. The model result for the Malang - Surabaya section (Kec. Singosari) is Y industries = 76,188 + 0,033 land area + 2,459 number of employee vehicles + 1,454 frequency goods vehicles with the goods vehicle value is 6.5%. While the industrial land use models for Panji Suroso - Tumenggung Suryo road segment is Y industries = 46,627 - 0,024 parking area + 0,046 land area + 1,816 number of employee vehicles with the value of goods vehicles is 10.71%.*

Keywords**—** *Modeling, interaction models, goods vehicles, industrial land use.*

I. INTRODUCTION

Malang Raya has a function as a National Activity Center (PKN) in East Java after Surabaya City and has the largest level of movement towards the Surabaya City for the movement of the entire East Java Province. PKN is an urban area that serves international scale activities, national activities, or activities of several provinces. The Development Area (WP) of Malang Raya with centers in Malang City includes Malang City, Batu City, and Malang District with the functions of food crops, plantations, horticulture, forestry, fisheries, livestock, mining, trade, services, education, health, tourism, and industry. The transportation network service between WP Malang Raya and Surabaya City which is the center of WP Germakertosusila Plus is served through the development of primary arterial road network between Malang Raya - Surabaya which is continued to Malang - Kepanjen, Malang - Surabaya toll road and repair of Malang - Surabaya Interchange Toll with underpass construction in Singosari District (East Java Province RTRW 2012).

Congestion that occurs in the movement between Malang Raya - Surabaya occurs along the arterial route. The decline in performance was influenced by the increase in the level of vehicle ownership which reached 20% in 2014 to 2015 with the largest proportion of passenger cars and then two-wheeled vehicles. Vehicle ownership growth is influenced by regional economic growth in East Java. From 2012 – 2015, the average of economic growth was 5.79% with the largest growth rate in 2012 to 2013. The driving factors for the growth of the economy of East Java which focused on Malang Raya included the establishment of Malang Raya as part of the economic acceleration at Locus Pasuruan - Malang in MP3EI. In addition, Tatrawil of East Java has predicted that one of the most affected by the increase in regional economic activities is the Malang - Pandaan section. Regional economic conditions are shown from GRDP data. The biggest contribution from Malang City and Malang District is in the manufacturing sector, while Batu City is dominant in the agricultural sector. However, if viewed from the contribution per sector, the growth of the industrial, agricultural and trade sectors tends to be above the average contribution per sector of each region. This is in line with the function of the Malang Raya as a function of food crops, plantations, horticulture, forestry, fisheries, livestock, mining, trade, services, education, health, tourism, and industry. Congestion that occurs is caused by several factors, namely:

1. Increase in vehicle ownership, indicated by the number of vehicle ownership
2. Increased economic activity, indicated by the increase in the rate of economic growth indicated by the increase in the average value of economic growth in regional GDP data, and the increase in the flow of goods delivery.

The following data shows the increase in the ratio of traffic volume in the Malang - Surabaya section from 2009 and 2017. In 2009, the traffic conditions were still at a ratio of 0.592 or C, where the traffic flow was still stable, the vehicle speed still reached> 65 km / hr and traffic volume reaches 70% of total road capacity. But in 2017, the conditions have changed, where the ratio becomes 1.111 or at level F, namely the condition of the traffic flow is held at a speed of <50 km/hour and the traffic volume is below 2000 pcu/hour.

TABLE I. Traffic Volume ratio on Jalan Malang - Surabaya in Singosari District on weekdays

Composition	Year 2009		Year 2017	
	Amount	%	Amount	%
MC	74133	77,99	15133	29,91
LV	16906.5	17,79	23533	46,51
MHV	2260	2,38	8259	16,32
LB	288	0,3	298.5	0,59
LT	1466.5	1,54	3375.5	6,67
V/C	0.592		1.111	

Source: Secondary data in 2018, processed

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The increase in the composition of heavy vehicles indicates the presence of congestion anomalies stemming from the imbalance in the composition of heavy vehicles and light vehicles in traffic. Heavy vehicles are assumed to be the biggest contributor to congestion. The Minister of Transportation Decree Number 655 of 2016 which contains rules regarding the prohibition of crossing for heavy vehicles on the Malang - Surabaya road section on weekends (except certain vehicles carrying fuel and staple goods) is a solution that is expected to reduce congestion on the Malang - Surabaya road segment. This solution was followed by the development of the Malang - Surabaya toll road network and the improvement of the Karanglo Junction capacity as a Toll Interchange in Singosari District through the construction of an underpass.

Malang Raya develops as a city based on industry, trade and services and agriculture. The main problem with the rapid development of regional economic activity is the increase in traffic volume. Goods delivery activities by 4-wheeled transport vehicles contribute 15-25% of the volume of vehicles that overload the road (Herzog, 2013). And Ofyar Tamin said that the 3 commodities had a large influence on the pattern of movement of goods transportation. This study aims to determine whether goods vehicles as part of heavy vehicles in Malang - Surabaya traffic are the main causes of congestion that has occurred so far.

The main problem of the region's economic activity which is developing rapidly is the increase in traffic volume. Goods delivery activities by 4-wheeled transport vehicles account for 15-25% of the volume of vehicles that overload the road (Herzog, 2013). If management is not done well, it will further reduce road performance. Goods vehicles provide significant problems with space use, road damage, congestion / delays, and even accidents (Herzog, 2013). Problems with the use of road space are related to their composition in traffic. Goods vehicles have a normal composition in traffic, according to MKJI, the composition of goods vehicles has a composition of 23% for MHV and 4% for LT. The current composition is 22.99% (2017 data), but with MC conditions it should be only 9%, and the reality on the ground is 29.91%. This data was taken in the preliminary survey activity on the Singosari road in Malang Regency as one of the segments in the Malang Raya vehicle lane and the calculation was carried out at peak hours with the lowest V / C value.

This study aims to see whether goods vehicles do contribute the largest portion of congestion in the Malang - Pandaan section, so special arrangements are needed through KP 655 in 2016 regarding the passage of goods transport in the Malang - Pandaan section to reduce congestion during weekend breaks.

II. RESEARCH METHODS

A. Research Hypothesis

Based on the formulation of the problem, the purpose of the study, and the research conceptual framework, the hypotheses to be tested in this study are formulated as follows:

1. There is a significant influence between the attraction model in an area with land use variables.
2. There is a significant influence between attraction model and the road capacity.

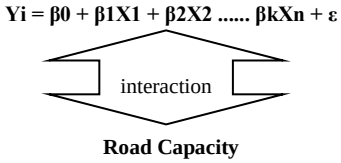

Fig. 1. Research Hypothesis Framework

B. Interaction Model

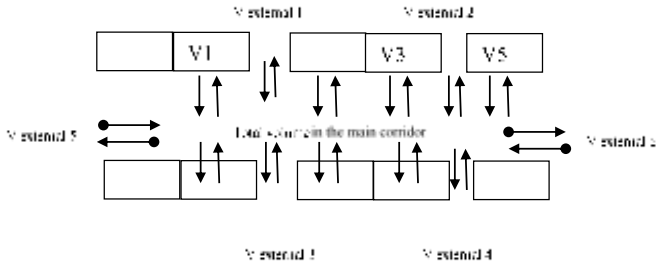

Fig. 2. Concept of land use interaction model - road network
Source: Guenter Emberger in Sugiarto, 2013

$$V_{Total} = \sum V_i + \sum V_{eksternal}$$

Where :

V_{Total} : Total vehicle volume in the main corridor.

$\sum V_1$: Amount of vehicle volume / hour from the attraction of land use.

$\sum V_{External}$: the number of external vehicle volume / hour on the main corridor originating from vehicle volume / hour from the alley plus the vehicle volume / hour continuously

C. Research Purposes

The research objectives are as follows:

1. Identifying the characteristics of industrial land use on the road of the object of study.
2. Identifying industrial land use attraction models on the road of the object of study.
3. Analyzing the interaction model of industrial land use - road network on the road of the object of study.
4. Planning the direction of handling road performance problems on the road of the object of study due to goods vehicles.

D. Research Concept

The relationship between activity systems and network systems is applied in the study area to predict what happens in city traffic if conditions are left as they are or do nothing. There is a treatment on land use (activity system) and on a network system, then the results are compared with conditions at do nothing, this is called the condition of treating something.

The condition of do nothing for the study area is the condition of the current road network and the problem. Common problems that arise as a result of rising vehicle volume are congestion, pollution and driving safety. In the study area, the road which according to KM 58 in 2012 was designated as a class I road network, which was able to function for vehicles with JBB> 10 tons, experienced mixed

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traffic conditions between private vehicles, two wheels and large tonnage vehicles for goods transportation activities.

E. Research Location

The location of the study included the Malang Raya region by looking at the contribution of congestion or a decrease in road performance due to the trajectory of goods vehicles. The study section is the industrial land use chosen because of its contribution in providing the volume of goods vehicles in the traffic in the section that serves it. The road used as the study samples are the Jalan Malang - Surabaya in Kecamatan Singosari and Jalan Panji Suroso - Tumenggung Suryo in Malang City.

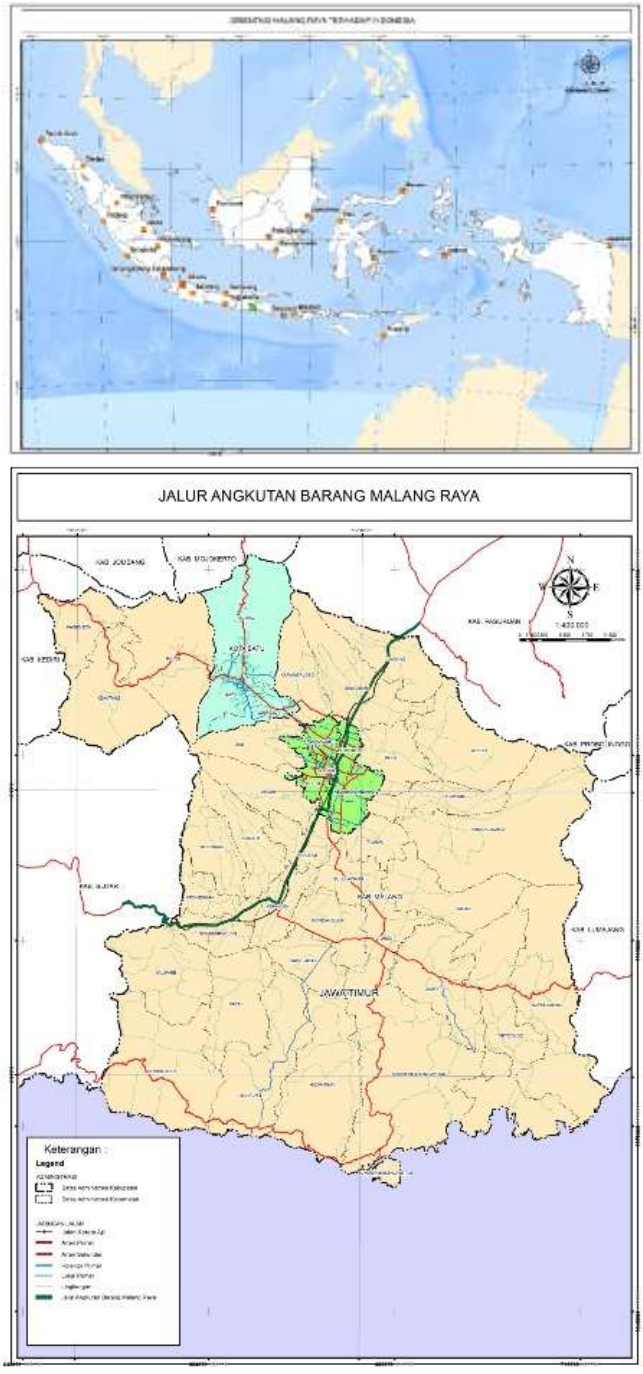

Fig. 3. Research location

F. Data

Land use taken as a study sample includes industrial, trade, education, health and office services land uses. Land uses other than industry is taken as part of the process of measuring the influence of industrial land use and other land uses as a comparison factor.

G. Survey

The survey conducted was a Traffic Survey and Land Use Survey. Data retrieval method is by observing each industry on the study road. Data taken is related to road data and industrial land use data. The followings are the methods used to retrieve each type of data:

1. Traffic Survey
   a. Traffic Volume
      Surveyors calculate the vehicles that pass on the study road. Vehicle datas recorded in the form are composition per vehicle, number of vehicles per 15 minutes and recap per hour for 20 hours a day. Road is considered to be 1 segment if there is no difference in slope, and geometric road.
   b. Geometric road: surveyors calculate the width of the road, the shoulder of the road, there are / are not separate directions, and side barriers.
2. Land use data
   Surveyors observe the conditions of land use in the field based on the variables used.

H. Research Variables

1. Dependent Variables (Y)
   The dependent variable that is tried to be developed is the attraction and generation of a certain time union within a certain time span. The time range used is because each location in the same area, can have the greatest attraction / peak value (peak attraction). Attraction units for each industrial location is different. For industry, a vehicle unit that goes in and out of industrial land use is used by looking at the composition of the largest goods vehicles, namely when shipping finished goods or sending raw materials. There are 5 (five) dependent variables included in this study. Each corridor has each of the following response variables:
   a. Industry ($Y_{industri\ 1}$ and $Y_{industri\ 2}$);
   b. Offices; ($Y_{perkantoran\ 1}$ and $Y_{perkantoran\ 2}$);
   c. Education ($Y_{pendidikan\ 1}$ and $Y_{pendidikan\ 2}$);
   d. Trade and services ($Y_{PDJ\ 1}$ and $Y_{PDJ\ 2}$);
   e. Health ($Y_{kesehatan\ 1}$ and $Y_{kesehatan\ 2}$).
2. Independent Variables (X)
   Candidates for explanatory variables are obtained from the characteristics of the region whose selection is based on the reliability of the data obtained. The chosen land use location is an industry with all classes that use goods vehicles in accordance with regulations regarding the type of vehicle goods. The independent variables for each research corridor are explained in Table II.

With the candidate variables in Table II, a comparative analysis is carried out to see the relationship (statistics) between the characteristics of the region variable and its generation and attraction. The coefficient between the two

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variables is between -1.0 and 1.0. The more launched 1.0 and 1.0, the higher the renewal between the two variables.

TABLE II. Independent variables

Corridor	Y	X
Jalan Panji Suroso – Sunandar Priyo Sudarmo – Tumenggung Suryo	Y industri	X1 = building area X2 = number of employees X3 = parking area X4 = land area X5 = number of employee vehicles X6 = frequency of goods vehicles
	Y perkantoran	X1 = building area X2 = parking area X3 = number of employees X4 = land area X5 = number of visits X6 = number of employee vehicles
	Y kesehatan	X1 = building area X2 = number of doctors & employees X3 = parking area X4 = land area X5 = number of visits X6 = number of inpatient rooms
	Y pendidikan	X1 = building area X2 = number of students X3 = number of teachers X4 = land area X5 = number of classes X6 = parking area
	Y PDJ	X1 = building area X2 = number of employees X3 = parking area X4 = land area X5 = number of visits X6 = frequency of goods vehicles
Jalan Malang – Surabaya in Kecamatan Singosari	Y industri	X1 = building area X2 = number of employees X3 = parking area X4 = land area X5 = number of employee vehicles X6 = frequency of goods vehicles
	Y perkantoran	X1 = building area X2 = number of employees X3 = parking area X4 = land area X5 = number of employee vehicles X6 = number of visits
	Y kesehatan	X1 = building area X2 = number of doctors & employees X3 = parking area X4 = land area X5 = number of visits X6 = numberof inpatient rooms
	Y pendidikan	X1 = building area X2 = number of teachers X3 = parking area X4 = land area X5 = number of students X6 = number of classes
	Y PDJ	X1 = building area X2 = number of employees X3 = parking area X4 = land area X5 = number of visits X6 = frequency of goods vehicles

Source: Primary Survey Results, 2018

I. Research Samples

Determination of the samples are using this following Slovin formula:

$$n = \frac{N}{1 + Ne^2}$$

n = the number of samples
N = number of population
e = error level (note: generally used 1% or 0.01, 5% or 0.05, and 10% or 0.1; notes can be chosen by the researcher)

The error level used in this study is 10%. The size of the sample in this study is presented in Table III.

TABLE III. Number of samples

Corridors	Population Number	Calculation	Samples Number
Jl Panji Suroso – Jl Sunandar PS – Jl. Tumenggung Suryo corridor	86	$n = \frac{86}{1 + 86.0{,}1^2}$	46
Jl. Malang – Surabaya corridors	172	$n = \frac{172}{1 + 172.0{,}1^2}$	62
Total	**258**		**108**

Source: Calculation Results, 2019.

J. Analytical Methods

1. Road Performance Analysis

a. Road Capacity Analysis

In the analysis of service levels several factors that must be considered include road capacity and traffic volume. For 2 / 2TT road types, capacity (C) is determined for total two-way flows. For roads of type 4 / 2T, 6 / 2T and 8 / 2T, currents are determined separately per direction and capacity determined per lane. Segment capacity can be calculated using a formula (PKJI, 2014):

$$C = C_O \times FC_{LJ} \times FC_{PA} \times FC_{HS} \times FC_{UK}$$

With:

C : Road capacity (pcu/hour)
Co : base capacity price (pcu/hour)
FC_{LJ} : capacity adjustment factors related to lane width or traffic lane
FC_{PA} : capacity adjustment factor related to separation of direction, only on undivided roads
FC_{HS} : the capacity adjustment factor related to KHS on roads that have shoulders or curbs
FC_{UK} : capacity adjustment factor related to city size

b. Degree of Saturation Analysis (DS)

DS is the main measure used to determine the performance level of a road segment. The DS value shows the quality of the traffic flow performance that varies from zero to one. A value close to zero indicates an unsaturated current, which is a quiet current condition where the presence of other vehicles does not affect other vehicles. Values close to 1 indicate current conditions at capacity conditions, moderate current densities with certain current speeds that can be maintained for at least one hour.

DS is calculated using the following equation:

DS = Q / C

Information:
DS = degree of saturation
Q = traffic flow (pcu / hour)
C = road capacity (pcu / hour)
The standard level of service of roads is as follows:

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TABLE IV. Standard level of service of roads

Level of Service	A	B	C	D	E	F
DS	0-0,2	0,2-0,45	0,45-0,7	0,7-0,85	0,85-1,0	>1,0

Sources : IHCM, 1997

2. Multiple Regression Analysis

Multiple linear regression analysis was conducted to determine the effect of industrial vehicle movement (attraction) on road performance. This linear regression analysis is one of the statistical methods used to find the linkages of more than one explanatory variable. The first step in the regression analysis is the selection of variables that are used as explanatory variables or independent variables. The formula used in multiple linear regression is as follows:

$$Y = a+b_1X_1 + b_2X_2.....+ b_nX_n$$

Information:

Y : Independent variable
A : Regression constant
b1……bn : Regression coefficients

III. RESULT AND DISCUSSION

A. *Jl. Malang – Surabaya, Kecamatan Singosari, Malang District*

1. Regional Orientation of Jalan Malang – Surabaya

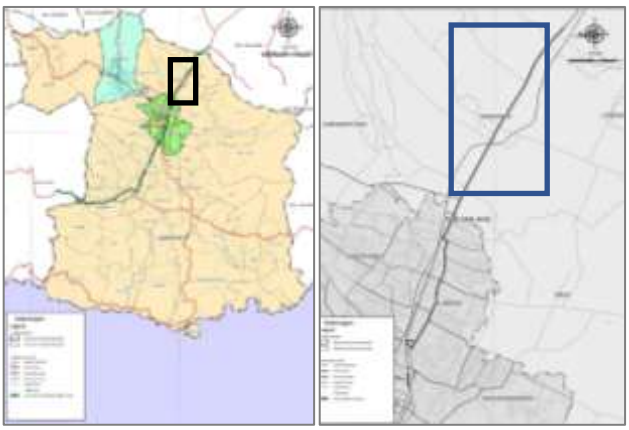

Fig. 4. Jalan Malang – Surabaya Location

2. Level of Service of Jalan Malang - Surabaya

The basic capacity of the corridor is 6985 pcu/hour for the southern corridor and 7128 pcu/hour for the northern corridor. Exixting level of service before treatment shown in Table V.

TABLE V. LOS of Jl. Malang – Surabaya segment 1 (Southern) on weekdays

Hours	Continuous Volume (pcu/hour)	Capacity (pcu/hour)	DS	LOS
06.00 - 07.00	3758	6985	0,538	C
07.00 - 08.00	5237	6985	0,750	D
08.00 - 09.00	3807	6985	0,545	C
09.00 - 10.00	3310	6985	0,474	C
10.00 - 11.00	3247	6985	0,465	C
11.00 - 12.00	4529	6985	0,648	C
12.00 - 13.00	5275	6985	0,755	D
13.00 - 14.00	5289	6985	0,757	D
14.00 - 15.00	5300	6985	0,759	D
15.00 - 16.00	5721	6985	0,819	D
16.00 - 17.00	7811	6985	1,118	F
17.00 - 18.00	8205	6985	1,175	F
18.00 - 19.00	6381	6985	0,913	E
19.00 - 20.00	5140	6985	0,736	D
20.00 - 21.00	4366	6985	0,625	C
21.00 - 22.00	3789	6985	0,542	C

Sources: Calculation Result, 2019

TABLE VI. LOS of Jl. Malang – Surabaya segment 2 (Northern) on weekdays

Hours	Continuous Volume (pcu/hour)	Capacity (pcu/hour)	DS	LOS
06.00 - 07.00	4507	7128	0,632	C
07.00 - 08.00	5873	7128	0,824	D
08.00 - 09.00	4490	7128	0,630	C
09.00 - 10.00	3856	7128	0,541	C
10.00 - 11.00	3714	7128	0,521	C
11.00 - 12.00	5362	7128	0,752	D
12.00 - 13.00	5970	7128	0,838	D
13.00 - 14.00	5924	7128	0,831	D
14.00 - 15.00	5870	7128	0,824	D
15.00 - 16.00	6715	7128	0,942	E
16.00 - 17.00	8441	7128	1,184	F
17.00 - 18.00	8174	7128	1,147	F
18.00 - 19.00	7004	7128	0,983	E
19.00 - 20.00	5933	7128	0,832	D
20.00 - 21.00	4548	7128	0,638	C
21.00 - 22.00	3231	7128	0,453	C

Sources: Calculation Result, 2019

3. Attraction Model of Jalan Malang – Surabaya

The land use attraction model obtained based on the calculation results is as follows.

TABLE VII. Atrraction model of land use of Jl. Malang – Surabaya

Land Use	Attraction Trip Model Equation	R^2
Industries	Y industri = 76,188 + 0,033 land area + 2,459 number of employee vehicles + 1,454 frequency of goods vehicles	0,993
Offices	Y perkantoran = -1,289 + 0,986 number of visits + 1,132 number of employee vehicles	0,998
Health	Y PDJ = 16,718 + 0,020 building area + 1,330 number of employees + 0,077 parking area + 0,608 number of visits + 1,087 frequency of goods vehicles	0,986
Education	Y kesehatan = -87,049 + 2,806 number of doctors & employees + 1,194 number of visits + 8,811 number or inpatient rooms	0,995
Trade and services	Y pendidikan = 21,079 + 0,116 jumber of students– 1,576 number of teachers + 0,010 land area + 12,560 number of classes	0,965

Sources: SPSS Analysis Result, 2019

Each land use will calculate the estimated movement produced to the road. To find out the movements resulting from the model on industrial land use, calculations are made through the average of each characteristic of the industrial land use explanatory variables, namely:

- Average of land area = 149 m^2
- Average of number of employee vehicles = 156,2 units
- Average of frequency of goods vehicles = 165 vehicles/day

Based on the data above, it can be seen that the number of movements of the average industrial land use model are:

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$Y_{industry}$ = 76,188 + 0,033 land area + 2,459 number of employee vehicles + 1,454 frequency of goods vehicles
= 76,118 + (0,033 × l149) + (2,459 × 156,2) + (1,454 × 165)
= 350,55 pcu/day

The population of industrial land use in the study area is 38 units, so that the number of movements from the model in the existing conditions is:

$Y_{existing\ industry}$ = $Y_{industri}$ × industrial population
= 350,55 pcu/days × 38
= 13320,98 ≈ 13321 pcu/day

Estimates of potential traffic due to land use attraction in the study area are as follows:

TABLE VIII. Application of atrraction model of land use of Jl. Malang – Surabaya (Kecamatan Singosari)

Land Use	Attraction Trip Model Equation	Units	Total Volume (pcu/day)
Industries	Y industri = 76,188 + 0,033 land area + 2,459 number of employee vehicles + 1,454 frequency of goods vehicles	38	13321
Offices	Y perkantoran = -1,289 + 0,986 number of visits + 1,132 number of employee vehicles	21	3439
Health	Y perjas = 16,718 + 0,020 building area + 1,330 number of employees + 0,077 parking area + 0,608 number of visits + 1,087 frequency of goods vehicles	1	407
Education	Y kesehatan = -87,049 + 2,806 number of doctors & employees + 1,194 number of visits + 8,811 number or inpatient rooms	11	2578
Trade and services	Y pendidikan = 21,079 + 0,116 jumber of students– 1,576 number of teachers + 0,010 land area + 12,560 number of classes	81	13382
Total			**33127**

Sources: Calculation Result, 2019

The total volume from the land use attaraction along the corridor of Jalan Malang – Surabaya is 33127 pcu / day.

4. Interaction Model of Jalan Malang – Surabaya

The interaction model between activity systems - network systems will be carried out through regression analysis methods and carried out the application of regression analysis results in the field to test the reliability of the models made and see potential problems and solutions that can be done. The interaction model is:

V total = ∑ Vi + ∑ Vexternal

TABLE IX. Total volume of vehicles on Jalan Malang - Surabaya segment 1 (southern) (pcu/hour)

Jam	V land use	V external	V continuous	V total
06.00-07.00	302	127	3727	**4155**
07.00-08.00	637	324	3821	**4782**
08.00-09.00	537	150	3427	**4114**
09.00-10.00	486	168	3466	**4120**
10.00-11.00	572	166	2934	**3672**
11.00-12.00	579	360	2266	**3204**
12.00-13.00	615	411	2249	**3275**
13.00-14.00	607	421	2639	**3666**
14.00-15.00	567	430	3370	**4368**
15.00-16.00	517	605	4226	**5348**
16.00-17.00	703	795	5785	**7283**
17.00-18.00	670	733	5149	**6553**
18.00-19.00	452	561	4366	**5379**
19.00-20.00	378	460	3042	**3879**
20.00-21.00	346	358	3149	**3852**
21.00-22.00	273	216	3294	**3783**
Total	**8244**	**6283**	**56907**	**71434**

Sources: Calculation Result, 2019

TABLE X. Level of service of Jalan Malang - Surabaya segment 1 (southern)

Jam	V total	Road capacity	DS	LOS
06.00-07.00	4187	6985	0,595	C
07.00-08.00	6198	6985	0,685	C
08.00-09.00	4494	6985	0,589	C
09.00-10.00	3964	6985	0,590	C
10.00-11.00	3985	6985	0,526	C
11.00-12.00	5468	6985	0,459	C
12.00-13.00	6301	6985	0,469	C
13.00-14.00	6317	6985	0,525	C
14.00-15.00	6297	6985	0,625	C
15.00-16.00	6843	6985	0,766	D
16.00-17.00	9309	6985	1,043	F
17.00-18.00	9608	6985	0,938	E
18.00-19.00	7394	6985	0,770	D
19.00-20.00	5978	6985	0,555	C
20.00-21.00	5070	6985	0,551	C
21.00-22.00	4278	6985	0,542	C
Total	**95691**			

Sources: Calculation Result, 2019

TABLE XI. Total volume of vehicles on Jalan Malang - Surabaya segment 2 (northern) (pcu/hour)

Jam	V land use	V external	V continuous	V total
06.00-07.00	1691	1634	1010	4335
07.00-08.00	2646	2832	1569	7047
08.00-09.00	2190	1973	963	5126
09.00-10.00	2037	1508	527	4071
10.00-11.00	2482	1764	441	4687
11.00-12.00	2422	2823	1270	6515
12.00-13.00	2524	3614	1151	7289
13.00-14.00	2571	3635	1191	7397
14.00-15.00	2363	3696	1135	7194
15.00-16.00	2185	4153	1756	8094
16.00-17.00	2774	5118	1917	9809
17.00-18.00	2597	4485	1178	8260
18.00-19.00	1755	3295	1115	6165
19.00-20.00	1456	3255	907	5618
20.00-21.00	1307	2223	501	4030
21.00-22.00	1029	1198	143	2370
Total	**34028**	**47206**	**16774**	**98009**

Sources: Calculation Result, 2019

TABLE XII. Level of service of Jalan Malang - Surabaya segment 2 (northern)

Jam	V total	Road capacity	DS	LOS
06.00-07.00	4335	7128	0,608	C
07.00-08.00	7047	7128	0,989	E
08.00-09.00	5126	7128	0,719	D
09.00-10.00	4071	7128	0,571	C
10.00-11.00	4687	7128	0,658	C
11.00-12.00	6515	7128	0,914	E
12.00-13.00	7289	7128	1,023	F
13.00-14.00	7397	7128	1,038	F
14.00-15.00	7194	7128	1,009	F
15.00-16.00	8094	7128	1,135	F
16.00-17.00	9809	7128	1,376	F
17.00-18.00	8260	7128	1,159	F
18.00-19.00	6165	7128	0,865	E
19.00-20.00	5618	7128	0,788	D

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20.00-21.00	4030	7128	0,565	C
21.00-22.00	2370	7128	0,332	B
Total	**98009**			

Sources: Calculation Result, 2019

5. Traffic Composition of Jalan Malang – Surabaya

The traffic composition that arises from the calculation of the interaction model above is:

TABLE XIII. Traffic composition of Jalan Malang - Surabaya

V continuous			V external			V land use		
MC	**LV**	**HV**	**MC**	**LV**	**HV**	**MC**	**LV**	**HV**
60.9%	32.1%	6.3%	36.7%	59.3%	4.0%	62.8%	26.7%	7.5%
16295	8596	1673	6235	10068	676	23139	9819	2766

Sources: Calculation Result, 2019

The global composition of traffic volume compared to the normal composition referring to PKJI is as follows:

TABLE XIV. Comparison of traffic composition of Jalan Malang - Surabaya

	MC	**LV**	**HV**
Study results	57.6%	35.9%	**6.5%**
PKJI	32%	60%	**8%**

Sources: Calculation Result, 2019

The composition of goods vehicles on the Jalan Malang - Surabaya (border of Kecamatan Singosari) is 6.5% and is within the normal limits according to the PKJI guidelines which is 8%.

B. Jalan Panji Suroso – Tumenggung Suryo, Malang City

1. Regional Orientation of Jalan Panji Suroso – T. Suryo

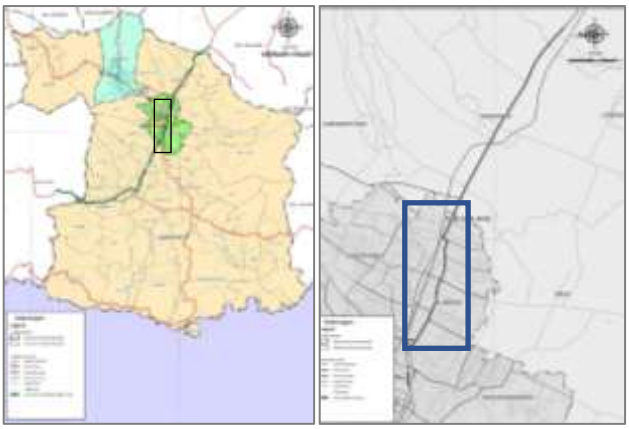

Fig. 5. Jalan Panji Suroso – Tumenggung Suryo Location

2. Level of Service of Jalan Panji Suroso – T. Suryo

The basic capacity of the corridor is 6985 pcu/hour for the southern corridor and 7128 pcu/hour for the northern corridor. Exixting level of service before treatment shown in Table IV.

TABLE XV. LOS of Jl P. Suroso – T. Suryo northern segment on weekdays

Hours	Continuous Volume (pcu/hour)	Capacity (pcu/hour)	DS	LOS
06.00 - 07.00	3351	4929	0,680	C
07.00 - 08.00	2739	4929	0,556	C
08.00 - 09.00	2298	4929	0,466	C
09.00 - 10.00	1964	4929	0,398	B
10.00 - 11.00	1828	4929	0,371	B
11.00 - 12.00	2206	4929	0,447	B
12.00 - 13.00	2205	4929	0,447	B
13.00 - 14.00	1943	4929	0,394	B
14.00 - 15.00	1757	4929	0,357	B
15.00 - 16.00	2025	4929	0,411	B
16.00 - 17.00	2958	4929	0,600	C
17.00 - 18.00	2341	4929	0,475	C
18.00 - 19.00	1749	4929	0,355	B
19.00 - 20.00	1744	4929	0,354	B
20.00 - 21.00	1750	4929	0,355	B
21.00 - 22.00	1271	4929	0,258	B

Sources: Calculation Result, 2019

TABLE XVI. LOS of Jl. P. Suroso – T. Suryo southern segment on weekdays

Hours	Continuous Volume (pcu/hour)	Capacity (pcu/hour)	DS	LOS
06.00 - 07.00	3684	4929	0,747	D
07.00 - 08.00	3006	4929	0,610	C
08.00 - 09.00	2504	4929	0,508	C
09.00 - 10.00	2144	4929	0,435	B
10.00 - 11.00	2012	4929	0,408	B
11.00 - 12.00	2412	4929	0,489	C
12.00 - 13.00	2409	4929	0,489	C
13.00 - 14.00	2139	4929	0,434	B
14.00 - 15.00	1929	4929	0,391	B
15.00 - 16.00	2208	4929	0,448	B
16.00 - 17.00	3257	4929	0,661	C
17.00 - 18.00	2581	4929	0,524	C
18.00 - 19.00	1924	4929	0,390	B
19.00 - 20.00	1924	4929	0,390	B
20.00 - 21.00	1912	4929	0,388	B
21.00 - 22.00	1408	4929	0,286	B

Sources: Calculation Result, 2019

3. Attraction Model of Jalan Panji Suroso – T. Suryo

The land use attraction model obtained based on the calculation results is as follows.

TABLE XVII. Atrraction model of land use of Jl. P. Suroso – T. Suryo

Land Use	Attraction Trip Model Equation	R^2
Industries	Y industri = 46,627 – 0,024 parking area + 0,046 land area + 1,816 number of employee vehicles	0,880
Offices	Y perkantoran = -8,425 + 1,083 number of employees + 0,834 number of employee vehicles + 0,116 number of visitors	0,987
Health	Y kesehatan = -0,424 + 0,333 number of visits + 3,537 number of inpatient rooms	0,946
Education	Y pendidikan = 35,700 + 0,017 building area – 0,011 parking area + 0,241 number of students	0,998
Trade and services	Y PDJ = -39,117 + 0,144 parking area + 0,016 land area + 0,532 number of visits	0,949

Sources: SPSS Analysis Result, 2019

Each land use will calculate the estimated movement produced to the road. To find out the movements resulting from the model on industrial land use, calculations are made through the average of each characteristic of the industrial land use explanatory variables, namely:

- Average of parking area = 513,7 m^2
- Average of land area = 2335,9 m^2
- Average of number of employee vehicles = 29,4 units

Based on the data above, it can be seen that the number of movements of the average industrial land use model are:

$Y_{industry}$ = 46,627 – 0,024 parking area + 0,046 land area + 1,816 number of employee vehicles

= 46,627 – (0,024 × 513,7) + (0,046 × 2335,9) + (1,816 × 29,4)

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= 195,14 pcu/day

The population of industrial land use in the study area is 36 units, so that the number of movements from the model in the existing conditions is:

$Y_{existing\ industry}$ = $Y_{industri}$ × industrial population
= 195,14 pcu/day × 36
= 7025,12 ≈ 7025 pcu/day

Estimates of potential traffic due to land use attraction in the study area are as follows:

TABLE XVIII. Application of atrraction model of land use of Jalan Panji Suroso – Tumenggung Suryo

Land Use	Attraction Trip Model Equation	Units	Trip Volume (pcu/day)
Industries	Y industri = 46,627 – 0,024 parking area + 0,046 land area + 1,816 number of employee vehicles	36	7025
Offices	Y perkantoran = -8,425 + 1,083 number of employees + 0,834 number of employee vehicles + 0,116 number of visitors	30	2946
Health	Y kesehatan = -0,424 + 0,333 number of visits + 3,537 number of inpatient rooms	9	560
Education	Y pendidikan = 35,700 + 0,017 building area – 0,011 parking area + 0,241 number of students	1	1398
Trade and services	Y PDJ = -39,117 + 0,144 parking area + 0,016 land area + 0,532 number of visits	87	15690
Total			**27619**

Sources: Calculation Result, 2019

The total volume from the land use attaraction along the corridor of Jalan Panji Suroso – Tumenggung Suryo is 27619 pcu/day.

4. Interaction Model of Jalan P. Suroso – T.Suryo

The interaction model between activity systems - network systems will be carried out through regression analysis methods and carried out the application of regression analysis results in the field to test the reliability of the models made and see potential problems and solutions that can be done. The interaction model is:

V total = ∑ Vi + ∑ Vexternal

TABLE XIX. Total volume of vehicles on Jalan Panji Suroso – Tumenggung Suryo northern segment (pcu/hour)

Jam	V land use	V external	V continuous	V total
06.00-07.00	125	222	2492	2839
07.00-08.00	277	264	1991	2532
08.00-09.00	808	232	1489	2529
09.00-10.00	835	170	2344	3349
10.00-11.00	823	236	2163	3221
11.00-12.00	911	203	2602	3715
12.00-13.00	858	218	2613	3689
13.00-14.00	905	200	2308	3413
14.00-15.00	862	297	2090	3249
15.00-16.00	768	238	2410	3416
16.00-17.00	757	322	2358	3437
17.00-18.00	677	323	1816	2816
18.00-19.00	239	254	1176	1669
19.00-20.00	128	252	1219	1599
20.00-21.00	86	240	1421	1747
21.00-22.00	54	256	1150	1459
Total	**9111**	**3927**	**31641**	**44679**

Sources: Calculation Result, 2019

TABLE XX. Level of service of Jalan Panji Suroso – Tumenggung Suryo northern segment (pcu/hour)

Jam	V total	Road capacity	DS	LOS
06.00-07.00	2839	4929	0,576	C
07.00-08.00	2532	4929	0,514	C
08.00-09.00	2529	4929	0,513	C
09.00-10.00	3349	4929	0,680	C
10.00-11.00	3221	4929	0,654	C
11.00-12.00	3715	4929	0,754	D
12.00-13.00	3689	4929	0,748	D
13.00-14.00	3413	4929	0,692	C
14.00-15.00	3249	4929	0,659	C
15.00-16.00	3416	4929	0,693	C
16.00-17.00	3437	4929	0,697	C
17.00-18.00	2816	4929	0,571	C
18.00-19.00	1669	4929	0,339	B
19.00-20.00	1599	4929	0,325	B
20.00-21.00	1747	4929	0,354	B
21.00-22.00	1459	4929	0,296	B
Total	**44679**			

Sources: Calculation Result, 2019

TABLE XXI. Total volume of vehicles on Jalan Panji Suroso – Tumenggung Suryo southern segment (pcu/hour)

Jam	V land use	V external	V continuous	V total
06.00-07.00	452	343	3273	4069
07.00-08.00	573	655	2795	4023
08.00-09.00	1631	678	2511	4819
09.00-10.00	1739	672	2587	4998
10.00-11.00	1612	543	2336	4491
11.00-12.00	1681	535	2419	4634
12.00-13.00	1635	677	2513	4825
13.00-14.00	1709	368	2270	4347
14.00-15.00	1766	488	2423	4678
15.00-16.00	1619	360	1863	3842
16.00-17.00	1731	569	2594	4894
17.00-18.00	1559	584	2377	4520
18.00-19.00	402	302	1884	2588
19.00-20.00	214	278	1778	2271
20.00-21.00	147	157	1405	1708
21.00-22.00	88	277	853	1219
Total	**18558**	**7485**	**35882**	**61926**

Sources: Calculation Result, 2019

TABLE XXII. Level of service of Jalan Panji Suroso – Tumenggung Suryo southern segment (pcu/hour)

Jam	V total	Road capacity	DS	LOS
06.00-07.00	4067	4929	0,825	D
07.00-08.00	4021	4929	0,816	D
08.00-09.00	4814	4929	0,977	E
09.00-10.00	4994	4929	1,013	F
10.00-11.00	4485	4929	0,910	E
11.00-12.00	4630	4929	0,939	E
12.00-13.00	4822	4929	0,978	E
13.00-14.00	4342	4929	0,881	E
14.00-15.00	4674	4929	0,948	E
15.00-16.00	3838	4929	0,779	D
16.00-17.00	4889	4929	0,992	E
17.00-18.00	4516	4929	0,916	E
18.00-19.00	2585	4929	0,525	C
19.00-20.00	2270	4929	0,461	C
20.00-21.00	1707	4929	0,346	B
21.00-22.00	1219	4929	0,247	B
Total	**61873**			

Sources: Calculation Result, 2019

5. Traffic Composition of Jalan P. Suroso – T.Suryo

The traffic composition that arises from the

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calculation of the interaction model above is:

TABLE XXIII. Traffic composition of Jalan P. Suroso – T. Suryo

V continuous			V external			V land use		
MC	LV	HV	MC	LV	HV	MC	LV	HV
22620	8102	2859	2071	3024	1957	8646	4316	1036
67,1%	24%	8,6%	36,3%	53%	34,3%	62,5%	31,2%	7,49%

Sources: Calculation Result, 2019

The global composition of traffic volume compared to the normal composition referring to PKJI is as follows:

TABLE XXIV. Comparison of traffic composition of Jalan Panji Suroso – Temenggung Suryo

	MC	LV	HV
Study results	61%	28.26%	**10.71%**
PKJI	32%	60%	**8%**

Sources: Calculation Result, 2019

The composition of goods vehicles on the Jalan Panji Suroso – Temenggung Suryo is 10,71% which is above the normal.

C. Sensitivity Analysis

Sensitivity analysis is the analysis of treatment on the subjects studied. The treatment given is to increase capacity or limit volume.

1. Sensitivity Analysis of Jalan Malang – Surabaya

For the Jalan Malang - Surabaya corridor in Kecamatan Singosari it is not possible to increase the capacity of road dividing or widening because existing conditions already have a direction separator and do not allow for widening the road. The treatment that can be given is to treat the traffic system as follows:

a. Potential reduction of vehicles due to the assumption of displacement using the toll road. Data from previous research (Hargo, 2017), showed 45,75% of vehicles will move. At certain hours are is still quite ceongested, required a maximum of RVK 0.45 so that the service level becomes B.

TABLE XXV. Comparison of traffic composition of Jalan Panji Suroso – Temenggung Suryo

Hours	Volume	Potential Movement		DS	LOS
06 - 07	3568	1643	1925	0.270	B
07 - 08	6431	1983	4448	0.624	C
08 - 09	4631	1674	2957	0.415	B
09- 10	3654	1648	2006	0.281	B
10 - 11	4233	1485	2748	0.386	B
11 - 12	6068	1363	4705	0.660	C
12 - 13	6700	1409	5291	0.742	D
13 - 14	6715	1558	5157	0.723	D
14 -15	6486	1827	4659	0.654	C
15 - 16	7314	2237	5078	0.712	D
16 - 17	9016	3084	5933	0.832	D
17 - 18	7587	2792	4795	0.673	C
18 - 19	5684	2254	3430	0.481	C
19 - 20	5109	1647	3462	0.486	C
20 - 21	3805	1609	2196	0.308	B
21 - 22	2215	1538	678	0.095	A

Sources: Calculation Result, 2019

b. Limitation of vehicle volume from land use attraction. The traffic composition in the Malang - Surabaya section is 30% continuous volume, 19.7% external volume and 50% volume of land use. It is necessary to limit the volume from the land use, especially industry (40.2%) and trade and services (40.4%). Limitation can be made during peak hour.

TABLE XXVI. Limitations on land use and assumed displacement using toll roads

Hours	Volume after using toll	Capacity	Limited volume	Volume after being limited	DS	LOS
06 - 07	1925	7128	0	1925	0.27	B
07 - 08	4448	7128	1597	2851	0.40	B
08 - 09	2957	7128	106	2851	0.40	B
09- 10	2006	7128	0	2006	0.28	B
10 - 11	2748	7128	0	2748	0.39	B
11 - 12	4705	7128	1854	2851	0.40	B
12 - 13	5291	7128	2440	2851	0.40	B
13 - 14	5157	7128	2306	2851	0.40	B
14 -15	4659	7128	1808	2851	0.40	B
15 - 16	5078	7128	2227	2851	0.40	B
16 - 17	5933	7128	3081	2851	0.40	B
17 - 18	4795	7128	1944	2851	0.40	B
18 - 19	3430	7128	578	2851	0.40	B
19 - 20	3462	7128	611	2851	0.40	B
20 - 21	2196	7128	0	2196	0.31	B
21 - 22	678	7128	0	678	0.10	A

Sources: Calculation Result, 2019

2. Sensitivity Analysis of Jalan Panji Suroso – T. Suryo

The results of the analysis carried out on Jalan Panji Suroso – Tumenggung Suryo, Malang City are as follows:

a. Capacity

The capacity of the road is added through the addition of a median or road divider. The existing capacity is 5244 pcu/hour, changing to 5598 pcu/hour.

b. Volume

Limiting the volume of vehicles to reach RVK <0.85 and level B (levels considered in KM 14 - 2006 and Permen PU 19/2011) carried out on trade and service land use which reached 57% of the total land use volume.

Recapitulation of the results of sensitivity analysis by combining the addition of medians and the reduction of vehicles from land use are as follows:

TABLE XXVII. Recapitulation of the results of sensitivity analysis

Hours	Volume	Capacity with median	Volume which is limited (pcu/hour)	DS	LOS
06 - 07	4070	5598	1831	0.40	B
07 - 08	4024	5598	1785	0.40	B
08 - 09	4815	5598	2576	0.40	B
09- 10	4994	5598	2755	0.40	B
10 - 11	4488	5598	2248	0.40	B
11 - 12	4631	5598	2392	0.40	B
12 - 13	4822	5598	2583	0.40	B
13 - 14	4344	5598	2104	0.40	B
14 -15	4675	5598	2436	0.40	B
15 - 16	3839	5598	1600	0.40	B
16 - 17	4890	5598	2650	0.40	B
17 - 18	4515	5598	2276	0.40	B
18 - 19	2587	5598	348	0.40	B
19 - 20	2270	5598	31	0.40	B
20 - 21	1708	5598	0	0.31	B
21 - 22	1218	5598	0	0.22	B

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Sources: Calculation Result, 2019

IV. CONCLUSIONS

The conclusions from the results of the study on Jalan Malang - Surabaya in Kecamatan Singosari are as follows:

1. The function of the Kecamatan Singosari is as an industrial and warehousing support for Malang City. The current land use on Jalan Malang - Surabaya consists 13.06% of industries and 27.84% of trade and services.
2. The attraction model of land use in the Jalan Malang – Surabaya is as follows:

TABLE XXVIII. Recapitulation of the model and number of attraction on Jalan Malang Surabaya (Kecamatan Singosari)

Land Use	Attraction Trip Model Equation	Average pcu/ hour	Average pcu/nnit/ hour
Industries	Y industri = 76,188 + 0,033 land area + 2,459 number of employee vehicles + 1,454 frequency of goods vehicles	833	351
Offices	Y perkantoran = -1,289 + 0,986 number of visits + 1,132 number of employee vehicles	215	164
Trade and services	Y perjas = 16,718 + 0,020 building area + 1,330 number of employees + 0,077 parking area + 0,608 number of visits + 1,087 frequency of goods vehicles	161	234
Health	Y kesehatan = -87,049 + 2,806 number of doctors & employees + 1,194 number of visits + 8,811 number or inpatient rooms	836	165
Education	Y pendidikan = 21,079 + 0,116 jumber of students– 1,576 number of teachers + 0,010 land area + 12,560 number of classes	25	407

For industrial land use, the biggest attraction is influenced by land area, number of employee vehicles and the frequency of goods vehicles.

3. Vehicle data in the field shows that goods vehicles are only 6.5% of the total traffic volume. However, the calculated data shows that 50% of the total traffic volume comes from land use.
4. Sensitivity analysis shows that the land use limitation treatment is effective if applied to Jalan Malang - Surabaya (Kecamatan Singosari). Meanwhile, changing road capacity is not possible.

The conclusions obtained from the study results for Jalan R. Panji Suroso - Tumenggung Suryo Malang City are as follows:

1. Regional functions crossed by Jalan Panji Suroso - Tumenggung Suryo in Kecamatan Blimbing are limited to industrial activities and warehousing and not recommended (Malang City Spatial Plan). Along the corridor, the land uses are as follows:

TABLE XXIX. Land use ratio on Jalan P. Suroso – T. Suryo

Types of land use	Amount of land use (units)	Land use ratio
Educational	7	0.04
Health	10	0.06
Trade and services	87	0.51
Industries	36	0.21
Offices	30	0.17
Others	2	0.01
Total	**172**	1.00

Industrial land use along Jalan Panji Suroso - Tumenggung Suryo is 21%, but what dominates is land use for trade and services (51%).

2. The land use model that is produced for Jalan Panji Suroso – Tumenggung Suryo is as follows.

TABLE XXX. Attraction model and number of attraction on Jalan Panji Suroso – Temenggung Suryo

Land Use	Attraction Trip Model Equation	Average pcu/ hour	Average pcu/nnit/ hour
Industries	Y industri = 46,627 – 0,024 parking area + 0,046 land area + 1,816 number of employee vehicles	439	195
Offices	Y perkantoran = -8,425 + 1,083 number of employees + 0,834 number of employee vehicles + 0,116 number of visitors	184	98
Health	Y kesehatan = -0,424 + 0,333 number of visits + 3,537 number of inpatient rooms	981	180
Education	Y pendidikan = 35,700 + 0,017 building area – 0,011 parking area + 0,241 number of students	87	200
Trade and services	Y PDJ = -39,117 + 0,144 parking area + 0,016 land area + 0,532 number of visits	38	61

For industrial land use, the influencing factors are the land area and the number of employee vehicles. These two factors have an influence on the results of the attraction that occurred from the use of industrial land on Jalan Panji Suroso. And the dominant attraction of land use is on trade land use and services.

3. Based on heavy vehicle data in the field, the volume of goods vehicles in the study section is 10.71% of the total traffic volume or 5853 pcu/day. While the results of the interaction model show the volume of goods vehicles from industrial land use is 245 pc /day or 7 pcu/unit/day. This value is above the normal PKJI limit of 8%.
4. Sensitivity analysis shows that the median treatment and limitation of traffic volume up to 55% of land use is needed to achieve ideal traffic conditions.

V. RECOMMENDATIONS

a. For Jalan Malang – Surabaya in Kecamatan Singosari
   - There needs to be an effective limitation of the land use for trade and services, especially after the functioning of the toll road, needs a further study.
   - There is a need to regulate the bus stops and city transportation in segments that are densely packed with generation from land use.

b. For Jalan Panji Suroso – Tumenggung Suryo in Malang City
   - This road segment has been dominated by local flows. It is no longer suitable for the continuous flow of heavy

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vehicles because of the growing of trade and service land use. There needs to be an alternative ring-road route for the continuous flow of goods vehicles.

- Based on the land use modeling, the biggest influence for industrial land use is the employee vehicles. The future proposal is to reduce the attraction of employee vehicles by changing the working hours, so that they don't coincide with the general operational hours to avoid volume build-up, as well as the procurement of employee buses if it is possible for the company.

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