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Model of the Road Capacity Influence on Traffic Congestion and Noise Disturbance on Wonocolo - Sepanjang Road at Sidoarjo Region

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Abstract: Traffic congestion and noise are significant issues in rapidly developing urban areas. This study examines the impact of road capacity on congestion and noise levels starting from Wonocolo to Sepanjang road in Sidoarjo regency. The objectives are to analyze the road capacity, its influence on traffic congestion, and the correlation with noise pollution. Using the MKJI 1997 method, traffic and noise data were collected and analyzed during peak hours. The results indicate that increased road capacity has a direct effect on reducing congestion, but also influences noise levels. The findings suggest that managing road capacity effectively can mitigate traffic congestion and noise pollution. Contributing to a better urban planning and transportation management.

Keywords: traffic congestion; road capacity; noise pollution; urban planning; transportation management

INTRODUCTION

Traffic congestion and noise pollution are significant issues in rapidly developing urban areas, such as Sidoarjo regency in East Java, Indonesia. Efficient transportation infrastructure is essential for supporting economic and social activities. According to the MKJI (1997), congestion occurs when traffic flow exceeds road capacity, reducing speeds to nearly zero and causing queues. Good transportation systems stimulate economic interactions and regional development. Despite ongoing road development, traffic congestion remains common, particularly on arterial roads like Wonocolo to Sepanjang in Sidoarjo regency. This road, a critical transportation link, struggles with increasing traffic volumes and noise pollution.

This study investigates the impact of road capacity on traffic congestion and noise pollution along the Wonocolo-Sepanjang road. Understanding the relationship between road capacity and these issues is crucial for urban planning and transportation management. Previous research highlights factors contributing to congestion, including road width, traffic volume, intersections, and market activities (Mustikarani & Suherdiyanto, 2016). Moreover, urban development has often overlooked its impact on road traffic, resulting in significant declines in service levels (Florentinus et al., 2021). Inadequate road networks cause congestion problems (Ismawanda & Zajuli, 2018).

On the other hand, according to Sukirman (1994), a traffic lane includes the entire road pavement intended for vehicles. Efficient methods are needed to control motor vehicle behavior, especially motorcycles, for traffic management (Wiwoho Mudjanarko, Winardi, & Daniel Limantara, 2017). Whilst traffic volume, speed, and density are used to plan and evaluate congestion (Abdi Grisela Nurinda et al., 2019). Julianto (2010) also states that traffic characteristics arise from the interaction between drivers, vehicles, roads, and the environment.

Therefore, discussions on traffic flow focus on variables such as volume, speed, and density. Increased traffic volumes significantly contribute to noise pollution, affecting residents' quality of life (Setiawan, 2014). Local environments suffer from excessive motor vehicles, leading to air and noise pollution, especially in major Asian cities (Tamin, 2007).

Traffic noise primarily comes from vehicle engines, exhaust systems, and tire-road interactions, with heavy vehicles and passenger cars being the main sources (AASHTO, 1993). Noise levels decrease with distance from the source (Syaiful & Mudjanarko, 2019) and are considered safe if ≤ 70 dB (Djalante, 2010). Noise consideration involves the emitted noise, the recipient, and the transmission pathway (Juniardi, 2014).

Using the MKJI 1997 method, this research analyzes traffic and noise data during peak hours to determine how road capacity changes influence these factors. The findings provide insights for managing road capacity to alleviate congestion and minimize noise pollution, enhancing urban transportation efficiency. This study offers practical solutions for transportation challenges in rapidly developing regions like Sidoarjo regency, aiding policymakers and urban planners in developing sustainable and efficient infrastructure.

METHODOLOGY

This research employs a quantitative approach to examine the impact of road capacity on traffic congestion, and noise pollution, on the Wonocolo - Sepanjang road in Sidoarjo regency. The subjects of the study include traffic flow and noise levels measured during peak hours. Focusing on both vehicular traffic and environmental noise parameters.

Research Procedure

The research procedure involves several steps. Initially, a preliminary survey was conducted to identify critical points along the Wonocolo-Sepanjang road, where congestion and noise pollution are most severe. Following this, detailed data collection has been carried out using systematic observation methods. As figure 1 shows the survey points during the research.

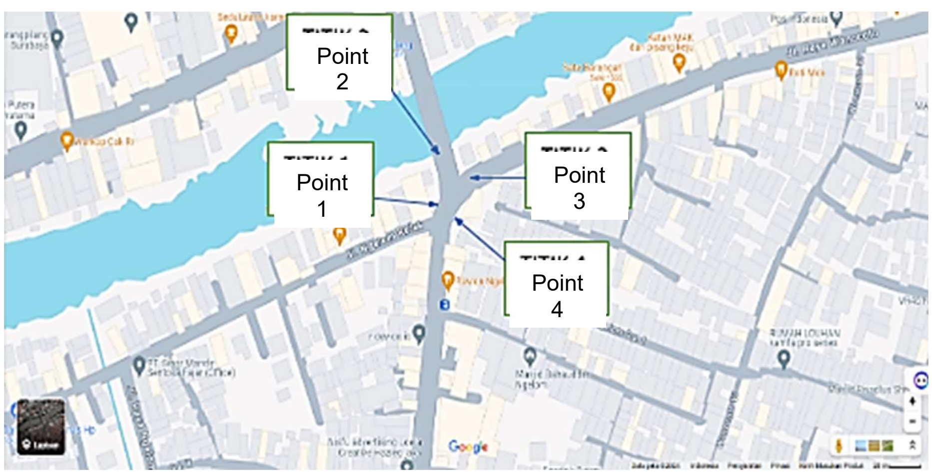

Figure 1. Data collection survey points appear on Google Maps

Source : https://www.google.com/maps/place/7%C2%B020'43.1%22S+112%C2%B041'30.4%22E/@-7.3452992,112.6911318,191m/data=!3m2!1e3!4b1!4m4!3m3!8m2!3d-7.3453005!4d112.6917755?entry=ttu

Materials and Instruments

The study utilizes various materials and instruments to gather data (figure 2). Traffic volume and speed were measured using traffic counters and radar guns.

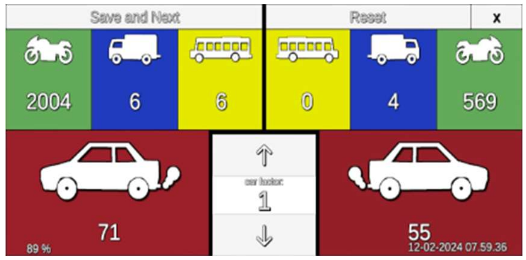

Figure 2. Vehicle count application

While noise levels were recorded using calibrated sound level meters (figure 3). These instruments were strategically placed at selected points, along the road, to capture accurate and representative data during peak traffic hours.

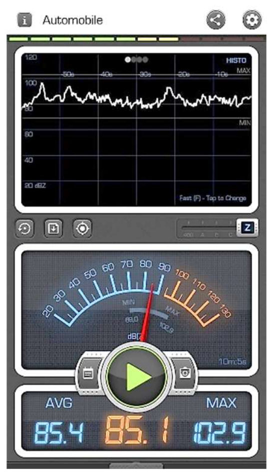

Figure 3. Vehicle noise meter applications

Data Collection

Data collection was conducted over a period of several weeks to ensure a comprehensive data set, that accounts for variations in traffic and noise levels. Traffic data were collected at different times of the day as illustrated in figure 4, focusing on the morning time, noon time, and the evening time peak hours. Noise levels were measured concurrently, to establish a correlation between traffic volume, and noise pollution.

Figure 4. Vehicle noise meter applications

Analysis Techniques

The collected data were analyzed using the MKJI 1997 method, which provides a framework for assessing road capacity, and its impact on traffic flow, and noise levels. Statistical analysis being performed to identify patterns and relationships, between: road capacity, traffic congestion, and noise pollution. Regression analysis and correlation tests, were used to determine the strength and significance of these relations.

1. Capacity

   Capacity is defined as the maximum flow through a point on the road, that can be maintained per unit hour, under certain conditions. For two-lane, two-way roads, capacity is determined for two-way flows (a combination of two directions), but for types of roads with multiple lanes, flows are separated per direction, and capacity is determined per lane.

   To determine capacity, Eq is usually used. 2.3 is as follows:

   C = Co x FCw x FCsp x FCsf x FCcs (pcu/hour)

   With: C = Capacity (pcu/hour)

   CO = Basic capacity (pcu/hour)

   FCw = Adjustment factor due to traffic lane width

   FcSP = Directional separation adjustment factor

   FCcs = Adjustment factor for city size

   FCsf = Side and shoulder resistance adjustment factor

2. Volume

   Volume is the number of vehicles that passes through an observation point, during a certain time period. The traffic volume value reflects the composition of traffic, by expressing the flow in passenger car units (SMP), which is converted by multiplying the passenger car equivalent value (EMP).

   Vehicle volume can be calculated based on the equation:

   Q =N/N

   With:

   Q = Volume (vehicles/hour)

   N = Number of vehicles (vehicles)

   T = observation time (hours)

   The classification of vehicle types for urban roads based on MKJI 1997 are as follows:

   Light vehicles (LV), are motorized vehicles with two axles with 4 wheels, with an axle spacing of 2.0-3.0 m (including passenger cars, mini buses, pick-up trucks and small trucks).

   Heavy vehicles, (MHV) are motorized vehicles with an axle distance of more than 3.50 m, usually with more than 4 wheels (including buses, 2-axle trucks, 3-axle trucks and combination trucks).

   Motorcycles (MC), are motorized vehicles with 2 or 3 wheels (including motorbikes and 3-wheeled vehicles).

   Non-motorized vehicles (UM), are included as a separate event in the side drag adjustment factor.

Various types of vehicles are equivalent to passenger car units, using the passenger car equivalent factor (EMP), whilst EMP is a factor that shows various types of vehicles compared to light vehicles.

3. Degree Of Saturation (DS)

The degree of saturation (DS) is defined as the ratio of road flow to capacity, which is used as the main factor in determining the level of performance, of intersections and road segments. The DS value indicates whether the road segment has capacity problems or not. To determine the degree of saturation, Equation 2.4 is usually used as follows:

DS = Q/C

With:

DS = Degree of saturation

Q = Traffic flow (pcu/hour)

C = Capacity (pcu/hour)

The degree of traffic saturation is used to analyze traffic behavior.

The methodology ensures a robust analysis of how changes in road capacity affect both traffic congestion, and noise pollution. Providing valuable insights for urban planning and transportation management, in rapidly developing urban areas such as the particular Sidoarjo region.

RESULTS AND DISCUSSION

The analysis of traffic volume and noise levels on the Wonocolo - Sepanjang road is recorded as seen in table 1, 2, 3, 4 and 5 reveals significant insights into the impact of road capacity, on congestion and pollution. Using the data collected, it is evident that the highest traffic volume occurs on Monday afternoon, between 4:00 PM and 5:00 PM, reaching a peak of 1633 pcu/hour.

This peak period is attributed to the dense market activities, and the high volume of commuters, returning from work places. The detailed examination of these factors provide understanding of how traffic patterns and noise pollution correlate, with road capacity and urban activity.

Tabel 1. Total Vehicle Volume in Passenger Car Units (pcu/hour)

Time	Friday	Saturday	Monday	Tuesday	Wednesday	Thursday
07.00 - 08.00	1,435	1,497	1,317	1,292	1,558	1,371
08.00 - 09.00	1,421	1,571	1,234	1,346	1,551	1,366
12.00 - 13.00	1,226	1,228	1,026	1,117	1,238	1,274
13.00 - 14.00	1,265	1,336	1,212	1,224	1,255	1,300
16.00 - 17.00	1,345	1,580	1,399	1,331	1,633	1,515
17.00 - 18.00	1,300	1,610	1,238	1,615	1,568	1,305

Tabel 2. Traffic Performance in year Of 2024

WAKTU	VOLUME LALU LINTAS (smp/ jam)			
	RUAS JALAN			
	1	2	3	4
PAGI				
06,00 - 06,15	186	47	255	154
06,15 - 06,30	143	45	223	161
06,30 - 06,45	155	35	247	79
06,45 - 07,00	225	48	272	74
07,00 - 07,15	184	52	258	87
07,15 - 07,30	204	28	291	71
07,30 - 07,45	195	46	262	83
07,45 - 08,00	143	41	224	65
SIANG		0	0	0
11,00 - 11,15	114	29	58	124
11,15 - 11,30	129	20	64	144
11,30 - 11,45	93	32	51	141
11,45 - 12,00	115	44	71	126
12,00 - 12,15	102	35	57	122
12,15 - 12,30	89	46	43	153
12,30 - 12,45	93	15	70	141
12,45 - 13,00	103	55	66	133
SORE		0	0	0
16,00 - 16,15	267	85	239	302
16,15 - 16,30	139	103	148	259
16,30 - 16,45	141	105	174	268
16,45 - 17,00	125	93	203	229
17,00 - 17,15	109	83	165	282
17,15 - 17,30	150	75	183	299
17,30 - 17,45	138	74	175	316
17,45 - 18,00	264	63	195	278

Tabel 3. Road Capacity

No	Notasi	Nilai Kapasitas			
		Ruas Jalan			
		1	2	3	4
1	Co	2.700	2.700	2.700	2.700
2	FCw	0,56	0,56	0,56	0,56
3	FCsp	1,00	1,00	1,00	1,00
4	FCsf	0,97	0,94	0,97	0,94
5	FCcs	1,00	1,00	1,00	1,00
6	C	1.467	1.421	1.467	1.421

Tabel 4. Traffic Volume in the year Of 2024

No.	Ruas Jalan	VOLUME LALU LINTAS JAM PUNCAK (smp/jam)		
		Pagi	Siang	Sore
1	1	808	451	672
2	2	179	157	386
3	3	1.083	243	763
4	4	468	549	1.126

Tabel 5. Degree Of Saturation in the year Of 2024

No.	Ruas Jalan	DERAJAT KEJENUHAN (DS=V/C)			LOS
		Pagi	Siang	Sore	
1	1	0,551	0,307	0,458	C
2	2	0,126	0,110	0,271	B
3	3	0,739	0,166	0,520	C
4	4	0,329	0,386	0,792	D

On the other hand, the calculated data for year of 2029 are shown in tables 6, 7 and 8.

Tabel 6. Traffic Performance in the year Of 2029

WAKTU	VOLUME LALU LINTAS (smp/ jam)			
	RUAS JALAN			
	1	2	3	4
PAGI				
06,00 - 06,15	260	66	357	216
06,15 - 06,30	200	62	313	226
06,30 - 06,45	218	48	347	111
06,45 - 07,00	315	67	382	104
07,00 - 07,15	258	73	362	123
07,15 - 07,30	286	39	408	100
07,30 - 07,45	274	64	367	116
07,45 - 08,00	201	58	314	91
SIANG	0	0	0	0
11,00 - 11,15	159	40	81	174
11,15 - 11,30	181	28	90	202
11,30 - 11,45	131	45	71	197
11,45 - 12,00	162	62	99	177
12,00 - 12,15	143	49	80	171
12,15 - 12,30	124	64	60	215
12,30 - 12,45	130	21	98	197
12,45 - 13,00	144	77	92	186
SORE	0	0	0	0
16,00 - 16,15	375	119	335	424
16,15 - 16,30	194	144	207	363
16,30 - 16,45	198	147	244	376
16,45 - 17,00	176	130	284	322
17,00 - 17,15	153	117	232	395
17,15 - 17,30	211	105	256	419
17,30 - 17,45	194	104	245	443
17,45 - 18,00	370	88	273	390

Tabel 7. Traffic Volume in the year Of 2029

No.	Ruas Jalan	VOLUME LALU LINTAS JAM PUNCAK (smp/jam)		
		Pagi	Siang	Sore
1	1	808	451	672
2	2	179	157	386
3	3	1.083	243	763
4	4	468	549	1.126

Table 8. Degree Of Saturation in the year Of 2029

No.	Ruas Jalan	DERAJAT KEJENUHAN (DS=V/C)			LOS
		Pagi	Siang	Sore	
1	1	0,551	0,307	0,458	C
2	2	0,126	0,110	0,271	B
3	3	0,739	0,166	0,520	C
4	4	0,329	0,386	0,792	D

Figure 5. Morning Time Observation Noise Data Results

At 8:44 AM on February 10th, 2024, data analysis highlighted significant value fluctuations over a period of 10 minutes and 16 seconds. Values ranged from around 70 to just over 100, using frequency weighting Z and 0.0 dBZ calibration, with a recorded dose of 33.1%. The Time-Weighted Average (TWA) was 54.3 dBZ, indicating the significance of these fluctuations.

Figure 5 shows the graph showed dynamic patterns, with an average value of 85.2, a minimum of 70.4, and a maximum of 106.9. The highest peak was 111.0, suggesting an event affecting the maximum value. This data provides a deep understanding of value dynamics over the observed period, significantly influencing interpretation and analysis.

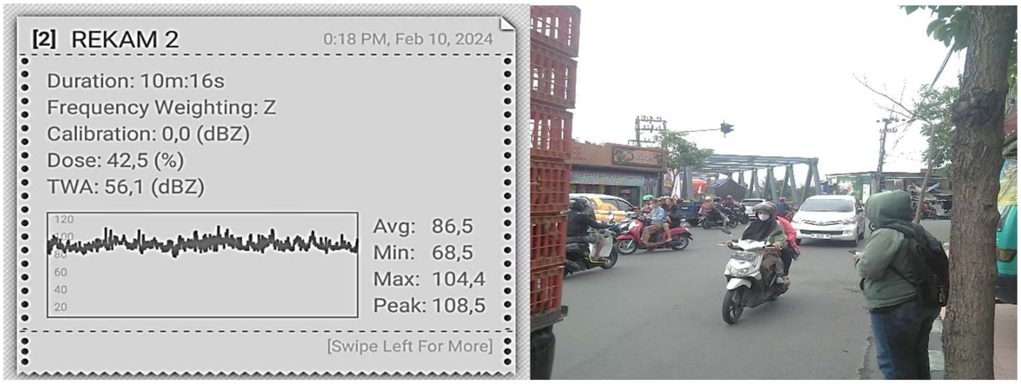

Figure 6. Noon Time Observation Noise Data Results

Moreover, based on data collected at 12:18 PM on February 10th, 2024, a 10-minute and 16-second observation period yielded significant results. Using frequency weighting Z and 0.0 dBZ calibration, the dose reached 42.5%. The Time-Weighted Average (TWA) was 56.1 dBZ, indicating the phenomenon's significance as seen in Figure 6.

The graph showed value fluctuations between 68 and just over 100. The documented data had an average value of 86.5, with a minimum of 68.5 and a maximum of 104.4. The highest peak was 108.5. This analysis provides crucial insights into value dynamics during the observation period, enhancing interpretation and decision-making.

Figure 7. Afternoon Time Observation Noise Data Results

Further, figure 7 is a recorded data At 4:18 PM on February 13th, 2024, a 10-minute and 18-second data analysis was conducted. Using frequency weighting Z and 0.0 dBZ calibration, the dose reached 21.9%, with a Time-Weighted Average (TWA) of 51.3 dBZ.

Finally, the graph showed value fluctuations between 71 and just over 96. The data had an average value of 83.4, with a minimum of 71.0 and a maximum of 96.8. The highest peak was 109.8. This analysis provides deeper insight into value characteristics over the observed period, essential for data interpretation and decision-making in the research context.

CONCLUSIONS

According to the results of the data analysis, the following conclusions were obtained:

1. Road capacity on a road section is obtained from the class D service level value, at a certain hour. The highest side obstacles on Monday were in the High (H) side obstacle category, namely 600 incidents/hour, because the side of the road was used as a traditional trading place so it really disrupted road activities.
2. Based on the observations that have been conducted, it was found that the worst service level value is class D. This shows that vehicle flow is hampered, the speed is low, the volume is above capacity. Traffic performance in existing conditions is in stable flow conditions, but vehicle speed and movement are controlled, the driver's ability is limited in choosing speed variations.
3. The influence of road capacity on road congestion on the Wonocolo road section during the morning rush hour, is dominated by 4,042 two-wheeled vehicles, and resulting in traffic jams. The prediction of traffic generation in the area for the next 5 years, with an average annual traffic volume growth of 7%, shows that the level of traffic service after the area operates, the traffic flow will be unstable.
4. The road capacity that influences noise factor on the Wonocolo road section - along Sidoarjo regency, obtained a maximum calculation result of 106.9 dB. Whilst according to the Decree of the Minister of the Environment KEP-48/MENLH/11/1996, the limit is 50 db. Means that it exceeds the specified maximum limit and can cause the streets to become too noisy.

Suggestions:

1. Put clearer and easier to read traffic signs.
2. Widen the roads and bridges connected.
3. Add more public transportation services to help reduce traffic congestion.
4. Reduce the level of road side obstacles due to public unawareness of not to park the vehicles and not to stop the vehicles on the roadside to purchase things, doing road side business transactions, etc. Suggest them to park the vehicles within the parking space provided.
5. Use special anti-noise asphalt to reduce noises.
6. Add more plants as natural noise barriers to dampen sounds around the road.

REFERENCES

AASHTO. (1993). Guide on Evaluation and Abatement of Traffic Noise. America Association of State Highway and Transportation Officials Highway Subcommitte, USA.

Abdi Grisela Nurinda, Priyanto Sigit, & Malkamah Siti. (2019). Hubungan Volume Kecepatan dan Kepadatan Lalu LintasPada Ruas Jalan Padjajaran (Ring Road Utara), Sleman. Teknisia, XXIV, 55–64.

Djalante, S. (2010). Analisis Tingkat Kebisingan di Jalan Raya yang Menggunakan Alat pemberi Isyarat Lalu Lintas (APIL) (Studi kasus: Simpang Ade Swalayan). Jurnal SMARTek, 8(4).

Florentinus, L. D., Lakawa, I., & Sulaiman, S. (2021). Model Hubungan Karakteristik Arus Lalu Lintas Pada Ruas Jalan Abdullah Silondae Kota Kendari. Sultra Civil Engineering Journal, 2(2), 55–64. https://doi.org/10.54297/sciej.v2i2.191

Ismawanda, Zajuli, A. 2018. "Analisis Kemacetan Lalu Lintas Di Simpang Empat Legundi Kabupaten Gresik." Swara Bhumi E-Journal Pendidikan Geografi FIS Unesa. 5:273–242.

Julianto, E. N. (2010). Hubungan antara kecepatan, volume dan kepadatan Lalu lintas Ruas Jalan Siliwangi

Semarang. Jurnal Teknik Sipil Dan Perencanaan, 12(2), 151–160.

JUNIARDI, J. (2014). Analisis Tingkat Kebisingan Lalu Lintas dan Penentuan Daerah Aman Terhadap gangguan Kebisingan (Jl. Soekarno – Hatta). Jurnal Teknik Sipil, 5(2).

Muhammad Isradi, Natasha Diaz Nareswari, Andri Irfan Rifai, Amar Mufhidin,Joewono Prasetijo, 2021,,Performance Analysis of Road Section and Unsignalized Intersections in Order to Prevent Traffic Jams on Jl H. Djole – Jl. Pasar Lama , Volume 6, Number 1, February 2021,http://adri.journal.or.id/index.php/aijce/index

Mustikarani, W., & Suherdiyanto, S. (2016). Analisis Faktor-Faktor Penyebab Kemacetan Lalu Lintas di Sepanjang Jalan H Rais A Rahman (Sui Jawi) Kota Pontianak. Edukasi: Jurnal Pendidikan, 14(1), 143-155.

Pu.go.id. (1997). Manual Kapasitas Jalan Indonesia (MKJI). Jakarta: Direktorat Jendral Bina Marga, Departemen Pekerjaan Umum. Retrieved from https://pu.go.id/pustaka/biblio/manual-kapasitas-jalan-indonesia-mkji/9J3GG

Setiawan, A. (2014). Pengaruh Kecepatan dan Jumlah Kendaraan terhadap Kebisingan (Studi Kasus Kawasan Kos Mahasiswa di Jalan Raya Prabumulih-Palembang KM 32 Indralaya Sumatera Selatan). Sriwijaya University. Retrieved from https://scholar.sriwijaya.ac.id/index.php/kebijakan/article/view/2019

Sukirman, & Silvia. (1994). Dasar–Dasar Perencanaan Geometrik Jalan. Nova, Bandung.

Syaiful, Syaiful, dan Sri Wiwoho Mudjanarko. (2019). Noise of Motor Vehicles at from of Baiturrahman Great Mosque Semarang City. THE SPIRIT OF SOCIETY JOURNAL, 2(2).

Tamin, O. Z. (1992). 1992. “Pemecahan Kemacetan Lalu Lintas Kota Besar. J.” Jurnal PWK 10–17

Wiwoho Mudjanarko, Sri, Slamet Winardi, dan Arthur Daniel Limantara. (2017). Pemanfaatan Internet of Things (Iot) Sebagai Solusi Manejemen Transportasi Kendaraan Sepeda Motor. Seminar Nasional Aplikasi Teknologi Prasarana Wilayah X (ATPW) (August).