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Determination of the Measurement of Un-signalized Intersection Elasticity for a Traffic Control System

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A B S T R A C T

Park-and-ride has been deployed at KTM Klang Commuter Station as to ease traffic congestion. The location of the station within the town center however invited doubt about the functionality of the park and ride facility which supposed to hijack vehicle from coming to the town center. A park and ride is supposed to be located at the fringe of a town area such that drivers and riders may opt to park their vehicles at the facility and take a public transport system as to continue their journey to the town center. This study aims to determine the measurement of traffic control system whether or not it can sustain the extra traffic demand as the outcome of the new P&R facility

1. Introduction

Park-and-ride services are an important component of many public transportation systems in Malaysia. Park-and-ride (P&R) facilities allow commuters to avoid the stressof driving a congested part of their journey and facing scarce, expensive city-central parking (Huanmei Q., 2013). Commonly it is constructed at the fringe of a town, however, there is also special cases where park and ride system is constructed within the town center. Thus, it is interesting to evaluate the performance of such facility by determining the elasticity of the affected traffic control system as per selected study area at Klang KTM Commuter Station. Duncan and Christensen(2013) utilized stated preference survey and logit model as to determine the effectiveness of the studied park-and-ride facilities at light rail station across the US, however study on the performance of the key infrastructure facilities leading to the park-and-ride such as link and intersection elasticity are not conducted. This study determines the performance of the affected traffic control system by measuring the elasticity to sustain the extra traffic demand from the provision of the new P&R system.

2. Processes and Methodology

2.1 Existing traffic condition analysis

The key intersections represent the traffic control system within the study area. Figure 1 shows the four key intersections layout around the Klang KTM Commuter Station.

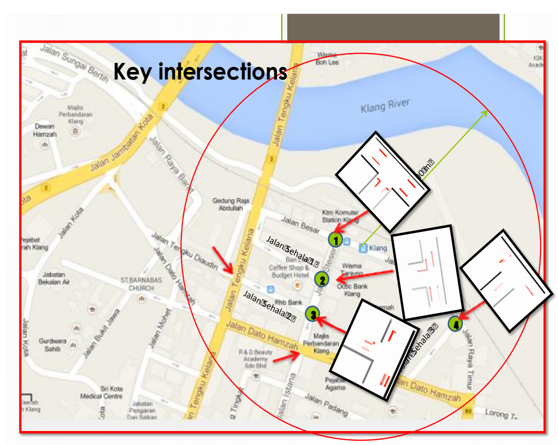

Figure 1: Key intersections.

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Current peak hour traffic volumes on the roads within the study area were determined by Mohammed, T. M. (2006) research methods. The data recorded from the video cameras at each intersection. Table 1 shows the existing morning and evening peak hour traffic volumes.

Table 1: Existing AM and PM peak hours (vph)

Period	JC1	JC2	JC3	JC4	Total
0600-0700	719	443	563	320	2045
0700-0800	1711	1349	1713	807	5580
0800-0900	1833	1351	1802	958	5944
0900-10000	1729	1294	1619	701	5343
1600-1700	1552	1176	2128	450	5306
1700-1800	1822	1245	1966	399	5432
1800-1900	2022	1477	2172	522	6193

The average percentage traffic composition in the study area is shown in Table 2. It could be observed that cars, which include four wheel drives and vans, constitute the highest percentage of the total traffic composition of some 76% followed by motorcycles (21%) and heavy vehicles of lorries and buses (3%).

Table 2: Average traffic composition.

Cars	Medium Lorries	Heavy Lorries	Buses	Motorcycles	Total
AM PEAK HOUR					
76%	2%	0%	1%	21%	**100%**
PM PEAK HOUR					
77%	**2%**	**0%**	**1%**	**20%**	**100%**

2.2 *Intersection elastic measurement*

Measurement of intersection elasticity include two stages, the first stage is intersection maximum capacity checking and the second stage is intersection control delay checking. Figure 2 shows the maximum capacity checking is the first important step, if the intersection existing capacity is less than the maximum capacity then can move to stage two control delay checking, if the existing capacity over the maximum capacity means the intersection is inelastic Trace, (1999). For stage two, all the intersections need to do control delay checking, if the control delay is less than 50 sec that means the intersection is elastic, if the control delay is over 50 sec that means the intersection is inelastic *Transport Elasticities (2013)*. The last step is to find the worse inelastic intersection and develop the worse intersection to improve the whole traffic system.

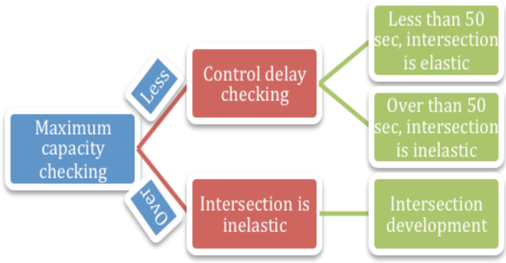

Figure 2: Intersection elastic measurement

3. Result and data analysis

According to MHCM (2000), each intersection control delay can be calculated by

$$D = \frac{3600}{C_{m,x}} + 900T\left[\frac{V_x}{C_{m,x}} - 1 + \sqrt{\left(\frac{V_x}{C_{m,x}} - 1\right)^2 + \frac{\left(\frac{V_x}{C_{m,x}}\right)\left(\frac{3600}{C_{m,x}}\right)}{450T}}\right] + 5$$

Table 3 shows the maximum control delay for each intersection, and the existing intersection control delay between without P&R project and after P&R project.

Table 3: Existing and maximum control delay.

Control Delay	MAX	WOP	WP	WOP	WP
		AM		PM	
Intersection 1	50	148	Over 200	Over 200	Over 200
Intersection 2	50	23	24	11	12
Intersection 3	50	67	144	199	19

3.1 *Intersection maximum capacity checking*

According to Li M.X, Chen J.W (2000) previous research and based on Malaysia condition, the lane maximum capacity can get from equation:

$$N = \frac{1000V}{(2+L_1)+\frac{V}{3.6}+\frac{0.67V^2}{254\emptyset}}$$

and equation:

$$N_1 = N * K_1 * K_2 * K_3 * K_4 * K_5$$

After rectified:

$$N_1 = N * 0.85$$

Where L_1 = 4m, V= 60 km/h, θ = 0.7 N_1 = N*0.85N_1 = N*0.85. Tables 4(a) and (b), and Figures3(a) and (b) show the maximum capacity for each intersection, and the existing intersection capacity between without P&R project and after P&R project.

Table 4(a): Intersection Maximum capacity.

Intersection	Left	Thru	Right	Total
Intersection 1	704	1408	704	2816
Intersection 2	704	1408	0	2112
Intersection 3	704	1408	704	2816
Intersection 4	0	1408	704	2112

Table 4(b): Existing intersection capacity.

Capacity	MAX	WOP	WP	WOP	WP
		AM	PM		
Intersection 1	2816	2490	3279	2566	2962
Intersection 2	2112	1538	1854	1477	1477
Intersection 3	2816	1802	2118	2192	2192
Intersection 4	2112	869	817	1499	2249

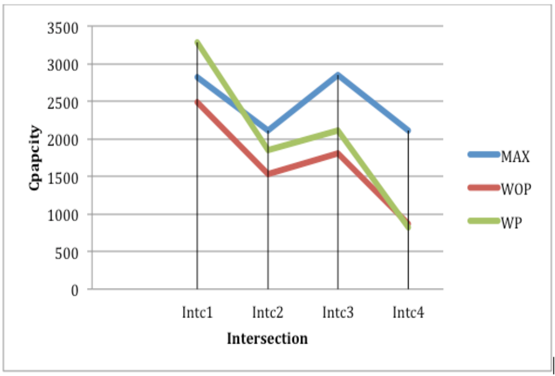

Figure 3(a): Intersection capacity during AM peak hour.

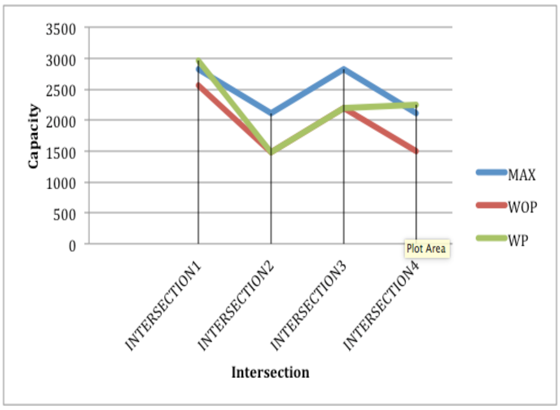

Figure 3(b): Intersection capacity during PM peak hour.

3.2 Intersection control delay checking

According to MHCM (2000), each intersection control delay can be calculated by

$$D = \frac{3600}{C_{m,x}} + 900T\left[\frac{V_x}{C_{m,x}} - 1 + \sqrt{\left(\frac{V_x}{C_{m,x}} - 1\right)^2 + \frac{\left(\frac{V_x}{C_{m,x}}\right)\left(\frac{3600}{C_{m,x}}\right)}{450T}}\right] + 5$$

Table 5, Figures 4(a) and (b) shows the maximum control delay for each intersection, and the existing intersection control delay between without P&R project and after P&R project.

Table 5: Existing and maximum control delay.

Capacity	MAX	WOP	WP	WOP	WP
		AM		PM	
Intersection 1	50	148	Over 200	Over 200	Over 200
Intersection 2	50	23	24	11	12
Intersection 3	50	67	144	199	19
Intersection 4	50	10	10	5	10

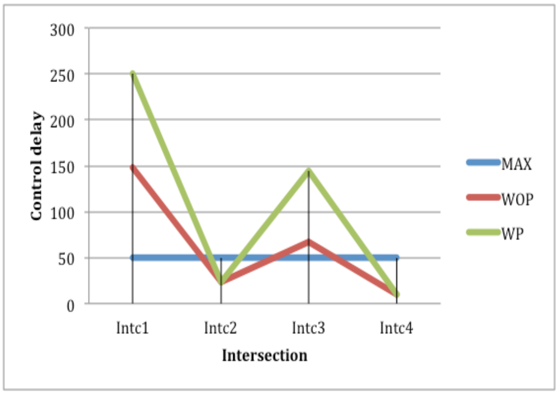

Figure 4(a): Existing and maximum control delay during AM peak hour.

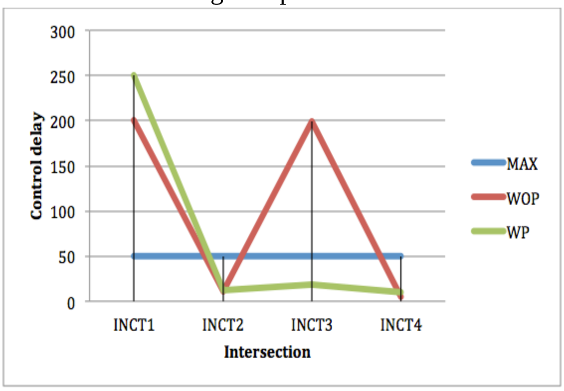

Figure 4(b): Existing and maximum control delay during PM peak hour.

3.3 Intersection development

Based on HCM (2000) can get the capacity of lane group at the intersection from formula c = BC x N x fw x fg x fa x fLT or RT x (1/fc). After that the v/c ratio can be calculated as Figure 5 shows. According to the data the v/c ratio is very high for the RT section so there need one more lane for RT section.

Intersection saturation degree (JSD) is calculated to be as follow JSD = critical vp/cLG of Φ1 + critical vp/cLG of Φ2 + critical vp/cLG of Φ3.= 0.16+0.16+0.26 =0.58 < 0.9.

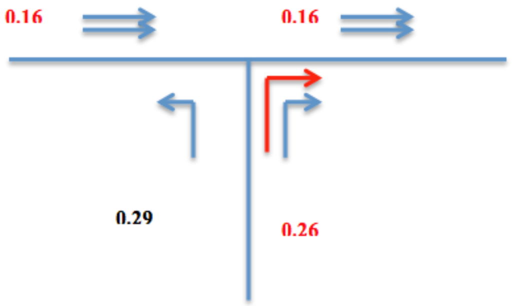

Figure 5: v/c ratio for intersection 1.

The JSD is less than 0.9 that means the new design is suitable for intersection1. For the intersection development the new design layout for intersection 1 as Figure 6 shows.

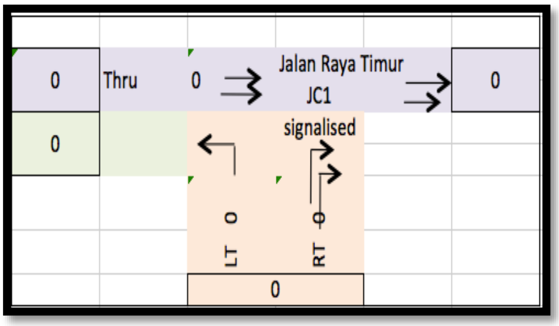

Figure 6: New design for intersection 1.

4. Conclusion

The conclusion of this study is based on the three objectives, which are establishing existing conditions; determine the measurement of un-signalized intersection elasticity, and intersection development. The study area at Klang Malaysia nearby the KTM commuter station and the special care is the new P&R system inside the Klang town. For the first objective is to establish the existing condition, this study did the road inventory according to the JKR standard. There are 4 un-signalized intersections had been choose and analyzed include carriageway type number of lanes lane width and shoulder width. Current peak hour traffic volumes on the roads within the study area were determined from Mohammed.T.M (2006) research methods. The data recorded from the video cameras from 8 am until 5 pm.

For the second objective is to determine of measurement of intersection elasticity. There are two stages for the determination, which are maximum capacity checking and control delay checking. Before that this study did the intersection analysis based on MHCM (2000). The data from recorded by the video cameras during the am peak hour and pm peak hour, and calculated the capacity until control delay for each intersection. There are also two conditions, which are existed traffic condition (without P&R) and future condition (with P&R). For stage one According to Li M.X, Chen J.W (2000) previous research and based on Malaysia condition, the maximum capacity for each intersection can be calculated then compared with two conditions to check the capacity is less than maximum capacity or over than maximum capacity. For stage two is control delay checking, according to MHCM (2000) the maximum control delay is 50 sec, then compared with the intersection control delay during the existed condition and future condition. At last this study determined which intersection is inelastic and how elastic it is.

For the last objective is to develop the worse intersection. Like bucket effect a bucket can hold much water, does not depend on the longest piece of wood, but on the shortest piece of wood for this study the shortest piece of wood is the worse intersection 1. Based on HCM (2000) signalized intersection this study analyzed and designed the new intersection for the worse intersection and changed the un-signalized intersection 1 to signalized intersection so that can improve the entire traffic system.

5. Recommendations

Based on this study, can use more methods to collect the traffic data during the am peak hour and pm peak hour to get exact traffic capacity. This study area does not have cross un-signalized intersection, so that the cross in-signalized should be considered. For the intersection development, the worse un-signalized intersection changed into signalized intersection but the measurement of signalized intersection have not done yet and the new intersection design can find the government to suggest the new intersection layout, and get more opinions form them professional engineers.

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