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TRAFFIC MANAGEMENT AT T INTERSECTIONS WITH ALWAYS-THRU TRAFFIC

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ABSTRACT

This study builds three simulation models of T intersection, to analyze delay and traffic lane change rate. The arterial road has two left lanes going straight and a rightmost lane for turning right to the secondary road. Model I simulates with traffic signals applied to all directions. Model II has the arterial road with the leftmost lane always-thru traffic. Model III has two left lanes always-thru traffic, with varied channelizing island length. For all models, there is a right turn lane from the secondary road to merge the arterial road. Model I is used as a reference for discrepancy delay to Models II and III. The varied V/c ratios have been set as 0.9, 0.6, and 0.3. Also, ratios of traffic volume in the conflict directions are taken into consideration. From the simulation result, traffic management on the T intersections with always-thru traffic (Models II and III) is suitable for medium to high volume of traffic. For low traffic volume, the efficiency of T intersections is unaffected when compared to Model I. When selecting channelizing island length, traffic lane change rate should be taken into account. Longer channelizing island length can reduce lane change rate as the turning right from the secondary road to merge the traffic of the arterial road.

1. INTRODUCTION

Traffic signal management is an important tool in solving traffic problems on intersections. But when the traffic flow is much beyond the capacity of traffic lights, causing traffic congestion and increase travel time of the vehicles. The solution may be achieved by increasing the capacity of the roadway intersections or reducing the traffic volume entering to the intersections, such as using tunnels or overpasses crossing the intersections. For controlled T intersections, it may also possible

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to consider allowing vehicles to get through the intersections without stopping at the traffic light.

1.1 CHARACTERISTIC OF DRIVING IN THAILAND

For bidirectional roads, Thailand uses Left-hand traffic (LHT). Thailand road rules and driving etiquette are different from other countries. It is often find vehicles change driving lane, i.e., cutting into lines of cars or cutting each other off (Travelonline, 2018). Bangkok, the capital city of Thailand, has quite traffic jam, especially during the rush hours. Outskirt provinces have better traffic flow.

1.2 T INTERSECTION TRAFFIC MANAGEMENT

T intersection is a place a road meet a straight road, at right angle. T intersections is good for low to medium traffic volumes but difficult to approach from when turning right if traffic is heavy (ICBC, 2015). For heavy traffics, traffic lights are recommended to increase safety. To serve higher traffic volume, the traffic management for T intersections may let the left traffic lanes on the straight path to run through. This may result in a direct conflict between the run thru vehicles and the turning right vehicles. So a channelizing island may be installed to reduce conflict of both directions, e.g. see Figure 3.

Even if the channelizing island is installed, conflict may remain at the island end position where traffics meet. The length of the island is anticipated to be an important factor that should take into account. This study thus also consider the island length for managing T intersection traffic with the straight path of leftmost lanes running through.

2. LITERATURE REVIEW

Hunter-Zaworski (1990) studied T-intersection simulator performance of drivers with physical limitations. It found that decision time increases with age, and age effects dominated the other factors studied. Also, decision time increases with age and level of impairment, as younger drivers can compensate for their impairments, while older drivers are unable to make compensations.

Sayed and Zein (1999) discussed traffic conflict survey to estimate traffic safety at signalized and unsignalized intersections, to develop an Intersection Conflict Index (ICI) measure. These index could be used a tool to evaluate the safety of intersections.

Jianmin et al. (2000) reported a study using a fuzzy control method for simulation of an isolated intersection traffic management of urban traffic system. The experimental gave that a proposed fuzzy logic controller outperformed the existing controllers in terms of the average delay of vehicles as well as the queue length.

Stanojevic (2011) studied stochastic simulation analysis of isolated intersection operation based on the time advance to the next-event. The models included signalized isolated crossroads, the unsignalized and signalized isolated Y–junction. The study took different values of cycle time and different volume levels.

Medina (2015) proposed automating road intersections via the virtual platooning concept to ensure a smooth, efficient and safe traffic flow. For a simulation study, the virtual platoon needed to define a virtual inter-vehicle distance between vehicles driving on different lanes. The distance was used by a cooperative adaptive cruise control system, which, in turn, generated the required safe gaps for the vehicles to cross the automated intersection.

Zhou and Sisiopiku (1997) examined relationship between volume-to-capacity ratios and accident rates. The study found accident rates were highest in the very low hourly V/C range, decrease rapidly with increased V/C ratio, and then gradually increase as the V/C ratio continues to increase. Jula et al. (2000) shown collision avoidance analysis for lane changing and merging. They analyzed the kinematics of lane changing/merging maneuver vehicles, with simulations lane changing maneuvers scenarios. The results could be used to assess the safety of lane changing maneuvers and provide warnings or take evasive actions to avoid collision. Deshpande (2003) conducted a simulation analysis to evaluating the impacts of transit signal priority strategies on traffic flow characteristics. Road accidents may also possible be monitored with dashboard camera (Witchayangkoon and Sirimontree, 2016).

From these literatures, there is a little work about traffic management at T intersections with always-thru traffic, in which this work is about. Effect from the use of channelizing island is also considered in this study.

3. STUDY DETAILS

Taking field data to be used in simulation modeling, this study selects the three intersections located in Samut Sakhon province, suburb of Bangkok. These are signalized T intersection bidirectional roads having concrete pavement, with lanes and driving directions shown in Figure 1. The data collection (counting personal vehicles (e.g., sedan, sport utility vehicle (SUV), pickup cars)) is made on five weekdays 15, 17, 19 October 2018 during 4.00-5.00pm. Averaged data is used in traffic simulation software for modeling traffic and analyzing traffic interactions. Traffic network is not considered in this study.

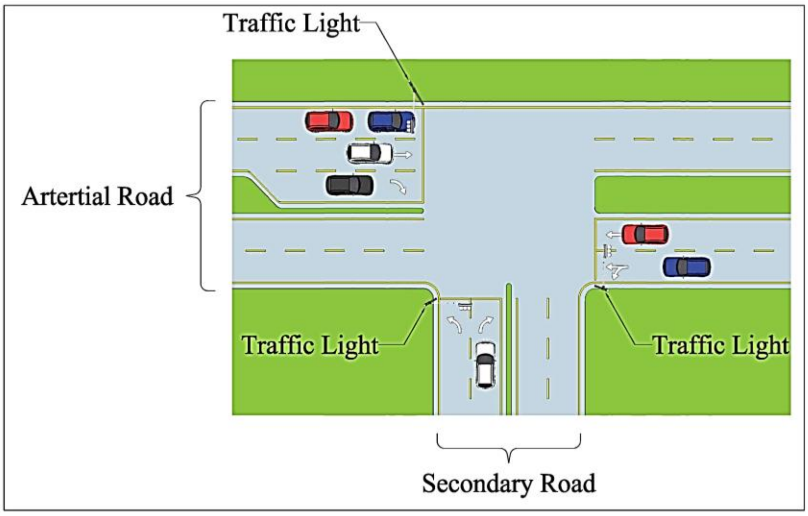

Figure 1: Model I – traffic signals applied to all directions of T intersection.

3.1 CONDITIONS OF TRAFFIC SIMULATION

This study, three T intersections traffic simulation models are built for traffic analysis. The

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arterial road has two left lanes going straight and a rightmost lane for turning right to the secondary road. Using the field observation data, the first model (Model I, *see* Figure 1) simulates with traffic signals applied to all directions. The second traffic simulation model of T intersection (Model II) is the arterial road with the leftmost lane always-thru traffic, *see* Figure 2. The last model (Model III), there is two left lanes always-thru traffic, with varied channelizing island length (*x*), *see* Figure 3. For all models, there is a right turn lane from the secondary road to merge the arterial road.

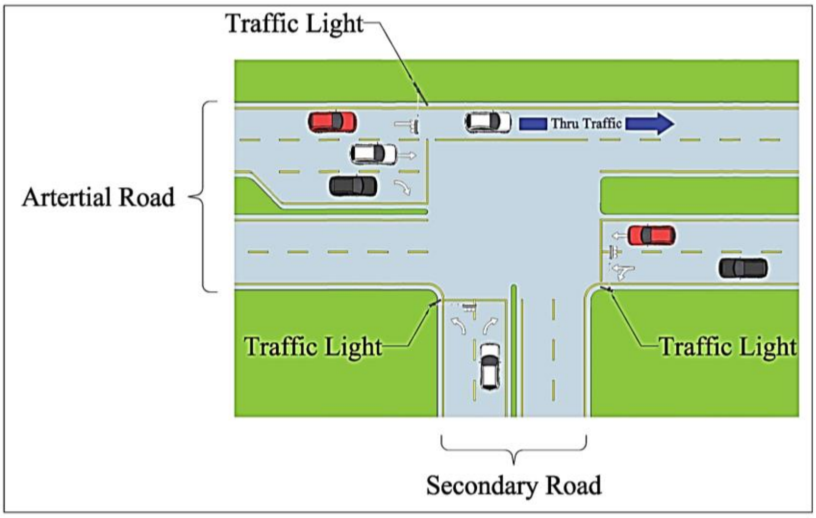

Figure 2: Model II –T intersection arterial road with the leftmost lane always-thru traffic.

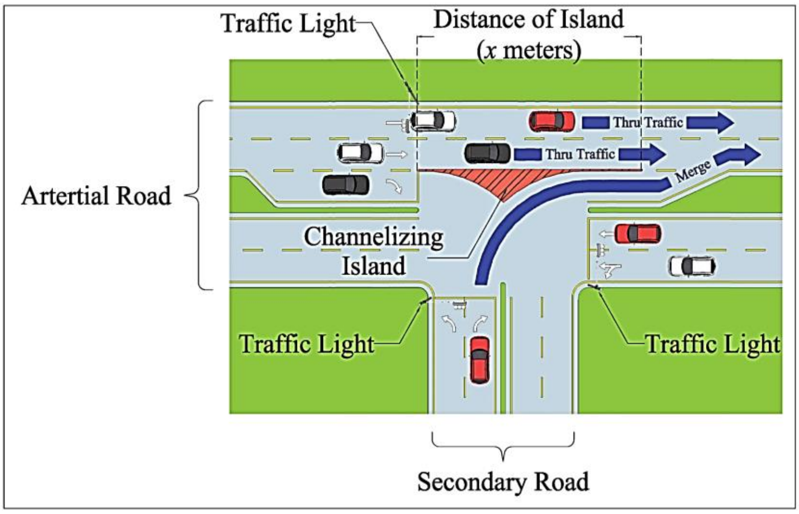

Figure 3: Model III –T intersection arterial road two left lanes always-thru traffic, with channelizing island.

3.2 MODELS WITH VARIED VOLUME CAPACITY RATIO (V/c)

Volume capacity ratio (V/c) is used as a key parameter to assess traffic status of the roadway, where V refers to the total number of vehicles passing a point within one hour and c for the maximum number of vehicles passing a certain point under reasonable traffic condition. All simulation models, varied V/c ratios have been set as 0.9, 0.6, and 0.3.

3.3 CONSIDERATION THE ARTERIAL ROAD THRU TRAFFIC VOLUME AND RIGHT TURN VOLUME FROM SECONDARY ROAD

Since traffic volumes from each direction approaching the T intersection play an important role on the analysis, the study therefore takes the varied amount ratios to learn the effect on the traffic flow. The ratios taken for this study are

$$V_I = \frac{(A+F)}{Total\ Traffic} \quad (1),$$

and

$$R_I = A:F \quad (2),$$

where A is the thru traffic volume of the arterial road and F is the right turn volume from secondary road to merge the arterial road traffic. Equation (1), impact volume V_I is taken as 25%, 50%, and 75%. From Equation (2), factor R_I is used as 30:70, 50:50, and 70:30, *see* Table 1.

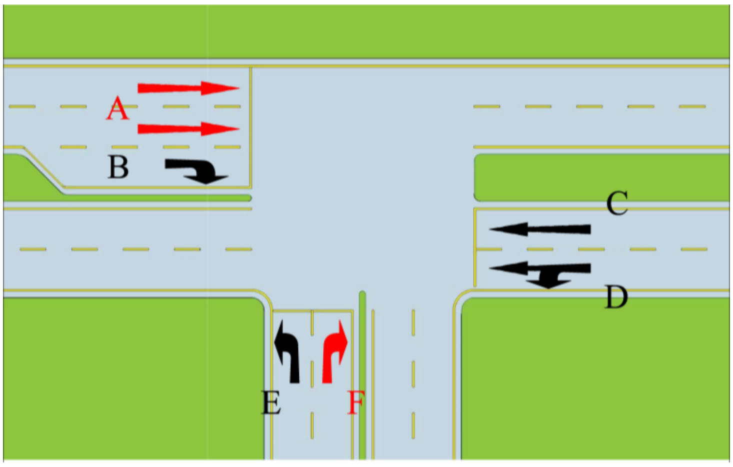

Figure 4: Traffic Directions

Table 1: Varied traffic volume used in the modeling analysis.

V/c = 0.9		V/c = 0.6		V/c = 0.3	
V_I	R_I	V_I	R_I	V_I	R_I
25%	30:70	25%	30:70	25%	30:70
	50:50		50:50		50:50
	70:30		70:30		70:30
50%	30:70	50%	30:70	50%	30:70
	50:50		50:50		50:50
	70:30		70:30		70:30
75%	30:70	75%	30:70	75%	30:70
	50:50		50:50		50:50
	70:30		70:30		70:30

4. RESULTS AND DISCUSSION

4.1 ANALYSIS OF DELAY

For analysis of delay, Model I is used as a reference for this study. From the yielded delay results of simulation Models II and III, the differences (compared to Model I) are plotted for varied V/c, V_I and R_I, see Figure 5.

In case of low vehicle volume (V/c = 0.3), very little differences in delay of Models II and III, compared to Model I, can be learned. Thus, using either Model I, II, or III, it give similar delay, *see* Figure 5, column 1 (V/c = 0.3).

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For case of high vehicle volume (V/c = 0.9), the higher delays can be observed. This is due to conflict between vehicle in directions A and F. For both Model II and III, when V_I gets higher, delays also higher, *see* Figure 5, column 3 (V/c = 0.9).

When simulating medium vehicle volume (V/c = 0.6), delays tend to decreases. For Model III, this is of particular true for V_I around 50%, delays decrease with a longer channelizing island distance. However, when V_I is 75% or greater causing delays to increase, *see* Figure 5, column 2 (V/c = 0.6).

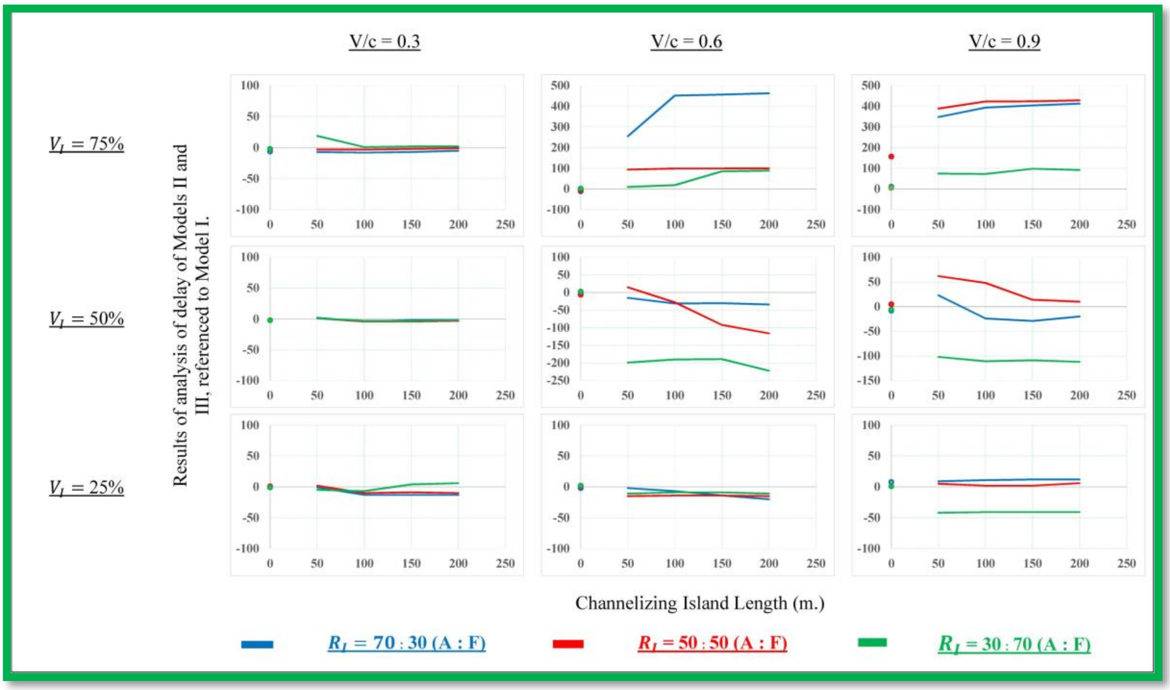

Figure 5: Results of analysis of delay of Models II and III, referenced to Model I.

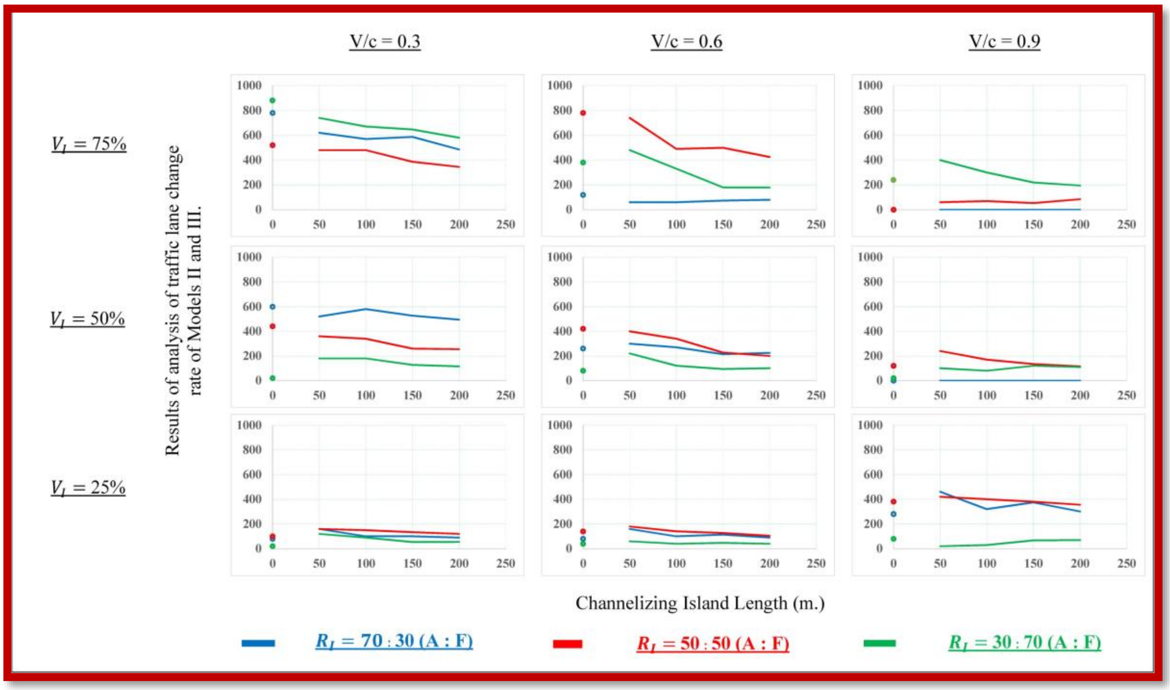

Figure 6: Results of analysis of traffic lane change rate of Models II and III.

4.2 TRAFFIC LANE CHANGE RATE

For analysis of lane change rate, only Models II and III are analyzed, by counting vehicles changing lane in direction A. This comes from the effect of merging, a right turn lane (direction F) from the secondary road to merge the arterial road (direction A).

In cases of low vehicle volume (V/c = 0.3), and medium vehicle volume (V/c = 0.6), V_I is low, traffic lane change rate is also low. When V_I gets higher, lane change rate is also higher. Longer channelizing island length (x) can reduce lane change rate, *see* Figure 6 columns 1 and 2.

When simulating high vehicle volume (V/c = 0.9), and high volume of traffic in direction A, then lane change rate is rarely occurred due to no area for the lane change, *see* Figure 6 columns 3.

5. CONCLUSION

From the simulation study, traffic management on the T intersections with always thru traffic (Models II and III) is suitable for medium to high volume of traffic. For low traffic volume, the efficiency of T intersections is unaffected when compared to Model I. Using Model II and III needs to consider moderate value of V_I (about 50%), and R_I should be either 70:30 or 30:70, but not 50:50. When selecting channelizing island length (x), traffic lane change rate should be taken into account. Longer channelizing island length can reduce lane change rate.

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