

## **PEDESTRIAN ARRIVALS AT SIGNALIZED INTERSECTIONS IN CENTRAL BUSINESS DISTRICTS**

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### **ABSTRACT**

Pedestrian flow pattern in coordinated signal networks may not be random or uniform. Statistical analysis of the data collected in downtown St.Louis along 7 routes supports the above hypothesis. A methodology was used to prove that there exist two significantly different flows within a cycle. The results from this study indicate that, the equation used to calculate the delay at signalized intersection might have to be improved. And also suggests that consideration of pedestrian progression might be a viable alternative to improve the quality of pedestrian flow in the cities.

### **PROBLEM STATEMENT**

Pedestrian walkways are an important mode of transportation in Central Business Districts(CBDs). Understanding the characteristics of the pedestrian movement along these walkways would be helpful in planning for better mobility of pedestrians.

Pedestrians are assumed to arrive randomly at signals (1). This may not be true when pedestrians are traveling in coordinated signal network. Pedestrians arriving randomly at an intersection will move in a group after the signal turns green and might continue as a significant group towards the downstream signal. The objective of this study is to test the validity of the random arrival characteristics of pedestrians in a coordinated signal network.

### **BACKGROUND INFORMATION**

Virkler has done related research in Australia (2) but to author's knowledge little or no work was done in America in this area. The equations used in this study are stated as follows

$$\text{Rate of flow} = \frac{\text{Number of pedestrians in the period (high or low)}}{(\# \text{ Cycles}) * (\text{Proportion of the flow (high or low)})} \quad (1)$$

$$\text{Pooled Standard Deviation}(3) = \sqrt{\frac{S_1^2 + S_2^2}{N_1 + N_2}} \quad (2)$$

$S_1, S_2$  are standard deviations for the high and low flow data

$N_1, N_2$  are the number of cycle lengths the data was collected.

Pedestrian delay for random arrivals at an intersection can be derived (4) as

$$d_u = \frac{r^2}{2C} = \frac{(C-g)^2}{2C} \quad (3)$$

where:  $d_u$  = averaged stopped delay per pedestrian

$r$  = effective red time

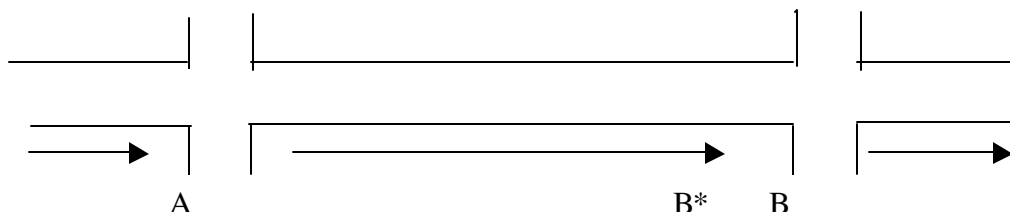
$C$  = cycle length

$g$  = effective green time

### METHODOLOGY

The Transportation professionals in and around St. Louis were contacted for best possible walkways carrying significant amount of pedestrians. The input from them and personal judgement was used in identifying the routes for this study. The following Methodology was used to conduct the study.

Number of pedestrians arriving at a signalized intersection (B or B\* in Figure1) from an upstream-signalized intersection (A in Figure1) were counted for a period equivalent to 15 minutes or approximately 15 minutes, so that the cycle length will be a factor of the time period. The data collected were then statistically analyzed.



A- Upstream intersection point where the pedestrians wait for walk signal to step on the cross walk

B\*- Possible Queuing point where pedestrians are likely to join the waiting queue

B- Downstream intersection

**FIGURE 1 Pedestrian Walkway Segment.**

### FIELD STUDY

The data for this study was collected in St. Louis CBD. The signals in the area of study were coordinated and pre timed. Each intersection had a cycle length of 60 seconds. The walkways lengths ranged from 200ft to 300ft and the walk times ranged from 6 to 25 seconds.

Data collection was performed on walkways, which had major pedestrian influx from offices and Metro Link Stations. A total of 12 data sets were collected on 7 different routes. On each route the number pedestrians arriving at the downstream intersection from the upstream intersection were counted in 5-second increments, for a period of 15minutes that was incidentally equal to 15 cycle lengths. The data were collected in the form similar to the one shown in Table 1.

**TABLE1 Platooning Study Form**

Route: Along Pine From 8 <sup>th</sup> street to 7 <sup>th</sup> street							Weather :Sunny					
Cycle Length:60 sec at both intersections							Date:8-18-2000					
Min\Sec	5	10	15	20	25	30	35	40	45	50	55	60
0	3	0	0	0	0	0	0	0	0	1	0	2
1	2	1	0	1	0	0	3	0	0	1	0	1
2	0	0	3	4	0	0	0	0	0	0	0	0
3	0	0	0	0	3	2	0	0	0	0	0	0
4	1	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	1	0	0	0	0	0	2	1	2
6	0	0	0	3	0	0	0	0	0	0	2	0
7	0	0	0	0	0	0	0	4	3	4	0	1
8	1	1	0	0	0	0	2	0	0	1	3	1
9	0	0	0	0	0	4	0	2	0	1	0	0
10	4	2	0	0	0	0	0	1	0	0	0	0
11	4	0	0	1	0	0	0	0	0	1	2	3
12	4	0	0	0	0	0	0	1	0	2	2	0
13	0	2	2	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	1	0
Sum	19	6	5	10	3	6	5	8	3	13	11	10

## Results and Discussion

Table1 helps in illustrating the statistical analysis procedure to be used for the analysis of the data.

1. The number of pedestrians was summed in all the cycle lengths for each 5-second increment.
2. By observing the flow within the cycle, the cycle length was divided into high flow and low flow periods.
3. Flow rates in these two periods were calculated using the equation 1.
4. The standard deviation among each flow period data was calculated.
5. The two standard deviations should be pooled using the equation 2.
6. Significant differences in flow rates were tested using the T-statistic.

Analyzing the twelve data sets using the above procedure indicated that high and low flow rates existed within a cycle length at a significant value less than 0.005. This supports the hypothesis “arrivals in coordinated signal networks are not random”.

**TABLE 2 Results Table**

Direction	Total	High Flow		Low Flow			Pooled	Calculated	Pvalue
	# Of	Flow rate	Std dev	# Of	Flow rate	Std dev	Std	T-stat	
	Peds	Peds/min		Peds					
P: 8-->7	103	9.4	2.2	56	5.6	3.7	1.11	3	<. 005
P: 8-->7	99	10.6	4.0	46	4.6	2.0	1.15	5	<. 001
P: 7-->8	73	8.6	3.9	30	3	4.8	1.60	4	<. 001
P: 8-->9	103	10	3.7	53	5.3	3.1	1.25	4	<. 001
O: 7-->8	46	5.8	5.3	17	1.7	1.4	1.42	3	<. 005

## CONCLUSIONS AND RECOMMENDATIONS

The knowledge of pedestrian arrivals would be very useful in designing a better-coordinated signal system. This study indicates that the delay equation used to calculate the pedestrian delay at signalized intersection might not be correct, as the arrivals are not random. Further research should be done to suggest appropriate equation to estimate the delay. Considering pedestrian progression in the CBD's might be useful in understanding the characteristics of pedestrian flow, as it will enhance the quality of flow.

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