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Abstract

Transportation decision makers need quality data. Making an investment decision based on an inaccurate delay measurement can prove costly, especially dealing with public trust. This study examined how to use an existing video surveillance system to determine the actual delay experienced by a vehicle and compare the actual results to commonly used software packages. Initially, a sample study was conducted in Huntsville, AL using a portable video camera to test the feasibility of using the closed circuit television on McFarland Blvd in Tuscaloosa, AL. This study will focus on control delay, which is the measure of delay a vehicle experiences because of a signalized intersection. Vehicles are given time stamps as they entered and exited the zone of influence for the traffic signal. The time a vehicle spends in the analysis zone is compared to the free flow travel time of the analysis zone, which is the time for a vehicle to pass through the intersection without stopping. Results from the video surveillance are compared to control delay obtained from Synchro 7 Software and HCS+ Software. The comparison examined the percent difference between actual and simulated delay. The comparison resulted in values for one intersection that were accurate and very poor results for the second intersection. Visualizing the delay from the video allowed us to identify the software's incorrect treatment of progression and arrival rates. The results suggest decision making can potentially be flawed using simulated results, and that a traffic engineer must strive to understand the actual signal system operation.

Introduction

In response to the University Transportation Centers of Alabama Traffic Signal Systems on Oversaturated Arterials Project, a study of traffic signal data collection techniques was conducted to find control and stopped delay. A sample study determined how to use the video surveillance to create data points. The existing traffic surveillance system of Tuscaloosa, AL was accessed through the UTCA ITS/ TMC at the University of Alabama. Video file were created monitoring McFarland Blvd in Tuscaloosa, AL and used to obtain the necessary parameters to model delay and create discrete control and stopped delay measurements. The video surveillance results from two intersections on McFarland Blvd. were then compared to control delay obtained by Synchro 7 Software and HCS+ Software.

Literature Review

HCM defines control delay to be the delay a vehicle experiences due to signalized intersection control. Several researchers have studied data collection for analyzing control delay. Control delay was calculated using GPS data in a study performed by Quiroga (3). The concept of Free Flow Travel Time and its comparison to the actual time through an intersection has its origin in a paper by Mousa (2). Mousa's method of data collection was different than the proposed method because of the utilization of CCTV (2). The data collection technique from Dixon (1) examined vehicle approach delay of a vehicle in comparison with an HCM approach delay calculation. This paper intends to determine vehicle control delay using video surveillance.

Methodology

As a researchers watches the video's made from the UTCA TMC, a time stamp is given to a vehicle as it enters the analysis zone at the point of deceleration, then a time stamp is given for a vehicle stopping. The last time stamp is given for a vehicle as it crosses the stop bar and exits the analysis zone. The entire method is based on Free Flow Travel Time versus the observed time to traverse the zone of influence. The observed time is the Departure Stamp minus the Arrival Stamp. If a car does not have to stop no stopped time stamp is taken. Control Delay was computed from the video surveillance by subtracting the FFTT from the actual time in the zone. Stopped delay was directly measured from the time stamps and is not relative to FFTT.

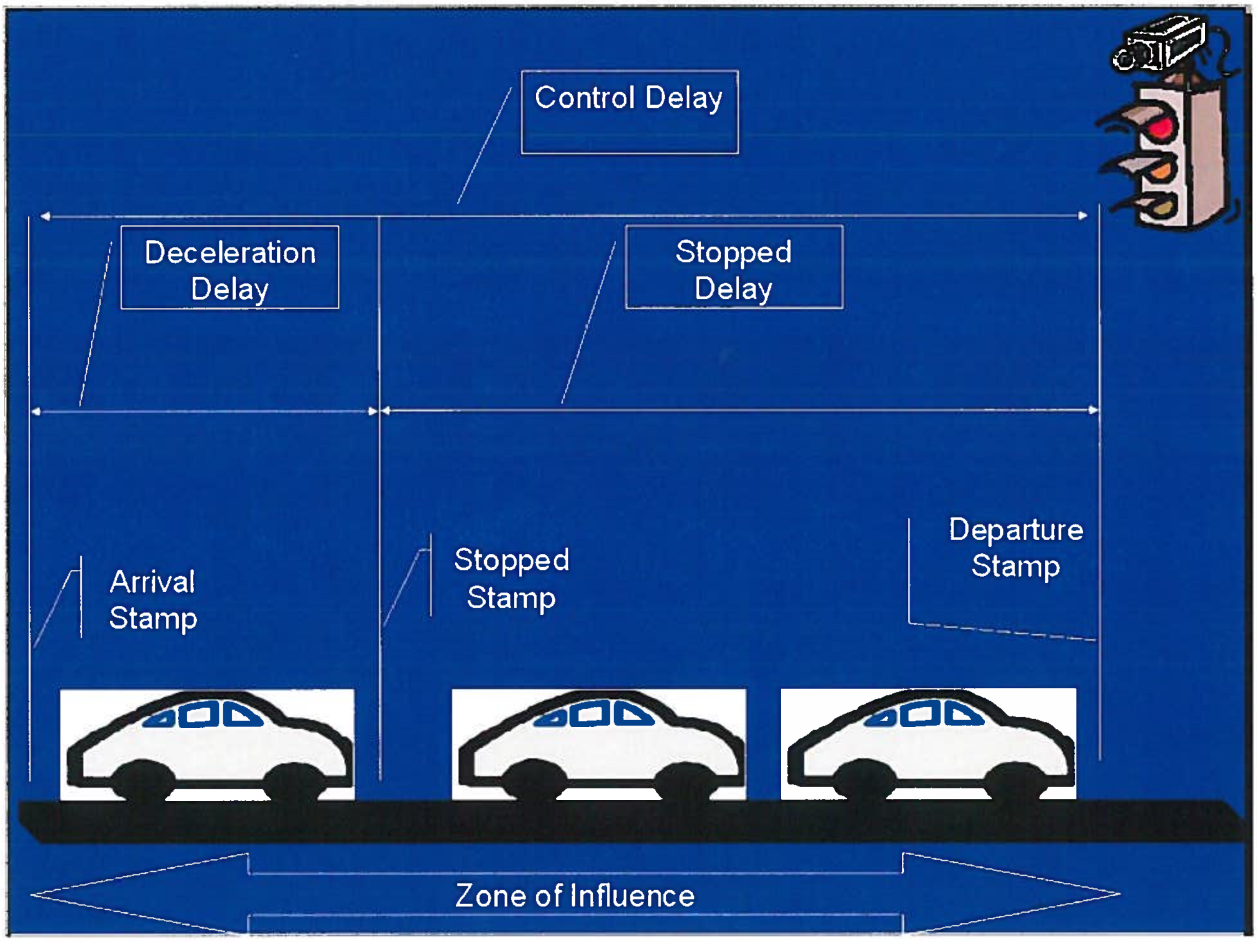
Deceleration Delay was computed by subtracting control delay from stopped delay. Stopped and deceleration delay were not used in any comparisons. The controller type (actuated-coordinated), timing patterns, vehicle volumes, and geometric considerations were also observed during the analysis period and the desired parameters were input into Synchro 7 and HCS+ software for the simulation results. The intersections studied were all actuated uncoordinated. HCS+ software was also used to help account for different equations and methods to calculate delay. The proposed video method follows these equations, and then the control delay for the hour is averaged to produce the results used for the comparisons.

Stopped Delay = Departure Stamp - Stopped Stamp

Control Delay = (Departure Stamp – Arrival Stamp) - FFTT

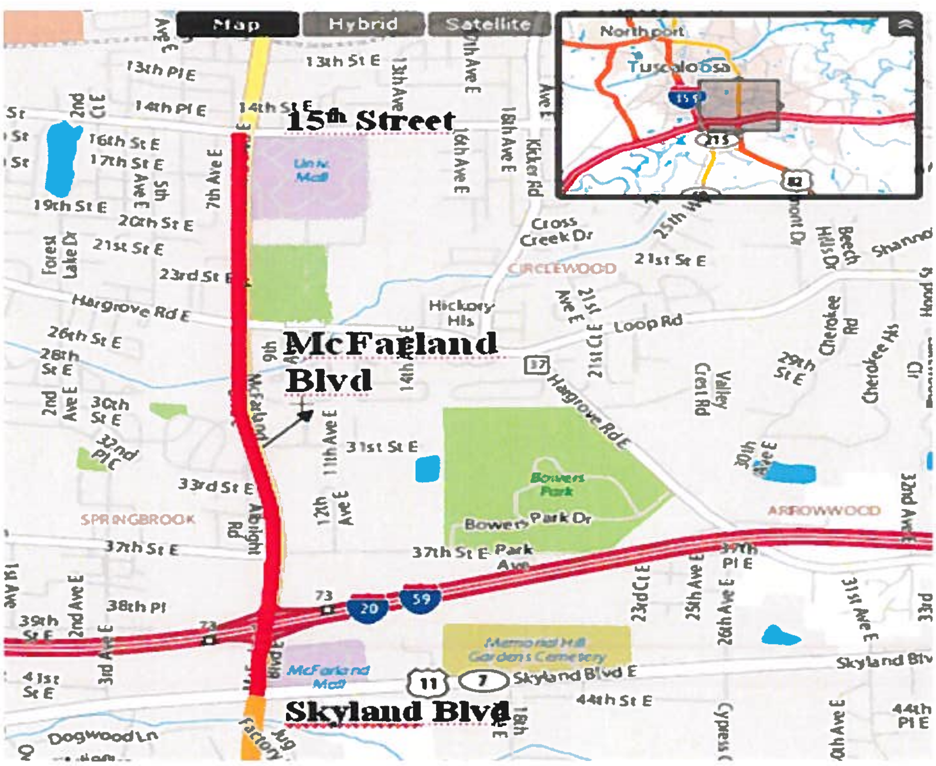
Deceleration Delay = Control Delay – Stopped

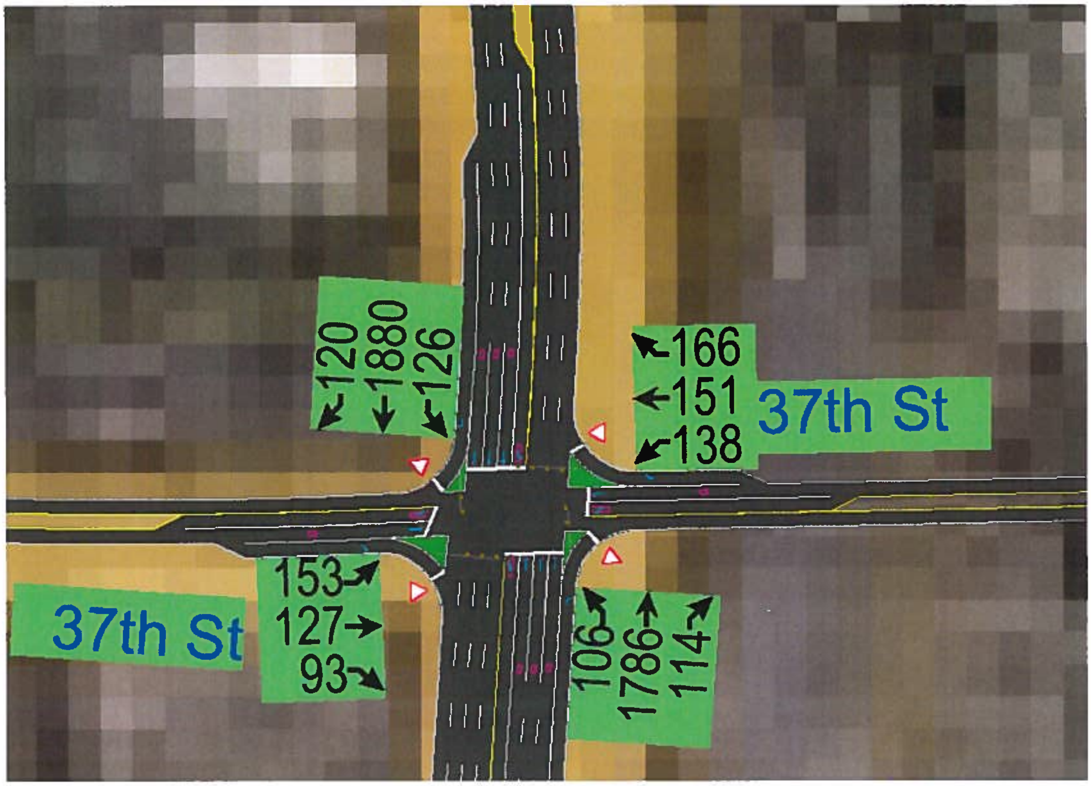
Delay



Case Study: McFarland Blvd. Tuscaloosa, AL

The two approaches analyzed were McFarland Blvd. 37th St. South Bound and McFarland Blvd. Skyland Blvd. North Bound. The camera was set up facing the oncoming approach traffic on the Skyland intersection and the camera was aligned with the flow of the traffic on the 37th St. approach. Data was collected between 4-7 p.m. for two consecutive days during September 2007. 12 control delay points were taken using the proposed method. Synchro and HCS+ also produced 12 data points using parameters extrapolated from the video. The intersections are pictured below with their volume counts and lane diagrams.




120
1880
126
166
151
138
37th St
153
127
93
37th St
106
1786
114


222
717
465
640
629
413
205
558
189
Skyland
157
557
312
and

Results

Synchro 7 calculates stopped delay by adding both the uniform delay and random delay together. Uniform and random delays are calculated based on the theoretical arrival rates, departure rates, cycle lengths, and effective green times. Synchro multiplies stopped delay by 1.3 to obtain control delay. The progression factor (PF) is calculated for an intersection based on the network surrounding it. The d3 term takes into account any pre-existing queue; however, in intersections studied this term was negligible. The d2 term accounts for randomness in the arrival rate, and the d1 term is standard uniform delay multiplied by the progression factor.

Synchro 7 Software

$$\text{Control Delay} = 1.3 \times (d1 \times PF + d2)$$

HCS+ Software follows the HCM manual methodologies for determining delay. The same basic equation is used in HCM as in Synchro's stopped delay. Lane group delay is initially uniform delay and is then adjusted to account for initial queues and progression. The Progression Factor must be hand calculated or assumed to be isolated with a standard value of 1. This is a major difference in the two different simulation packages. D2 is also subjective depending on using Synchro or HCS+ as they assume different values.

$$\text{Lane Group Delay} = d1 \times PF + d2 + d3$$

HCS+ Software follows the HCM manual methodologies for determining delay. The main difference in HCS+ and Webster Delay is some assumptions the respective software make. Such as Synchro computes a RTOR (right turn on red) volume per hour, progression factor (PF), and determines d2 slightly different.

Figure 1. Synchro / HCM % difference

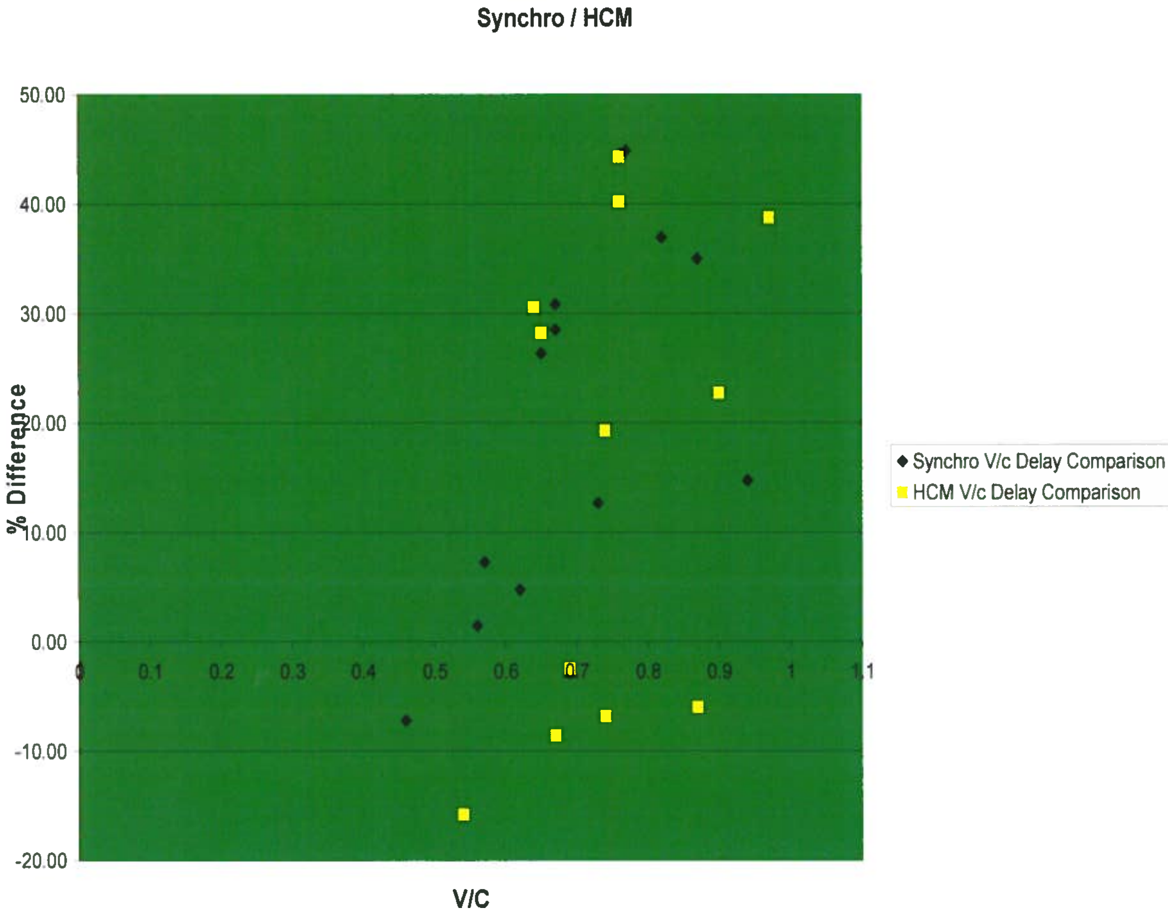


Figure 2. Synchro % difference

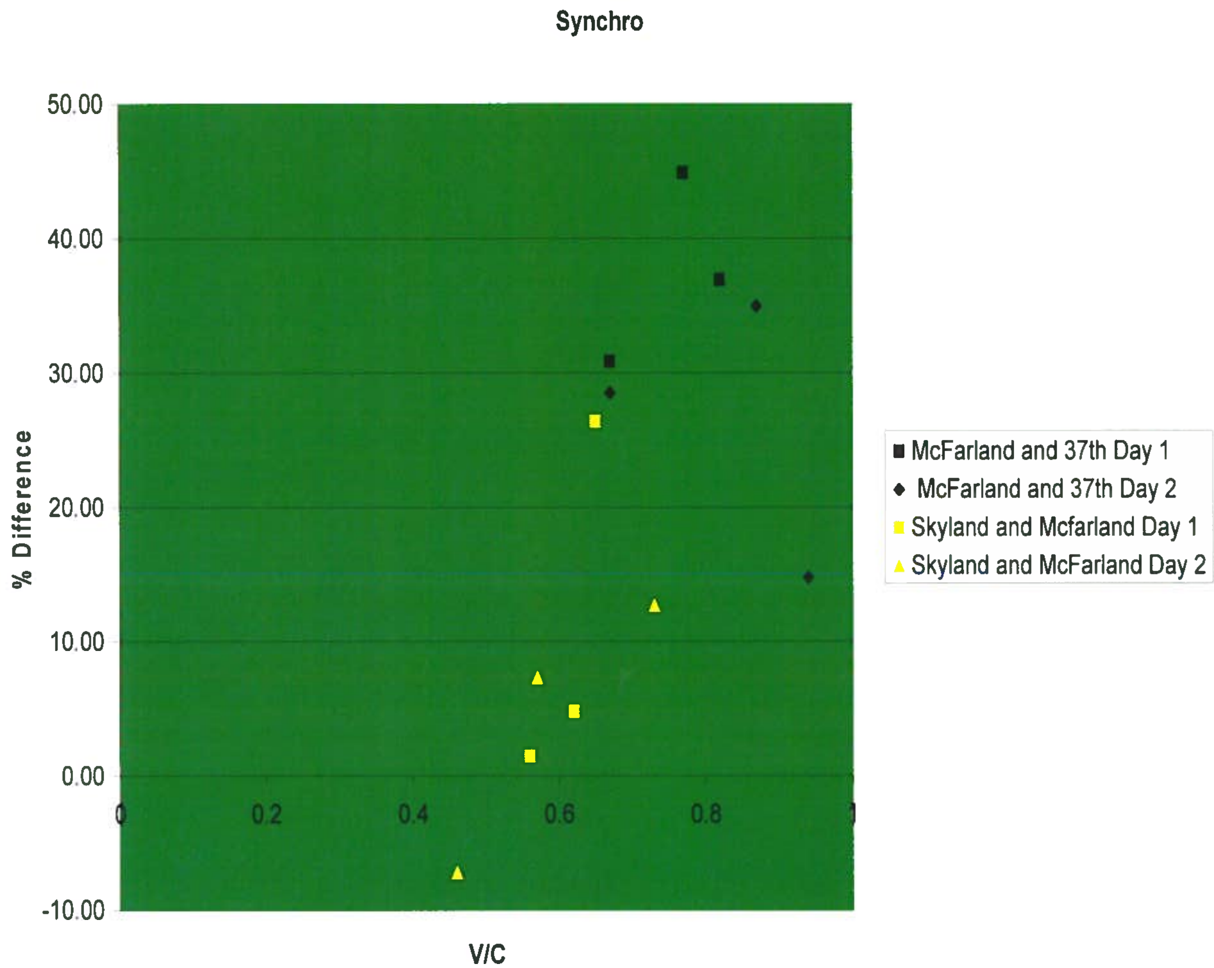


Figure 3. HCM % difference

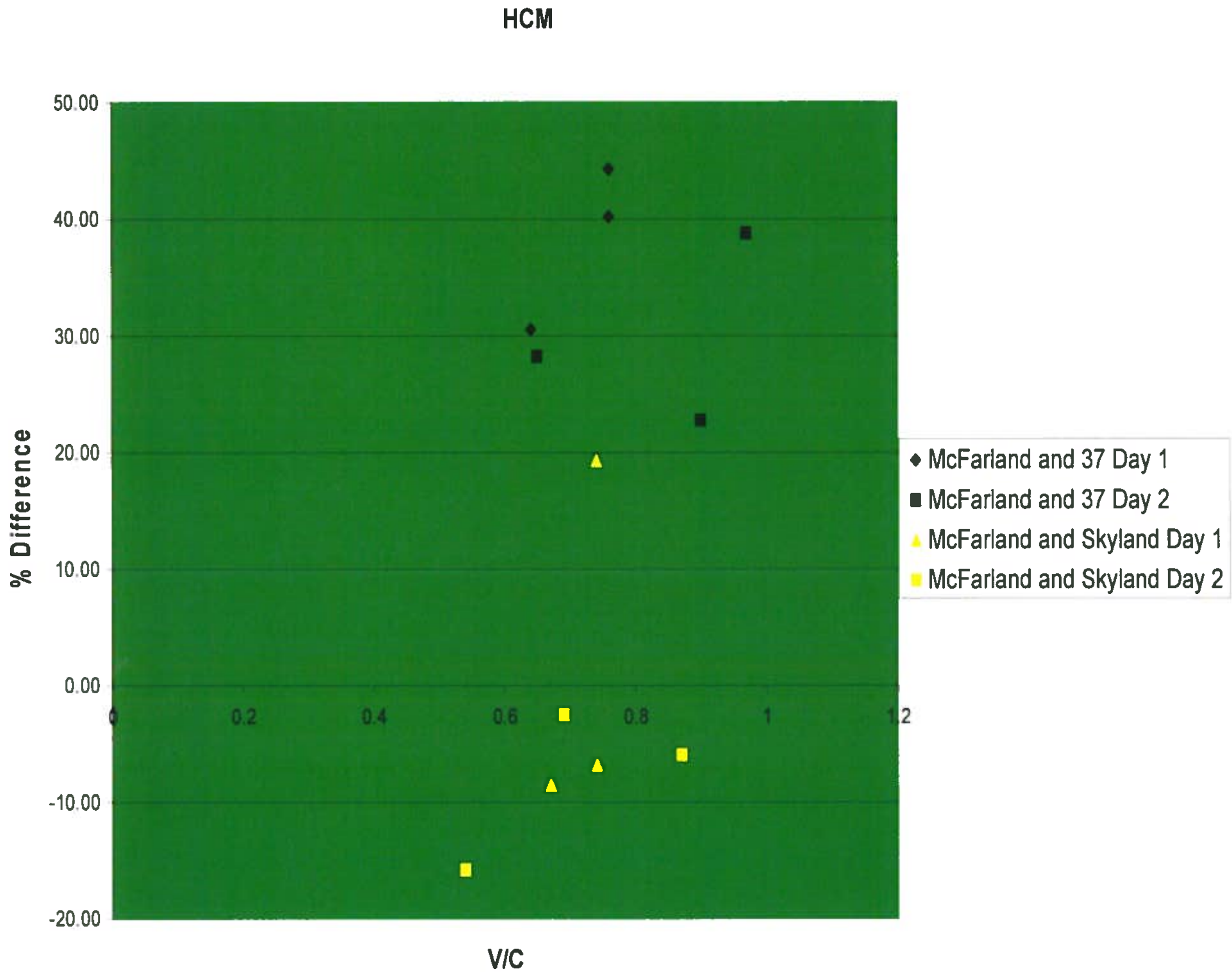


Table 1. LOS

McFarland and 37th St.

		Video Method Delay	LOS	Synchro Delay	LOS	HCS++ Delay	LOS	
Day 1	Hour 1	46	D	29	C	27.5	C	
	Hour 2	49	D	27	C	27.2	C	
	Hour 3	35	C	24.2	C	24.3	C	
Day 2	Hour 1	49	D	32	C	30	C	
	Hour 2	44	D	37.5	D	34	C	
	Hour 3	34	C	24.3	C	24.4	C	
								7 LOS Incorrect

McFarland and Skyland

		Video Method Delay	LOS	Synchro Delay	LOS	HCS++ Delay	LOS	
Day 1	Hour 1	58	E	46.8	D	42.7	D	
	Hour 2	44	D	47	D	41.9	D	
	Hour 3	41	D	44.5	D	40.4	D	
Day 2	Hour 1	44	D	40.8	D	45.1	D	
	Hour 2	52	D	45.4	D	55.1	D	
	Hour 3	36	D	38.6	D	41.7	D	
								2 LOS Incorrect

Conclusion and Future Studies

From Figures 1, it is obvious that a delay measurement from the software packages could be incorrect. 9 data points from Table 1 have enough percent error to change the LOS of an intersection. Of the 9 false data points, 7 data points are from the McFarland and 37^{th} St. intersection. From the incorrect data, 4 of the bad data points were from Synchro 7 and 5 were from HCS+. This could prove unbeneficial for decision making if no confidence can be taken in the delay measurement for an intersection. From Figures 2 and 3 it can be seen that the percent differences between the two intersections are very different. The percent errors for McFarland

and Skyland are much closer to 0%, and because of this, they also have much more Level of Service's that are correct.

Why were more data points incorrect for one of the intersections? From observations made from the video, the progression was poor on the South Bound approach, and neither of the software packages accounted for the poor efficiency of the intersection. Video showed about 10 seconds of wasted green time per cycle because of the upstream queue had not arrived yet. Synchro is supposed to be better at modeling networks of intersections due to being able to input the surrounding intersections in the software. McFarland and Skyland intersection also had no offset as it was the master intersection; this explains some of the error in the other intersections.

The labor cost involved in this project would make it unfeasible to practice the collection of actual delay data points. The benefits of not trusting the software packages can be seen in with the 9 incorrect LOS's that would have otherwise not been found without the video methodology. Sampling techniques should be determined to make an estimate of the delay for a lane group. This process would significantly increase data points allowing a better understanding of the methods and conclusions drawn from this study, and it would be beneficial to those concerned with the actual conditions of an intersection.

References

1. Dixon, M., Kebab, W., Abdel-Rahim, A. Field Measurement of Approach Delay at Signalized Intersections Using Point Data. *Transportation Research Board*, CD-Rom, National Research Council, Washington, D.C., 2007.

2. Mousa, R.M. (2002). "Analysis and Modeling of Measured Delays at Isolated Signalized Intersection," *Journal of Transportation Engineering* 128 (4): 347-354

3. Quiroga, C. A., and Bullock, D. (1999). "Measuring control delay at signalized intersections," *Journal of Transportation Engineering* 125(4): 271-280.

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Form 3 – Submit with completed thesis. All signatures must be obtained.

Name of candidate: Roy Berryman

Department: Civil Engineering

Degree: Bachelor of Science in Civil Engineering

Full title of project: A Comparison of Actual Delay to Simulated Delay

Approved by:

[signature] 4-22-08
Project Advisor Date

[signature] 4/22/08
Department Chair Date

[signature] 4-23-08
Honors Program Director for Honors Council Date

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