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**Estimating Queue Lengths Using SIGNAL94, SYNCHRO3, TRANSYT-7F,  
PASSER II-90, and CORSIM**

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## INTRODUCTION

The focus of this paper is to compare queue lengths estimated by models mostly used by traffic engineers to evaluate intersection performance. In this paper, one performance measure – queue length is examined in detail. Different terminology is available in the literature on queue length – examples include average queue length, maximum queue length, and maximum back of queue. Very often the procedure employed to make the queue length estimates and an account of how these estimates vary is not readily available. In addition, the terminology used for each varies considerably. This paper addresses the following:

1. provides a review of queue length definitions, and how they relate to each model
2. describes queue length estimation methodology for each
3. evaluates the estimates from CORSIM, PASSER II-90, SIGNAL94, SYNCHRO3, and TRANSYT-7F

Studies have been done to compare various measures of effectiveness (MOE) estimated by some of the programs evaluated here, but not all. One study conducted for Virginia Department of Transportation [1] evaluated stopped delay and queue length. The queue length data was collected from stopped delay studies that measured the number of vehicles stopped at any given time. The maximum queue length was not observed but was estimated. A more dated paper [2] mainly compares NETSIM, TRANSYT-7F, and SATURN and the focus is on link and approach delay and stops. Another compared SOAP and NETSIM's delay and fuel consumption for both pre-timed and actuated controlled intersection, where the comparison is strictly between the models without any field data study [3]. For some studies the focus was on comparing the timing plans developed by each model in terms of several measures such as number of stops and travel time [4].

The focus of this paper however is to compare the queue length estimates based on several models and field results. The models considered were CORSIM, version 4.01 [5]; PASSER II-90, version 2.0 [6]; SYNCHRO3, version 3.0 [7], SIGNAL94, version 1.22 [8]; TRANSYT-7F, version 7 [9]. This paper also documents the methods used to estimate queue length and provides clarification on the definitions used for the different models. Often, comparing the output of one model to another is difficult and sometimes inappropriate due to differences in assumptions and terminology. This paper also attempts to use consistent terminology and compare the estimates accordingly. The methods used to develop estimates are described in detail in the methodology section of this paper and the results of the analysis are presented in the evaluation section.

## METHODOLOGY

Queue estimation relies on modeling the building-up and dissipation of queues before a signalized intersection based on either a deterministic or stochastic microscopic or macroscopic representation of flow. Most models described here rely on steady-state queuing theory to estimate the uniform and random component of delay. This approach remains valid when the average demand is less than average capacity. The individual models vary depending on the assumptions of arrival and departure distributions. An additional drawback of the steady-state models is that the arrival distribution assumed is usually either uniform or Poisson, which represent isolated intersections and not the effects of an upstream signal.

Therefore, the models (PASSER II-90, SIGNAL94, SYNCHRO3, and TRANSYT-7F) presented in this paper make one or more of the following assumptions:

- i. the arrival distribution is uniform
- ii. the departure distribution is uniform and is the saturation flow rate or the arrival rate, depending on the presence of a queue

iii. there is no initial queue at the start of the green

Performance of models based on these assumptions can be expected to remain valid for lower flows. As flows increase, cycle failures are more likely to occur and therefore assumption (iii) is less likely to remain valid. In order to address the effects of upstream signals, some models include a platoon dispersion model or a progression factor, and to address (iii) others include a random and oversaturation queue term.

In this section, the details of each of the models reviewed will be presented to (a) discuss the underlying assumptions of each separately and (b) to allow better evaluation of the estimates developed by the models. First a review of the terminology is presented next using Figure 1. Queue length comparisons are made which correspond to the definitions below with the exception of the average queue (AQ) length for CORSIM.

<b>Maximum Queue Length (MQ)</b>	number of vehicles in queue at the beginning of green
<b>Average Queue Length (AQ)</b>	average length of queue based on estimate of queue every time interval or a time-based average
<b>Average Maximum Queue Length (AMQ)</b>	average of the maximum queue length every cycle
<b>Maximum Back of Queue (MBQ)</b>	number of vehicles (cumulative) in queue, including the vehicles that join the queue after beginning of green

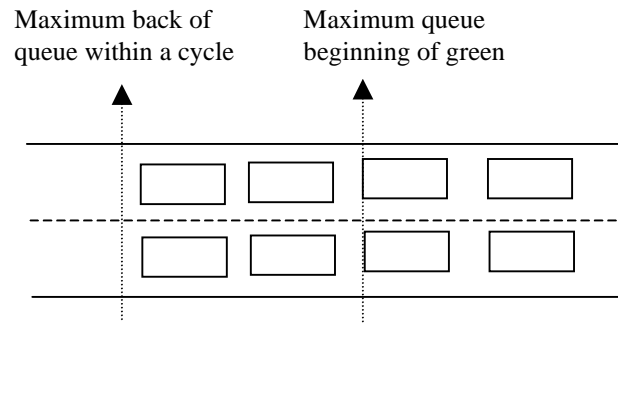


Figure 1: Illustration of queue description

The queuing diagram shown below (Figure 2) summarizes the queue length calculated by each of the programs referred to in these analyses. As shown in this figure, the maximum queue length, defined previously, is measured at the beginning of the effective green time and is the term used by PASSER II-90 and CORSIM. The maximum back of queue length measurement, also defined previously, accounts for vehicles that join the back of the queue after the green time starts and this is the terminology used for both SYNCHRO3 (50%)<sup>3</sup> and TRANSYT-7F. Figure 2 is for a cycle with average arrivals. SYNCHRO3 (95%)<sup>3</sup> and SIGNAL94 are compared to the maximum queue observed during the analysis period.

<sup>3</sup> SYNCHRO3 provides two queue estimates. The fifty percent estimate is for an average cycle and is comparable to the average maximum queue length (AMQ) defined above. A 95 percent queue length estimate is also calculated which is comparable to the maximum queue observed during the analysis period.

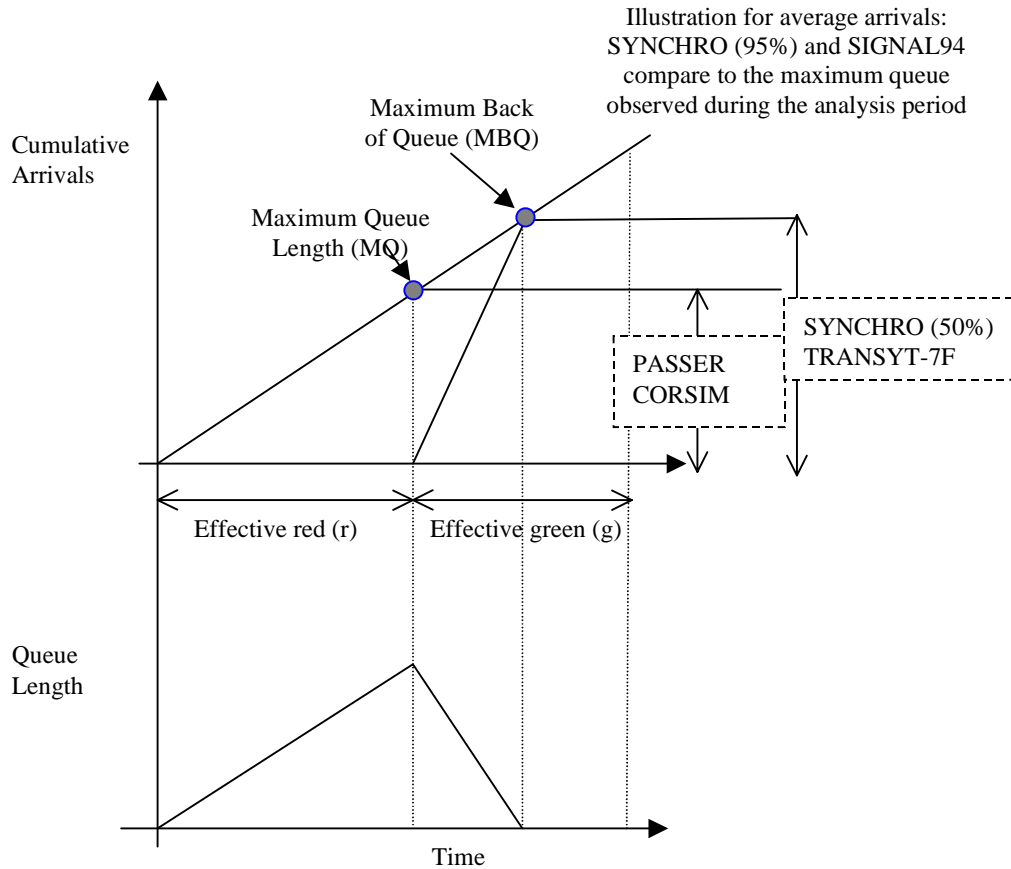


Figure 2: Queue length comparison

The following paragraph describes how the results of the analyses are expected to relate both to the field measurements and between the programs:

The field measured queue lengths are maximum queue lengths and they do not include vehicles that joined the back of the queue after the light turned green. These field measured queues should be fairly closely related to the CORSIM values as well as the PASSER II-90 and SIGNAL94 values. The estimated queue lengths from SYNCHRO3 and TRANSYT-7F may be greater than or equal to the field measured queue lengths, the PASSER II-90 estimates, the SIGNAL94 estimates, and the CORSIM estimates because they account for vehicles joining the back of the queue after the signal indication has turned green.

### SYNCHRO3

SYNCHRO3 is a windows-based traffic signal timing program with modeling and optimization capabilities. The key features of the program include capacity analysis, coordination, actuated signal modeling, and time-space diagrams. [7] SYNCHRO3 calculates average (50th) and 95th percentile queue lengths and indicates queue spillback. The 50th percentile queue length (SYNCHRO(50%)) is the maximum back of queue length for a cycle with average arrivals. The 95th percentile queue length (SYNCHRO(95%)) is adjusted using a Poisson distribution. The departure pattern from upstream intersections is taken from the 90th percentile scenario. The queue length calculated is proportional to the red time. The maximum back of queue length is calculated as follows:

$$Q = \frac{A}{\left[ \left( 1 - \frac{A}{D} \right) 3600 \right]} R \quad 1$$

where:  $A$  = Arrival Rate  
 $D$  = Departure Rate or Saturated Flow (vph)  
 $R$  = Red Time

For saturated conditions, unserved vehicles are accounted for from the previous cycle, plus all arrivals on the current cycle. The following formula is used in the queue length calculation when  $v/c > 1$ :

$$Q = \left[ \left( A_{95} - D \left( \frac{G}{C} \right) \right) \left( \frac{C}{3600} \right) + A_{95} \left( \frac{C}{3600} \right) \right] \left[ \frac{L}{n} \right] \quad 2$$

where:  $A_{95}$  is the 95th percentile volume based on Poisson arrival distribution  
 $L$  = average vehicle length  
 $N$  = number of lanes

For each lane group, SYNCHRO3 provides: 50 % and 95% queue lengths (maximum back of queue length), link length, percentage of the link used, whether or not the queue blocks upstream, storage length, percentage of the storage used, whether or not the storage is filled, percentage of the turning storage, and whether or not the turning storage is blocked.

## CORSIM

CORSIM is part of the TSIS Version 4 and contains both the NETSIM and FRESIM programs. [5] NETSIM is a microscopic network simulation model while FRESIM is a microscopic freeway simulation model. Every vehicle in CORSIM is modeled as a distinct object, identified by category, which is moved every second and every variable control device (traffic signals) and events are updated every second. Stochastic elements of the model include driver behavior characteristics, vehicle characteristics, traffic characteristics such as turn movements, free flow speed, queue discharge headways and other attributes. Relationships of the vehicles on the streets or links are recalculated every second. Vehicles are moved according to car following logic, in response to traffic control devices and demand. Intralink lane-changing is also modeled. Shared lane logic has recently been enhanced such that all lanes can accommodate more than one turn movement.

CORSIM provides average and maximum queue lengths by lane for the analysis period as well as intermediate periods. The average queue estimated by CORSIM is determined by incrementing a counter for each queued vehicle in each lane for every time step. This is then divided by the total number of seconds in the reporting interval. This average queue length is related to the number of seconds that the queues exist. The maximum queue estimated by CORSIM is the greatest number of vehicles that are queued at any time during the reporting interval for an individual link. A vehicle in CORSIM is considered to be in the queue when its speed drops below 3 ft/sec.

## PASSER II-90

PASSER II-90 is a macroscopic, deterministic traffic analysis and signal timing optimization model. [6] PASSER II-90 optimizes and analyzes isolated intersections or coordinated arterials. PASSER II-90 does not explicitly model platoons of vehicles. However, the effect of platoon dispersion is modeled by “stretching” the queue to estimate the portion of traffic that arrives outside of the downstream green. Traffic

performance measures are estimated using discrete, deterministic models. It estimates the effect of signal timing on the measures of effectiveness. Traffic movements are handled differently in PASSER II-90 than any other model. It only deals with eight movements (left and through) and does not evaluate right turns directly.

The critical measure of effectiveness output by PASSER II-90 of interest here is the maximum queue length, which is expressed as vehicles per lane. Within the PASSER II-90 program the queue length is estimated from a queue profile. PASSER II-90 first calculates the total control delay by integrating the demand curve over the representative cycle. This is referred to as the "First Term". Next, overflow delay is estimated using Highway Capacity Manual's [10] "Second Term". These two terms are summed to provide an estimate of total delay. PASSER II-90 also monitors the maximum queue length estimated during the representative cycle. This maximum queue value is referred to as  $Q_1$ . An average overflow queue is estimated from the "Second Term" delay. This overflow queue is referred to as  $Q_2$  and is equal to  $D_2 * \text{Flow}$ . The total queue on the phase is then  $Q_1 + Q_2$  and is referred to as  $Q_T$ . The total queue is then converted to a per lane basis.

The PASSER II-90 program models traffic for a single cycle. Therefore, the queue lengths estimated represents the queue during an individual cycle and queues do not build over time.

### **TRANSYT-7F**

TRANSYT-7F is a macroscopic, deterministic optimization and simulation model that was originally developed in the United Kingdom by the Transport and Road Research Laboratory (TRRL). TRANSYT-7F is a macroscopic model that considers platoons of vehicles instead of individual vehicles. TRANSYT-7F simulates traffic flow in small time increments, so its representation of traffic is more detailed than other macroscopic models that assume uniform distributions within the traffic platoons [6]. A platoon dispersion algorithm that simulates the spreading out of platoons as they travel downstream is also utilized by the model. TRANSYT-7F simulates traffic for a single cycle and therefore any measures of effectiveness should be considered as an average for the analysis period. For the analyses, cycle length, phasing data, approach volumes and turning movements, link lengths, saturation flow rates and approach speed are required inputs.

TRANSYT-7F calculates the maximum back of queue. This calculation includes any vehicles which join the back of the queue after the signal indication has turned green and the front of the queue is moving. The queue lengths calculated are the queues that occur due to the given flow rates and they do not build over time [6]. Therefore, it is assumed that the queues have cleared at the end of each cycle and there are no residual vehicles. TRANSYT-7F also reports a queue capacity value for each link based upon a user input value such as a left turn storage length or it is calculated by TRANSYT-7F based upon the link length. This value can then be compared to the estimated queue lengths to determine where spillover may occur. It should be noted that the recently released TRANSYT-7F, version 8 now models the spillback effects of queue.

### **SIGNAL94**

SIGNAL94 is a program for performing capacity analysis, signal timing optimization and design of intersection geometry and control. [8].

The SIGNAL94 methodology is based upon the capacity analysis procedures documented in the 1994 update to the 1985 Highway Capacity Manual. SIGNAL94 calculates the maximum queue length based upon queuing theory, also referred to as the "red time formula". The formula is as follows:

$$Q_n = 2.0qR$$

3

where:

- $Q_n$  = number of vehicles in queue
- 2.0 = approximately 90th percentile randomness factor (Poisson distribution)
- $q$  = arrival rate (vehicles per second) =  $v/3600$
- $R$  = time that is not green

When the intersection operations are over-saturated with a  $v/c$  ratio greater than 1, an adjustment to the queue length estimation is made in order to account for the over-saturated conditions. The following formula is used for  $Q_n$  to account for the number of over-saturated arrivals in one hour:

$$Q_n = \frac{[2qR + 0.25v(X - 1)]}{X}$$

4

where:

- $Q_n$  = number of vehicles in queue
- 2.0 = 90th percentile randomness factor - Poisson distribution (approximately)
- $v$  = adjusted volume (vph)
- 0.25 = proportion of hour in analysis period
- $X$  =  $v/c$  ratio

The following table (Table 1) summarizes the model assumptions and queue estimate terminology.

Table 1: Models Reviewed

<i>Model</i>	<i>Method/Assumption</i>	<i>Estimate Provided</i>
CORSIM (version 4.01)	Microscopic, stochastic simulation, models queue left over from previous cycle	Average and maximum queue
PASSER II-90 (version 2.0)	No initial queue (default)	Maximum queue
SIGNAL94 (version 1.22)	Uniform arrivals on red No initial queue, Adjustment factor of 2 is used to provide a 90 <sup>th</sup> percentile randomness factor	Maximum queue
SYNCHRO3 (version 3.0)	No initial queue for $v/c < 1$ For $v/c < 1$ considers queues for one previous cycle	Maximum back of queue 50% and 95% queue length estimates
TRANSYT-7F (version 7.0)	Macroscopic simulation, models platoon progression No initial queue No adjustments	Maximum back of queue

## FIELD DATA

Field data was collected at three locations in the Denver metropolitan area. One isolated intersection was selected, while the second and third sites selected each consisted of closely spaced intersections.

At each location, the data collection technique selected was videotape. At the second and third sites, which consisted of the successive intersections, the video cameras were synchronized so that the same vehicles were observed as they passed through each intersection.

A summary of the intersection geometry is provided the table below.

Table 2: Intersection geometry

<b>Intersection</b>	<b>Site</b>	<b>Northbound</b>	<b>Eastbound</b>	<b>Southbound</b>	<b>Westbound</b>
<b>Intersection 1:</b> Speer Blvd. Colfax Ave.	1	n/a	n/a	4T	3T
<b>Intersection 2</b> Blake St. and 17th Street	2	n/a	n/a	1T, 1T/R	1T/L, 1T, 1T/R
<b>Intersection 3</b> Blake St. and 18th St.	2	1L, 1T/L, 2T	n/a	n/a	2T, 1T/R
<b>Intersection 4</b> Blake St. and 19th St.	2	n/a	n/a	1T, 1T/R	1T/L, 1T/R
<b>Intersection 5:</b> County Line Rd. and Parkway Dr.	3	1L, 1T, 1R	1L, 2T, 1R	1L, 1T/R	1L, 2T, 1R
<b>Intersection 6</b> County Line Rd. and Quebec St.	3	2L, 2T, 1R	1L, 2T, 1R	2L, 2T, 1T/R	2L, 2T, 1R
L - Left Turn Lane    R - Right Turn Lane    T - Through Lane    T/R - Shared Through/Right Lane					

One direction at each site was selected for collecting data and the video cameras were set up to focus on these critical approaches in the field. For each cycle, at each intersection, queue lengths and total intersection traffic volumes were collected. The field queue lengths are maximum queue (MQ) lengths, as defined earlier. The field measured queue lengths for every cycle were then averaged to obtain the observed average maximum queue length for each intersection. Additionally, the maximum queue observed during the analysis period was recorded for comparison to SIGNAL94 and SYNCHRO3(95%). At all the intersections, vehicles joined the back of the queue after the signal indication turned green for less than 5 percent of the cycles and therefore, no MBQ observations were recorded.

The total intersection traffic volumes were grouped into 15-minute time periods. At the first site, five 15-minute time periods (60 cycles) of data were collected. At the second site and third sites, three 15-minute time periods (36 cycles) and seven 15-minute time periods (63 cycles) of data were collected, respectively. These 15-minute time periods were compared to determine if the flow rates through these time periods were similar by evaluating the coefficient of variation (ratio of the standard deviation to the mean). At the first location, the coefficient of variation is 6 percent for the total intersection volume. The total intersection volume coefficient of variation for the second location ranged from five to twelve percent for

the three intersections. Finally, at the third location, the coefficients of variation were four and six percent for the two intersections. The small variations seen in these results indicate that the flow rates are consistent. Therefore, the same entry flows were specified for CORSIM for all time periods. Passage detectors were specified to compare the flow rates obtained from the field to the flow rates simulated by CORSIM. At the first site, Speer Boulevard and Colfax Avenue, the simulated flow rates over the detectors are 1.5 percent less than the field measured. At the second site, the Blake Street system of three, the simulated flow rates are 2 percent larger than the field measurements, while they are within one-half of a percent at the third site.

In addition to the total intersection volumes and the maximum queue length data, the saturation flow rates for the critical approaches were measured. The Highway Capacity Manual [10] method for measuring saturation flow rates was used. The following table summarizes the saturation flow rates applied in the analysis.

Table 3: Field Measured Saturation Flow Rates

Intersection	Saturation Flow Rate
County Line Road at Quebec Street	2120
County Line Road at Parkway Drive	1900 <sup>2</sup>
1. Not enough data available for entire Blake Street segment 2. Consistent with ideal values in SYNCHRO3, SIGNAL94 and Chapter 9 of the Highway Capacity Manual [10]	

## EVALUATION

The following table summarizes the v/c ratios for all intersections.

Table 4: Intersection Level of Service

Intersection	Intersection v/c Ratio
County Line and Quebec Street	>1
Speer Boulevard and Colfax Ave	.70
County Line and Parkway Drive	.526
Blake Street and 17th Street	.494
Blake Street and 18th Street	.374
Blake Street and 19th Street	.349

The v/c ratios were categorized for the analysis as shown in Table 5.

Table 5: v/c Ratio Categories

Category	v/c Ratio Range
Low	0.1 - 0.39
Medium	0.40 - 0.69
High	0.70 - >1

As noted previously, SYNCHRO3 and TRANSYT-7F provide maximum back of queue (MBQ) estimates, and PASSER II-90 and CORSIM provide maximum queue (MQ) estimates. Although observed queue lengths cannot be directly compared to SYNCHRO3 and TRANSYT-7F, they can be used to

determine whether SYNCHRO3 and TRANSYT-7F may provide higher estimates as illustrated in Figure 2.

Table 6 compares the queue lengths estimated by the various programs with the field measured queue lengths in terms of number of vehicles. For the intersection of County Line Road and Quebec Street, the through lane and left turn lane evaluations are separated. Each of these lane groups has a v/c ratio greater than 1.0. The first three rows of this table illustrate the results of the high v/c conditions. The next two rows are a summary of the medium v/c conditions while the final two rows summarize the low v/c conditions. The same comparisons are made in Table 7 in terms of the percentage difference from the field measurements. In addition, this table indicates the number of vehicles by which the program estimates vary from the field measurements.

As shown in Table 6 and described previously, the SIGNAL94 and SYNCHRO3 (95%) results are compared to the maximum queue observed during the analysis period, while the remaining estimates are compared to the observed average maximum queue length.

### **High v/c Conditions**

For the high v/c conditions, CORSIM and TRANSYT-7F both produce reasonable results that are within two vehicles of the field measurements. The variation for all is less than or equal to 8 percent. On the other hand, PASSER II-90 consistently produces low estimates ranging from 13 percent less to 29 percent less. Not as definitive are the SYNCHRO3(50%) results which are accurate for the County Line Road intersections but which overestimates the results by 4 vehicles (13 percent) at the Speer and Colfax intersection. The results of the SIGNAL94 and SYNCHRO3(95%) are reasonable, differing from field measurements by one to three vehicles.

### **Medium v/c Conditions**

For the medium v/c conditions, CORSIM produces the most reasonable results which are within one to two vehicles of the field measurements. For the PASSER II-90 results, the County Line/Parkway Drive results are 3 vehicles less than the field measurements, while the Blake/17th Street intersection results are 6 vehicles greater. For PASSER II-90, SYNCHRO3(50%), TRANSYT-7F, and SYNCHRO3(95%) at least one of the intersections is overestimated by four or more vehicles. SIGNAL94 underestimate one of the intersections by 5 vehicles but produces a reasonable estimate for the other.

### **Low v/c Conditions**

When low v/c conditions are analyzed, the results are reasonable for one intersection for all programs, but only 50 percent of the time for the other intersection. PASSER II-90, SYNCHRO3(50%) and SYNCHRO3(95%) produced the most reasonable results for both intersections. All other programs over or underestimated one of the intersections by four or more vehicles.

### **Maximum Back of Queue vs. Maximum Queue**

As noted earlier, TRANSYT-7F and SYNCHRO3 both estimate maximum back of queue. The following table (Table 8) shows for the intersection of County Line Road and Quebec Street, as an example, that the maximum back of queue estimates for the majority of the lanes were not greater than the observed maximum queue lengths.

Figure 3 illustrates queue length estimates by all programs and the field data. As explained previously, it was expected that the MBQ estimates (SYNCHRO3 (50%) and TRANSYT-7F) would be greater than or equal to the observed and estimated average maximum queue (PASSER II-90, CORSIM) and this occurred for 66 percent of the cases. It was also expected that the MBQ estimates from SYNCHRO3(95%) would be greater than or equal to the maximum queue observed during the analysis period and the SIGNAL94 estimates and this occurred for 57 percent of the cases.

Table 6: Summary of Queue Length Estimation Results (In Vehicles)

INTERSECTION	Westbound approach v/c	ANALYSIS PACKAGE					
		COMPARED TO OBSERVED AVERAGE MAXIMUM QUEUE LENGTH				COMPARED TO MAXIMUM QUEUE LENGTH SEEN DURING OBSERVATION PERIOD	
		PASSER II-90	CORSIM	SYNCHRO3 (50%)	TRANSYT-7F	SIGNAL94	SYNCHRO3 (95%)
SPEER/COLFAX	0.74	⬇	●	⬆	●	●	●
COUNTY LINE ROAD/QUEBEC STREET (THRU LANES)	>1	⬇	●	●	●	◐	◐
COUNTY LINE ROAD/QUEBEC STREET (LEFT LANES)	>1	⬇	●	●	●	●	◐
COUNTY LINE ROAD/PARKWAY DRIVE	0.526	◐	●	⬆	⬆	⬇	●
BLAKE STREET/17TH STREET	0.494	⬆	●	⬆	●	◐	⬆
BLAKE STREET/19TH STREET	0.349	●	◐	◐	●	●	◐
BLAKE STREET/18TH STREET	0.374	◐	⬆	◐	⬇	⬇	◐

- Accurate Estimation (within two vehicles)
- ◐ Slight Overestimation (within three vehicles)
- ◑ Slight Underestimation (within three vehicles)
- ⬆ Overestimation by four or more vehicles
- ⬇ Underestimation by four or more vehicles

Table 7: Summary of Queue Length Estimates (in Percentage)

INTERSECTION	EXISTING LOS / (v/c)	ANALYSIS PACKAGE <sup>1</sup>					
		COMPARED TO OBSERVED AVERAGE MAXIMUM QUEUE LENGTH				COMPARED TO OBSERVED MQ	
		FLOW LEVEL	PASSER II-90	CORSIM	SYNCHRO3 (50%)	TRANSYT-7F	SIGNAL94
SPEER/COLFAX	B/.74	13% LESS	3% GREATER	13% GREATER	EQUAL	7% LESS	13% LESS
	HIGH	(4 VEH)	(1 VEH)	(4 VEH)	(0 VEH)	(1 VEH)	(2 VEH)
COUNTY LINE ROAD/QUEBEC STREET (THRU LANES)	F/ >1	16% LESS	EQUAL	4% LESS	8% LESS	7% LESS	7% LESS
	HIGH	(4 VEH)	(0 VEH)	(1 VEH)	(2 VEH)	(3 VEH)	(3 VEH)
COUNTY LINE ROAD/QUEBEC STREET (LEFT LANES)	F/ >1	29% LESS	6% GREATER	6% GREATER	6% LESS	4% LESS	11% LESS
	HIGH	(5 VEH)	(1 VEH)	(1 VEH)	(1 VEH)	(1 VEH)	(3 VEH)
COUNTY LINE ROAD/PARKWAY DRIVE	B/.526	20% LESS	7% GREATER	33% GREATER	27% GREATER	17% LESS	3% GREATER
	MEDIUM	(3 VEH)	(1 VEH)	(5 VEH)	(4 VEH)	(5 VEH)	(1 VEH)
BLAKE STREET/17TH STREET	B/.494	40% GREATER	13% GREATER	80% GREATER	7% GREATER	10% GREATER	20% GREATER
	MEDIUM	(6 VEH)	(2 VEH)	(12 VEH)	(1 VEH)	(3 VEH)	(6 VEH)
BLAKE STREET/19TH STREET	B/.349	28% GREATER	43% GREATER	43% GREATER	28% GREATER	14% GREATER	14% GREATER
	LOW	(2 VEH)	(3 VEH)	(3 VEH)	(2 VEH)	(2 VEH)	(2 VEH)
BLAKE STREET/18TH STREET	B/.374	33% GREATER	67% GREATER	33% GREATER	67% LESS	28% LESS	14% LESS
	LOW	(3 VEH)	(6 VEH)	(3 VEH)	(6 VEH)	(6 VEH)	(3 VEH)

**KEY**

Percentage by which estimates differ from observed (ie, P290 results are 20% less than field measurements)

16% LESS
(4 VEH)

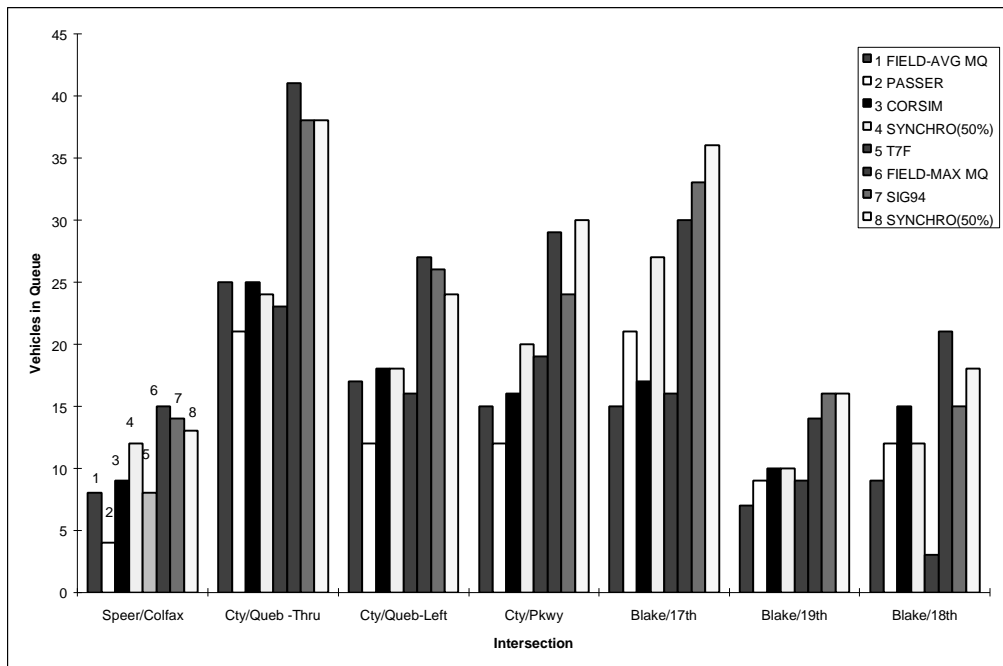
Number of vehicles which result in percentage difference

Table 8: County Line and Quebec Queue Length Comparison

	ANALYSIS PACKAGE QUEUE LENGTH ESTIMATE	QUEUE LENGTHS (number of vehicles) <sup>1</sup>				
		Left Turn Lane (interior)	Left Turn Lane (exterior)	Left Through Lane	Right Through Lane	Right Turn Lane
Observed Average Maximum Queue Length		5	12	13	12	0
PASSERII-90	MQ	6	6	11	10	n/a
CORSIM <sup>2</sup>	MQ	9	9	12	13	2
Synchro3 (50%)	MBQ	9	9	12	12	1
TRANSYT-7F	MBQ	8	8	12	11	1
Maximum Queue Length observed during analysis period		10	17	21	20	0
SIGNAL94	MQ	13	13	19	19	3
Synchro3 (Webster's Delay - 95%)	MBQ	12	12	19	19	2

1. Assumes average 25' vehicle length
2. 10 simulation runs completed

Figure 3: Queue Length Comparison for All Intersections



## CONCLUSIONS

The programs all have different methodologies for estimating queue lengths. This analysis attempts to explain the methodologies behind each of the programs and compares the program estimates to field data.

The results of the PASSER II-90, SYNCHRO3(50%), CORSIM, and TRANSYT-7F are compared to the observed average maximum queues. The results of the SIGNAL94 and SYNCHRO3(95%) are compared to the maximum queue length observed during the analysis period.

As illustrated in the queuing diagram, it was expected that the programs estimating the maximum back of queue would produce a queue estimate greater than or equal to the field measurements and the estimates of the maximum queue. This occurred in 66 percent of the cases for PASSER II-90, CORSIM, SYNCHRO3(50%), TRANSYT-7F, and the observed average maximum queue lengths. When these comparisons are made between the maximum queue length observed during the analysis period, SIGNAL94 and SYNCHRO3(95%), the maximum back of queue estimates were greater than or equal to the estimated and observed maximum queue lengths for 57 percent of the cases.

As shown in Tables 6 and 7, for the low v/c conditions, the program estimates varied from the field measurements by a minimum of 2 vehicles to a maximum of 6 vehicles (average four). Many of the programs overestimate the observed queue lengths under low v/c conditions, given random arrivals. For medium v/c conditions CORSIM produces fairly reasonable results (within one to two vehicles) when compared to the field data. The remaining software packages tend to over or underestimate queue lengths for at least one of the intersections operating at medium v/c conditions. The best results are for the high flow conditions, especially when compared to CORSIM and TRANSYT-7F. For the intersection with a v/c ratio exceeding 1, all estimates with the exception of PASSER II-90 produce reasonable estimates.

The results of the analyses indicate that the anticipated relationship between the maximum queue estimates and maximum back of queue estimates did not occur as often as expected. For sixty percent of the cases, the maximum back of queue estimates were greater than or equal to the maximum queue estimates from the programs or the observed average maximum queue lengths.

The results reported in this paper are based on data from six intersections.

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