Evaluation of Signalized Intersections Using Transit Vehicle's AVL/APC Data

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Introduction

Intersection performance evaluation is very important for transportation authorities, in particular, when prioritizing the allocation of resources for intersection improvements. The performance of signalized intersections is commonly quantified in terms of the average delay and the maximum queue length.

Intersection delay and queue length are generally estimated using software tools, which require empirical data such as traffic counts, signal timings, pedestrian volumes, traffic stream composition, and saturation flow rates. The required data are often unavailable or outdated, which significantly affect the accuracy of intersection performance analysis.

The objective of this research is to propose a methodology to use archived transit Automatic Vehicle Location (AVL)/Automatic Passenger Count (APC) data for estimating the delay and queue length at signalized intersection approaches containing a near-side transit station. The proposed methodology eliminates the need for empirical data for intersection performance evaluation.

AVL/APC Data

AVL/APC systems use GPS sensors and passenger counting sensors to:

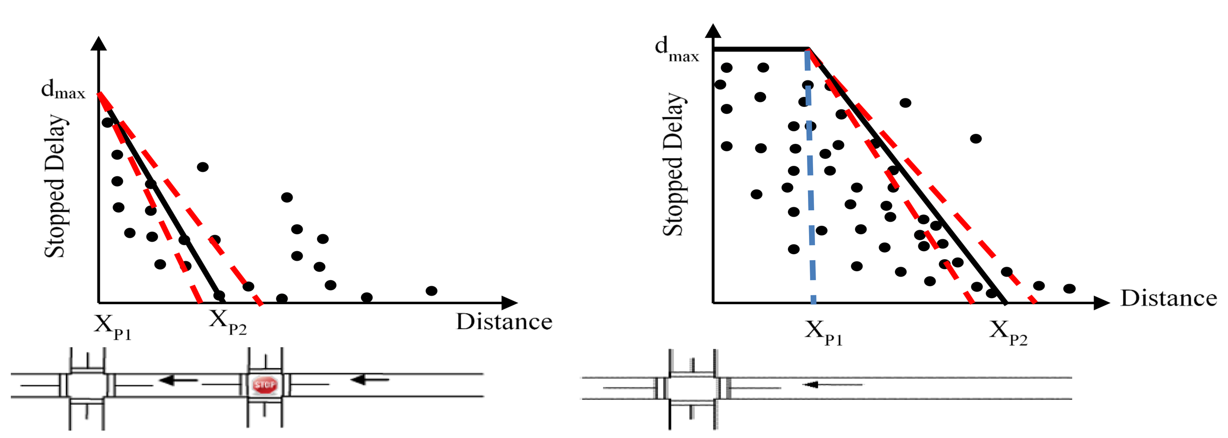
- Track the position of the transit vehicle
- Create an archived database containing records associated with ***events*** of interest

Common ***event*** types:

- **Scheduled Stops**: transit vehicle makes a scheduled stop at a transit station and may board and/or discharge passengers
- **Unscheduled Stops**: transit vehicle stops at a location that is not a transit station
- **Drive through**: transit vehicle passes by a transit station without stopping

Intersections with Far-sided Transit Stations

Yang and Hellinga proposed a methodology to use AVL/APC data to estimate the performance of signalized intersections with far-sided transit stations.



(a) Under-saturated conditions (b) Over-saturated conditions

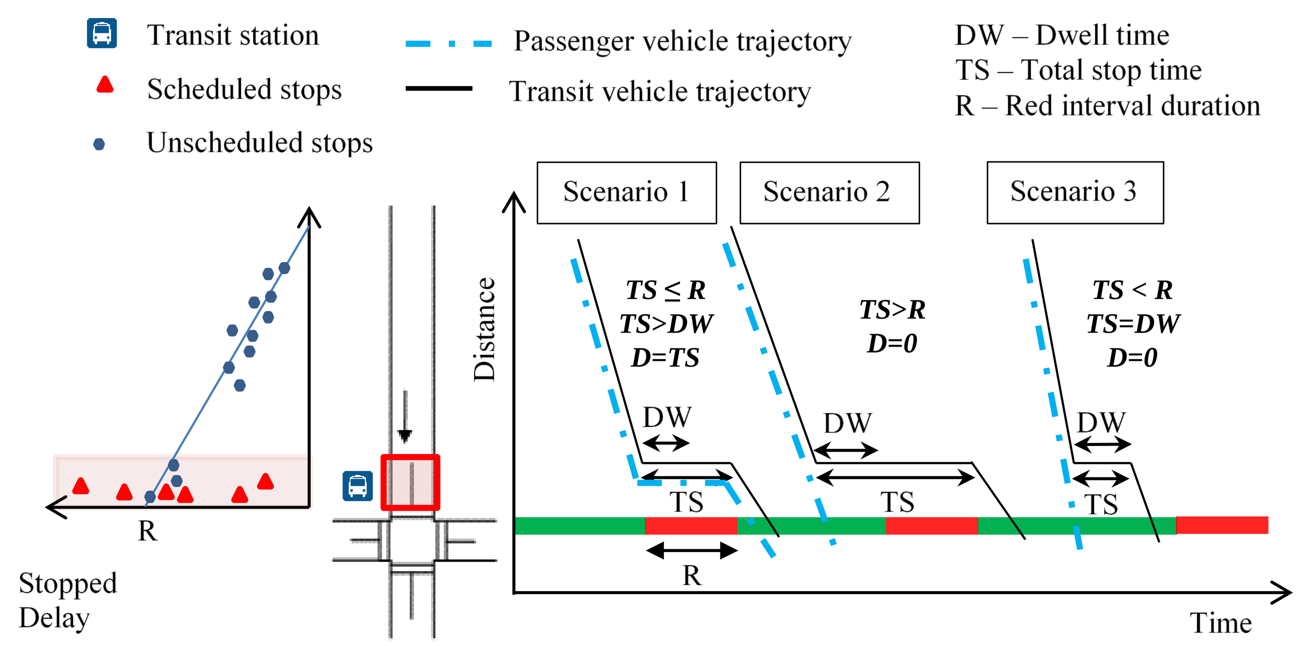
Using unscheduled stop ***event*** types:

- Stopped delay is plotted versus distance for each route segment (for all observations)
- A boundary line is fitted to the unscheduled stop observations that separates the stop events due to signalized intersection from other causes of unscheduled stop such as parking maneuver or other geometric characteristics.

Intersections with Near-sided Transit Stations

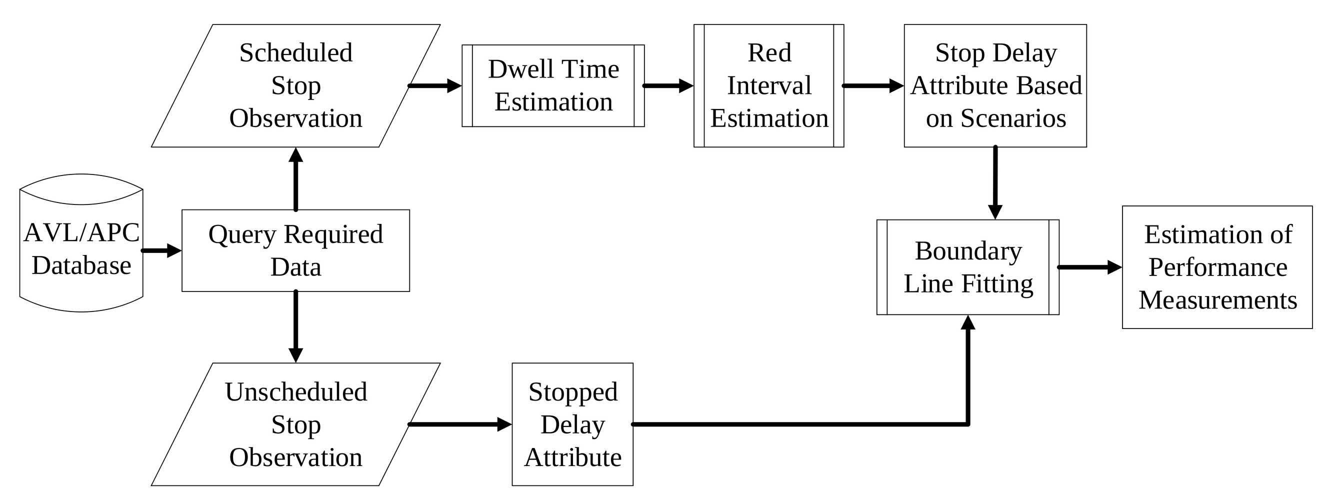
A transit vehicle stopping at station to serve passengers generates a *Scheduled Stop* record in the archived AVL/APC data.

The objective is to utilize transit vehicles as probe vehicles to estimate the stopped delay experienced by other vehicles at signalized intersections



AVL/APC data only provides the total stop time (*TS*). The dwell time (*DW*) and the red interval (*R*) should be estimated indirectly from the data.

Methodology



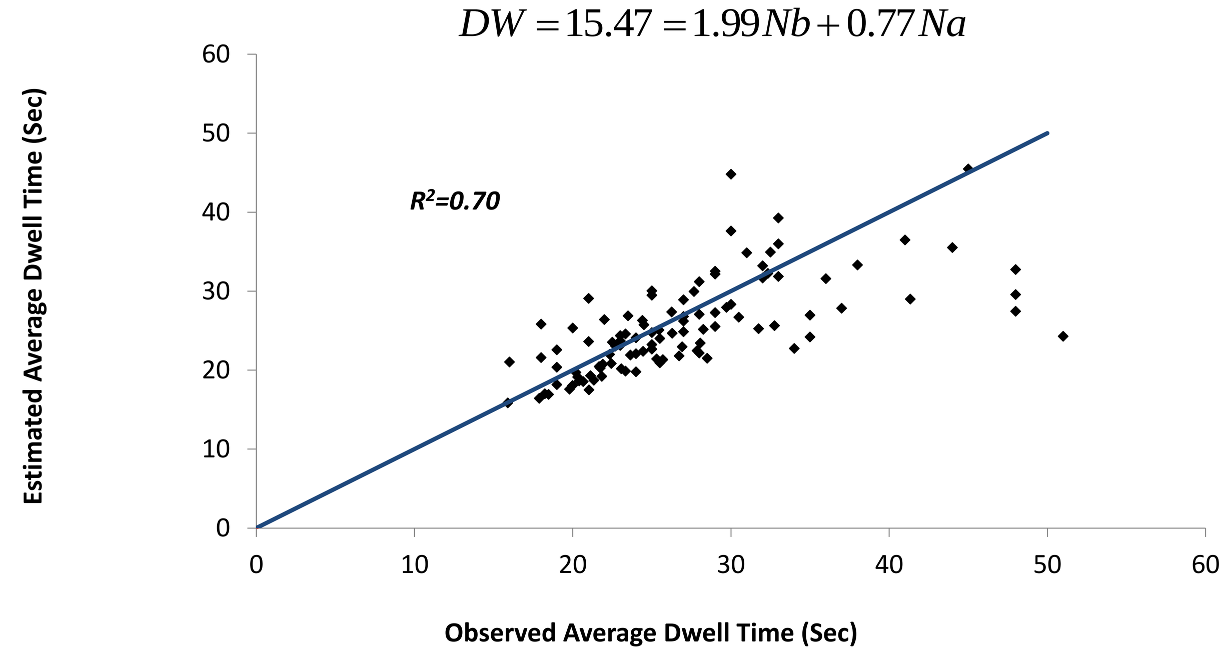
Dwell Time Model

- There is significant variability in observed average dwell time as function of the number of passenger boarding (*Nb*) and alighting (*Na*)
- A two-staged dwell time estimation model is proposed

First stage:

- Calibrate a weighted linear regression model to estimate average dwell time as function of passenger boarding and alighting activity

$$\overline{DW} = 15.47 = 1.99Nb + 0.77Na$$



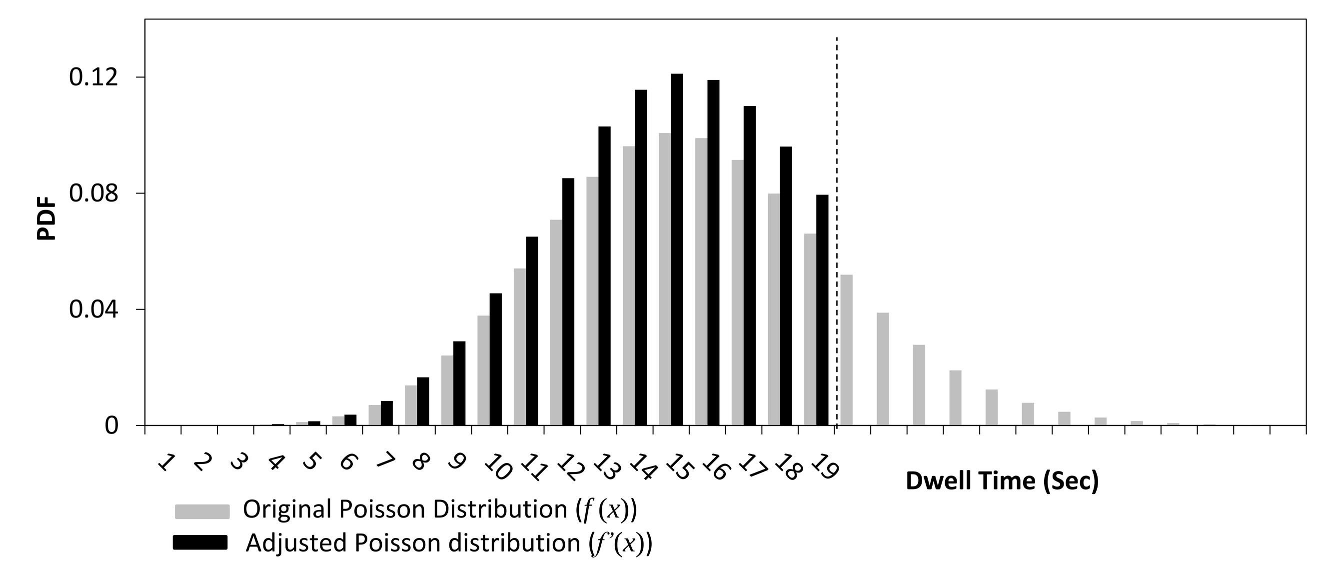
Dwell Time Model (continued)

Second Stage:

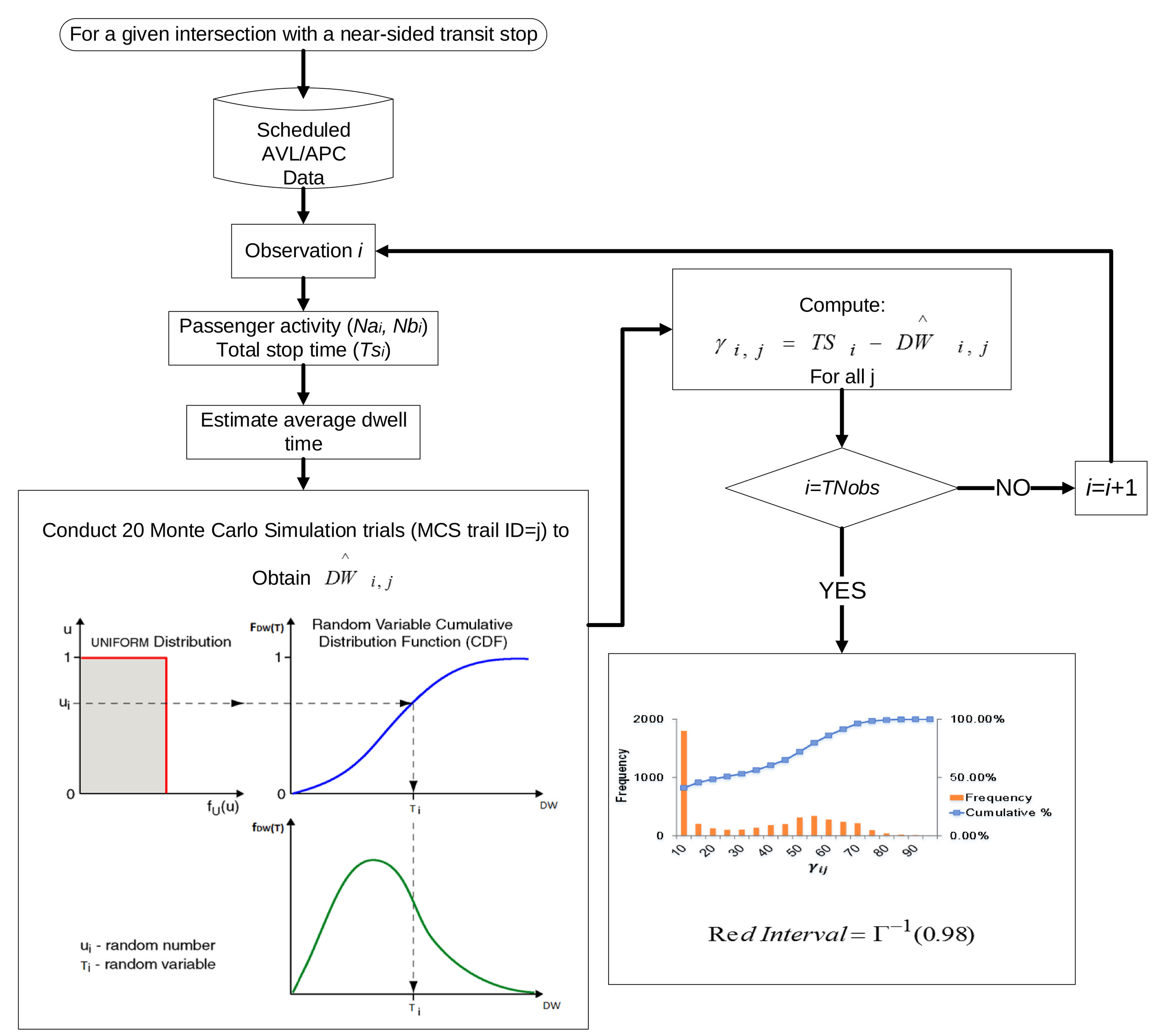
- Model the variations in individual observed dwell times using Poisson distribution (*f (x)*)
- Adjust the original Poisson model (*f'*(*DW*)) considering that the dwell time cannot be longer than the total stop time (*TS*)

$$f(X) = P(X = DW) = \frac{\overline{DW}^{DW} e^{-\overline{DW}}}{DW!}$$

$$f'(DW) = P(DW < X \le DW + \delta \mid X \le TS) = \frac{f(DW)}{F(TS)}$$



Red Interval Estimation



Stopped Delay Attribute

- For ***unscheduled*** stop observations the magnitude of stopped delay is equal to the observation's total stop time (*TS*)
- For ***scheduled*** stop observations the magnitude of stopped delay is determined based on the scenarios described earlier

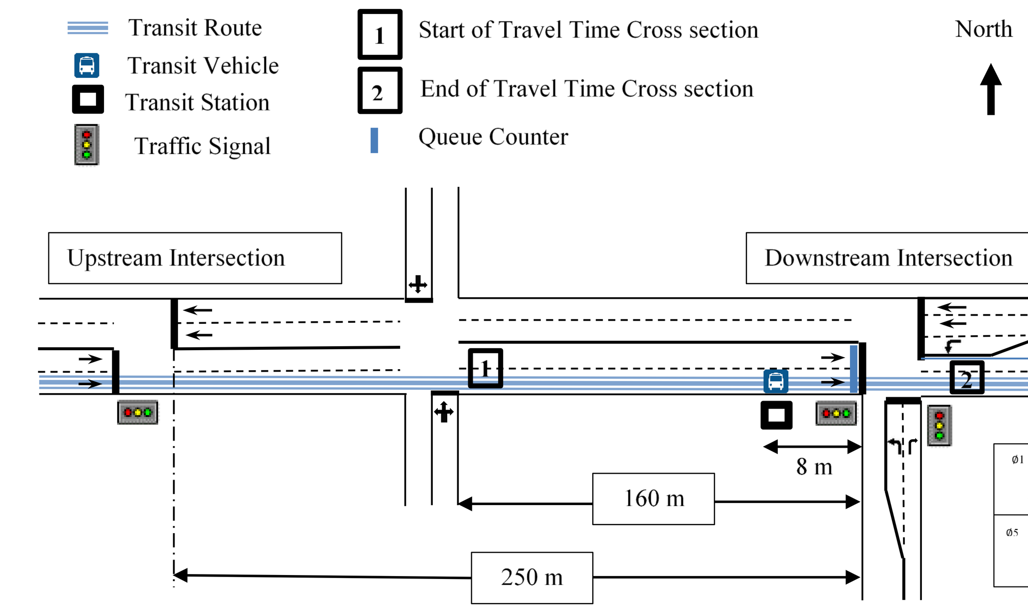
Boundary Line Fitting

- Scheduled and Unscheduled observations are aggregated
- A boundary line is fitted to the data using Yang and Hellinga's methodology
- The observations under the boundary line are used to estimate the performance of signalized intersections

Evaluation of the Proposed Methodology

VISSIM Simulation

- 35 hours
- 138 transit trips

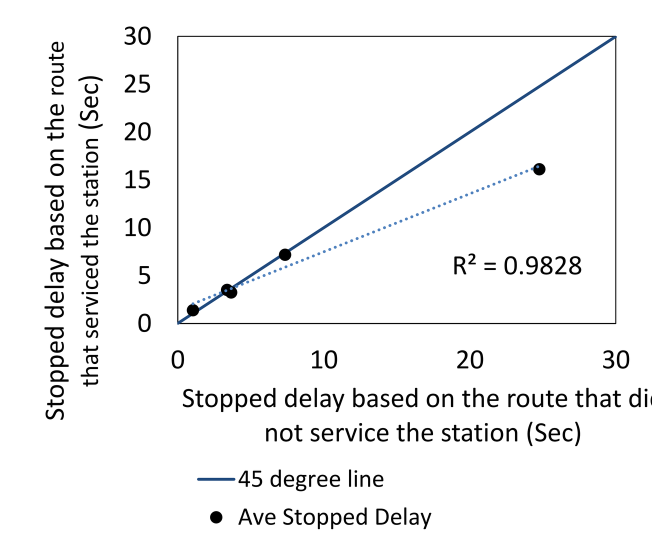


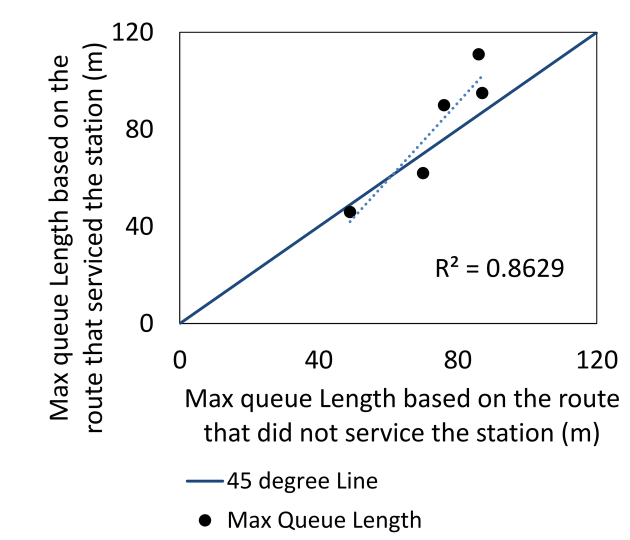
		Observed (VISSIM Output)	Estimated using proposed method
Red Interval Duration (sec)	Min	25	27
	Mean	25.5	
	Max	30	
	98th percentile	29	
Stopped Delay (sec)	Average	3.7	3.0
	Std	6.6	8.6
Queue Length (m)	Maximum	47.9	44.0

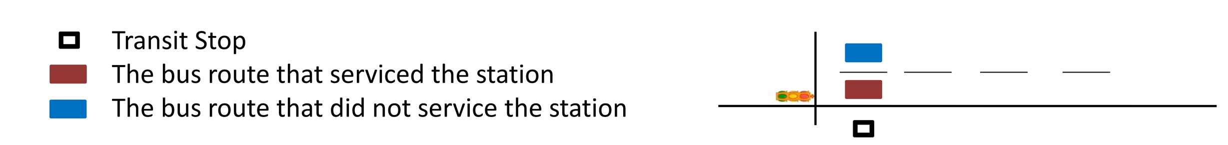
Field Data

Available Data and Analysis Period:

- Three months of AVL/APC data, in Region of Waterloo, Ontario, Canada
- The PM peak period (4:30 to 6:00 pm) for non-holiday weekdays from in-service transit trips
- Five intersection approaches with a near-side transit station
- Each intersection was traversed by at least one route that serviced the transit station, and one route that did not service the station







Conclusions

- AVL/APC data can be used to evaluate the performance of intersections within the road network
- Evaluation showed delay and queue lengths can be measured accurately
- Further evaluation is needed for approaches on which transit vehicles make left or right turning movements and to improve the performance of the boundary line fitting algorithm