

CHAPTER 8

CONCLUSIONS AND RECOMMENDATIONS

8.1 INTRODUCTION

The research embodied in this dissertation reviews and expands the methods currently available for estimating the delay, queue size and number of vehicle stops incurred by motorists at signalized intersections. Specifically, the research effort identifies the main limitations of these methods and extends the applicability of these models by developing new models. The goal of the dissertation is to compare the delay, queue and stop estimates obtained using car-following behavior against state-of-the-practice analytical models that are derived from deterministic and stochastic queuing and shock wave analysis theory. In doing so, the research effort identifies the assumptions, limitations and domains of applications of the different models. Furthermore, the research effort expands the application of analytical procedures by developing an analytical approach for estimating vehicle stops at oversaturated signalized intersections. Finally, the dissertation attempts to quantify the impact of non-homogeneous traffic flows on signalized delay estimates and demonstrates the limitations of analytical approaches for such applications. The analyses included in this research provide an extensive and valuable knowledge base that is of particular interest to the operational performance of signalized intersections. With the rapid growth in computer speed, the use of microscopic traffic simulation tools is gradually becoming the current state-of-practice. However, the credibility of such simulation approaches needs to be demonstrated. This research effort tests the validity of the INTEGRATION model for simple scenarios where analytical solutions to the problem can be computed. The research effort finally demonstrates the need for a simulation approach to evaluate scenarios that are beyond the scope of current state-of-the-art analytical approaches.

8.2 CONCLUSIONS

The main conclusions of this research effort can be summarized as follows:

- a. In the case of under-saturated homogeneous vehicle arrivals at signalized intersection approaches the following conclusions were derived:
 - Analytical queuing models estimate delays that are consistent with shock wave analysis.
 - The car-following models within the INTEGRATION software result in delays that are typically higher than the analytical models because they include both acceleration and deceleration delays.
 - The number of stops estimated by the analytical models are consistent with those measured in the INTEGRATION simulation environment.
 - Queue length extents are consistent between the INTEGRATION model and shock wave analysis.

- b. In the case of over-saturated homogeneous vehicle arrivals at signalized intersection approaches the following conclusions were derived:
 - Standard queuing theory models estimate delays that tend to infinity at v/c ratios that approach 1.0. These unrealistic delay estimates are a result of the assumption that the oversaturation period extends indefinitely.
 - Analytical models and the car-following behavior were all found to be consistent.
 - Current state-of-the-art analytical approaches for estimating the number of vehicle stops at signalized intersections underestimate the number of vehicle stops for v/c ratios from 1.0 to 1.5 and overestimate vehicle stops for v/c ratios that exceed 1.5.
 - As part of this research effort, an analytical model was developed to estimate vehicle stops at over-saturated signalized intersection approaches. The model provides a significant improvement of current state-of-the-practice models.
 - The queue length extents were found consistent between INTEGRATION and shock wave analysis.

- c. The mixed flow analysis demonstrated the need for microscopic simulation tools, like INTEGRATION, to capture the intricacies of vehicle interactions. These types of realistic networks are beyond the scope of current analytical models because of the complexity of the problem.

8.3 RECOMMENDATIONS

The analysis of the existing models that was conducted as part of this research revealed that the current methods for estimating delays, number of vehicle stops and queue lengths at signalized intersections are severely limited in many aspects, thus undermining their generality. This confirms the pressing need in the field to develop new approaches that can address the limitations in the current state-of-practice models. The importance of developing new procedures stems from the fact that signalized network analysis is a part of virtually every traffic analysis and that it is of great utility to professionals from all transportation applications.

In light of the favorable research findings, it is demonstrated that a traffic simulation model, like INTEGRATION, provides a viable tool for the evaluation of signalized intersections. The research that is presented in this dissertation is a first step in validating current state-of-the-art simulation models. However, further validation is required to address the more challenging network and traffic configurations in the field. Some examples for further research include the following:

- a. Validation of vehicle distribution across traffic lanes for different network, traffic, and lane striping configurations.
- b. Quantifying the impact of bus network configurations of overall network MOEs. For example, what are the impacts of moving a bus stop from near side to far side on the approach performance.
- c. Evaluating the potential benefits of transit signal priority for different network and traffic configurations.

The validation of the simulation models for these scenarios would require intensive and systematic field data collection.