INTRODUCTION

According to the 2011 Mobility Report, roadway congestion does not only occur during peak hours, it also becomes commonplace in non-peak hours.

Traffic signal retiming is the most cost-effective method for maintaining efficient traffic signal operations. Usually the signal timing was determined by peak-hour volumes. In benefit-cost-analysis (BCA) of signal retiming projects, the impacts in non-peak hours (with same signal timing as the corresponding peak hour) are usually ignored or roughly estimated based on the judgment of traffic engineers. With the increase of traffic delay in non-peak ours, the effects of signal retiming to the traffic in non-peak hours attract more attention.

To develop a complete BCA while taking practical concerns under consideration, this paper explores approximation formulas to quantify the benefits in non-peak hours given measures of effectiveness (MOEs) during peak-hours and flow relationship between non-peak and peak hours by applying constrained exponential regression modeling.

PROPOSED APPROACH

The objective of this study is to design a comprehensive procedure and discover approximation formulas to quantify the benefits in non-peak hours for traffic signal retiming without requiring additional and expensive field data collection and tedious simulation.

1. Determining the volume ratio between non-peak hour volume and its corresponding peak hour volume based on 24 hour segment counts;
2. Estimating Turning Movement Counts for non-peak hours;
3. Modeling data from Steps 1 and 2 in Synchro and getting MOEs;
4. Applying regression analysis to find approximation formulas of delay/fuel consumption in non-peak hours;
5. Validating regression results. The proposed procedure is demonstrated as follows.

RESULTS

Constrained Exponential Regression Model (1st Model)

Approximation formulas found by constrained exponential regression:

Existing Delay for non-peaks: $D_{\text{Non-pk}}^E = e^{p_{\text{Non-pk}}^E} \cdot (2.84 + R_{\text{Non-pk}}^E)$

Implemented Delay for non-peaks: $D_{\text{Non-pk}} = e^{p_{\text{Non-pk}}} \cdot (2.55)$

Existing Fuel Consumption for non-peaks: $F_{\text{Non-pk}} = e^{p_{\text{Non-pk}}} \cdot (1.78 + R_{\text{Non-pk}})$

Implemented Fuel Consumption for non-peaks: $F_{\text{Non-pk}} = e^{p_{\text{Non-pk}}} \cdot (1.71 + R_{\text{Non-pk}})$

CONCLUSION

This study develops a comprehensive methodology to estimate the benefits during non-peak hours of signal retiming. The outcomes of the case studies demonstrate the applicability of the proposed method. It is easy to be used by practitioners and is recommended for future benefit-cost-analysis of signal retiming.

Simulation modeling is a very effective way of providing the test and validation of the data required by the analytical model to estimate the unknown parameters. The benefits in each non-peak hour could be negative because traffic signal optimization of traffic retiming is based on the traffic volume condition in peak hours. With the increasing delay in non-peak hours, the tradeoff between peak hour and non-peak hour should be simultaneously considered in the future. The findings in this study can be compared to the field data by using BlueTOADTM technology, a Bluetooth-based travel time measuring platform developed by TrafficCast, to measure travel times before and after signal retiming from peak hours to non-peaks in the future.

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