ABSTRACT

Lavrenz, Steven Michael, Ph.D., Purdue University, December, 2015. High-Resolution Data-Based Methods to Enhance Signalized Intersection Maintenance, Performance, and Safety. Major Professor: Darcy Bullock.

This research is focused on the development of a comprehensive suite of methodologies for agencies to enhance the management of their traffic signal infrastructure. It has been found that data-based decision making is inconsistently applied within existing traffic signal management systems, and that the benefits of data-driven management activities are not widely understood. A new strategy, based on the concept of active traffic management, uses high-resolution signal controller data to achieve the following results:

- Development of enhanced techniques to identify malfunctioning signal communications and detection. The impacts of signal maintenance based on these techniques were demonstrated for a heavily traveled urban arterial, which resulted in over $900,000 in annual user benefit.
- New insights into the relationship between signal maintenance and the optimization of signal timing, including a case-based demonstration of the benefits resulting from tandem maintenance and optimization activities.
- The development of new microscopic tools which measure individual vehicle delay to improve signalized intersection performance.
- A demonstration of the benefits associated with the long-term, actively managed maintenance of signal timing coordination. On one case-study corridor, a 5-year intensive retiming plan resulted in a 12% increase in percent arrivals on green, despite a 36% increase in traffic volumes. Additionally, a net present value of $3.7 million was achieved through travel time reductions and reliability improvements over the study period.

- Development of a new methodology to identify red light running (RLR) vehicles using stop bar detection. Detailed investigation for one oversaturated intersection approach showed that a 20% increase in green time decreased the likelihood of RLR incidences by a factor of 1.7.

- An econometric analysis of the relationship between safety and intersection performance, in which a statically significant relationship was shown between RLR and split failures.

The results and methods demonstrated through this research can help guide transportation agencies in determining the best mix of resource deployment in a constrained fiscal environment. The methodologies can be utilized to quickly identify locations with maintenance deficiencies, and can be easily scaled across large numbers of intersections. They can also enhance the business case to invest in the proactive, long-term maintenance of signal hardware and active traffic management strategies. Finally, by linking intersection performance with crash exposure and safety, traffic engineers have an additional tool in their arsenal to address some of the potential causes of RLR crashes. Law enforcement can find similar benefit, by selectively focusing on intersections with higher RLR rates, especially in cases where detailed crash histories are unknown or too infrequently occurring.