Project Summary

Texas Department of Transportation

0-6576: Safety Implications of Using Active Traffic Strategies on TxDOT Freeways

Background

Traffic congestion is an increasing problem in the nation's urban areas, leading to personal inconvenience, increased pollution, hampered economic productivity, and reduced quality of life. While traffic congestion tends to continuously increase, growth in transportation infrastructure is limited by financial and land availability constraints. This has placed an increasing emphasis on using active traffic management strategies (ATM), such as speed harmonization, peak-period shoulder use, and ramp metering, to efficiently manage congestion using existing freeway capacity. Safety implication of these strategies is of prime concern before they can be implemented on the ground. This project developed a series of interdependent models and a simulation framework to evaluate the traffic operations and safety benefits of ATM strategies. Four ATM scenarios were evaluated in this study: variable speed limits (VSL), peak-period shoulder use, VSL and shoulder use, and ramp metering. Overall these ATM strategies were found to homogenize traffic and create safer driving conditions, but did not increase the throughput of the freeway. The study calls for caution and comprehensive evaluation in the case of shoulder use, as a sudden one-lane drop at the end of the shoulder-use section may have an adverse effect on traffic operations and safety. It also provided a feasibility analysis and a cost-benefit analysis framework for implementing these strategies in Texas.

What the Researchers Did

To accomplish the purpose of the project, the following tasks were undertaken:

1. Surveyed past experiences with active traffic management strategies use across the globe.
2. Identified a test corridor in Texas to determine the feasibility of these active traffic management strategies in the State.
3. Developed a series of interdependent models and a modeling simulation framework to evaluate traffic operations and safety benefits of these strategies.
4. Developed code to interactively implement variable speed limits and ramp metering in real time based on prevailing traffic conditions.
5. Implemented four active traffic management strategies scenarios (variable speed limits, peak-period shoulder use, variable speed limits in conjunction with shoulder use, and ramp metering) and evaluated their impact on traffic operations and safety.
6. Developed and implemented a multi-resolution framework to study the impact of these strategies at a network level.
7. Provided recommendations on ITS requirement, enforcement, and potential impediments in their implementation.
8. Presented a cost-benefit analysis (CBA) framework and operational deployment plan for variable speed limits and peak-period shoulder use.

Research Performed by:

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What They Found

The impact of active traffic management strategies on freeway traffic were classified into two broad categories: traffic operations and safety. These results are summarized below

Impact on traffic operations: VSL harmonized traffic flow, reduced lane-changing conflicts, and created safer driving conditions. Shoulder use decreased speed at the end of the shoulder-use segment due to bottleneck creation as a result of one lane-drop. However, shoulder use improved traffic conditions in the middle of the shoulder-use segment by reducing traffic density and increasing operating speed. Simultaneous implementation of VSL and shoulder use consistently harmonized the traffic flow and improved travel conditions by reducing speed variability, traffic density, and stop-and-go condition. Smoother flow of traffic results in less emissions, less fuel consumption, and less wear and tear on the vehicles, and leads to safer driving conditions. It did not have a significant impact on throughput, as is reported in previous studies on VSL, but it did have an overall positive effect on speed harmonization for the traffic, reducing the severity of conflicts. VSL and shoulder use decreased delay per vehicle, and overall these strategies created safer driving conditions by reducing speed variability. Ramp metering reduced the average number of stops per vehicle and speed variation. It also reduced freeway corridor delay, but at the expense of overall network delay, which worsened due to vehicles queued at on-ramps during peak-hours.

Impact on traffic safety: The safety implications of active traffic management strategies were assessed using various surrogate safety measures. VSL and ramp metering reduced both the likelihood and severity of conflicts, and had an overall positive effect on safety. Shoulder use had a positive effect on traffic operations and safety in the middle of the testbed section. Strategies involving shoulder use call for caution and a comprehensive evaluation to avoid their adverse effect on traffic operations and safety toward the end of the shoulder-use segment due to a sudden one-lane drop. A smoothly tapered geometry along with adequate safety measures while opening the shoulder to traffic during peak hours will mitigate some of its adverse effects towards the end of the shoulder-use segment.

What This Means

This research is the first of its kind, which implemented various active traffic management strategies to study their impact on traffic operations and safety by developing a comprehensive simulation framework comprised of microscopic, mesocopic, and safety models. VSL, shoulder use, and ramp metering control strategies homogenized traffic and reduced stop-and-go conditions by moving the traffic more steadily. The smoother and more homogenized traffic stream leads to less emissions, less fuel consumption, less wear and tear on vehicles, and safer driving conditions. Based on the research findings of this study, it can be concluded that ATM strategies have the potential to make freeway traffic harmonized and safer if peak period shoulder use is implemented with adequate safety measures. This study also provided recommendations on ITS devices requirements, enforcement issues, potential impediments in their implementation, and a framework for cost-benefit analysis to determine the economic viability of the project.

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