MPC-610
February 18, 2020

Project Title

Impact of Regulatory Hybrid Changeable Message Sign on Traffic Safety under Different Freeway Geometric Designs

University

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Research Needs

To increase safety and operational efficiency on a section of I-80, which travels through the mountains east of Salt Lake City and experiences frequent periods of winter weather, the Utah Department of Transportation (UDOT) has implemented a Variable Speed Limit (VSL) zone (from MP 128.0 to MP 141.0 in both directions) using regulatory hybrid Changeable Message Signs (CMSs). As required by the guidelines (MUTCD, 2009), amber/yellow LED digits are commonly used to represent warnings or ahead notifications, while white LED digits fall in line as regulatory traffic control devices with law enforcement consequences. Hence, in the current systems, the CMSs have been operated with white LED numbers on the black background. However, it has been found that the visibility of those numbers that indicate speed limits has become a problem during the time of snowstorms when it is most likely to have the need of activating VSL controls for safety improvement. Moreover, the strong sunlight during the summertime can also affect the visibility of CMSs. Hence, the Traffic Operation Center and Traffic Safety Office in UDOT are in the process of installing a new CMS system which replaces the color of white CMS LED by yellow.

In the literature, it shows the crash severity and frequency are strongly related to freeway geometric features such as roadside condition, the number of lanes, lane width, shoulder width, superelevation and curve radii and profile gradient designs (Haghighi et al., 2018). Although many recent studies have studied the impacts of CMS's visibility on improving safety, limited efforts have been placed on studying such impacts under different freeway geometric designs (Xu et al., 2018). To address this issue, this project will conduct a spatial-temporal analysis to understand the interactions of CMS designs and crash severity/frequency. By collecting historical crash locations in the VSL zones, our research team will further discuss how the new CMS can help to prevent crashes in various scenarios. In addition, this project will record field videos during both summer and winter seasons to compare the visibility of yellow-legend and

white-legend CMS systems. The results will be discussed for the legend color selection for CMS. The collected information will be used to analyze the impacts of CMS on potential crash rate and severity using surrogate safety evaluation method. The results of this study will provide insights into the CMS safety impact and will support government agencies, such as UDOT, in future technology and infrastructure investment.

Research Objectives

The research objectives of this project are summarized as follows:

1. Studying the intercorrelation between crash severity/frequency and freeway geometric characteristics based on a statistical analysis of crash data in the I-80 VSL zones.
2. Evaluating the visibility of the yellow-legend and white-legend CMS systems through field video recording and investigating the potential safety impacts.
3. Collecting crash data before and after implementing the yellow-legend CMSs and discussing its benefits on mitigating crash severity and reducing crash rate by surrogate safety evaluation.
4. Presenting the research outcomes at the national level.

In summary, grounded on a statistical analysis of crash data and the field experiment study of the recorded videos, this research will further study CMS safety impact under different scenarios of freeway geometric designs. The yellow-legend CMS-enabled cases will be compared with the ones with white-legend CMSs involved for safety performance assessments. At the conclusion of this project, we will be able to ascertain whether the stated objectives have been achieved.

Research Methods

Research methods of this project are designed to study the intercorrelations between CMS designs, crash rate, and freeway geometric features. Statistical models will be implemented to identify the most significant design factors that may impact traffic safety. In addition, our research team will recognize improper freeway designs and investigate how the new CMS system can help prevent resultant crashes.

Besides the adoption of the crash data from UDOT and the Utah Department of Public Safety (UDPS), additional data collection and analysis efforts will be carried out with the following three steps:

1. Review related studies in the literature and investigate existing white-legend CMS systems in other states of the U.S.
2. Conduct field video recording during both summer and winter in various geometric designs to study the visibility of CMS systems.
3. Obtain additional data such as VSL records and traffic detector data (e.g., flow and speed) after replacing white-legend by yellow-legend CMS systems.

With the literature review and the collected data from multiple resources, the second part of this project focuses on examining whether the new CMS system can help reduce the corresponding crash risks on the I-80 freeway segment. More specifically, it will involve the following activities:

1. Develop a freeway safety assessment model that takes occurrence data, geometric design parameters, and crash records as input.
2. Evaluate freeway safety and speed compliance rate improvement after the implementation of the new CMS system.
3. Compare the performance of the white-legend and yellow-legend of CMS systems.
4. Prepare the final report.

Expected Outcomes

At the end of this project, the research outcomes will help transportation community better understand how the color of CMS legend would impact the crash severity and frequency when freeway geometric design also plays a key factor in affecting traffic safety. Further, this research can provide an overview of safety-related CMS applications. Such information would benefit decision-makers in determining further infrastructure investment for supporting CMS operations. More specifically, the expected outcomes of this research project are summarized as follows:

1. Literature review report that summarizes the current CMS applications in the U.S.
2. Analysis of the crash data and traffic sensor data before and after installing yellow-legend and white-legend CMS systems.
3. Data analysis based on the collected videos.
4. A crash likelihood estimation model which uses occurrence data and crash record as input.
5. Report on system performance.
6. Final project report.

Relevance to Strategic Goals

- Safety
- Livable Communities

This project aims to study the effects of freeway geometric designs on traffic safety and discuss whether yellow-legend CMS can help reduce crash risk in Utah. Taking the I-80 VSL zone as the study site, the outcomes of this research will offer an overview of freeway safety performance and identify the crash hotspots that might be caused by improper geometric designs. Based on the field experiment of yellow-legend and white-legend CMS systems, this study will provide insights into the guideline and best practice of the CMS legend color selection. This research will assist in improving public safety and reducing transportation-related fatalities and injuries. Moreover, with a better understanding of CMS applications' benefits on improving freeway safety and reducing geometrical-related crash risks, this project would support the long-term urban planning strategic goal in terms of infrastructure investment so as to support CMS implementations. It would foster the development of livable communities.

Educational Benefits

This project will directly fund one Ph.D. students from the Department of Civil and Environmental Engineering at the University of Utah. Females and students from underrepresented groups will also be encouraged to participate in the project. The student will be responsible for conducting the research activities under the supervision of the PI. He or she will also lead the writing of peer-reviewed journal and conference articles resulting from this project. The research outcomes will directly support his/her dissertation work as well. In addition, we will foster the integration of research and teaching in transportation engineering. Students enrolled in the following courses will directly benefit from this research: Transportation Engineering (CMSEEN 3520), Quantitative Methods in Transportation (CMSEEN 6530), Highway Designs (CMSEEN 5620), Optimization in Transportation (CMSEEN 5920/6920), Traffic Network Modeling (CMSEEN 7545), and Transportation Planning (CMSEEN 5560).

Technology Transfer

The proposed research will support the freeway safety improvement plans of UDOT, UDPS, Salt Lake County, and Park City. It will also inform the long-range transportation planning of UDOT on investing CMS-related infrastructures. In addition, the current VSL system requires traffic engineers to manually change speed limit values (usually started at 2-3 AM) based on the observed traffic speeds. Considering tremendous labor works are needed to carry out such tasks, UDOT Traffic Operation Center is developing an online-based system that can automatically change the VSL when needed. The system is expecting to be fully functioning in September or October 2019. To assist UDOT to evaluate the new system's performance, another goal of this project is to conduct an analysis of I-80 safety performance and drivers' compliance rate before and after the system implementation. Notably, this project will also examine the condition when traffic is light and there are not enough speed data to determine the VSL.

The potential audiences of this research would include traffic engineers, traffic safety agencies, transportation asset managers, transportation planners, and policy decision-makers. The following agencies, offices, and committees are those most likely to implement the research results:

- Utah Department of Transportation
- Utah Department of Public Safety
- FHWA Office of Safety and Office of Planning
- TRB Standing Committee on Safety Data, Analysis, and Evaluation (ANB20), Highway Safety Performance (ANB25), Vehicle-Highway Automation (AHB30).

The research outcomes will also be published in peer-reviewed journals and conferences such as traffic injury prevention, accident analysis and prevention, ASCE journal of urban planning and development, and Transportation Research Board Annual Meeting. The PI of this project has been actively participated in the activities in TRB committees and is serving as member and friend of several standing committees. The PI is also serving as an editorial board member of several transportation-related journals. Research findings will be shared with those communities the PI involved at the end of this project.

Work Plan

1. Literature review
2. Field video recording and results analysis
3. Crash data collection and analysis
4. CMS safety impact study
5. Final project report preparation

The proposed research work will take one year to complete. Research tasks with associated work schedules are listed as follows:

Task 1: Review studies in the literature and existing VSL systems in other states of the US (3 months)

Our research team will review studies in the literature regarding the configuration plan, the operational methodology and potential outcomes and the settings and field evaluations of existing VSL systems.

Task 2: Conduct field video recording during both summer and winter to study the visibility of CMS (2 months)

To compare the effectiveness of implementing yellow-legend CMS systems in improving speed limit sign visibility and resulting roadway safety, one main motivation of this project is to perform comprehensive before-and-after comparisons of VSL system's performance based on the VSL records, onsite traffic detector data, and field trip videotapes.

Task 3: Analyze the crash data and traffic sensor data before and after installing yellow-legend and white-legend CMS (4 months)

Our research team will collect the crash data from UDOT and UDPS safety database. Then statistical analysis will be placed on studying the safety improvement of using yellow-legend CMSs in both summer and winter seasons. The analysis will be based on the examination of three pre-defined safety surrogate measures

Task 4: Freeway geometrical design impact study (2 months)

Based on the data analysis in Task 3, we will further evaluate the safety performance improvement of the new CMS system at different locations. By classifying the CMS stations into a set of groups according to the roadway geometric features of those station sites, this task will help understand the role of freeway geometrical design in affecting CMS visibility and the corresponding traffic safety.

Task 5: Final project report preparation (1 month)

All research outcomes and findings will be summarized in the final project report.

Project Cost

Total Project Costs:	$175,000
MPC Funds Requested:	$ 75,000
Matching Funds:	$100,000
Source of Matching Funds:	Utah Department of Transportation

References

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