MPC-495
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Project Title:
Safety Effects of Protected and Protected/Permitted Left-Turn Phases

University:
University of Utah

Principal Investigator:
Juan C. Medina, PhD
Research Assistant Professor
Department of Civil and Environmental Engineering
CME 122 S Central Campus Dr, Room 413
Salt Lake City, UT 84112
University of Utah
Phone: (801) 585-1952
Email: juan.c.medina@utah.edu

Research Needs:
Protected left-turn phases at signalized intersections are intended to reduce the frequency of angle collisions that result from conflicts between left-turning vehicles and opposing through vehicles. AASHTO's "NCHRP 500 series" also notes that the frequency of rear-end and sideswipe crashes between left-turning vehicles and following through vehicles can also be reduced with properly timed, protected left-turns. Various studies have demonstrated the overall safety effectiveness of protected left-turn phases (e.g., Harkey et al., 2008; Davis and Aul, 2007). A consensus on the extent of this safety effectiveness under different intersection conditions does not exist. While separate left-turn phasing may reduce delay for left-turning vehicles, it may increase the overall intersection delay and disrupt traffic progression. It is therefore important to understand the safety effects of protected left-turn phases under a variety of intersection conditions so that appropriate operational and safety trade-offs can be quantified and considered by agency decision makers. Protected/permitted left-turn phasing is sometimes used as a compromise between fully-protected and permitted only phasing. Information on the safety effects of protected/permitted under a variety of intersection conditions is needed as well. This project will estimate the safety effects of protected and protected/permitted left-turn phases for different intersection conditions. Intersection conditions of interest may include factors such as turning volumes, opposing through volumes, pedestrian crossing volumes, approach speeds, sight distance, number of lanes, and type of channelization.

Research Objectives:
The primary objective of this research project is to estimate the safety effects of left-turn phases for different conditions and provide operational recommendations. The operational recommendations will be in the form of a framework that demonstrates how the results of this research can be incorporated into a performance-based analysis of operational and safety trade-offs associated with different left-turn phasing alternatives.

Research Methods:
The methodology for this project will incorporate a synthesis of literature, policies, and practice; an observational before-after or cross sectional road safety study; an in-depth, clinical analysis of left-turn

crashes; and development of a decision-making framework in the form of operational recommendations. First, the research team will review literature and practice regarding left-turn phasing considerations, safety effects of left-turn phasing, and operational and safety trade-offs associated with different left-turn phasing alternatives. A comprehensive data matrix of all applicable intersection types, phasing types, and corresponding data elements relevant to this study will then be prepared, followed by a pilot data collection effort. The pilot data collection effort will involve gathering preliminary information on left-turn signal phasing, turning volumes, opposing through volumes, pedestrian crossing volumes, approach speeds, sight distance, number of lanes, types of channelization, and other elements at a sample of Utah intersections drawn from different parts of the comprehensive data matrix. Using lessons learned during the pilot data collection effort, intersection types, phasing types, and corresponding data elements for this study will be prioritized and a detailed work plan for estimating the safety effects of protected and protected/permitted left-turn phases under the selected, high-priority intersection conditions will be developed. The work plan will include study designs, sample sizes, data collection protocols, and data analysis approaches that can be reasonably implemented under the project time and budget constraints. The plan will also include an approach to supplement the statistical crash analysis with a more in-depth, clinical-style analysis of a selected number of individual left-turn crashes to identify "causal type groupings" that are possibly associated with different phasing alternatives.

At this stage, the research team will meet with a technical advisory panel of practitioners (TAC) from the Utah Department of Transportation (UDOT). The TAC will provide feedback on the draft detailed work plan, after which, it will be revised and finalized. The research team will then execute the detailed work plan, including all data collection and analysis activities. A preliminary set of models will be estimated when data collection is at the "half-way" point. This preliminary analysis will be used to assess the data being collected and determine if any adjustments to the data collection and quality control procedures are needed. A set of preliminary "causal type groupings" will also be developed from the in-depth, clinical-style analysis completed up to this point in the project. Data collection and analysis will continue (with any needed adjustments based on the preliminary analysis) until the detailed work plan has been fully executed. The entire research effort will be documented in a final research report, including a stand-alone framework that demonstrates how the results of this research can be incorporated into a performance-based analysis of operational and safety trade-offs associated with different left-turn phasing alternatives as a chapter or appendix in the final research report.

Expected Outcomes:
The expected outcomes of the project will include 1) a more in-depth understanding of how left-turn phasing alternatives impact safety under a variety of intersection conditions, and 2) a stand-alone framework that demonstrates how the results of this research can be incorporated into a performance-based analysis of operational and safety trade-offs associated with different left-turn phasing alternatives.

Relevance to Strategic Goals:
The project scope and expected outcomes are directly related to *Safety*, as they will result in knowledge to support: 1) the full, explicit consideration of expected safety effects of protected and protected/permitted left-turn phases under a variety of intersection conditions, with the expected safety effects likely to be expressed in the form of crash modification factors and crash modification functions, disaggregated by crash type (e.g., total, angle, sideswipe) and crash severity (e.g., total, fatal-plus-severe-injury, fatal-plus-injury) where the sample sizes allow; and 2) a stand-alone framework that demonstrates how the results of this research can be incorporated into a performance-based analysis of operational and safety trade-offs associated with different left-turn phasing alternatives.

Educational Benefits:
The project team will include two graduate students and one undergraduate student from the University of Utah's Department of Civil and Environmental Engineering. Results of the project will be incorporated into the University of Utah's CvEEN 6525, Highway and Traffic Engineering, which currently covers key issues in roadway safety management, practices for design and safety considerations in resurfacing, restoration, and rehabilitation projects, performance-based roadway design, roadside design, work zone management and design, project development and delivery.

Work Plan:
The project objectives will be accomplished through executing the following nine major tasks:

1. **Synthesize Literature and Practice.** Review and synthesize literature and practice regarding left-turn phasing considerations, safety effects of left-turn phasing, and operational and safety trade-offs associated with different left-turn phasing alternatives.
2. **Conduct Pilot Data Collection.** Prepare a comprehensive data matrix of all applicable intersection types, phasing types, and corresponding data elements relevant to this study. Conduct a pilot data collection effort by gathering preliminary information on left-turn signal phasing, turning volumes, opposing through volumes, pedestrian crossing volumes, approach speeds, sight distance, number of lanes, types of channelization, and other elements at a sample of Utah intersections drawn from different parts of the comprehensive data matrix. At this initial stage, all types of left-turn phasing will be considered. Prioritize intersection types, phasing types, and corresponding data elements for this study using the experience gained during the pilot data collection effort.
3. **Develop Draft Detailed Work Plan.** Develop a draft, detailed work plan for estimating the safety effects of protected and protected/permitted left-turn phases under a variety of intersection conditions. The plan will include study designs, sample sizes, data collection protocols, and data analysis approaches that can be reasonably implemented under the project time and budget constraints. The plan will also include an approach to supplement the statistical crash analysis with a more in-depth, clinical-style analysis of a selected number of individual left-turn crashes to identify "causal type groupings" that seem to be associated with different phasing alternatives.
4. **Hold Interim TAC Meeting.** Meet with a technical advisory panel of UDOT practitioners (TAC) to review the draft, detailed work plan.
5. **Prepare Final Detailed Work Plan.** Revise the detailed work plan based on comments received from the TAC.
6. **Execute Approved Work Plan.** Execute the detailed work plan, including all data collection and analysis activities.
7. **Develop Preliminary Models and Causal Types.** A preliminary set of models will be estimated when data collection is at the "half-way" point. This preliminary analysis will be used to assess the data being collected and determine if any adjustments to the data collection and quality control procedures need to be made. A set of preliminary "causal type groupings" will also be developed from the in-depth, clinical-style analysis completed up to this point in the project.
8. **Hold Interim TAC Meeting.** Meet with the project TAC to review the preliminary models. Continue with data collection and analysis (with any needed adjustments based on the preliminary analysis) until the detailed work plan has been fully executed.
9. **Prepare Report and Framework.** Document the entire research effort in a final research report. A stand-alone framework will be developed that demonstrates how the results of this research can

be incorporated into an analysis of operational and safety trade-offs associated with different left-turn phasing alternatives. The stand-alone framework will be included as a chapter or appendix in the final research report.

A schedule associated with this work plan is provided on the following page.

Technology Transfer Plan

The research results have the potential to 1) improve the way in which expected safety effects of left-turn phasing alternatives are considered under a variety of intersection conditions, 2) create operational recommendations in the form of a framework that demonstrates how the results of this research can be incorporated into a performance-based analysis of operational and safety trade-offs associated with different left-turn phasing alternatives. Dr. Porter will deliver one presentation of the findings to a UDOT technical advisory panel of practitioners and other UDOT personnel as part of Task 9 in the work plan. Dr. Porter will also volunteer to present the findings at the annual UDOT Engineering Conference. Findings will be shared at a national level by submitting the results for presentation at one or more TRB Annual Meetings as well as for publication in *Transportation Research Record,* ASCE *Journal of Transportation Engineering*, *Transportation Research Part A: Policy and Practice,* or *Accident Analysis & Prevention*. Dr. Porter will volunteer one presentation at a meeting of the AASHTO Subcommittee on Traffic Engineering/National Committee on Uniform Traffic Control Devices as well as a research seminar via the Transportation Learning Network.

No.	Major Task	Q 2 2015			Q 3 2015			Q 4 2015			Q 1 2016			Q 2 2016			Q 3 2016			Q4 2016		
1	Synthesize literature/practice																					
2	Conduct pilot data collection																					
3	Develop draft work plan																					
4	Hold interim TAC meeting																					
5	Submit final work plan																					
6	Execute approved work plan																					
7	Develop preliminary models																					
8	Hold interim TAC meeting																					
9	Prepare report and framework																					

Project Cost:

Total Project Costs:	$95,000
MPC Funds Requested:	$45,000
Matching Funds:	$50,000
Source of Matching Funds:	Utah Department of Transportation

TRB Keywords:

Intersections, Left-turn phase, Permissive phasing, Performance evaluations, Protected phasing, Safety management

References:

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