NEVADA DEPARTMENT OF TRANSPORTATION
RESEARCH PROBLEM STATEMENT

Internal Submission Form (not to exceed 3 pages with font size 11)

I. PROBLEM TITLE (Required): State the title of the research study that highlights the focus of the proposed research problem statement.

Evaluating Safety Impacts of Permissive Green Signal Phasing on Observed Conflicts Between Left-turning Vehicles and Pedestrians

II. PROBLEM DESCRIPTION (potential 10 Points): Define the specific problem the proposed research will address. Describe why NDOT needs to research the proposed problem (i.e., how the existing research nationally and internationally does not fully solve the problem for NDOT).

When a traffic signal turns green, left-turning vehicles will experience three types of phasing:

- A green arrow is a protected turn phase. Oncoming traffic is stopped by a red light, and a driver may perform a protected left turn.
- On a flashing yellow arrow, left turns may proceed with caution after yielding to oncoming traffic.
- On a circular green, left-turns are permitted when there are sufficient gaps in opposing traffic flow to allow a left-turning vehicle to safely make the turn.

The last two scenarios are referred to as *permissive left turns*, as they are "permitted" after the driver yields to oncoming traffic.

During a green arrow phase, parallel pedestrian traffic is stopped. However, during a permissive signal phase (yellow arrow or circular green), parallel pedestrian traffic may receive a "walk" signal at the same time a left-turning vehicle may turn. For these permissive turns, the driver of the left-turning vehicle is often focused on oncoming traffic, and if there is a brief gap, the driver may make a quick, aggressive turn—only to discover a pedestrian in the crosswalk. This creates a hazardous situation as shown in the figures below.

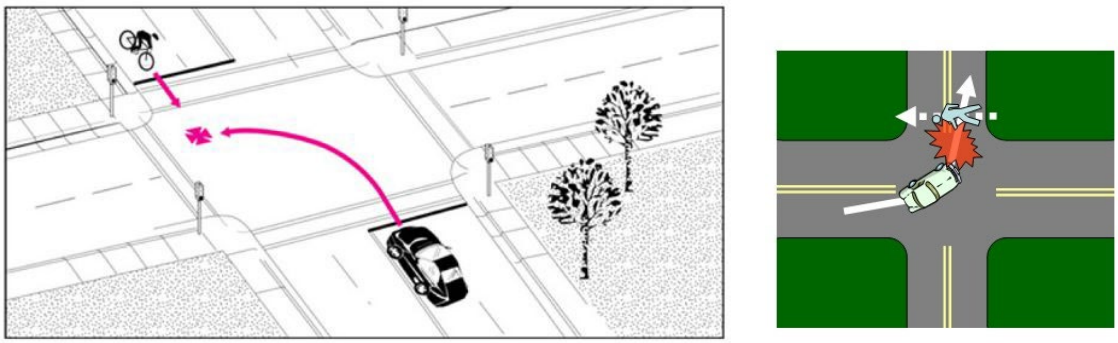

Figure 1. Parallel Path Problem: Permissive left turns

Crashes often occur when a pedestrian is waiting at a curb and the section of traffic the pedestrian wants to cross is stopped at a red light. The pedestrian assumes that it is safe to enter an intersection because that person sees a "walk" signal, not realizing that oncoming vehicles may perform a permissive left turn directly into the lane that he or she has just entered.

While there is existing research recognizing the relationship between left-turning vehicles and pedestrian crashes, there are no clear recommendations that direct DOTs or other agencies regarding how to improve safety. While some national and international studies address the conflict between permissive left-turn phasing and pedestrian safety, Nevada still has a high number of pedestrian/vehicle crashes – over 950 pedestrian/left turn crashes where 15 were fatal and over 80 were life changing injuries in the last five years. NDOT needs a better understanding of how permissive left-turn phasing impacts safety for parallel crossing pedestrians and other non-motorists. Particularly because in most cases non-motorists are crossing legally in a crosswalk when these conflicts occur.

III. OBJECTIVE (Required): Include clearly defined objectives (anticipated deliverables including products) for the proposed research.

This research will analyze a sample of intersections in Nevada with permissive left-turn signals, identify the factors contributing to pedestrian-vehicle conflicts, and provide NDOT with clear, comprehensive recommendations for safety improvements at these locations. The deliverables will include:

- A detailed analysis report of the current safety conditions at the selected intersections.
- A detailed report on the recommendations for specific signal phasing adjustments, signal system improvements, or changes to the pedestrian facilities.
- A final report with specific recommendations for improvements to NDOT policies, practices, and infrastructure

IV. CURRENT PRACTICE and RELATED RESEARCH (potential 10 Points): Provide a clear description on the state of the practice in addressing the problem within NDOT and provide a brief summary of literature related to the proposed problem.

The research on conflicts between left turns and non-motorists is confined to answering three main questions. First, how dangerous are left-turning vehicles for non-motorists? Second, what factors make these maneuvers so dangerous? And third, does the design of the non-motorist environment/facilities impact or reduce conflicts with left-turning vehicles?

A pedestrian is about four times more likely to be hit by a left-turning vehicle than by a right-turning vehicle at signalized intersections. A study of high-risk intersections in Utah determined that the presence of a left turn green arrow (protected phase) at an intersection resulted in over five additional non-motorized crashes per year at the location (Burbidge, 2014). The left-turning maneuver at signalized intersections is more demanding for drivers than right-turning or through maneuvers, particularly for older drivers. Research has found that drivers appear to struggle with the visual search and detection of pedestrians. Drivers perform more head movements to the right than to the left while turning left. As the driving task difficulty increases, drivers have increasing difficulty with the peripheral detection of targets (Lord, Smiley, and Haroun, 1998). This difficulty increases when drivers must identify gaps in traffic to make a left turn, as well as the presence of pedestrians at a parallel crossing.

Research examining permissive left turns has found that pedestrian volume, opposing through-vehicle volume, left-turn-vehicle volume, and the width of the intersection in the opposing direction, contribute significantly to the safety of pedestrians under permissive left-turn signal control (Qi and Yuan, 2012). Another study determined that the percentage of left-turning trucks and pedestrian volume both had significant impacts on pedestrian safety (Qi and Guoguo, 2017). A video assessment of left-turning

vehicles in Japan examined how surrogate safety measures (SSM) can be utilized for pedestrian versus left-turning vehicle conflict assessment. The analysis found that high turning speed, in conjunction with higher frequency of short Post Encroachment Times, resulted in higher crash rates (Chen, Nakamura, and Asano, 2014).

Lastly, pedestrian facility design was investigated. This safety performance study examined the effect of three crosswalks designed with different materials, including red-colored material and brick pavement. The study considered left-turning driver's gap acceptance behavior and the severity of traffic conflict events between left-turning vehicles and pedestrians. The results indicated that using brick pavement on a crosswalk increased the safety level of the crosswalk because drivers at these crosswalks were more likely to yield to pedestrians (Iasmin, Kojima, and Kubota, 2016).

V. IMPLEMENTATION POTENTIAL (potential 10 Points): Identify what stage of the research deployment (page 2) the proposed research falls under and **also** clearly identify if the proposed research will result in deliverables that are ready for implementation. Any institutional, political, or socio-economic barriers to implementation of the anticipated research results/products should also be identified.

This research will be conducted in the Concept Stage. This will include conducting a thorough literature review and evaluation of existing DOT policies and best practices nationwide, evaluating existing conditions and needs at a sample of Nevada's non-motorist high-risk intersections, and an evaluation of the data and safety assessments. The research will provide NDOT with comprehensive guidance for improving safety at intersections with permissive left turn signal phasing. This may include recommendations for signal timing or signal phasing changes, strategies for improving driver attention, and recommendations for improvements to pedestrian infrastructure, crossings, and signals.

A final report will be provided to NDOT including specific recommendations for improvements to policies, practices, and infrastructure. Research findings will be presented to NDOT and identified partners. The project team will also work with NDOT to craft an appropriate implementation plan to integrate recommendations into NDOT's existing practices. This may also include one or more potential pilot project locations to test safety recommendations on the ground. Potential barriers for implementation may include:

- An unwillingness to change existing standards and policies
- Political pushback against recommended built environment changes
- The cost of new infrastructure

VI. URGENCY and PAYOFF POTENTIAL (potential 10 Points each, total 20 Points): Include a statement on the importance of this particular research in this fiscal year. **Identify and quantify the potential payoff** from successful achievement of the project objective.

Addressing this issue **now** is critical because Nevada has experienced nearly 1000 pedestrian crashes in the last five years, making it essential to prioritize this research in the current fiscal year to address immediate safety interventions. One pedestrian crash is too many. With pedestrian safety becoming a growing concern, the research will be instrumental in developing strategies to reduce the risks to pedestrians and other vulnerable road users of left-turning vehicles. Data from other states have

shown a **reduction in pedestrian-related crashes by up to 30%** when protected left turn phases were introduced. Based on these findings, implementing similar changes in Nevada could provide a significant reduction in pedestrian crashes, potentially preventing numerous fatalities and injuries. The research outcomes suggest that implementing changes to signal phasing could provide a similar reduction in pedestrian crashes in Nevada.

VII. DATE and SUBMITTED BY (Required): Provide name, title, NDOT section, telephone number, and e-mail address(es) for the person(s) who developed/submitted the problem statement**.**

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VIII. ADDITIONAL CHAMPIONS (Additional 10 Points total for multiple champions from more than one section):

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Sources:

Burbidge, S.K. 2014. *Identifying Characteristics of High-Risk Intersections for Pedestrians and Cyclists: Phase 2*. Utah Department of Transportation. Report #14-8340. August 2014.

Chen, P., H. Nakamura, and M. Asano. (2014). Application of surrogate safety measures for assessment of pedestrian versus left-turning vehicle conflict at signalized crosswalks. *Advances in Transportation Studies*, Special Vol 1. p37.

Iasmin, H., A. Kojima, and H. Kubota. (2016). Safety effectiveness of pavement design treatment at intersections: Left turning vehicles and pedestrians on crosswalks. *International Association of Traffic and Safety Sciences (IATSS) Research*. 40(1). Pp47-55.

Lord, D., A. Smiley, and A. Haroun. (1998). Pedestrian Accidents with Left-Turning Traffic at Signalized Intersections: Characteristics, human factors, and unconsidered issues. *Paper presented at the 77th Annual Meeting of the Transportation Research Board*: Washington D.C.

Qi, Y. and A. Guoguo. (2017). Pedestrian safety under permissive left-turn signal control. International *Journal of Transportation Science and Technology*. 6(1). Pp 53-62.

Qi, Y. and P. Yuan. (2012). Pedestrian Safety at Intersections under Control of Permissive Left-Turn Signal. *Transportation Research Record*, 2299(1), 91-99.

FIVE STAGES OF RESEARCH DEPLOYMENT

Based on Caltrans Research and Innovation Stages

1. **Concept Stage**
   - First steps following Problem Statement and Proposal Development
   - Includes detailed literature search
   - Involves experimental design, data collection, analysis, and reporting
   - Assesses results of research
   - Defines barriers to implementation (e.g., policies, specifications, standards)
   - Submits a Final Report and outlines a recommended implementation plan
   - Includes collaboration with outside agencies or other state DOTs and US DOT (Applies to all Stages of Deployment)
2. **Laboratory Prototype Stage**
   - Develops breadboard circuit or computer system modeling
   - Demonstrates operation in laboratory setting
   - May incorporate customized or one-of-a kind components
   - Assesses results
   - Submits Final Report and recommends design of full-scale demonstration
   - Potential end users are enlisted to support the field pilot stage
3. **Controlled Field Demonstration Stage**
   - Prepares for full scale testing of demonstration project
   - Controlled tests at specialized facilities are observed and supported by cooperating agencies, industry, and technical associations
   - Potential end users are enlisted to support the field pilot stage
   - Assesses results
   - Submits Final Report and recommends site/conditions for first application pilot stage
4. **First Application (Contract) Field Pilot Stage**
   - Works with potential end users to select site and to conduct pilot testing under real world operating conditions
   - Test specifications and standards are developed
   - Research assistance given to assure proper installation and operation
   - Problems are corrected and adjustments made, as necessary, to complete pilot testing
   - To the extent possible, potential end users operate the project under careful research surveillance
   - Assesses results
   - Submits Final Report and recommends initial sites for full corporate deployment
   - Potential end users are enlisted to support the field pilot stage
5. **Specification & Standards with Full Corporate Deployment Stage**
   - End users select site(s) and deploy the method/process/equipment using resident management, supervision, staff, and contracting forces (where applicable)
   - Deployment is without research supervision or direction
   - On call assistance is available upon request
   - Assesses results