Research Project Work Plan

for

Improved Safety and Efficiency of Protected/Permitted Right Turns in Oregon

Submitted by

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for

Oregon Department of Transportation
Research Section
555 13th Street NE
Salem, Oregon 97301

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1.0 Identification

1.1 Organizations Sponsoring Research

Oregon Department of Transportation (ODOT)
Research Section
555 13th Street NE
Salem, Oregon 97301
Phone: (503) 986-2700

Federal Highway Administration (FHWA)
Washington, D.C. 20590

1.2 Principal Investigators

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1.3 Technical Advisory Committee (TAC) Members

Mark Joerger, ODOT Research Coordinator
Phone: 503 986-3464; Email: mark.d.joerger@odot.state.or.us

TBD

1.4 Friends of the Committee

TBD

1.5 Project Champion

TBD

2.0 Problem Statement

The design of phasing schemes at signalized intersections are complex multifaceted transportation engineering problems. Right-turn operations place a significant challenge to engineers attempting to develop optimal phasing solutions for safety and efficiency. There is a surprising absence of specific guidance at the national and state level on how phasing alternatives should be selected, and how they compare in terms of operational and safety performance. Available documents such as the Traffic Signal Timing Manual (FHWA, 2008) or the ODOT Traffic Signal Policy and Guidelines (ODOT, 2013) are excellent resources, but critical questions remain with regard to what in-situ conditions: turning volumes (vehicles, bicycles, and pedestrians), vehicle classifications, lane configurations (single receiving lane for both right turns and conflicting lefts), and gap profiles warrant protected/permitted right turns. Turning vehicles are the primary collision risk for non-motorized users and when these turning movements need to be controlled directly, proper driver response to traffic control is critical.

The challenge of designing the phasing schemes for protected/permitted right turns in Oregon has been widely identified by local traffic signal experts, presenting an opportunity for a research-based solution. Staff members from ODOT, Washington County, Clackamas County, the City of Salem, and several other agencies have been participating in an ad hoc collaboration to identify and document issues, and have determined that the gaps in the existing knowledge necessitate new research. This need has intensified with the recent allowance of the Flashing Yellow Arrow (FYA) to indicate a permitted right turn (MUTCD, 2009). While traffic engineers have a good understanding of driver comprehension and response to the circular green ball or a solid green arrow for right turning movements, significant questions remain regarding the FYA for right turn movements, as well as driver responses to the solid red arrow in Oregon.

3.0 Objectives of the Study

The goal of the research is to develop an understanding of the safety and operational implications of using the FYA to indicate a permitted right turn, and to provide general guidance as to when Protected/Permitted Right Turns (PPRT) phasing should be used to maximize the safety of non-motorized road users and the overall efficiency of ODOT's signalized intersections.

4.0 Implementation

The research results will be formatted in such a way, that if the FYA in PPRT phasing is proven to be beneficial to the safety and operation of ODOT's intersections guidance will be added to the ODOT Signal Policy and Guidelines and possibly the ODOT Traffic Design Manual. This guidance will aim to establish thresholds similar to those currently provided by ODOT for left turn phasing and may include factors such as conflicting turning traffic volumes or suggestions as to when it is not appropriate to use permitted right turning, i.e. when it conflicts with a U-turn. Michael Kimlinger, Craig Black and

Scott Cramer are ODOT staff members committed to the effective implementation of these research results.

5.0 Research Tasks

Each of the specific tasks to be performed in the research project is described in the following section. The research will include five distinct tasks including preparation of a brief literature and crash data review, conduct of an online survey, a driving simulator study, and a software in the loop simulation, and preparation of the final report. These individual tasks are further described in the following sections.

Task #1: Complete a Brief Literature and Crash Data Review

Review past literature and practices related to the selection of right turn phasing alternatives to promote the safety and efficiency of alternative phasing schemes for right turn movements. This review would focus on mixed mode conflicts between right turning vehicles and bicycles and pedestrians and would consider research findings from the implementation of the FYA for permitted left turns. If any current related research projects are underway as identified in TRB's Research in Progress, the investigator will be contacted to clarify the research objectives to minimize any duplication of efforts. Preliminary analysis of Oregon crash data will be conducted to expand upon our understanding of right turning crash topology.

Time Frame: 3 months
Responsible Parties: David Hurwitz, OSU & Chris Monsere, PSU
Cost: $15,000
Deliverable: At the conclusion of Task #1, the project team will submit the draft literature review as *Interim Report #1*.
TAC Decision/Action: The TAC will review *Interim Report #1* and will provide comments. As appropriate, these comments will be incorporated in the *Draft Final Report*.

Task #2: Develop a Sampling and Subject Recruiting Plan

Develop a plan for engaging participants in the research. The participant sample will be controlled for age, gender, and education level, and 30 participants for the driving simulator study. Ten years of DMV driver age and gender data, sample size calculations, and a review of similar projects contributed to the proposed sample size. The sampling plan, planned testing activities, online survey, and post-drive questionnaire will be prepared and submitted for Institutional Review Board (IRB) approval.

Time Frame: 2 months
Responsible Parties: David Hurwitz, OSU
Cost: $10,000
Deliverable: At the conclusion of Task #2, the project team will submit the recruitment material, demographic survey, informed consent, and experimental protocol approved by the IRB at OSU.
TAC Decision/Action: None.

Task #3: Develop, Pilot, Conduct and Analyze Survey of Driver Comprehension

Conduct a survey of Oregon driver's evaluation of right turn phasing alternatives to establish relative rates of driver comprehension and self-reported driver responses. Survey will be designed to include the display (circular green ball, solid green arrow, FYA, and the solid red arrow) and the geometry of the receiving lane (single or multi-lane). Depending on the selected survey design, types of questions, and expected response rates, the survey will either online or mailed out. IRB approval for survey protocol and administration will be obtained from PSU IRB/ Human Subjects Research Review Committee.

Time Frame: 4 months
Responsible Parties: Chris Monsere, PSU
Cost: $15,000
Deliverable: At the conclusion of Task #3, the project team will prepare the results in *Interim Report #2*.
TAC Decision/Action: The TAC will review *Interim Report #2* and will provide comments. As appropriate, these comments will be incorporated in the *Draft Final Report*.

Task #4: Conduct Software in the Loop Simulation

Develop and calibrate a simulation model in VISSIM with software in the loop to explore the operational performance of PPRT phasing alternatives. A simulation-based approach will allow testing of a wider array of situations (volume ranges, delays, conflicts, etc.) while controlling for field variability. The simulation scenarios will be designed to inform the design of the driving simulator study by identifying feasible operational windows for PPRT timing approaches.

Time Frame: 4 months
Responsible Party: Chris Monsere, PSU
Cost: $20,000
Deliverable: At the conclusion of Task #4, the project team will prepare the results in *Interim Report #3*.
TAC Decision/Action: The TAC will review *Interim Report #3* and will provide comments. As appropriate, these comments will be incorporated in the *Draft Final Report*.

Task #5: Experimental Design and Coding of Simulation Test Environment

Develop a counterbalanced experimental design using the OSU driving simulator which includes the most meaningful traffic control configurations and scenarios identified from the literature review and static survey.

Task #5a: Determine the Dependent and Independent Variables

The dependent and independent variables and variable levels will be established. It is anticipated that independent variables such as PPRT phasing alternatives to be tested, variable vehicle and pedestrian traffic volumes, and alternative lane configurations. With the number of variables and variable levels determined, the total number of experimental scenarios will be set.

Task #5b: Develop the experimental counterbalance and test track

The sequence of the scenarios presented to the driver will be established. To minimize errors of confounding (influence of scenario sequence on subject performance) the scenarios will be counterbalanced. The counterbalancing strategy will depend on the number of variables and levels arrived at in Task #4a. Once the counterbalancing is arrived at, model test tracks will be developed showing the roadway segments that the driver will traverse identifying the locations of scenarios and distractors.

Task #5c: Code the Static and Dynamic Scenario Elements

The results of Task#3b provide the roadmap for coding the static and dynamic elements of the virtual environment the drivers will interact with. First, the static elements (roadway, pavement markings, adjacent land use, etc.) will be coded. Next the dynamic elements of the database (signal timings, vehicle volumes, bicycle volumes, etc.) are coded. Lastly, data collection protocols will be coded so that the correct measure are collected at the appropriate times and locations.

Task #5d: Beta Test the Experimental Design

With the experiment fully coded a beta test will be conducted. An estimated 3 to 5 subjects will participate in the beta test to verify that the experiment functions exactly as intended. Subject data will be analyzed to verify that the measures are captured where and when they should be. Any errors that appear in the experimental protocol or experimental scenarios will be corrected at this time before the full scale subject testing in Task #5.

Time Frame: 5 months
Responsible Party: David Hurwitz, OSU
Cost: $45,000
Deliverable: At the conclusion of Task #3, the project team will submit an *Interim Report #4* summarizing the experimental design. The report will include a list of the dependent and independent variables and levels, the counterbalanced scenario sequence and draft experimental course, and any challenges and modifications that were required as a result of the beta testing. Figures showing the images of the simulated designs to test. *TAC Decision/Action:* TAC will review *Interim Report #4*. The research team will schedule a short conference call to review with the TAC prior to beginning data collection in Task #5.

Task #6: Conduct Subject Testing in Simulator

Conduct driving simulation testing in which the study participants traverse the scenarios developed in the experimental design. Record the simulator data (eye tracking, vehicle position, and instantaneous speed) during the entire experimental trial for further analysis.

Time Frame: 4 months
Responsible Party: David Hurwitz, OSU
Cost: $25,000

Deliverable: None – Details on the progress of the task will be provided in the quarterly reports.

Task #7: Data Analysis

Analyze the simulator data collected to evaluate driver comprehension and response to each of the tested PPRT phasing alternatives, and the influence of confounding factors such as traffic volumes (vehicles, pedestrians, and bicyclists) and lane configuration (shared or exclusive).

Time Frame: 2 months
Responsible Party: David Hurwitz, OSU & Chris Monsere
Cost: $20,000
Deliverable: None – Details on the progress of the task will be provided in the quarterly reports.

Task #8: Prepare and Submit Draft and Final Reports

Prepare and submit a final report which describes the research study, conclusions, and recommendations.

Time Frame: 2 months
Responsible Party: David Hurwitz, OSU & Chris Monsere, PSU
Cost: $10,000
Deliverable: The result of this task will be a draft final project report followed by a final project report. Researchers will provide minutes of TAC meeting.
TAC Decision/Action: PIs will present the final report to the TAC at a meeting. The draft report will be submitted 7 to 10 days prior to the final TAC meeting. The TAC will review and provide written comments for the draft final report as appropriate. The Principal Investigator(s) will resubmit the final report with an incorporation of any TAC comments no less than 1 month after the final TAC meeting.

The following matrix summarizes the seven work tasks previously identified:

Task	Responsible Party(ies)	Approximate Cost
Task #1: Complete a Brief Literature and Crash Review *Time Frame:* 3 months *Deliverable:* Interim Report #1 (to be submitted at the end of Task #1). *TAC Decision/Action:* Review and comment as appropriate.	David Hurwitz & Chris Monsere	*$15,000*
Task #2: Develop a Sampling and Subject Recruiting Plan *Time Frame:* 2 months *Responsible Parties:* David Hurwitz, OSU *Cost:* $10,000 *Deliverable:* Recruitment material, demographic survey, informed consent, and experimental protocol approved by the IRB. *TAC Decision/Action:* None.	David Hurwitz	*$10,000*
Task #3: Develop, Pilot, Conduct and Analyze Survey of Driver Comprehension *Time Frame:* 4 months *Deliverable:* Interim Report #2 (to be submitted at the end of Task #3). *TAC Decision/Action:* Review and comment as appropriate.	Chris Monsere	*$15,000*

Task #4: Conduct Software in the Loop Simulation *Time Frame:* 4 months *Deliverable:* Interim Report #3 (to be submitted at the end of Task #4). *TAC Decision/Action:* Review and comment as appropriate.	Chris Monsere	*$20,000*
Task #5: Develop an Experimental Design *Time Frame:* 5 months *Deliverable:* Interim Report #4 (to be submitted at the end of Task #5). *TAC Decision/Action:* Review and comment as appropriate.	David Hurwitz	*$45,000*
Task #6: Conduct Subject Testing in Simulator *Time Frame:* 4 months *Deliverable:* 2 page summary of major findings *TAC Decision/Action:* None	David Hurwitz	*$25,000*
Task #6: Data Analysis *Time Frame:* 2 months *Deliverable:* 2 page summary of major findings *TAC Decision/Action:* None	David Hurwitz & Chris Monsere	*$20,000*
Task #8: Prepare and Submit Draft and Final Project Report *Time Frame:* 2 months *Deliverable:* Draft Final Report and Final Report *TAC Decision/Action:* Review and comment as appropriate.	David Hurwitz & Chris Monsere	*$10,000*

All reports will be produced in the standard ODOT Research Section report format unless some alternative format is deemed to be more appropriate as a supplement to the ODOT format. Quarterly reports will be submitted for each calendar quarter the project is active.

6.0 Time Schedule

This section specifies the time line for the project, listing the task headings and showing monthly and/or quarterly time blocks in which each task will be accomplished. Also shown are interim and final deliverables. The matrix below shows shaded cells and asterisks for designating task time lines and deliverables. For the purposes of this proposal, the starting date has been assumed as September 15, 2015; however, this date is flexible and the schedule will be modified to reflect actual contract start time at some future date. Total project duration will be a period of twenty months.

	FY16									FY17											
Project Tasks	**Qtr 2** Oct – Dec			**Qtr 3** Jan – Mar			**Qtr 4** Apr – Jun			**Qtr 1** July – Sep			**Qtr 2** Oct – Dec			**Qtr 3** Jan – Mar			**Qtr 4** Apr-Jun		
Task 1: Literature Review			* X																		
Task 2: IRB					*																
Task 3: Survey							*														
Task 4: SITL Simulation										* X											
Task 5: Simulator Design												*									
Task 6: Subject Testing																*					
Task 7: Data Analysis																		*			
Task 8: Final Report																			* X	*	

*Deliverables

x = TAC Meeting

7.0 Budget Estimate

An itemized budget for the project is shown below including total anticipated expenditures.

OSU Budget	
Personnel	**Total**
David Hurwitz, OSU	$
Graduate Students	$
Total Salaries	**$**
Fringe Benefits	
Faculty	$
Graduate Student (GRA)	$
Total Fringe Benefits	**$**
Total Personnel Costs	**$**
Travel	$
Services and Supplies	$
Simulator Hardware & Software Maintenance	$
Simulator Subjects (80 subjects)	$
Consulting (Technical Editing)	$
Student Tuition Waiver	$
Total Direct Costs for OSU	**$**
Indirect Costs for OSU Activity (26% State overhead rate)	**$**
Total OSU Project Costs	**$ 90,000**

PSU Budget	
Personnel	**Total**
Chris Monsere, PSU	$
Graduate Students	$
Total Salaries	**$**
Fringe Benefits	
Faculty	$
Graduate Student	$
Total Fringe Benefits	**$**
Total Personnel Costs	**$**
Travel	**$**
Services and Supplies	**$**
Student Tuition Waiver	$
Total Direct Costs for PSU	**$**
Indirect Costs for PSU Activity (45.5% Federal overhead rate)	**$**
Total PSU Project Costs	**$ 70,000**

Total Project Budget (OSU & PSU Combined)	
Total Salaries	**$**
Total Fringe Benefits	$
Total Personnel Costs	$
Travel	$
Services and Supplies	$
Student Tuition Waiver	$
Total Direct Costs	$
Indirect Costs	$
Total Project Costs	**$ 160,000**