

SPR 839 Work Order Authorization

**EXHIBIT A**  
**ODOT WORK ORDER AUTHORIZATION**  
**Agreement No. 30530 Work Order No. 21-08**

Under the terms of the Oregon Department of Transportation (ODOT) and Oregon State University (UNIVERSITY) Agreement dated 7/23/2015, which is hereby incorporated by reference, the following Project work is authorized:

**Project Name: BEST PRACTICES FOR WORK ZONE SAFETY DURING TRAFFIC CONTROL PLACEMENT, REMOVAL, AND MODIFICATIONS**

**ODOT Work Order Coordinator: Jon Lazarus, T 503-986-2852, E [jon.m.lazarus@odot.state.or.us](mailto:jon.m.lazarus@odot.state.or.us)**

**Total Authorized Amount of this Work Order \$166,000.00**  
**Expenditure Acct. No.: 21RF0839-000**

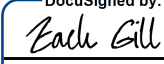
**Work Order Start Date: October 1, 2020**

**Work Order End Date: January 31, 2022**

Effective Date: No Work shall occur until signed by all parties.	State Totals
A. Amount authorized for this Work Order	\$166,000
B. Amount authorized on prior Work Orders	\$11,204,089
C. Total Amount authorized for all Work Orders (A+B=C)	\$11,370,089
D. Agreement Not-to-Exceed amount	\$25,000,000
E. Amount remaining on Agreement (D-C=E)	\$13,629,911

STATEMENT OF WORK is attached, and incorporated by this reference. *Please indicate which type of transportation research, policy analysis, or quality assurance services are to be undertaken by listing assumptions & expectations; roles and responsibilities; tasks; deliverable(s); deliverable due date(s); standards for work acceptance; and task breakdown, showing hours per task, estimated cost per task, and staff classifications and names assigned to each task, and summary of estimated cost per task. The work must be within the original scope of work in the Agreement.*

**ACCEPTANCE OF TERMS AND ACTION APPROVED BY ODOT: I acknowledge and certify that the work in this work order authorization is within the scope of work of the original Agreement.**

Name/Title	Date
ACCEPTANCE OF TERMS BY UNIVERSITY <small>DocuSigned by:</small>  <small>22F9C8D1-404E-481E-8000-000000000000</small>	10/26/2020   11:40:42 PDT
Name/Title	Date

Director of Sponsored Programs, Award Contracting  
 APPROVED AS TO LEGAL SUFFICIENCY: If work order exceeds \$150,000 signature required

Electronically Approved Herbert Lovejoy	Mon 10/19/2020 4:12 PM
Asst. Attorney General	Date
cc: UNIVERSITY	ODOT's Work Order Coordinator Construction Contracts Section, Support Services Branch for General Files ( <i>original</i> )

**Research Project Work Plan**  
**for**  
**BEST PRACTICES FOR WORK ZONE SAFETY DURING TRAFFIC**  
**CONTROL PLACEMENT, REMOVAL, AND MODIFICATIONS**

SPR 839

Submitted by

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for

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**September 2020**

**Research Project Work Plan  
for  
BEST PRACTICES FOR WORK ZONE SAFETY DURING TRAFFIC  
CONTROL PLACEMENT, REMOVAL, AND MODIFICATIONS**

**1.0 Identification**

1.1 Organizations Sponsoring Research

Oregon Department of Transportation (ODOT)  
Research Section  
555 13<sup>th</sup> Street NE  
Salem, OR 97301

Phone: (503) 986-2700

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

1.2 Principal Investigator

John Gambatese, PhD, PE(CA)  
School of Civil and Construction Engineering  
Oregon State University  
101 Kearney Hall  
Corvallis, OR 97331

Phone: 541-737-8913

1.3 Technical Advisory Committee (TAC) Members

Nick Fortey, FHWA Safety  
Cory Hamilton, ODOT District Manager 2B (R1)  
Justin King, ODOT State Traffic Work Zone Engineer  
Casey Evans, ODOT Transportation Maintenance Coordinator D9 (R4)  
Darrin Neavoll, ODOT District Manager 7 (R3)  
ODOT R2 Safety or Statewide Safety - pending  
Contractor representative (external) – pending  
Contractor representative (external) - pending

1.4 Research Coordinator

Jon Lazarus, ODOT Research Coordinator, *TAC Chair*  
[Jon.m.lazarus@odot.state.or.us](mailto:Jon.m.lazarus@odot.state.or.us)

Tel: 503-986-2851

1.5 Project Champions

Mike Kimlinger, State Traffic-Roadway Engineer & Section Manager  
Heidi Shoblom, State Roadway Engineer Unit Manager

## 2.0 Problem Statement

Safety in construction and maintenance work zones continues to be a top priority for ODOT and other transportation agencies across the country. The US Bureau of Labor Statistics (BLS) reports in its most recently published data that the construction industry experienced approximately 1,000 worker fatalities—more than three fatalities each work day—in 2018 due to construction operations (BLS 2020a). The industry with the second greatest number of fatalities is transportation and warehousing (BLS 2020a). The BLS data reveal that the rates of worker fatalities experienced in construction and transportation (9.5 and 14.0 per 100,000 full-time equivalent workers, respectively) are higher than all other industries except the agriculture, forestry, fishing, and hunting industry (23.4). BLS also reports that the rates of nonfatal occupational injuries and illnesses for the construction industry and the transportation and warehousing industry in 2018 were 3.0 and 4.5, respectively (BLS 2020b), both of which are higher than the rate for all industries combined (2.8). These rates amounted to approximately 200,000 injuries/illnesses in construction and 220,000 injuries/illnesses in transportation and warehousing.

Many of the fatalities and injuries occur as a result of motor vehicle crashes in which both workers and the travelling public are injured or killed. The US Department of Transportation (USDOT) reports that 36,560 people died in motor vehicle crashes on roadways across the US in 2018 (USDOT 2019). Of those crash-related fatalities, many occurred in work zones. In 2018, there were 755 fatalities in work zones (Workzonesafety.org 2019). Worker fatalities in work zones amounted to 124, and 238 involved large trucks or busses. Some of those injuries and fatalities occurred in Oregon.

Archival data shows that clearly there is room for improvement with respect to safety in construction and maintenance work zones. As a result, addressing and preventing work zone crashes is a high priority. Work zone injuries and fatalities have a high emotional impact on the public and our workforce. The impacts also go beyond the social and emotional effects of the loss of life and injured citizens. The cost associated with each fatal crash can amount to millions of dollars (Blincoe et al. 2015). Additional losses incurred by the public due to road closures, decreased mobility, and increased travel times as a result of crashes in work zones can have a negative impact on a state's economy (Blincoe et al. 2015).

### 2.1 Background and Significance of the Work

Studies have shown that drivers are at a higher risk of a crash when they are in a work zone (Hall and Lorenz 1989; Meng et al. 2010; Weng and Meng 2011). Research further suggests that the crashes that do occur in work zones are, on average, more severe than crashes that occur outside of work zones, and the crashes impact both workers and drivers (Bédard et al. 2002; Ha et al. 1995; Ullman et al. 2006). In addition, rate of speed is positively correlated to the severity of a crash; a higher rate of speed typically results in a more severe crash (FHWA 2018).

Past research studies sponsored by ODOT that were related to safety in construction and maintenance work zones focused on traffic control measures in place during the work operations (e.g., SPR 791, SPR 790, SPR 769, SPR 751, and ODOT Work Order No. 19-03). The studies

collected and analyzed data (typically vehicle speed data) after the traffic control was put in place and while the construction and maintenance work was being conducted. The studies successfully resulted in recommendations for the design of work zones and selection of traffic control measures to lower vehicle speeds, reduce crashes, and enhance work zone safety. Many of the recommendations are now being put into practice on current construction projects and during roadway maintenance.

Before the temporary traffic control is present on the roadway, time and effort are required to place it on the roadway. The temporary traffic control may need to be modified during construction, and must be removed after the work is complete. During these periods of time, the workers installing/removing/modifying the traffic control devices are often exposed to additional risk and/or different hazards than during the course of the work after the traffic control is set up. In addition, during these periods, passing motorists are transitioning from the normal traffic flow and patterns to the temporary traffic flow and patterns. These transition periods can create difficult roadway environments for both drivers and workers, create confusion about the driving path, distract drivers, and alter the driving path such that a queue temporarily develops that results in both safety and mobility impacts. Prior studies conducted by ODOT, however, did not address safety during the process to place, remove, and modify traffic control measures.

The safety issues created during these transition periods were mentioned in a recent ODOT Industry Staging Meeting involving ODOT staff, contractors, the Oregon Trucking Association, and other stakeholders in Fall 2019. During the meeting there was discussion about the prevalence of crashes, near misses, risky driver behavior, and hazardous worker exposures during the periods of time when traffic control measures are being put in place and removed from the roadway. Recent worker fatalities on Oregon roadways have occurred during the operations undertaken to set up or modify the traffic control.

Research has been conducted that addresses safety risk at specific locations within the work zone (e.g., the transition and active work areas) after the traffic control is set up. However, as mentioned above, prior ODOT research has not focused on best practices during the periods of time when the traffic control is being set up, removed from the roadway, and modified during the work operations. In addition, limited guidance is devoted in the *Oregon Temporary Traffic Control Handbook* (ODOT 2016) and the *Manual on Uniform Traffic Control Devices* (MUTCD) (FHWA 2012) to the process of placing, modifying, and removing traffic control, the sequence of activities during these operations, and the safety risks to be expected in each step of the operations. Performance of the work and safety of the workers during these operations are the contractor's responsibility. Due to the potential increased risk exposures during traffic control transition periods, research is needed to identify traffic control implementation practices that lead to hazardous situations and develop guidance to reduce the risk associated with these traffic control transition periods. Research questions that remain include:

1. What are the overarching principles and common practices associated with planning and executing the operations during the temporary traffic control transition periods?
2. What aspects of the set-up, removal, modification process are particularly hazardous and create high levels of risk for workers and motorists?

3. What guidance should be given to state DOTs and contractors to help improve safety during temporary traffic control transition periods?

The study aims to answer the research questions stated above. By doing so, the research is expected to provide a significant contribution to roadway work operations performed for and by ODOT. A significant amount of funding is spent by ODOT on construction and maintenance annually. According to its 2019-2021 budget, ODOT will spend \$567 million on highway maintenance, \$405 million on preservation projects, \$557 million on bridge projects, \$167 million for modernization of highways, and \$387 million on operations/safety programs (ODOT 2019). These amounts total to \$2.08 billion, which is approximately 46% of ODOT's \$4.52 billion budget for the biennium. Research shows that for every dollar spent on improving safety on a construction project, there is a return of three dollars in benefits to project cost (Ikpe et al. 2012). Cost savings through improved safety could be used for other ODOT needs, including expanding the scope of projects undertaken by ODOT.

A safe and efficient transportation system is a central component of ODOT's mission. Protecting the safety of both the traveling public and ODOT employees and other workers who build, operate, and maintain the state's transportation system is one of ODOT's core values. The proposed research will help ODOT fulfill its mission by further identifying ways to improve safety in construction and maintenance work zones, and by providing ODOT personnel and contractors with guidance to minimize and mitigate safety hazards associated with work zones.

### **3.0 Objectives of the Study**

The overall goal of this research is to develop additional knowledge and guidance for state transportation agencies and contractors that can be used to improve driver and worker safety on roadways. The part of work zone safety specifically targeted by the research is that during the set-up, removal, and modification of temporary work zones on high speed roadways. These operations are commonly performed by contractors on construction projects and by ODOT personnel when performing roadway maintenance. As described above, these operations also create unique hazards for workers and motorists to recognize, comprehend, and respond to, and have received limited attention in prior ODOT research.

The research will focus on temporary construction and maintenance operations on multi-lane, high-speed roadways (e.g., Interstates 5, 205, and 84 in Oregon). The work operations targeted will be those which include traffic control to close off one or more lanes of traffic to accommodate the work operations. For example, traffic control measures may be needed to reduce free flow traffic conditions by one or two lanes to allow for repaving or restriping on the roadway. The traffic control devices deployed in such situations may include temporary signage, barriers, striping, variable message signs, radar speed signs, flaggers, and other common traffic control technologies. Temporary barriers may include barrels or cones, or positive protection such as a Jersey barrier/K rail. Both daytime and nighttime operations will be considered for the study. Appropriate average annual daily traffic (AADT) levels for such cases will be reviewed with ODOT and considered within the research when selecting specific work operations and roadway locations to study.

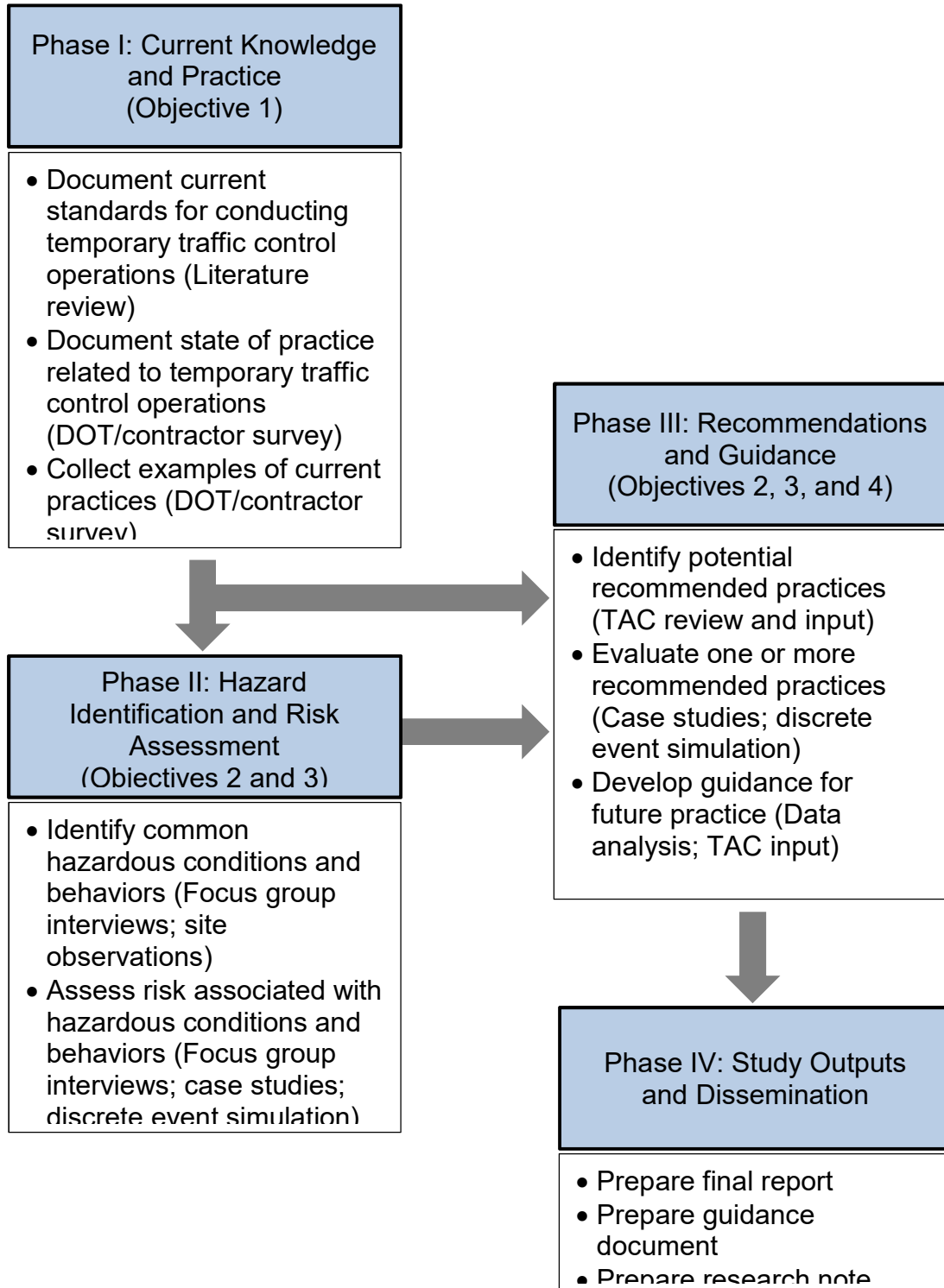
To meet this goal, the proposed research will involve examining the conditions and practices during traffic control set-up, removal, and modification to assess the associated risk and identify potential risk reduction measures. Specifically, the objectives of the research are to:

1. Document the guiding principles, common work practices, and corresponding risk exposures during traffic control transition periods;
2. Identify promising practices to improve safety during the transition periods;
3. Compare differences in risk and implementation feasibility associated with current and promising practices through both quantitative and qualitative measures; and
4. Develop guidance for ODOT and contractors to enhance safety during the transition periods.

Given that the study focuses on active work operations, the research will require close communication and cooperation with ODOT staff and construction contractors. For onsite observations and data collection, the researchers will discuss and coordinate performance of the study tasks with those involved in planning and performing the work operations. The research activities will be conducted such that they do not interrupt or inhibit the work operations, and do not put the workers and researchers at greater risk of injury.

Figure 1 depicts the overall research plan for meeting the study objectives. The study will be conducted via multiple tasks intended to collect knowledge relevant to the topic, evaluate current and recommended practices, and develop guidance for ODOT. The overall plan contains four main phases. The first phase (Phase I) will document existing knowledge and practice related to the operations conducted during temporary traffic control transition periods. Phase II involves hazard identification and risk assessment associated with the typical jobsite activities undertaken to set-up, remove, and modify temporary traffic control on the roadway. Phase III entails identifying and evaluating potential recommended practices to further improve worker and motorist safety during temporary traffic control transition periods. Completion of all three phases will be followed by the preparation and submittal of a final research report that will include guidance for future practice (Phase IV). Phase I is designed to address Objective 1, Phase II will contribute to Objectives 2 and 3, and Phase III supports Objectives 2, 3, and 4. Figure 1 also shows the research activities (i.e., data collection and analysis, and document preparation) to be conducted in each phase to fulfill the objectives.

The specific tasks in each phase, along with the data needed, are described in more detail in Section 5.0. As shown in the study timeline (Section 6.0), the phases will be performed primarily in series (i.e., Phase I, then II, then III, and lastly Phase IV), although there is some overlap in timing. The results of Phase I will, in part, inform the data to be collected and steps to be taken in Phase II. Similarly, Phase II outputs will support Phase III. The results of all prior phases will be accumulated in the outputs of Phase IV. Later phases will take into consideration the input received from the TAC at the identified milestones after each prior phase.





## Figure 1. Research Plan

### 3.1 Benefits

The research study is expected to provide ODOT and other transportation agencies with new information that can be implemented during future construction and maintenance work to help improve roadway safety. The study will provide information about hazardous situations during temporary traffic control operations, along with guidance to minimize the risk of worker and motorist injuries and fatalities. Such information can be utilized to strategically plan and execute work zone traffic control operations. The recommendations and guidance will help guide both ODOT staff and contractors on how to safely perform the set-up, removal, and medication operations on future projects. The ultimate benefactors will be the motorists travelling through the work zones and the workers on the roadway who create and work in the work zones.

The construction and maintenance programs within ODOT are extensive, with many workers on the roadways throughout the year all over the state. Each work zone exposes drivers and workers to risk of injury. On average, Oregon experiences approximately 500 crashes in work zones each year (ODOT 2017a; 2017b). Each crash has the potential to cause injury or death to a driver and/or worker. The proposed research has direct influence on the risk of injury/fatality related to work zones, a driving environment that often creates additional risk to drivers and impacts mobility. It is expected that the research will contribute to ODOT further reducing the number of crashes in work zones.

Safety and mobility affect the economic efficiency of both ODOT and the state's economy, as well as the public's perception of ODOT and construction contractors. A substantial portion of the public's interaction with ODOT operations occurs during roadway construction and maintenance. The guidance developed through the study will highlight ways in which ODOT and contractor interaction with the driving public, during the temporary traffic control transition periods, can be tailored to accommodate driver needs and behavior. Implementing this guidance is expected to result in better relations with the driving public as a result of roadway operations that minimize safety risk and mobility impacts. Improving safety and mobility will also lead to lower overall construction and maintenance costs and greater potential for ODOT to continue to support the state's economy and fulfill its mission.

### 4.0 Implementation

The study outputs will include guidance for efficient and effective placement, removal, and modification of temporary traffic control. This output is targeted at those ODOT and contractor personnel who plan such operations and also those who conduct such operations on the roadway. The output will be communicated in the form of a research report submitted to ODOT that describes in detail the conduct and findings of the study along with recommended guidance for implementation in practice. In addition, the researchers will prepare and submit to ODOT a research note that summarizes the study findings, potential impact, and recommendations for implementation. The research report and research note will be submitted to ODOT for publication and distribution.

As additional outputs, after the completion of this work order, the researchers plan to submit one or more papers on the study for publication in an academic journal and/or conference (e.g., Transportation Research Board Annual Conference). The researchers will also submit an abstract on the study for consideration as a presentation at the Northwest Transportation Conference following the completion of the study. Lastly, when invited and sufficient resources/time are available, the researchers will give presentations on the study at local and regional meetings, conferences, and workshops of organizations and associations (e.g., Asphalt Pavement Association of Oregon, and AGC of Oregon).

It is expected that the research outputs will be used by the ODOT Traffic Standards and Regions Traffic Control Plan designers as they plan and design traffic control for work zones. The results are expected to be incorporated into the activities of the Statewide Construction Office and implemented through communication and education of the Construction Project Managers statewide. Lastly, it is also expected that the guidance will be beneficial to and used by ODOT Maintenance personnel as they plan and implement temporary traffic control during maintenance operations.

## **5.0 Research Tasks**

As described in Section 3.0, the study will contain three phases, each containing multiple tasks. To start-up the research study, the first task (Task 1, TAC Meeting #1) will be to hold a kick-off meeting with the Technical Advisory Committee (TAC). The meeting is intended to introduce the study to the TAC members, gather their initial input and suggestions for the research tasks, and coordinate the collection of study data and identify potential case study projects.

Following the study kick-off meeting, the research team will conduct a detailed literature review (Task 2) to document current knowledge and practice. The literature review will target prior research, industry standards, and published practical guidance related to the placement, removal, and modification of traffic control for temporary work zones. The researchers will also conduct a survey of state DOTs and regional roadway construction contractors to help identify guiding principles and existing and promising practices (Task 3). The intent of the literature review and survey is to document the typical principles and practices for placing, removing, and modifying traffic control devices in construction and maintenance work zones, and identify practices that are not currently employed in Oregon but which could be further investigated for potential adoption.

The completion of Tasks 2 and 3 will provide the initial data needed for the study. Table 1 provides detail about the data needed with respect to each of the research objectives. The data will be collected and analyzed as part of the tasks as described below.

Table 1. Data Requirements for the Study

<b>Phase</b>	<b>Research Objective</b>	<b>Data Needed</b>	<b>Research Tasks</b>
I	1. Document current knowledge and practice	<ul style="list-style-type: none"> <li>Principles followed when planning traffic control operations</li> <li>Common practices employed with implementing traffic control operations</li> </ul>	2, 3
I, II, III	2. Identify promising practices	<ul style="list-style-type: none"> <li>Examples of practices in other states</li> <li>Suggestions for new practices</li> </ul>	1, 3, 5
II, III	3. Compare practices based on risk and feasibility of implementation	<ul style="list-style-type: none"> <li>Typical steps, order, and timing of traffic control operations</li> <li>Personnel and equipment used/needed for traffic control operations</li> <li>Hazards and exposures associated with the traffic control operations</li> </ul>	6, 7, 8
III	4. Develop guidance for future traffic control operations	<ul style="list-style-type: none"> <li>Characteristics and impacts of different options for traffic control operations</li> </ul>	9

Informed in part by the literature review and survey results, the researchers will also prepare a detailed description of the proposed research methodology (Task 4) for the remaining research tasks. The methodology is intended to provide further structure to, and confirmation of, the research plan following the knowledge gained from Tasks 1-3. The literature review, survey results, and draft research methodology will be submitted to the TAC for review and comment. A TAC meeting (Task 5, TAC Meeting #2) will be held to discuss the documents and prepare for the next steps in the study. Feedback from the TAC will be incorporated into the final versions of each document. The completion of Tasks 1-5 will constitute the completion of Phase I of the study.

Starting with the list of common and promising practices identified in Phase I, Phase II will focus on evaluating the hazards present during the work practices and the risk associated with each hazard. This phase will begin with Task 6 to gather input from industry and site observations regarding the hazards associated with traffic control operations. Task 6 is intended to expose those parts of the work operations in which the risk of vehicle crash and worker injury/fatality are especially high. Where possible, quantitative and qualitative measures from the literature will be used to quantify risks. Determination of the hazards and risk will also be accomplished through the use of

focus group interviews of DOT, construction, and traffic control personnel. The personnel will be asked to provide input on the safety issues present during the traffic control transition periods. For Task 7, the researchers will visit ongoing construction and maintenance operations to observe and document the typical traffic control operations in Oregon. During the observations, the prevalence of situations that pose high risk to workers (as indicated by the TAC) will be recorded for analysis. Speed data relative to the traffic control operations will also be collected. Given that the study focuses on an operational process, an analysis technique that incorporates time, such as discrete event simulation, will be used to account for hazards and risk at different points in the process. Completing Tasks 6 and 7 will constitute the completion of Phase II.

The outputs of Tasks 6 and 7 will provide information that enables identifying promising practices to study further. Task 8 will begin with obtaining the TAC's input regarding which practices to evaluate further in the field. It is expected that one or two promising practices will be selected to investigate further. Those practices selected will then be evaluated as part of Task 8. With ODOT's assistance, the researchers will identify potential projects on which to implement the selected practices. The practices will then be implemented by the construction contractors and/or ODOT staff. When implemented, the researchers will document the practice (e.g., videorecord the operation) and, while observing the operations, record any safety concerns and speeds of passing vehicles. Finally, the researchers will interview the workers to gain their perspectives on the feasibility of the recommended practices and their impact on safety.

Following the implementation and evaluation of promising practices, in Task 9 the researchers will prepare a draft guide that describes the recommended practices and supports ODOT personnel when implementing the practices on site. The guide will be provided to ODOT for review, evaluation, and feedback. The completion of Tasks 8 and 9 will constitute the completion of Phase III.

Lastly, the research findings will be documented in Phase IV (Tasks 10-14). The study activities will include the preparation, submittal, and presentation of a final research report that describes the study methods, results, conclusions, and recommendations for practical implementation of the results. A research note that succinctly summarizes the findings of the study will also be drafted and submitted to ODOT. The research report, research note, and guidance document will constitute the formal outputs of the study.

The specific research tasks to be undertaken, along with the timeline and budget associated with each task, are described in detail below. It is anticipated that, following the notice to proceed, the research activities will begin on September 1, 2020.

**Task 1: TAC Meeting #1 (Study Kick-Off Meeting)**

The PI will meet with the TAC and ODOT Research Coordinator to discuss and plan the overall study. The PI will prepare a presentation and supporting material for the meeting that further describe the research study and which can be used by the TAC to provide recommendations for the study. Following the meeting, the PI will incorporate the

information provided by the TAC into the study and, if needed, revise the planned research activities, schedule, and budget based on the input provided by the TAC.

- Time Frame:** October 2020  
**Responsible Party:** PI, ODOT Research Coordinator, TAC  
**Cost:** \$1,050  
**Deliverable:** TAC meeting attendance, TAC meeting presentation, TAC Meeting Minutes  
**TAC Action:** Review and understand project research problem statement, research questions, the limits of the research, and the project schedule. Advise ODOT Research Coordinator regarding any critical issues with the project's scope or schedule. Advise PI regarding related professional practices, standards, methods and context for the project.  
**ODOT Action or Decision:** Review TAC advice, discuss with PI, and if necessary direct PI to make changes to project documents.

### **Task 2: Draft Literature Review**

The literature review will focus on issues and information that are relevant to the process of placing, removing, and modifying temporary traffic control on high speed roadways. A variety of topics will be researched, evaluated, and presented as part of the literature review, including the following:

- The problem to be addressed, gap in knowledge, research question(s), and practical need for the study, including excluded related issues
- Theoretical context for the study
- Research methods that may be used to answer the research question, including a brief discussion of those methods proposed for the study and commonly applied methods that may not be appropriate for use on the study
- Data resources, including availability and quality of the data
- Prior research and findings related to the topic

The review will target literature contained in publicly-available academic and industry databases, such as the Transport Research International Documentation (TRID) database, ASCE Publications database, and other related online resources. Applicable state and federal standards, such as the *Oregon Temporary Traffic Control Handbook* (ODOT 2016) and the *Manual on Uniform Traffic Control Devices* (MUTCD) (FHWA 2012) will also be identified and reviewed. For example, Section 6F.77 Pavement Markings in the MUTCD states: "The work should be planned and staged to provide for the placement and removal of the pavement markings in a way that minimizes the disruption to traffic flow approaching and through the TTC zone during the placement and removal process." The literature review will be conducted and presented in accordance with common academic and industry standards.

- Time Frame:** November 2020 – February 2021  
**Responsible Party:** PI

Cost: \$13,285  
Deliverable: Draft Literature Review  
TAC Action: Read draft literature review and advise ODOT Research Coordinator regarding any gaps in the literature.  
ODOT Action or Decision: Review TAC advice, discuss with PI, and if necessary direct PI to make changes to the document.

### **Task 3: DOT and Industry Survey**

The researchers will conduct an online survey of state DOTs and construction contractors regarding their experience with and perspectives of operations related to the set-up, removal, and modification of temporary traffic control on high speed roadways. The intent of the survey is to gather additional information that is not, or cannot be, gathered from a literature review. In addition, the survey will provide perspectives from a wider range of the industry. The survey questionnaire will be developed using the online survey tool Qualtrics, and will be administered via an email containing a link to the survey questionnaire. The researchers will coordinate with ODOT staff for assistance with distributing the survey questionnaire to state DOT representatives. For distribution to construction contractors, the researchers will utilize their personal contacts and the contact information of roadway contractors found on industry association websites such as the AGC of Oregon and Washington, and AGC of America. Survey questions will be asked to collect the following information:

- Respondent demographics (e.g., position, years of work experience, type of work experience, work location/state, etc.)
- Description of the practices, and the sequence of the activities/tasks, typically undertaken to set-up, remove, and modify traffic control
- Those traffic control activities/tasks that are perceived to expose workers and motorists to the greatest safety risk
- Recommendations for maintaining safety during traffic control operations, along with examples of innovative means for traffic control operations

Prior to its distribution, the researchers will present a draft of the survey questions to the TAC for review and input, and to pilot test the online survey. Feedback from the TAC will be incorporated into the survey questions. Survey responses will be analyzed to capture trends in the industry and potential promising practices to evaluate in the study.

Time Frame: November 2020 – February 2021  
Responsible Party: PI, TAC  
Cost: \$20,275  
Deliverable: Initial draft survey questions for TAC review; Documentation of Institutional Review Board approvals for survey of human subjects; Description of survey results and findings.  
TAC Action: Pilot test the survey and provide feedback on survey questions; Review and provide feedback on survey results; advise ODOT Research Coordinator regarding additional analyses of survey results.

ODOT Action or Decision: Review TAC advice, discuss with PI, and if necessary direct PI to make changes to the document.

**Task 4: Draft Research Methodology**

This task includes identification and description of required data and study variables, and specification of analysis techniques to fulfill the remaining study objectives. The draft research methodology will document the proposed data collection including data availability, data quality, optional data, excluded data, costs, and risks to the study related to failure of the data collection. The draft research methodology will discuss sampling methods and identify the expected sample size. The draft research methodology will identify the metrics and kinds of statistical techniques that will be used to analyze the collected data. The draft research methodology will document approval for work with human subjects and protections of personal private information related to human subjects involved in the study.

Methods related to experiment design and data analysis will be drawn from existing literature and industry standards. The source of each method will be cited. When necessary, a justification of the selection of a given method over another commonly-used method will be documented.

Time Frame: January – February 2021

Responsible Party: PI

Cost: \$4,200

Deliverable: Draft research methodology section for final report; Documentation of Institutional Review Board approvals for any work with human subjects. Draft focus group survey tool. Draft metrics for onsite analysis.

TAC Action: Read draft research methodology in preparation for TAC Meeting #2.

ODOT Action or Decision: Schedule TAC Meeting #2

**Task 5: TAC Meeting #2**

The PI will meet with the TAC and ODOT Research Coordinator to discuss and plan the next steps of the study. This TAC meeting is intended to set the course for the completion of the study. The PI will prepare a presentation and supporting material for the meeting. Following the meeting, the PI will incorporate the information and recommendations provided by the TAC into the study and, if needed, revise the planned research activities, schedule, and budget based on the input provided by the TAC.

Time Frame: March 2021

Responsible Party: PI, ODOT Research Coordinator, TAC

Cost: \$3,585

Deliverable: TAC meeting attendance, TAC meeting presentation, TAC meeting agenda and minutes

TAC Action: TAC review of draft literature review and draft research methodology. Advise ODOT Research Coordinator regarding any

critical issues with the project's research design. Reach consensus regarding the content and methods contained in the draft research design and the next steps to take. Advise ODOT Research Coordinator regarding project next steps.

**ODOT Action or Decision:** Review TAC advice. Assess project potential for successful completion. If necessary direct PI to make changes to project documents. Provide formal acceptance of draft research methodology. Authorize PI to proceed with subsequent steps, notify by memo or email.

### **Task 6: Focus Group Interview**

The researchers will gather input from ODOT and industry personnel regarding the hazards associated with traffic control operations. This task is intended to expose those parts of the work operations in which the risk of vehicle crash and worker injury/fatality are especially high. Determination of the hazards and risk will be accomplished through the use of focus group interviews of DOT, construction, and traffic control personnel. One or more focus group interviews will be convened. The TAC members will be asked to participate in the focus groups. A list of questions will be developed to guide the focus group discussion. Questions will be asked to gather the following information:

- For those traffic control activities/tasks identified in the previous tasks, the safety issues associated with each activity/task
- The perceived relative risk associated with each traffic control activity/task
- Those activities/tasks that the research study should focus on to improve safety
- Ideas for how to change the traffic control operations to mitigate the perceived risk

The researchers will record the discussions for subsequent analysis. The analysis will target common trends and themes that are exposed during the focus group discussions. Where possible, quantitative and qualitative measures from the literature and ODOT sources will also be used to quantify risks. For example, near misses and crashes that are reported by ODOT Maintenance personnel could be reviewed to identify the traffic control conditions and actions in which safety issues commonly occur. This information, along with the extent to which the traffic control operations take place, can be used to assess the risk associated with specific parts of the operation.

**Time Frame:** April – July 2021

**Responsible Party:** PI, TAC

**Cost:** \$14,340

**Deliverable:** Results of focus group interviews

**TAC Action:** Review results of focus groups. Advise ODOT Research Coordinator regarding any additional suggestions and next steps for the study.

**ODOT Action or Decision:** Review TAC advice, discuss with PI, and if necessary direct PI to make changes to the next steps.



**Task 7: Onsite Observations**

The researchers will visit ongoing construction and maintenance operations to observe and document typical traffic control operations in Oregon. Two to three different construction and/or maintenance operations will be observed based on the availability of operations. The researchers will collaborate with ODOT staff to identify available operations to observe. During the observations, the prevalence of situations that pose high risk to workers will be recorded for analysis. This task will only include observations; no changes to the planned operations will be made or new treatments applied and evaluated at this point. Following the observations, and with hazard and risk information collected in prior tasks, the researchers will analyze the operations to assess the associated risk and identify potential changes to the operations. Given that the study focuses on an operational process, an analysis technique that incorporates time, such as discrete event simulation, will be used to account for hazards and risk at different points in the process.

Time Frame: May – July 2021

Responsible Party: PI

Cost: \$16,071

Deliverable: Results of onsite observations and analysis

TAC Action: Review results of onsite observations and analysis. Advise ODOT Research Coordinator regarding any additional suggestions and next steps for the study.

ODOT Action or Decision: Review TAC advice, discuss with PI, and if necessary direct PI to make changes to the next steps.

**Task 8: Selection, Implementation, and Evaluation of Promising Practices**

Task 8 will begin with obtaining the TAC's input regarding which practices (identified in prior tasks) to evaluate further in the field. It is expected that those tasks which are deemed to be promising but which further data and analysis are needed to verify their feasibility and benefit will be selected. The TAC will be asked to select one or more promising practices to investigate further through implementation as part of actual temporary traffic control operations, and within the time and budget constraints of the study.

After identifying promising practices to study further, the researchers, with ODOT's assistance, will identify at least three potential projects (case studies) on which to implement the selected practices. The case study projects are expected to be located on high speed roadways (e.g., Interstate 5) in Oregon, and involve temporary closure of one or more lanes of traffic to allow the construction work to proceed. It is also expected that the traffic control design on the projects will be similar to that typically designed for construction and/or maintenance work in Oregon. The promising practices will be evaluated on the selected case studies. The evaluation will be to confirm the promising practices are implementable with desired positive benefits. The research team's goal will be to find case studies that can allow the research team to observe and collect data without interfering with the contractor's work. The researchers will aim to select case

study opportunities for evaluation and implementation that allow for maintaining the planned study schedule, however, due to the lack of control that the researchers have over the roadway construction, as well as higher priorities to operate/maintain the transportation system, case study evaluation may be delayed and affect the research project schedule.

The roadway construction field staff will be asked to conduct their operations according to two procedures: as originally planned (without the new, promising practice – called “control”), and as revised with the promising practice (called “treatment”). Data will be collected for two days of control and two day of treatment on each case study project. The data collected on the control days will be used as the baseline for comparison. For both the treatment and control cases, the researchers will document the operations (e.g., videorecord, photograph, and record pesonal observations) and record any observed benefits, limitations, and safety concerns. The observations and video recording will be performed from inside the work vehicles, inside the researchers’ personal vehicles, and/or at a safe location in the right-of-way (e.g., on the shoulder/median) depending on the nature of the operation and the traffic and site conditions. Vehicle speeds adjacent the traffic control operations will also be recorded. To place the speed sensors on the roadway, OSU will need assistance from ODOT personnel and/or the contractor (e.g., rolling slowdown). Finally, while onsite, the researchers will interview the workers to gain their perspectives on the feasibility of the promising practices and their impact on safety.

The researchers will analyze the data collected to assess the impacts of the applied treatment(s) and highlight the potential feasibility and value of their application in practice. Discrete event simulation (DES) or similar analysis technique that allows for analysis at discrete points in time during the work operation will be used. DES is used to model the operation of a system as a series of distinct events in time. Each event occurs at a particular instant in time and marks a change of state in the system. Between consecutive events, no change in the system is assumed to occur. This assumption allows for directly stepping to the occurrence time of the next event. For application to the operations associated with temporary traffic control, the researchers will use DES to evaluation the hazards and risk at different points in time during the operation, which will then allow for quantification of the cumulative risk for the entire operation. Comparisons of risk will be made for both the control and treatment cases to objectively show whether the treatment is beneficial.

*Time Frame:* July – December 2021  
*Responsible Party:* PI  
*Cost:* \$38,030  
*Deliverable:* Results of onsite implementation and data analysis (provided in final report)  
*TAC Action:* Review results of onsite implementation and data analysis. Advise ODOT Research Coordinator regarding any additional suggestions for the analysis.

ODOT Action or Decision: Review TAC advice, discuss with PI, and if necessary direct PI to make changes to the analysis.

**Task 9: Develop Guidance Document**

The results of the application and evaluation of the practices (Task 8) combined with the findings from the literature review, focus groups, survey, and onsite observations, will inform the development of recommendations for set-up, removal, and modification of temporary traffic control. These recommendations will be described in a guidance document that provides detailed information for ODOT staff and contractors to help them plan and implement traffic control operations. Following initial development of the guidance, the researchers will consult with the TAC to obtain their input. Feedback from the TAC will be incorporated into the final version of the document.

Time Frame: January – March 2022

Responsible Party: PI

Cost: \$10,475

Deliverable: Draft guidance document

TAC Action: Review draft guidance document. Advise ODOT Research Coordinator regarding any additional suggestions for the document.

ODOT Action or Decision: Review TAC advice, discuss with PI, and if necessary direct PI to make changes to the document.

**Task 10: Draft Final Report**

The researchers will prepare a publication-ready draft final report according to the prescribed ODOT report format. The report formatting will include the prescribed fonts, spacing, citations, and graphics. Report contents will include: an updated abstract (in accordance with ANSI/NISO Z39.14-1997, Rev. 2015, “Guidelines for Abstracts”), acknowledgement, disclaimer, introduction, updated literature review (Task 2), final research methodology (Task 4), draft description and analysis of data collected (Tasks 3, 6, 7, 8), discussion of results, conclusions, and potential for future research, application, or technology transfer, and other sections as appropriate. The report will also include the guidance document (Task 9).

Time Frame: April – July 2022

Responsible Party: PI

Cost: \$19,235

Deliverable: Draft final report using ODOT’s report template

TAC Action: TAC review and feedback to the ODOT Research Coordinator

ODOT Action or Decision: Review and counsel prior to final TAC meeting

**Task 11: Draft Research Note**

The researchers will write a 1,000 – 1,500-word summary of the research study. The summary will concisely document the research findings, value of the research to the agency, science, and society, and any limitations on the use of the findings. ODOT will provide a template for the research note. The research note will serve as an executive

summary of the study. The final research note is intended for distribution to the general public and will have a Flesch-Kincaid Grade Level between eight (8) and thirteen (13).

*Time Frame:* April – July 2022  
*Responsible Party:* PI  
*Cost:* \$8,703  
*Deliverable:* Draft research note using ODOT's template  
*TAC Action:* None  
*ODOT Action or Decision:* Review and advise regarding modifications

**Task 12: TAC Meeting #3**

This TAC meeting will include a review of the draft final report and draft research note prior to the TAC meeting. The PI will prepare a presentation and supporting documents to be presented at the TAC meeting that describe the results of the study and recommendations. The TAC will offer advice on the content and clarity of these work products. The TAC will also advise on post research implementation.

*Time Frame:* July 2022  
*Responsible Party:* PI, assisted by the ODOT Research Coordinator, TAC  
*Cost:* \$3,440  
*Deliverable:* TAC meeting attendance, TAC meeting presentation, TAC meeting agenda and minutes  
*TAC Action:* TAC review of draft final report and draft research note. Advise ODOT Research Coordinator regarding any required final edits to the draft final report and draft research note  
*ODOT Action or Decision:* Review TAC advice. If necessary direct PI to make changes to project documents

**Task 13: Final Report**

Revise draft final report to incorporate edits identified by the ODOT Research Coordinator after the last TAC meeting.

*Time Frame:* August 2022  
*Responsible Party:* PI  
*Cost:* \$8,375  
*Deliverable:* Final Report  
*TAC Action:* None  
*ODOT Action or Decision:* Review report. Provide formal acceptance of Final Report. Publish Final Report on ODOT's research website.

**Task 14: Final Research Note**

Revise draft research note to incorporate edits identified by the ODOT Research Coordinator after the last TAC meeting.

*Time Frame:* August 2022  
*Responsible Party:* PI



2. Draft Literature Review									
3. DOT and Industry Survey									
4. Draft Research Methodology			*						
5. TAC Meeting #2									
6. Focus Group Interviews									
7. Onsite Observations				*					
8. Evaluation of Practices									
9. Develop Guidance Document						*			
10. Draft Final Report								R	
11. Draft Research Note								*	
12. TAC Meeting #3									
13. Final Report								F	
14. Final Research Note								*	

\* Deliverable

R - Draft report submitted for ODOT review

F - Revised report submitted to ODOT for publication. End of contract.

## 7.0 Budget Estimate

An itemized budget for the study is shown in the table below. The budget is shown for each task by fiscal year and in total. The budget includes the cost of the investigators' salaries and benefits, student researcher tuition, minor supplies and equipment, travel to meetings and field test sites, and University indirect (F&A) costs.

Since the specific promising practices to be evaluated as part of the study (Phase III, Task 8) are not known at this time, the budget does not include the purchase/lease of equipment or supplies associated with the practices, if any. The cost of purchasing and/or leasing traffic control equipment and supplies to be evaluated in the research will be determined at a later date and added to the study budget with approval from ODOT.

In addition, the cost of utilizing ODOT personnel and resources to assist with the data collection, if needed, is not included in the budget estimate. It is assumed that, if needed, ODOT will provide the needed personnel and resources to support the data collection and cover the associated costs.

Task	FY 2021	FY 2022	FY 2023	Total
	7/1/2020 – 6/30/2021	7/1/2021 – 6/30/2022	7/1/2022 – 6/30/2023	
1. TAC Meeting #1	\$1,050	\$0	\$0	\$1,050
2. Draft Literature Review	\$13,285	\$0	\$0	\$13,285
3. DOT and Industry Survey	\$20,275	\$0	\$0	\$20,275
4. Draft Research Methodology	\$4,200	\$0	\$0	\$4,200
5. TAC Meeting #2	\$3,585	\$0	\$0	\$3,585

6. Focus Group Interviews	\$12,340	\$2,000	\$0	\$14,340
7. Onsite Observations	\$14,071	\$2,000	\$0	\$16,071
8. Evaluation of Practices	\$0	\$38,030	\$0	\$38,030
9. Develop Guidance Document	\$0	\$10,475	\$0	\$10,475
10. Draft Final Report	\$0	\$14,235	\$5,000	\$19,235
11. Draft Research Note	\$0	\$7,703	\$1,000	\$8,703
12. TAC Meeting #3	\$0	\$0	\$3,440	\$3,440
13. Final Report	\$0	\$0	\$8,375	\$8,375
14. Final Research Note	\$0	\$0	\$4,936	\$4,936
<b>Total (OSU Contract Amount)</b>	<b>\$68,806</b>	<b>\$74,443</b>	<b>\$22,751</b>	<b>\$166,000</b>
ODOT Support/management (ODOT)	\$6,000	\$11,000	\$2,000	\$19,000
<b>Total for ODOT (ODOT)</b>	<b>\$74,806</b>	<b>\$85,443</b>	<b>\$24,751</b>	<b>\$185,000</b>

## 8.0 References

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Work Order No. 21-08

### CONSULTANT BILLING FORM

Agency/Firm OSU FAP No. SPR 839 Billing No. \_\_\_\_\_

Project: BEST PRACTICES FOR WORK ZONE SAFETY DURING TRAFFIC CONTROL PLACEMENT, REMOVAL, AND MODIFICATIONS

Billing Period \_\_\_\_\_ through \_\_\_\_\_ Final \_\_\_\_\_

Authorized Amount \_\_\_\_\_ Percentage of Work Completed \_\_\_\_\_

Billing Amount \_\_\_\_\_ EA \_\_\_\_\_

### DETAIL OF PROJECT COSTS ARE ATTACHED.

CERTIFICATION OF CONSULTANT

*I certify to the best of my knowledge all amounts invoiced herein are for appropriate purposes and in accordance with the agreements set forth in the contract.*

\_\_\_\_\_  
Signature of Authorized Official Title Date

\_\_\_\_\_  
Person to contact for audit Address Phone No.

CERTIFICATION OF STATE OFFICIAL

*I have reviewed the above project, the local agency narrative report, and related costs and, in my opinion, subject to audit, the costs reflect the progress to date and are eligible for reimbursement in the amount of*

\$ \_\_\_\_\_.

\_\_\_\_\_  
Oregon Department of Transportation Certification Phone No. Date