Research Project Work Plan

for

Work Zone Intrusion Alert Technologies: Assessment and Practical Guidance

SPR 790

Submitted by:

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1.0 IDENTIFICATION

1.1 Organizations Sponsoring Research:

Oregon Department of Transportation (ODOT)
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Federal Highway Administration (FHWA)
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1.2 Principal Investigator (PI):

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1.3 Technical Advisory Committee (TAC) Members:

Jon Lazarus, ODOT Research Unit, Research Coordinator
Add others….

1.4 Project Champion:

1.5 Friends of the Committee:

2.0 PROBLEM STATEMENT

Roadway construction and maintenance operations commonly require workers to conduct their work in close proximity to ongoing traffic. Short-term work zones on high speed roadways often involve working adjacent to passing vehicles separated by only a line of tubular markers or drums. This worksite condition presents significant safety risk for both the workers and passing motorists. Inattentive or speeding drivers, careless workers, misplaced drums, and hazardous roadway conditions can lead to crashes and ultimately work zone injuries and fatalities. Other factors that can cause increased numbers of work zone crashes include: extensive nighttime work; lack of consistency of work zones; distracted drivers (e.g., cell phone use); and greater vehicle miles travelled.

Data from the Bureau of Labor Statistics (BLS) show that 962 workers were killed in road construction work zones from 2003 to 2010 (Pegula 2013). Studies conducted by Bryden and Andrew (1999; 2000) reported that work zone intrusion crashes accounted for 10% of all total traffic accidents and 8% of fatal injuries. For the last decade, the fatal injuries in work zones led to over 100 deaths every year, and the trend has been persistent (NHTSA 2014). Approximately 50% of these deaths were attributed to vehicles or mobile equipment striking the worker (Pegula 2013). Based on NYSDOT data collected from 2000 to 2005, Ulman et al. (2010) found that approximately 59% of the intrusion crashes occurred in work zones involving lane closures, 44% of which were the result of deliberate driver decisions and actions to enter the work zone (e.g., driver deliberately decides to enter closed lane to reach exit, intersection, or driveway). These studies highlight the importance of establishing an effective safety buffer between moving vehicles and workers in work zones, and any safety measures to prevent intrusion crashes can significantly enhance the overall safety level of work zones (Morgan et al. 2010).

Specific to the state of Oregon, a total of 14 deaths have been reported in road construction work zones from 2003 to 2013 (National Work Zone Safety Information Clearinghouse 2015). In an effort to develop effective mitigation measures, research has recently been conducted by ODOT to evaluate the impacts of various traffic control devices on high speed roadways (e.g., SPR 751 and SPR 769). These studies have targeted devices aimed at reducing vehicle speeds through work zones. However, the studies did not specifically address errant vehicles crossing the line of cones into the closed lane and entering the active work area. On occasion during the course of these studies, vehicles were seen mistakenly intruding into the work area on their own or while following behind a construction vehicle that was entering the active work area. When interviewed, construction personnel involved in the prior studies also commented that they have witnessed vehicles crossing into the work area. Errant vehicles driving into the work area is a serious safety risk for workers on the roadway and for the driving public.

New technologies are publicly available that alert workers of work area intrusions. The work zone intrusion incident on I-5 in Region 3 (https://www.youtube.com/watch?v=W2PeRyEr8MU) is an example where technologies could have added to the ability to detect intrusions and alert the workers. The following are examples of currently available technologies and technologies that have high potential for preventing injury due to work zone intrusions:

- SonoBlaster Dual Alert work zone intrusion alarm, by Transpo Industries: An impact-activated device attached to a barricade, cone, drum, or other traffic control device that emits a loud warning sound to the workers when the traffic control device is struck and knocked over. (http://www.transpo.com/SonoBlaster.html; cost approximately $170 each)
- Intellistrobe AFAD Lane Intrusion Safety System, by IntelliStrobe Safety Systems, LLC: An audible alarm and light system that is activated when a vehicle crosses over a pneumatic hose into the work area. (http://www.streetsmartrental.com/products/automated-flaggers-sales.html; cost approximately $21,000 each)
- Intellicone, by Highway Resource Solutions (UK): A lamp-integrated motion sensor attached to a traffic cone that can detect being hit by a vehicle and when vehicles cross between cones. An alert is sent wirelessly to a web portal to enable automated on-line reporting. (http://www.intellicone.co.uk; not yet commercially available in US)
- Wireless technologies, such as ultra-wideband and GPS, that could be used to create customized intrusion alert systems for short- and long-term work zones. (costs depend on the system design)
- Bluetooth systems that could be used to alert workers and drivers with active Bluetooth capabilities of the drivers' intrusion into a work area. (costs depend on the system design)

Prior work zone safety studies conducted by ODOT did not target work zone intrusions and the technologies available to warn of intrusions. Literature is available from the device manufacturers that describes the specifications of each individual technology; however no studies have been found that provide a comprehensive review and comparison of the available technologies and present recommendations for their use in practice. Objective evaluation is needed that addresses the capabilities and effectiveness of the technologies, ease of use, viable application conditions (e.g., short-term/long-term work zone; stationary/mobile operation; and nighttime/daytime shift), and current cost and feasibility of implementation.

3.0 STUDY OBJECTIVES

The overall goal of the research is to assist ODOT with enhancing the safety of motorists and workers in construction work zones on high-speed roadways. To meet this goal, the proposed research intends to assess the value and capabilities of an engineered control used in work zones. Specifically, the proposed research study is designed to provide ODOT traffic control, construction, and maintenance staff with guidance on the use of an intrusion alert system in work zones. To attain this goal, the research will include the following tasks:

1. Document the work zone intrusion alert technologies and practices that are currently available and being developed.
2. Select and pilot test a sample of intrusion alert technologies for evaluation and testing in ODOT work zones.
3. Evaluate each of the selected technologies in active ODOT construction and/or maintenance work zones.
4. Prepare documentation for ODOT that describe the capabilities and cost effectiveness of each technology evaluated.

5. Provide recommendations for use of the technologies on future ODOT construction and maintenance work zones.

The research will focus on technologies developed to alert workers of errant vehicle intrusions in the work area. Only work zone intrusion alert technologies that are currently available to the public will be included; the study does not include designing, fabricating, and testing new technologies. Available technologies that alert drivers of their passage into a closed work zone will also be considered for inclusion in the study.

The work zone intrusion technologies included in the study will be purchased, leased, and/or borrowed for the study. In addition, as described below, some of the technologies have been donated for use in the study. Equipment used to conduct the testing (e.g., roadway speed sensors, video cameras, etc.) is available for use from previous ODOT studies. New research equipment needed to conduct the testing will be purchased if needed. The researchers will be able to utilize their experience and knowledge learned from past ODOT studies to efficiently and effectively conduct the present research.

3.1 Benefits

ODOT will benefit from the proposed research by having comprehensive and accurate information about innovative technologies to improve safety in its work zones. The study will complement the previous work zone safety studies by providing additional knowledge of the performance of work zone safety measures. The study will also result in recommendations for implementing intrusion alert technologies on future projects. Implementation of intrusion alert technologies is expected to reduce the risk exposure of workers and motorists, and lead to fewer worker injuries and fatalities in work zones. Lastly, successful completion of the research and implementation of the research results are expected to strengthen the capability of ODOT in implementing advanced technologies related to work zone safety and intelligent transportation systems.

4.0 IMPLEMENTATION

The product of the research will be a report that describes the identification and testing of technologies that are feasible and effective in preventing work zone intrusion crashes, and provides guidelines and recommendations for their use in practice. The results and products of the research will be used by the Statewide Construction and Maintenance Offices for planning construction and maintenance work. The outputs will also be used by the Transportation Safety Division, and by the Transportation Safety Coordinators in each Region, as a resource for effectively designing work zones and planning construction and maintenance operations.

5.0 RESEARCH TASKS

The research will include multiple tasks aimed at gathering information about work zone intrusion alert technologies, gaining experiential input and advice from ODOT staff and practitioners, and testing technologies under controlled conditions and in active work zones. The following table

presents the tasks that will be undertaken to conduct the entire research study. The order in which the tasks will be conducted and their timing are shown in Section 6.0. The actual timing and duration of the live testing (Task 5) may vary depending on the construction schedule and progress of case study projects selected for this research and the technologies selected for inclusion in the testing. It is however expected that the selected case study projects will be undertaken in the 2016 construction season. The costs shown in the table exclude ODOT Administration costs. All reports will be produced in the standard ODOT Research Unit report format unless another format is deemed to be more appropriate as a supplement to the ODOT format.

ID	Task
1.	**Documentation of Technologies** Literature on currently available technologies and technologies that have high potential for preventing injury due to work zone intrusions will be collected and reviewed. To collect the literature, the researchers will conduct a comprehensive search of archival publications and the Internet using on-line search engines. All documents found that are germane to the research topic will be accessed and reviewed. Task 1 will lead to the creation of a catalog of the technologies for use during the research and in the future by ODOT. The catalog will contain a description of each technology along with associated benefits, limitations to its use, and summaries of findings from prior research on the technology. *Cost*: \$16,110* *Duration*: 2 months *Deliverable*: Interim report to the TAC describing the results of Tasks 1 and 2. Final report (see Task 7) which includes a description of the results of Task 1. *TAC Decision/Action*: TAC shall meet with the PI at the completion of this task to review the results of Tasks 1 and 2, and select a sample of technologies for pilot testing. TAC shall also meet with the PI at the completion of the study to review and provide input on the results and final report.
2.	**Survey of Current Practice** Task 2 is to conduct a survey of state DOTs, construction and traffic control contractors, equipment vendors, and automobile manufacturers. The survey will aim at documenting current and recommended practices, barriers, enablers, and impacts associated with work zone intrusion alert technologies. To conduct the survey, a questionnaire will be developed that addresses the aims listed above. The TAC will be asked to review the questionnaire and provide feedback. The questionnaire will be revised to incorporate the TAC's input, and then distributed by the researchers to the entities listed above. The survey sample will be developed based on input from the TAC, the researcher's personal contacts, and the companies and organizations identified in Task 1. Task 2 will lead to the identification of the status quo of the construction industry and its current best practice in terms of preventing work zone intrusion crashes.

	Cost:	$16,524*
	Duration:	3 months
	Deliverable:	Interim report to the TAC describing the results of Tasks 1 and 2. Final report (see Task 7) which includes a description of the results of Task 2.
	TAC Decision/Action:	TAC shall meet with the PI at the completion of this task to review the results of Tasks 1 and 2, and select a sample of technologies for pilot testing. TAC shall also meet with the PI at the completion of the study to review and provide input on the results and final report.
3.	**Pilot Testing of Technologies** Based on the results of Tasks 1 and 2, and input from the TAC, a sample of feasible technologies will be selected for pilot testing. Selection will consider technology availability, cost, ease of use, potential for improving safety, and potential for incorporating the technology in typical transportation control plans. Those selected for testing will be purchased, leased, borrowed, or if possible, acquired through a donation. Pilot testing will be conducted as initial testing of the selected technologies under controlled, off-roadway conditions. Each selected technology will be assessed to capture its capabilities, and record how it is implemented. The results of the pilot testing will be used to assess feasibility of use, capabilities, and limitations related to each technology under investigation. *Cost*: $77,940* *Duration*: 4 months *Deliverable*: Interim report to the TAC describing the results of Task 3. Final report (see Task 7) which includes a description of the results of Task 3. *TAC Decision/Action*: TAC shall meet with the PI at the completion of this task to review the results of Task 3 and plan the performance of Task 4. TAC shall also meet with the PI at the completion of the study to review and provide input on the results and final report.	
4.	**Selection of Technologies for Live Testing** Following completion of the pilot testing and analysis of the results, Task 4 is to conduct focus group sessions with ODOT personnel and construction contractors to identify and select specific technologies to implement and test in an active work zone. The TAC will be asked to recommend focus group participants from within ODOT and construction companies. The researchers will plan, schedule, and conduct the focus group sessions. In each session, feedback on each of the technologies will be solicited. Those technologies that are deemed promising by the focus group participants, and fit within the research budget, will be selected. In addition, the researchers will work with ODOT to select construction and/or maintenance projects on which to conduct live testing of the technologies. *Cost*: $16,938* *Duration*: 2 months (following completion of Task 3)	

	Deliverable: Final report (see Task 7) which includes a description of the results of Task 4. *TAC Decision/Action*: TAC shall meet with the PI at the completion of the study to review and provide input on the results and final report.
5.	**Implementation and Testing of Selected Technologies** Task 5 involves implementing the selected technologies on each case study project. Depending on the case study projects selected, it is planned to apply the technologies under different work zone conditions (e.g., construction and maintenance, short-term and long-term, daytime and nighttime, and stationary and mobile). Each selected technology will be implemented during actual work operations. The researchers will monitor the technology installation, use, and removal. The researchers will videotape the operations and monitor vehicle speeds as needed to assess each technology. The testing results of each technology will be evaluated and compared based on a variety of criteria including, but not limited to: ease of implementation and use, ability to detect intrusions, ability to warn of intrusions, sensitivity to false alarms, impact on risk to worker safety, and implementation cost. Upon the completion of testing, feedback on each technology will be collected directly from the construction and maintenance workers involved in each case study project. The live testing on multiple case study projects is expected to entail multiple days of observation. For budget purpose, it is assumed that the data collection will be conducted over three days on four different occasions (total of 12 days of testing). This testing is expected to require researcher travel to and overnight accommodations at the case study locations due to the proximity of the case study projects relative to Corvallis, OR. This task will use technologies obtained in Task 3; no additional technologies will be acquired. *Cost*: $58,770* *Duration*: 5 months (following completion of Task 4) *Deliverable*: Final report which includes a description of the results of Task 5. *TAC Decision/Action*: TAC shall meet with the PI at the completion of the study to review and provide input on the results and final report.
6.	**Data Analysis** The data collected from the case study projects will be analyzed to determine the feasibility, barriers, enablers, and impacts of each technology and develop guidance for future use of the technologies by ODOT. Where appropriate, multi criteria decision analysis will be applied to rank order the cost effectiveness of each technology. Such comparisons are expected to determine the relative benefits provided by each technology in preventing work zone intrusion crashes. *Cost*: $17,347* *Duration*: 3 months *Deliverable*: Final report which includes a description of the results of Task 6.

	TAC Decision/Action: TAC shall meet with the PI at the completion of the study to review and provide input on the results and final report.
7.	**Documentation and Dissemination** A draft final research report will be prepared and submitted to ODOT for review and comment. The draft report will present the findings of the research and provide recommendations to ODOT for implementation in practice. The draft final research report will be revised based on the comments received from ODOT, and a final research report will be prepared and submitted to ODOT for publication. *Cost*: $17,699* *Duration*: 3 months *Deliverable*: Final report which includes a description of the results of Task 7. *TAC Decision/Action*: TAC shall meet with the PI at the completion of the study to review and provide input on the results and final report.

* Budgeted costs for OSU only; excludes ODOT Administration costs.

5.1 Reporting

All reports will be produced in the standard ODOT Research Section report format provided to the Project Investigator by the Research Coordinator unless some other format is deemed to be more appropriate. The Project Investigator will be responsible for submitting reports of professional-level written composition equivalent to the writing standards of peer-reviewed journals. These writing considerations include grammar, spelling, syntax, organization, and conciseness.

The Project Investigator, in consultation with the TAC and Research Coordinator, will deliver to ODOT in electronic format the data produced during the project. The Project Investigator will ensure the data is labeled and organized to facilitate future access. ODOT shall warehouse the data.

5.2 Safety and Related Training

Prior to accessing ODOT right-of-way (ROW), all personnel who will work on ODOT ROW will complete safety training appropriate to the work to be performed within the ROW. The Project Investigator will notify Project Coordinator in writing (email accepted) prior to the first day of work within the ROW that all project personnel who will access ODOT ROW have been trained. Until all ROW work is completed, the Project Investigator shall notify Project Coordinator in writing (email accepted) annually that an active safety training appropriate to the work to be performed within the ROW has been completed by all personnel who will work on ODOT ROW.

6.0 TIME SCHEDULE

This section specifies the timeline for the project, listing the task headings and showing monthly time blocks in which each task will be accomplished. Also shown are interim and final deliverables. The proposed research is expected to take 18 months of effort, and for the purposes of this work plan, the starting date is planned for July 1, 2015. As indicated above, completion of Task 5 will depend on the schedule and progress of the case study projects selected for this research. The timeline shown below assumes that the case study projects will be conducted in the spring and summer of 2016. The timeline may change if the case study projects are conducted at later dates.

Project Tasks	FY2016												FY2017					
	Q1			Q2			Q3			Q4			Q1			Q2		
	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Task 1: Documentation of Technologies Duration: 2 months Deliverable: Interim report (with Task 2), and final report describing results of Task 1																		
Task 2: Survey of Current Practice Duration: 2 months Deliverable: Interim report (Tasks 1 and 2), and final report describing results of Task 2				* †														
Task 3: Pilot Testing of Technologies Duration: 3 months Deliverable: Interim report and final report describing results of Task 3							* †											
Task 4: Selection of Technologies for Live Testing Duration: 2 months Deliverable: Final report describing results of Task 4																		
Task 5: Implementation and Testing of Selected Technologies Duration: 5 months Deliverable: Final report describing results of Task 5																		
Task 6: Data Analysis Duration: 2 months Deliverable: Final report describing results of Task 6																		
Task 7: Documentation and Dissemination Duration: 2 months Deliverable: Draft and final reports describing entire research study																		* †

* = Deliverable
† = TAC Meetings

7.0 BUDGET ESTIMATE

An itemized budget for the research is shown below that presents the expenditures for each item by fiscal year and the total anticipated expenditures. The ODOT Administration expenses will be charged internally to the appropriate Expenditure Account (EA), which may involve ODOT staff time on-site, travel expenses, and deliverable reviews[1,2]. An estimated amount of $50,000 is included in the budget to cover the cost of the work zone intrusion alert technologies. This amount may be less depending on the technologies selected. The technologies to be included in the study will depend on the results of Tasks 1 and 2. The manufacturers/vendors will be contacted to solicit their donating the technologies for use in the study.[3]

Item	FY2016	FY2017	Total
Personnel			
John Gambatese, OSU (PI)	$13,696	$6,848	$20,544
Hyun Woo "Chris" Lee, OSU (Co-PI)	$9,838	$4,919	$14,757
Graduate Student Researchers, OSU (2)	$29,513	$17,118	$46,631
Undergraduate Student Researchers, OSU	$0	$0	$0
Total Salaries	$53,047	$28,885	$81,932
Fringe Benefits			
Faculty	$12,238	$6,354	$18,592
Graduate Student Researchers (2)	$4,213	$2,537	$6,750
Undergraduate Student Researchers	$0	$0	$0
Total Fringe Benefits	$16,451	$8,891	$25,342
Total Personnel Costs (Salaries + Benefits)	$69,498	$37,776	$107,274
Travel to project site	$2,410	$7,230	$9,640
Services and Supplies	$1,000	$1,000	$2,000
Total Direct Costs for OSU (sum of items above)	$72,908	$46,006	$118,914
Indirect Costs for OSU Activity (26.0%)[2]	$18,956	$11,962	$30,918
Major Equipment (Intrusion Alert Technologies)[3]	$50,000	$0	$50,000
Student Tuition	$15,960	$5,535	$21,495
Sub-total – OSU	$157,824	$63,503	$221,327
ODOT Administration[1]	$10,000	$8,000	$18,000
Total Estimated Costs	**$167,824**	**$71,503**	**$239,327**

[1] ODOT administration includes overtime for on-site participation during in-field site visits.
[2] The indirect cost rate for this study is 26% regardless of the source of funds.
[3] Estimated. The researchers have contacted the SonoBlaster vendor who has donated five SonoBlaster units for use in the study.

8.0 REFERENCES

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