

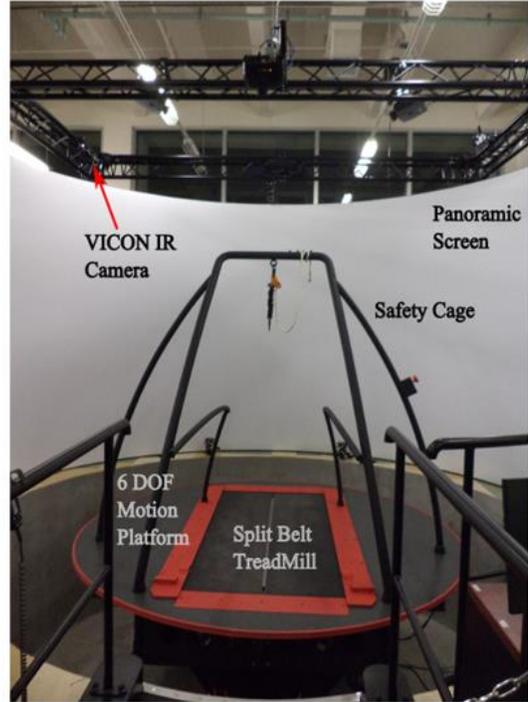
Request for Research Funding for FY 2023–2024

Project Number (Research Center Use Only): TEO-24-06

Requesting Office	State Traffic Engineering and Operations	Priority High	6 of 11
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Proposed Title Evaluation on Effectiveness of Countermeasures to Deter Impaired Freeway Wrong-Way Driving via Virtual-Reality Simulation

Justification	<p><i>Current Situation</i></p> <p>Although wrong-way crashes are random and infrequent, and represent a small percentage of total crashes, they have a high probability of severe injuries or fatalities compared to any other types of crash. Despite the smaller number, “losing a loved one to a preventable traffic crash is unacceptable, heartbreaking, and life-changing” (SHSP, 2021). A freeway wrong-way crash always has a significant societal impact after being reported on by the media. In addition, the monetary and societal costs of wrong-way driving (WWD) can be enormous due the likelihood of associated losses. The Florida Department of Transportation (FDOT) is one of the leading state agencies in the U.S. to develop and deploy innovative countermeasures to prevent and mitigate wrong-way driving. Supported by research, FDOT’s WWD Initiative explores various WWD countermeasure systems to aid in warning wrong-way drivers, sending notifications to alert other motorists, and notifying law enforcement. Based on an FDOT statewide study, off-ramps were identified that could be associated with higher rates of WWD entries. All 1,447 off-ramps (1,282 service off-ramps and 165 system-to-system off-ramps) on the State Highway System were analyzed. Based on a risk analysis, 520 off-ramps were found to be in WWD hotspots. FDOT evaluated several countermeasures from the research projects and found the Light-emitting Diode (LED) Highlighted WRONG WAY Sign (R5-1a) to be one of the most effective, followed by red Rectangular Rapid Flashing Beacons (RRFBs) and other countermeasures. However, due to most nighttime WWD incidents on freeways being associated with impaired driving, it becomes essential to investigate and identify effective countermeasures to deter impaired WWD.</p>
	<p><i>Research Needed</i></p> <p>Based on many previous studies, wrong-way crashes usually occur at night and are frequently associated with impaired driving. A study conducted by the National Transportation Safety Board (NTSB) on WWD found that of the 1,150 drivers whose blood alcohol content (BAC) was reported, 114 (10%) had a BAC of 0.08–0.15 and 684 (59%) had a “high BAC” of above 0.15. Based on this study, 69% drivers involved in WWD had a BAC of 0.08 or higher. An FDOT research project completed in 2015 (Boot 2015) assessed performance of participants wearing impaired goggles to simulate impaired WWD and concluded that alcohol and drug impairment appeared to be the largest risk factor associated with wrong way crashes. The researchers suggested that efforts should be continued with respect to reducing impaired driving. Although earlier research indicated that the LED Highlighted WRONG WAY Signs and red RRFBs are effective countermeasures in reducing wrong-way crashes, as are wigwag flashing beacons, large “Wrong Way” signs, and double “Wrong Way” signs, limited studies focused on evaluating countermeasures for deterring WWD for impaired drivers. The major objective of this proposed research is to evaluate the effectiveness of existing WWD countermeasures to determine their effectiveness for deterring impaired WWD and determine whether new WWD countermeasures are needed. FDOT will benefit significantly from knowing the effectiveness of countermeasures to reduce WWD that involves impaired drivers based on BAC levels as well as age groups and gender.</p> <p><i>Proposed Research Goal and Approach</i></p> <p>The major goal of this project is to research and evaluate WWD countermeasures to identify effective countermeasures and their degrees of effectiveness to deter impaired WWD via virtual-reality simulation. This project will follow Institutional Review Board (IRB) protocol to recruit, assess, and select 40-50 qualified participants to serve as “impaired drivers” for the study. Researchers will use the virtual-reality simulation system CAREN (Computer Assistive Rehabilitation Environment) on the USF Tampa campus, which can provide an immersive dynamic experience much better than traditional simulation systems to test driver impairment in a safe and simulated way. It can help to safely, accurately, and reliably simulate impaired WWD and aid in conducting a comprehensive assessment of driver behaviors based on BAC levels.</p> <p>During testing, drivers with different BAC levels will be asked to drive using the CAREN system that will simulate various freeway off-ramp WWD countermeasures under different scenarios. The behaviors of the drivers and their reactions to each WWD countermeasure, including LED highlighted WRONG WAY Signs, red RRFBs, and other selected countermeasures, will be observed based on BAC levels. The degrees of sensing by drivers will be measured using different scenarios—for example, drivers braking when they see a WWD countermeasure or reacting to instructions or warnings given by each countermeasure. The project team will include medical professionals to help screen qualified study participants and monitor the testing. IRB approval will be obtained. An agreement will be signed by each study participant to ensure there will be no liability to USF and FDOT. Incentives will be provided to participants for their participation for this research. The CAREN camera system can be used to observe driving behaviors of impaired drivers, and the human performance data and vital-sign data collected from CAREN sensors during the simulation can be used for detailed analysis to understand reactions from impaired drivers under different BAC levels to various WWD countermeasures, off-ramps, and roadway conditions.</p>



Images of State-of-the-Art CAREN Virtual-Reality Simulation System

Research Effects on FDOT Mission Critical Focus Areas

FDOT’s mission is to provide a safe transportation system that moves people and goods, improves economic prosperity, and preserves the quality of Florida’s environment and communities. The mission of the FDOT Traffic Engineering and Operations office is to improve safety and mobility through the efficient application of traffic engineering principles and practices. The focus areas of this proposed project are on both WWD and impaired driving. This proposed project fully aligns with the missions of FDOT and the Traffic Engineering and Operations office and will recommend appropriate WWD countermeasures to reduce wrong-way fatalities and injuries that involve impaired drivers.

Impact

The proposed research will involve a comprehensive evaluation of WWD countermeasures and determine their degrees of effectiveness to reduce impaired WWD. Previous research highlighted effective countermeasures for deterring WWD in general; however, knowledge of their effectiveness on impaired drivers involved in WWD is limited. A good understanding of the effectiveness of current WWD countermeasures to deter impaired WWD under various BAC levels could be impactful in reducing WWD-related fatalities and serious injuries. The outcomes could lead to important recommendations of effective WWD countermeasures for deterring impaired WWD or the need to identify other countermeasures if the current countermeasures are not effective. Overall, testing results and research findings could lead to major safety improvements for reducing fatalities and serious injuries caused by impaired WWD.

Consequences of not conducting the research include the following:

- FDOT would not obtain the results and findings on the degrees of effectiveness of current WWD countermeasures to deter impaired WWD under various BAC levels, age groups, and gender.
- FDOT would not know the driving behaviors of impaired drivers and their human performance and vital-sign information under different BAC levels.
- FDOT would not be able to compare the effectiveness of most popular LED highlighted WRONG WAY Signs and red RRFBs to deter impaired WWD with supporting information and data.
- FDOT would not be able to know whether new WWD countermeasures are needed to effectively deter impaired WWD.

Affected Offices Traffic Engineering and Operation Office, Safety Office, District Traffic Operations and Safety Offices.

Existing Work

- Huaguo Zhou, Qing Chang, Yukun Song, Mohammad Jalayer, Parisa Hosseini, Pei-Sung Lin, Cong Chen, Priscilla A. Tobias NCHRP 03-135 Project Report, Wrong-Way Driving Solutions, Policy and Guidance, Transportation Research Board (TRB) (This NCHRP report will be published in 2023)
- R.V., Ponnaluri, “The Odds of Wrong-way Crashes and Resulting Fatalities: A Comprehensive Analysis,” Accident Analysis & Prevention, 88, 2016, 105-116.
- R.V., Ponnaluri, “Modeling Wrong-Way Crashes and Fatalities on Arterials And Freeways” IATSS Research, 42(1), 2018, 8-17.

	<ul style="list-style-type: none"> • Pei-Sung Lin, Cong Chen, Elzbieta Bialkowska-Jelinska, “Testing and Evaluation of Thermal Camera-based and Video-Analytic Systems on Wrong-Way Driving, Stopped Vehicles, and Pedestrians,” Final Report, Project C9W13 TWO 18, prepared for Johnson, Mirmiran & Thompson, Inc. and for FDOT by Center for Urban Transportation Research, University of South Florida, October 2019. • Pei-Sung Lin, Cong Chen, Seckin Ozkul, “Evaluation on Implementation of Rectangular Rapid Flashing Beacons at Freeway Off-Ramps to Mitigate Wrong-Way Driving,” Final Report, FDOT Project BDV26 TWO 962-6, prepared for FDOT District 7 by Center for Urban Transportation Research, University of South Florida, December 2018. • Pei-Sung Lin, Cong Chen, Seckin Ozkul, “Testing and Evaluation of Freeway Wrong-way Driving Detection Systems,” Final Report, FDOT Project BDV25 TWO 977-40, prepared for FDOT by Center for Urban Transportation Research, University of South Florida, November 2018. • Pei-Sung Lin, Seckin Ozkul, Walter Boot, Priyanka Alluri, Rui Guo, Larry Hagen, “Comparing Countermeasures for Mitigating Wrong-Way Entries onto Limited Access Facilities,” Final Report, FDOT Project BDV25 TWO 977-29, prepared for FDOT by Center for Urban Transportation Research, University of South Florida, March 2017. • M. Pour-Rouholamin, H. Zhou, and J. Shawn, “Overview of Safety Countermeasures for Wrong-Way Driving Crashes, ITE Journal, 84(12), December 2014, 31-38. • P. Alluri, W. Wu, S.R. Nafis, C. Kadeha, and L. Hagen, “Strategies to Mitigate Wrong-way Driving Incidents on Arterials,” Final Report, FDOT Project BDV29-977-50, prepared for FDOT by Florida International University and Hagen Consulting Services, LLC, November 2019. • M. Pour-Rouholamin and H. Zhou, “Analysis of Driver Injury Severity in Wrong-Way Driving Crashes on Controlled-Access Highways,” Accident Analysis & Prevention, 94, 2016, 80-8. • M. Jalayer, R. Shabanpour, M. Pour-Rouholamin, N. Golshani, and H. Zhou, “Wrong-Way Driving Crashes: A Random-Parameters Ordered Probit Analysis of Injury Severity,” Accident Analysis & Prevention, 117, 2018 August, 128-135. • H. Zhou, J. Zhao, M. Pour-Rouholamin, and P.A. Tobias, “Statistical Characteristics of Wrong-Way Driving Crashes on Illinois Freeways,” Traffic Injury Prevention, 16(8), 2015, 760-7. • M. Jalayer, M. Pour-Rouholamin, and H. Zhou, “Wrong-Way Driving Crashes: A Multiple Correspondence Approach to Identify Contributing Factors,” Traffic Injury Prevention, 19(1), 2018 Jan, 35-41. • S.R. Nafis, P. Alluri, W. Wu, and B.G. Kibria, “Wrong-Way Driving Crash Injury Analysis on Arterial Road Networks Using Non-Parametric Data Mining Techniques,” Journal of Transportation Safety & Security, 2021, 1-29. 		
Keywords Used in Existing Work Search	Wrong-way driving, WWD, Wrong-way crashes, Red RRFB, LED Wrong Way Sign, Countermeasures, Freeways, Off-ramps, Alcohol, Impairment, Simulations, Virtual reality, Safety		
Related Contracts (Give contract numbers)	FDOT BDV26-762-6 “Evaluation on Implementation of Rectangular Rapid Flashing Beacons at Freeway Off-Ramps to Reduce Wrong-Way Driving” FDOT BDV29-977-29, “Comparing Countermeasures for Mitigating Wrong-Way Entries onto Limited Access Facilities” FDOT BDV29-977-40, “Testing and Evaluation of Freeway Wrong-Way Driving Detection Systems” FDOT BDV29-977-50, “Strategies to Mitigate Wrong-way Driving Incidents on Arterials” FDOT BDV30-977-10, “Driving Simulator Studies of the Effectiveness of Countermeasures to Prevent Wrong-Way Crashes” JMT/FDOT C9W13 TWO 18, “Testing and Evaluation of Thermal Camera-based and Video-analytic Systems on Wrong-Way Driving, Stopped Vehicles, and Pedestrians”		
Funding Request	\$280,000	Anticipated Duration	21 months
Project Manager	Edith Wong, P.E.	Contracting Method	Direct contract with Center for Urban Transportation Research (CUTR) at the University of South Florida, Dr. Lin
Urgency	Score - 4	WWD crashes and incidents always cause significant concern and attention, and impaired driving contributes significantly to wrong-way fatal crashes and injuries. There is an urgent need to understand the degrees of effectiveness of current WWD countermeasures and select the most effective one for widespread implementation to effectively reduce impaired WWD fatalities and injuries in Florida. It is important to identify the need for developing and testing other countermeasures to stop or effectively mitigate impaired WWD if existing countermeasures are not effective to reduce impaired WWD.	
Implementability	Score - 5	The findings and results from this research will help understand the degrees of effectiveness of current WWD countermeasures to deter impaired freeway WWD and help identify the most effective one for widespread implementation with supporting research results and data.	
Project Benefits (Succinct, complete explanation)			
<ul style="list-style-type: none"> • FDOT can obtain results and findings on the degrees of effectiveness of current WWD countermeasures to deter impaired WWD under various BAC levels. 			

<ul style="list-style-type: none"> • FDOT can know driving behaviors of impaired drivers and their human performance and vital-sign information under different BAC levels. • FDOT can compare the effectiveness of LED highlighted WRONG WAY signs and red RRFBs to deter impaired WWD. • FDOT can select the most effective WWD countermeasures to deter impaired WWD with supporting information and data. • FDOT can determine whether new WWD countermeasures are needed to effectively deter impaired WWD. 		
Project Benefits (Select all that apply and explain)	Quantifiable Benefits (units, dollars, etc....if applicable)	Methodology or Data Sources Used to Determine Quantifiable Benefits. If not applicable, please give justification of project benefits.
○ Materials Enhancement		
○ Materials Savings		
○ Time Savings	Reduction of vehicle delays due to impaired freeway WWD crashes	Most freeway wrong-way crashes occur at night, but the impact on vehicle delays at night is relatively low. If crashes cause freeway closure, then there will be more impact, and there will be some reduction in vehicle delays if there is a reduction in impaired freeway WWD crashes.
○ Lives Saved/ Injuries Prevented	Up to 28 lives saved and 300 injuries prevented per year (Up to \$327.7M of total cost saving per year for saving lives and preventing injuries)	<p>A recent AAA study revealed between 2015 and 2018, 135 people were killed in wrong-way crashes, averaging approximately 34 deaths per year in Florida (AAA, 2021). According to the study, 6 in 10 wrong-way crashes involved an alcohol-impaired driver. One study concluded that the odds of a fatal WWD crash on arterials was only 25% of that on freeways or toll roads (Ponnaluri, 2016), meaning that 80% of fatal wrong-way crashes occur on freeways or toll roads.</p> <p>With the implementation of an effective countermeasure to deter impaired WWD, avoiding even 50% of the impaired WWD deaths on divided highways could save lives and lead to an estimated yearly savings of \$103M ($=34*\\$10,100,000*6/10*50/100=\\$103,020,000$) for Florida, based on AAA data.</p> <p>Based on data obtained from the Traffic Crash Facts Annual Report published by the Florida Department of Highway Safety and Motor Vehicles for 2020, a total of 115 wrong-way fatalities and 1,249 wrong-way injuries occurred on Florida roadways in 2020. Given those numbers, the total savings for eliminating even 50% of the WWD fatalities on limited access roadways due to impaired driving in Florida would be \$278.8M ($=115*\\$10,100,000*6/10*50/100*0.8=\\$278,760,000$). For reducing 50% of the WWD injuries on limited access roadways due to impaired driving in Florida, the estimated savings would be \$48.9M ($=1,249*\\$163,254*6/10*50/100*0.8=\\$48,937,019$). The estimated total saving in social costs in terms of loss of productivity would be \$327.7M ($=\\$278.8M+\\$48.9M$).</p>
○ Other (Explain)		Reduction in the number of freeway fatalities, injuries, and crashes due to impaired WWD on freeways will increase FDOT's reputation for safety and the public's trust in and praise of FDOT's determination and actions to reduce impaired freeway WWD fatalities and injuries.