AASHTO Innovation Initiative

[Proposed] Nomination of Innovation Ready for Implementation

Sponsor

Nominations must be submitted by an AASHTO member DOT willing to help promote the innovation. If selected, the sponsoring DOT will be asked to promote the innovation to other states by participating on a Lead States Team supported by the AASHTO Innovation Initiative.

1. Sponsoring DOT (State): Florida Department of Transportation (FDOT)

2. Name and Title: Raj Ponnaluri, PhD, PE, PTOE, PMP

Organization: FDOT

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Innovation Description (10 points)

The term "innovation" may include processes, products, techniques, procedures, and practices.

3. Name of the innovation:

FDOT Statewide Wrong-Way Driving (WWD) Countermeasures Deployment Program

4. Please describe the innovation.

Wrong-Way Driving (WWD) crashes occur randomly and less frequently than other crash types; however, they often involve multiple vehicles, resulting in multiple fatalities and/or serious injuries. The FDOT has installed the required DO NOT ENTER and WRONG WAY signs and pavement markings (wrong-way arrow, etc.) per the Manual on Uniform Traffic Control Devices (MUTCD), as well as the higher Signing

and Pavement Marking Standards per FDOT Design Manual (FDM) Section 230.4. The FDOT has also been exploring various WWD countermeasure systems for warning wrong-way drivers, verification of the wrong-way vehicles and sending alerts to Regional Transportation Management Center (RTMC)/ Traffic Management Center (TMC) upon the detection of wrong-way vehicles. To reduce the number of WWD crashes more aggressively, the FDOT conducted a statewide study and identified the off-ramps which could be associated with WWD crashes. The study followed a data-driven approach and analyzed 1,447 off-ramps on the state highway system were analyzed. Based on a risk analysis, 520 off-ramps were found to occur in the WWD hotspots. The FDOT evaluated several countermeasures and found the Light Emitting Diode (LED) highlighted WRONG WAY signs to be one of the most effective countermeasures to warn a wrong-way entering motorist, notify other motorists and send alerts to RTMC/TMC. These highlighted wrong-way signs comply with the Manual on Uniform Traffic Control Devices (MUTCD). The FDOT has updated the FDM, the Standard Plans for Road and Bridge Construction (Standard Plans), the Standard Specifications for Road and Bridge Construction (Standard Specifications), and the Basis of Estimates Manual (BOE) with the details of the highlighted wrong-way signs through the publication of a statewide bulletin. Currently, the countermeasures are being deployed statewide with a significant number of off-ramps already completed.

5. What is the existing baseline practice that the innovation intends to replace/improve?

Prior to the FDOT undertaking the WWD countermeasure deployment initiative, there was no statewide consistent guidance to specifically address wrong-way entry at freeway off-ramps. The FDOT initiated the practice with developing a comprehensive standard for signing and pavement markings (S&PM) by publishing a statewide bulletin and updating the FDM Section 230.4 guidelines for freeway intersections. Simultaneously, the FDOT conducted pilot studies by deploying LED highlighted WRONG WAY signs and Red-Rectangular Rapid Flashing Beacons (RRFB) and studied their effectiveness in preventing WWD crashes along with other advanced countermeasures. Based on conducted statewide studies, the FDOT has developed a countermeasure implementation plan for deploying LED highlighted WRONG WAY signs at 520 hotspot off-ramps and gradually all statewide off-ramps. This does not replace any existing baseline practice, this initiative of S&PM implementation and advanced technology enabled countermeasures enhances the FDOT's capability to reduce WWD crashes.

6. What problems associated with the baseline practice does the innovation propose to solve?

The baseline practice did not include any specific countermeasure to prevent wrong-way entry at the freeway off-ramps. The S&PM deployment ensures consistent signing and pavement marking across the state that benefits motorists. The LED highlighted countermeasures provide enhanced warning to the wrong-way driving motorists which did not exist. Moreover, adopting a consistent practice will enable the FDOT to create a consistent driving experience along freeways statewide as well as a competitive market to deploy countermeasures at a lower rate. The LED highlighted countermeasures are also capable of tracking a wrong-way driver and send alerts to a Traffic Management Center (TMC). This enables TMC operators to quickly coordinate with law enforcement for dispatch and activate Dynamic Message Sign (DMS) or other warning systems to notify the right-way motorists of an the WWD.

7. Briefly describe the history of its development.

The hallmark of the ongoing WWD effort at the FDOT rests in continual consultation, coordination, and communication. The FDOT management's active suggestion to proactively address WWD concerns, fatal crashes became the trigger to seeding this program. The first step in the process can be traced to two important projects: one each in FDOT Panhandle region (District 3) and Florida's Turnpike Homestead Extension in south Florida. While the pilots were being deployed, the need for studying WWD crashes on limited-access facilities across the state became a priority. The WWD initiative thus took firm seeding in the ground with active consultations between the State Traffic Engineering and Operations (STEO) and District Traffic Operations offices. The statewide wrong-way studies helped to generate the new S&PM standard for ramp termini and provided input to a human factors study to understand the role of people's cognition to mitigating wrong-way potential. In the meantime, during fatal WWD incidents, the media inquiries and suggestions from well-meaning citizens helped the FDOT move forward with experimenting potential WWD warning devices at FDOT's Traffic Engineering Research Laboratory. The outcome of these device evaluations was to seek approval from the Federal Highway Administration (FHWA) on two Requests for Experiments: the red-RRFB and internally illuminated solar LED in-road pavement markers (IIPM). While the FDOT's public information officers actively worked toward addressing queries from the media and citizens, from a technology perspective, the FDOT developed and incorporated a WWD response module into its SunGuide® freeway management system. The essential feature of the method presented here is that, in addition to *engineering, education*, and *enforcement*, a fourth '*E*', i.e., the *evolution* of ways to mitigate WWD incidence should take center stage. From an engineering perspective, this work not only studied the WWD concern and developed a set of countermeasures in the form of design standards and guidance, but also understood ways to provide education and advocacy on concerns with driving under the influence of alcohol or drugs; this, while the Florida Highway Patrol worked closely with the FDOT and took a positively proactive approach to addressing WWD incidents when and where possible. STEO began working with the Florida Turnpike Enterprise (FTE), and Panhandle region to develop pilot projects. FTE and District 3 offices evaluated locations that may benefit from WWD pilot deployments. Considerations included prior crash history, 911 call information, if any, any available detail from the traffic management center (TMC), and Florida Highway Patrol's (FHP) citation information. The initial FTE pilot effort was on an 18-mile northern section of the Homestead Extension in South Florida. Initially, FTE deployed DO NOT ENTER, WRONG WAY, ONE WAY, No Left/U Turns, and Keep Right signs. Additional wrong-way arrows were added to the pavement along the exit ramps. Later, vehicle-alerting technology was implemented along with mainline detection of a WWD movement. Also, LED blinker signs with vehicle detection were included. STEO helped support the development of a module in the Department's SunGuide® software for decision-making at the TMCs. District 3, on the other hand, identified four I-10 interchanges for designing and implementing WWD countermeasures in the Tallahassee area. Similar to the FTE, this pilot project installed additional S&PM and vehicle-activated wrong-way blank-out signs. Overhead guide sign trusses provided an opportunity to include large WRONG WAY sign panels. Interstate pavement shields with straight arrows were added to the adjoining arterial turn lanes. While the above process was underway, FDOT's District 7 region comprising Tampa Bay had been experiencing several fatal WWD crashes. As a result, the District Office conducted an

inventory of exit ramps, upgraded S&PM districtwide, and installed red RRFBs. A statewide study of the baseline situation of signing and pavement marking identified some specific signs and pavement marking that could potentially reduce wrong-way entries. Another human-factor study investigated the effectiveness of the S&PM in a simulation environment. The combined findings from both of these studies were used to develop the new S&PM which have been deployed throughout state at all off-ramps. Another study compared the effectiveness of seven WWD countermeasures that were deployed in different pilot projects statewide and compared their effectiveness by comparing before and after crash data, field testing using focus groups, a public opinion survey, and a human factors approach using driving simulation. Another comprehensive data driven study identified the WWD hotspots based on WWD crash data and other factors including impaired drivers, drivers aged 65 years and older, and tourists. The study identified 520 off-ramps in the state for priority deployment. The FDOT has allocated $15 million in two years for deploying LED highlighted countermeasures at these 520 off-ramps. A significant portion of the off-ramps are already deployed and other in design phases. Gradually all off-ramps will be deployed with S&PM countermeasures and LED highlighted signs with TMC WWD warning system and communication to the TMC capabilities.

8. What resources—such as technical specifications, training materials, and user guides—have you developed to assist with the deployment effort? If appropriate, please attach or provide weblinks to reports, videos, photographs, diagrams, or other images illustrating the appearance or functionality of the innovation (if electronic, please provide a separate file). Please list your attachments or weblinks here.

FDOT's WWD initiatives webpage: https://www.fdot.gov/traffic/its/projects-deploy/wrong-way-driving

Statewide Bulletins: FDOT has issued two statewide bulletins. One of the bulletins was for deploying S&PM countermeasures at all off-ramps. Bulletin link: https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/traffic/traffic/doc_library/pdf/rdb15-08.pdf?sfvrsn=1caac098_0

FDOT has issued another bulletin to deploy LED highlighted wrong-way signs at 520 off-ramps on a priority basis and gradually all off-ramps in the state. Bulletin link: https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/traffic/doc_library/pdf/wwd-joint-bulletin_revised-doc-310046356.pdf?sfvrsn=272ebb43_2

FDOT Design Manual Update: The countermeasures for WWD are outlined in FDM Section 230.4. Link: https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/roadway/fdm/2020/2020fdm230spavtmarkings.pdf?sfvrsn=9b9934b8_4

Standard Plans: FDOT Standard Plans Index 700-120 outlines the design details of a typical wrong-way sign assembly. (Link: https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/design/standardplans/2021/idx/700-120.pdf?sfvrsn=f16272b8_2)

Standard Specifications: In the FDOT Standard Specifications, the wrong-way vehicle detection

system requirements are outlined under sections 660-2.2.1.4 Wrong Way Vehicle Detection Systems, 660-3.7 Wrong Way Vehicle Detection Systems (WWVDS) Installation, and 660-4.4 Wrong Way Vehicle (WWVDS) Detection System. The color of LEDs on the highlighted wrong-way signs is specified in Section 700-3.2.2 Highlighted Signs. Configuration and communication requirements for the highlighted wrong-way signs are outlined in Section 995-2.7 Wrong Way Vehicle Detection Systems (WWVDS). Performance of the highlighted wrong-way sign assembly is outlined under Section 995-2.11 Wrong Way Vehicle Detection System (WWVDS) Performance. (Link: https://www.fdot.gov/programmanagement/implemented/specbooks/default.shtm)

Completed Research/Studies:

Title: Statewide Wrong-way Crash Study (link: https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/research/reports/statewide-wrong-way-crash-study.pdf?sfvrsn=e905dafb_2)

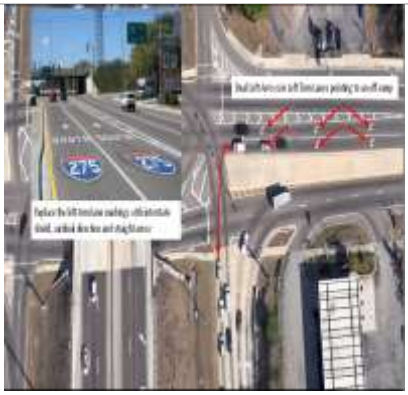
Title: Driving Simulator Studies of the Effectiveness of WWD Countermeasures (link: https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/research/reports/fdot-bdv30-977-10-rpt.pdf)

Title: Comparing Countermeasures for Mitigating Wrong-Way Entries onto Limited Access Facilities (link: https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/research/reports/fdot-bdv25-977-29-rpt.pdf)

Title: Testing and Evaluation of Freeway Wrong-way Driving Detection Systems (link: https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/research/reports/fdot-bdv25-977-40-rpt.pdf)

Title: A Data-Driven Approach to Implementing Wrong-way Driving Countermeasures (link: https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/research/reports/fdot-bdv29-977-36-rpt.pdf)

Attach photographs, diagrams, or other images here. If images are of larger resolution size, please provide as separate files.





State of Development (40 points)

Innovations must be successfully deployed in at least one State DOT. The AII selection process will favor innovations that have advanced beyond the research stage, at least to the pilot deployment stage, and preferably into routine use.

9. How ready is this innovation for implementation in an operational environment? Please select from the following options. Please describe.

☐ Prototype is fully functional and yet to be piloted

☒ Prototype has been piloted successfully in an operational environment

☒ Technology has been deployed multiple times in an operational environment

☒ Technology is ready for full-scale implementation

Through extensive research, the FDOT identified 1,282 ramps to be of particular interest in wrong-way driving (WWD) incidents. A total of 1,110 off-ramps out of 1,282 off-ramps were flagged for advanced countermeasure implementation. Again, 520 off-ramps of them were selected for priority deployment with an allocation of $15 million. The FDOT approach to improving these adverse incidents was implement signing and pavement markings (S&PM) and deploy with advanced detection and warning system through Light-Emitting Diodes (LEDs) surrounding the Wrong Way Signs. This is being conducted statewide.

10. What additional development is necessary to enable implementation of the innovation for routine use?

The FDOT coordinated with the Federal Highway Administration and internal FDOT offices. The FDOT issued the Traffic Engineering and Operations Bulletin 19-03 on July 1, 2019 with additional minimum requirements for limited-access facility exit ramp interchanges throughout the State of Florida. The highlighted wrong-way signs comply with the Manual on Uniform Traffic Control Devices (MUTCD). FDOT has updated the FDOT FDM, the Standard Plans for Road and Bridge Construction (Standard Plans), the Standard Specifications for Road and Bridge Construction (Standard Specifications), and the Basis of Estimates Manual (BOE) with the details of the highlighted wrong-way signs through the publication of a Joint Bulletin. FDOT is now currently including vendor products in its Approved Product List. Already a vendor has successfully completed all testing to be included while several others are in the process. FDOT has also developed and distributed Standard Operating Guidelines for RTMCs and Traffic Management Centers (TMCs) for consistent practice across the state in the event of wrong-way driving notification.

11. Are other organizations using, currently developing, or have they shown interest in this innovation or of similar technology?? ☒ Yes ☐ No

If so, please list organization names and contacts. Please identify the source of this information.

Organization	Name	Phone	Email
FDOT – District 7 Traffic Operations Engineer	Ronald Chin	813-975-6253	ronald.chin@dot.state.fl.us
FDOT – District 7 Traffic Operations	Peter Hsu	813-975-6251	ping.hsu@dot.state.fl.us
FDOT – Central Office Safety	Lora Hollingsworth	850-414-4177	lora.hollingsworth@dot.state.fl.us
FDOT – Central Office Safety	Brenda Young	(850) 414-4146	brenda.young@dot.state.fl.us

Potential Payoff (30 points)

Payoff is defined as the combination of broad applicability and significant benefit or advantage over baseline practice .

12. How does the innovation meet customer or stakeholder needs in your State DOT or other organizations that have used it?

WWD crashes occur randomly and less frequently than other crash types; however, they often involve multiple vehicles, resulting in multiple fatalities and/or serious injuries. With the updated S&PMs and LEDs surrounding WRONG-WAY signs at the high-risk ramps, the FDOT has been able to improve safety at these locations. A pilot study was conducted by the Florida's Turnpike Enterprise on its 17 off-ramps in the South Florida region. The off-ramps were equipped with ELD highlighted wrong-way signs with detection technologies and communication to the regional transportation management Center. The countermeasures also included verification cameras to verify if the wrong-way vehicles have turned around or not. Turn-around rate was used a measure of performance for the deployed systems. The deployed systems began operation in October of 2014. From the beginning of the operation to 2019, 110 confirmed cases of WWD entries were reported of which 107 (97%) turned around (self-corrected) after activation of the warning signs. Highlighted Wrong-Way signs have been proven to be one of the most effective wrong way countermeasure. These detection-triggered signs provide warning to motorists driving the wrong way on an off-ramp, send real-time alert to RTMCs for DMS activation and law enforcement dispatch, encourage wrong-way drivers to turn around and correct their path prior to entering the freeway thereby reducing documented history of fatalities & serious injuries resulting from WWD incidents.

13. Identify the top three benefit types your DOT has realized from using this innovation. Describe the type and scale of benefits of using this innovation over baseline practice. Provide additional information, if available, using quantitative metrics, to describe the benefits.

Benefit Types	Please describe:
Improved Safety	The advanced countermeasures reduced the risk of WWD events on high-risk off-ramps. A before-after study in D7 shows that in the before-period (2013-2015) seven crashes occurred resulting in 12 fatalities. Among these seven crashes, four crashes were fatal and three were injury crashes. In the after-period (2016-2018), no WWD crash occurred in the deployed area. So, a 100% reduction in WWD crashes was observed. Deployment of same countermeasures long 17 off-ramps in South Florida, five on Sawgrass Expressway, and 12 on the HEFT by Florida's Turnpike Enterprise recorded 68 WWD entries at these off-ramps from October 2014 through February 2019, of which 96% turned around and made self-corrections (i.e., 96% success rate).
Organizational Efficiency	The FDOT worked with FHWA and internal offices to add additional requirements to the FDOT FDM, Standard Specifications, Standard Plans and BOE.
Cost Savings	Though infrequent, WWD crashes come at high costs with serious injuries and fatalities. Reducing these crashes at the exit ramps with the advanced countermeasures result is high benefit-cost ratios. Benefit-cost analyses were conducted for statewide implementation of advanced countermeasures at all off-ramp locations. If we assumed all WWD crashes within 0.5 mile of the ramp were mitigated, the B/C ratio is 8. If assumed all WWD crashes within 2 miles of ramp are mitigated, the B/C ratio is 13. Just an 9% crash reduction across the freeway system is the break-even point of the signing and pavement marking retrofit deployment.
Improved Operation Performance	The FDOT's WWD Countermeasure Implementation Plan provides specific guidance to proactively deploy WWD countermeasures. Particularly, it provides guidance on a proactive approach for identifying locations that are prone to WWD incidents, and the WWD incident categories to be addressed at these locations. In addition to implementing

	engineering countermeasures that target specific WWD incident categories, knowing at-risk locations can assist law enforcement agencies and advocacy groups in identifying where to focus their efforts to deploy resources such that their efforts can be most effective.
Improved Customer Service	If the suggested WWD countermeasures were deployed at the top-ranked off-ramps across Florida, a majority of WWD crashes (if not 100%) resulting from drivers going the wrong way from an off-ramp would be eliminated. The WWD countermeasures that were suggested in this research have already been deployed at a few off-ramp locations across Florida. The review of the performance of these countermeasures at the deployed sites and anecdotal evidence suggested a close to 100% success in preventing WWD incidents.

Provide any additional description, if necessary:

The FDOT has a webpage dedicated to WWD. Please visit https://www.fdot.gov/traffic/its/projects-deploy/wrong-way-driving

14 How broadly might this innovation be deployed for other applications. in the transportation industry (including other disciplines of a DOT, other transportation modes, and private industry)?

WWD crashes are not limited to Florida. States that would like to reduce WWD crashes, especially on limited-access facility ramps, can use the same process and documentation that the FDOT developed: determine the most predominant factor that could potentially contribute to WWD incidents at each off-ramp locations, prioritize the off-ramp locations for installing WWD countermeasures, and implement advanced countermeasures. The review of the performance of these countermeasures at the deployed sites and anecdotal evidence suggested a close to 100% success in preventing WWD incidents. States will also know what institutional changes are needed to execute this project. For instance, the FDOT issued a joint bullet with the help of other external offices that affected the FDM, SSRBC, and BOE.

Market Readiness (20 points)

The AII selection process will favor innovations that can be adopted with a reasonable amount of effort and cost, commensurate with the payoff potential.

15. What specific actions would another organization need to take along each of the following dimensions to adopt this innovation?

Check boxes that apply	Dimensions	Please describe:
☒	Gaining executive leadership support	The FDOT worked with the FHWA and FDOT internal offices to issue a joint bulletin for the advanced countermeasures.
☒	Communicating benefits	The FDOT prepared the WWD Performance Measurement and Management Plan (PMMP) to track the performance of the deployed countermeasures on off-ramps. The WWD PMMP details the performance measures and how to record and monitor the performance of the system periodically.
☒	Overcoming funding constraints	The FDOT used the federal Highway Safety Improvement Program (HSIP) funds which sole purpose is to achieve a significant reduction in traffic fatalities and serious injuries on public roads.
☒	Acquiring in-house capabilities	The FDOT used its Districts and research from Florida's universities to analyze the high-risk ramps and develop the advanced countermeasures.
☒	Addressing legal issues (if applicable) (e.g., liability and intellectual property)	No legal issues with deployment of LED highlighted signs.

☒	Resolving conflicts with existing national/state regulations and standards	The FDOT worked with FHWA to ensure that the LED WWD signs conform to the MUTCD.
☐	Other challenges	Click or tap here to enter text.

16. Please provide details of cost, effort, and length of time expended to deploy the innovation in your organization.

Cost: A total of $15 million was allocated for priority deployment at 520 off-ramps out of 1,282 off-ramps statewide within WWD hotspots. The cost of deployments varies from area to area within the state and functionalities desired (e.g. availability of fiber optic connection or cellular back-haul, availability of AC power source or solar panels and detection technologies). If all these ramps were to be deployed with these countermeasures, this would incur a total cost of $45 million. Cost for S&PM deployment per ramp may vary from $5,000 to $10,000.

Level of Effort: The level of effort has been moderate. All the FDOT Districts are actively implementing the advanced countermeasures.

Time: The WWD implementation has been ongoing since 2014 on a pilot basis. However, statewide implementation of LED highlighted WRONG WAY signs are ongoing since 2019.

17. To what extent might implementation of this innovation require the involvement of third parties, including vendors, contractors, and consultants? If so, please describe. List the type of expertise required for implementation.

The innovation may require vendors to install the S&PMs and LED signs. The type of expertise would be technicians and system engineers skilled in intelligent transportation systems, configuration, and integration.