ITS DEPLOYMENT EVALUATION

EXECUTIVE BRIEFING


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Errant Driving Behavior Countermeasure Systems

Highlights

- Errant driving can result in exceptionally high severity crashes – with fatality rates in the range of 25% for Wrong Way crashes.
- Payback periods for investments in deploying countermeasures can be favorable.
- Effectiveness of countermeasures is important to assess at early stages. Variability in component or overall performance can lead to ineffective systems with many false alerts.

This briefing is based on past evaluation data contained in the ITS Benefits, Costs and Lessons Learned databases at: www.itskrs.its.dot.gov. The databases are maintained by the U.S. DOT's ITS JPO Evaluation Program to support informed decision making regarding ITS investments.

U.S. Department of Transportation
Intelligent Transportation Systems
Joint Program Office

Introduction

Errant driving behaviors, such as impaired, distracted and drowsy driving, result in thousands of fatalities every year, and numerous more injuries and crashes result from this safety challenge. Alcohol impairment-related crashes made up 29 percent of all fatal crashes in the United States during 2018, resulting in 10,511 fatalities[1]. In 2018, distracted driving was associated with an additional 2,841 fatalities[2] and crashes involving a drowsy driver resulted in 775 fatalities[3]. Strategies to address this significant problem area have incorporated the four E's: Engineering, Education, Enforcement, and Emergency Medical Services, using a multi-faceted approach.

In addition to traditional strategies, Intelligent Transportation System (ITS) technologies offer the opportunity to implement countermeasures focusing on preventing these crashes. Errant driving actions and errors often escalate rapidly to high-risk scenarios - such as drivers entering the roadway travelling in the wrong direction, or Wrong Way Driving (WWD), especially if the driver is under the influence of alcohol. Some solutions have utilized ITS technologies to detect, warn, and mitigate hazardous scenarios associated with specific errant driver behaviors. Some examples of errant driving countermeasures developed in recent years have included:

Introduction (continued)

- **Errant Driving Detection and Warning** - for drivers involved in specific scenarios resulting from errant behaviors, such as entering divided highways travelling in the wrong direction, providing countermeasures to remediate the situation and warn other drivers, and
- **Enhanced Situational Awareness** – providing countermeasures (e.g., alerts to turning drivers when pedestrians are present, or to truck drivers when approaching a low clearance area) for travelers experiencing loss of situational awareness due to distraction or other impairments.

Automated vehicle (AV) and connected vehicle (CV) technologies have the potential to enhance the effectiveness of these countermeasures. For example, future AV technology has the potential to detect errant driving and take over vehicle operation from an impaired driver. Additionally, CV technology will allow messages to be transmitted to the vehicle offering the driver advanced detection and warning, and enable connected infrastructure and signage that can inform other drivers.


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Benefits

Significant findings from projects implementing Errant Driving Detection and Warning for Wrong Way Driving are summarized in Table 1. The projects use a range of radar, thermal cameras and video, and loop detectors for detection and the use of Rectangular Rapid Flashing Beacons (RRFB) or traditional red flashing beacons as warnings.[5]

Researchers estimated that advances in active and passive in-vehicle safety technologies are expected to significantly reduce crash fatalities associated with a lack of situational awareness. Specific assessed technologies that target errant driving as the primary focus include alcohol interlocks and fatigue management systems.

Some situational awareness enhancement systems target a particular scenario, such as bridge hits from errant truck drivers who are not aware of the lack of overhead clearance for their cargo's

Benefits (continued)

height. Installation of overheight vehicle detection systems on I-10 in Houston were associated with a 5-7 percent increase in trucks using the advised alternate route and a decrease in bridge hits of 66% (2019-01364).

Table 1: Errant Driving Detection and Warning

Use Case	Selected Findings
Wrong Way Driving – Reduction in incidents	In San Antonio, Texas, the San Antonio Police Department, Texas DOT, FHWA and Texas Transportation Institute, collaborated to identify locations where Wrong Way Driving incidents were concentrated. A pilot project along US-281 utilized radar to detect wrong way drivers and illuminate red LED "Wrong Way" signs to warn drivers. Reductions in wrong way driving incidents of 29 and 30 percent were observed over a 14-month period (2014-00957).
Wrong Way Entry Detection and Advisory	Florida's Turnpike Enterprise installed a ramp-based wrong way detection and deterrent system on six interchanges and ten ramps. The system used front radar to detect vehicles and trigger a camera to collect and send additional information to the Traffic Management Center and Florida Highway Patrol. LED-highlighted signage and Dynamic Message Signs were used to advise motorists. Over a three-month period, six wrong way vehicles were detected and no crashes were reported (2017-01148).
Wrong Way Entry Detection Accuracy	In Phoenix, Arizona, a wrong-way detection system was installed over a 15-mile segment of I-17. The system uses thermal detection cameras installed above exit ramps and the interstate mainline to detect errant drivers and send automated alerts to Arizona DOT operations center and highway patrol. Detections at off-ramps trigger flashing LED warnings and if the driver continues, operations personnel can activate digital message boards to alert motorists of the danger. Over the first six months of operation, the system was found to accurately detect 33 vehicles that had entered I-17 via off-ramps and frontage roads (2019-01379).

Costs

Systems to address Errant Driving are sometimes integrated into larger ITS deployments that leverage common functionality. For example, the Indiana Toll Road Concession Company (ITRCC) deployed Wrong Way Detection Systems at two Indiana Toll Road exit ramps with flashing LED signs and a broadcast alert to the Traffic Management System. The deployment was part of a larger $34 million ITS project that implemented advanced incident messaging and monitoring functions that support the wrong way alert (2019-00438).

Costs (continued)

Larger deployments specifically targeting detection of Wrong Way Driving have also been implemented separately and integrated into existing Traffic Management Systems. Arizona DOT completed deployment of a system including 90 thermal cameras for detection and video feeds and background-illuminated wrong-way signs at a cost of $3.7 million. The system provides added information and alerts to existing Traffic Management Center and Department of Public Safety personnel to quickly focus on the specific camera views and location of the errant driver (2019-00426).

Table 2: Cost Ranges for Enhanced Situational Awareness Systems

Installation Type	Enhanced Situational Awareness Functionality	Cost
Light Vehicle	Driver assistance technologies to advise and warn drivers integrated into consumer-purchased options in new vehicles.	Range from $300 to $10,800 per vehicle (average of $4,500 or less) (2017-00373)
Transit Bus	Warning system for pedestrians in vicinity of transit bus providing auditory and visual alerts under specific higher-risk scenarios such as turns.	Range for vendor to equip fleet from $58,500 to $97,200 for 45 buses; in bulk, per-bus representative unit costs ranged from $1,522 to $3,531 (2015-00345)
Heavy Truck	Advanced Collision Mitigation Technology to enhance speed control, provide alerts, and add additional/automatic braking when driver does not respond to vehicle ahead	Range for typical system reported to be $2,500 to $4,000 per tractor (2017-00382)
Infrastructure	Pedestrian crossing treatments to address special locations where an enhanced desire to gain drivers' attention exists. Range illustrates simple sign markings, in-road warning lights, rectangular rapid flashing beacons, LED-enhanced signs, and signal installation.	Range from less than $10,000 to $125,000 + operational costs (2019-00423)

Costs (continued)

In 2012, San Antonio, Texas started with a pilot for Wrong Way Driving Countermeasure System on US-281 which had a project cost of $378,000 for 28 exit ramps and two mainline locations covering 15 miles (2020-00461). Estimated annual cost savings to TxDOT and San Antonio Police Department for this corridor were $280,000, resulting in a benefit/cost ratio of 14.8:1[6]. Based on the successful results in the US-281 pilot corridor, additional deployments in the San Antonio region have been completed or are under construction.

Technologies to enhance situational awareness can be installed in or on vehicles, or at infrastructure locations depending on the scenarios being targeted. Table 2 illustrates the ranges of costs reported for various situational awareness enhancements installed on vehicles or infrastructure.

Best Practices

Recent successful deployments were enabled by prior work in assessing technologies and products, building and testing proof-of-concept systems, and conducting pilot implementations.

- Implementation details can have a significant influence on the overall effectiveness and success of Errant Driving Detection and Warning Systems. For example, single point radars were considered unreliable for Wrong Way Detection due to too many false positives[6]. A FDOT study of three vendor products ranged significantly from 40-95% in detection system accuracy and 12-94% in actual detection accuracy[7]. Detection system accuracy and actual detection accuracy were excellent indicators of vendor detection, but real system performance should be further assessed based on actual wrong way driving detection over a sufficiently long time, or under a controlled environment (2020-00966).
- As connected vehicle technology becomes more mature, it provides the opportunity to leverage infrastructure-broadcast data and messages such as Signal Phase and Timing (SPaT) and MAP to enable vehicle on-board units to detect and warn of errant behavior. The Tampa CV Pilot Deployment modified the messages for the Red Light Violation Warning application to allow vehicles to determine and warn both errant and surrounding drivers if a vehicle enters the Selmon Expressway's reversible lanes in the wrong way (2018-00812).
- It is important to assess the impact of advanced driver assistance systems (ADAS) and partial automation (Level 2) in reducing the incidence of errant driving. ADAS systems were associated with a reduction in speeding behavior while Level 2 automated systems increased speeding behaviors.

Best Practices (continued)

While data was limited, Level 2 automation systems appeared to increase drowsy driving incidences but not distracted driving (2019-00925).

- Supporting data should be used to help implement focused efforts on addressing speeding behaviors. Crash databases and supporting forms should be enhanced to improve reporting of speeding-related incidents, and data allows countermeasures to target areas where vehicles and vulnerable road users commonly share the road (2019-00858).

As part of Tampa's Connected Vehicle Pilot Deployment project, when the driver of a connected vehicle enters the downtown end of the Reversible Express Lanes in the wrong direction, the driver receives an alert in their rearview mirror.

Case Study

Arizona DOT Wrong-Way Driving Detection System

In order to address Wrong-Way crashes, which based on Arizona statistics were fatal in 38% of cases[8], Arizona Department of Transportation (ADOT), working in conjunction with partner agencies including the Arizona Department of Public Safety, has deployed a pilot system to reduce the impact of these errant driving incidents[9].

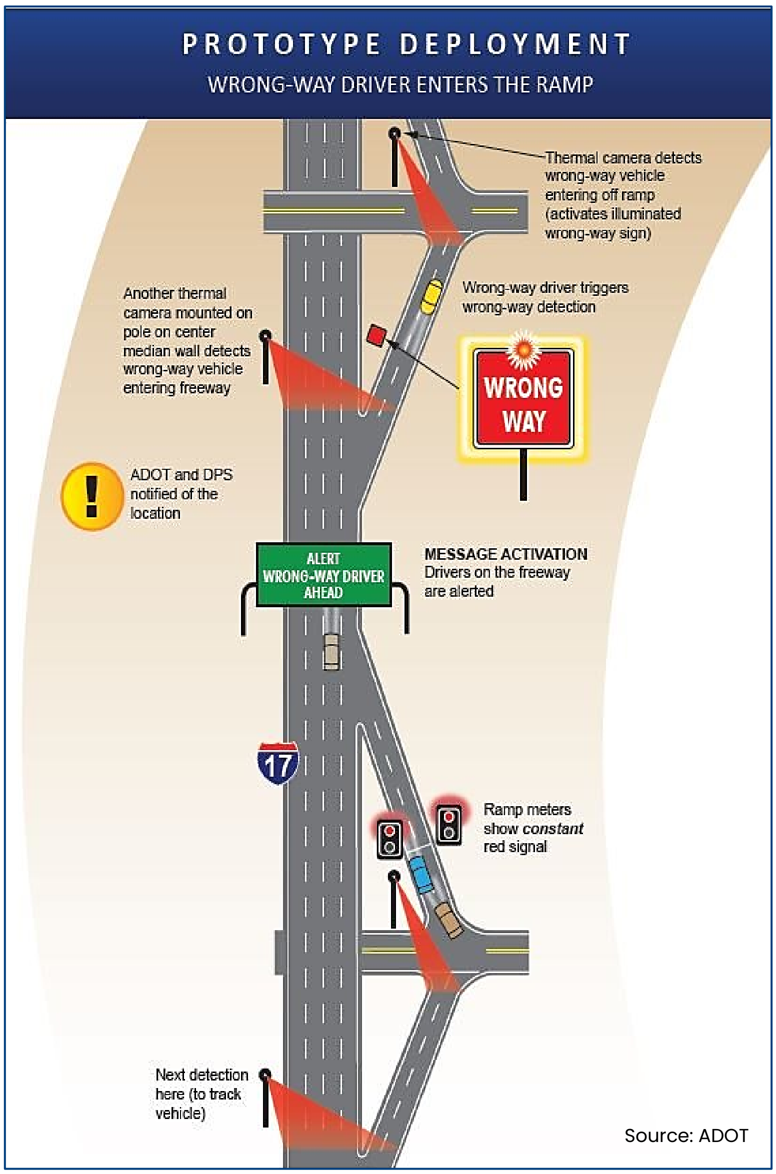
> **"Often wrong-way drivers crash within a couple minutes of driving the wrong way on the freeway, and immediate response is critical."**

The $4 million system installed along 15 miles of I-17 uses thermal cameras to detect and track wrong-way vehicles while also immediately alerting ADOT and the Arizona Department of Public Safety. This can save state troopers valuable time in responding to incidents rather than waiting for 911 calls from other motorists, while also allowing ADOT to quickly alert other drivers via overhead message boards.

Case Study (continued)

Methodology

- ADOT has built upon significant prior work in studying the magnitude and characteristics of the wrong way driving problem, testing wrong way detection technologies, developing a proof-of-concept[8], and now engaging in a pilot deployment[10].
- The system's 90 thermal cameras are positioned to detect wrong-way vehicles entering off-ramps or traveling along I-17. A detection also triggers an internally illuminated wrong-way sign with flashing red lights aimed at getting the attention of wrong-way drivers.
- The system integrates readily available component technologies with the existing Freeway Management System (FMS) infrastructure in conjunction with development of customized software for this scenario.
- ADOT Personnel and Department of Public Safety officers are provided with rapid information and decision support, triggered by the initial detection. Corresponding video is made available to Traffic Operations Center (TOC) operators.
- Decision Support Software allows TOC operators to confirm and quickly activate automated countermeasures to post warnings to other drivers on the Dynamic Message Signs corresponding to the affected segment, and limit flow of additional vehicles onto the road ahead of the wrong-way driver. The decision support software also provides immediate tracking of the wrong-way vehicle to traffic operations and Department of Public Safety personnel.



Scenario depiction of ADOT's prototype thermal camera Wrong-Way Detection system.

Case Study (continued)

Findings

- Since ADOT installed the system in early 2018, the system has detected more than 90 wrong-way drivers, 86 of whom turned around on off-ramps or frontage roads. For the 10 wrong-way vehicles that made it to the mainline, law enforcement was alerted immediately and arrived in the area within minutes[11].
- The decision support system reduces the response time from minutes to seconds – with the traffic operator typically being provided with an alert less than 5 seconds after detection of a wrong-way vehicle, and allows personnel to focus on automatically prioritized views of cameras showing the wrong-way vehicle.
- Prior testing to evaluate the performance of the detection system focused on missed detections and false detections.
  After installation, false detections were found to be common due to wind-induced camera shaking and thermal reflections from windshields of moving vehicles. ADOT is working with the manufacturer to reduce false detections.
- Initial observations are promising and reduce risk from wrong-way incidents. Detailed detection data will provide the ability to evaluate effectiveness and benefits, and potentially identify other countermeasures to deter errant drivers from the initial entry going the wrong way.

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