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ENTERPRISE

Potential Approaches for Wrong-Way Driving Applications Phase 2

ENTERPRISE TRANSPORTATION POOLED FUND STUDY TPF-5(490)

FINAL REPORT

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16. Abstract

Wrong-way driving (WWD) is a growing concern because the resulting crashes tend to be severe and often result in fatalities and serious injuries. Advancements in cooperative automated technologies will enable significant possibilities to provide WWD warnings through in-vehicle navigation systems and smartphone-based mobile applications. A national communication standard for incident data including WWD events would enable data from multiple sources (e.g., 911 calls, on-road detection field equipment, self-reporting mobile applications) to become available through a data feed for in-vehicle mechanisms to access and provide alerts to errant drivers and nearby motorists. This research completed a synthesis documenting several commercially available WWD in-vehicle systems and mobile applications, promoted the concept of a national communication standard and data feed for WWD events, and gathered input from transportation agencies regarding the readiness of agency-generated WWD event data to be contributed to a data feed. The project concluded that there is agency and industry interest in a national WWD communication standard and data feed. However, the WWD event data currently available from sources such as 911 calls, on-road detection equipment, and traffic management center observations is likely not yet ready to be pushed to such a feed. Future efforts to advance this concept can build upon national initiatives that are exploring the development of a data and communication standard for disruptive incidents, which could include WWD events.

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The cover page image is provided courtesy of Athey Creek Consultants.

Project Champions

Cory Johnson from the Minnesota Department of Transportation and Willy Sorenson from the Iowa Department of Transportation were the ENTERPRISE Project Champions for this effort. The Project Champions served as the overall leads for the project.

ENTERPRISE Members

The ENTERPRISE Board consists of a representative from each of the following member entities.

- Illinois Department of Transportation
- Iowa Department of Transportation
- Kansas Department of Transportation
- Michigan Department of Transportation
- Minnesota Department of Transportation
- Ontario Ministry of Transportation
- Texas Department of Transportation
- Wisconsin Department of Transportation

Project Input

ENTERPRISE would like to thank the ENTERPRISE member agencies that provided input to the project through an online survey and the following state transportation agencies that provided input to the project through interviews.

- Arizona Department of Transportation
- Iowa Department of Transportation
- Rhode Island Department of Transportation

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List of Abbreviations

API	Application programming interface
ATMS	Advanced traffic management system
CAD	Computer-aided dispatch

DMS	Dynamic message sign
DOT	Department of Transportation
FHWA	Federal Highway Administration
ITS	Intelligent transportation systems
Lat/long	Latitude/Longitude
NTCIP	National Transportation Communications for ITS Protocol
PFR	Police Fire and Rescue
TMC	Traffic management center
TMDD	Traffic Management Data Dictionary
TSMO	Transportation systems management and operations
WWD	Wrong-way driving
WZDx	Work Zone Data Exchange

Executive Summary

Wrong-way driving (WWD) is a growing concern on roadways as the resulting crashes tend to be severe and often result in fatalities and serious injuries. Advancements in cooperative automated technologies will enable significant possibilities to provide WWD warnings through in-vehicle navigation systems and smartphone-based mobile applications. These interventions could supplement on-road countermeasures by influencing wrong-way drivers to correct their wrong-way movements while also alerting other nearby drivers. Many transportation agencies have installed on-road sensors that detect wrong-way vehicle movements and communicate WWD events to traffic management centers. In addition, public safety agencies also become aware of wrong-way drivers through calls from nearby motorists.

A national communication standard for incident data including WWD events would enable data from multiple sources (e.g., 911 calls, on-road detection field equipment, self-reporting mobile applications) to become available through a data feed for in-vehicle mechanisms to access and provide alerts to errant drivers and nearby motorists.

To advance the concept of developing a communication standard for WWD event data, this ENTERPRISE Pooled Fund Study project completed a synthesis of wrong-way driving in-vehicle systems and mobile applications, conducted outreach to the Federal Highway Administration (FHWA), and gathered input from selected transportation agencies regarding WWD event data reports and detection field equipment.

The project concluded that there is agency and industry interest in communicating WWD event data, signifying an interest in a national WWD communication standard and data feed. However, the WWD event data currently available from sources such as 911 calls, on-road detection equipment, and traffic management center observations is likely not yet ready to be pushed to such a feed. The outreach to FHWA resulted in productive discussions and interest in including WWD data in FHWA's current efforts to develop a national communications standard for disruptive incidents. Once developed, state and local agencies (and industry products) could use the communication standard to communicate WWD event data and work collaboratively to develop standards for when and how to communicate notification messages to the traveling public.

Chapter 1: Introduction

Wrong-way driving (WWD) is a growing concern on roadways, as the resulting crashes tend to be severe and often result in fatalities and serious injuries. Transportation agencies are deploying on-road countermeasures such as low-mounted wrong-way signs, pavement marking improvements, and detection-activated signs, but these countermeasures can only go so far to reduce wrong-way crashes.

Project Objectives

Expand outreach efforts and further explore the potential for in-vehicle navigation systems and mobile apps to provide WWD alerts.

Advancements in cooperative automated technologies will enable significant possibilities to provide WWD warnings through in-vehicle navigation systems and smartphone-based mobile applications. These types of interventions could supplement on-road countermeasures by influencing wrong-way drivers to correct their wrong-way movements while also alerting other nearby drivers. Many transportation agencies have installed on-road sensors that detect wrong-way vehicle movements and communicate WWD events to traffic management centers. In addition, public safety agencies also become aware of wrong-way drivers through calls from nearby motorists.

A national communication standard for incident data including WWD events would enable data from multiple sources (e.g., 911 calls, on-road detection field equipment, self-reporting mobile applications) to become available through a data feed for in-vehicle mechanisms to access and provide alerts to errant drivers and nearby motorists. See Figure 1.1.

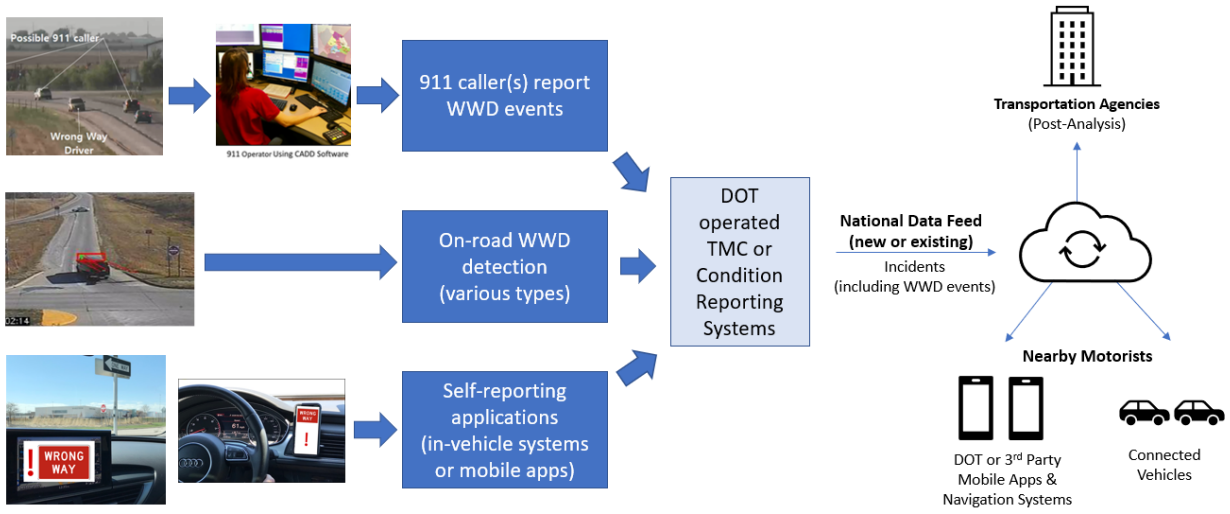


Figure 1.1 Concept of WWD Events Communicated Through a National Incident Data Feed

This ENTERPRISE *Potential Approaches for Wrong-Way Driving Applications – Phase 2* project built upon efforts that began in the ENTERPRISE *Potential Approaches for Wrong-Way Driving Applications* project. This Phase 2 project investigated commercially available WWD in-vehicle systems and mobile apps, promoted the concept of a national communication standard for wrong-way driving incidents, and explored the feasibility of a data exchange for wrong-way driving event data.

The project completed a synthesis of wrong-way driving in-vehicle systems and mobile applications, conducted outreach to the Federal Highway Administration (FHWA), and gathered input from selected transportation agencies regarding WWD event data reports and detection field equipment. Figure 1.2 shows the project approach.

Figure 1.2 Project Approach

Chapter 2: Wrong-Way Driving In-Vehicle Systems and Mobile Applications

This section provides a synthesis of WWD in-vehicle systems and mobile applications identified through an online search completed in June 2023. Table 2.1 provides a listing of the systems and applications identified and synthesized.

Table 2.1 WWD In-Vehicle Systems and Mobile Applications

Product	Type
Ford Focus Wrong Way Alert	Vision-based in-vehicle WWD detection and alert system
Bosch Wrong-Way Driver Warning System	Cloud-based warning system for in-vehicle infotainment systems and smartphone apps
HAAS Alert Safety Cloud® Digital Alerting Service	Cloud-based warning system for in-vehicle infotainment systems
Wrong-Way Driver Alert App	Smartphone-based mobile app
Sygic GPS Navigation App	Smartphone-based GPS navigation app with wrong-way driver feature

2.1 Ford Focus Wrong Way Alert

Announced in Cologne, Germany, the Wrong Way Alert in the Ford Focus warns drivers before they drive on to the wrong carriageway of a motorway or dual carriageway. The Wrong Way Alert system builds on Ford's existing Traffic Sign Recognition technology that uses GPS information from the onboard navigation system to identify the car's location and a forward-facing, windscreen-mounted camera to detect signs such as speed limits and displays them to the driver on the dashboard or Head-up display.

Figure 2.1 Screenshot of Wrong-Way Visual Alert on Ford Focus
Accessed 3/17/23: https://www.youtube.com/watch?v=V-au9oHm7xY

In situations where a driver passes two "no entry" signs on either side of a slip road on to a motorway or dual carriageway, Wrong Way Alert sounds a warning and displays to the driver a red "no entry" symbol as well as a message to "check driving direction." Figure 2.1 shows a visual warning "Check Driving Direction" displayed to the errant driver when a wrong-way vehicle maneuver is detected. A video

showing how the Ford Focus Wrong Way Alert system works can be accessed at: https://www.youtube.com/watch?v=V-au9oHm7xY. (YouTube, n.d.)[1]

Source: New Tech for All-New Ford Focus Could Help Prevent the Nightmare of Wrong-Way Drivers on the Motorway (Ford Media Center, 2018)[2]

2.2 Bosch Wrong-Way Driver Warning System

Bosch's cloud-based Wrong-Way Driver Warning System alerts drivers to instances of wrong-way vehicles. If a vehicle approaches a highway entrance ramp or exit ramp, the system automatically sends the anonymized data of the current movement to the cloud. The function compares the vehicle's actual movements with the permitted direction of travel and stores the information in a web-based database. If the two sets of information clash, the wrong-way driver automatically receives a warning. At the same time, the cloud immediately transmits a warning to all networked road users within the danger area. When leaving the highway entrance ramp the communication with the cloud is interrupted again. The function relies on regular, anonymized reporting of each vehicle's position to the cloud – a central computer center in which data are stored and analyzed over the internet. See Figure 2.2.

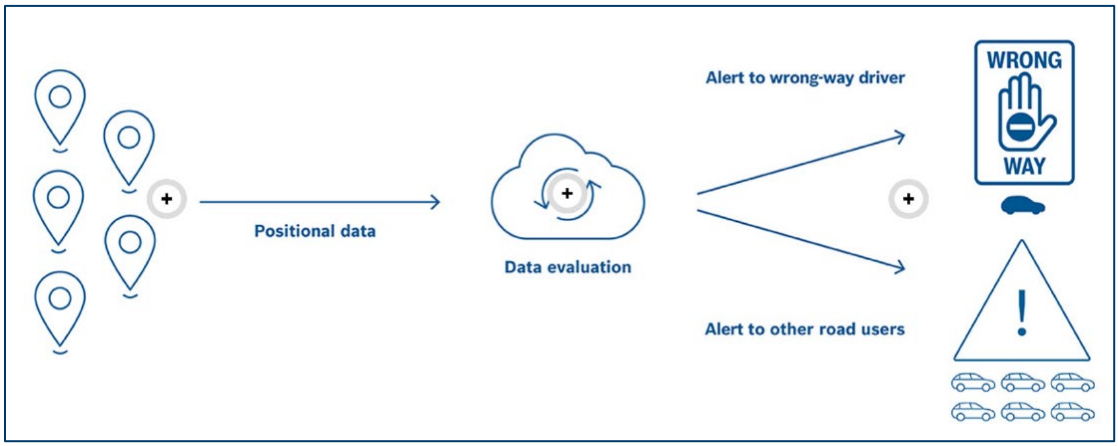


Figure 2.2 Screenshot Showing a Schematic of the Bosch Wrong-Way Driver Warning System
Accessed 5/15/23: www.bosch-mobility.com/en/solutions/assistance-systems/cloud-based-wrong-way-driving-warning/

Upon detection, warnings from the Bosch Wrong-Way Driver Warning System can be provided through the following mechanisms:

- *Display in the vehicle's cockpit*. European automobile manufacturer ŠKODA offers the Bosch Wrong-Way Driver Warning System in the infotainment system of several vehicle models.
- *Smartphone application*. This feature can be activated through several smartphone applications offered by Bosch's partners. Users can download one of the partner apps, activate the feature, and use the service free of charge.

Figure 2.3 shows a screenshot of the alert display in the cockpit of the ŠKODA vehicle. Figure 2.4 shows a screenshot of a wrong-way alert displayed on a smartphone application operated inside a vehicle.

Figure 2.4 Screenshot of Alert Displayed in ŠKODA Vehicle

Accessed 5/15/23: www.bosch-mobility.com/en/solutions/assistance-systems/cloud-based-wrong-way-driving-warning/

Figure 2.3 Screenshot of Alert Displayed on a Smartphone App

Accessed 5/15/23: www.bosch-mobility.com/en/solutions/assistance-systems/cloud-based-wrong-way-driving-warning/

Source: Bosch Cloud-based Wrong-Way Driver Warning (Bosch Mobility, n.d.)[3]

2.3 HAAS Alert Safety Cloud®

The HAAS Alert Safety Cloud® Digital Alerting Service integrates with existing WWD detection systems through a secure application programming interface (API). When a WWD system detects a WWD event, a single API call into Safety Cloud® activates a pre-programmed and customizable "WWD Digital Alerting Zone" managed by the infrastructure owner/operator, and connected drivers within and approaching the "WWD Digital Alerting Zone" receive a safety alert in their vehicle infotainment screen or mobile application. Departments of Transportation and transportation authorities with an internet-connected WWD detection system can ask their vendor to contact HAAS Alert about adding Digital Alerting to the solution. See Figure 2.5 for a schematic of the HAAS Alert WWD Digital Alerting System.

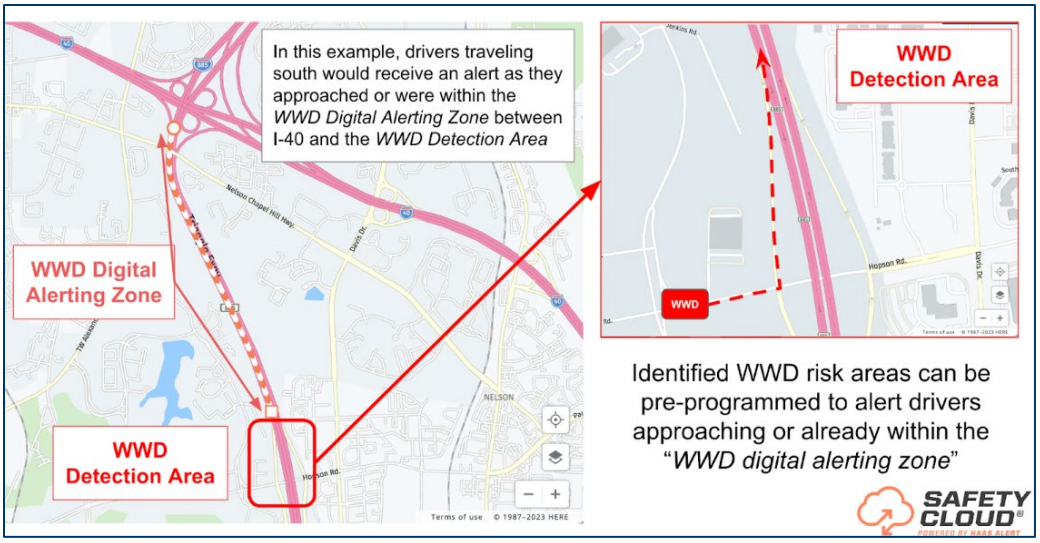


Figure 2.5 Screenshot of HAAS Alert WWD Digital Alerting System
Accessed 5/5/23: https://www.haasalert.com/news/combating-wrong-way-drivers-with-digital-alerting

The HAAS Alert Safety Cloud's WWD Digital Alerting capability is available on Stellantis' lineup of compatible Jeep, Dodge, Chrysler, and RAM vehicles with an active Uconnect subscription. Figure 2.6 shows a Wrong Way Driver digital alert message received by a Stellantis vehicle via Uconnect.

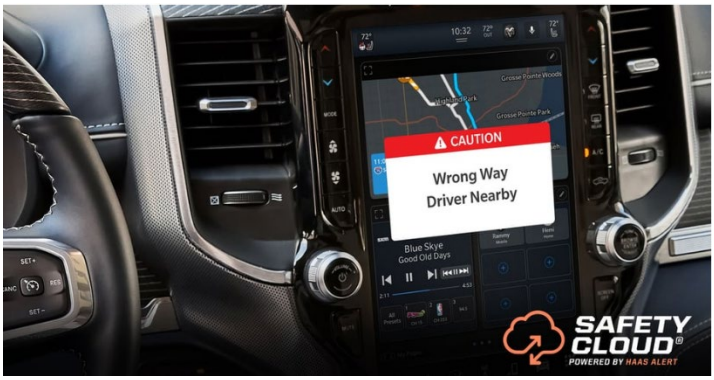


Figure 2.6 Screenshot of Wrong Way Driver Digital Alert Message Received by a Stellantis Vehicle via Uconnect
Accessed 5/5/23: https://www.haasalert.com/news/combating-wrong-way-drivers-with-digital-alerting

Source: Combating Wrong Way Drivers with Digital Alerting (HAAS Alert, 2023)[4]

2.4 Wrong Way Driver Alert Smartphone App

Wrong Way Driver Alert is a smartphone app-based detection system for wrong way driving. The app's algorithms detect and notify the driver, persons within a 10-mile radius of the driver, and highway authorities of a potential wrong way driver. A corresponding PFR (Police Fire and Rescue) application monitors users of the app within their pre-set radius to pick up wrong way driving activity. (App Store Preview, n.d.). See Figure 2.7.

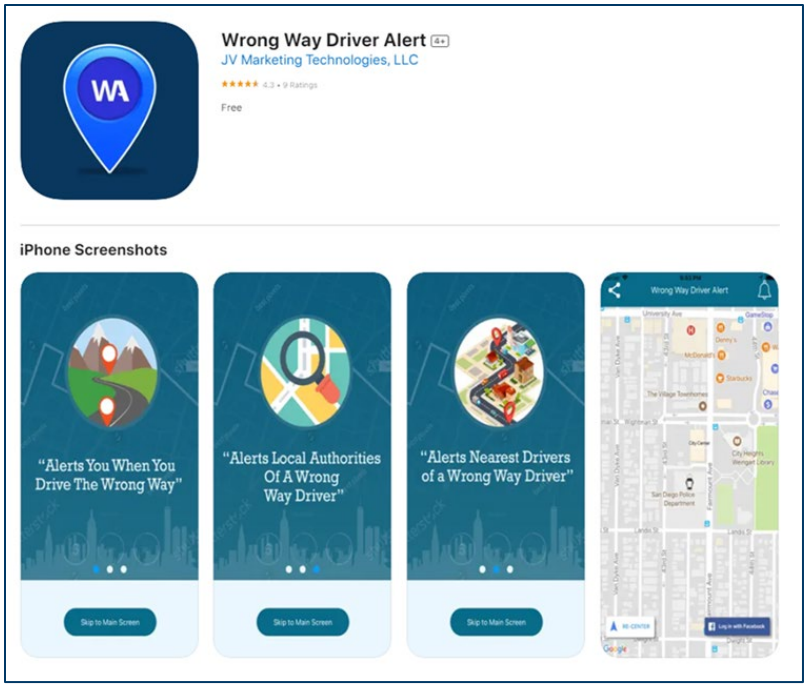


Figure 2.7 Screenshot of Wrong Way Driver Alert Smartphone App

Accessed 5/5/23: https://apps.apple.com/us/app/wrong-way-driver-alert/id1356015696

(Note: As of 6/24/24, the app was no longer available from the link above)

The Wrong Way Driver Alert app's algorithm will detect whether a user is driving the wrong way, then provide voice and text alerting the user. Users of the app can also report wrong way drivers, and that information is then shared with other nearby drivers who also have the app. Agencies can purchase a PFR unit, and the software will automatically alert law enforcement within a 50 mile radius of a wrong way driver, giving them the exact location. To use the software, participating agencies will pay seven million dollars for five years. (Handy, 2022).

Sources:

Wrong Way Driver Alert (JV Marketing Technologies, LLC, n.d.)[5] and San Diego Company Unveils App to Combat Wrong Way Crashes (Handy, 2022)[6]

2.5 Sygic GPS Navigation App

The Sygic GPS Navigation App conducts analysis of GPS data it receives from a user's mobile device and determines whether the device is going in the opposite direction of traffic, then issues warnings to both the driver operating the app and other drivers in the vicinity who are also operating the Sygic software. (Popa, 2022). Supported countries of the Sygic GPS Navigation App Wrong-way Driver feature include: Germany, France, United Kingdom, Italy, Spain, Poland, Netherlands, Belgium, Portugal, Austria, Switzerland, Ireland, Luxembourg, Norway, Sweden, Finland, Bosnia Herzegovina, Bulgaria, Cyprus, Czech

Republic, Denmark, Greece, Croatia, Hungary, Lithuania, Romania, Serbia, Slovenia, Slovakia, Ukraine, USA, and Canada. (Sygic, n.d.)

Figure 2.8 shows a screenshot of the Sygic GPS Navigation App's Wrong-Way Driver feature.

The main limitation of this system is that everyone must be using Sygic's software in order to be effective in warning both the errant driver and nearby drivers. The only way to address these shortcomings is to develop a universal standard that would eventually be adopted by all navigation apps. (Popa, 2022)

Sources:
How a Google Maps Competitor Developed a Wrong-Way Driver Warning Feature (Popa, 2022)[7] and Wrong-way Driver (Sygic, n.d.)[8]

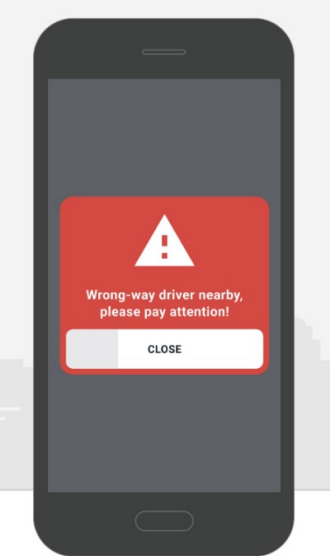


Figure 2.8 Screenshot of Sygic GPS Navigation App's Wrong-Way Driver Alert
Accessed 5/4/23: https://www.sygic.com/what-is/wrong-way-warning

2.6 Synthesis Key Findings

Task 1 of this project completed an online scan to identify and synthesize known WWD in-vehicle and mobile applications. Five products were identified through the online search. Table 2.2 provides a listing of each product, sorted by type of system or application.

Table 2.2 WWD In-Vehicle and Mobile Application Products by Type

Type	Product
In-vehicle WWD detection and alert system	• Ford Focus Wrong Way Alert
Cloud-based systems	• Bosch Wrong-Way Driver Warning System • HAAS Alert Safety Cloud® Digital Alerting Service
Mobile apps	• Wrong-Way Driver Alert App • Sygic GPS Navigation App

Key findings from this synthesis include the following:

- In-vehicle WWD system:
  - The in-vehicle system identified uses sign recognition detection technology and alerts only the driver.
  - Deployment was announced in Germany with no evidence of further deployment in the United States.
- Cloud-based systems:
  - The cloud-based WWD systems perform detection by processing vehicle location and movement data, comparing it to map data or in-place wrong-way detection systems.

  - These systems integrate with on-board vehicle technology and/or smartphone apps to warn errant drivers in the vehicle and nearby motorists.
  - There is some integration with transportation agency-operated Internet-connected WWD detection devices to receive data when a wrong-way vehicle is detected.

- Mobile Apps
  - Products identified are technically capable of detecting wrong-way movements (based on vehicle location and movement, with map data) and providing alerts.
  - In order to warn nearby motorists, both the errant driver and nearby motorist need to be simultaneously using the same app, emphasizing the need to develop a universal standard that can be implemented across multiple on-board technologies and mobile applications.

- Implementation
  - Overall, a higher degree of implementation of in-vehicle WWD systems is seen in countries outside the United States, with the Ford Focus technology deployed in Germany and the Bosch Wrong-Way Driver Warning System integrated into European-manufactured ŠKODA vehicles.
  - The potential for these types of systems to be implemented widely, even in the United States, is evident and appears to be growing with increased industry interest over time.

Overall, the industry advancements identified in this synthesis are encouraging, as they demonstrate a growing number of in-vehicle systems and mobile applications that perform WWD detections and provide alerts. In the future, these technologies are possible sources of WWD event data that could be communicated (using a national data communication standard) via local or national data feeds, to warn nearby vehicles or for post-analysis.

Chapter 3: Outreach to FHWA

To further advance the objectives of this project, the ENTERPRISE project champions and the research team conducted outreach to staff from FHWA to promote the concept of a national communication standard for WWD event data. Specifically, this effort promoted the inclusion of WWD event data in current efforts that are considering the development of a national data feed for disruptive traffic incidents, similar to the USDOT's Work Zone Data Exchange (WZDx).

As a first step, a white paper was prepared to outline the concept and industry interest. The white paper, which was also posted to the project page on the ENTERPRISE website, provided the project background, described the overall concept of a national standard and incident data feed that could include WWD events, summarized commercially available WWD in-vehicle systems and mobile apps, and supplied rationale for developing a national communication standard for WWD events. See Appendix A for the white paper that was developed and utilized during project outreach.

Project Outreach

The ENTERPRISE project champions and the research team conducted outreach to promote the concept of a national communication standard for WWD event data.

The ENTERPRISE project champions and research team then participated in national meetings and conversations with staff from FHWA who were exploring concepts for a national roadway digital infrastructure and a national data exchange for disruption reports to discuss the concept and explore national interest in creating a national standard for WWD event data.

During these conversations with FHWA staff, WWD events were recognized as a disruption that could one day be part of a national data exchange. The opportunity to participate in these early discussions and represent the challenges of WWD event reporting as well as the possible national benefits of a WWD data exchange were seen as a success for moving towards national WWD reporting. These meetings also led the project team to reflect on how ready the incident reporting that is conducted by state and local agencies is for consistent and standardized WWD reporting, which is expanded upon in subsequent chapters of this report. See Chapter 4 for an overview of outreach that explored the feasibility and readiness of WWD event data that might someday be contributed to a national incident data feed.

Chapter 4: Readiness of WWD Event Data

During investigations and outreach during the initial ENTERPRISE *Potential Approaches for Wrong-Way Driving Applications* project and the initial tasks of this Phase 2 effort, a secondary research question emerged. If a national data communications standard and one or more data exchange mechanisms are developed, is WWD event data from agencies currently in a "state of readiness" to be communicated and exchanged? To explore this question, the project conducted outreach to the following groups:

- Traffic Management Center (TMC) managers and 911 dispatch supervisors
- Agency staff familiar with capabilities of deployed WWD detection field equipment

The purpose of this outreach was to understand how TMC and 911 dispatch processes for learning of WWD events when they occur, how WWD data is logged and tracked, and the capabilities of WWD detection field equipment to communicate WWD detection data.

4.1 Traffic Management Center and 911 Dispatch Processes

The purpose of outreach to TMC managers and 911 dispatch supervisors was to better understand how agencies learn about WWD events, and how these events are coded, logged, and tracked.

To gather input on TMC processes, information was gathered from TMC managers at ENTERPRISE agencies (survey) and selected non-ENTERPRISE agencies (survey questions were asked in interviews and responses were entered into the online survey.) A separate survey was sent to 911 dispatch supervisors, to understand similar processes used by 911 dispatch operators to log and code WWD events reported through 911 calls. Detailed questions for TMC managers and 911 dispatch supervisors are included in Appendix B.

The survey of TMC managers received nine responses. The survey geared toward 911 dispatch supervisors received one response. The results from both surveys are presented in the following sections, with similar questions and responses grouped together.

4.1.1 Alerts to TMC Operators

The survey for TMC managers first asked "How are TMC operators alerted when a wrong-way driving event has occurred? Select all that apply." Every respondent (9 of 9 responses) indicated that the TMC receives notification from 911 dispatch. In addition, 6 of 9 respondents indicated notification from detection field equipment, 5 of 9 respondents indicated a call from the traveling public, and 5 of 9 respondents indicated "other." See Figure 4.1.

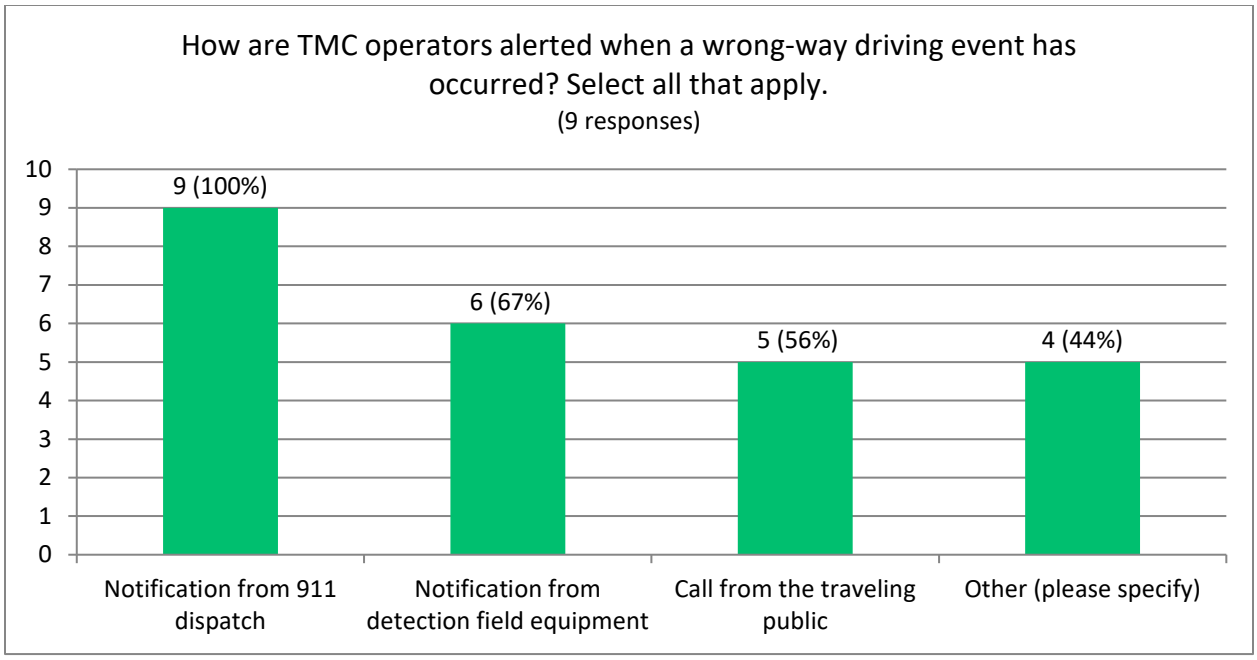


Figure 4.1 Alerts to TMC Operators (TMC Responses)

For respondents indicating "other," responses included:

- Notification from DOT staff (e.g., on-road DOT staff or traffic safety engineer who is monitoring WWD field equipment). *(Iowa DOT)*
- Real-time and after-the-fact reports are received from statewide law enforcement agencies. *(Wisconsin DOT)*
- Occasionally freeway service patrol will see one and report it. The vast majority are via State Patrol 911. *(Minnesota DOT)*
- Observation on camera by a TMC operator. *(Texas DOT – Transguide San Antonio)*

The survey of 911 dispatch managers did not have a similar question because it was assumed that 911 dispatch operators learn of WWD events from 911 callers.

4.1.2 Mechanisms for Logging WWD Events

The next question asked, "How do TMC operators log wrong-way driving events?" Of the nine responses to this question, four respondents indicated that TMC operators log wrong-way driving events" in the Advanced Traffic Management System (ATMS) or condition reporting system." No respondents indicated that wrong-way driving events are logged "manually (e.g., logbook, spreadsheet." Similarly, no respondents indicated that "we do not log wrong-way driving events." Five respondents provided "other" methods for logging wrong-way driving events. See Figure 4.2.

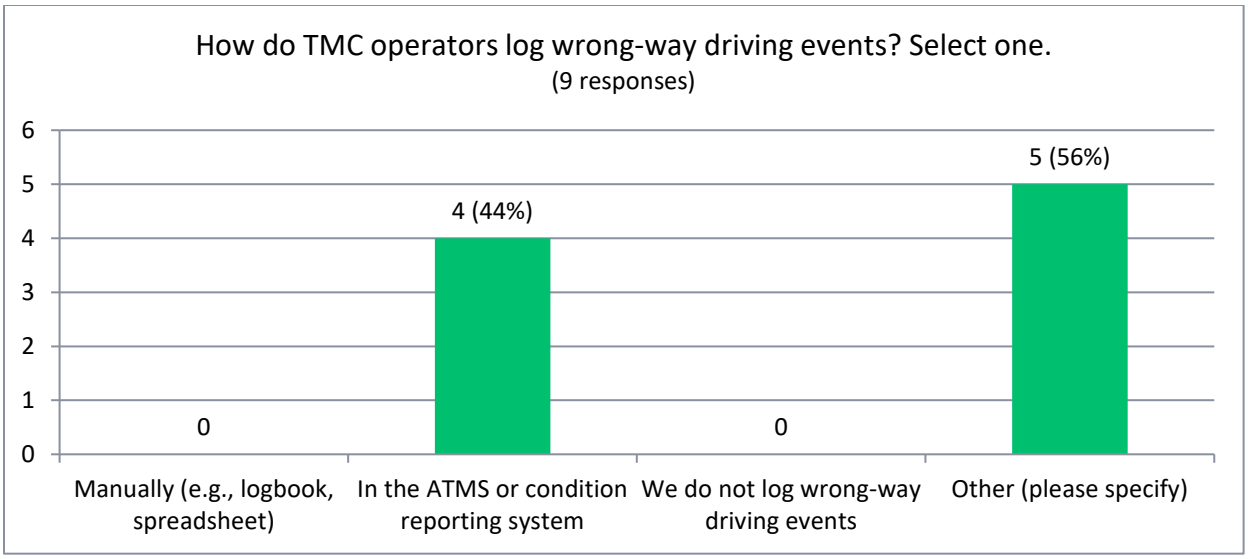


Figure 4.2 Mechanisms for Logging WWD Events (TMC Responses)

"Other" responses included:

- Entered/logged in ATMS and also logged in a Microsoft Access database. *(Wisconsin DOT)*
- TMC staff will log wrong-way driving events when they result in a stationary incident (crash, LEO stop, etc.) on shoulder and/or lanes of traffic. *(Kansas City Scout)*
- MN TMC uses State Patrol's computer-aided dispatch (CAD) system. Since the majority of wrong ways originate from State Patrol dispatch we don't need to create new events, we use theirs. *(Minnesota DOT)*
- Lonestar Events are created and emails are sent for notification purposes. *(Texas DOT – Transguide San Antonio)*
- If the call comes in via 911 or the public, we then log that into the Lonestar ATMS system if found active. If it is from our Tapco WWD field devices, that is sent to us automatically and then we watch that car if it never passes the gore or enters onto main lanes of the Tier 1 highway it doesn't get logged as an active WWD. *(Texas DOT – Fort Worth TMC)*

The survey of 911 dispatch managers did not have a similar question.

4.1.3 Designation for Logging WWD Events

Next, respondents were asked, "What designation is used to log wrong-way driving events?" Eight of the nine responses for this question indicated that the TMC operator designates the event as wrong-way driving while the remaining respondent indicated that they do not log wrong-way driving events. See Figure 4.3.

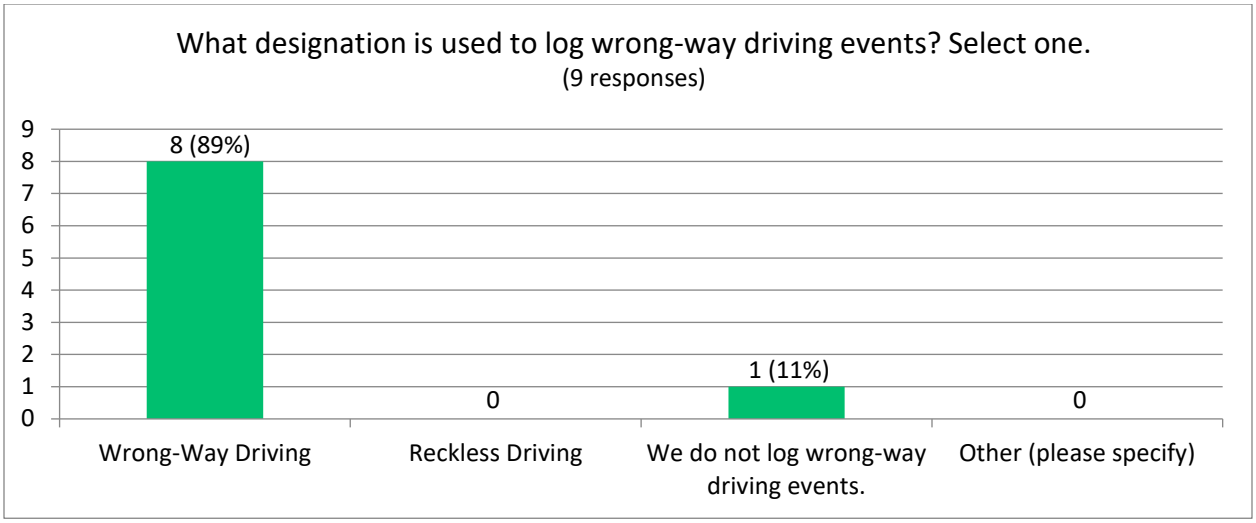


Figure 4.3 Designation for Logging WWD Events (TMC Responses)

The survey of 911 dispatch managers asked a similar question, "When a 911 caller reports seeing a wrong-way vehicle, how do you record (log) the event?" The 911 dispatch manager (Wisconsin State Patrol) responded, indicating "other" and sharing "In our CAD we don't have a 'Wrong-Way' option, so it gets coded as a '10-65 Driving Complaint' with a status note of Wrong-Way Driver. We then change the status priority from 'Routine' to 'High' so that it not only changes the color of the CFS in our CAD but also changes the alert times for that specific call to require more status checks and follow up."

4.1.4 Type of WWD Event Data Logged

Next, the survey of TMC managers asked, "What details do operators log for each wrong-way driving event?" Of the eight responses, all indicated that they log the highway/route of the wrong-way vehicle. Seven of the eight respondents indicated that they also log the nearby exit, milepost, or other location information. Six of the eight respondents log a description of the wrong-way vehicle and the time the wrong-way vehicle was observed by the caller. Four respondents also log the caller's location and six responded that they also log "other" information. See Figure 4.4.

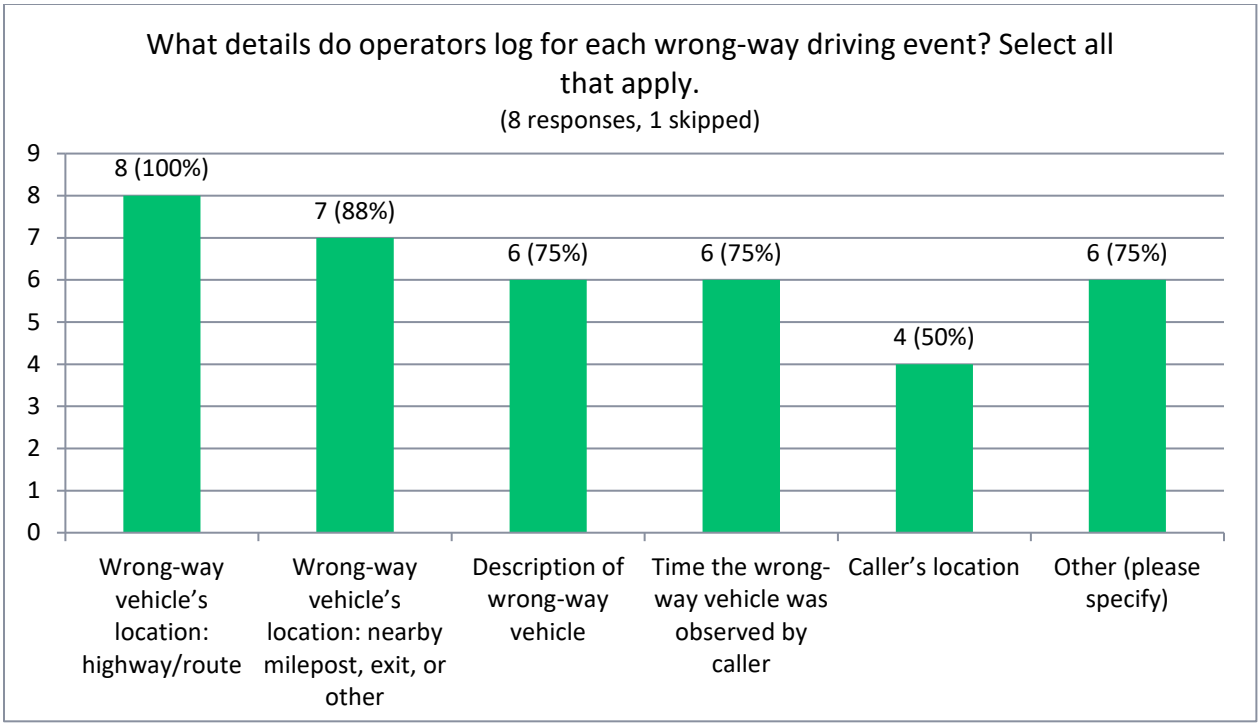


Figure 4.4 Type of WWD Event Data Logged (TMC Responses)

Details shared in the six "other" responses included:

- Date and time that the TMC was made aware of the reported WWD event and verified it. *(Rhode Island DOT)*
- Data from detection field equipment that is logged and stored includes date, time, location, lat/long, time of day, event type, lane the WWD vehicle entered on, and if it made to WWD entry. *(Arizona DOT)*
- Resolution, if a crash has occurred, law enforcement contact with wrong way driver, and injuries or fatalities if involved in a crash. *(Wisconsin DOT)*
- A vast majority of these calls originate from State Patrol 911/CAD. Location, description, etc. TMC then works with Patrol to verify on camera or on playback. *(Minnesota DOT)*
- Outcome if available (for example, were crashes involved.) *(Texas DOT – Transguide San Antonio)*
- The time we visually confirmed the WWD was driving on our highway. *(Texas DOT – Fort Worth TMC)*

The survey of 911 dispatch managers asked a similar question, "What details do you typically record/log when a wrong-way vehicle event is called into 911?" The respondent indicated that they document:

- Date and time the wrong-way vehicle was observed by caller.
- Wrong-way vehicle's location: highway/route.
- Wrong-way vehicle's location: nearby milepost, exit, or other.
- Description of wrong-way vehicle.
- Caller's location.

The 911 dispatch respondent (Wisconsin State Patrol) also indicated "We try to keep the caller on the line if they still have visual of the vehicle. We also try to locate the wrong-way vehicle on our camera system, then notify DTSD to change the highway signboards to warn motorists."

4.1.5 Ability to Export/Push WWD Event Data

Finally, the survey gathering TMC processes asked, "Does your ATMS or condition reporting system support an export/push of wrong-way driving event data?" Most respondents (8 of 9) indicated that their ATMS/condition reporting system does support an export/push of wrong-way driving event data. Some agencies indicated that these systems push the data via email or to traveler information mechanisms such as 511 or digital message sign (DMS). Other agencies noted that though the system capability exists, the feature is not activated and therefore the WWD event data is not exported or pushed out. See Figure 4.5.

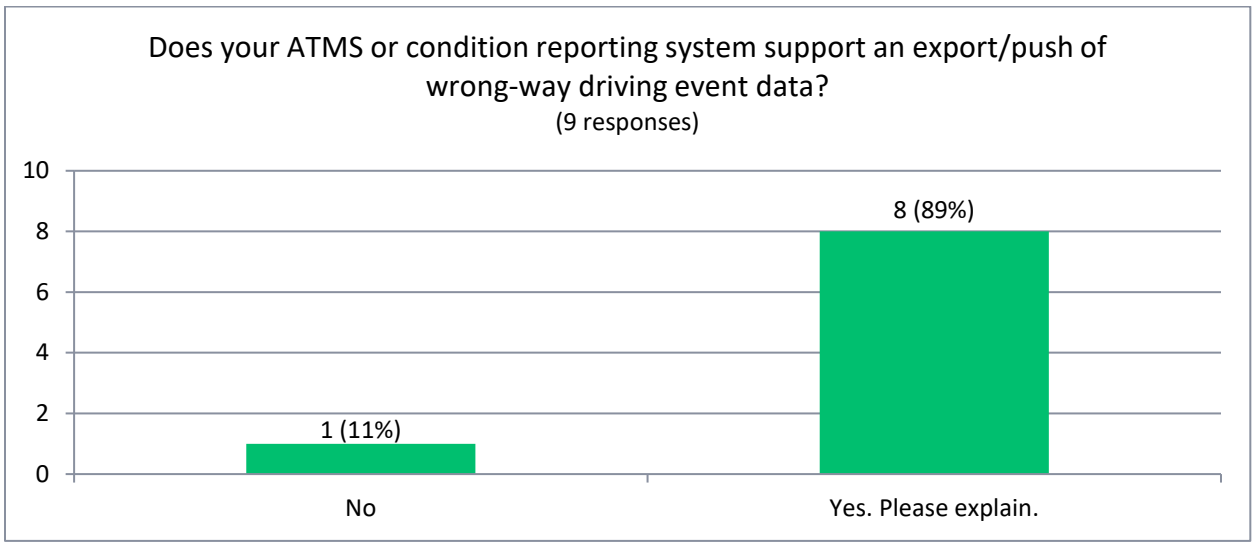


Figure 4.5 Ability to Export/Push WWD Event Data (TMC Responses)

Responses indicating that their ATMS/condition reporting system supports an export/push of wrong-way driving event data further explained:

- An email is sent to selected individuals. *(Iowa DOT)*
- The RoadWAYS system is technically capable of exporting/pushing WWD event data, however it does not do this today. Would need to obtain approvals within RIDOT to do this. The TAPCO system is technically capable of exporting/pushing WWD event data, as they offer an API solution(s). RIDOT would need to allow them to share this data. *(Rhode Island DOT)*
- For the I-17 pilot deployment, data can be pushed to DMS. For other locations, data would need to be brought into the central system, and there is concern about the capacity of the system to handle the large volume of data. There is also a time lag with the dispatcher reviewing video and verifying the WWD event. *(Arizona DOT)*
- Data can be exported from the ATMS as well as our Access database, but information is not pushed from either system. *(Wisconsin DOT)*

- We don't have the feature turned on nor the real time sensors needed to push the information. FDOT has done this and is available in our software. *(Kansas DOT – WICHway)*
- There is a feed from State Patrol CAD to ATMS and to 511. The 511 will send an alert. *(Minnesota DOT)*
- ATMS Lonestar does support a FLIR/FLUX plugin used by wrong way driving devices. We currently have two of these devices in service. *(Texas DOT – Transguide San Antonio)*
- We can email the condition that we are working to an email address if provided. The only one we currently do that with is the City of Fort Worth. *(Texas DOT – Fort Worth TMC)*

The survey of 911 dispatch managers did not include a similar question.

4.2 WWD Detection Field Equipment

The next phase of investigation included interviews with selected agencies to gather information about WWD detection field equipment locations, location data, and capabilities of field equipment to communicate WWD detection data.

Agency interview questions included:

- Where is WWD detection field equipment located? Is the field equipment capable of providing the location of where a WWD event started? If yes, in what format is the location provided?
- Does the field equipment send notifications? If yes, is a data standard used for communicating the detection data?
- Is wrong-way vehicle detection data from field equipment logged? If so, how?
- Does your agency test WWD field equipment to understand the number of false calls? If yes, how well does the equipment perform?

Three state transportation agencies were interviewed for this project: Rhode Island DOT, Arizona DOT, and Iowa DOT. The following sections show a summary of abbreviated responses from the agency interviews. Appendix C contains a complete summary of each agency interview completed.

4.2.1 Equipment Locations and Location Data

All agencies noted that their WWD detection field equipment is located at interchange ramps, with some equipment located on mainlines or at-grade expressway intersections. The equipment is typically capable of providing the location of the equipment itself, which allows the agency to derive the location of the start of the WWD event. Location data of the equipment varies but is typically reported as latitude/longitude (lat/long) along with descriptions such as highway designation and direction, mainline marker, and/or ramp designation and direction. Rhode Island DOT reports the locations of WWD sensors on a web page including lat/long, highway designation, ramp designation, and direction for each sensor. Table 4.1 provides abbreviated interview responses related to WWD equipment locations and location data. See Figure 4.6 for a screenshot of WWD sensor location information available at the Rhode Island DOT website.

Table 4.1 Abbreviated Responses from Agency Interviews: Equipment Locations and Location Data

Question	Agency and Abbreviated Response	
Where is WWD detection field equipment located?	Rhode Island DOT	• Interchange ramps
	Arizona DOT	• Interchange ramps • Mainlines
	Iowa DOT	• Interchange Ramps • At-grade expressway intersections (median-separated, 2 lanes in each direction)
Is the field equipment capable of providing the location of where a WWD event started? If yes, in what format is the location provided?	Rhode Island DOT	Yes (typically). The location of WWD field equipment is known and can assume the location of where the WWD event started. Location format: • Lat/long • Highway designation • Ramp designation and direction
	Arizona DOT	Yes. Location format: • Lat/long • Some descriptions (e.g., route number, ramp description, vehicle direction.) Varies by deployment.
	Iowa DOT	Yes, with additional help. Cameras send an email to selected DOT staff, who manually look up the location of the camera, using a lookup table. Location format: • Intersection of two routes/highways • Mainline mile marker • Direction the vehicle is headed

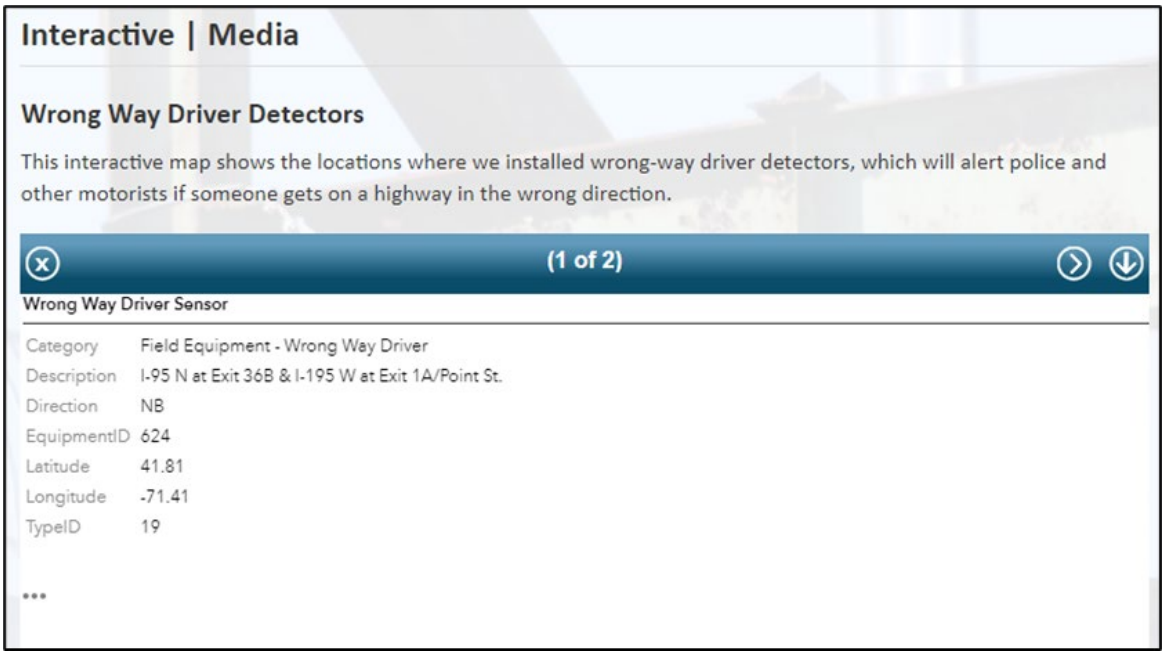


Figure 4.6 WWD Sensor Location Information Available at Rhode Island DOT Website
(Source: https://www.dot.ri.gov/Safety/wrong_way_safety.php)

4.2.2 Notifications and Data Standards

All three agencies interviewed indicated that their WWD field equipment sends notifications. However, these agencies indicated that a data standard for communicating the detection data is not used or that they were unsure. Table 4.2 provides abbreviated responses from agency interviews related to WWD notifications and use of data standards.

Table 4.2 Abbreviated Responses from Agency Interviews: Notifications and Data Standards

Question	Agency and Abbreviated Response	
Does the field equipment send notifications?	Rhode Island DOT	Yes. DOT staff are provided with an alert through the vendor's software. State police receive alerts. In some cases, local police also receive alerts.
	Arizona DOT	Yes. A notification is sent to the TMC dispatcher. They verify the event, then the message is sent on to ADOT law enforcement partners.
	Iowa DOT	Yes. An email is sent to selected DOT staff.
If yes, is a data standard used for	Rhode Island DOT	Unsure. The vendor software sends the notifications.
	Arizona DOT	Data comes into DOT software, then operators verify the event.

Question	Agency and Abbreviated Response	
communicating the detection data?	Iowa DOT	No. The data in the body of email is basically the same, with some unique information, but not a standard.

4.2.3 Logging WWD Data

All agencies interviewed noted that they log WWD event data, though the type of data logged varies and entries logged (e.g., by operators) are not always consistently entered as WWD events. Iowa DOT maintains an extensive database of WWD event data used for post-analysis, to help determine locations for safety improvements such as geometric changes or modifications to pavement markings and signing. Table 4.3 shows abbreviated responses from agency interviews related to logging WWD event data and type of data logged.

Table 4.3 Abbreviated Responses from Agency Interviews: Logging WWD Data

Question	Agency and Abbreviated Response	
Is wrong-way vehicle detection data from field equipment logged?	Rhode Island DOT	Yes.
	Arizona DOT	Yes.
	Iowa DOT	Yes.
If yes, what data is logged?	Rhode Island DOT	Date, time, location of detection (route/highway number, ramp designation, lat/long), and operator comments. Entries of WWD events are not always consistent.
	Arizona DOT	Date, time, location, lat/long, time of day, event type, lane the WWD vehicle entered on, and if the vehicle made it to a WWD entry.
	Iowa DOT	Several data types are logged in a separate database, used for post-analysis. (See the Iowa DOT interview summary in Appendix C for details.)

4.2.4 False Calls

All agencies interviewed noted that their WWD equipment is tested on a regular basis. The agencies indicated that false calls (i.e., false alerts, or false positives) routinely occur, due to weather events and wind as well sensor/camera placement. Though the rate of false calls appears to be improving over time, the WWD detections from field equipment need to be verified by DOT staff prior to taking action. See Table 4.4 for abbreviated responses from agency interviews.

Table 4.4 Abbreviated Responses from Agency Interviews: False Calls

Question	Agency and Abbreviated Response	
Does your agency test your field equipment to understand the number of false calls?	Rhode Island DOT	Yes. A vendor performs service checks 3-4 times per year and annually drives a vehicle through to test the system.
	Arizona DOT	Yes, field equipment is tested.
	Iowa DOT	Yes, the DOT does test the detection equipment.
How well does the equipment perform in terms of false calls versus verified wrong-way vehicle detections?	Rhode Island DOT	Service checks completed by the vendor help to reduce the number of false alarms. However, there are still several 'false alarms' (i.e., false positives) during any given week. Overall, this is improving over time.
	Arizona DOT	Several issues cause false alarms. Often false calls occur during weather events. The biggest challenge is wind, as the mast arms with cameras mounted on them will move. Agency verification is in place to weed out false calls.
	Iowa DOT	There are lots of false calls (approximately 7,400 in 3 months, from 62 cameras). The vendor recommends where to place it, but the agency needs to place cameras at locations where power, pole, and communications exist. Many false calls could be minimized with better analytics, especially to filter out headlights, sunrise, and other light-based effects.

4.2.5 Other Input

Other relevant input gathered during agency interviews included the following:

- Wrong-way driving data is very dynamic, which makes it difficult for a real-time data feed. Detection capabilities are vendor driven. The idea of a real-time WWD data feed is a solid idea but premature at the current time.
- Installation is the most important aspect of WWD detection, to minimize false calls.
- A national standard for messaging to oncoming (right-way) drivers is needed, for example what message should be displayed and when to post messages.
- It would be helpful to have a National Transportation Communications for ITS Protocol (NTCIP) protocol for wrong-way detection for detection, false call rates, and dissemination/messaging, to advance this nationally.

Chapter 5: Summary and Implementation

The ENTERPRISE Pooled Fund Study completed this project to promote the concept of a national communication standard for incident data (including WWD events) and to explore the readiness of WWD event data to be contributed to a data feed. An incident data feed would enable WWD data from multiple sources (e.g., 911 calls, on-road detection field equipment, self-reporting mobile applications) to become available through a data feed for in-vehicle mechanisms to access and provide alerts to errant drivers and nearby motorists.

The project completed a synthesis of commercially available WWD in-vehicle systems and mobile applications, conducted outreach to FHWA to promote the concept of a national communication standard and data feed for WWD events, and gathered input from transportation agencies regarding the readiness of agency-generated WWD event data (e.g. from 911 calls, traffic management center systems and observations, and on-road detection field equipment) to be contributed to a data feed.

5.1 Key Observations

The following key observations were noted from the research activities including opportunities, challenges, and overall conclusions.

Opportunities:

- Several in-vehicle systems and mobile applications that perform WWD detections and provide alerts are commercially available. In the future, these technologies are possible sources of WWD event data that could be communicated (using a national data communication standard) via local or national data feeds, to warn nearby vehicles or be used for post-analysis.
- Transportation agencies are increasingly deploying WWD detection field equipment, which equates to more WWD event data that could be exported to a data exchange platform.
- The locations of agency-deployed WWD detection sensors are known, which can be used to derive and verify the locations where WWD events begin.
- WWD event data from agency on-road detection sensors is often capable of being exported or pushed to external sources. This indicates that data and communication standards, if implemented, could facilitate a future export/push of this data to systems that could ingest the data and provide warnings.
- On a national level, FHWA is advancing efforts to explore a data exchange for “disruptive incidents,” which could include WWD event data.
- There is agency interest in standardizing WWD event data and protocols such as data communications standards and when it is appropriate to alert right-way traffic of a WWD event.
- The more WWD events are recorded and shared, the more that the causes and “triggers” of these events can be understood. This in turn can help roadway designers and operators take steps to preventing WWD events in the future.

Challenges:

- Variation exists in how agencies code, log, and communicate WWD events, indicating a need for data and communications standards.
- Detection technology is improving, but agencies still see a lot of false positives. Detection equipment installation is a key aspect in minimizing false calls.
- Many WWD vehicles self-correct after detection, therefore the field equipment detection alone is often not a reliable indicator of a wrong-way driver entering the freeway. This indicates that the detection equipment alone (without human verification) may not be a reliable mechanism to communicate directly to a WWD data feed.
- The nature of wrong-way driving data is very dynamic. Agency verification of WWD detections is often needed before external notifications or data exports could be provided for public consumption.

Overall Conclusions:

The project concluded that there is agency and industry interest in communicating WWD event data, signifying an interest in a national WWD communication standard and data feed. However, the WWD event data currently available from sources such as 911 calls, on-road detection equipment, and traffic management center observations is likely not yet ready to be pushed to such a feed. The outreach to FHWA resulted in productive discussions and interest in including WWD data in FHWA's current efforts to develop a national communications standard for disruptive incidents. Once developed, state and local agencies (and industry products) could use the communication standard to communicate WWD event data and work collaboratively to develop standards for when and how to communicate notification messages to the traveling public.

5.2 Implementation

ENTERPRISE members and other transportation agencies can implement the results of this research through disseminating the findings and supporting the concept of a national communication standard for WWD events.

Recommended implementation steps could include the following actions:

1. Distribute the report to the following ENTERPRISE agency State DOT leaders, managers, and staff:
    - Transportation system management and operations (TSMO) leaders
    - Traffic operations (e.g., TMC) managers and staff
    - Traffic safety engineers
    - ITS and emerging technologies staff
2. Share the report and findings with USDOT/FHWA staff responsible for planning and implementing national communications standards(s) and data feed, for their continued consideration of WWD event data to be included in applicable FHWA-led efforts.

3. Consider the following steps to implement a national communications standard for WWD event data:
    - Encourage agencies that implement WWD detection systems to include automated reporting/sharing capabilities;
    - Participate in standards development efforts (e.g., the Next Generation Traffic Management Data Dictionary (TMDD)) to encourage the creation of standards to accommodate WWD events; and
    - Continue to participate in national efforts directed toward roadway digital infrastructure and disruption event data exchanges, further expanding the messages about WWD that have previously been shared. This includes continual advocacy for the inclusion of WWD event data in these efforts.

4. ENTERPRISE may consider conducting a project to investigate the state of practice for standardizing WWD event protocols such as detection parameters, alerts to right-way traffic (e.g., when to provide automated alerts, standard messages), and protocols for logging WWD events for post-analysis.

As federal, state and local transportation agencies continue their efforts to mitigate WWD crashes, the results of this research will inform these advancements.

Appendix A
Potential Approaches for Wrong-Way Driving Applications – Phase 2 White Paper

ENTERPRISE

June 2023

Potential Approaches for Wrong-Way Driving Applications – Phase 2

Background

Wrong-way driving (WWD) is a growing concern on roadways, as the resulting crashes tend to be severe and often result in fatalities and serious injuries.

On-road countermeasures that capture the attention of drivers who have made a wrong-way maneuver can only go so far to reduce wrong-way crashes. Advancements in cooperative automated technologies will enable significant possibilities to provide WWD warnings through in-vehicle navigation systems and smartphone-based mobile applications. These types of interventions could supplement on-road countermeasures by influencing wrong-way drivers to correct their wrong-way movements while also alerting other nearby drivers.

In-vehicle navigation systems, together with on-board GPS, are typically able to detect when vehicles are no longer traveling on the pre-defined route and initiate re-routing algorithms. A similar concept could detect wrong-way movements and provide alerts to drivers, especially on divided highways.

A 2015 survey showed that 64% of drivers reported using a smartphone application to assist with their travel.[1,2] The most used applications were navigation and real-time traffic information, both that typically rely on underlying map tools that include directional travel. Mobile devices with applications providing navigation services could receive wrong-way driving information and alert drivers or passengers, potentially reaching more than half the drivers with wrong-way alerts.

Many transportation agencies have installed on-road sensors that detect wrong-way vehicle movements and communicate WWD events to traffic management centers. Public safety agencies also become aware of wrong-way drivers through calls from nearby motorists.

A national communication standard for incident data including WWD events would enable data from multiple sources (911 calls, on-road sensors, self-reporting mobile applications) to become available through a data feed for in-vehicle mechanisms to access and provide alerts to errant drivers and nearby motorists. See Figure 1.

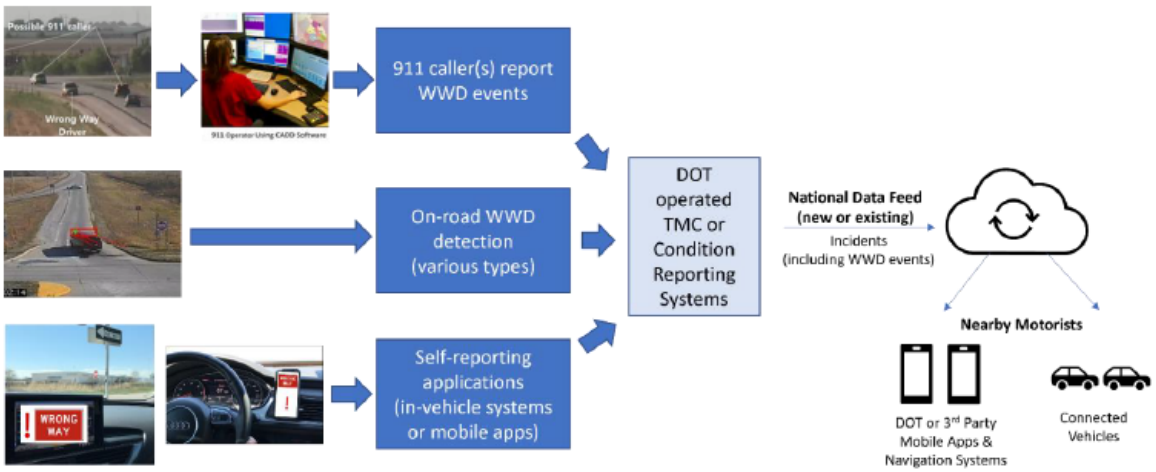


Figure 1: Wrong-way Driving (WWD) Events Communicated Through a National Incident Data Feed

[1] www.sciencedirect.com/science/article/pii/S2046043016300648 (Kamalanthsharma, et al., 2015)
[2] https://money.cnn.com/2016/10/10/autos/car-navigation-frustration/index.html (Valdes-Dapena, 2016)

Potential Approaches for Wrong-Way Driving Applications – Phase 2

Industry Interest

The ENTERPRISE Pooled Fund Study *Potential Approaches for Wrong-Way Driving Applications* project conducted industry outreach to generate interest in and explore the potential for in-vehicle navigation systems and mobile apps to provide wrong-way driving alerts. Meanwhile, the following mechanisms for WWD detection and alerts are now on the market, indicating industry progress toward broader implementation:

- Wrong Way Alert technology for Ford Focus vehicles (announced in Germany in 2018) utilizes Ford's Traffic Sign Recognition technology to detect "no entry" signs and provide alerts to the driver.[3]
- In 2021, European automobile manufacturer ŠKODA announced it will offer the Bosch Wrong-Way Driver Warning System in the infotainment system of several vehicle models.[4]
- The Sygic GPS Navigation mobile app uses GPS to determine whether the device is going in the opposite direction of traffic, then issues warnings to both the driver operating the app and other drivers in the vicinity who are also operating the app.[5]
- The Wrong Way Driver Alert mobile app detects wrong-way events and notifies the driver, persons within a 10 mile radius of the driver, and highway authorities of a potential wrong way driver. A corresponding PFR (Police Fire and Rescue) application monitors users of the app within a pre-set radius to pick up wrong-way driving activity.[6]
- The HAAS Alert Safety Cloud® digital alerting service integrates with existing WWD detection systems. When a WWD system detects a WWD event, a single API call into Safety Cloud® activates a pre-programmed and customizable "WWD Digital Alerting Zone" managed by the infrastructure owner/operator, and connected drivers within and approaching the "WWD Digital Alerting Zone" receive a safety alert in their vehicle infotainment screen or mobile application.[7]

While encouraging, these technologies are often limited to warning only the errant driver or require both the errant driver and nearby motorists to be simultaneously operating the same application to receive an alert that a wrong-way driver may be approaching. This suggests the need for a common communication standard and data feed for exchanging wrong-way event data, expanding the ability for WWD events to be communicated and received as they occur.

Why a National Standard?

A national communication standard for wrong-way driving data (or the inclusion of WWD event information in another national data exchange) would establish data parameters for the location and time of wrong-way vehicle reports received through multiple sources. This would enable WWD event data to become available through a data feed for in-vehicle applications to access and provide alerts to errant drivers and nearby motorists. Sources of WWD event data could include:

- Public Safety Answering Points / 911 call centers;
- On-road WWD detection devices; and
- Self-reporting mobile applications

The ENTERPRISE *Potential Approaches for Wrong-Way Driving Applications – Phase 2* project is continuing outreach and initiating discussions with USDOT to advocate for including WWD event data in one or more national data exchanges to enable contributors and recipient technologies of WWD data to operate with common parameters, advancing the ability for the traveling public to learn of WWD events as they occur.

Contacts

The following individuals are leading this effort on behalf of ENTERPRISE and can be contacted to discuss this effort.

- Cory Johnson, Minnesota Department of Transportation Coryj.Johnson@state.mn.us
- Willy Sorenson, Iowa Department of Transportation Willy.Sorenson@IowaDOT.us

[3] https://media.ford.com/content/fordmedia/feu/en/news/2018/08/06/new-tech-for-all-new-ford-focus-could-help-prevent-the-nightmare.html (Ford, 2018) (Accessed 3/17/23)
[4] https://www.aftermarketnews.com/boschs-wrong-way-driver-warning-system-now-on-skoda-vehicles/ (After Market News, 2021) (Accessed 3/17/23)
[5] https://www.autoevolution.com/news/how-a-google-maps-competitor-developed-a-wrong-way-driver-warning-feature-197738.html (2022) (Accessed 5/4/22)
[6] https://apps.apple.com/us/app/wrong-way-driver-alert/id1356015696 (JV Marketing Technologies) (Accessed 3/17/23)
[7] https://www.haasalert.com/news/combating-wrong-way-drivers-with-digital-alerting (HAAS Alert, 2023) (Accessed 5/5/23)

ENTERPRISE Pooled Fund: http://enterprise.prog.org/

Appendix B
Survey Questions: Traffic Management Centers and 911 Dispatch Processes

Survey Questions: Traffic Management Center (TMC) Managers

1. Contact information:
    - Name:
    - Agency:
    - Email address:
2. How are TMC operators alerted when a wrong-way driving event has occurred? Select all that apply.
    - Notification from 911 dispatch
    - Notification from detection field equipment
    - Call from the traveling public
    - Other (please specify)
3. How do TMC operators log wrong-way driving events?
    - Manually (e.g., logbook, spreadsheet)
    - In the ATMS or condition reporting system
    - We do not log wrong-way driving events. (If selected, go to #6.)
    - Other (please specify)
4. What designation is used to log wrong-way driving events?
    - Wrong-Way Driving
    - Reckless Driving
    - We do not log wrong-way driving events. (If selected, go to #6.)
    - Other (please specify)
5. What details do operators log for each wrong-way driving event? Select all that apply.
    - Wrong-way vehicle's location: highway/route
    - Wrong-way vehicle's location: nearby milepost, exit, or other
    - Description of wrong-way vehicle
    - Time the wrong-way vehicle was observed by caller
    - Caller's location
    - Other (please specify)
6. Does your ATMS or condition reporting system support an export/push of wrong-way driving event data?
    - No
    - Yes. Please explain.
7. Please provide any additional information that may be of interest for this research.

Survey Questions: 911 Dispatch Supervisors

1. Contact information:
    - Name:
    - Agency:
    - Email address:
2. When a 911 caller reports seeing a wrong-way vehicle, how do you record (log) the event?
    - Wrong-Way Driving
    - Reckless Driving
    - We do not record or log wrong-way driving events. (If this is selected, go to #4)
    - Other (please specify)
3. What details do you typically record/log when a wrong-way vehicle event is called into 911? Select all that apply.
    - Date and time the wrong-way vehicle was observed by caller
    - Wrong-way vehicle's location: highway/route
    - Wrong-way vehicle's location: nearby milepost, exit, or other
    - Description of wrong-way vehicle
    - Caller's location
    - No details are logged.
    - Other (please specify)
4. Who is your computer-aided dispatch (CAD) vendor? Please provide the company and a point of contact (name, email, phone number).
5. Please provide any additional information that may be of interest for this research.

Appendix C
Agency Interview Summaries

ENTERPRISE

Potential Approaches for Wrong-Way Driving Applications – Phase 2

Agency Interview for Wrong-Way Driving Detection Equipment and Reports to the TMC

Interview Summary: Rhode Island DOT

Participant and Date of Interview

Interview Participant:

- Russell Holt, Rhode Island DOT (RIDOT)

Interview Date: 2/8/23

Part 1: Wrong-Way Driving (WWD) Detection Field Equipment

NOTE: **Bold text** indicates interview responses.

1. Where is your agency's wrong-way driving (WWD) detection field equipment located?
   - **Yes - Interchange ramps (30-40 detectors selected locations around the state, only at limited access highway ramps, TAPCO is the vendor.)**
   - No - Mainlines
   - No - Other

2. Is your agency's detection field equipment capable (or would it be capable) of providing the location of where a WWD event started? For example, if the equipment is located on an off-ramp and a wrong-way vehicle is detected, would the start point of the WWD event be known?

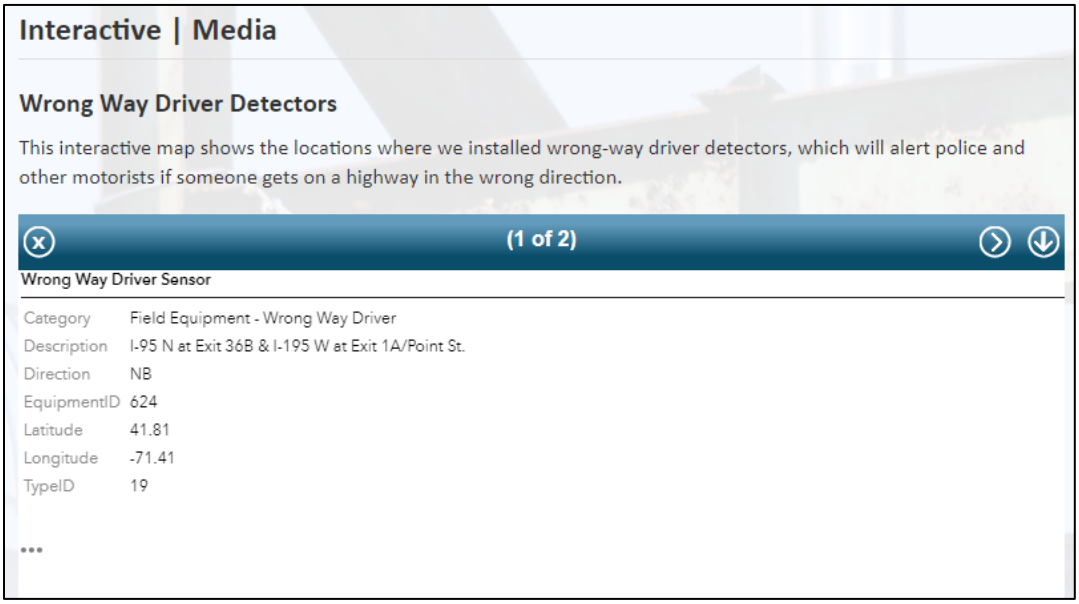
   Short answer is typically yes, but it depends on the limitations of the detection technology. The TAPCO system includes cameras, but the camera viewing range varies by site and may not always be able to see where the wrong-way event started. Sometimes it is hundreds of feet up or down the ramp where you cannot know definitively where the wrong-way vehicle entry occurred.

   RIDOT's WWD detection systems include activation of signs as well as alert notifications. With the TAPCO-offered system, there are several zones that can be set up, including "alert," "notification," and "confirmation" zones. RIDOT has experienced some operational issues with radar detection that has been used with its initial WWD systems. In some sites, RIDOT now has both radar and thermal detection technologies at the same location. Radar has been at least somewhat reliable in all weather conditions, but certain types of large vehicles (e.g., trucks with tarp arms on trailers) routinely generate false alarms. Every site is unique. Some ramps have unique geometry, others are standard diamond interchanges.

   Despite all the above, the location of each piece of RIDOT's WWD field equipment is known and tracked in TAPCO's software, and so in most cases it is safe to assume the location of where the WWD event started (i.e., at the downstream end of the associated ramp, at its intersecting roadway(s)).

2a. If yes, in what format is the location provided (e.g., lat/long, highway and ramp designation)?

Lat/long, highway designation, ramp designation, and direction. (See the screenshot, showing location information for a WWD sensor.)



WWD Sensor Location Information Available at Rhode Island DOT Website (Source: https://www.dot.ri.gov/Safety/wrong_way_safety.php)

3. Does the field equipment send notifications to the traffic management center, DOT staff, or law enforcement?

   Yes.

   - **DOT staff are provided with an alert through the TAPCO Blinklink® software.**
   - **State police receive alerts.**
   - **In some cases, local police also receive alerts.**

   3a. If yes, is a data standard used for communicating the detection data? Please describe.

   Unsure if a standard is used by TAPCO.

4. Is wrong-way vehicle detection data (e.g., date, time, location) from field equipment logged?

   Yes.

   4b. If yes, what data is logged? (E.g., date, time, location of detection, route/highway number, ramp designation.)

   Date, time, location of detection (route/highway number, ramp designation, lat/long), and operator comments are logged.

   Two systems are used by RIDOT to manage WWD events:

   1) TAPCO's web interface: Blinklink® (a turnkey solution) is used at some locations.
   - **Includes a map, list of detector locations, and provide notifications.**
   - **Sends a text to pre-selected RIDOT employees.**
   - **Provides an audible alert to the traffic management center (TMC).**

2) **RhodeWAYS, an internally built software system for incident management tracking by TMC operators.**

- **Contains a field for "Wrong-way Driver" to designate a WWD event.**
- **This system is used to log 911 calls (i.e., state police), to document WWD events.**
- **For confirmed WWD events originating from field equipment, an incident report is created in RhodeWAYS.**
- **WWD event data is logged in RhodeWAYS:**
    - **Mainline highway route and direction (e.g., I-95 WB).**
    - **Exit number of the ramp, e.g.: Exit 2@route 103/US-44 Broadway.**
    - **The raw .csv data contains the lat/long.**
    - **Operator comments, which are not consistently logged.**
    - **Note that in this instance above, Type of Incident was not coded as WWD.**

Type of Incident: Other **Created By:**
Work Zone Crash: No **Incident Status:** Closed **By:**
Secondary Incident: No
Incident Time: 12/17/2023 5:50 PM **Cleared Time:** 12/17/2023 5:52 PM
Closed Time: 12/17/2023 5:54 PM **Duration:** 4 **minutes.**
Incident Location: I-195 WB
1D@Gano Street/India Point in PROVIDENCE
Incident Severity: 0
Injury: None & Unknown **Fire:** No
Rollover: No **Truck Rollover:** No **Hazards:** No
Damage to State Property: No
Incident Vehicles Involved:
Lane Blocked/Affected

Lane(s)	Time
Right Shoulder	12/17/2023 05:51:48 PM

On Scene

Responder	Arrival Time	Departure Time
State Police	12/17/2023 5:52 PM	12/17/2023 5:54 PM

Notifier: RISP State Police Scanner at 12/17/2023 05:52 PM
Weather Condition
Pavement: Short **Visibility:** 2.05 mile
Precipitation: Light Precipitation **Wind:** 3 mph
Operation Comments

Time	Operator	Comment
12/17/2023 5:53 PM		state police turned it around.

Example Incident Report from RhodeWAYS System
(Source: Rhode Island DOT)

5. Does your agency test your field equipment to understand the number of false calls? How well does the equipment perform in terms of false calls versus verified wrong-way vehicle detections?

Yes. A vendor performs service checks 3-4 times per year and annually drives a vehicle through to test the system. This helps to reduce the number of false alarms. However, there are still typically several 'false alarms' (false positives) occurring during any given week. The RIDOT can monitor and track this via the Blinklink® software and its alerts. Overall, this is improving over time.

The screenshot below shows the vendor's (TAPCO) categories for WWD detections, including false positives.

Tapco Blinklink® software WWD categories
(Source: Rhode Island DOT)

Part 2: Wrong-Way Vehicle Reports to Traffic Management Center (TMC)

NOTE: **Bold text** indicates interview responses.

6. How are TMC operators alerted when a wrong-way driving event has occurred? Select all that apply.
   - **Yes - Notification from 911 dispatch**
   - **Yes - Notification from field equipment**
   - **Yes - Call from the traveling public**
   - No – Other (please specify)

   Clarification to "Notification from 911 dispatch" bullet: The 911 notification goes to state police, who then contacts the RIDOT TMC.

7. How do TMC operators log wrong-way driving events? Select all that apply.
   - No - Manually (e.g., logbook, spreadsheet)

- **Yes - In the ATMS or condition reporting system**
- No - Other (please specify)
- No - We do not log wrong-way driving events

Clarification to "In the ATMS or condition reporting system" response: This refers to RhodeWAYS, RIDOT's incident management and reporting software.

8. What designation is used to log wrong-way driving events? Select all that apply.
   - **Yes - Wrong-Way Driving**
   - No - Reckless Driving
   - **Yes - Other (please specify) – WWD designation is available in the RhodeWAYS software, but this designation isn't always used by operators as a standard practice.**
   - No - We do not log wrong-way driving events.

9. What details are logged? Select all that apply.
   - **Yes - Wrong-way vehicle's location: highway/route**
   - **Yes - Wrong-way vehicle's location: nearby ~~milepost~~, exit, or other (NOTE: milepost is not logged)**
   - No - Description of wrong-way vehicle
   - No - Time the wrong-way vehicle was observed by caller
   - No - Caller's location
   - **Yes - Other (please specify): Date and time that the TMC was made aware of the reported WWD event and verified it.**

10. Does your ATMS or condition reporting system support an export/push of wrong-way driving event data?
    Yes.

    The RoadWAYS system is technically capable of exporting/pushing WWD event data, however it does not do this today. Would need to obtain approvals within RIDOT to do this. The TAPCO system is technically capable of exporting/pushing WWD event data, as they offer an API solution(s). RIDOT would need to allow them to share this data. Not currently done today.

Part 3: Other

11. Please provide any additional information that may be of interest for this research.
    RIDOT believes that some agencies have made the decision to post messages to "right way drivers" via on-road dynamic message signs (DMS). Although RIDOT envisioned this would be done after the system was installed, they have not done that yet after 8 years of detection equipment being in place. RIDOT has not yet standardized upon what message would or should be displayed, nor what is best and feasible to advise in such cases. This is an issue RIDOT assumes all DOTs are struggling a bit with, as there is no nationwide standard in place for messaging to right way drivers.

ENTERPRISE

Potential Approaches for Wrong-Way Driving Applications – Phase 2

Agency Interview for Wrong-Way Driving Detection Equipment and Reports to the TMC

Interview Summary: Arizona DOT

Participants and Date of Interview

Interview Participants:

- Bruce Dressel, Arizona DOT
- Susan Anderson, Arizona DOT

Interview Date: 2/14/24

Part 1: Wrong-Way Driving (WWD) Detection Field Equipment

NOTE: **Bold text** indicates interview responses.

12. Where is your agency's wrong-way driving (WWD) detection field equipment located? Indicate all that apply.
    - **Yes - Interchange ramps**
    - **Yes - Mainlines**
    - No - Other. Please describe.

    This varies from deployment to deployment. The agency tries to have lots of coverage with field equipment. In rural areas, detection cameras are mounted on dynamic message signs (DMS) on the mainline.

13. Is your agency's detection field equipment capable (or would it be capable) of providing the location of where a WWD event started? For example, if the equipment is located on an off-ramp and a wrong-way vehicle is detected, would the start point of the WWD event be known?

    Yes.

    If yes, in what format is the location provided (e.g., lat/long, highway and ramp designation)?

    Lat/long, plus some descriptions. For the pilot roadway segment, this includes route number and ramp description. For the other deployments, ADOT would know the location and vehicle's direction based on two cameras.

14. Does the field equipment send notifications to the traffic management center, DOT staff, or law enforcement?

    Yes. A notification is sent to the TMC dispatcher. They verify the event, then the message is sent on to Arizona DOT's (ADOT) law enforcement partners.

    If yes, is a data standard used for communicating the detection data? Please describe.

    All detection cameras are infrared. The cameras serve two roles: traffic detection and wrong-way detection. The WWD detection information comes back into the TMC. The information is sent to ADOT's Flux software and Cameleon software. When the WWD alarm comes in, the

dispatcher sees it on the screen, with real-time video, entry point, and an interactive map with video view. They can see the wrong-way vehicle's location and direction of travel. Operators then verify the WWD event and activate messaging. Operators verify because lots of wrong-way drivers self-correct. And some detections aren't wrong-way vehicles.

15. Is wrong-way vehicle detection data (e.g., date, time, location) from field equipment logged?
    Yes
    If yes, what data is logged? (E.g., date, time, location of detection, route/highway number, ramp designation.)
    Data is stored in the Flux system on the servers for one year. It is designated as WWD. Data logged and stored includes date, time, location, lat/long, time of day, event type, lane the WWD vehicle entered on, and if it made to WWD entry.

16. Does your agency test your field equipment to understand the number of false calls? How well does the equipment perform in terms of false calls versus verified wrong-way vehicle detections?
    Yes, field equipment is tested. Several issues cause false alarms. Often false calls occur during weather events. The biggest challenge is wind, as the mast arms with cameras mounted on them will move. However, verification is in place to weed out false calls. All WWD detection devices are cameras/video. Because most cameras are performing both traffic detection and WWD detection, ADOT quickly becomes aware when a detector is not performing.

Part 2: Wrong-Way Vehicle Reports to Traffic Management Center (TMC)

NOTE: **Bold text** indicates interview responses.

17. How are TMC operators alerted when a wrong-way driving event has occurred? Select all that apply.
    - **Yes - Notification from 911 dispatch**
    - **Yes - Notification from field equipment**
    - **Yes - Call from the traveling public**
    - No - Other. Please specify.

    Comment on first bullet: Notification from 911 dispatch occurs in both urban and rural areas.

18. How do TMC operators log wrong-way driving events? Select all that apply.
    - No - Manually (e.g., logbook, spreadsheet)
    - **Yes - In the ATMS or condition reporting system**
    - **Yes – Other (please specify): Each month, the data is also reported out in a spreadsheet format, for use by ADOT management.**
    - No - We do not log wrong-way driving events

19. What designation is used to log wrong-way driving events?
    - **Yes - Wrong-Way Driving**
    - No - Reckless Driving
    - No - Other (please specify)

- No - We do not log wrong-way driving events.

20. What details are logged? Indicate all that apply.
    - **Yes - Wrong-way vehicle's location: highway/route**
    - **Yes - Wrong-way vehicle's location: nearby milepost, exit, or other**
    - **Yes - Description of wrong-way vehicle**
    - **Yes - Time the wrong-way vehicle was observed by caller**
    - **Yes - Caller's location**
    - **Yes – Other (please specify): Data from detection field equipment that is logged and stored includes date, time, location, lat/long, time of day, event type, lane the WWD vehicle entered on, and if it made to WWD entry.**

21. Does your ATMS or condition reporting system support an export/push of wrong-way driving event data?
    Yes. For the I-17 pilot deployment, data can be pushed to DMS. For other locations, data would need to be brought into the central system, and there is concern about the capacity of the system to handle the large volume of data. There is also a time lag with the dispatcher reviewing video and verifying the WWD event.

Part 3: Other

22. Please provide any additional information that may be of interest for this research.
    Wrong-way driving data is very dynamic, which makes it tough for a real-time data feed. Detection capabilities are vendor-driven. The idea of a real-time WWD data feed is a solid idea but premature at the current time.

    Installation is the most important aspect of WWD detection, to minimize false calls (e.g., to reduce false calls with wind, cameras need to be mounted on a rigid pole.) There is a need to warn oncoming traffic, and it would be helpful to have a National Transportation Communications for ITS Protocol (NTCIP) protocol for wrong-way detection for detection, false call rates, and dissemination/messaging, to advance this nationally.

Additional Information:

- Arizona DOT Wrong-Way Drivers web page: https://azdot.gov/about/transportation-safety/wrong-way-drivers#:~:text=When%20ADOT%20is%20alerted%20to,exit%20as%20soon%20as%20possible
- Final Report: Interstate 17 Wrong-Way Vehicle Detection Pilot Program (June 2020) https://azdot.gov/sites/default/files/2020/07/Wrong-Way-Vehicle-Detection-Report-June-2020.pdf

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Potential Approaches for Wrong-Way Driving Applications – Phase 2

Agency Interview for Wrong-Way Driving Detection Equipment and Reports to the TMC

Interview Summary: Iowa DOT

Participant and Date of Interview

Interview Participant:

- Willy Sorenson, Iowa DOT

Interview Date: 2/15/24

Part 1: Wrong-Way Driving (WWD) Detection Field Equipment

NOTE: **Bold text** indicates interview responses.

1. Where is your agency's wrong-way driving (WWD) detection field equipment located?
   - **Yes - Interchange ramps (specifically at ramp terminals, where the ramp meets the "side road")**
   - No - Mainlines
   - **Yes - Other (please describe): At grade expressway intersections (median separated, 2 lanes in each direction, were wrong-way drivers turn before going past the median)**

2. Is your agency's detection field equipment capable (or would it be capable) of providing the location of where a WWD event started? For example, if the equipment is located on an off-ramp and a wrong-way vehicle is detected, would the start point of the WWD event be known?

   Yes, with additional help. Cameras send an email to selected DOT staff. (See example below.) The format of the email is vendor-specific. DOT staff manually look up the location of a camera, using a lookup table.

   2a. If yes: In what format is the location provided (e.g., lat/long, highway and ramp designation)?

   Lookup table includes: Camera number, the intersection of two routes/highways where the camera is located, mainline mile marker, and direction the vehicle is headed (e.g., vehicle heading SB in NB lanes).

From: BoschWWD46_V@iowadot.us <BoschWWD46_V@iowadot.us>
Sent: Monday, February 12, 2024 9:43 AM
To: Sorenson, Willy <Willy.Sorenson@iowadot.us>
Subject: WWD Detected at US 30 & Ia 330 (Ia 330 ML-SB in NB) (IV)

Alarm Mail from BoschWWD46_V@iowadot.us

Unit name: WWD46N-D1TV00*

Local Unit time: 02/12/2024 09:42:00

Condition of the alarm inputs (logical states):
Local Input 01 'Input 1 ': idle
Local Input 02 'Input 2 ': idle
VCA alarm cam 1: : idle
Virtual alarm input 1: : idle
Virtual alarm input 2: : idle
Virtual alarm input 3: : idle
Virtual alarm input 4: : idle
Virtual alarm input 5: : idle
Virtual alarm input 6: : idle
Virtual alarm input 7: : idle
Virtual alarm input 8: : idle
Virtual alarm input 9: : idle
Virtual alarm input 10: : idle
Virtual alarm input 11: : idle
Virtual alarm input 12: : idle
Virtual alarm input 13: : idle
Virtual alarm input 14: : idle
Virtual alarm input 15: : idle
Virtual alarm input 16: : idle
Audio alarm input 1: : idle
Manipulation alarm 1: : idle
Manipulation alarm 2: : idle

Condition of relay outputs (logical states):
Relay Output 01 'Output 1 ':idle

Unit's IP address: http://192.168.0.50/

Unit's IP address: https://192.168.0.50/

Email with WWD Notification from Field Equipment/Camera (Source: Iowa DOT)

3. Does the field equipment send notifications to the traffic management center, DOT staff, or law enforcement?

   Yes. An email is sent to selected DOT staff when a WWD detection occurs.

   Each camera has multiple detection zones. Each zone provides a unique email. The email subject line contains the camera number, intersection, and sometimes the direction the vehicle is traveling, and sometimes the timestamp. Cameras are all capable of producing a timestamp, but in some cases the timestamp is not in the subject line of the email.

   As a test concept, a DOT intern wrote a python code to receive the WWD notifications and based on certain conditions, would automatically create and send an email to a phone translator, which then called the TMC or 911 center. This was very specific to where the event

occurred – route number, mile marker, etc. It was working, however the IT department would not allow automated emails to be sent from a DOT laptop.

Currently, there are no detection-activated signs to alert active wring way drivers. If the TMC is notified by a 911 dispatch agency, and there are DMS within 10 miles, the TMC operators will post a warning for all right way drivers in the area for 10 minutes.

3a. If yes, is a data standard used for communicating the detection data? Please describe.
The data in the body of email is all the same, except unique information – but not a standard.

4. Is wrong-way vehicle detection data (e.g., date, time, location) from field equipment logged?
Yes.

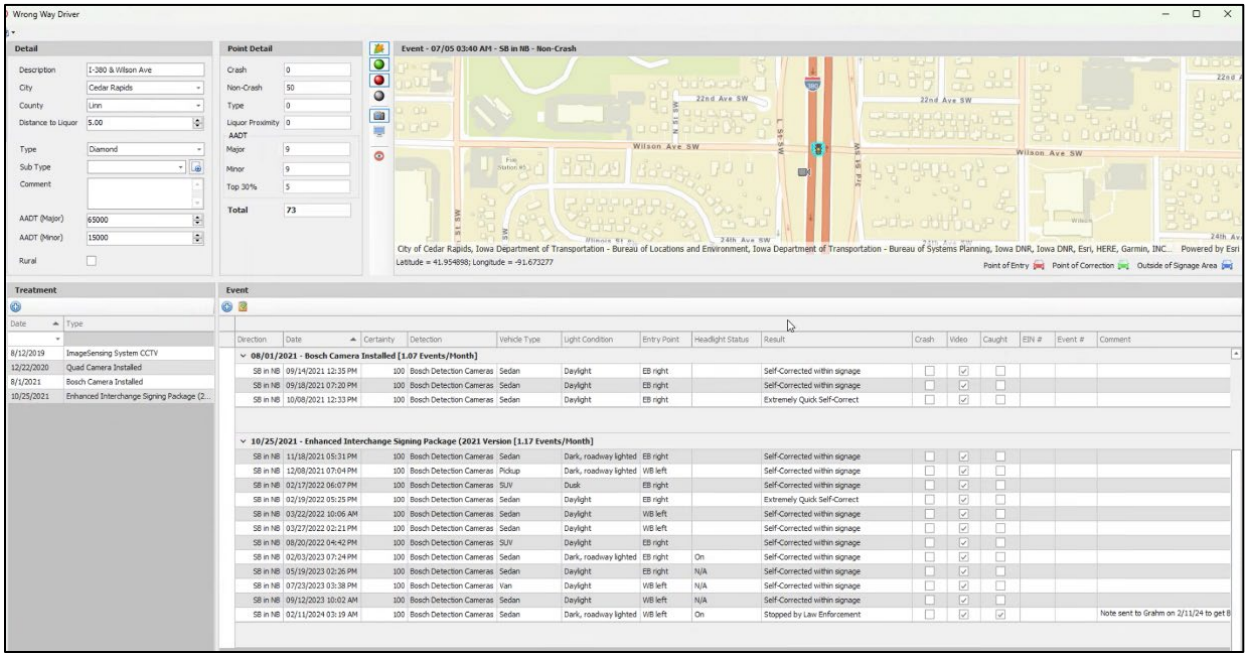
   4a. If yes. what data is logged? (E.g., date, time, location of detection, route/highway number, ramp designation.)

   TMC staff developed a database where the data is logged. Iowa DOT staff enters the information into the database manually. The data is exported to spreadsheet for post-analysis. This WWD database is not integrated into the agency's ATMS.

   Data logged includes:

   - **County**
   - **City**
   - **Intersection Location (e.g., I-235 & 2nd Ave/3rd St)**
   - **Intersection Type**
   - **Intersection Sub Type**
   - **Date/Time**
   - **EIN #**
   - **Event #**
   - **Direction (e.g., EB in WB)**
   - **Certainty**
   - **Detection (e.g., camera, TMC informed)**
   - **Vehicle Type**
   - **Light Condition**
   - **Entry Point (e.g., WB right, Turned left (short)**
   - **Headlight Status**
   - **Result (e.g., self-corrected outside signage area, stopped by law enforcement)**
   - **Reason (e.g., confused, impaired)**
   - **BAC**
   - **Crash (yes/no)**
   - **Video (yes/no)**
   - **Caught (yes/no)**
   - **Damage**
   - **Injury (possible, minor, major, fatality)**
   - **Comments**

See below for a screenshot from Iowa DOT Wrong-Way Driver database.



Screenshot from Iowa DOT Wrong-Way Driver Database
(Source: Iowa DOT)

5. Does your agency test the field equipment to understand the number of false calls? How well does the equipment perform in terms of false calls versus verified wrong-way vehicle detections?

   Yes, the DOT does test that the detection equipment works.

   There are lots of false calls (approximately 7400 in 3 months, from 62 cameras). The vendor recommends where to place it, but the DOT needs to place cameras at locations where power, pole, and communications exist. Many of these false calls could be minimized with better analytics, especially to filter out headlights, sunrise, and other light-based effects. Other false calls include mowers or vehicles moving the wrong way down a ramp to assist a stalled vehicle; the DOT is not as concerned about these instances.

Part 2: Wrong-Way Vehicle Reports to Traffic Management Center (TMC)

NOTE: **Bold text** indicates interview responses.

6. How are TMC operators alerted when a wrong-way driving event has occurred? Select all that apply.
   - **Yes - Notification from 911 dispatch**
   - No - Notification from field equipment
   - No - Call from the traveling public
   - **Yes – Other: Notification from DOT staff (e.g., from on-road DOT Staff or traffic safety engineer who is monitoring WWD field equipment.)**

7. How do TMC operators log wrong-way driving events? Select all that apply.
   - No - Manually (e.g., logbook, spreadsheet)
   - **Yes - In the ATMS or condition reporting system**
   - **Yes - Other: WWD events are logged in an event notification system (database). This creates an email that is sent to a selected group of DOT staff. As more info is known, another email is sent, and the log continues to be populated including additional details about the WWD event. (See an example email below.) DOT staff then enters this information into the Wrong-Way Driver database noted above. Unsure if this is connected to the ATMS, but is connected to the incident.**
   - No - We do not log wrong-way driving events.

From: IowaDOT.Traffic@iowadot.us <IowaDOT.Traffic@iowadot.us>
Sent: Tuesday, February 13, 2024 2:32 AM
Subject: Wrong Way Driver, I-380, Linn County, Incident #300565
Incident #300565 - Cleared
Wrong way driver event on I-380 S @ MM 21.6 in Cedar Rapids.

Comments

Comment	Date/Time
Cedar Rapids Police advised they have the vehicle stopped on the shoulder at J Avenue.	02/13/2024 02:28 AM
Cedar Rapids Police reported a wrong way driver traveling northbound in the southbound lanes on I-380 at H Ave.	02/13/2024 02:24 AM

Summary

Priority	3 (Notify)
Status	Cleared
DOT Assistance Requested	No
Wrong Way	

Details

Date	02/13/2024 02:21 AM
Reported By	Cedar Rapids State Radio (Department of Public Safety)
Reported	02/13/2024 02:21 AM
Clearance Confirmed By	Cedar Rapids Joint Comm Agency (Dispatch)

Location

Highway	I-380
Direction	South
Milepost	21.6
City	Cedar Rapids
County	Linn
District	6 - East Central
Garage	Cedar Rapids

Contact

Position	Name	Phone	Phoned	Emailed	EnRoute	OnScene	Departed
PD	Cedar Rapids Police	(319) 286-5491	02:25 AM		02:25 AM		
ISP	Iowa State Patrol		02:25 AM				

(CM)
Traffic Management Center
(515) 237-3300
Request Video

Email Containing a Wrong-Driver Incident Log
(Source: Iowa DOT)

8. What designation is used to log wrong-way driving events?
   - **Yes - Wrong-Way Driving**
   - No - Reckless Driving
   - No - Other (please specify)
   - No - We do not log wrong-way driving events.

9. What details are logged? Indicate all that apply.
   - **Yes - Wrong-way vehicle's location: highway/route**
   - **Yes - Wrong-way vehicle's location: nearby milepost, exit, or other**
   - **Yes - Description of wrong-way vehicle**
   - **Yes - Time the wrong-way vehicle was observed by caller**
   - **Yes - Caller's location.**
   - No - Other (please specify)

   Comments:
   - **Description of wrong-way vehicle is logged only if known. Time the wrong-way vehicle was observed by caller is logged only if known.**
   - **Caller's location is important but misleading if the WWD event didn't happen there.**

10. Does your ATMS or condition reporting system support an export/push of wrong-way driving event data?
    Yes. An email is sent to selected individuals.

Part 3: Other

11. Please provide any additional information that may be of interest for this research.
    Iowa DOT is testing a camera from Axis that uses a fusion of two detection methods: video analytics and radar. This picks up certain types of truck/trailer vehicles as a false call.

Appendix D
References

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