WRONG-WAY DRIVING
TAXONOMY AND IMPLEMENTATION CONSIDERATIONS
TECHNICAL BRIEF

RESEARCH CONDUCTED BY THE AAA FOUNDATION FOR TRAFFIC SAFETY INDICATES AN AVERAGE OF 430 PEOPLE ARE KILLED EACH YEAR IN WRONG WAY DRIVING CRASHES.

(Controlled-access highways, 2010-2018)

ABC 15 Arizona

Wrong-way Driving (WWD) Detection Systems use a customizable "kit" of tools to detect and track wrong-way drivers, trigger notifications and countermeasures, and stream CCTV feeds from supporting cameras to the traffic management center (TMC) where operators continue to manage or activate countermeasures. Practitioners can use a variety of technology elements and customize them to work within various roadway configurations, existing infrastructure (physical and software) and budgets to reduce WWD crashes.

This technical brief presents a WWD taxonomy that structures the life cycle of a WWD event and offers design and implementation considerations for agencies interested in deploying mitigating systems.

Wrong-way Driving Taxonomy

The WWD taxonomy presented on the next page is divided into three conceptually sequential phases of a WWD event:

- Detection and Surveillance
- Notification
- Response/Countermeasures

The taxonomy breaks each phase down into several components and their definitions. Temporal overlap is common among the three phases, and the actions suggested by each component may correspond to more than one phase.

Taxonomy	Definition
Detection and Surveillance	**Identification and monitoring of WWD event**
Fixed	***WW vehicle entry point detection***
Vehicle Identification	Method of initial detection/imaging
WWD Alert Trigger	Ability to alert for self-correction
TMC/Law Enforcement Trigger	Ability to alert TMC/law enforcement for awareness and countermeasure activation
Moving	***WW vehicle path monitoring***
Secondary Confirmation	Method of WWD confirmation
Tracking	Method of tracking path; trigger of other Traffic Control Devices (TCD)/ITS devices along path
Notification	**Message transmission to predetermined location(s)**
Communication Media	***Communication network options***
Alerts	***Notification alert characteristics***
Recipients	Alert recipients for countermeasure
Modes (e.g. email, text)	Method of alert
Additional ITS Device Activation	Automated actions tied to alert
Response/Countermeasure	**Actions taken by alert recipients**
Warning	***Method of driver information***
To the WW Driver	Method of information to WWD
To Correct-Way Drivers	Method of information to correct-way drivers
Broadcast	Amber alert type area broadcast
Interception	***Law enforcement action to stop WWD***
Enforcement/Control	***Use of methods to control potential upstream traffic***

DETECTION AND SURVEILLANCE

The first component is *Detection and Surveillance,* which consists of initial detection *(Fixed)* of the WWD event on a limited access roadway offramp and potentially secondary confirmation *(Moving)* of the event before the vehicle reaches the roadway mainline. *Detection and Surveillance* also consists of tracking the vehicle as it progresses along the mainline in the wrong direction *(Moving)*.

Description

- The ***Fixed*** point of initial detection is performed by WWD imaging or sensing equipment, including visible light video, thermal video, radar, and LiDAR *(Vehicle Identification)*. Detection of the wrong-way (WW) vehicle may trigger activation of signage to warn the WW driver *(WWD Alert Trigger)* and allow for self-correction. It may trigger an alert to a traffic management center (TMC) and/or law enforcement *(TMC/Law Enforcement Trigger)*, often via specialized software, so that countermeasures can be taken.
- The ***Moving*** surveillance of the WW vehicle may include secondary confirmation of the WW vehicle further along the ramp *(Secondary Confirmation)* using the same or an alternate method as the initial detection. A secondary confirmation helps eliminate false warnings, and in this sense, can also be considered part of the *Fixed* point detection. If the WW vehicle continues onto the roadway mainline, its path may be tracked using available ITS equipment and TMC surveillance software *(Tracking)*. Other ITS equipment or traffic control devices (TCD) may be activated to warn or manage correct-way drivers.

Some potential tools may include:

- Detection cameras (thermal, radar, infrared)
- Interface with TMC systems
- Specialized, illuminated and reflective signage and striping treatments
- Interface with dynamic message signs for driver alerts
- Additional cameras for tracking
- Integration with ramp sensors and traffic signals
- Interface with law enforcement

Design and Implementation Considerations

What vehicle detection and confirmation considerations should be addressed?

- What is the method of vehicle detection?
- Is there secondary confirmation detection?
- When does an alert get sent to the TMC? After initial detection? After a secondary confirmation detection?
- For detection by camera, how many images are taken after detection and for how long? If video is recorded, what should the length of the video be?
- What consideration needs to be given to detection sensitivity to different vehicle types? For example, will large trucks trigger the system when stopped at the off-ramp intersection?
- How does the system or TMC operator determine if the WWD self corrects or continues onto the mainline (e.g. from integrated video recording)?

What integration issues need to be considered?

- Will the detection equipment integrate with the existing TMC/Advanced Traffic Management System (ATMS) and existing TCD/ITS devices?
- Are there any limitations or opportunities with the existing ATMS to ensure device interoperability?
- Will the detection equipment use fiber communication to connect with signage that warns the WW driver and to connect with the TMC? Or will the detection equipment use point-to-point (P2P) communication to connect with signage and cellular backhaul to connect with the TMC?

What weather conditions will the equipment operate under (rain, snow, temperature extremes, fog, wind, dust, sun glare)?

What lighting conditions will the system operate within?

Is equipment installation intrusive or non-intrusive (e.g. to what extent is existing traffic impacted by installing equipment within or above traffic lanes)?

What location design considerations should be addressed?

- Are there limitations on where devices can/cannot be located?
- Is the equipment located for accessibility and ease-of-maintenance?
- Is the location subject to vandalism (e.g. lower than 12 feet to the ground)?
- Can immobile mounting locations be provided to ensure devices do not vibrate or move?

What new equipment will be installed (or existing equipment used) for passive alerts to notify WWD for self-correction?

What existing field devices can be integrated into the system or communicated with (detection and surveillance, dynamic message signs (DMS), ramp meters, traffic signals)?

How will the system be tested for accuracy (e.g. in a laboratory environment) to ensure false alerts are minimized and no positive events are missed?

NOTIFICATION

The second component is *Notification*, which focuses on the software and communication methods for transmitting alerts to predetermined recipients or devices. These alerts may occur from initial WWD event detection, a secondary confirmation, or during the tracking of the WW driver along the mainline.

Description

- Communication Media are the communication network options for vehicle identification equipment to connect with the TMC and ITS equipment.
- Alerts describe the notification characteristics, such as an image/video or audio warning messages. Additional characteristics of the alert include Recipients who can take countermeasures, Modes (e.g. email, text) which refer to the alert methods themselves, and Additional ITS Device Activation describing automated actions tied to the alert, typically managed by a TMC's ATMS software or the WWD equipment software. This ITS equipment can include DMS that post warning messages and upstream (from the WWD entry point) ramp meters that lock up to prevent additional drivers from entering the roadway.

Although WWD crashes occur relatively infrequently, accounting for only about 3 percent of crashes on high-speed divided highways, they are much more likely to result in severe and fatal injuries than other types of crashes.

Design and Implementation Considerations

Will new software be required and integrate with an existing ATMS? Will the existing ATMS be modified to handle the notifications, to trigger automated responses (e.g. TCD/ITS device activation, alerts, event logging), and to support operator interaction?

For images/video alerts sent to the TMC, what duration of WWD detection should be defined? Should image/video be sent one at a time or in a batch?

Who/what entities will be on the alert recipient list(s) by mode (email, text, etc.)? What are their roles and responsibilities upon receiving an alert?

What kind of documentation and interagency agreements might be required to ensure full coordination between all parties?

What CCTV camera view presets and default distances upstream of the activated WWD detector or WWD's current location are necessary to provide visual tracking along the mainline?

What default distance upstream of the activated WWD detector or WWD's current position is necessary for triggering ramp meter lock-up? What considerations should be given to ramp meters if the WWD event occurs when the ramp meters are not in use?

Is coordination necessary with local agencies who may own/operate the roadways that intersect the instrumented limited access roadway?

RESPONSE/ COUNTERMEASURE

The third component is the *Response/ Countermeasure*, which includes the specific actions taken by the alert recipients to manage the WWD event. Responses and countermeasures consist of Warning, Interception, and Enforcement/Control.

Description

- ***Warning*** is the method of providing information to drivers. Warning methods To the WW Driver typically occurs at the point of initial detection and optionally during secondary confirmation via signage and warning lights/beacons to cause the WW driver to self-correct. Warning methods to Correct-Way Drivers are typically managed by the TMC ATMS and include warning messages or instructions posted to DMS or provided in-vehicle for those equipped with connected vehicle technology. Warning methods also can include a local Broadcast to all drivers/individuals within an affected region, Amber Alert-style.
- ***Interception*** refers to the actions taken by law enforcement to intercept and stop the WW driver.
- ***Enforcement/Control*** are the methods to control correct-way traffic upstream of the WW vehicle. These actions include the automated actions described under Additional ITS Device Activation and are included under the Response/Countermeasure component for clarity and for when the actions are initiated manually by the TMC.

Design and Implementation Considerations

What statewide or multijurisdictional Standard Operating Procedure or Standard Operating Guidelines should be adopted for handling WWD events?

What DMS messaging considerations should be addressed?

- Who are the stakeholders to include in developing the appropriate messaging?
- What are the messages and what duration should they be broadcast?
- What distance from the activated WWD detector or current WW driver location should DMS be activated?
- How will the public be educated prior to system activation or use of the DMS messages?

What coordination and consultation is necessary with law enforcement on the operation of the systems and protocols for response?

Is there consideration for integration with ramp traffic signal systems to add a phase omission that prevent drivers from entering the roadway during a WWD event?

Technology choices structured around the WWD Taxonomy and that take into account the design and implementation considerations will better position an agency for success in preventing and mitigating WWD events.

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