

Transportation  
Safety and  
Mobility

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Wrong Way Driver Mitigation

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## Vision-Based Sensor System for Site Monitoring: Wrong-way Driving, Phase 1

Assess wrong way driving and evaluate the efficacy of enhancement and technologies to reduce accidents and fatalities.

### WHAT WAS THE NEED?

Wrong-way collisions account for only about 3 percent of accidents on high-speed divided highways, but they are much more likely to result in fatalities or serious injuries than other types of highway crashes. As noted in Assembly Bill AB 162, wrong way driving on state highways kills or injures numerous Californians each year. Wrong way incident rates in the first half of 2015 were unusually high, particularly in California Department of Transportation (Caltrans) Districts 3 (Sacramento area) and 11 (San Diego area). As of May 12, fourteen people had been killed in 2015 in wrong way head-on collisions in the Sacramento area alone. There was a need to assess the magnitude of wrong way driving in California and evaluate the efficacy of enhancements and technologies with the potential to reduce the number of instances of wrong way driving on state highways.

### WHAT WAS OUR GOAL?

The objective of this research was to determine three things:

1. The rate of wrong way drivers on monitored off ramps as determined by counting the instances of vehicles entering the off ramps in the wrong direction as well as the total number of vehicles;
2. The effectiveness of the district off ramp enhancements by comparing the number and behavior of wrong way vehicles before and after the enhancements were installed, as well as the number and behavior of wrong way vehicles entering control off ramps that did not receive enhancements; and
3. The accuracy of the active wrong way monitoring and warning system installed by the districts in a subset of off ramps.

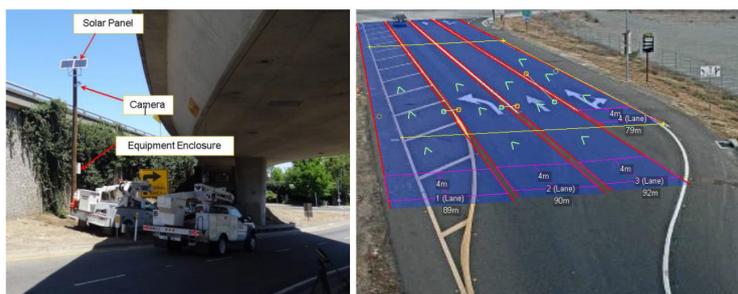


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## WHAT DID WE DO?

This research was part of a larger Caltrans project that installed enhancements on several off ramps in Districts 3 and 11 to warn drivers, and notify authorities, when vehicles enter from the wrong direction. Active monitoring systems capable of identifying wrong way drivers, transmitting information to a central location, and activating local flashing beacons were installed in a subset of these off ramps. Existing white and yellow one-way retro-reflective pavement markers in the lane lines, channelizing lines, and gore areas were replaced by two-way white/red and yellow/red markers in all off ramps.

Caltrans' Division of Research, Innovation and System Information (DRISI) worked with its research contractor, the Advanced Highway Maintenance and Construction Technology Research Center (AHMCT), at the University of California at Davis, to develop and install zone-triggered video image processing systems (VIPS) at a subset of district off ramps equipped with active monitoring systems. These systems were also installed on four control off ramps that did not receive the district enhancements. Zone-triggered video segments of Wrong Way Driving (WWD) were collected and analyzed.



WWD VIPS installed at SB SR-51 & T St detection zones at WB US-50 & S River Rd

The VIPS automatically counted all vehicles on each off ramp. They also automatically detected WWD events and locally recorded a short video clip of those events. A circular

video buffer designed into the VIPS enabled capture of a few seconds of video before each WWD event and about 30 seconds after it. The researchers uploaded the vehicle counts and low-resolution versions of the WWD event video clips. After manual review of each video clip, they determined which ones constituted actual WWD events and then uploaded higher resolution versions for further manual analysis.

This method minimized cellular data transmission costs while allowing the researchers to accurately determine the number of actual WWD events. The researchers also looked to determine how well the district-installed active wrong way monitoring and warning systems performed and to identify the causes of some verified WWD events, e.g. off ramp geometric design issues or visibly identifiable driver impairment.

## WHAT WAS THE OUTCOME?

In the period evaluated for this research study, the Vision-Based Site Monitoring systems captured 22 significant WWD events in which it appears that the drivers were initially unaware of driving in the wrong direction up the off-ramp. A summary of these WWD events are as follows:

- Eighteen (81.8%) of the 22 WWD events occurred on the Sacramento mitigated off-ramps. One (4.5%) of the WWD events on the San Diego mitigated off-ramps. Three (13.6%) of the WWD events occurred on the Sacramento non-mitigated off-ramps.
- For the Sacramento mitigated off-ramps, the rate of wrong-way events per year per off-ramp dropped from 3.0 to 1.2 in the period following installation of mitigations, a 60% drop in the rate of wrong-way events.
- Ten (45%) of the 22 WWD events occurred in the early morning hours (midnight to 6 am), consistent with the results of prior research.
- Nine (41%) of the 22 WWD events were due to wrong-way travel on a one-way street, followed by direct entry to the off-ramp.

- Seven (32%) of the 22 WWD events occurred at the same off-ramp [westbound (WB) US 50 at South River Road], with essentially identical behaviors, indicating that there may be an issue with off-ramp configuration or signage. Similar conclusions apply for WB US 50 at 26th Street, southbound (SB) State Route (SR) 51 at J Street, and WB US 50 at 10th Street (see WWD Events Table). All of these off-ramps exhibited a higher percentage of events.
- One WWD event occurred under poor visibility and rain conditions.
- In one WWD event, the driver appears to be under the influence based on the car's weaving during its approach to the off-ramp. In that case, the WWD driver passed five or more vehicles driving in the correct direction and still proceeded wrong-way onto the off-ramp (see photo).

WWD Events

Location	Date	Time	After Mitigate	Entry Manner	Note
SB SR 51@J St.	1/9/17	1:50 am	No	Left Turn	Past camera, medium recovery, very rainy
SB SR 51@J St.	4/13/17	1:51 am	No	Left Turn	Medium recovery, 3-point turn
SB SR 51@J St.	3/18/18	1:30 am	No	Right Turn	Most of the way to the camera, 3-point turn
WB US 50 @Jefferson Blvd	8/11/16	4:11 am	No	Left Turn	Past camera, long recovery
WB US 50 @Jefferson Blvd	8/23/17	12:49 am	Yes	Right Turn	Through camera, eventually recovered
WB US 50 @South River Rd.	10/21/16	1:53 pm	No	Right Turn	Recovered quickly
WB US 50 @South River Rd.	11/6/16	4:47 pm	No	Right Turn	Recovered quickly
WB US 50 @South River Rd.	3/29/17	9:51 am	Yes	Left Turn	Left from 5th, onto shoulder, then quick U-turn recover
WB US 50 @South River Rd.	7/30/17	6:13 am	Yes	Right Turn	Truck turned right onto off-ramp into middle lane, recovered (U-turn) before camera
WB US 50 @South River Rd.	4/17/18	1:05 pm	Yes	Right Turn	Right onto off-ramp, tried to go lane 1, blocked, swerved to shoulder, then U-turn recover
WB US 50 @South River Rd.	5/18/18	5:15 pm	Yes	Right Turn	Entered on shoulder, quick U-turn recovery
WB US 50 @South River Rd.	5/26/18	7:31 am	Yes	Left Turn	Entered on shoulder, most of way to camera, then U-turn recover
WB US 50@10th St.	12/22/16	5:41 am	Yes	One Way	Likely impaired, all the way onto off-ramp

WB US 50@10th St.	5/4/17	3:47 am	Yes	One Way	Wrong way up W St, quick U-turn recover
WB US 50@10th St.	5/16/17	11:43 pm	Yes	Right Turn	Right onto W, all the way onto off-ramp
WB US 50@26th St.	11/2/16	1:05 am	No	One Way	Recovered quickly
WB US 50@26th St.	5/26/17	4:12 am	Yes	Right Turn	Turned onto side street just before committing to off-ramp
WB US 50@26th St.	10/10/17	3:13 pm	Yes	Left Turn	Left from 26th onto W, U-turn just into off-ramp
WB US 50@26th St.	11/23/17	7:49 am	Yes	One Way	Red SUV, wrong way up W St, took street left of off-ramp. See other unrelated 11/23 incident.
WB US 50@26th St.	11/23/17	7:50 am	Yes	One Way	Silver car, wrong way up W St, U-turn just after entering off-ramp. See other unrelated 11/23 incident.
EB US 50 @5th St.	8/18/18	7:21 am	Yes	One Way	Full wrong-way, no recovery, broad daylight, drove right past a car coming down the off-ramp
WB I-8 Sunset Cliffs Blvd.	5/1/18	3:46 am	Yes	Right Turn	Entered on shoulder, most of way to camera, then corrected. Likely prompted by either a sign or pavement arrow marking.



Wrong-way driver (circled in yellow) entering the off-ramp at WB US 50 at 10th Street. The driver continued onto the off-ramp despite at least five cars passing in the other (correct) direction.

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In addition to the above WWD events, this research recorded numerous WWD events that were intentional and may not be of interest. These intentional WWD events include:

- Bicyclists riding up the off-ramp (extremely common for certain off-ramps).
- Maintenance and emergency response vehicles moving up the off-ramp.
- Tow trucks backing up the off-ramp to disabled vehicles.
- Vehicles backing up the off-ramp to change lanes.
- Vehicles deliberately entering the off-ramp to assist other vehicles.
- At least one case of an apparent road rage event.

## WHAT IS THE BENEFIT?

This research benefits Caltrans and the traveling public by assessing the baseline magnitude and frequency of wrong-way driving, which is essential in determining the scope of any future efforts to mitigate the hazard of drivers entering state highways in the wrong direction via off ramps.

The scientific, measurement-based approach taken will allow Caltrans to make informed, data-driven decisions regarding future detection and mitigation strategies based on their effectiveness as demonstrated by this research. This study and the resulting data set makes a substantial contribution to wrong-way driving research, thus enhancing the safety and stewardship of the transportation system.

## LEARN MORE

Final report:

<https://dot.ca.gov/-/media/dot-media/programs/research-innovation-system-information/documents/final-reports/ca20-2970-finalreport-a11y.pdf>

Wrong Way Driving Pilot Project Reports:

<https://dot.ca.gov/-/media/dot-media/programs/safety-programs/documents/wrong-way/ww-pilot-projects-for-prevention-of-ww-collisions-on-freeways-a11y.pdf>