Preliminary Investigation

Caltrans Division of Research, Innovation and System Information
Produced by Lai T. Saetern

Wrong-Way Driving Prevention Methods

Requested by Thomas Schriber, Caltrans Traffic Operations
January 21, 2015

Table of Contents

Key Word Search: Wrong-way Signs, Do Not Enter, Regulatory Signs, Drunk Driving Wrong-way Prevention Signs, Full Diamond Cloverleaf, Interchange Designs

Background

Drivers who get on the highway can go the wrong way and potentially cause wrong-way accidents and fatalities. Wrong-way accidents have a higher chance of causing fatalities than non wrong-way accidents. Any methods to lower the rate of wrong-way crashes will improve the safety of the highway systems. This preliminary investigation is to investigate the strategies states outside of California use to prevent wrong-way accidents.

Summary of findings

In general, most states' wrong-way prevention signs are governed by the use of Manual on Uniform Traffic Control Devices (MUTCD.) The MUTCD govern the type of signage and pavement marking that would indicate that a driver is going the wrong way. Caltrans has California Manual on Uniform Traffic Control Devices (CA MUTCD.) The National Transportation Safety Board (NTSB) has a highway special investigation report on wrong-way driving dated December 2012. It mentions methods to increase the visibility of the signs to the wrong-way driver. It also indicates that Full Cloverleaf interchange design has low wrong-way driving incidents.

The NTSB report found that the majority of wrong-way drivers are those who operate their vehicles under the influence of alcohol. NTSB shows that 69% of wrong-way drivers have a Blood Alcohol Content (BAC) greater than the legal limit of 0.08 g/dL. The statistics show that most of the wrong-way driving occurs between 12 am to 5 am and peaking at 2 am. The other major portion of wrong-way driving involves the elderly who have an age of 70 years old or above. Therefore, the wrong-way driving prevention techniques have put priority on addressing Driving Under the Influence (DUI) wrong-way drivers.

Arizona Department of Transportation (ADOT) recently is addressing wrong-way driving by installing larger signs at a lower level at highway exits. The Illinois DOT (IDOT) has wrong-way prevention guidelines that emphasize highly visible warning signs, interchange designs, detection system, law enforcement, and education. Texas DOT (TxDOT) studied the effectiveness of the various wrong-way prevention methods and found that many wrong-way prevention measures are less effective against inebriated drivers.

To that effect, the prevention techniques can be roughly categorized as follows:

- Warning signage – Warning signs that would be more obvious, such as red reflective tape/background, and LED lights.
- Interchange design – Full Cloverleaf design has less wrong-way driving than Full Diamond or Half Cloverleaf interchange designs.
- Detection system – If all other systems fail, then a good way to prevent fatalities is to remove the wrong-way driver from the road. A detection system would help warn others and notify law enforcement personnel of an early instance of wrong-way driving, giving them a quicker response time.
- Law Enforcement – Set up check points at problem areas.

Gaps in findings

There have not been too many studies of whether detection systems are effective at reducing wrong-way driving.

Contacts

This was a literary search, no contacts were made.

Body of Preliminary Investigation

National Guidance

Wrong-way Driving - National Transportation Safety Board Highway Special Investigation Report
http://www.ntsb.gov/safety/safety-studies/Documents/SIR1201.pdf

In December 2012, National Transportation Safety Board (NTSB) completed a report that looked at wrong-way driving accidents. In this report, NTSB investigated nine specific wrong-way crashes. Using case studies and past research into wrong-way driving, NTSB developed findings and recommendations to combat wrong-way driving. NTSB found that drunk drivers represent 69% of wrong-way driving incidents. The other large portion of wrong-way drivers are represented by older drivers who are age 70 and above.

The following signage strategies can be employed to prevent these drivers from going the wrong-way:

- Lowering the height of "Do Not Enter" and "Wrong-way" signs.
- Using oversized "Do Not Enter" and "Wrong-way" signs.
- Mounting both "Do Not Enter" and "Wrong-way" signs on the same post, paired on both sides of the exit travel lane.

Figure 1: Double-posted "Do Not Enter" and "Wrong-way" signs on an exit ramp.

- Illuminating "Wrong-way" signs that flash when a wrong-way vehicle is detected.
- Applying red retro-reflective tape to the vertical posts of exit ramp signs.
- Installing red delineators on each side of exit ramps.

- Installing LED-illuminated in-pavement markers or delineators parallel with the stop bar at the crossroad end of exit ramps.

Other than sign designs, certain interchange designs have more wrong-way driving incidents than others. The three common interchanges are the Full Diamond, Full Cloverleaf, and Partial Cloverleaf interchange designs. These designs are shown in figure 2.

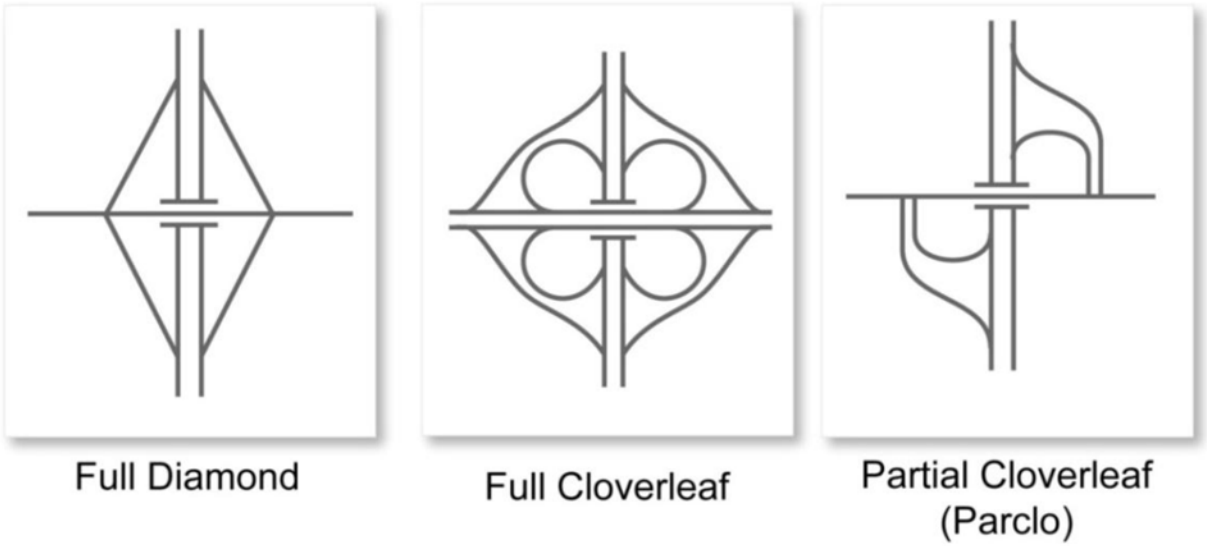

Figure 2: Common interchange designs.

The Partial Cloverleaf design is the one most prone to wrong-way driving. The Full Cloverleaf interchange has the least amount of wrong-way driving incident when comparing the three most common interchange designs.

State Practices

Arizona

ADOT installs lower larger signs to stop wrong-way drivers
http://www.azcentral.com/story/news/local/phoenix/2014/06/25/phoenix-wrong-way-drivers-adot-signs-abrk/11361437/

Arizona Department of Transportation (ADOT) installed new signs in highway exit throughout the state in June 2014. These new signs include larger "Do not enter" signs and an additional "Wrong-way" sign below. ADOT has used two reflectors large arrows equipped with lights to signal the correct direction of travel.

Florida

Exclusive: Pilot Program Shows Hope For Preventing Wrong-way Wrecks
http://miami.cbslocal.com/2014/12/12/exclusive-pilot-program-shows-hope-for-preventing-wrong-way-wrecks/

Florida Department of Transportation (FDOT) installs radar and camera at highway interchanges to snapshot and alert the driver and highway officers that a vehicle is going the wrong-way in December 2014.

Sunshine Disseminator "Wrong-Way Pilot Projects in Florida Update"
http://www.dot.state.fl.us/trafficoperations/Newsletters/2014/2014-Mar.pdf

FDOT Wrong-way Pilot Project is in the middle of replacing signs with oversized signs, installing wrong-way alerts possibly using induction loop technology to alert police of wrong-way drivers. FDOT is also installing light flashing wrong-way signs.

Illinois

Guidelines for Reducing Wrong-Way Crashes on Freeways
https://www.ideals.illinois.edu/bitstream/handle/2142/48998/FHWA-ICT-14-010.pdf?sequence=2

IDOT's May 2014 guidelines on wrong-way driving prevention can be categorized in five categories: Signage, geometry of interchanges, advanced technology, enforcement, and education. The following is a summarized list of guidelines:

Signs

1. Red retro reflective tape on mounting poles and signs can improve visibility.
2. Signs with LED lights are more visible, but it is more expensive.
3. Barrier delineator that would be visible when traveling the wrong-way can help against wrong-way driving.

Figure 3: "Do Not Enter" and "Wrong-way" Sign in conjunction with barrier delineator that is visible when going the wrong-way.

Geometry of Interchanges

1. Acute angles between the interchanges and the access roads can help guard against wrong-way driving.

2. Two way frontage roads are more susceptible to wrong-way driving.
3. Diamond interchanges have more incidents of wrong-way driving than full cloverleaf interchanges.

Advanced Tech

1. Detections of wrong-way drivers.
    a. Inductions loop.
    b. Magnetic sensors.
    c. Video Image Processors (VIP) – use video to find the car and direction of travel.
    d. Microwave radar.
2. Use changeable message signs (CMS) to alert drivers that a wrong-way driver is on the highway.
3. Pavement embedded warning lights can deter wrong-way driving.

Enforcement

1. Police stops/check points at problem areas.
2. Methods to stop wrong-way.
    a. Tire deflation.
    b. Parallel with wrong-way driver and use signals and sirens to stop the driver.
    c. Use car to ram the wrong-way driver or create roadblock.
    d. Pin wrong-way driver's car to the median with law enforcement vehicles.
3. Wrong-way crash reporting – report entry point.
4. Require ignition interlock system (IIS) for Driving Under the Influence (DUI) offenders.

Education

1. Educate the populace about the dangers of drunk driving.

"What to do about wrong-way drivers." Chicago Tribune February 08, 2012
http://articles.chicagotribune.com/2012-02-08/news/ct-met-wrong-way-drivers-0208-20120208_1_wrong-way-drivers-wrong-way-crashes-drunken-driver

Illinois Department of Transportation (IDOT) installed four larger wrong-way signs at every exit ramp in the state to prevent wrong-way driving. Radar was also included in a 14 mile stretch of road to inform the police of a wrong-way driver.

Texas

Countermeasures for Wrong-Way Movement on Freeways: Guidelines and Recommended Practices
http://d2dtl5nnlpfr0r.cloudfront.net/tti.tamu.edu/documents/4128-2.pdf

Texas' October 2003 checklist and recommendations is a wrong-way improvement documents. This checklist will allow a TxDOT official to review the interchange signage and pavement markings. This checklist ensures that there are at least the minimum numbers of signage and pavement marking and that these indicators are visible and in good repair.

Related research

Assessment of the Effectiveness of Wrong-Way Driving Countermeasures and Mitigation Methods
http://d2dtl5nnlpfr0r.cloudfront.net/tti.tamu.edu/documents/0-6769-1.pdf

In December 2014, Texas Department of Transportation (TxDOT) researched and evaluated the effectiveness of various wrong-way prevention methods. The research has information on alcohol intoxicated drivers, who represent the majority of wrong-way drivers. About 90% of wrong-way crashes in Texas involved wrong-way drivers who have a Blood Alcohol Content (BAC) level at or above the legal limit of 0.08 g/dL. It has also found that most wrong-way driving happen between 12 am to 5 am peaking at 2 am.

This research studied the behaviors of drivers who were intoxicated. The following are the significant findings:

1. Higher BAC levels make the driver look towards the pavement more.
2. Alcohol impaired drivers do not scan/search horizon as much as a regular drivers.
3. Alcohol impaired drivers must be closer to signs before recognizing it.
4. Lowering signs do not improve the inebriated driver's ability to find the signs quickly or easily.
5. Making larger, adding retro reflective background, or blinking light to signage did not improve the alcohol intoxicated driver's ability to find the signs.
6. Alcohol impaired drivers take a longer time to recognize pavement markings.
7. Blinking signs help reduce wrong-way driving, but statistics data are too sparse to find its relation with wrong-way crashes. Blinking signs may be effective with confused driver, but it may be ineffective with intoxicated drivers.

With the findings above the research recommended the following:

1. Use detection system, because wrong-way signs may not stop drunk drivers.
2. Use pavement arrow, since drunk drivers look at pavement more.
3. Add red retro reflective elements to "Wrong-way" and "Do Not Enter" signs.
4. Add blinking LED lighted signs, but this may be cost prohibitive.
5. Lowering signs does not improve visibility for alcohol inebriated drivers.

Wrong-way Vehicle Detection: Proof of Concept
http://ntl.bts.gov/lib/47000/47400/47414/AZ697.pdf

ADOT's March 2013 proof of concept showed that the available products can be used to detect wrong-way vehicles. The detection systems this project studied was: 1. Microwave, radar, video, thermal, and magnetic detection systems.

Research in Progress

Directional Rumble Strips for Reducing Wrong-Way Driving Freeway Entries
http://www.roadwaysafety.umn.edu/research/search/projectdetail.html?id=2015039

University of Minnesota, Minneapolis is investigating directional rumble strips to prevent wrong-way driving. In this project, the researchers will test and model how different rumble strips perform. The researchers will develop a rumble strip that will only produce a noise when a car is going one way and not the other. This will allow a driver to hear a rumble when the driver is going the wrong way, and hear nothing when the driver is going the right way. This direction rumble strip can help prevent drivers from entering the highway in the wrong-way.

Wrong-way Driving Countermeasures
http://swutc.tamu.edu/research/new-research/0-6769/

There are many wrong-way countermeasures, but it is not clear which of them are the best. Texas A&M University is investigating the most successful methods at getting the attention of wrong-way drivers.