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Utah Department of Transportation - Research Division
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LITERATURE SEARCH AND SCAN TOUR OF WRONG-WAY DRIVING MITIGATION MEASURES ACROSS THE UNITED STATES

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- Cameron Kergaye, Research Division Director
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- Glenn Blackwelder, Traffic Operations Engineer
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16. Abstract

The Utah Department of Transportation (UDOT) has long been on the forefront of nationwide efforts to improve roadway safety. Their safety focus encompasses infrastructure improvements as well as non-infrastructure elements such as education and enforcement.

Wrong-way driving on limited access freeways has been a growing safety concern in Utah and across the United States in recent years. While Utah experiences lower rates of impaired driving (a leading contributing factor to wrong-way driving events) than its peer states, it still occurs frequently enough to merit attention from UDOT researchers and engineers. The severity of wrong-way crashes tends to be much higher than for other types of crashes because of the speeds involved and their propensity to yield head-on impacts. As a result, wrong-way crashes represent a disproportionate share of severe crashes relative to total crashes of that type.

With this background in mind, UDOT embarked on a research project and scan tour to study potential wrong-way driving countermeasures for deployment in Utah. Staff members from key UDOT divisions and other partner agencies with an interest in wrong-way driving issues were included in the technical advisory Committee. Committee members were instrumental in helping to determine the research focus and scan tour locations.

This report documents the process used to determine scan tour locations, describes the information learned during the scan tour visits, and then presents recommendations for using the information to inform wrong-way driving mitigation efforts in Utah.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF ACRONYMS

DOT	Department of Transportation
DUI	Driving Under the Influence
HCTRA	Harris County Toll Road Authority
TAC	Technical Advisory Committee
UDOT	Utah Department of Transportation
UHP	Utah Highway Patrol
US	United States
VMS	Variable Message Sign
WWD	Wrong-Way Driving

EXECUTIVE SUMMARY

The Utah Department of Transportation (UDOT) has long been on the forefront of nationwide efforts to improve roadway safety. Their safety focus encompasses infrastructure improvements as well as non-infrastructure elements such as education and enforcement. UDOT's Traffic and Safety Division is tasked with managing the Zero Fatalities initiative in cooperation with other divisions and the region offices. These varying groups within UDOT work together to reduce fatalities and serious injury crashes on Utah's roadways.

Roadway safety is influenced by many elements, some of which are intrinsic to roadway characteristics such as pavement, geometry, adjacent land use, roadside barriers, and regulatory devices like traffic signals. Other elements of roadway safety are related to human factors such as drowsiness, distraction, aggression, impairment, and improper restraint. UDOT continually seeks to address a wide variety of roadway and human factor elements in their quest to reduce injuries and fatalities.

Wrong-way driving (WWD) on limited access freeways has been a growing safety concern in Utah and across the United States (US) in recent years. While Utah experiences lower rates of impaired driving (a leading contributing factor to WWD events) than its peer states, it still occurs frequently enough to merit attention from UDOT researchers and engineers. The severity of WWD crashes tends to be much higher than for other types of crashes because of the speeds involved and their propensity to yield head-on impacts. As a result, WWD crashes represent a disproportionate share of severe crashes relative to total crashes of that type.

With this background in mind, UDOT embarked on a research project and scan tour to study potential WWD countermeasures for deployment in Utah. Staff members from key UDOT divisions and other partner agencies with an interest in WWD issues were included in the Technical Advisory Committee (TAC). TAC members were instrumental in helping to determine the research focus and scan tour locations.

This report documents the process used to determine scan tour locations, describes the information learned during the scan tour visits, and then presents recommendations for using the information to inform WWD mitigation efforts in Utah. The original plan was to develop a list of survey questions to send to various Departments of Transportion (DOTs) for the purpose of soliciting up-to-date information about WWD mitigation measures being implemented around

the country. It quickly became apparent to the TAC, however, that two states in particular – Texas and Arizona – had recently published extensive literature searches on the topic and that repeating such an effort would not be the best use of UDOT's research funds. As a result, the research effort refocused around making TAC members aware of the recently-completed literature documents and turning attention to the scan tour visits.

The decision was made to visit the Houston and San Antonio areas of Texas based on their relatively deep experience with WWD mitigation measures, presence of both public and private road operators, and their geographic proximity to one another. The scan tour group visited Houston on May 23, 2016 and San Antonio on May 25, 2016.

Chapter 2 contains summaries of each of the main recently-completed literature search documents that precluded the need for creation of a similar document. Descriptions of the scan tour group's experience in Houston and San Antonio are given in Chapter 3. Chapter 4 provides recommendations for translating the knowledge gained during this effort into action items for follow up by specific groups represented on the TAC.

1.0 INTRODUCTION

1.1 Background

The Utah Department of Transportation (UDOT) has long been on the forefront of nationwide efforts to improve roadway safety. Their safety focus encompasses infrastructure improvements as well as non-infrastructure elements such as education and enforcement. UDOT's Traffic and Safety Division is tasked with managing the Zero Fatalities initiative in cooperation with other divisions and the region offices. These varying groups within UDOT work together to pursue long-term goals of fewer fatalities and serious injury crashes on Utah's roadways.

Roadway safety is influenced by many elements, some of which are intrinsic to roadway characteristics such as pavement, geometry, adjacent land use, roadside barriers, and regulatory devices like traffic signals. Other elements of roadway safety are related to human factors such as drowsiness, distraction, aggression, impairment, and improper restraint. UDOT continually seeks to address a wide variety of roadway and human factor elements in their quest to reduce injuries and fatalities.

Wrong-way driving is a problem that UDOT and the Utah Highway Patrol (UHP) address jointly with a combination of infrastructure and non-infrastructure solutions. The primary non-infrastructure method is enforcement, particularly of driving under the influence (DUI) laws. For infrastructure, UDOT uses static signing and dynamic devices to address the problem of wrong-way driving. These signs and devices are located at exit ramps to discourage drivers from entering limited access roadways going the wrong direction, and to encourage them to turn around as soon as possible in the event that they do enter a location going the wrong way.

1.2 Problem Statement

UDOT commissioned a scan tour and research study to identify wrong-way driving mitigation measures and practices in use around the US that could be adapted to Utah's roadway system. Key UDOT staff members with an interest in safety and wrong-way driving device

deployment were included in the Technical Advisory Committee (TAC). TAC members were instrumental in helping to determine the research focus and destinations for the scan tour.

1.3 Objectives

The objectives of this study were to:

- Research WWD countermeasures in use around the country
- Gather information from other roadway operators about their use of those devices
- Organize a scan tour for a group of UDOT employees to visit a few locations where the selected devices are being used
- Record activities and discussion points of the scan tour group
- Determine a subset of devices with the greatest potential for adaptation to Utah's roadway environment
- Formulate a final report to document the study process and summarize information

1.4 Technical Advisory Committee Composition

A TAC comprised of staff from UDOT and other partner agencies with a stake in roadway safety was formed for the purpose of guiding the research study and scan tour effort. Table 1.1 lists TAC members' names, groups, and positions.

Table 1.1 TAC Members

Name	UDOT Group	Position
Cameron Kergaye	Research Division	Director of Research
Tom Hales	Research Division	Research Project Manager
Scott Jones	Traffic & Safety Division	Safety Programs Engineer
Glenn Blackwelder	Traffic & Safety Division	Traffic Operations Engineer
Rob Clayton	Traffic Operations Center	Traffic Management Engineer
John Leonard	Traffic Operations Center	Operations Engineer
Mark Taylor	Traffic Operations Center	Traffic Signal Operations Engineer
Patrick Cowley	Region 2	Traffic Operations Engineer
Chris Rueckert	Department of Public Safety	Salt Lake Comm. Center Manager
Roland Stanger	Federal Highway Administration	Safety Operations Engineer

1.5 Report Outline

The rest of the report is organized as follows:

- Chapter 2 – Literature Search
- Chapter 3 – Scan Tour Visits
- Chapter 4 – Summary of Recommendations

2.0 LITERATURE SEARCH

2.1 Overview

The original intent of the literature search element of this project was to solicit responses from states across the country regarding their use of WWD mitigation measures and devices, and then to formulate it into a synthesis of current practice. However, it became apparent that other agencies had recently produced very good syntheses on this exact topic. As a result, the decision was made to simply document the existing literature searches rather than recreate the same work.

2.2 Syntheses of WWD Mitigation Practices

The Texas and Arizona DOTs both produced research documents on the subject of WWD within one year of UDOT's initiation of their research effort. These documents are described in further detail in the subsections that follow. The TAC made a conscious decision to summarize these comprehensive documents and refer interested readers to them rather than produce an additional literature search for UDOT specifically.

2.2.1 Texas

The document sponsored by Texas DOT is titled *Assessment of the Effectiveness of Wrong Way Driving Countermeasures and Mitigation Methods*. It was written by researchers from the Texas Transportation Institute and published in December 2014. DUI is known to be the primary contributing factor for WWD crashes in Texas. Therefore, researchers designed and conducted two closed-course studies to determine the effectiveness of select wrong-way driving countermeasures on alcohol-impaired drivers.

In addition, they obtained data from several Texas agencies that had installed wrong-way driving countermeasures on their road networks. Using those datasets, researchers assessed the effectiveness of these strategies in actual operational environments. Researchers used the findings from these studies to develop recommendations regarding the implementation of wrong-way driving countermeasures and mitigation methods.

The most practical contribution of this document to Utah's needs is the information provided in Appendix A, which is titled *Catalog of Wrong Way Driving Countermeasures and Mitigation Methods*. This appendix contains one-page summaries of a comprehensive listing of potential WWD mitigation measures. Each summary shows a basic description, advantages and disadvantages, historical effectiveness, challenges, and deployment sites. Both infrastructure and non-infrastructure solutions are proposed. Readers can use this appendix to quickly sort through potential treatments and gain a basic understanding of which treatments are most likely to help in a given context and how effect they can reasonably expect them to be. The list of treatments is as follows:

- Traffic Control Device Countermeasures
    - Lowered Signing
    - LED-Enhanced Regulatory Signing
    - Supplemental Sign Placards
    - Enhanced Static Signing
    - Overhead Wrong Way Signing
    - Reflective Tape on Sign Mount Post
    - Raised Pavement Markers
    - Painted Arrows on Ramp
    - Stop Bars at Exit Ramps
    - Painted Islands
    - Left Turn Pavement Marking Extensions
    - Supplemental Flashers
- Intelligent Transportation Systems
    - Detection and Notification Systems
    - Closed-Circuit TV Cameras
    - In-Pavement Warning Lights
    - Blank Out Signs
    - Right-Way Driver Warnings
    - IntelliDrive
    - Advanced In-Vehicle Technologies

- Geometric Modifications
    - Roadway Layout Changes
    - Entrance/Exit Ramp Offsets
    - Off-Ramp Throat Reductions
    - Approach Pavement Marking and/or Signing Modifications at Diamond Interchanges
- Institutional Coordination
    - Enforcement
    - Public Education
    - Legislative Modification
    - Field Checklist for Problem Locations

2.2.2 Arizona

The document produced by Arizona DOT is titled *Detection and Warning Systems for Wrong-Way Driving*. It provides a comprehensive, easy-to-digest literature search summary of the WWD practices in place in various states around the US and in select international locations. The main contribution related to Utah's needs is Chapter 2, which is where the literature search is located. Countermeasures are specifically highlighted in the following locations:

- Domestic
    - Virginia
    - California
    - Arizona
    - Florida
    - Illinois
    - New Mexico
    - Texas
    - Wisconsin
- International
    - Japan
    - Germany
    - Sweden

3.0 SCAN TOUR VISITS

3.1 Overview

The TAC decided to visit two agencies in Texas based on conversations with roadway operators in multiple states. The selected agencies were the Harris County Toll Road Authority (HCTRA) and the San Antonio district office of the Texas DOT. The major factors in the decision to visit these agencies were a demonstrated willingness to host visitors, a history of WWD device deployment and testing, and geographic proximity that allowed for both visits to occur within the same week. Table 3.1 lists the people from Utah that participated in the scan tour. Table 3.2 shows the participants that joined us from HCTRA and Texas DOT

Table 3.1 Scan Tour Participants from Utah

Name	UDOT Group	Position
Patrick Cowley	Region 2	Traffic Operations Engineer
Scott Jones	Traffic & Safety Division	Safety Programs Engineer
Glenn Blackwelder	Traffic & Safety Division	Traffic Operations Engineer
John Leonard	Traffic Operations Center	Operations Engineer
Chris Rueckert	Department of Public Safety	Salt Lake Comm. Center Manager

Table 3.2 Scan Tour Participants from Texas Agencies

Name	Group	Position
Chris Carroll	HCTRA	Maintenance and Traffic Director
Quinton Alberto	HCTRA	Maintenance and Traffic Assistant Director
Calvin Harvey	HCTRA	Incident Management
Leilany Lugo-Reyes	HCTRA	Maintenance and Traffic Assistant Engineer
John Gianotti	Texas DOT	TransGuide Manager
Matt Snead	Texas DOT	TransGuide Control Room Manager
Marco Cameron	Texas DOT	Transportation Engineer

The scan tour group was able to learn from both agencies' successes and challenges with particular products and procedures. Several overriding themes emerged from these visits. First, that maintenance of installed devices is a large consideration when determining which countermeasures to deploy. For example, HCTRA described how their efforts to use in-pavement LED lighting were hampered by maintenance headaches. The bulbs burned out much more

quickly than the manufacturers had predicted and in order to replace them, shutting down the ramps temporarily was required. As a result, HCTRA no longer installs in-pavement lighting and instead has transitioned to other countermeasures that require less frequent maintenance and don't require ramp closures.

Another important theme was recognizing that most WWD events occur in a geographically random fashion throughout the roadway system. This truism has bearing on how to best approach decisions about device deployment. It would make sense to funnel greater resources into fewer locations if events were more aggregated. However, geographic randomization lends itself more to a wider disperson of lower-cost mitigation measures systemwide.

Both HCTRA and Texas DOT implemented higher-cost detection systems in a few locations where WWD event clusters could be found, but for the most part their strategy has evolved toward the direction of blanketing more ramps with lower-cost measures such as additional sets of WRONG WAY signs, LED flashers around sign faces, and red retroreflective tape on sign poles. Their experience has shown that these low-cost measures are just as effective at mitigating WWD events as some of the more expensive treatments.

Several particular insights from the Texas scan tour related to low-cost measures are worth mentioning here:

- It may be easier and less expensive to equip LED flashing signs with solar power and run the flashers around the clock than to install ramp detection to activate the flashers only when an event triggers them. Right-way drivers do not see the flashers, so leaving them on all day and night has little or no impact on normal traffic flow. Also, round-the-clock operations make periodic inspection very easy because a maintenance person can see from the bottom of the ramp whether the flashers are working, whereas a detection system would require a closure for a maintenance vehicle to drive the wrong way up the ramp to verify that detection is working properly.
- HCTRA and Texas DOT didn't think that lowered sign heights had a measurable impact.
- HCTRA and Texas DOT think the following two mitigation measures yield the best value:

- A series of two sets of WRONG WAY signs placed on the ramp (one on each side) – the first approximately 250’ up from the ramp entrance and the second set another 250’ further up the ramp, with the second set bordered by LED flashers
- Red retroreflective tape on the backside of sign poles (so that only those driving the wrong way will see the reflection)

4.0 SUMMARY OF RECOMMENDATIONS

4.1 Overview

Various groups within UDOT were moving forward with specific efforts to combat WWD issues prior to and during this research effort. One example is collection of "negative speed" data through existing sensors at mainline freeway locations, which has been ongoing for several years. UDOT has also been performing similar data collection at exit ramp locations. To date, both attempts at using automatic speed data collection to identify WWD events have been hampered by persistent issues with "false positive" readings. UDOT continues to work with speed data collection manufacturers to calibrate equipment in the hopes that they will be able to successfully capture WWD events through negative speed readings in the future.

UDOT has also been using the message "Wrong Way Driver Reported – Use Caution" on overhead VMS signs when there has been a report of someone going the wrong way. The message was first used in Texas and was duplicated later in Utah.

Utah's scan tour participants learned many lessons while in Texas that have helped to inform subsequent conversations around how to best address WWD events. The overarching recommendation brought back from Texas was to blanket potential WWD entry points systemically with low-cost treatments as an initial measure, and then to continue monitoring crash events thereafter to see if specific locations warrant more advanced treatments.

4.2 Development of Standard Drawings

The primary tangible outgrowth of this research effort was development of a standard drawing incorporating low-cost elements that can be applied to Utah's roads. This standard drawing was included in the 2017 set as SN 2C – *Wrong Way Signing, Delineation, and Markings for Off-Ramps and Divided Highways*. The TAC reviewed this drawing during its development. It features a combination of solutions including pavement markings, LED flashers, and red retroreflective tape on sign poles in addition to the standard dual array of WRONG WAY and DO NOT ENTER signs. This drawing can be downloaded from the UDOT Standards webpage**.**

UDOT is pushing ahead with plans to deploy the measures shown in Standard Drawing SN 2C at select interchange ramps in 2017. The overall strategy is to install these low-cost mitiations measures on as many ramps as possible while leaving open the possibility of installing higher-level detection and notification systems in the future if particular WWD hotspots emerge.