Preventing Wrong-Way Driving on Freeways

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EXECUTIVE SUMMARY

Driving the wrong way on freeways has been a consistent traffic safety problem since the interstate system was opened in the 1950s. According to the Fatality Analysis Reporting System (FARS), a total of 1,753 people died and thousands more were injured in wrong-way crashes in the United States from 1996 to 2000. The number of fatalities caused by wrong-way driving ranges between 300 and 400 per year. In Illinois, there were 217 freeway crashes caused by wrong-way driving from 2004 to 2009, resulting in 44 killed and 248 injured. The average direct economic loss due to wrong-way crashes on freeways was estimated to be approximately $11.5 million per year in Illinois.

The purpose of this research project was to identify the factors that contribute to wrong-way crashes and develop countermeasures to reduce these driving errors and related crashes.

Wrong-way driving countermeasures were pioneered by the California Department of Transportation (Caltrans) and focused on the improvement of signage, pavement marking, and geometric design. Early research results indicated that low-mounted **DO NOT ENTER** signs paired with **WRONG WAY** signs were an effective countermeasure. The wrong-way crash rate was significantly reduced in California after implementing the research recommendations in the 1970s and 1980s. More recent research in 2004 by the Texas Transportation Institute (TTI) provided updated information on wrong-way crash characteristics and application of advanced intelligent transportation systems technologies. These innovative systems have allowed many state departments of transportation (DOTs) to implement modern traffic management centers to monitor and quickly respond to traffic incidents. Because of the availability of these coordinated surveillance and response tools, some wrong-way detection and warning systems that previously had not worked became feasible for stopping wrong-way drivers before crashes occurred.

For this project, traffic crash data from 2004 to 2009 were collected from the Illinois Department of Transportation (IDOT). Wrong-way crashes were identified based on different criteria and followed by and evaluation of the actual crash and crash reconstruction reports. General statistical characteristics of wrong-way crashes were analyzed. Causal tables, Haddon matrices, and significance tests were used to identify factors that contribute to wrong-way crashes. Alcohol impairment; driver age group; driver gender; driver physical condition; driver skills, experience, and knowledge; time of day, interchange type; and urban and rural areas were found to be significant factors in wrong-way crashes on freeways. The vehicle type, seat belt use, lighting, roadway alignment, driver age group, first vehicle contact point, and driver condition (blood alcohol concentration level) were found to have an impact on crash severity.

The weighted number of possible wrong-way entries from 2004 to 2009 was used to rank the interchanges for field review. Twelve high-frequency crash locations were investigated through extensive field reviews by project researchers and Technical Review Panel members. A checklist was used to identify the conditions of existing signage, pavement marking, and geometric features. Based on the review results, general issues relating to existing signage, pavement marking, and road geometry were identified. Site-specific countermeasures were developed for those interchanges for future implementation. In addition, general countermeasures were also developed from the different perspectives of "4 E's" (engineering, education, enforcement, and emergency response) based on the literature review results, crash analysis findings, contributing factors, and site-specific countermeasures.

LIST OF ACRONYMS

AASHTO	American Association of State Highway and Transportation Officials
AG	Angle
BAC	Blood alcohol concentration
Caltrans	California Department of Transportation
DMS	Dynamic message signs
DOTs	Departments of transportation
DUI	Driving under the influence
FARS	Fatality Analysis Reporting System
HO	Head-on
HSIP	Highway Safety Improvement Plan
HSIS	Highway Safety Information System
HSRC	Highway Safety Research Center
IDOT	Illinois Department of Transportation
ISPERN	Illinois State Police Emergency Radio Network
ITARDA	Institute of Traffic Accident Research and Data Analysis
ITS	Intelligent transportation system
MUTCD	*Manual on Uniform Traffic Control Device*
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Association
NMSHTD	New Mexico State Highway and Transportation Department
NTTA	North Texas Tollway Authority
PDO	Property damage only
SHSP	Strategic Highway Safety Plan
SPUI	Single-point urban interchange
SSO	Sideswipe opposite direction
SWOV	Stichting Wetenschappelijk Onderzoek Verkeersveiligheid
TTI	Texas Transportation Institute
UNC	University of North Carolina
USDOT	United States Department of Transportation
VMT	Vehicle miles traveled
WSDOT	Washington State DOT

CONTENTS

CHAPTER 1 INTRODUCTION

The importance of transportation safety continues to be strongly emphasized by the United States Department of Transportation (USDOT) as well as by state agencies. The number of deaths on highways in the United States has remained steady over the past 15 years at approximately 40,000 fatalities per year. The Illinois Department of Transportation (IDOT) continues to make transportation safety a high priority. IDOT has introduced numerous campaigns and programs to increase traffic safety awareness and to reduce the number and severity of crashes on Illinois roadways. While great strides have been made in traffic safety, there is still room for improvement.

1.1 BACKGROUND

The National Highway Transportation Safety Administration (NHTSA) defines a head-on collision as one where the front end of one vehicle collides with the front end of another vehicle while the two vehicles are traveling in opposite directions (Neuman et al. 2008). There are two types of head-on collisions on freeways/expressways: cross-median head-on crashes and wrong-way driving head-on crashes. The American Association of State Highway and Transportation Officials' (AASHTO) Strategic Highway Safety Plan (SHSP) identified 22 goals to pursue in order to reduce highway crash fatalities. Goal 18 is "reducing head-on and across-median crashes" (Neuman et al. 2008). Recent work has been done by IDOT to reduce head-on (HO), sideswipe opposite direction (SSO), and angle (AG) crashes resulting from vehicles crossing the medians on freeways. However, the research for that effort uncovered similar crashes resulting from wrong-way driving. A brief review of data from the IDOT Safety Data Mart reveals that wrong-way driving is involved in HO, SSO, and AG crashes on freeways and is particularly associated with severe crashes. For the recent six years of reporting (2004 through 2009), there were 31 fatal and 45 A-injury crashes related to the wrong-way driving errors on freeways in Illinois.

On average, approximately 350 fatalities occur each year nationwide from wrong-way freeway crashes, based on NHTSA's Fatality Analysis Reporting System (FARS) (NHTSA). There has been no national level program to combat the wrong-way driving problem. Some states, such as California, Washington, and Texas, operated wrong-way prevention programs that funded safety improvements (Cooner, Cothron, and Ranft 2004). Some state departments of transportation (DOTs) have taken additional measures to improve signage, striping, and ramp designs to prevent wrong-way driving incidents (Shepard 1975; Cooner and Ranft 2008). Other states have experimented with intelligent transportation systems (ITS) technologies to address the problem.

Based on study results of NCHRP (National Cooperative Highway Research Program) Report 500 (Neuman et al. 2008), the most common strategies to minimize the likelihood of wrong-way driving are to implement channelization, signing, and striping improvements at freeway interchanges susceptible to wrong-way movements. The State of Illinois decided that an in-depth investigation of wrong-way crashes on Illinois freeways could provide a better understanding of such events. The purpose of this research was to review the severe crashes in depth, to determine the contributing factors that are most commonly involved, and to generate ideas to consider in reducing the frequency and severity of these crashes.

1.2 REPORT STRUCTURE

This report is organized into seven chapters. Chapter 2 is a literature review of previous studies and research related to wrong-way crash prevention in the United States and other countries. General characteristics of wrong-way crashes in terms of crash frequency, crash severity, temporal distribution, location, and wrong-way drivers are summarized. This chapter also synthesizes previous findings on wrong-way countermeasures from engineering, education, enforcement, and emergency response viewpoints. Chapters 3 and 4 document the data collection, data analysis methods, and detailed analysis results. Chapter 5 identifies contributing factors and their significance on the probability of wrong-way crashes. Chapter 6 documents the field review results, proposed countermeasures, and a draft implementation plan. Final conclusions and future research needs are summarized in Chapter 7.

CHAPTER 2 LITERATURE REVIEW

This literature review presents the results of previous studies on wrong-way crash characteristics, contributing factors, and countermeasures. This research focuses only on freeway crashes. Freeways are defined as road facilities with full control of access (AASHTO 2011). On freeways, most entry points for wrong-way driving are exit ramps at interchange areas. A wrong-way crash was defined as any traffic crash caused by a wrong-way driver (Scaramuzza and Cavegn 2007). A wrong-way driver was defined either as a driver traveling in the wrong direction on a physically separated motorway (Scaramuzza and Cavegn 2007) or a driver traveling in the opposite direction along a one-way street (Stichting Wetenschappelijk Onderzoek Verkeersveiligheid (SWOV) 2007).

2.1 GENERAL CHARACTERISTICS OF WRONG-WAY CRASHES

Many studies have analyzed the general characteristics of wrong-way crashes, such as crash frequency, crash severity, and driver and temporal distribution. The results of these studies are summarized in this chapter.

2.1.1 Wrong-Way Crash Frequency and Rates

A total of 1,753 people died and thousands more were injured in wrong-way crashes in the United States from 1996 to 2000 (NHTSA FARS). The number of fatalities caused by wrong-way driving ranged between 300 and 900 per year (Figure 2.1). The data were collected from NHTSA FARS by search criteria of driver related factor (51 = driving on wrong side of road) and number of fatalities in crashes. The number of fatalities caused by wrong-way driving in 2009 (more than 900) is much higher that other years (average 420 per year). It should be noted that the data include fatal crashes caused by wrong-way driving on all types of roadways.

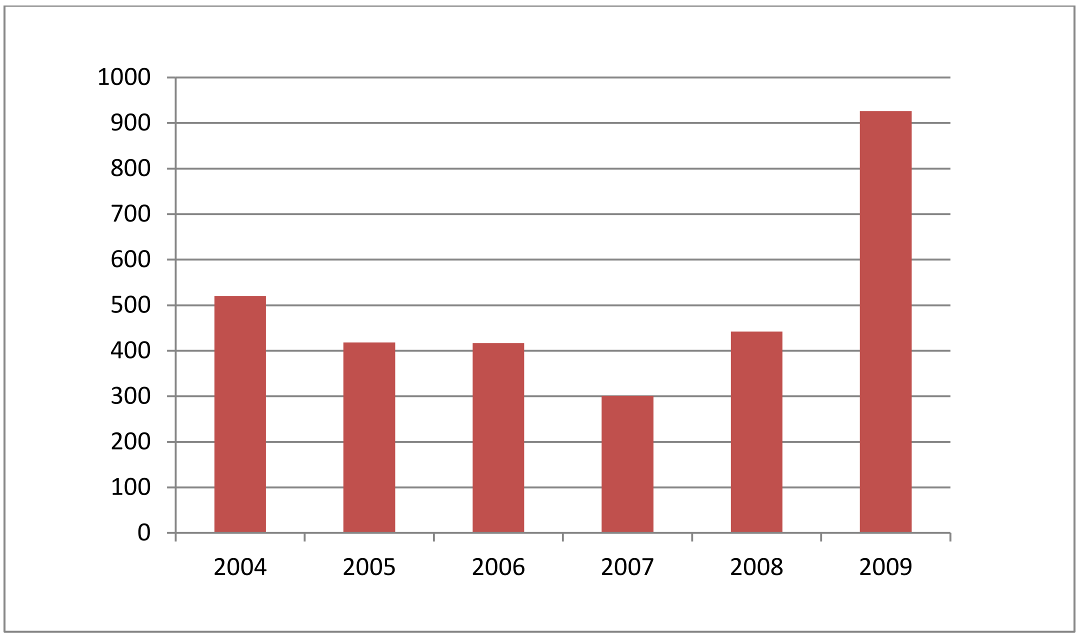


Figure 2.1. Fatalities caused by driving on wrong side of road in the United States (NHTSA FARS).

Studies conducted by other states, including California, Connecticut, New Mexico, North Carolina, and Texas, also documented the frequency of wrong-way crashes over the past several decades:

- California (1965–1985): The number of fatal wrong-way crashes averaged 35 per year. The number of fatal wrong-way crashes, however, remained constant even as the miles of freeway and travel increased substantially (Copelan 1989). Therefore, the fatal wrong-way crash rate per million vehicle traveled has decreased.
- Connecticut (2004–2006): There was an average of 9 wrong-way crashes on its interstate highway system annually, according to data collected by the Connecticut Department of Transportation (Leduc 2008).
- New Mexico (1990–2004): There were 49 fatal wrong-way crashes on interstate freeways from 1990 to 2004 (Lathrop, Dick, and Nolte 2010).
- North Carolina (2000–2005): There were 162 wrong-way crashes on freeways from 2000 to 2005 and 5 reported wrong-way crashes in the Charlotte, North Carolina, area from October 2005 to March 2006 (Braam 2006).

Wrong-way crashes are not unique to the United States. They were also reported in other countries in several studies:

- Netherlands
  - 1991-1997: an average of 22 wrong-way crashes per year (SWOV 2007)
  - 1998–2003: an average of 7 wrong-way crashes per year (SWOV 2007)
- Japan
  - 1997–2000: an average of 31 wrong-way crashes per year (Institute of Traffic Accident Research and Data Analysis (ITARDA) 2002)
- Switzerland
  - 2000–2004: an average of 27 wrong-way crashes per year (Scaramuzza and Cavegn 2007)

Studies have shown a significant reduction in fatal wrong-way crash rates in some states and countries. For example, in California, fatal crash rates dropped from approximately 1.5 per billion vehicle miles traveled (VMT) in 1965 to 0.5 per billion VMT in 1985 (Copelan 1989) due to improvements in traffic signs and pavement markings. In the Netherlands, the average annual number of wrong-way crashes was reduced from 22 in 1991–1997 to 7 in 1998–2003 (SWOV 2007).

2.1.2 Crash Severity

Since wrong-way driving often leads to head-on collisions, wrong-way crashes tend to be more severe when compared with other types of crashes. They also have a greater likelihood to result in death or injury. Studies showed that although a very small percentage of overall traffic crashes were caused by wrong-way driving, a relatively large percentage of fatal crashes were. Table 2.1 lists the percentage of wrong-way and fatal crashes compared with all crashes and shows this trend is consistent between states and countries.

Table 2.1. Wrong-Way Crashes and Total Crashes

Country		Year	Wrong-Way Crashes/All Crashes	
			All Crashes	**Fatal Crashes**
U.S.	California	1987	0.24%	2.9%
	New Mexico	1990–2004	—	5.3%
	North Carolina	2000–2005	0.16%	5.6%
Netherlands		1991–1997	0.10%	2.6%
		1998–2003	—	1.5%

Several states reported a high percentage of wrong-way crashes resulting in fatality and injury. Table 2.2 lists the distribution of three types of wrong-way crashes (fatal, injury, and property-damage-only [PDO]) in three U.S. states. Drivers and passengers in wrong-way vehicles and in vehicles traveling in the correct direction can be killed in wrong-way crashes (Lathrop, Dick, and Nolte 2010). For the 49 fatal wrong-way crashes on the New Mexico interstate highway system between 1990 and 2004, 35 drivers and 11 passengers in the wrong-way vehicles were killed; 18 drivers and 15 passengers in vehicles traveling in the correct direction were killed as well (Lathrop, Dick, and Nolte 2010).

Table 2.2. Distribution of Wrong-Way Crash Severity

State	Year	Total	PDO	Injury	Fatal
California	1987	204	70 (34.3%)	105 (51.5%)	29 (14.2%)
Texas	1997–2000	323	—	260 (80.5%)	63 (19.5%)
North Carolina	2000–2005	161	—	—	34 (21.1%)

2.1.3 Temporal Distribution

Wrong-way crashes are more prevalent during non-daylight hours, particularly in the early morning. Table 2.3 lists the percentages of wrong-way crashes during the hours from 12:00 midnight to 6:00 a.m. in Texas. These six hours covered 52% of all wrong-way crashes. However, only 10.4% of overall freeway crashes occurred during that time period. Studies (Braam 2006; Cooner, Cothron, and Ranft 2004) showed that wrong-way crashes occurred more frequently during the weekends, including Friday night. Monthly distribution of wrong-way crashes varies among different states (Cooner and Ranft 2008; Braam 2006) and countries (ITARDA 2002), showing no consistent trend.

Table 2.3. Wrong-Way Crashes During Early Morning Hours in Texas (Cooner, Cothron, and Ranft 2004)

Time of Day (a.m.)	Number of Wrong-Way Crashes	Percentage of total Wrong-Way crashes	Percentage of Total Crashes
12:00–12:59	26	8.0%	2.2%
1:00–1:59	39	12.1%	2.0%
2:00–2:59	54	16.7%	2.5%
3:00–3:59	23	7.1%	1.5%
4:00–4:59	17	5.3%	1.0%
5:00–5:59	9	2.8%	1.2%
Total	**168**	**52.0%**	**10.4%**

2.1.4 Crash Location

Research in both California (Copelan 1989) and Texas (Cooner, Cothron, and Ranft 2004) has found that urban areas have many more wrong-way crashes than rural areas. The Texas study (Cooner, Cothron, and Ranft 2004) also found that most of the wrong-way collisions occurred in the inside lane of the correct direction and at the locations with left-side exit ramps or one-way streets that transitioned into a freeway section. A study in the Netherlands found that between 1983–1998, 79% of wrong-way crashes took place on the main carriageway, 5% on joining and leaving lanes, and 17% on entry and exit roads (SWOV 2007).

Although some previous studies concluded that wrong-way crashes happened so randomly that it was hard to identify the high-frequency crash locations for engineering improvement (Braam 2006; Cooner, Cothron, and Ranft 2004; NTTA 2009), Caltrans has developed an analysis tool to identify locations where wrong-way collision concentrations have occurred on freeways and expressways (Copelan 1989). Two separate wrong-way collision rates, total and fatal, were used to conduct an engineering analysis at identified locations in the Caltrans 2008 Highway Safety Improvement Plan (HSIP) guide. The minimum collision criteria are a total wrong-way collision rate of 0.5 collisions of any severity per mile per year and a minimum of three wrong-way collisions in a five-year period, or a fatal wrong-way collision rate of 0.12 fatal collisions per mile per year and a minimum of three fatal wrong-way collisions in a five-year period.

According to the SWOV (Stichting Wetenschappelijk Onderzoek Verkeersveiligheid, the Dutch Institute for Road Safety Research) fact sheet, from 1983–1998, 80% of wrong-way crashes occurred when it was dry (SWOV 2007). A study in North Carolina found that 33% of the crashes occurred during dark conditions (at night without street lighting), and 28% occurred at night on roads with streetlights (Braam 2006).

2.1.5 Wrong-Way Driver

Wrong-way drivers characteristics such as driver sobriety, age, and gender have been discussed in many studies. Wrong-way driver information has also been used to develop countermeasures to combat wrong-way crashes. A significant portion of wrong-way crashes on freeways was caused by driving under the influence (DUI) of alcohol or drugs. The percentages of these drivers in wrong-way crashes from previous studies in six states and other countries are listed in Table 2.4.

Table 2.4. Percentage of Wrong-Way Crashes Attributed to DUI

Region	United States						Other Countries		
	CA	VA	IN	TX	NM	NC	Netherlands		Japan
Year	1983–1987	1977	1970–1972	1997–2000	1990–2004	2000–2005	1983–1990	1991–1998	1997–2000
Percentage	59.4%	50%	55%	60.7%	63%	43%	45%	20%	15%

Most studies concluded that young drivers and older drivers are overrepresented in wrong-way crashes (Vicedo 2006; Cooner and Ranft 2008; SWOV 2007). Table 2.5 compares the percentage of freeway crashes and wrong-way crashes for different age groups in North Carolina. It shows that 17.3% of wrong-way crashes on freeways involved an older driver compared to just 5% of all freeway crashes (Braam 2006). For wrong-way crashes involving older drivers in North Carolina, 75% occurred during daylight conditions (Braam 2006). Similar results in California found that drivers age 70–79 experienced over twice as many freeway wrong-way crashes than would be expected based on their proportion of the driving population (Cooner, Cothron, and Ranft 2004).

Table 2.5. Driver Age for Freeway Crashes in North Carolina (Braam 2006)

Age Group	Percentages	
	All Crashes on Freeway	**Wrong-Way Crashes on Freeway**
<21	7.9%	4.3%
21–64	71.1%	62.0%
>64	5.0%	17.3%
Unknown	16.0%	15.4%

In Japan, the number of wrong-way crashes peaked in three age ranges: 25–29, 45–54, and 75–79 (ITARDA 2002). The older drivers contributed to 29% of wrong-way crashes, although they contributed to only 4% in total highway crashes (ITARDA 2002). The SWOV fact sheet stated that the risk groups causing wrong-way driving crashes are young, inexperienced drivers and elderly drivers (SWOV 2007).

The contributing factors for wrong-way crashes in different age groups vary. Most of the crashes caused by drivers in the young and middle-age range were brought about by inattention, while most crashes caused by drivers in the senior age range occurred because of some physical illness such as dementia or not understanding how to use the highway (ITARDA 2002).

The overwhelming majority of wrong-way crashes involved male drivers, and most of the female drivers were in the young age range (ITARDA 2002). Studies in New Mexico found that drivers in wrong-way crashes were significantly more likely to be males (Lathrop, Dick, and Nolte 2010). A Texas study showed that 67% of wrong-way drivers (216 in 323) were male (Cooner, Cothron, and Ranft 2004). Although a study from the Netherlands found 81% of wrong-way crashes involved males, gender was not cited as a primary contributing factor (SWOV 2007).

2.1.6 Wrong-Way Driving Incidents

Wrong-way driving incidents differ from wrong-way crashes in that the wrong-way drivers were stopped or corrected, either by themselves or by law enforcement, to the right direction before causing any vehicle crashes. A wrong-way monitoring system in California between 1971 and 1977 showed that about 7% of the freeway ramps studied had five or more wrong-way entries per month, with some as high as 50 to 60 per month (Cooner, Cothron, and Ranft 2004). Similarly, a study in Georgia found wrong-way entry rates as high as 14 per month (Cooner, Cothron, and Ranft 2004). Finally, a study in Washington State recorded 18 wrong-way incidents, among which 12 drivers turned around (Moler 2002). In the United States, a majority of wrong-way drivers corrected their error—turning around before causing a crash.

Similar behaviors have been documented in Europe. Every year, radio stations report about 1,800 wrong-way driving incidents in Germany (BMW 2007). In France, a wrong-way driving incident was reported every 10 to 15 days on the roadway network. Of these incidents in France, about 25% were confirmed, and 1% to 3% of the wrong-way driving incidents resulted in a crash (Vicedo 2006).

2.2 CONTRIBUTING FACTORS FOR WRONG-WAY CRASHES

In the 1960s, many wrong-way movements and crashes were caused by drivers who were confused by ramp configurations. Since then, many ramps have been modified with traffic signs, pavement markings, and other improvements. The number of wrong-way entries caused by confusion was believed to be reduced (Copelan 1989).

In 1989, a Caltrans survey concluded that the most common cause of wrong-way crashes is alcohol (Copelan 1989). Other studies indicated that the reason for wrong-way driving "does not lie in the driver as such but in inadequate road surfaces at specific spots as well as in traffic signalization systems" (Topolsec 2009).

Previous studies concluded that driving under the influence, older drivers, and driving fatigue were the primary causes of wrong-way crashes (Moler 2002; Copelan 1989; NTTA 2009), but road design configuration was not an identified factor (NTTA 2009). Others speculated that poor lighting conditions and insufficient signage and pavement marking at an interchange could be contributing factors to wrong-way crashes (Vicedo 2006; Braam 2006). Table 2.6 lists the contributing factors for wrong-way crashes based on past research (ITARDA 2002; Vicedo 2006) in six categories: (1) traffic violations, (2) inattention, (3) impaired judgment, (4) insufficient knowledge, (5) infrastructure deficiency, and (6) others.

Table 2.6. Contributing Factors for Wrong-Way Crashes

Categories	Description
Traffic violation	• Driving under the influence (DUI) • Intentional reckless driving • Suicide • Test of courage • Escaping from a crime scene • Avoiding traffic congestion
Inattention	• Falling asleep at the wheel • Carelessness, absent-mindedness, distraction • Inattention to informational signposts
Impaired judgment	• Physical illness • Elderly driver • Drivers with psychiatric problems
Insufficient knowledge	• Lack of understanding of how to use the highway • Unfamiliar with the infrastructure • Loss of bearings
Infrastructure deficiency	• Insufficient lighting • Insufficient field view • Heavy vegetation
Others	• Inclement weather

2.3 WRONG-WAY START POINT

One of the most challenging aspects of studying wrong-way crashes is identifying where the driver first turned the wrong direction on the roadway. Based on previous studies, most common wrong-way driving scenarios occur when drivers

- Miss an intended exit (ITARDA 2002)
- Choose the exit road instead of the entry road when joining from a non-freeway (SWOV 2007; Cooner, Cothron, and Ranft 2004; NTTA 2009)
- Enter a roadway going the wrong direction at the road's terminus (NTTA 2009)
- Make a U-turn and misunderstand that the next lane will be in the opposite direction (ITARDA 2002; Cooner, Cothron, and Ranft 2004; NTTA 2009)
- Attempt to get back on the main road after stopping at a service or parking area (ITARDA 2002)

Several previous studies used information sources such as police crash reports, surveys, and images from camera surveillance systems to determine where a wrong-way movement originated (Cooner, Cothron, and Ranft 2004; Cooner and Ranft 2008; NTTA 2009). Most entry points for two-thirds of the crashes were unknown because the wrong-way driver usually could not provide information due to his/her intoxicated condition or because he/she died in the crash (Cooner, Cothron, and Ranft 2004; Copelan 1989). Nevertheless, some useful conclusions were drawn based on the limited available information. Table 2.7 summarizes the distribution of wrong-way crash entry points.

Table 2.7. Distribution of Wrong-Way Crash Entry Points

	Percentage (%)					
	U.S.					
Starting Point	**NM**	**TX**	**VA**	**WA**	**Netherlands**	**Japan**
Interchanges and junctions	10%	19.5%	50%	50%	24%	39%
Service and parking areas	—	—	15%	—	—	27%
Main road	8%	3.7%			20%	21%
Vicinity of toll booth	—	—	—	—	—	10%
Other	—	8.7%	—	—	9%	2%
Unspecified	73%	68.1%	35%	50%	47%	1%
Non-standard entrance point	6%	—	—	—	—	—
Construction site	2%	—	—	—	—	—

2.4 WRONG-WAY DRIVING AND INTERCHANGE TYPE

There are seven basic interchange types: diamond, cloverleaf, partial cloverleaf, trumpet, single-point urban interchange (SPUI), directional, and semi-directional. Past research (Howard 1980; Copelan 1989; Moler 2002; Braam 2006; Cooner, Cothron, and Ranft 2004; Neuman et al. 2008) has shown that some ramp and interchange types are more problematic and susceptible to wrong-way movements. Some conclusions from different studies are summarized as follows:

- Partial cloverleaf interchanges were the most probable locations for wrong-way entries to the freeway. The side-by-side on- and off-ramp configuration contributed to the wrong-way entry at partial cloverleaf interchanges. In some cases, concrete barriers separated the looping ramps so that drivers could not see the entrance ramp on the barrier's other side (Howard 1980; Moler 2002; Neuman et al. 2008).
- Full cloverleaf interchanges are the most desirable type of interchange to avoid wrong-way movements, especially if traffic control devices such as reflective markings and double yellow stripes are used on the overcrossing bridge to keep motorists on the proper side (Howard 1980; Moler 2002; Braam 2006).
- Trumpet interchanges are more susceptible to wrong-way movements, while full cloverleaf and full-diamond interchanges seldom have problems (Howard 1980; Copelan 1989).
- A full-diamond interchange minimizes driver confusion and wrong-way movement. However, sometimes motorists will mistake an off-ramp of a diamond interchange for a frontage road parallel to the ramp or highway, mistakenly turning left from the overcrossing street to the off-ramp (Howard 1980; Moler 2002; Braam 2006).

- Incomplete or partial interchanges may cause motorists to use an off-ramp to enter a freeway if the on-ramp is miles away. Similarly, some drivers will use on-ramps to exit the freeway if the off-ramp is too far away (Copelan 1980; Moler 2002).
- Left-side off-ramps are at risk for wrong-way freeway entrances because drivers might naturally expect to enter the freeway using a right-turn and may mistakenly make this turn and travel the wrong way from the exit of the left-side off-ramp (Howard 1980; Cooner, Cothron, and Ranft 2004).

2.5 COUNTERMEASURES

The common countermeasures for wrong-way driving include engineering (signage pavement marking, roadway geometry, and ITS), education (training), and enforcement (emergency response, confinement, and radio messages) (Braam 2006; Vicedo 2006). Wrong-way countermeasures historically have had mixed results (Braam 2006).There is no one-size-fits-all solution to the problem of wrong-way crashes. The wrong-way countermeasures differ on feasibility, applicability, effectiveness, implementation priority, and associated cost. Others have found that a combination of engineering countermeasures, increasing DUI enforcement and education campaigns, and proactive steps to influence social behavior may lessen the frequency of wrong-way crashes (NTTA 2009). Transportation agencies should consider the causal factors for the incidents that occur in their jurisdictions and implement countermeasures that address the identified causes.

The following subsections summarize the wrong-way countermeasures from the aspect of the four main approaches used to reduce wrong-way crashes: engineering, enforcement, and education.

2.5.1 Engineering

Engineering countermeasures strive to provide positive warnings to drivers at the earliest decision points and, in some cases, supplemental warning to wrong-way drivers after they have begun traveling in the wrong direction (NTTA 2009). The Texas Transportation Institute (TTI) report classified engineering countermeasures into the following four basic categories (Cooner, Cothron, and Ranft 2004):

- “Traditional signing and pavement marking techniques
- Innovative signing and pavement marking techniques
- Geometric modifications
- Intelligent transportation systems (ITS) applications”

Major geometric modifications are seldom implemented because of the tremendous costs. Wrong-way detection and warning systems are also expensive, both in initial costs and long-term operation/maintenance and often are installed at only the most problematic interchanges (Braam 2006). Improvements with traffic signs and pavement markings are more feasible in most cases. Wrong-way countermeasures should focus on low-cost measures for traffic signs at interchanges. In contrast, improvements of the layout of junctions are recommended only in areas with higher numbers of wrong-way crashes or incidents. Electronic systems for the detection of wrong-way drivers are not an adequate countermeasure (Scaramuzza and Cavegn 2007). When evaluating the effectiveness of countermeasures for preventing wrong-way driving, the Virginia DOT considered whether the countermeasures could deter wrong-way movements effectively and whether the countermeasures impact the right-way motorists (Howard 1980).

2.5.1.1 Traffic Signs and Pavement Markings

2.5.1.1.1 **DO NOT ENTER** and **WRONG WAY** Signs

The **DO NOT ENTER** sign is the most universal and recognizable countermeasure for wrong-way driving. In 1964, Caltrans developed a black-on-white **DO NOT ENTER** sign mounted on the same post with a white-on-red **WRONG WAY** sign. The **DO NOT ENTER** sign was later revised to white on red (Copelan 1989).

Japan, Australia, and some European nations also use a traffic sign similar to the **DO NOT ENTER** sign used in the United States. In the Netherlands, road sign **C2** (forbidden to enter) has been positioned along motorway exit roads since 1981 (SWOV 2007). However, most countries use only the symbol portion of the sign. The U.S.-style **WRONG WAY** sign is not used in other countries except Australia, where the white-text **WRONG WAY** was replaced with **WRONG WAY GO BACK** (Cooner, Cothron, and Ranft 2004).

The 2009 edition of the *Manual on Uniform Traffic Control Devices* states that the **DO NOT ENTER** sign "shall be used where traffic is prohibited from entering a restricted roadway" (MUTCD 2009). The MUTCD also suggested that the **WRONG WAY** sign may be used as a supplement to the **DO NOT ENTER** sign in where an exit ramp intersects a crossroad or a crossroad intersects a one-way roadway in a manner that "does not physically discourage or prevent wrong-way entry."

DO NOT ENTER and **WRONG WAY** sign packages are widely used for deterring wrong-way movements. TTI distributed surveys to 50 state DOTs and received responses from 28 states (Cooner, Cothron, and Ranft 2004). Table 2.8 summarizes the findings about sign use in the responding states.

Table 2.8. Use of **DO NOT ENTER** and **WRONG WAY** Signs

	Roadway Location		
Sign	**Exit Ramp**	**Frontage Road**	**Divided Highway**
DO NOT ENTER	97%	72%	86%
WRONG WAY	97%	59%	76%

The MUTCD recommended that the **WRONG WAY** sign be placed at a location "along the exit ramp or the one-way roadway farther from the crossroad than the **DO NOT ENTER** sign." However, the TTI report recommended that **DO NOT ENTER** and **WRONG WAY** signs be mounted on the same post so that drivers can more easily see them (Leduc 2008). The 1989 Caltrans study suggested that a second set of **DO NOT ENTER** and **WRONG WAY** signs be used to give the driver a second chance to correct his/her wrong-way error (Copelan 1989).

The MUTCD identified the standard mounting height for road signs as 7 feet in urban areas and 5 feet in rural areas. TTI reported that about 86% of the 28 DOTs that responded to its survey followed the standard mounting height for **DO NOT ENTER** and **WRONG WAY** signs (Leduc 2008).

The **DO NOT ENTER** and **WRONG WAY** sign packages were lowered to 2 feet above the pavement in California in 1973. Lowering the height of **DO NOT ENTER** and **WRONG WAY** signs was found to be an effective countermeasure for preventing wrong-way drivers from entering highways. A lower mounting height was reported to make the signs more visible at night because lower signs are more directly in the path of a car's headlights. A lower mounting height also makes the sign more visible to impaired and older drivers, who tend to look for visual cues from the pavement area (Leduc 2008). A lowered mounting height could also avoid sight restrictions (Cooner, Cothron, and Ranft 2004).

Caltrans reevaluated the low-mounted **DO NOT ENTER** and **WRONG WAY** signs in 1989. The lowered sign packages were considered still to be effective. Figure 2.2 illustrates a low-mounted sign package currently used in California. Georgia and Virginia also use lowered **DO NOT ENTER** and **WRONG WAY** signs mounted together as standard practice. Several agencies in the United States also use the mounted **DO NOT ENTER** and **WRONG WAY** signs at exit ramps. However, this treatment has not received widespread use.

Figure 2.2. California's lowered **DO NOT ENTER/WRONG WAY** sign package.

Table 2.9 lists the sizes of **DO NOT ENTER** and **WRONG WAY** signs used in the 28 states based on the TTI survey results. MUTCD recommends using large **DO NOT ENTER** and **WRONG WAY** signs at multi-lane exit ramps or on one-way streets. The 1989 Caltrans study recommended the use of oversized **DO NOT ENTER** signs for locations with a recurring wrong-way driving problem (Copelan 1989; Cooner, Cothron, and Ranft 2004).

Table 2.9. Traffic Sign Size in the United States

Category	DO NOT ENTER			WRONG WAY			
Size (inches)	30 × 30	36 × 36	48 × 48	30 × 18	36 × 24	42 × 30	48 × 36
Percentage	83%	79%	55%	28%	93%	38%	17%

In Japan, large signposts, large gate-type signposts, and additional signposts are used (ITARDA 2002). It is claimed that driver caution can be encouraged through the use of additional and larger signposts.

The MUTCD recommended that the **DO NOT ENTER** sign, if used, be placed "directly in view of a road user" at the point where a road user could wrongly enter a divided highway, one-way roadway, or ramp.

Internally illuminated traffic signs can help provide greater visibility, especially in areas frequented by tourists or other unfamiliar drivers. In Japan, internally illuminated signposts are used, and nighttime visibility is improved with the use of lights (ITARDA 2002). The NTTA proposed using flashing, internally illuminated signs or adding small LED units along the sign's borders to catch a wrong-way driver's attention. The TTI report stated that 10% of the 28 DOTs that responded to their survey used internally illuminated signs (Cooner, Cothron, and Ranft 2004).

Some state DOTs have evaluated high-intensity reflective sheeting for signs because they are more visible to drivers, particularly those who are impaired, disoriented, or confused (Moler 2002). The Ohio DOT and NTTA also affix red reflective tape to the signposts to enhance nighttime visibility (NTTA 2009). In the Netherlands, the road sign *C2* and the *GO BACK* panel have a florescent yellow background to make them more noticeable and visible during the night as well as during daytime.

In some cases, supplemental items such as placards, flashing beacons, or flags have been added to **DO NOT ENTER** and/or **WRONG WAY** signs as an enhancement to the traditional approach (Figure 2.3). The TTI reported that some states used supplemental items on the **DO NOT ENTER** and **WRONG WAY** signs, as listed in Table 2.10 (Cooner, Cothron, and Ranft 2004). The **ONE WAY** sign is the most common supplemental sign.

Supplemental placards on ramp

Supplemental **ONE WAY** sign

Figure 2.3. **DO NOT ENTER** sign with supplemental signs (Cooner, Cothron, and Ranft 2004).

Table 2.10 Supplemental Signs on Wrong-Way Sign Packages

Supplemental Item	Percentage
Word plaque with "FREEWAY"	3%
ONE WAY **sign**	62%
Red flashing beacons	3%
Yellow flashing beacons	3%
Flags	3%

Researchers at the University of Massachusetts used a driving simulator to evaluate the effectiveness of a three-dimensional **DO NOT ENTER** sign and a modified two-dimensional **DO NOT ENTER** sign in discouraging wrong-way movements (Laurie et al. 2004). Results indicated that adding a **NO RIGHT TURN** sign to the two-dimensional **DO NOT ENTER** plus **ONE WAY** sign decreased the number of wrong-way entries.

The standard **DO NOT ENTER** sign could help deter wrong-way movements. Most traffic engineers agree that MUTCD is adequate for wrong-way markings (Moler 2002). The lowered **DO NOT ENTER** and **WRONG WAY** sign packages are even more effective. The upgraded **DO NOT ENTER** package and other improvements in California reduced the frequency of wrong-way moves from 50–60 to 2–6 per month at problem ramps and completely eliminated them at the majority of ramps (Copelan 1989). Recently, the number of wrong-way crashes at the south end of the Dallas North Tollway declined after the installation of additional **WRONG WAY** and **DO NOT ENTER** traffic signs and additional pavement markings (NTTA 2009). The number of wrong-way crashes in the Netherlands declined considerably after installation of the road sign **C2** along exit roads (Brevoord 1998; SWOV 2007).

California has been a leading state in developing signs to deter wrong-way driving. Caltrans' sign standards (Figure 2.4) include the following:

- "Place the bottom of the **DO NOT ENTER** and **WRONG WAY** sign package 2 feet above the pavement.
- Mount **ONE WAY** arrows 1.5 feet above the pavement.
- Place at least one **DO NOT ENTER** and **WRONG WAY** sign package to fall within the area covered by a car's headlights and visible to the driver from the decision point on each likely wrong-way approach.
- Install **FREEWAY ENTRANCE** signs as near to the on-ramp and cross-street intersection as possible.
- Do not use symbol-only right- or left-turn prohibition signs at ramps because of the risk that impaired drivers might misinterpret them as directional arrows; word signs may be used."

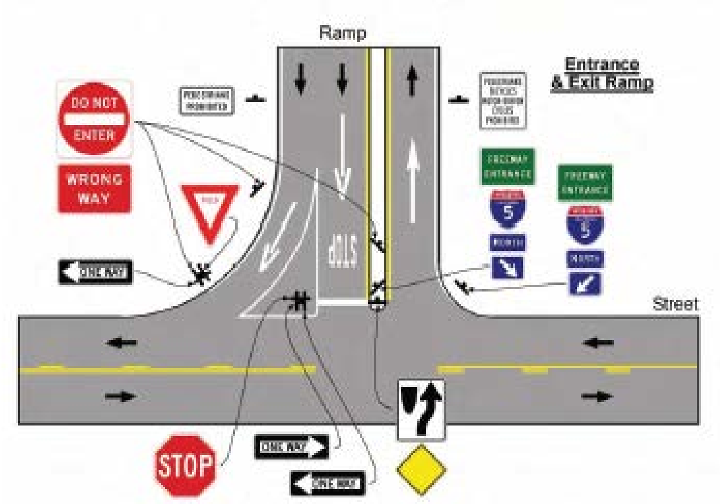


Figure 2.4. Standard signing and marking layout in California
(Cooner, Cothron, and Ranft 2004).

In Ohio, the typical layout (Figure 2.5) uses enhanced red background signs installed in pairs, as follows:

- **DO NOT ENTER** signs at the ramp throat.
- Double **WRONG WAY** signs partway down the ramp.
- **DO NOT ENTER** and **WRONG WAY** signs farther along the ramp closer to the highway.

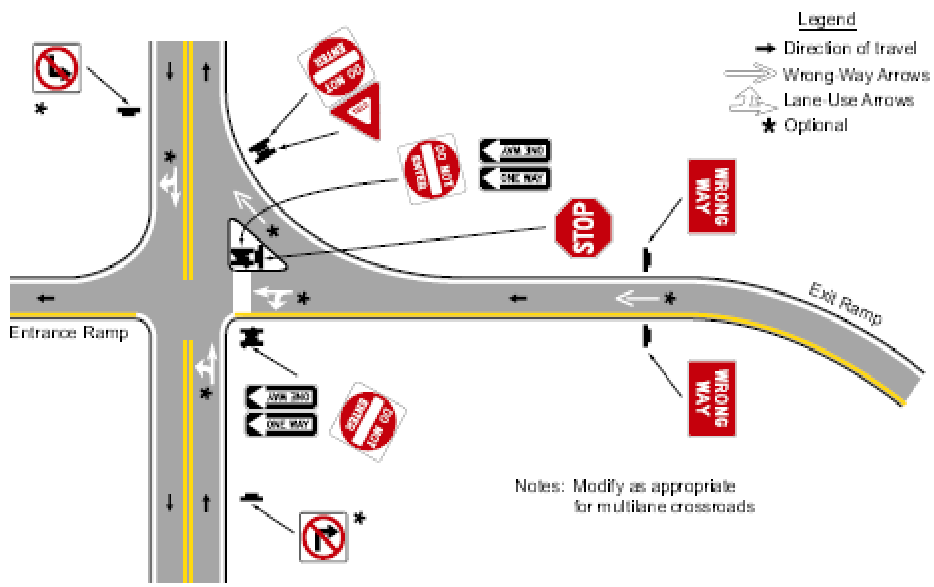


Figure 2.5. Wrong-way signing and pavement markings at exit ramp in Ohio (Cooner, Cothron, and Ranft 2004).

<u>2.5.1.1.2 Pavement Arrows</u>

Pavement arrows are another countermeasure for deterring wrong-way entries. Lane direction arrows on two-way frontage roads were tested as a means to reduce wrong-way driving for vehicles exiting the freeway (Schrock, Hawkins, and Chrysler 2005). The MUTCD recommends that where crossroad channelization or ramp geometrics do not make wrong-way movements difficult, a lane-use arrow should be placed in each lane of an exit ramp near the crossroad terminal (Leduc 2008). Since 1997 in the Netherlands, the Ministry of Transportation has installed extra arrows on the road surface that pointed in the correct direction (SWOV 2007).

Recently, the NTTA deployed pavement arrows on each exit ramp (NTTA 2009). The standard pavement arrow used by TxDOT is slightly longer and wider than that of the national standard (Cooner, Cothron, and Ranft 2004). The TTI report recommended that reflective and raised pavement arrow markers be installed and maintained on exit ramps, particularly at newly constructed ramps, left-side exits, and locations with a history of wrong-way crashes (Leduc 2008). The TTI survey results showed that 24% of the 28 state DOTs that responded to the survey used pavement arrows on all exit ramps, and 28% of them used such arrows only at known or suspected problem areas (Leduc 2008). To improve nighttime visibility of the arrows, some state DOTs have used thermoplastic, methyl methacrylate, and preformed cold-applied-tape arrows that are “more visible to drivers, including impaired, disoriented, and confused drivers” (Moler 2002). In addition to pavement arrows, an earlier study (Vaswani 1973) found that placement of stop lines across exit ramps near their junctions with crossroads, continuation of pavement edge lines across exit ramps, and continuation of double yellow lines on two-lane divided crossroads are also effective in reducing wrong-way driving.

<u>2.5.1.1.3 Red Reflective Raised Pavement Markers</u>

Red reflective raised pavement markers on one-way divided roadways to indicate the wrong direction of travel could help drivers realize when they are going the wrong direction (Cooner, Cothron, and Ranft 2004). Caltrans installed red-backed reflective pavement markers on the lane lines of freeways during the late 1960s to delineate roadways that must not be entered or used (Copelan 1989). Some DOTs use raised pavement markers with a red side facing the wrong-way direction along the edge of highway lanes and exit ramps. The TTI report stated that 38% of the 28 DOTs that responded to its survey use raised pavement markers on highways (Cooner and Ranft 2008). However, based on the California study results, the reflectors proved to be of limited value, especially with drunk drivers (Copelan 1989).

2.5.1.2 Geometric Modifications

Geometric modifications, although seldom adopted, can be used to reduce wrong-way movements. The AASHTO Green Book (AASHTO 2011) and the IDOT Bureau of Design and Environment Manual (IDOT 2010) provide guidance on how to prevent wrong-way driving at different types of interchange areas. Typical countermeasures include (1) using raised curb medians; (2) using channelized medians, islands, and adequate signing; (3) increasing the distance from the gorge of the exit ramp to the entrance ramp for partial cloverleaf interchanges; (4) reducing the wrong-way turning radius; and (5) not using off-ramps that join two-way frontage roads.

Studies (Copelan 1989; Moler 2002; Leduc 2008; Braam 2006) have suggested similar geometric modification countermeasure

- For partial cloverleaf interchanges:
  - Separate the on- and off-ramps
  - Orient the on-ramp for easy access
  - Construct a better-lit and larger opening for the on-ramp than the off-ramp
  - Reconstruct the curb nose between adjacent ramps
  - Grade the on-ramp entrance for better visibility than the off-ramp as viewed from the crossroad
  - Remove concrete barriers for better visibility of the exit ramp
- For full-diamond interchanges:
  - Construct an island to overlap a portion of the off-ramp so that a motorist would have to make an unnatural turn to enter the off-ramp
  - If an attraction exists on a frontage road parallel to the ramp, place signage about the attraction away from the off-ramp

2.5.1.3 ITS Technologies to Prevent Wrong-Way Driving

ITS technologies have been used by many transportation agencies to develop wrong-way countermeasures. A typical ITS system consists of a detection subsystem using Doppler radar or a loop detector and a warning system with luminous signaling, light barriers, and a sound alarm. Since sensors are used in most systems to detect the wrong-way movements, it was recommended that inductive loops or other detectors be installed on new exit ramps to allow for wrong-way detection and warning systems in the future (Cooner, Cothron, and Ranft 2004).

<u>2.5.1.3.1 San Diego: Airport-Type Red Pavement Lights</u>

In 1976, Caltrans installed airport-type red pavement lights (Figure 2.6) together with induction loops and extra wrong-way sign packages on freeway off-ramps in District 11 (Copelan 1989). When a wrong-way vehicle drives over an inductive loop detector, it activates warning lights embedded in the pavement, alerting the driver that he/she has entered the roadway in the wrong-way. The initiative was based on the theory that a drunk driver could concentrate on pavement lights fairly well even though his/her attention to roadway signs was extremely poor. Other studies also indicated that red pavement lights could deter the wrong-way entries effectively. However, this improvement was relatively expensive and required constant maintenance (Copelan 1989). Its effectiveness has not been verified by any data yet.

Figure 2.6. In-pavement warning lights for wrong-way vehicle (Cooner, Cothron, and Ranft 2004).

2.5.1.3.2 WSDOT: Embedded Sensor and Flashing Lights System

In 2003, the Washington State DOT (WSDOT) embedded electromagnetic sensors in the ramp pavement of I-5/Bow Hill Road to detect wrong-way movements (Figure 2.7). When wrong-way movements are detected, a sign mounted on each side of the northbound exit ramp began to flash an alternating red/yellow "wrong way" message. However, the system did not record a wrong-way incident (NTTA 2009). The NCHRP Report 500 noted that the system was also "plagued with maintenance problems." It was removed in 2005.

Electromagnetic sensor

Flashing light

Figure 2.7. WSDOT wrong-way detection and warning system (Moler 2002).

2.5.1.3.3 WSDOT: Video Wrong-Way Detection and Warning System

In 2004, WSDOT tested a video wrong-way detection and warning system at the I-90/161st Avenue southeast interchange. This system used a video detection system to monitor wrong-way movements. When a wrong-way movement was detected, a message sign was activated, which flashed a "wrong way" message to the wrong-way drivers. The system had many false alarms and maintenance problems and failed to record any wrong-way incidents (Moler 2002). The system was removed in 2005.

2.5.1.3.4 New Mexico: Directional Traffic Sensor System

The New Mexico State Highway and Transportation Department (NMSHTD) developed a wrong-way traffic sensor system, which was implemented in 1998 (on the southbound exit of I-25/Montgomery) (Moler 2002). The system detects wrong-way drivers with loop detectors; when wrong-way traffic is detected, two sets of warning lights turn on—a red set of lights that faces wrong-way drivers to warn them of imminent danger and a yellow set that faces right-way traffic to warn of a possible incoming wrong-way traffic (Figure 2.8). The system was designed to be effective with disoriented drivers or in bad weather.

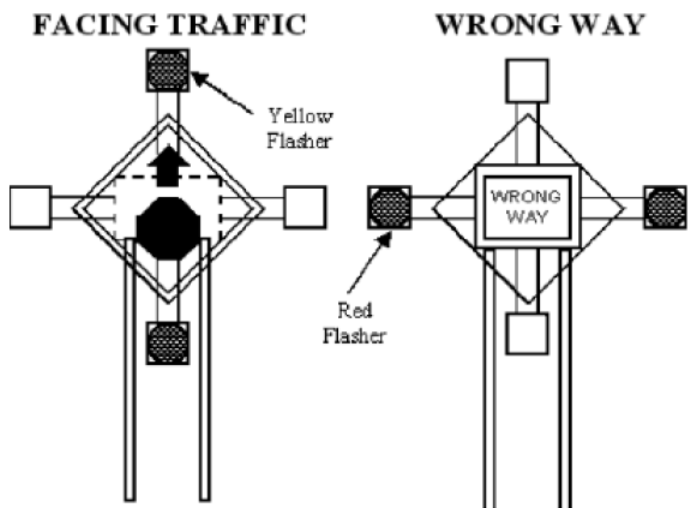


Figure 2.8. New Mexico directional traffic sensor system (Cooner, Cothron, and Ranft 2004).

2.5.1.3.5 Houston: Westpark Tollway Wrong-Way Detection System

Recently, the Harris County Toll Road Authority in Houston installed 14 microwave radar detectors on the Westpark Tollway to detect wrong-way driving incidents. After wrong-way driving was detected, a message was transmitted to a traffic management center to be verified manually through closed-circuit television. The incident manager can post warnings to right-way drivers using dynamic message signs (DMS) for verified wrong-way driving incidents. At the same time, the incident manager can notify law enforcement officers to stop the wrong-way driver by using a portable spike tool. The system has detected seven wrong-way driving incidents since implementation of the system, all of which were stopped by police before causing a crash (NTTA 2009). However, the NTTA report stated that the human resources required to provide adequate response to detections can be a constraint on implementation of the system (NTTA 2009). Furthermore, providing a message on a DMS telling right-way drivers to take a specified course of action could expose them to harm and perhaps raise claims if the instructions are followed and the driver is then involved in a crash (NTTA 2009).

2.5.1.3.6 Florida: Pensacola Bay Bridge Wrong-Way Detection System

FDOT installed a wrong-way driving detection and warning system on the Pensacola Bay Bridge (Figure 2.9). The system uses microwave radar to detect wrong-way vehicles and is not affected by inclement weather (Williams 2006). When radar detectors identify a wrong-way driver, the system activates overhead flashing lights to warn oncoming motorists. The system also simultaneously notifies a nearby police substation of the incident (Cooner, Cothron, and Ranft 2004).

System configuration

Traffic signs

Figure 2.9 Pensacola Bay Bridge wrong-way detection system (Williams 2006).

2.5.1.3.7 France: Smart System

In 2005, some French motorway associations installed a smart system to prevent wrong-way crashes. The system is based on the intelligent camera mvBlueLYNX and can record irregular incidents. Each camera observes one motorway exit and detects wrong-way motorists. When wrong-way driving is detected, the digital I/O generates a signal and sends it to a light system, which optically warns the misrouted road user optically (Lansche 2005).

2.5.1.3.8 In-Vehicle Driver Information System

BMW has developed a system that recognizes when the car's driver is heading toward a roadway in the wrong direction. The system warns the driver both audibly and visually. BMW was also reportedly developing a system to "speak" to other vehicles that could help warn their drivers when approaching a wrong-way driver. Information about the wrong-way driver can be sent to a service center by the wrong-way vehicle and be available to all road users in just a few minutes (BMW 2007).

2.5.2 Enforcement

Enforcement and emergency response are also very important in limiting wrong-way driving crashes. Many wrong-way driving incidents have been corrected by proper enforcement and response before severe crashes occurred. Some enforcement strategies include setting up DUI checkpoints, responding to alerting systems, using portable spike tools, confining wrong-way drivers, and warning right-way drivers.

Because DUIs are a major contributing factor to wrong-way driving crashes, many past enforcement countermeasures focused on enhanced legislation and DUI checkpoint programs (Copelan 1989; NTTA 2009). Enforcement and quick emergency response are required for implementation of some ITS wrong-way countermeasures. The deployment of a wrong-way detection and warning system is successful only if there is sufficient staff to receive the alert and quickly respond to the wrong-way driving incident (NTTA 2009).

Several wrong-way driving incident response strategies have been tried and implemented by different agencies. Caltrans tested parking-lot spike barriers at freeway off-ramps to see whether they could be used to stop wrong-way movements (Copelan 1989). The test results indicated that the devices were not feasible because the spikes could not deflate tires quickly enough to prevent a vehicle from entering the freeway, the spikes broke under high-volume traffic, and some right-way drivers brake when they see the spikes. According to the 1989 Caltrans survey (Copelan 1989), no states had developed special devices to physically prevent wrong-way entries and no traffic engineers endorsed the use of parking lot spike barriers, raising curbs, etc. The Georgia Department of Transportation tested a device that raised a physical, curb-like barrier to impede the wrong-way driver. This device was not feasible for reasons similar to those for the directional in-pavement spike (Copelan 1989).

The French Motorway Company implemented wrong-way driver confinement as an emergency management strategy. For any wrong-way driving alert, the freeway operation manager triggers confinement procedures that activated “closure of toll barriers, tunnels, and motorway access” in the direction of the zone concerned (Vicedo 2006). The alert was also broadcast over a radio frequency following the detection of the wrong-way driving incident. The problem with wrong-way confinement is that it could not protect vehicles already driving inside the confined area.

In Switzerland, radio stations broadcast radio warnings to alert drivers about the presence of wrong-way drivers on freeways. The police inform radio stations of the location, direction, and time of the wrong-way driving incident; the messages are then broadcast and received by all drivers listening to the radio program (Scaramuzza and Cavegn 2007). However, the location and time of crashes and radio warnings rarely matched up. Nevertheless, it was assumed that this system had some effect on reducing wrong-way crashes because wrong-way driving incidents warned by radio rarely resulted in crashes and crashes involving wrong-way driving were rarely preceded by a warning (Scaramuzza and Cavegn 2007).

2.5.3 Education

To help prevent wrong-way crashes, specific education programs have been developed for special age groups of drivers. The California Highway Patrol (CHP), working with student groups, local individuals, and local organizations such as Mothers Against Drunk Driving, started the Sober Graduation Program in 1985 to reduce drinking and driving among young people. It was conducted during May and June. The community-based effort involved 15- to 19-year-old drivers who abided by the “don’t drink and drive” message and agreed to deliver it to their peers (Copelan 1989; NTTA 2009). The CHP ran television and radio public service announcements and distributed posters, bumper stickers, decals, key chains, and book covers. The results of this program were rewarding. In May to June 1985 alone, fatal crashes in this age group dropped 25%, and injury crashes decreased 19%.

In 2009, NTTA developed a comprehensive public safety plan to educate the public (NTTA 2009). A major component of the plan was reducing drunk driving and publicizing the ramifications of making the decision to drink and drive. The plan included quarterly safety forums for the public, co-sponsored by Mothers Against Drunk Driving (MADD).

To help guide their educational programs, several states, including California and Washington, initiated a wrong-way monitoring program to collect information about wrong-way driving behaviors. In 1967, Caltrans developed a wrong-way camera system, which consisted of a pair of road tubes and a camera to count and record wrong-way entries on exit ramps. The system used the road tubes to detect wrong-way movements. When a wrong-way vehicle was detected, the camera would be triggered to take a snapshot of the wrong-way entry, and a digital counter would simultaneously record the wrong-way entry. Approximately 4,000 exit ramps were included in the monitoring program, and each exit ramp had at least 30 days of camera surveillance (Cooner, Cothron, and Ranft 2004).

Similarly, WSDOT monitored wrong-way driving with several different types of technologies. One deployment included cameras and videocassette recorders at two exit ramps of the I-82/Highway 22 interchange in south-central Washington. The system included two 6-foot induction loops, a loop detector, and a digital recorder to record wrong-way driving (Moler 2002). After wrong-way driving was detected, a signal was sent to the digital recorder, which began to record the wrong-way driving, saving it on a hard drive. In 2001, the system recorded 18 wrong-way incidents from May to December. The second WSDOT system, deployed at I-5/Bow Hill Road, consisted of electromagnets embedded in the ramp, a closed-circuit video camera, and a videocassette recorder. The wrong-way maneuver should have been recorded after it was detected by electromagnetic sensors, but none were recorded during the study period (Moler 2002). WSDOT also used a monitoring system at the I-90/161st Avenue southeast interchange. That system used a video detection system to detect wrong-way movements. The videocassette recorder recorded the wrong-way incident and saved it after it was detected.

Table 2.11 presents a summary of these deployments and their reported performances.

Table 2.11. Wrong-Way Monitoring Systems in the United States (Copelan 1989; Moler 2002)

Location	Wrong-Way Detection	Wrong-Way Recording	Performance
California	Paired road tube	Camera	Excellent
Washington	Loop detector	Digital recorder	Poor
Washington	Electromagnetic sensor	VCR	Poor
Washington	Video detection system	VCR	Poor

2.5.4 Guidelines and Recommended Practices

Caltrans traffic engineers extracted wrong-way crash reports from the crash database every year and generated wrong-way crash concentrations. Field investigations were then conducted at the locations where wrong-way crashes were most prevalent and at ramps where possible wrong-way entries had occurred. Reports documented the areas where wrong-way crashes were concentrated, contained descriptions of observed deficiencies, and made recommendations for improvements.

TxDOT also developed similar procedures for reviewing wrong-way entry issues and suspected problem locations. The wrong-way entry analysis procedure appeared to be effective in pinpointing deficiencies in the field.

Although Caltrans recommended a three- to five-year cycle, shorter review cycles were required by the NTTA (reviewing the condition of the ramp signage every two weeks). Caltrans and TxDOT both developed a checklist for field inspections.

Field inspections should be conducted during both daylight and nighttime hours on all ramps located within 3 miles of the wrong-way crash locations (NTTA 2009). The main purpose of a field inspection is to check the conditions of traffic signs and pavement markings at exit ramps, as listed in Table 2.12.

Table 2.12. Wrong-Way Field Inspection Checklist
(Copelan 1989; Cooner, Cothron, and Ranft 2004)

	Items	Requirements
Traffic Sign	• DO NOT ENTER • WRONG WAY • ONE WAY • NO RIGHT/LEFT/U TURN • KEEP RIGHT • DIVIDED HIGHWAY	• Present in minimum quantity • Mounted at standard MUTCD height • Nighttime visibility is sufficient • High-intensity sheet • In good repair and free of graffiti
Pavement Markings	• Pavement arrows • Red reflective raised pavement markers • Turning guide lines • Stop line at end of exit ramp	• Present at required locations • In good condition

The TTI report (Cooner, Cothron, and Ranft 2004) summarized the following guidelines for wrong-way countermeasures and treatments:

- Existing left-side exit ramps on freeways shall have reflectorized pavement arrows installed.
- Left-side exit ramps on freeways should be avoided in future freeway construction.
- Revise the Typical Standard Freeway Pavement Markings with Raised Pavement Markers Standards Plan Sheet.
- Repair deficient pavement arrows and make their maintenance a priority, particularly in urban areas.
- Consider the use of lowered **DO NOT ENTER** and **WRONG WAY** signs mounted together on the same post to address alcohol and nighttime problem locations.
- Coordinate with the primary 911 public safety answering points to share information on reports of wrong-way movements on freeway facilities.
- Use inductive loops or other detectors on exit ramps in future construction.
- Use the wrong-way entry checklist for reviewing wrong-way entry issues and suspected problem locations.

2.6 SUMMARY

In this chapter, the general characteristics of wrong-way crashes, crash rates, crash severity, temporal distribution, locations, and wrong-way driver were summarized. Literature on wrong-way driving countermeasures was reviewed and discussed. The literature review showed that wrong-way crashes rates have been reduced significantly in some states and countries through use of improved signage and pavement marking.

CHAPTER 3 DATA COLLECTION

3.1 CRASH DATABASES

Three crash databases were used for wrong-way driving data collection:

1. The original crash database for 2004 through 2009 was obtained from the IDOT Division of Traffic Safety. These data, provided as text files, included most of the variables in three separate but related files: crash file, person file, and vehicle file (Appendix A contains a list of the variables in each file).
2. A GIS-format crash database for 2005 through 2009 was collected from the IDOT Bureau of Safety Engineering. This crash database has one GIS file that contains the most relevant information for each crash, including roadway, vehicle(s), and driver(s). The advantage of this database is that the geographical distribution of crashes can be illustrated with GIS software.
3. A third source of data was obtained from the Highway Safety Information System (HSIS), a multi-state database that contains crash, roadway inventory, and traffic volume data for a selected group of states, including Illinois. HSIS is managed by the University of North Carolina Highway Safety Research Center (HSRC) under contract with the FHWA. The research team obtained HSIS data for all the freeway crashes in Illinois from 2005 through 2007.

A summary of the three crash databases is shown in Table 3.1. HSIS included freeway crashes only. The IDOT text file contained six years of crash data, as well data on the largest number of crashes per year.

Table 3.1. A Comparison of Three Crash Databases

Data Source	Year	HSIS	IDOT	IDOT
Format		Microsoft Excel	GIS database	Text
Time Period		2005–2007	2005–2009	2004–2009
Number of Files Included		3	1	3
Variables Included (Number)		Accident (17)	Crash (51)	Crash (70)
		Vehicle (17)		Person (32)
		Injured occupant (6)		Vehicle (37)
		Road log (38)		
Number of Crashes	2004	—	—	433,259
	2005	24,375	412,452	421,757
	2006	26,715	402,064	408,858
	2007	33,313	415,725	423,090
	2008	—	401,598	408,487
	2009	—	287,720	292,426
	Total	84,403	1,919,559	2,387,877

3.2 WRONG-WAY CRASH IDENTIFICATION

A two-step approach was used to identify the wrong-way crashes on freeways. The first step was to separate the possible wrong-way crashes from the total crashes, based on the relevant variables in the crash database. The second step was to review hard copies of crash reports of the possible wrong-way accidents to identify those that were actual wrong-way crashes. Two criteria, freeways and wrong-way movement, were used to identify possible wrong-way crashes on freeways. Different variables can be used to define wrong-way movements in the different crash databases; therefore, different methodologies were used to select the possible wrong-way crashes on freeways in Illinois for each database.

3.2.1 IDOT Crash Database (Text File)

The variable “class of trafficway” in the crash file was used to identify crashes on freeways. Four variables were used to identify the possible wrong-way crashes, including the “primary cause (cause 1)” and “secondary cause (cause 2)” in the crash file, the “vehicle maneuver prior” in the vehicle file, and the “driver action” in the person file. In the crash database, a numerical code was used to define each variable.

- Class of trafficway 1 = controlled rural, or class of trafficway 5 = controlled urban freeways
- Code 5 = driving on wrong side/wrong way for cause 1 or cause 2
- Code 12 = driving the wrong way for the vehicle maneuver prior
- Code 6 = driving on wrong side/way for the driver action

These five variables were used to identify the possible wrong-way crashes on freeways. Freeway crashes were separated as the first step when selecting the “class of trafficway” to be 1 (controlled rural) or 5 (controlled urban).

To identify all possible wrong-way crashes on freeways, any crashes that listed driving on the wrong side or wrong way as a primary or secondary cause, vehicle movement prior to crash, or driver action were selected for further analysis. Crash records from the crash, vehicle, and person files were then combined and assigned the same crash ID number.

Figure 3.1 illustrates the process followed for identifying possible wrong-way crashes from the IDOT text file database. Altogether, 632 possible wrong-way crashes on freeways were identified from a total of 2,387,877 crashes from 2004 through 2009 in Illinois. A total of 217 actual wrong-way crashes were confirmed by reviewing hard copies of the crash reports.

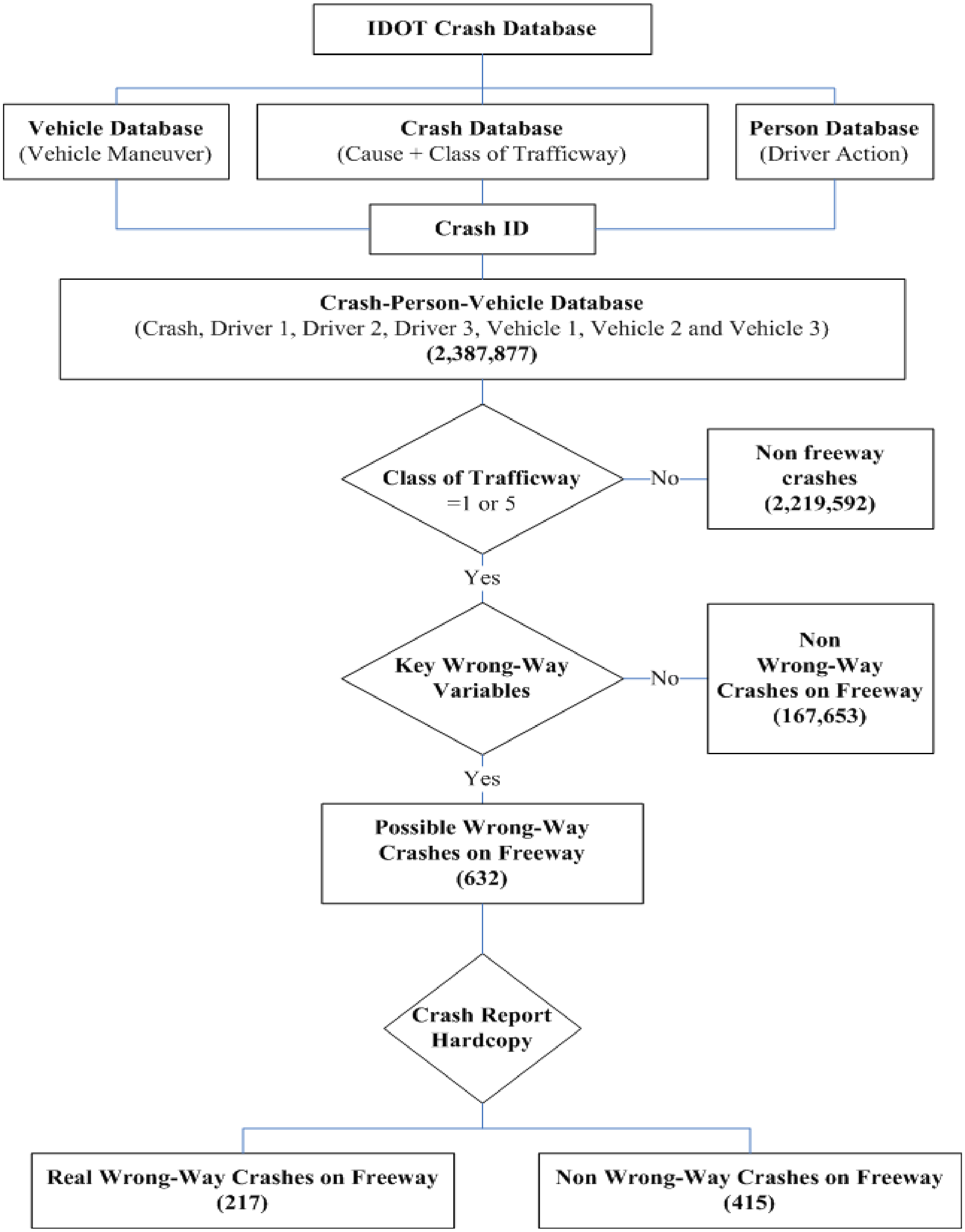


Figure 3.1. A flowchart for wrong-way crash identification.

3.2.2 IDOT Crash Database (GIS File)

The IDOT GIS crash database was developed from the IDOT crash database (text file) used for the federally required annual 5% report. This report describes the 5% of freeway locations that demonstrate the largest highway safety needs (FHWA 2006). The IDOT crash database (GIS file) contained only limited variables because of its intended purpose in the 5% project. To identify freeway crashes in the GIS database, crashes with a route number beginning with 2 (interstate business loop), 7 (interstate business loop one-way couples) or 9 (interstate) were defined as freeway crashes. Two variables, "vehicle 1 maneuver" and "vehicle 2 maneuver," contained information relevant to wrong-way driving behaviors. Crashes with either "vehicle 1 maneuver" or "vehicle 2 maneuver" listed as "driving wrong way" were identified as possible wrong-way crashes. Altogether, 228 possible wrong-way crashes on freeways were identified from a total of 1,919,559 crashes that occurred from 2005 through 2009.

3.2.3 HSIS Crash Database

The HSIS crash database contains the common variables from all participating states, which is less than the information in the IDOT original crash database. The variable "roadway classification" was used to identify crashes on freeways. Crashes with a roadway classification of 01 (urban freeway) or 06 (rural freeway) were first selected from the total crash database. The HSIS crash database also included four variables that can be used to identify wrong-way crashes: "cause 1," "cause 2," "vehicle maneuver," and "driver action." To collect all the possible wrong-way crashes, any freeway crashes that had either "cause 1" or "cause 2" as 05 (driving on wrong side/wrong way), "vehicle maneuver" as 12 (driving wrong way), or "driver action" as 06 (wrong way or side) were selected for further analysis.

3.2.4 Possible Wrong-Way Crashes

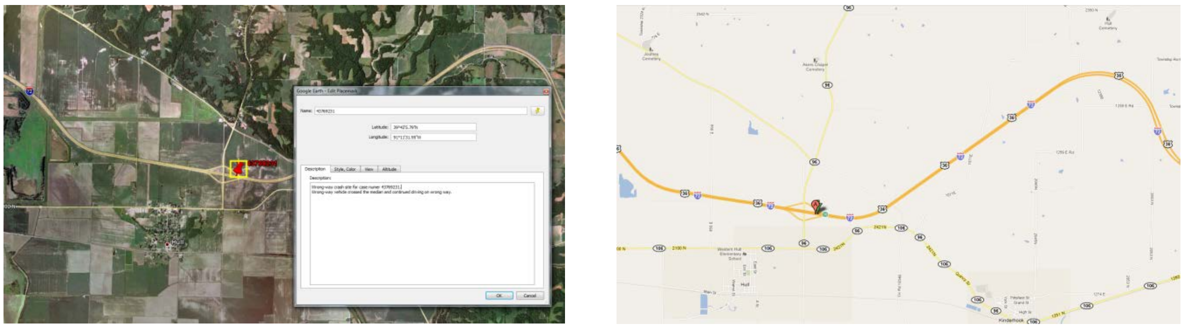
Possible wrong-way crashes were independently identified from three crash databases. As shown in Table 3.2, the number of possible wrong-way crashes varies among the three crash databases. The IDOT crash database (text file) provided the largest number of possible wrong-way crashes for the longest time period.

Table 3.2. Possible Wrong-Way Crashes

	Crash Database		
Year	**HSIS**	**IDOT (text file)**	**IDOT (GIS file)**
2004	—	125	—
2005	115	137	64
2006	109	103	51
2007	115	106	52
2008	—	88	34
2009	—	73	27
Total	**339**	**632**	**228**

3.2.5 Wrong-Way Crash Identification

To verify actual wrong-way crashes on freeways, hard copies of crash reports for the 632 possible wrong-way crashes were requested from IDOT, with assistance from the Illinois State Police (ISP). The first step was to verify whether the crashes occurred on freeways. The longitude and latitude information from the crash records was used to locate the crash location; map and satellite images were derived from Google Earth and Google Maps (Figure 3.2).



(Data Source: Google Earth) (Data Source: Google Maps)

Figure 3.2 Satellite image and map for wrong-way crash location.

Street view and aerial photography were used as supplementary tools to verify the crash location (Figure 3.3). The route number, road description, and roadway functional class for the crashes were also used to determine whether the crashes occurred on freeways. The freeway consists of interstate highway and other non-interstate expressway, including roadway segments and exit/entrance ramps. It was determined that 63 of the 632 possible freeway wrong-way crashes did not occur on freeways.

Street view of wrong-way crash site (Data Source: Google Maps)

Aerial photography of wrong-way crash site (Data Source: Bing Maps)

Figure 3.3. Additional data collection for crash site information.

The second step was to review crash reports for all the possible freeway wrong-way crashes. The crash narrative description, crash diagram, original crash code, and even the crash reconstruction report were used to verify whether the possible wrong-way crashes were the result of any wrong-way driving behaviors. The actual wrong-way crashes were verified by key phrases, such as “traveling EB on the WB lanes,” “was traveling NB (the wrong direction),” “drove the wrong way on I-94, going SB in NB lanes,” etc. from the crash narrative description. Altogether, 217 crashes were identified as actual wrong-way crashes. Table 3.3 lists total crashes, freeway crashes, possible wrong-way crashes, and actual wrong-way crashes from 2004 through 2009 in Illinois.

Table 3.3. Number of Crashes Under Different Categories

Category	Year						
	2004	**2005**	**2006**	**2007**	**2008**	**2009**	**Total**
Total crashes	433,259	421,757	408,858	423,090	408,487	292,426	2,387,877
Freeway crashes	31,908	30,156	24,772	29,200	30,289	21,960	168,285
Possible W-W crashes	125	137	103	106	88	73	632
Actual W-W crashes	40	32	31	39	37	38	217

The researchers classified these wrong-way crashes into the following four scenarios:

- Type I: Vehicle 1 collided with other vehicles driving in the right direction.
- Type II: Vehicle 1 hit a roadway structure or other fixed object. No other vehicles were involved in the crash.
- Type III: To avoid a head-on crash with vehicle 1, other vehicle(s) hit a roadway structure or other fixed object or collided with another vehicle traveling in the right direction. Vehicle 1 was not involved in the crash.
- Type IV: Vehicle 1 was involved in a crash while driving in the right direction. To flee the crash site, vehicle 1 drove the wrong way and crashed into other vehicle(s).

The number of different wrong-way crashes for each year is listed in Table 3.4. Researchers found four types of crashes that were incorrectly identified as wrong-way crashes:

- A total of 72 crashes were coded incorrectly from the crash report into the crash database.
- There were 186 crashes that occurred between vehicles that traveled in the same direction, including crashes caused by a lane-changing maneuver, driving off the road, backing up, etc.
- In another 82 crashes, the researchers found that the at-fault vehicle crossed the median and collided with other vehicles immediately after the median crossing.
- The researchers found 12 crashes with no narrative descriptions and thus no conclusive evidence of wrong-way driving behaviors. This information would be useful to those updating and maintaining state and national crash databases who are interested in continuous improvement of data entry and crash description.

Table 3.4. Distribution of Wrong-Way Crash Types

Category	2004	2005	2006	2007	2008	2009	Total
Type I	25	18	27	29	29	33	161
Type II	8	8	3	4	5	3	31
Type III	6	4	1	4	3	2	20
Type IV	1	0	0	1	0	0	2
Others	0	2	0	1	0	0	3
Total	**40**	**32**	**31**	**39**	**37**	**38**	**217**

3.3 ADDITIONAL INFORMATION FROM CRASH REPORTS

Additional data related to the wrong-way crashes were also collected from the crash reports. Specifically, information about the vehicles, drivers, possible entry points, vehicle location, number of freeway lanes, police involvement, and driver physical condition could all be useful for identifying factors that contribute to wrong-way driving and describing the wrong-way driving behaviors.

The crash database included all the vehicles and drivers involved in wrong-way crashes in a format of unit numbers and driver numbers. In most cases, unit 1 was the wrong-way vehicle and driver 1 was the wrong-way driver; however, it was also found that unit 2 was the wrong-way vehicle in some cases.

One important task is to identify the wrong-way entry point. The wrong-way entry point was defined as the starting point of the wrong-way driving maneuver. Based on review of the crash reports, it was determined that wrong-way driving maneuvers usually start at a freeway interchange area, a freeway segment (wrong-way driver made a U-turn on a freeway and then drove in the wrong way), or a freeway median (wrong-way driver crossed the median and drove in the wrong way). For some of the wrong-way crashes, the wrong-way entry points were already documented in the narrative description of the crash reports; however, for most of the wrong-way crashes, no information about the wrong-way entry points was available.

The exact location of the wrong-way vehicle was collected from the crash report hard copies, either from the narrative description or from the diagram. When no information was available, the researchers used Google Earth and/or Google Maps to identify the likely wrong-way entry points as the first two closest possible wrong-way entry points, such as the nearest freeway exits. Next, each crash report was reviewed to identify whether an Illinois State Police Emergency Radio Network (ISPERN) broadcast was made about the wrong-way driving event before the crash and whether a police vehicle was involved in the wrong-way crash, especially if the squad car was involved in stopping the wrong-way vehicle.

Finally, information about the physical condition of the wrong-way driver was collected from the narrative description of the crash report hard copies, when provided.

3.4 SURVEY AND INTERVIEWS

To capture institutional knowledge on the history of wrong-way driving countermeasures throughout Illinois, researchers developed and presented online surveys to IDOT and ISP personnel. The following sections detail the findings of those surveys.

3.4.1 Survey to Selected IDOT Employees

The survey was sent to selected employees of IDOT who were familiar with signing and striping practices on freeways and at interchanges. Responses were received from 20 participants from eight of the nine different districts. The responses from this IDOT survey were presented by signage type, predicted causes, and suggested countermeasures. Participants noted that **DO NOT ENTER** signs were just as common as **WRONG WAY** signs on Illinois freeway exit ramps, but both were significantly more common than **ONE WAY** signs. Almost all survey participants (91%) noted that if multiple signs were used, they were not on the same pole. The districts (9%) that did mount signs on the same pole (at some time) did not have a standard for which sign was on top. All agencies noted that there was a policy for the order and placement of signage along freeway ramps.

An investigation of sign sizes indicated that a common size of **DO NOT ENTER** (R5-1) signs was 30 × 30 inches (54%) and that a common choice for **WRONG WAY** signs (R5-1a) was 36 × 24 inches (83%). Similarly, the results indicated a clear trend in mounting height of at least 5 feet for **DO NOT ENTER**, **WRONG WAY**, and **ONE WAY** signs; these results were supported by interview findings. Survey participants indicated that most districts either do not or have not used supplemental signage or pavement markings to prevent wrong-way driving.

The next section of the IDOT survey asked the participant's professional opinion about the causes of wrong-way driving events. The findings, as displayed in Figure 3.4, indicate a lack of consensus on the true causes of wrong-way driving and justify the research effort described herein.

The final part of the survey to IDOT employees found that only 18% of districts were aware of any countermeasures used and that any countermeasures that existed had been since discontinued. These countermeasures included additional lighting (67%) and gates/spikes (33%).

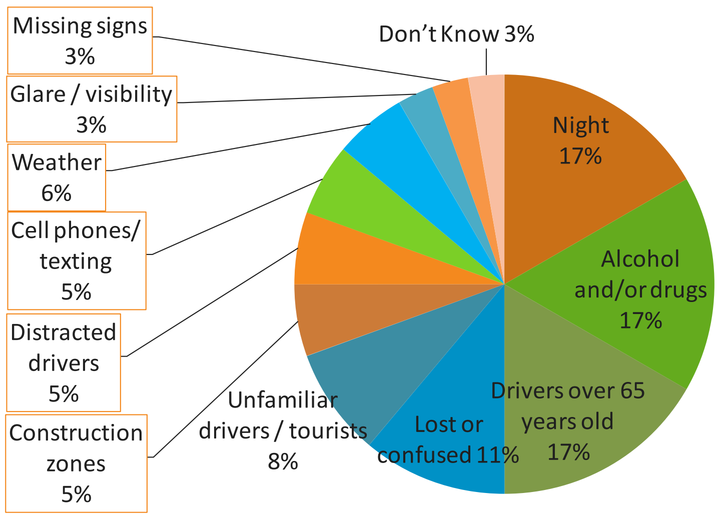


Figure 3.4. Survey responses for wrong-way driving causes.

3.4.2 Survey to ISP Officers

The survey distributed within the ISP solicited 249 responses from 12 districts. The first few questions asked the officer's estimate of the number of reported wrong-way driving reports and arrests his/her district had during the previous year. Table 3.5 displays these findings.

Table 3.5 Estimated Annual Wrong-Way Driving Reports and Arrests

ISP District	Reports	Arrests/Tickets
11	45	11
District Chicago	37	8
10	17	2
14	11	3
9	11	3
18	8	1
6	7	2
20	7	1
12	3	1
22	3	0
2	1	0
21	0	0
Districts Not Responding: 1, 5, 6, 7, 13, 15, 16, 17, 19		

Officers were also asked which countermeasures they perceived to be most effective at preventing wrong-way driving events. The feedback indicated that markings, signs, reflectors, and lighting were preferred options. Other common choices include enforcement of DUI laws and improved entry and exit ramp designs.

Officers were also asked which freeways and segments had the highest occurrence of wrong-way driving in their districts. The researchers received a significant amount of information that correlated with data found from the crash reports. Finally, the survey asked what the most significant factor in apprehending wrong-way drivers was. The most common responses were availability of a law enforcement officer at time of the call (77 responses), response officer location (50 responses), and wrong-way drivers quickly turning around (48 responses).

3.4.3 Findings from Stakeholder Interviews

The key findings of discussions with Jason Salley and Julia Fox, engineers at IDOT District 1, included identification of three common wrong-way entry locations in the Chicago area and the fact that winter maintenance conflicts with some wrong-way driving countermeasures such as low-mounted signs (snow drifts may cover them) and spike/raised pavement markings (snow plows could damage/remove them). The engineers noted that a ranking of interchange design types that were least likely to cause wrong-way driving would be helpful.

During the interview with IDOT District 8 personnel, including Wendy Southerland, Jim Wessel, John "Bo" Wedmore, and Jeff Abel, researchers found similar issues with low-mounted signs and other countermeasures. For example, engineers in this district were cautious about the maintenance/ liability issues associated with many countermeasures such as power needs, mowing clearance, and MUTCD adherence.

The research team also interviewed personnel at other agencies to collect best practices from throughout the United States regarding wrong-way driving prevention. When the research team interviewed officials with the NTTA in Dallas, they learned that the agency found no correlation between wrong-way driving events and ramp geometries. The North Texas Tollway has used a variety of countermeasures to prevent wrong-way driving, including through-arrows on arterials, LED-illuminated signs, raised pavement markings, signpost tape, and a detection system for wrong-way drivers.

At a meeting with the Harris County Toll Road Authority in Houston, researchers found that the agency uses radar and in-pavement sensors for detecting wrong-way drivers and were just beginning to deploy a video detection system.

The last interview was conducted with personnel at Caltrans District 7, Los Angeles. The agency has been using low-mounted signs for many years and has created and operated a program that tracks the prevalence of wrong-way driving events.

CHAPTER 4 DATA ANALYSIS

The purpose of the data analysis was to investigate the characteristics of wrong-way driving behaviors. The results were used to identify factors contributing to wrong-way crashes and effective countermeasures. The wrong-way crash database that was analyzed consisted of three sub-databases: crash, vehicle, and person. Information for the same crash can be linked together from the three different crash sub-databases, based on crash ID. In this study, wrong-way crash data were separately analyzed from these three different perspectives.

4.1 CRASH

In the crash sub-database, each crash record consisted of 70 possible variables in either text or numerical format. A list of the variable names and types is shown in Table A.1. From this database, the researchers determined the temporal distribution, roadway characteristics, geographic distribution, and other crash characteristics.

4.1.1 Temporal Distribution

The temporal distributions of wrong-way crashes included crash year, month, day, and hour. The weather and light conditions were considered part of the temporal distribution since both are highly correlated with the crash time (month and time of day). The annual wrong-way crash frequency from 2004 through 2009 varied between 31 and 40, with an average frequency of 36. The monthly distribution variation, from 9 to 25, was greater than the annual distribution.

The crash database also indicated that a large proportion of wrong-way crashes occurred on weekends between 12 midnight and 5 a.m. Approximately 80% of wrong-way crashes occurred when the road surface was dry, under clear weather conditions, and during nighttime hours. It should be noted that the lighting condition is highly correlated with the hourly distribution. More wrong-way crashes occurred on lighted roads when it was dark. Figures B.1 through B.7 illustrate the temporal distribution of wrong-way crashes.

4.1.2 Roadway Characteristics

The crash database was then examined to determine the roadway characteristics of wrong-way crashes, specifically the route number, route type, traffic control device, road surface condition, road defects, intersection, and work zone. Wrong-way crashes occurred on 30 different routes. Approximately 60% of them happened on five routes: I-55 (19.4%), I-94 (14.7%), I-57 (9.7%), I-74 (7.8%), and I-64 (7.4%). Table C.1 lists the number of wrong-way crashes on all of these routes.

Approximately 80% of wrong-way crashes were located in urban areas. Ninety-five percent of wrong-way crashes occurred on roadways where no traffic control device malfunctions were reported. Furthermore, construction/maintenance zone was noted in approximately 7% of wrong-way crashes. Less than 3% of wrong-way crashes were related to a work zone, and 5% of wrong-way crashes were reported to be related to a specific intersection. The limited information on possible road design/traffic control problems was included in the crash reports. Figures B.8 through B.14 provide information on roadway-related characteristics for wrong-way crashes.

4.1.3 Geographical Distribution

Next, the geographical distribution characteristics of wrong-way crashes were extracted from the crash database, including county, city, and township. Although wrong-way crashes were reported in 43 of 102 counties in Illinois, about 64% of wrong-way crashes were located in the following four counties: Cook County (37.8%), St. Clair County (9.7%), Madison County

(9.2%), and Will County (6.5%). It should be noted that Cook County and Will County are in the Chicago metropolitan area, while St. Clair County and Madison County are in the St. Louis metropolitan area. In 35 other counties, the reported wrong-way crashes averaged less than four per county over the six-year period. Approximately 25.8% of wrong-way crashes were reported in the city of Chicago. Tables C.2 through C.4 list wrong-way crash distribution for the different counties and cities in Illinois.

4.1.4 Crash Characteristics

The researchers reviewed crash characteristics, including the number of vehicles involved, collision type, crash severity, cause 1, cause 2, and hit-and-run (Figures B.15 through B.17). Approximately 67% of wrong-way crashes were found to involve multiple vehicles and resulted in head-on (45%) or sideswipe opposite direction crashes (22%). The collision types for single-vehicle wrong-way crashes (14%) were mainly fixed objects. Together, the crash characteristics of multi- and single-vehicle crashes suggested that wrong-way crashes are more severe than other crash types. Most wrong-way crashes involved two or three vehicles that were the at-fault wrong-way vehicles, which collided with other vehicle(s) traveling in the correct direction(s). Findings indicated that the crash severity levels were directly related to collision types. Ninety-seven percent of fatal crashes were head-on crashes or opposite direction sideswipe crashes. The collision types for A-injury crashes were also mainly head-on (71%), opposite direction sideswipe (11%) and fixed object (9%). Almost 60% of head-on crashes caused fatalities or incapacitating crashes, while only 17% of opposite direction sideswipe crashes resulted in one or more fatalities and/or A-injuries. A significant proportion of wrong-way vehicles fled the crash sites after wrong-way crashes (17.5%).

The collision types were also related to the number of vehicles involved in wrong-way crashes. For example, rear-end crashes caused by wrong-way drivers were usually between two or more vehicles traveling in the correct directions that collided while avoiding wrong-way vehicles. Most of the rear-end crashes were not severe. Also, collisions for single-vehicle wrong-way crashes were mainly fixed object. The collisions involving multiple-vehicles were frequently either head-on crashes or opposite direction sideswipe crashes. There were no fatal crashes for single-vehicle wrong-way crashes; however, many single-vehicle wrong-way crashes resulted in A- or B-injuries. The crash severity usually increased when more vehicles were involved. More than 50% of wrong-way crashes involving four or more vehicles caused at least one fatality or A-injury (Tables C.5 through C.8). The primary causes frequently listed in the crash database were driving on the wrong side or the wrong way or being under the influence of alcohol and/or drugs (80% in total). The secondary causes for wrong-way crashes were diversified (Table C.9).

4.2 VEHICLE

The number of vehicles involved in wrong-way crashes ranged from one to six (Table C.10). The first step was to separate wrong-way vehicles based on the narrative description of the crash report. Information was available on 203 out of the 217 total wrong-way crashes (the remaining 14 wrong-way vehicles fled the scene). Of the 203 known vehicles involved in wrong-way crashes, 200 were recorded as “vehicle 1” and three were recorded as “vehicle 2” in this database. The following subsections describe what the researchers found from the 37 variables in this database (Table A.2).

4.2.1 Vehicle Characteristics

Vehicle characteristics, including vehicle type, use, defects, commercial vehicle indicator, and number of occupants, were analyzed. Results indicated that no wrong-way vehicles were commercial vehicles. Nearly 70% of wrong-way vehicles were passenger cars, and less than 2% of wrong-way crashes involved tractors. Approximately 90% of wrong-way vehicles were used for personal purposes, and about 85.2% of wrong-way vehicles had a single occupant. No vehicle defects were reported for more than 98% of wrong-way crashes (Tables C.11 through C.14).

4.2.2 Vehicle Operation

More than 80% of wrong-way vehicles contacted other vehicles and/or fixed objects with the front or the left and right front quarter panels, resulting in head-on collisions. Although information on the event, including location, was not recorded in the database for more than half of wrong-way cases, the researchers reviewed the common events and locations for those available. The majority of known events for wrong-way crashes were either “motor vehicle in traffic” or “ran off roadway.” The most frequently reported locations for the crash events were on roadway pavement (Tables C.15 through C.20).

4.2.3 Collision Results

The vehicle database included information about the collision result. Researchers found that more than 80% of wrong-way vehicles that crashed were towed away, and approximately 5% of wrong-way vehicles caught fire after a crash. The findings also indicated that no wrong-way vehicles spilled hazardous material during or after a crash (Tables B.18 and B.19).

4.3 PERSON

To analyze the characteristics of wrong-way drivers, the person database for the 203 crash records was used. There were 32 variables in the person file (Table A.3). Eleven of them were duplicates in different formats (code or text). In all, 660 persons were involved in the 217 wrong-way crashes, among which 6.7% were killed, 38% were injured, and 56% incurred no injuries. For those injured, 43% and 46% were incapacitating injuries (A-injury) and non-incapacitating injuries (B-injury), respectively. Only about 10% of injuries were classified as possible injuries (C-injury). Compared with other crash types, wrong-way crashes were more severe in that large proportions resulted in severe injuries and/or fatalities.

4.3.1 Driver Demographic Information

Driver demographic information refers to date of birth, age, sex, and state of residence (as indicated on a driver’s license). The drivers were classified into different age groups based on the NHTSA criteria, which classify drivers under age 25 as young drivers and those 65 years and above as older drivers. The study results showed that younger drivers and older drivers were proportionally over-represented in all crash types. With respect to the sex of wrong-way drivers, the database revealed that males represented nearly 67%, particularly those in the age groups of 21–24, 25–34, and greater than 65. Female wrong-way drivers were most prevalent in the 35–44 age groups. Demographic information indicated that most (77%) wrong-way drivers were licensed in the State of Illinois. The state with the next largest frequency (6%) was Missouri. Sixteen percent of wrong-way crashes included no residence information for the drivers (Figures B.19 through B.22).

4.3.2 Driver Physical Condition

The driver’s physical condition, including the apparent observed condition of the driver, driver’s blood alcohol concentration (BAC) test result, and driver vision, were analyzed to investigate the possible impact of DUI on wrong-way crashes. The illegal BAC limits in Illinois are 0% for school bus drivers and drivers under the age of 21, 0.04% for commercial driver’s license holders, and 0.08% for drivers age 21 and over. A large proportion of wrong-way drivers were found to be DUI: 50% by alcohol and nearly 5% by other drugs. However, the actual percentage is higher because 50% of drivers refused or were tested with no results. Eighty percent of the drivers completing a BAC test had a level greater than 0.1%. Most of the DUI drivers were in the age range of 21–54, and almost no senior wrong-way drivers were driving under the influence. Driver vision was not reported as a possible reason for wrong-way crashes: nearly 99% of reports note that drivers' vision was not obscured or the information was unknown. Only about 17% of wrong-way drivers were in normal physical condition (Tables C.21 through C.24).

4.3.3 Driver Injury Severity

An analysis was conducted to identify the factors related to wrong-way driver injury severity. Seat belt use, air bag deployment, driver age, sex, condition, and ejection or extrication were analyzed. More than 70% of wrong-way drivers were using their seat belts when wrong-way crashes occurred. Less than 7% of wrong-way drivers who used a seat belt were killed in wrong-way crashes; however, the wrong-way driver fatality rate was raised to more than 30% when seat belts were not used. Even though wrong-way crashes were more severe than most other crash types, more than 50% of wrong-way drivers who used a seat belt were not injured in the crashes. Air bag deployment for wrong-way vehicle was investigated as well. However, for more than 50% of wrong-way vehicles, the air bag deployment was unknown. Less than 10% of wrong-way vehicles' air bags were deployed from either the front, side, or combined. Additionally, the person database revealed that nearly 10% of wrong-way drivers were ejected or trapped/extricated as a result of the collision (Tables C.25 and C.26).

The relationship between driver severity level and driver condition was apparent. Approximately 80% of wrong-way drivers killed in the crashes were impaired by alcohol or drugs. The DUI percentage was also relatively high among A-injured wrong-way drivers. The BAC for 65% of wrong-way drivers killed in the crashes was higher than 0.1%, and 25% of them were completely ejected or trapped/extricated in the crashes. On the contrary, less than 10% of wrong-way drivers under normal physical conditions were killed in wrong-way crashes (Tables C.27–C.32).

The comparison between age, sex, and injury severity showed several trends. First, wrong-way drivers who were killed or incapacitated in wrong-way crashes were mainly in the age group 21–45. Next, although the total number of fatalities and A-injuries contributed by older drivers was not as high as those of the 21–45 age group, the percentage of older wrong-way drivers who ended up as fatalities was much higher than the other age groups. The majority of wrong-way driver fatalities were caused by male drivers.

4.4 CRASH SEVERITY LEVEL ANALYSIS

To further explore the relationship between the level of crash severity and the possible contributing factors, researchers collected and analyzed information including crash severity level from the crash sub-database, wrong-way driver information from the person sub-database, and wrong-way vehicle information from the vehicle sub-database. The crash severity level is different than the driver injury level in that it was defined based on the most severe injury level for all the persons involved in the crash, including the wrong-way driver, the right-way driver(s), and any passengers, pedestrians, and others involved. The distribution of crash severity level was compared to the following possibly relevant factors: (1) driver age group, (2) driver condition, (3) lighting condition, (4) roadway alignment, (5) trafficway description, (6) first vehicle contact point, (7) driver sex, (8) weather, (9) roadway functional class, and (10) vehicle defects. For different factors, the percentages of total fatal or A-injury crashes were calculated, and the relevant factors that had a higher percentage of fatal or A-injury crashes were considered as factors that contributed to the severe wrong-way crashes.

Driver age was found to be related to wrong-way crash severity level. Wrong-way crashes for the driver age groups of 45–54 and 65–69 were more likely to result in fatal crashes than other driver age groups. The percentage of A-injury crashes in total wrong-way crashes for driver age groups of 16–20 and 21–24 was much higher than that of drivers in other age groups.

Driver condition was also a significant factor for crash severity level. Crashes for wrong-way drivers under the influence of alcohol or drugs were more likely to result in a fatality compared to drivers under normal physical conditions. Special attention should be paid to the effect of driver BAC test results on wrong-way crash severity levels. Results indicated that the ratio of fatal crashes to total wrong-way crashes increased from 33% to 100% when the BAC increased from 0.1% to 0.4%. (It should be noted that the driver BAC test result was between 0.3% and 0.4% for only one wrong-way driver.)

The researchers analyzed injury severity with respect to the lighting conditions, finding that nearly 20% of wrong-way crashes were fatal in darkness without lighting compared to 13% in darkness with lighting. During daytime, 10% of wrong-way crashes were found to be fatal (Tables C.33 through C.36).

Roadway alignment had an impact on the wrong-way crash severity level in that the fatal crash rate on straight and level roadway segments was much lower than that for other roadway alignment conditions. It was likely because the right-way drivers have more perception/reaction time on straight and level roads.

The researchers compared crash severity with the type of highway. The databases revealed that the percentages of fatal crashes were 14.7 and 19.0 for divided highways with and without a median barrier, respectively (Tables C.38 through C.40).

Analysis suggested that weather conditions, road functional class, and vehicle defects had no significant role in fatal or A-injury wrong-way driving crashes. Although the sample sizes were relatively small, the weather condition did not seem to play a role in wrong-way crash severity because ratios for total crashes to fatal crashes in snow and rain were much lower than those for clear weather conditions (Table C.37). The effect of roadway functional class, vehicle maneuver, and the most harmful event on wrong-way crash severity level was not apparent, especially for fatal and incapacitating crashes. Finally, the effects of vehicle defects on wrong-way crash severity level were likely minimal because vehicle defects were recorded for very few wrong-way vehicles. This same situation also applied to the factors of fire indicator, hazardous material spill, driver vision, and driver action (Tables C.41 through C.43).

The ratios of fatal crashes to total crashes and A-injury crashes to total crashes were the highest when the first contact points were the front of the vehicle. The left front quarter panel was the other first contact point that resulted in a high percentage of fatal and incapacitating wrong-way crashes. Compared with passenger cars and all vehicle types in total, wrong-way crashes were more likely to be fatal when wrong-way vehicles were pickup trucks, and wrong-way crashes were more likely to be A-injury crashes when wrong-way vehicles were SUVs or mini-vans (Tables C.44 throughC.51).

4.5 ADDITIONAL DATA ANALYSIS

As discussed in the data collection section, in addition to the crash data collected from the IDOT crash database (text file), additional information on the characteristics of wrong-way crash location and other relevant factors was collected from the narrative description of wrong-way crash reports and publicly available online aerial photographs. All the information included in this study was not available from a conventional crash database, and the additional data were helpful in developing the countermeasures for wrong-way driving on freeways.

4.5.1 Response to Wrong-Way Driving

Another consideration in wrong-way crashes is the safety of police responders before and during wrong-way crashes. ISPERN broadcasted approximately 6% of wrong-way crashes before their occurrence (Table C.52). Altogether, police squad cars were involved in seven wrong-way crashes, five in which the squad cars were trying to stop wrong-way vehicles. In the other two cases, wrong-way vehicles were traveling in the right direction and either crossed the median or made U-turns to escape police pursuit, thereby driving in the wrong direction. In the five instances when officers tried to stop wrong-way vehicles, one officer incurred an A-injury and another a C-injury; none were killed.

4.5.2 Wrong-Way Crash Lane

Wrong-way crash locations were available from the narrative description of the crash report hard copies for 56% of all wrong-way crashes. For those with known crash locations, the percentage of wrong-way crashes that happened in the passing lane, driving lane, middle lane, shoulder, and ramp were 51%, 20%, 16%, 8%, and 7%, respectively. The available information suggests that to reduce the likelihood of involvement in wrong-way crashes, right-way drivers should not drive in the passing lane (Table C.53).

4.5.3 Direct Economic Loss Due to Wrong-Way Crashes

To estimate the economic loss due to wrong-way crashes, the unit cost of each fatality and injury was collected from the 2011 Illinois Strategic Highway Safety Plan (ISHSP), as shown in Table 4.1.

Table 4.1. Cost per Fatality/Injury

Severity	Cost per Fatality/Injury ($)
Killed	1,300,000
A-Injury	67,000
B-Injury	22,000
C-Injury	12,000
PDO	8,000

The number of fatalities and injuries of wrong-way crashes is shown in Table 4.2. The number of each type varies greatly by year because of the rarity of these events.

Table 4.2. Number of Wrong-Way Fatalities, Injuries, and PDO

Severity	2004	2005	2006	2007	2008	2009	Sum
Killed	12	3	8	10	4	7	44
A-Injury	27	9	18	14	21	17	106
B-Injury	14	14	15	24	25	23	115
C-Injury	6	6	5	6	3	1	27
PDO	14	11	12	13	16	20	86

By multiplying the numbers in Tables 4.1 and 4.2, the aggregate costs are obtained, as listed in Table 4.3. Summation by severity as well as by year is also presented. From 2004 through 2009, annual economic costs of wrong-way crashes ranged from $4.97 million to $17.9 million. The median, $11.5 million (rather than the mean, $11.3 million, which is less representative than the median due to the large range of data), is a proper approximation of annual economic cost. When considering the costs by severity, it is obvious that fatal crashes account for 84.3% of total costs of wrong-way crashes. Reducing fatal wrong-way crashes should lead to a substantial decrease in economic loss.

Table 4.3. Aggregate Costs of Wrong-Way Crashes

Type	2004	2005	2006	2007	2008	2009	Sum by Severity	% of Total
Killed	15.6 M	3.9 M	10.4 M	13.0 M	5.2 M	9.1 M	57.2 M	84.3%
A-Injury	1.8 M	0.6 M	1.2 M	0. 94 M	1.41 M	1.14 M	7.1 M	10.5%
B-Injury	0.31 M	0.31 M	0.33 M	0.53 M	0.55 M	0.51 M	2.53 M	3.7%
C-Injury	72 K	72 K	60 K	72 K	36 K	12 K	324 K	0.5%
PDO	112 K	88 K	96 K	104 K	128 K	160 K	688 K	1.0%
Sum by Year	**17.9 M**	**4.97 M**	**12.1 M**	**14.6 M**	**7.3 M**	**10.9 M**	**67.8 M**	**100%**

4.5.4 Wrong-Way Entry Points

Identifying wrong-way entry points can help develop proper countermeasures to combat wrong-way driving at a specific interchange area. However, information on wrong-way entry points was usually unavailable from the crash database. To obtain wrong-way entry points information, the narrative description of the crash report hard copies were reviewed case by case and the crash locations were examined using aerial photographs. Some vehicles began driving the wrong way after they crossed the median, made a U-turn on the freeway, or tried to leave the freeway from an entrance ramp. No entry points existed for these wrong-way crashes. For nearly 20% of wrong-way crashes, wrong-way entry points were recorded in the crash report hard copies. For crashes without recorded entry points, the first and second possible wrong-way entry points were estimated.

As shown in Table 4.4, the total number of recorded entry points was 47, and the numbers of first and second possible entry points were 147 and 146, respectively. There were 14 confirmed wrong-way crashes starting with a U-turn on freeways. Compressed diamond (26%, 30%, 30%, 29%) and diamond interchanges (34%, 27%, 26%, 27%) were the top two interchange types for the recorded first, second, and total wrong-way entry points.

Table 4.4. Interchange Type for Wrong-Way Crash Entry Point

Interchange Type	Recorded		1st Entry Point		2nd Entry Point		Total	
	#	(%)	#	(%)	#	(%)	#	(%)
Cloverleaf	3	6.4%	12	8.2%	12	8.2%	27	7.9%
Compressed Diamond	12	25.5%	44	29.9%	44	30.1%	100	29.4%
Diamond	16	34.0%	39	26.5%	38	26.0%	93	27.4%
Directional	1	2.1%	1	0.7%	2	1.4%	4	1.2%
Freeway Feeder	5	10.6%	3	2.0%	6	4.1%	14	4.1%
Modified Diamond	3	6.4%	4	2.7%	4	2.7%	11	3.2%
Partial Cloverleaf	5	10.6%	28	19.0%	23	15.8%	56	16.5%
Rest Area	1	2.1%	9	6.1%	6	4.1%	16	4.7%
Semi-Directional		0.0%	3	2.0%	4	2.7%	7	2.1%
SPUI	1	2.1%	2	1.4%	3	2.1%	6	1.8%
Trumpet		0.0%	2	1.4%	4	2.7%	6	1.8%
Total	**47**	**100%**	**147**	**100%**	**146**	**100%**	**340**	**100%**

A comparison of driving distance between recorded and predicted entry points was conducted to see whether the possible entry points have characteristics similar to those recorded in crash reports. The accumulative wrong-way driving distance distribution for recorded first and second entry points was plotted (Figure 4.1). Results indicated that wrong-way driving distance for recorded and estimated first entry points was very close. Wrong-way driving distance for estimated second entry points was much longer. For example, more than 75% of recorded and estimated first wrong-way entry points had fewer than 3 miles of wrong-way driving distance; however, only 50% of estimated second wrong-way entry points had a wrong-way driving distance less than 3 miles. The average driving distance for recorded wrong-way crashes is about 1.2 miles, and 2.5 miles for estimated first and second entry points (Table 4.5). The maximum wrong-way driving distances for recorded, estimated first and second wrong-way entry points were 6.4 miles, 13 miles, and 17.6 miles, respectively.

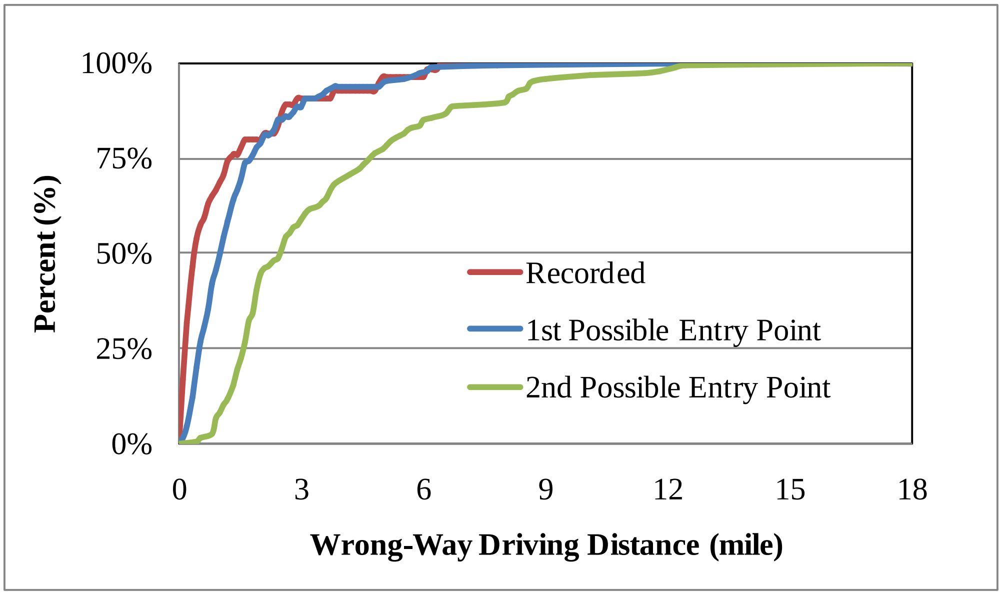


Figure 4.1. Accumulative distribution for wrong-way driving distance.

Table 4.5. Average Driving Distance for Wrong-Way Crashes

Items	Recorded Entry Points	Estimated Entry Points
Total Number	48	295
Mean	1.19 miles	2.55 miles
Maximum	6.40 miles	17.60 miles
Minimum	0.10 miles	0.10 miles
Standard Deviation	1.627	2.554
Variance	2.647	6.521
Median	0.400	1.700

The recorded, first, and second estimated wrong-way entry points were used to rank the top ten locations for field review based on the total weighted entry point frequencies, which were the summation of recorded, first, and second estimated wrong-way entry frequencies. A weight of 1.0 was assigned for the recorded entry point, 0.5 was assigned for the first entry point, and 0.25 was assigned to the second entry point. There were 265 wrong-way entry points identified for all crashes. Twelve percent were recorded, 35% for first estimated, and 37% for the second estimated. Wrong-way entry was an uncommon event, and the entry frequencies for most points were relatively low, varying from one to four. Among the 265 entry points, approximately 76% experienced one wrong-way entry and 20% experienced two. Table 4.6 lists the top ten locations based on weighted wrong-way entry points, including five compressed diamond and diamond interchanges, three partial cloverleaf, one directional, and one single-point urban interchange (SPUI).

Table 4.6. Top Ten Locations with the Highest Wrong-Way Entry Points in Illinois (2004–2009)

County	Route	Longitude	Latitude	Type of Interchange	# of WW Entries	Weighted Entry Points
Cook	I-55/S Damen Ave	87°40'31.60"W	41°50'13.89"N	Single-Point Urban	4	2
Cook	I-94/87th St	87°37'29.50"W	41°44'9.52"N	Compressed Diamond	4	1.5
Cook	I-94/ W Peterson Ave	87°45'1.36"W	41°59'24.79"N	Partial Clover	4	1.5
Cook	US 41/W Belmont Ave	87°38'17.10"W	41°56'25.90"N	Compressed Diamond	4	1.5
Cook	I-94/W Foster Ave	87°44'45.24"W	41°58'31.93"N	Partial Clover	3	2
St. Clair	I-64/IL 157	90°2'45.89"W	38°36'50.80"N	Partial Clover	3	1.75
St. Clair	I-64/IL 3	90°8'42.63"W	38°37'58.74"N	Directional	3	1.75
Cook	I-90/35th St	87°37'50.10"W	41°49'51.52"N	Compressed Diamond	3	1.25
Cook	I-57/S Halsted St	87°38'35.08"W	41°42'53.41"N	Compressed Diamond	3	1.25
Madison	I-70/111	90° 5'33.93"W	38°39'46.20"N	Diamond	3	1.25

Another concern about wrong-way entry points was the prevalence of interchange types for different drivers. The interchange types of partial cloverleaf, diamond, and compressed diamond were investigated. The driver age groups over-represented in those interchange types included 21–24 and over 65 for diamond, and 16–20 and 35–44 for partial cloverleaf. Male drivers were over-represented in a cloverleaf interchange, while female drivers were over-represented in a diamond interchange. Alcohol-impaired drivers were over-represented for partial cloverleaf and diamond interchanges (Tables C.53 through C.55).

4.6 SUMMARY

Data analysis findings suggested that a large proportion of wrong-way crashes occurred during the weekend from 12 midnight to 5 a.m. Although wrong-way crashes were reported in 43 of 102 counties in Illinois, about 64% of wrong-way crashes were in four counties, which are adjacent to the urban areas of Chicago and St. Louis. Most of the multiple-vehicle wrong-way crashes were HO and SSO crashes, which represented 67% of total wrong-way crashes. A large proportion of wrong-way drivers were DUI, among which more than 50% were confirmed to be impaired by alcohol and 5% were impaired by drugs, and more than 3% had been drinking. Vehicle type, seat belt use, lighting, roadway alignment, age group, first vehicle contact point, and driver condition (BAC level) were found to have an impact on crash severity. Wrong-way entry points were identified from the crash reports or estimated based on the crash locations. The top ten locations were selected for field review based on the weighted number of wrong-way entry points.

CHAPTER 5 CONTRIBUTING FACTORS

Contributing factors can be considered any behavior, omission, or deficiency that sets the stage for a crash or increases the severity of injuries caused by a crash. In this sense, therefore, eliminating or reducing the severity of a crash, thorough identification of contributing factors, is a focused approach to safety improvement. This identification is a timely and continuous process in which reviewing the previous crashes is required in order to elicit these factors.

For roadway crashes in general, driver behavior and roadway (sight distance) or vehicle deficiencies (obscured view) are causal factors. However, when investigating specific types of crashes, such as wrong-way crashes, it is necessary to clarify the particular behaviors or omissions (and their associated driver groups), roadway designs or locations, and types of vehicles that increase the risk of a crash, and to what amount.

To discern the contributing factors that lead to a particular type of crash, the first step is to extract a valid sample on which statistical analysis can be conducted. Next, the causal factors (human errors, vehicle and roadway deficiencies) for each crash are identified by a comprehensive review of each sampled case. In the last step, statistical analysis is conducted to examine each of the extracted factors for their significance and frequency.

5.1 METHODOLOGY

In the first step, a causal table was developed in which all possible causes were grouped into five categories and their frequencies were calculated. In the second step, Haddon matrices were developed for each of these crashes. Analysis of weights, analysis of variances, and significance tests were used to find the factors that contributed most significantly to the frequency and severity of these crashes.

5.1.1 Causal Table and Correlation Analysis

The Illinois crash database comprises 61 attribute columns, two of which are CAUSE1 and CAUSE2. The Illinois Department of Transportation defines CAUSE1 as the most significant reason for a crash and CAUSE2 as the second most significant reason for a crash. Accordingly, investigators collected all possible causes of wrong-way crashes and grouped them into the following categories:

- Impairment or distraction
- Injudicious actions
- Behavior or inexperience
- Driver error or reaction
- Road environment

To find the factors that contributed to wrong-way crashes, the percentage of each cause in each category was determined for each level of severity to provide a comparison tool. This method provided a way to determine the factors that contributed most to wrong-way crashes in Illinois. A correlation analysis was then conducted based on the time and severity of each crash and the age and condition of each driver. This analysis assisted investigators in connecting contributing factors to the time, driver age, and condition.

5.1.2 Haddon Matrices and Analysis of Weights

A Haddon matrix, developed by William Haddon in 1970, is a tool to identify contributing factors related to personal attributes, agent attributes, and environmental attributes. The matrix divides these pieces of information into categories of before, during, and after an injury or death. In this project, the report of each wrong-way crash was reviewed and a corresponding Haddon matrix was generated. These Haddon matrices contain information about all drivers and vehicles involved in each wrong-way crash, the road environment, the noted causes to the crash, and the entry point for the crash. the frequency of the human factors, vehicle factors, and environmental factors were determined from these matrices.

Weighted analysis is a method that provides a basis for further statistical analysis. For each crash, all possible contributing factors were given equal weights that summed to one. For example, if there are two contributing factors to a particular crash, each was assigned a weight equal to one-half. Next, for each contributing factor, each of the weights from all 217 wrong-way driving crashes was summed to obtain a comparison between the different factors.

5.1.3 Significance Test

A significance test was used to identify contributing factors that significantly affected freeway wrong-way crashes in Illinois. The collected wrong-way crash data were used to calculate the confidence interval of each contributing factor to measure its significance level. For this purpose, the number of wrong-way crashes due to a particular factor was summed for the entire six-year period (all 217 crashes). For example, the number of wrong-way crashes that occurred on a specific weekday was summed for all the years during the entire study period. Factors that had significant impacts on wrong-way crashes were then identified and tested for their confidence levels. The confidence interval of a factor was based on the average data value and its associated standard deviation over the entire study period. The confidence interval for a factor was determined with the following equation:

$$\overline{X} - t_{\frac{\alpha}{2},DF}\frac{S}{\sqrt{n}} \le \mu \le \overline{X} + t_{\frac{\alpha}{2},DF}\frac{S}{\sqrt{n}}$$

In the equation, n is number of years, S is the standard deviation, and t is the value of t-distribution with a degree of freedom (DF) at α/2, where α is the level of significance. X and μ are the sample mean and population mean for the factor, respectively. The t-distribution was used instead of the normal distribution because of the smaller sample size of many of the contributing factors. Based on this analysis, any two factors that did not have overlapping confidence intervals could be considered significantly different.

In this study, two types of variables were defined for the significance test. The first type of variable was the number of wrong-way crashes that occurred during the study period. Examples include the number of crashes on a specific weekday and the number of crashes in a certain county. The second type of variable was the ratio between the percentage values for all wrong-way crashes and the percentage values for all freeway crashes. This variable helped researchers identify factors over-represented in wrong-way crashes. Based on the method described above, nine different contributing factors were identified and tested.

5.2 RESULTS

5.2.1 Causal Table and Correlation Analysis

Categorizing the primary and secondary crash causes reported by the corresponding law enforcement officer, the causal tables illustrated in Appendix D were generated. The results suggested that the major categories, such as impairment and distraction, injudicious actions and behavior, and inexperience were contributing factors in 67%, 22%, and 17% of wrong-way crashes, respectively. Driving under the influence of alcohol and physical conditions of driver that related to his/her impairment, were factors in 54% and 16% of wrong-way crashes, respectively. Moreover, improper lane use; driver skills, knowledge, and experience; operating the vehicle in a reckless manner; and inability to determine were found as major factors in 14%, 9%, 8%, and 7% of wrong-way crashes, respectively. It was notable that the percentage of fatal crashes (12%) caused by driver impairment was four to ten times more than the percentage of fatal crashes generated by other factors. Also, 78% and 80% of wrong-way crashes occurred in urban areas and in darkness, respectively.

In order to assign each of these factors to an age group, correlation analysis was conducted. The closer the results are to a value of one, the more relation the two factors share and the stronger the correlation. If the results indicate a negative relation, one factor increases as the other decreases. Table 5.1 illustrates the results of this analysis.

Table 5.1. Correlation Analysis

	% Young Drivers	% Older Drivers	% DUI Drivers	% Night Crashes	% Male Drivers	% Weekend Crashes	% Fatal/Injury Crashes
% Young Drivers	1.00						
% Older Drivers	–0.11	1.00					
% DUI Drivers	0.07	–0.45	1.00				
% Night Crashes	0.06	–0.32	0.60	1.00			
% Male Drivers	0.27	–0.11	0.59	0.35	1.00		
% Weekend Crashes	0.12	–0.16	0.54	0.30	0.50	1.00	
% Fatal/Injury Crashes	–0.08	–0.15	0.46	0.19	0.27	0.07	1.00

This analysis suggested that neither younger nor older drivers had any large correlation with alcohol impairment; most of the wrong-way driving crashes related to driver impairment were caused by middle-aged (> 24 and < 65) drivers. This finding implies that physical condition was related primarily to older drivers and that driver skill corresponded to younger drivers. Table 5.2 summarizes these results.

Table 5.2. Contributing Factors and Correlation Analysis

Contributing Factor	In Correlation with
Alcohol/drug impairment	Middle-age drivers/night-time
Physical condition	Older drivers
Inexperience/knowledge	Younger drivers
Improper lane usage	Impaired/experience
Disregarding traffic signs	Impairment/darkness
Not using seat belt (for fatality)	Reckless driver/impairment
Urban area	Bars/complex environment
Midnight–3 a.m./weekends	Drinking and driving

5.2.2 Haddon Matrices and Analysis of Weights

Contributing factors were classified into nine categories using Haddon matrices: pre-crash human, pre-crash vehicle, pre-crash environment; during-crash human, during-crash vehicle, during-crash environment; post-crash human, post-crash vehicle, and post-crash environment. For each crash case, researchers also referenced small-scale and large-scale aerial photographs of the crash locations and the reported or possible entry points. The frequency of each contributing factor was counted to identify the prevalent factors for each severity type.

In the pre-crash human category, younger drivers (16–24 years old) accounted for 23% of fatal and 36% of A-injury crashes for wrong-way driving. Older drivers (above 65 years old) were more prevalent in B-injury crashes (27%). Male drivers accounted for more than 70% in each severity type. Alcohol impairment was the most common condition of drivers involved in each severity type.

In the pre-crash vehicle category, more than 50% of vehicles involved were passenger cars. The maneuvers of the other vehicles involved in each crash case were either straight ahead (>70%) or avoiding vehicle/objects (>18%). As expected, a large number (81%) were driving the wrong way during fatal crashes. For A-injury and B-injury crashes, the most prevalent causes were driving the wrong way (approximately 42%) and driving under the influence of alcohol/drugs counts (approximately 33%).

In the during-crash vehicle category, air bags deployed in 65% of fatal crashes, slightly higher than in A-injury (58%) and B-injury crashes (46%). Seat belts were not used in 23% of both fatal and A-injury crashes, while only 5% did not use seat belts in B-injury crashes.

With respect to the environment during wrong-way driving crashes, more than 75% of roadway surfaces were dry in each severity type. Darkness accounted for more than 45% of crashes in each severity type. Lighted roads in darkness accounted for 42% of fatal crashes and 29% of A and B-injury crashes. The weather was clear in 94% of fatal, 80% of A-injury, and 73% of B-injury crashes. Although poor weather did not appear to cause the wrong-way crashes studied, the time of day was a key factor. Forty-eight percent of fatal crashes occurred between 12 midnight and 3 a.m.; 22% of A-injury crashes occurred between 3 and 4 a.m.; and 19% of B-injury crashes occurred between 1 and 2 a.m. and another 19% between 3 and 4 a.m. For each wrong-way crash, the average number killed was 1.4 and the average number of A-injuries was 2.1. The detailed frequency tables can be found in Appendix E.

A ranking and significance analysis of all contributing factors was then conducted. The researchers assumed that for each crash case, all contributing factors were weighted equally; therefore, each factor was assigned a weight of 1/total number of contributing factors in a case.

The factors were then ranked by their average weights. An analysis of variance (ANOVA) and a Tukey test were both used to determine whether there were any significant differences in ranking among contributing factors.

The results showed that for human factors, the most significant pre-crash factors were younger drivers (16–24 years), older drivers (above 65 years), drivers under the influence of alcohol, and drug-impaired drivers. The most significant during-crash human factors were improper lane usage, physical condition of driver, and driver skills, knowledge, and experience. With respect to vehicle factors, the most significant pre-crash factor was the vehicle maneuver of avoiding vehicles or other objects. The most significant during-crash vehicle factor was failing to use seat belts. The most significant environment factors were darkness (no significant difference between lighted and unlighted roads). Among these factors, younger drivers were especially prevalent in fatal and A-injury crashes, while older drivers were prevalent in B-injury crashes. Not using seat belts ranked high in fatal and A-injury crashes but not in B-injury crashes, indicating that seat belts do contribute to reducing fatality and A-injuries from wrong-way crashes. Tables 5.3a, 5.3b and 5.3c illustrate the ranking of contributing factors for fatal, A-injury, and B-injury crashes.

Table 5.3a. Significance of Contributing Factors for Fatal Crashes

Rank	Top Contributing Factors	%	Significance Among Top Factors
1	Under influence of alcohol/alcohol impaired	12.4%	Significantly larger than 2nd and afterward
2	Road lighting: Darkness	8.6%	Significantly larger than 4th and afterward
3	Road lighting: Darkness, lighted road	8.1%	Significantly larger than 4th and afterward
4	Vehicle 2 maneuver: Avoiding vehicle/objects	4.7%	No significant difference among others
5	Young driver: Age 16–24	4.0%	
6	Seat belts not used	4.0%	
7	Old driver: Age above 65	3.8%	
8	Driver condition: Drug impaired	3.0%	
	Total Percentage	**82.5%**	

Table 5.3b. Significance of Contributing Factors for A-Injury Crashes

Rank	Top Contributing Factors	%	Significance Among Top Factors
1	Under influence of alcohol	10.7%	Significantly larger than 3rd and lower
2	Road lighting: Darkness, lighted road	9.3%	Significantly larger than 4th and lower
3	Young driver: Age 16–24	5.9%	No significant difference 2nd and between lower values
4	Road lighting: Darkness	5.4%	
5	Improper lane usage	5.0%	
6	Vehicle 2 maneuver: Avoiding vehicle/objects	4.2%	
7	Seat belts not used	3.4%	
8	Physical condition of driver	3.2%	
	Total Percentage	**82.2%**	

Table 5.3c. Significance of Contributing Factors for B-Injury Crashes

Rank	Top Contributing Factors	%	Significance Among Top Factors
1	Under influence of alcohol/alcohol impaired	11.5%	Significantly larger than 3rd and afterward
1	Road lighting: Darkness, lighted road	10.6%	
3	Road lighting: Darkness	6.4%	Significantly larger than 8th
4	Old driver: Age above 65	5.5%	No significant difference among others
5	Physical condition of driver	3.2%	
6	Weather: Rain	2.7%	
7	Vehicle 2 maneuver: Avoiding vehicle/objects	2.7%	
8	Driver skills/knowledge/experience	2.1%	
	Total Percentage	**82.9%**	

5.2.3 Significance Tests

The significance test concentrated primarily on the crash frequency (month, week, and hour), driver age, driver gender, driver condition (DUI, normal, other), with or without road lighting, and road surface conditions.

5.2.3.1 Monthly Crash Frequency

Figure 5.1 depicts the 95% confidence intervals of the monthly wrong-way crash frequency in an average year. The diamonds in Figure 5.1 represent the average wrong-way crash number for each month, as estimated from the database information. The lines demonstrate the range within which the researchers are 95% confident that is where the true average lies. A longer line indicates a greater variability in the number of monthly wrong-way crashes between years. Months whose lines overlap had no significant difference in the average number of wrong-way crashes. The figure illustrates that the wrong-way crash frequency in May was relatively low compared with the months of January and April.

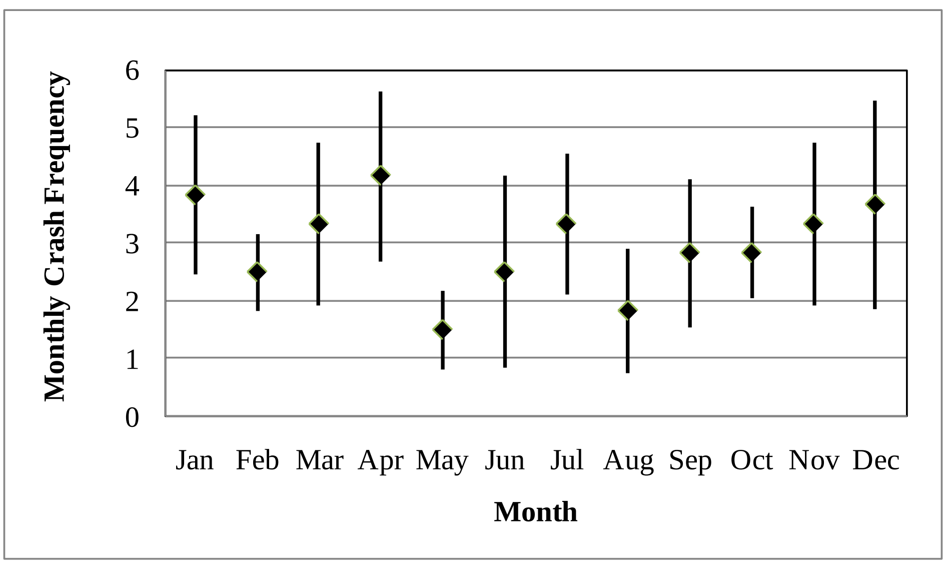


Figure 5.1. Ninety-five percent confidence interval for monthly crash frequency.

5.2.3.2 Weekly Crash Frequency

The wrong-way crash frequency on different weekdays was analyzed to examine whether wrong-way crashes were more likely to occur on specific weekdays. Figure 5.2 illustrates that wrong-way crash frequencies on the weekend, particularly Saturdays, were significantly higher than those for weekdays (note that Saturday's bar does not overlap with bars from any other weekdays). This information could be used when considering law enforcement deployment to combat wrong-way driving behaviors.

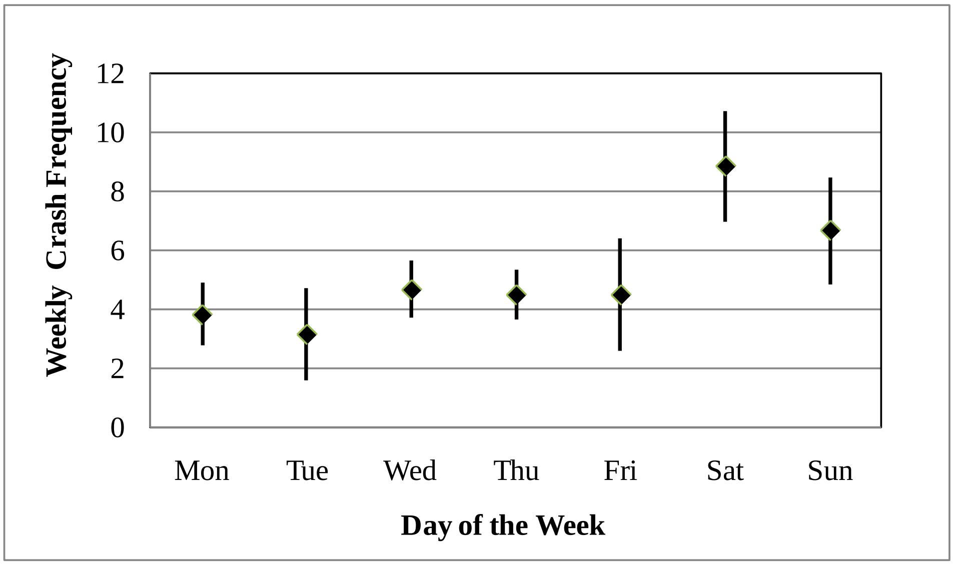


Figure 5.2. Ninety-five percent confidence interval for weekly crash frequency.

5.2.3.3 Hourly Crash Frequency

Figure 5.3 illustrates the distribution of the wrong-way crashes across the hours of the day. The wrong-way crash frequency between 12 midnight and 5 a.m. was significantly higher than that of any other time period. This information could also be considered when deploying law enforcement to combat wrong-way driving behaviors.

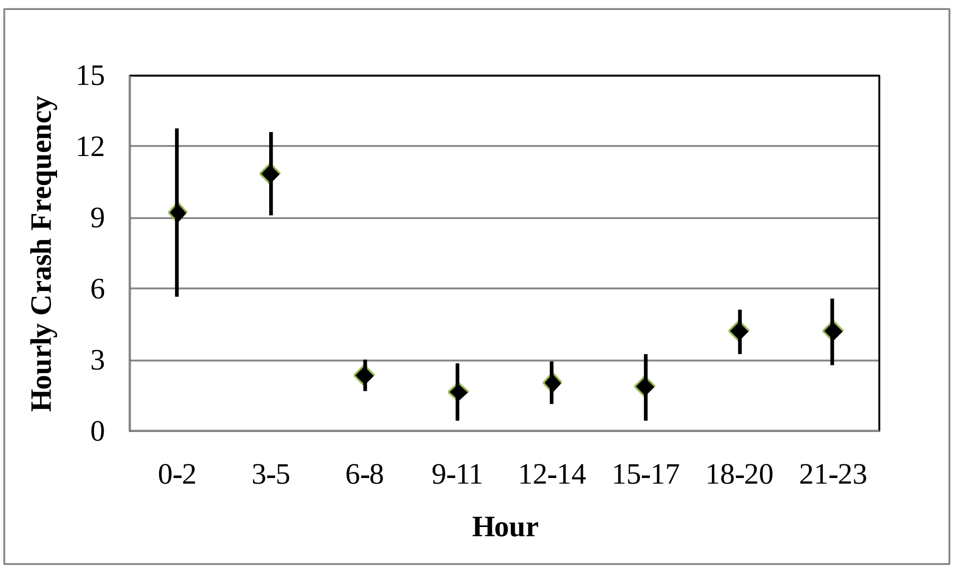


Figure 5.3. Ninety-five percent confidence interval for hourly crash frequency.

5.2.3.4 Driver Age

To evaluate the impact of driver age and gender on wrong-way crashes, the percentage of wrong-way drivers for each age and gender group was normalized with the percentage of all freeway crashes for the same age and gender group. This ratio was then used for the significance test. Any driver age groups with the calculated ratio significantly greater than 1.0 could be considered to be overrepresented in wrong-way crashes. Figure 5.4 showed that older drivers (> 65 years old) were approximately three times more likely to be involved in wrong-way crashes than other crashes on freeways. In addition, results also showed that male drivers were over-represented in wrong-way crashes (more than 70%).

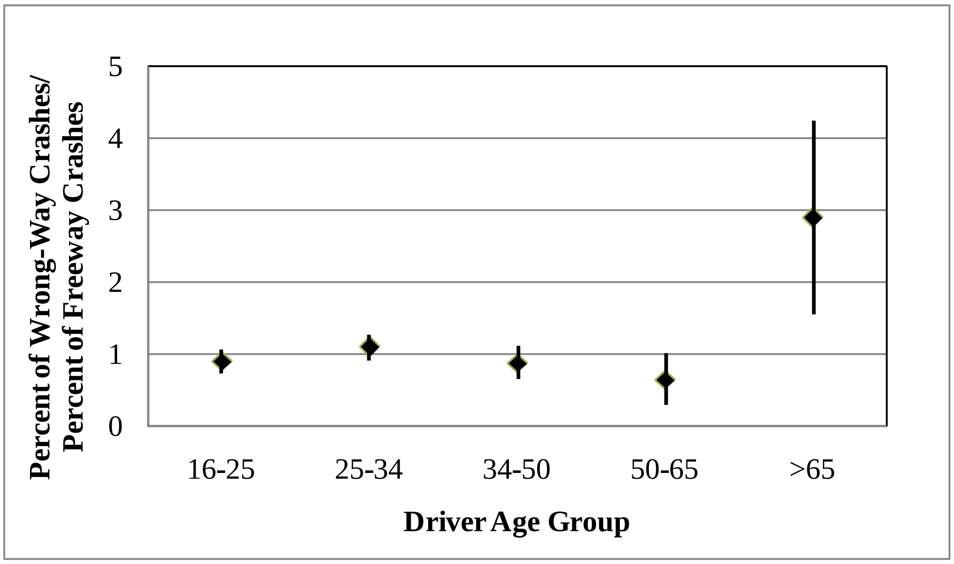


Figure 5.4. Ninety-five percent confidence interval for wrong-way to freeway crash ratio.

5.2.3.5 Driver Condition

Driver condition was classified into the following three categories for this study: alcohol or drug impaired, normal conditions, and other conditions. Other conditions here referred to fatigue, sickness, sleepiness, etc. To test the significance of driver condition on wrong-way crashes, the ratios between the percentage of wrong-way drivers under each condition and the percentage of drivers for all freeway crashes under the same condition were calculated. Results in Figure 5.5 illustrate that the percentage of DUI drivers in wrong-way crashes was 13 to 18 times higher than the percentage of DUIs in all freeway crashes in Illinois.

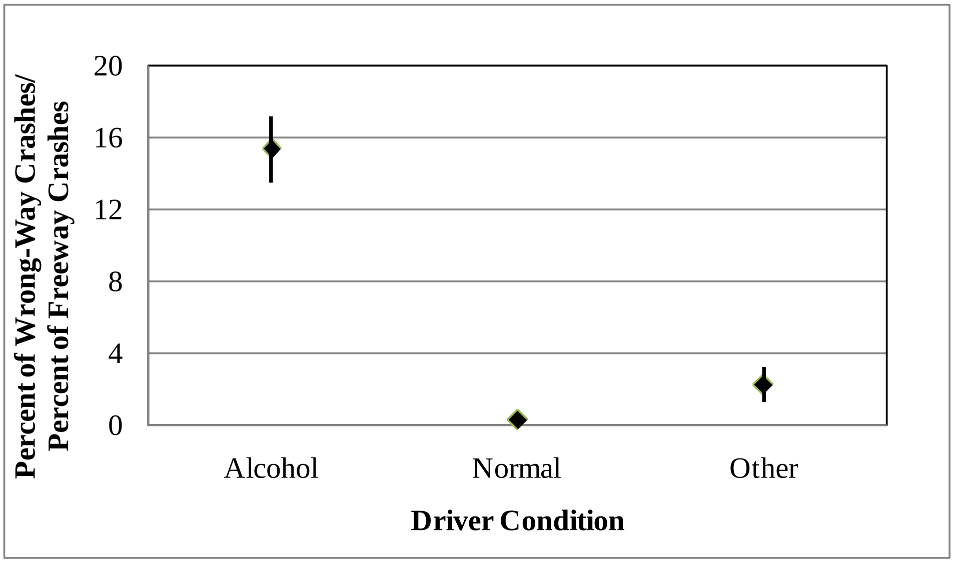


Figure 5.5. Ninety-five percent confidence interval for wrong-way to freeway crash ratio.

5.2.3.6 Roadway Lighting

The effect of lighting conditions on wrong-way crashes was tested to see whether there is any significant difference between roadways with and without lighting. The results presented in Figure 5.6 illustrate that darkness was over-represented in freeway wrong-way crashes, but there was no significant difference between darkness with and without lighting.

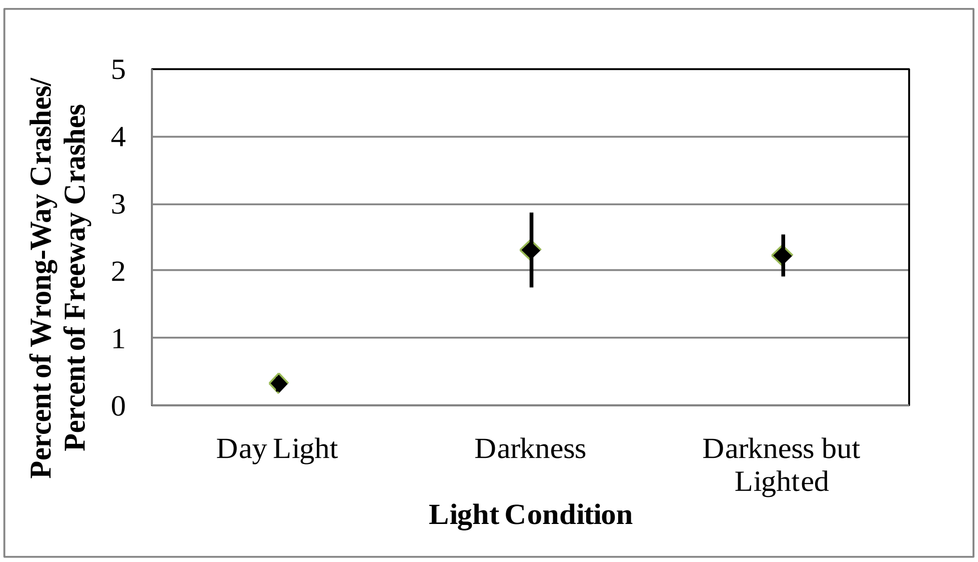


Figure 5.6. Ninety-five percent confidence intervals for crash frequency by driver condition.

5.2.3.7 Roadway Surface Condition

Results indicated that there were similar distributions of wrong-way crashes as all freeway crashes under different roadway surface conditions; approximately 80% occurred on dry road surfaces, 16% on wet road surfaces, and the rest on icy surfaces. The findings indicated that road surface condition did not significantly contribute more to wrong-way crashes than it did to other freeway crashes.

5.2.3.8 Significance Test Results

Table 5.4 summarizes the significance test results for all the possible factors related to wrong-way crashes on a freeway.

Table 5.4. Significance Test Results

Factor	Significantly Contributes	Factor	Significantly Contributes
Month	√	Driver age	√
Day of the week	√	Driver condition	√
Crash time	√	Darkness	√
Driver gender	√	Road surface condition	×

5.3 SUMMARY

Haddon matrices were used to identify the contributing factors for wrong-way crashes involving fatalities and injuries in Illinois. The most significant human factors were driver age (most frequent for ages 16–24 and > 65 years), alcohol impairment, drug impairment, physical condition, and driver skills, knowledge, and experience. The most significant vehicle factor was the vehicle maneuver of avoiding vehicles/objects and failing to use seat belts (especially significant in fatal crashes). The most significant environmental factor was road darkness. Among these factors, younger drivers were found especially prevalent in A-injury crashes, while older drivers were especially prevalent in fatal and B-injury crashes. Not using seat belts ranked within the top ten factors in fatal and A-injury crashes but not in B-injury crashes, indicating that seat belts do contribute in reducing fatality and A-injuries caused by wrong-way crashes.

To combat freeway wrong-way crashes, it is important to keep DUI drivers away from the freeway, possibly by establishing more DUI checkpoints near freeway entrances.

Significance test results indicated that wrong-way crashes occurred more frequently in the months of January, April, and December and between midnight and early morning, especially on weekends.

Other significant contributing factors such as driver gender, age, and condition were identified through the significance test. Additional correlation analysis indicated that some contributing factors are related to each other; for example, there is a relationship between middle-aged male drivers and alcohol impairment.

In the next step of this project, the findings about factors that contribute to wrong-way crashes on freeways will be applied in developing countermeasures based on engineering, education, and enforcement.

CHAPTER 6 FIELD REVIEWS AND COUNTERMEASURES

Based on the contributing factors identified in Chapter 5, this chapter presents a general set of potential engineering countermeasures to address wrong-way crashes on Illinois freeways. General issues such as wrong-way signage, pavement marking, and geometric design were identified at the 12 interchange areas based on a thorough field review. The results from the field review and crash data analyses were used in combination with countermeasures by other states to identify possible recommendations for each study site.

6.1 FIELD REVIEWS

Field reviews were conducted by the researchers and project TRP members with the assistance of IDOT districts 1 and 8. The first field review of four interchanges at IDOT District 8 was conducted on November 8, 2011. The review team consisted of three faculty members and two student researchers from SIUE, two IDOT engineers, and two road safety assessment team members from the FHWA. The four interchanges were two partial cloverleaf interchanges (I-64/IL 157, I-64/IL 159), one diamond interchange (I-70/IL 111), and one directional interchange (I-64/IL 3). During the field review, the team found that two (I-64/IL 159 and I-64/IL 3) of the four interchanges are currently under construction and suggested that they be removed from the study site list.

A checklist was used by each team member (Appendix F). A meeting was held at the end of the field review to summarize the key findings related to wrong-way driving/crashes, as follows:

- Absence of **NO RIGHT TURN** signs at the off-ramp terminals
- Absence of a stop line at the end of the off-ramps
- Some **DO NOT ENTER** signs do not face potential wrong-way drivers
- Lack of elephant track pavement markings to guide large-turning radii
- Median extensions were found to prevent left-turn wrong-way driving

The second field review of ten interchanges was conducted in the Chicago area November 21–23, 2011. The ten sites were four compressed diamond interchanges (I-94/87th, 1-94/35th, I-57/Halsted, US 41/Belmont), five partial cloverleaf interchanges (I-94/ Peterson, I-94/Touhy, I-94/W. Foster, I-94/Ohio, and I-94/Cermak), and one SPUI (I-55/S. Damen). Two (I-94/Ohio and Cermak) of these ten interchanges were recommended by IDOT District 1. I-94/Peterson and I-94Touhy are very close to each other. Some wrong-way crashes near I-94/Peterson might be caused by wrong-way entries at I-94/Touhy.

The checklist was used to take notes for each site. The most noticeable issue with the compressed diamond interchange was that neither **DO NOT ENTER** signs nor **WRONG WAY** signs were placed along the one-way streets (operated by the local municipality) connecting to the off-ramps. Some partial cloverleaf interchanges have multiple lanes on the off-ramps; in those cases, the sizes of the **DO NOT ENTER** and **WRONG WAY** signs are not proportional to the width of the cross section.

6.2 GENERAL ISSUES

Some common issues with the existing signage, pavement markings, and geometric designs related to wrong-way driving were identified in the field reviews. The signage commonly used to prevent wrong-way driving on Illinois freeways includes **DO NOT ENTER**, **WRONG WAY, ONE WAY, NO RIGHT TURN/NO LEFT TURN** signs.

General issues with the existing **DO NOT ENTER** and **WRONG WAY** signs are (1) some **DO NOT ENTER** signs do not face the potential wrong-way drivers, (2) the sizes of some **DO NOT ENTER** and **WRONG WAY** signs on the multi-lane off-ramps are not proportional to the width of the cross section, and (3) neither **DO NOT ENTER** nor **WRONG WAY** signs were placed along the one-way streets that lead from freeway exit ramps.

General issues with the existing **ONE WAY** and **NO RIGHT TURN**/**NO LEFT TURN** signs are (1) the size of some **ONE WAY** signs on multi-lane off-ramps could be larger at certain locations, (2) the location and size of **NO RIGHT TURN**/**NO LEFT TURN** signs vary among the reviewed intersections, and (3) these two types of signs at some locations are not in good condition.

General issues concerning pavement markings are (1) lack of elephant track pavement markings to guide the large-turning radii present at some ramp terminals, (2) absence of a stop line at the end of the off-ramps, and (3) absence of directional pavement arrows at the end of the off-ramps.

Raised curb medians and median extensions were observed at two interchange areas (I-70/IL 111 and I-94/Peterson) to prevent wrong-way entry into the off-ramps. Installation of raised medians should also be considered at other diamond, partial cloverleaf, and single-point urban interchanges to discourage wrong-way maneuvers.

6.3 GENERAL COUNTERMEASURES

To reduce wrong-way driving crashes on freeways, regular inspections of the condition of existing signage and pavement marking are necessary to make sure they are effective in preventing wrong-way driving. Enhanced signage should be considered at high crash locations to improve the visibility of **DO NOT ENTER** and **WRONG WAY** signs. General countermeasures for signage, pavement markings, and geometric designs are listed in Table 6.1. Most of these countermeasures are the standard methods in the MUTCD (2009) or AASHTO Green Book (2010), or have been proven to be effective by past studies.

Table 6.1. General Countermeasures

Item	General Countermeasures
DO NOT ENTER signs	• Place one **DO NOT ENTER** sign for potential one-direction wrong-way drivers. • Reorient **DO NOT ENTER** signs to face potential wrong-way drivers. • Use a larger sign (35 × 35 inches) for multi-lane off-ramps. • Use red reflective tape on sign support(s) to increase nighttime visibility • (Note: Due to snow and sight distance problems, low-mounted **DO NOT ENTER** signs are not recommended in Illinois.)
WRONG WAY signs	• Place at least one **WRONG WAY** sign at the end of ramp terminals, ensuring that it faces potential wrong-way drivers. • Use a larger sign (42 × 30 inches) for multi-lane off-ramps. • Use red reflective tape on sign support(s) to increase nighttime visibility. • Consider using a second set of **WRONG WAY** signs or additional **WRONG WAY** signs on the backside of existing signage along the main line at high crash locations. • Use LED-illuminated **WRONG WAY** signs at high crash locations. • (Note: Due to snow and sight distance problems, low-mounted **WRONG WAY** signs are not recommended in Illinois.)
ONE WAY signs	• Use **ONE WAY** signs at the end of the off-ramp on the side with the highest visibility to potential wrong-way drivers. • Use a larger sign (54 × 18 inches) along multi-lane frontage roads that connect to freeway off-ramps. *(table continues, next page)*

Item	General Countermeasures
KEEP RIGHT signs	• Use **KEEP RIGHT** signs at the median between the on- and off-ramps at partial cloverleaf interchanges.
NO RIGHT TURN or **NO LEFT TURN** signs	• Adding **NO RIGHT TURN** or **NO LEFT TURN** sign next to overhanging traffic signals to increase the sight distance. • Install additional **NO RIGHT TURN** signs at right corner facing potential right-turning wrong-way drivers. • Install additional **NO LEFT TURN** signs at left corner facing potential left-turning wrong-way drivers.
Pavement markings	• Use pavement marking for guiding traffic (through-arrows, turning arrows, elephant tracks). • Add reflective pavement arrows at off-ramps. • Paint stop lines at the end of off-ramps. • (Note: Raised pavement marker arrows are not recommended in Illinois because of potential damage from snow plows.)
Geometric design	• Use raised curb median and channelized islands. • Increase the distance from the gorge of the exit ramp to the entrance ramp for partial cloverleaf interchanges. • Reduce the turning radius for wrong-way movements. • Do not use off-ramps joining two-way frontage roads.
Traffic signals	• Use solid arrow signal for through-only travel lanes.

6.4 SITE-SPECIFIC COUNTERMEASURES

A potential wrong-way maneuver might occur due to lack of supplemental signage and/or geometric designs for preventing such a maneuver, lack of proper supplemental pavement markings, or lack of a directional traffic signal head for guiding the driver in right direction. To prevent potential wrong-way maneuvers, some short-term and long-term engineering countermeasures are recommended based on field observations for each individual intersection, including (1) improving existing signage, (2) adding supplemental signage and pavement markings, (3) improving the specificity of traffic signal heads, and (4) improving intersection layout and geometry. Table 6.2 summarizes the potential countermeasures for the 12 studied interchanges. These site-specific countermeasures are consistent with the standards and guidance from the MUTCD 2009 and AASHTO Green Book 2010. Some were proven to be effective based on previous studies. Detailed information on the specific countermeasures is contained in Appendix G.

Table 6.2. Potential Countermeasures for the 12 Study Interchanges

#	Interchange Information	Wrong-Way Crashes (2004–2009)	Potential Countermeasures
1	I-94 & 87th St. Compressed Diamond Cook County, IL 87°37'29.50"W, 41°44'9.52"N	Four wrong-way entries	**Signage** • Add **ONE WAY** sign at the end of off-ramp • Add **DO NOT ENTER** and **WRONG WAY** signs at both sides of off-ramp with red reflective tape on the signposts • Add **NO RIGHT TURN** sign to the overhanging traffic light mast arm **Pavement Marking** • Add straight-arrow on through-lanes before intersection **Geometric Design** • Reduce wrong-way turning radius **Signal** • Use solid green arrows for through-lane traffic signals
2	US 41 & W. Belmont Ave. Compressed Diamond Cook County, IL 87°38'17.10"W, 41°56'25.90"N	Four wrong-way entries	**Signage** • Add **ONE WAY** sign at the end of right side of the off-ramp • Upgrade **DO NOT ENTER** sign at both sides of the off-ramp with red reflective tape on the signposts • Reorient **DO NOT ENTER** signs to face potential wrong-way drivers • Replace the faded **NO RIGHT TURN** sign hung on the traffic signal mast arm **Pavement Marking** • Repaint straight-arrow on through-lanes
3	I-90 & 35th St. Compressed Diamond Cook County, IL 87°37'50.10"W, 41°49'51.52"N	Four wrong-way entries	**Signage** • Add **ONE WAY** sign at the end of the off-ramp • Install **DO NOT ENTER** and **WRONG WAY** signs with red reflective tape on signposts, on both sides of the one-way street **Pavement Marking** • Repaint straight-arrow on through-lanes **Signal** • Upgrade through-lane traffic signal with solid arrows *(table continues, next page)*

#	Interchange Information	Wrong-Way Crashes (2004–2009)	Potential Countermeasures
4	I-57 & S. Halsted St. Compressed Diamond Cook County, IL 87°38'35.08"W, 41°42'53.41"N	Four wrong-way entries	**Signage** • Install **DO NOT ENTER** and **WRONG WAY** signs with red reflective tape on signposts, on both sides of the one-way street **Pavement Marking** • Add straight-arrow on through-lanes **Signal** • Upgrade through-lane traffic signal with solid arrows
5	I-70 & IL 111 Diamond Madison County, IL 90°5'33.93"W, 38°39'46.20"N	Three wrong-way entries	**Signage** • Upgrade existing wrong-way signage with red reflective tape on the signposts **Pavement Marking** • Place stop lines at the end of off-ramps • Add reflective pavement marking arrow to the off-ramp terminal (5 feet from upstream the stop line)
6	I-94 & Foster Ave. Partial Cloverleaf Cook County, IL 87°44'45.24"W, 41°58'31.93"N	Two wrong-way entries	**Signage** • Upgrade **DO NOT ENTER** and **WRONG WAY** signs with flashing LED light **Pavement Marking** • Add stop line at the end of the off-ramp • Place pavement marking arrows on the exit ramp 5 feet upstream from the stop line • Use yellow reflectors for median markings • Repaint left-turn stop line and double yellow median line markings **Geometric Design** • Consider installing raised curb median to reduce the wrong-way turning radius onto the off-ramps
7	I-94 & Peterson Ave. Full Cloverleaf Cook County, IL 87°45'1.36"W, 41°59'24.79"N	Four wrong-way entries	**Signage** • Add **DO NOT ENTER** sign at the beginning of off-ramps **Pavement Marking** • Repaint faded markings of right-turn arrow *(table continues, next page)*

#	Interchange Information	Wrong-Way Crashes (2004–2009)	Potential Countermeasures
8	I-94 & Touhy Ave. Full Cloverleaf Cook County, IL 87°45'2.38"W 42°0'42.50"N	Four wrong-way entries	**Signage** • Add overhead **NO LEFT TURN** sign on northbound Touhy Ave. **Pavement Marking** • Place pavement arrows on through-lanes of Touhy Ave. • Repaint double yellow lines on Touhy Ave. • Add reflectors at the end of double yellow line **Geometric Design** • Consider installing raised curb median
9	I-64 & IL 157 Partial Cloverleaf St. Clair County, IL 38°36'51.46"N 90° 2'45.01"W	Three wrong-way entries	**Signage** • Add **DO NOT ENTER** and **WRONG WAY** signs at the end of off-ramps **Pavement Marking** • Place all arrows 1.5 to 5 feet behind the stop bars **to** alert wrong-way drivers **Geometric Design** • Remove existing raised curb median on I-64 south off-ramp between through- and left-exiting lanes
10	I-90 & Cermak Ave. (Chinatown) Partial Cloverleaf Cook County, IL 41°51'10.28"N 87°37'52.28"W	No wrong-way crash history found Review Recommended by IDOT District 1	**Signage** • Use larger size **DO NOT ENTER** (36 × 36 inches) and **WRONG WAY** (42 × 30 inches) signs **Pavement Marking** • Place elephant tracks pavement marking for the turning movement to on-ramp **Geometric Design** • Extend raised curb median
11	I-94 & Ohio St. Partial Cloverleaf Cook County, IL 41°53'32.60"N 87°38'13.44"W	No wrong-way crash history found Review Recommended by IDOT District 1	**Signage** • Add larger **DO NOT ENTER** and **WRONG WAY** sign with flashing LED lights • Reorient **DO NOT ENTER** sign for the left-turning traffic **Pavement Marking** • Place pavement arrows for through-traffic **Signal** • Remove corner signal at the left side of off-ramp *(table continues, next page)*

#	Interchange Information	Wrong-Way Crashes (2004–2009)	Potential Countermeasures
12	I-55 & Damon Ave. Single-Point Urban Interchange Cook County, IL 87°40'31.60"W 41°50'13.89"N	Four wrong-way entries	**Signage** • Add **DO NOT ENTER** sign on both sides of the off–ramps • Reorient some **DO NOT ENTER** signs **Pavement Marking** • Repaint pavement markings to guide large turning radius movements **Geometric Design** • Extend raised curb median

6.5 IMPLEMENTATION STRATEGIES

The general and site-specific countermeasures can be implemented in two phases. Phase one focuses on short-term, low-cost countermeasures, such as regular maintenance and inspection of the existing signage and pavement marking. Phase two is a long-term, systematic approach.

Phase one countermeasures include the use of supplemental or advanced signage and pavement markings at high crash locations, including oversized **DO NOT ENTER** and **WRONG WAY** signs and solid-arrow signal heads. Due to high maintenance costs for in-pavement lights and potential damage from snow plows by raised pavement marker arrows, these two countermeasures were reviewed but are not recommended by most members of this project's Technical Review Panel for implementation in Illinois. Some ITS automatic wrong-way monitoring and warning systems were found to be effective because they quickly notify law enforcement, who can respond immediately.

Phase two countermeasures entail a more comprehensive 4 E's approach (engineering, education, enforcement, and emergency response). It is recommended that a wrong-way inspection team conduct field reviews of selected freeway sections or interchanges. Also, it is recommended that guidelines for wrong-way related signage, pavement marking, and geometric designs be developed. Education strategies can be implemented to improve public awareness and understanding of (1) the basics of road designs and interchange types, (2) potential risks, (3) what to do when witnessing a wrong-way driver, and (4) possible damages to family and/or society. Education programs should focus especially on young drivers, older drivers, and DUI drivers. Enforcement strategies that could be implemented include data-driven DUI checkpoints, stopping wrong-way drivers by using portable spike barriers, and using radio and DMS to warn right-way drivers of oncoming wrong-way drivers. An advanced detection and warning system can be implemented by coordinating with traffic management centers and incident responders to enable quick actions to stop wrong-way driving before crashes occur.

CHAPTER 7 CONCLUSIONS

7.1 CONCLUSIONS

The literature review showed that early research on wrong-way driving countermeasures was pioneered by Caltrans and focused mainly on improvement of signage, pavement marking, and geometric design. These early research results indicated that low-mounted **DO NOT ENTER** signs mounted together with **WRONG WAY** signs was an effective countermeasure. In addition, Caltrans' wrong-way monitoring program was recommended for identifying locations for wrong-way crash investigations. The wrong-way crash rate was significantly reduced in California after implementing the research results in the 1970s and 1980s.

More recent research in 2004 by the Texas Transportation Institute (TTI) provided updated information on wrong-way crash characteristics and application of advanced intelligent transportation system technologies. Use of innovative information techniques allowed many DOTs to develop modern traffic management centers to monitor and quickly respond to traffic incidents. Because of the availability of these coordinated surveillance and response tools, it became feasible to use some of the earlier wrong-way detection and warning systems for stopping wrong-way drivers before crashes occurred.

The main purpose of this project was to identify factors that contribute to wrong-way crashes on freeways. The IDOT crash database (text file) provides information about all crashes on Illinois freeways. The database and hardcopies of crash reports were reviewed to identify the crashes that were caused by wrong-way drivers. It was found that wrong-way freeway crashes in Illinois had general statistical characteristics similar to those found in previous studies in other states. Most wrong-way crashes in Illinois occurred in the Chicago and St. Louis metropolitan areas during early morning and on weekends. There were significantly more wrong-way crashes on Saturday and during early morning hours (12 midnight to 5 a.m.) than other weekdays and time periods. Vehicle type, seat belt use, lighting, roadway alignment, age group, first vehicle contact point, and driver condition (BAC level) were found to have an impact on crash severity.

Three methods (causal tables, Haddon matrices, and significance tests) were used to identify various details of the contributing factors. Causal tables were used to analyze the primary and secondary causes (Cause 1 and Cause 2) for each wrong-way crash. The causes in the crash database were classified into five categories. Haddon matrices were then used to analyze the more detailed factors during three stages (pre-crash, during-crash, and post-crash) for all the fatal, A-injury, and B-injury crashes. A weight analysis was used to rank the top factors for each severity level. Furthermore, significance tests were conducted to determine whether there was a significant difference for each contributing factor when the entirety of freeway crashes was compared. The results showed that alcohol, older drivers, male drivers, and nighttime crashes are over-represented in wrong-way crashes compared to all other freeway crashes.

In this study, a new method was developed to rank high wrong-way crash locations based on the weighted number of wrong-way entries. This method was applied successfully to identify the top ten locations for field reviews in Illinois. The three interchange types with the most wrong-way entries were compressed diamond (29%), diamond (27%), and partial cloverleaf (16%). Overall, 12 interchanges (4 compressed diamond, 1 diamond, 6 partial cloverleaf, and 1 single-point urban interchange) were selected for field review. The field reviews showed that some **DO NOT ENTER** signs were not angled toward potential wrong-way drivers and that the size of some **DO NOT ENTER**, **WRONG WAY**, and **ONE WAY** signs could be increased, particularly for multi-lane off-ramps. General issues pertaining to pavement marking included the absence of stop lines and pavement arrows at the end of off-ramps. Some faded **NO LEFT TURN** and **NO RIGHT TURN** signs were observed at particular intersections. It was observed that a raised curb median could be installed at some partial cloverleaf and compressed diamond interchanges.

A set of short-term, low-cost countermeasures for improving existing wrong-way related signage, pavement markings, and geometric designs were identified for the 12 study interchanges and are ready for immediate implementation. A comprehensive 4 E's approach was proposed for implementation over the long term. Some advanced technologies can be applied to stop wrong-way driving with the cooperation of law enforcement.

7.2 FUTURE RESEARCH

The next step is to coordinate with IDOT districts to implement the site-specific countermeasures at the 12 study sites. Most of the improvements recommended can be performed by IDOT's maintenance department. A wrong-way inspection team should be established to conduct field checks for some high crash freeway segments. System-wide countermeasures and/or strategies can then be developed and implemented. The systematic approach will allow review of high crash freeway segments within a county or an IDOT district.

Advanced signage and wrong-way detection and warning systems can also be considered for installation at some locations. Research in other states indicates that some ITS countermeasures have proven successful in reducing wrong-way driving and wrong-way crash frequency. A comprehensive evaluation of the effectiveness of the wrong-way countermeasures implemented is necessary.

The researchers received and recorded the latest wrong-way crashes reports from IDOT project managers and the ISP while conducting this research in 2011 and 2012. Monitoring of wrong-way driving reports should be undertaken on a monthly basis through coordinating with the ISP and traffic management centers in the Chicago and east St. Louis urban areas. The monthly reports could be used to help IDOT districts track problematic ramp terminals and corridors where wrong-way crashes have occurred. Further research is also needed to develop procedures for traffic management center operators in responding to wrong-way driving reports.

In this project, a pilot study found that the possibility of wrong-way driving had a strong relationship with nighttime traffic volume distribution at the ramp terminals. A probability model can be developed to estimate the chance of wrong-way driving at specific ramp terminals. The model can be used to guide selection of locations for installing advanced signage and detection system at the locations with no historical crash data.

It was also found that a large portion of wrong-way crashes occurred on non-freeway roads. These crashes resulted in many fatal and severe injury crashes as well. However, the contributing factors, traffic operation, and control on non-freeway roads are different from those on freeways; therefore, a study of wrong-way crashes on non-freeway roads is highly recommended as a means to improve safety on Illinois roads.

As discussed at the final TRP meeting on May 18, 2012, most members believe a nationwide peer-to-peer workshop to collect more ideas on wrong-way countermeasures would be helpful. Current practices for preventing wrong-way freeway crashes can be presented at a conference. A guidebook for developing wrong-way driving countermeasures can also be developed. Training classes or materials can be provided to designers, especially new engineers.

REFERENCES

American Association of State Highway and Transportation Officials (AASHTO) (2011). *A policy on geometric design of highways and streets*. Washington DC: AASHTO.

Braam, A.C. (2006). W*rong-way crashes: Statewide study of wrong-way crashes on freeways in North Carolina.* Traffic Engineering and Safety System Branch, North Carolina Department of Transportation.

Cooner, S.A., A.S. Cothron, and S.E. Ranft (2004). *Countermeasures for wrong-way movement on freeways: Guidelines and recommended practices*. College Station: Texas Transportation Institute.

Cooner, S.A., and S. E. Ranft (2008). "Wrong-way driving on freeways: problems, issues and countermeasures." 2008 Annual Meeting of the Transportation Research Board, Washington, DC.

Copelan, J.E. (1989). *Prevention of wrong-way accidents on freeways.* Sacramento: California Department of Transportation.

Bayerische Motoren Werke (BMW) AG (2007). "Advance warning of drivers heading in the wrong direction—the "wrong-way driver" information." Press release. https://www.press.bmwgroup.com/pressclub/p/pcgl/pressDetail.html?outputChannelId=6&id=T0012266EN&left_menu_item=node__2374 (accessed January 18, 2011).

Federal Highway Administration (2006). Guidance: Highway Safety Improvement Program 23 U.S.C 148(c)(1)(D) "5 Percent Report." April 5. http://safety.fhwa.dot.gov/safetealu/guides/guide040506.cfm (accessed October 2012).

Howard, C. (1980). Wrong-way driving at selected interstate off-ramps. Charlottesville: Virginia Highway & Transportation Research Council. http://www.virginiadot.org/vtrc/main/online_reports/pdf/81-r30.pdf (accessed July 9, 2012).

Illinois Department of Transportation (IDOT) (2010). *Bureau of Design & Environment Manual.* Springfield: IDOT.

Institute of Traffic Accident Research and Data Analysis (ITARDA) (2002). *Highway accidents involving dangerous wrong-way traveling.* Tokyo: ITARDA.

Lathrop, S.L., T.B. Dick, and K.B. Nolte (2010). "Fatal Wrong-Way Collisions on New Mexico's Interstate Highways, 1990–2004." *Journal of Forensic Sciences,* 55(2):432–437.

Lansche, U. (2005). *Detecting motorists driving against the traffic*. Oppenweiler, Germany: Matrix Vision GmbH. http://www.matrix-vision.com/professional-article/items/detecting-motorists-driving-against-the-traffic.html?file=tl_files/mv11/Articles/EA05_Matrix_en.pdf (accessed July 9, 2012).

Laurie, N.E., S. Zhang, R. Mundoli, S.A. Duffy, J. Collura, and D.L. Fisher (2004). "An evaluation of alternative Do Not Enter signs: Failures of attention." *Transportation Research,* Part F 7(1):151–166.

Leduc, J. (2008). *Wrong-way driving countermeasures* Hartford, CT: Office of Legislative Research. http://www.cga.ct.gov/2008/rpt/2008-r-0491.htm (accessed January 17, 2011).

Miles, J.D., P.J. Carlson, B. Ullman, and N. Trout (2008). "Driver understanding of the purpose of red retroreflective raised pavement markings." *Compendium of the Transportation Research Board 2008 Annual Meeting*, Washington, DC, Jan. 10–14, 2008.

Moler, S. (2002). "Stop. You are going the wrong way!" *Public Roads*, 66(2):110.

Neuman, T.R., J.J. Nitzel, N. Antonucci, S. Nevill, and W. Stein (2008). *NCHRP Report 500: Guidance for Implementation of the AASHTO Strategic Highway Safety Plan.* Washington, DC: Transportation Research Board.

North Texas Tollway Authority (NTTA) (2009). *Keeping NTTA roadways safe: Wrong-way driver task force staff analysis*. Plano: NTTA.

Scaramuzza, G., and M. Cavegn (2007). "Wrong-way drivers: Extent-interventions." *The European Transport Conference*, The Netherlands, Oct. 17–19, 2007.

Schrock, S.D., H.G. Hawkins Jr., and S.T. Chrysler (2005). "Effectiveness of lane direction arrows as pavement markings in reducing wrong-way movements on two-way frontage roads." *Transportation Research Record: Journal of Transportation Research Board,* No. 1918: 63–67.

Shepard, F.D. (1975). *Evaluation of raised pavement markers for reducing incidences of wrong-way driving.* Charlottesville: Virginia Highway and Transportation Research Council.

Stichting Wetenschappelijk Onderzoek Verkeersveiligheid (SWOV) (2007). *SWOV fact sheet: Wrong-way driving.* Leidschendam, the Netherlands: SWOV.

Topolsec, M.D. (2009). *Dynamic model of measures for reducing the number of road accidents due to wrong-way movement on freeways*. Maribor, Republic of Slovenia: Centre for Interdisciplinary and Multidisciplinary Studies and Research.

Vaswani, N.K. (1973). *Measures for preventing wrong-way entries on highways.* Charlottesville: Virginia Highway Research Council.

Vicedo, P. (2006). "Prevention and management of ghost drivers incidents on motorways: The French experience the contribution of ITS to immediate detection and optimum management of ghost drivers incidents." The European Association of Motorway Concessionaries, Pula, Croatia, May 21–24, 2006.

Williams, C. (2006). *Pensacola Bay Bridge wrong way detection system*. Chipley: Florida Department of Transportation. http://www.dot.state.fl.us/trafficoperations/pdf/District%20Presentations/pdf/District_3.pdf (accessed January 19, 2011).

APPENDIX A LIST OF VARIABLES FOR IDOT CRASH DATABASE

Table A.1. List of Variables in Crash File

Number	Field name	Type	Note	Number	Field name	Type	Note
1	Casenum	Text		36	Intersection related	Text	Y/N
2	CrashID	Numeric		37	Hit and run	Text	Y/N
3	County code	Numeric		38	Crash date	Text	
4	Crash Year	Text		39	Number of lanes	Numeric	
5	Crash month	Numeric		40	Alignment code	Numeric	
6	Crash day	Numeric		41	Trafficway description Code	Numeric	
7	Nbr of Vehicles	Numeric		42	Roadway functional class	Numeric	
8	Day of Week	Numeric		43	Work Zone related	Text	Y/N
9	Hour	Numeric		44	City_township flag	Text	
10	City Code	Numeric		45	Crash coordinate Y	Text	
11	City Class code	Numeric		46	Crash coordinate X	Text	
12	Township	Numeric		47	Crash latitude	Text	
13	Collision type code	Numeric		48	Crash longitude	Text	
14	Total killed	Numeric		49	County name	Text	For field 3
15	Total injured	Numeric		50	Day of Week	Text	
16	No injuries	Numeric		51	Type of crash	Text	For field 13
17	A-injuries	Numeric		52	City name	Text	For field 10
18	B-injuries	Numeric		53	City class	Text	For field 11
19	C-injuries	Numeric		54	Class of trafficway	Text	For field 24
20	Crash severity	Text		55	Cause1	Text	For field 31
21	Agency code	Text		56	Cause2	Text	For field 32
22	Route number	Numeric		57	Traffic Device	Text	For field 26
23	Milestation	Numeric		58	Device condition	Text	For field 35
24	Class of trafficway	Numeric		59	Roadway surface	Text	For field 27
25	National Highway System	Text	Y/N	60	Road defects	Text	For field 28
26	Traffic control device code	Numeric		61	Crash injury severity	Text	See field 68
27	Road surface condition code	Numeric		62	Light condition	Text	For field 29
28	Road defects code	Numeric		63	Weather code	Text	For field 30
29	Light condition code	Numeric		64	Alignment	Text	For field 40
30	Weather code	Numeric		65	Trafficway description	Text	For field 41
31	Cause 1 code	Numeric		66	Roadway functional class description	Text	For field 42
32	Cause 2 code	Numeric		67	Investigating agency description	Text	For field 21
33	Railroad crossing number	Text		68	Crash injury severity code	Numeric	For field 61
34	Time of crash	Text		69	Property description 1	Text	
35	Traffic control condition code	Numeric		70	Property description 2	Text	

Table A.2. List of Variables in Vehicle File

Number	Field Name	Type	Note	Number	Field Name	Type	Note
1	Case number	Text		21	LOC2	Numeric	Second event location
2	Unit_No	Numeric		22	LOC3	Numeric	Third event location
3	VIN11	Text	VIN w/o serial number	23	First_Contact	Numeric	Point of first contact
4	No_of_occupants	Numeric		24	Direction_Prior	Text	For field 9
5	VEHT	Numeric	Vehicle type	25	Vehicle_Defects	Text	For field 7
6	VEHU	Numeric	Vehicle use	26	Vehicle_Maneuver	Text	For field 8
7	VEHD	Numeric	Vehicle defects	27	Vehicle_Type	Text	For field 5
8	MANV	Numeric	Vehicle maneuver	28	Vehicle_Use	Text	For field 6
9	DIRP	Numeric	Direction prior to crash	29	Most Harm Event	Text	
10	TOW	Text	Y/N	30	Most Harm EventLoc	Text	
11	FIRE IND	Text	Y/N	31	Event 1	Text	For field 17
12	HAZMAT	Text	Y/N	32	Event 2	Text	For field 18
13	CV IND	Text	Y/N	33	Event 3	Text	For field 19
14	Most_Harmful_Event	Numeric		34	Loc 1	Text	For field 20
15	Location_of_Most_Harmful	Numeric		35	Loc 2	Text	For field 21
16	Most_Harmful_EventNo	Numeric		36	Loc 3	Text	For field 22
17	EVNT1	Numeric	First event	37	Vehicle Model Year	Numeric	
18	EVNT2	Numeric	Second event	38	Vehicle Make	Text	
19	EVNT3	Numeric	Third event	39	Vehicle Model	Text	
20	LOC1	Numeric	First event location				

Table A.3. List of Variables in Person File

Number	Field Name	Type	Note	Number	Field Name	Type	Note
1	Case number	Text		17	EMS	Text	
2	Person_Type	Numeric		18	Hospital	Text	
3	UnitNo	Numeric		19	PPA	Numeric	Pedestrian action
4	DOB	Date/time	mm/dd/yyyy	20	PPL	Numeric	Pedestrian location
5	Age	Numeric		21	PEDV	Numeric	Pedestrian/bike visibility
6	Sex	Text	M/F	22	Description	Text	For field 2
7	Driver_License_State	Text		23	Ped_Bike_visibility	Text	For field 21
8	DRAC	Numeric	Driver condition	24	Driver condition	Text	For field 8
9	BAC	Numeric	BAC of driver	25	Air_Bag_Deployed	Text	For field 15
10	VIS	Numeric	Driver vision	26	PED_Action	Text	For field 19
11	DRVA	Numeric	Driver action	27	Driver_BAC_Test	Text	For field 9
12	SEAT_NO	Numeric	Seating position	28	Ejection	Text	For field 16
13	INJ	Numeric	Injury severity	29	Driver_Action	Text	For field 11
14	SAFT	Numeric	Safety equipment	30	PED_Location	Text	For field 20
15	AIR	Numeric	Air bag deployment	31	Driver _Vision	Text	For field 10
16	EJCT	Numeric	Extricated/ejected	32	Safety_equipment	Text	For field 14

APPENDIX B FIGURES FOR WRONG-WAY CRASH DATA ANALYSIS

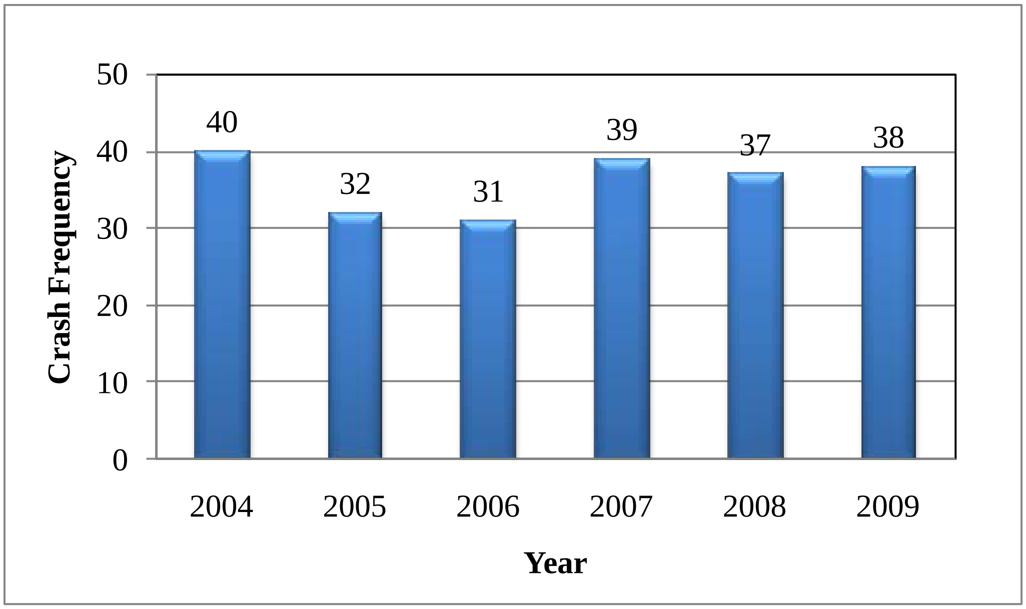


Figure B.1. Annual distribution of wrong-way crashes.

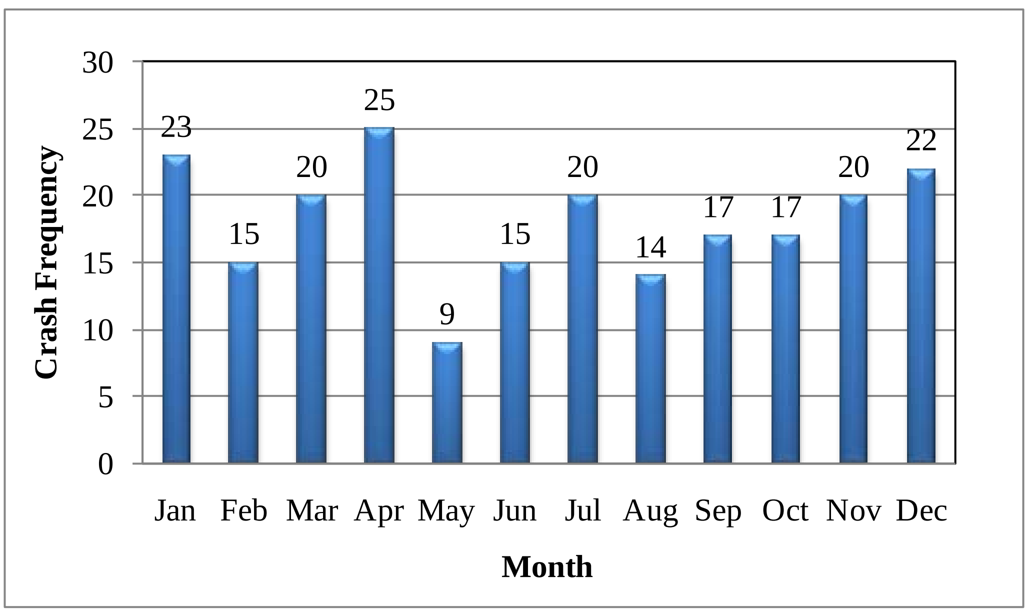


Figure B.2. Monthly distribution of wrong-way crashes.

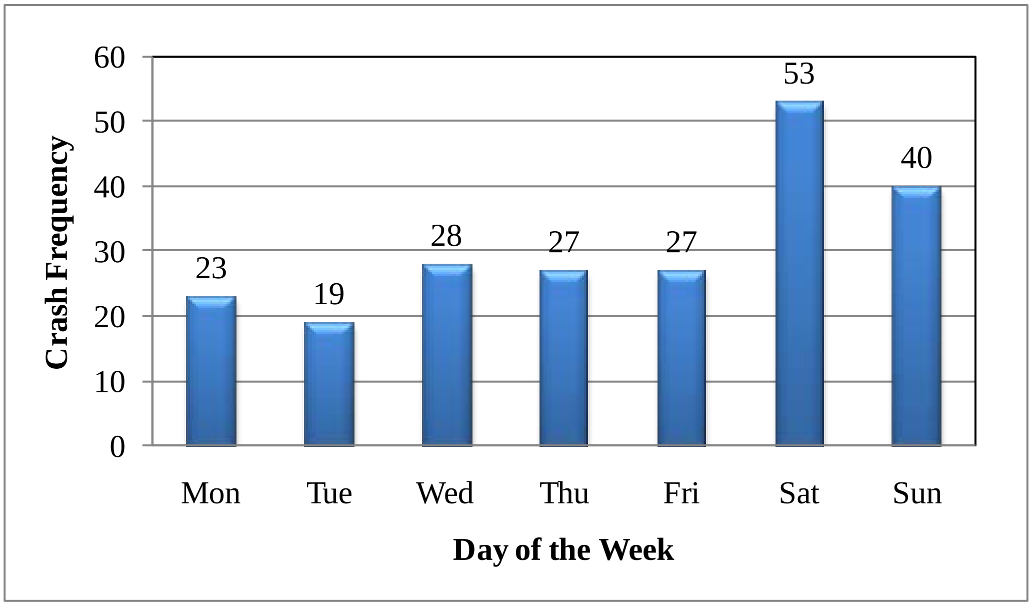


Figure B.3. Weekly distribution of wrong-way crashes.

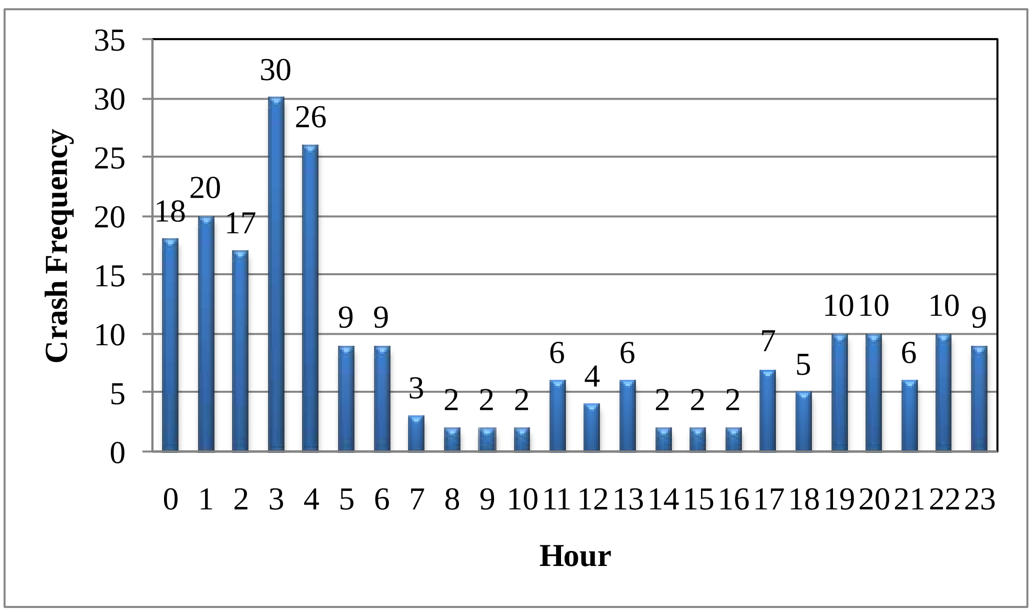


Figure B.4. Hourly distribution of wrong-way crashes.

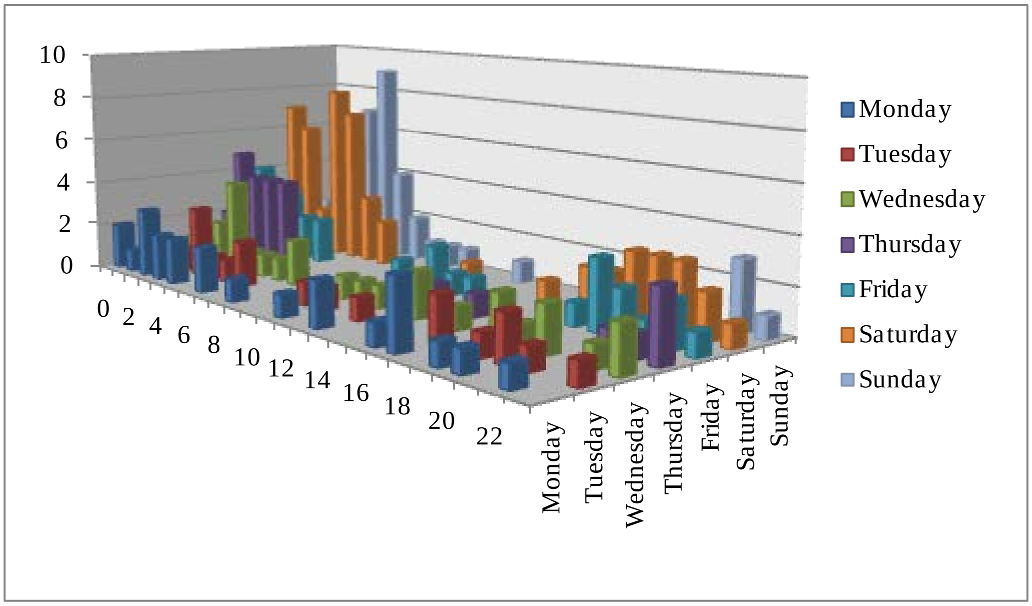


Figure B.5. Temporal distribution of wrong-way crashes.

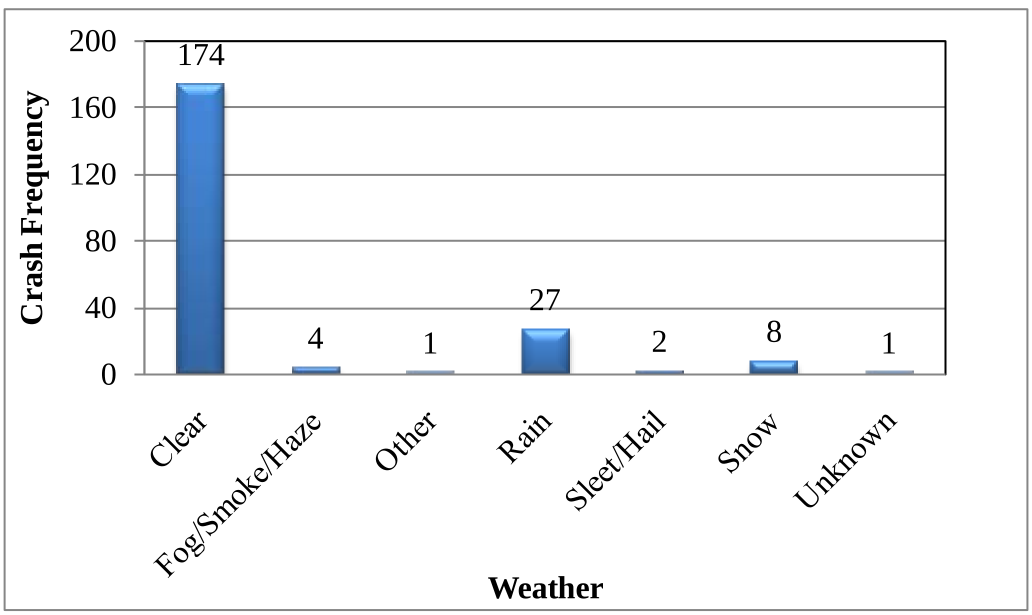


Figure B.6. Weather condition for wrong-way crashes.

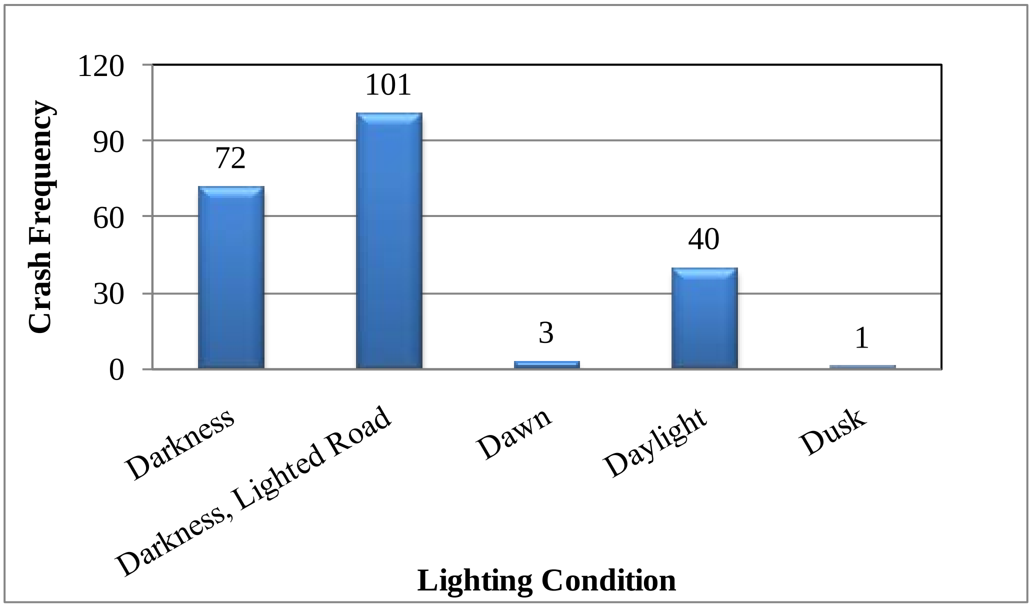


Figure B.7. Lighting condition for wrong-way crashes.

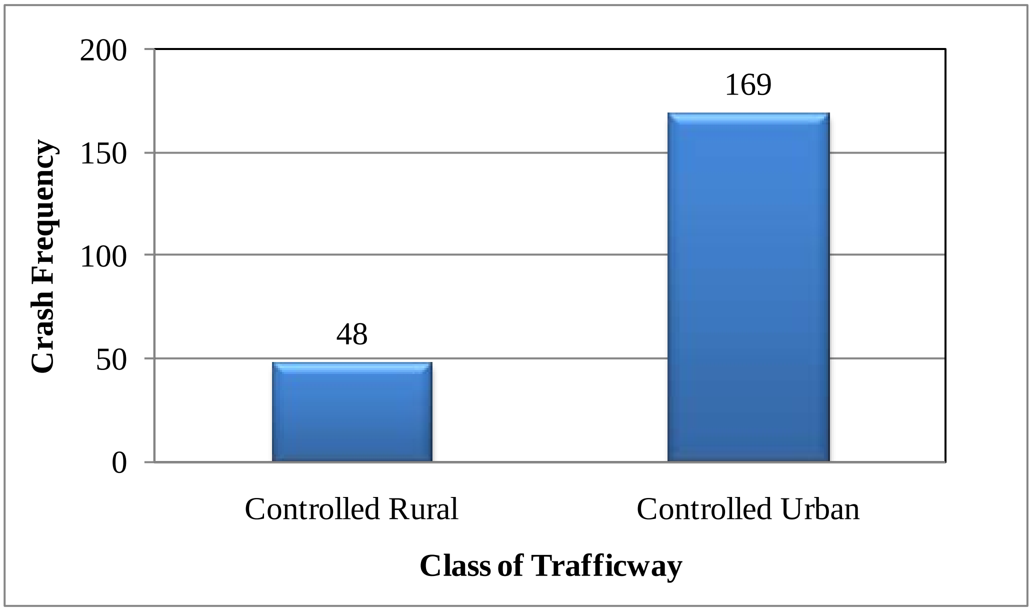


Figure B.8. Class of trafficway for wrong-way crashes.

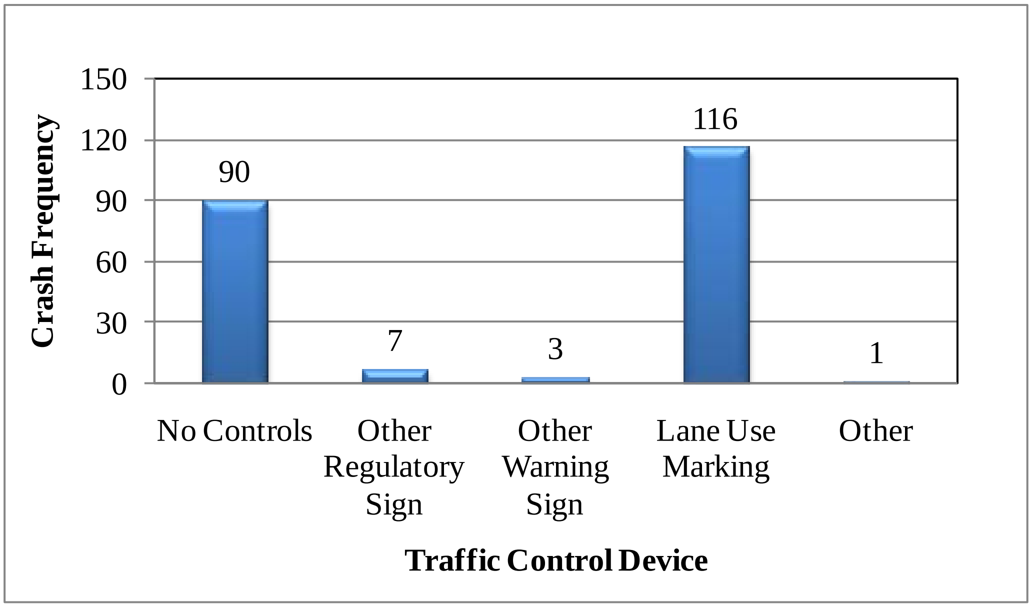


Figure B.9. Traffic control device presence for wrong-way crashes.

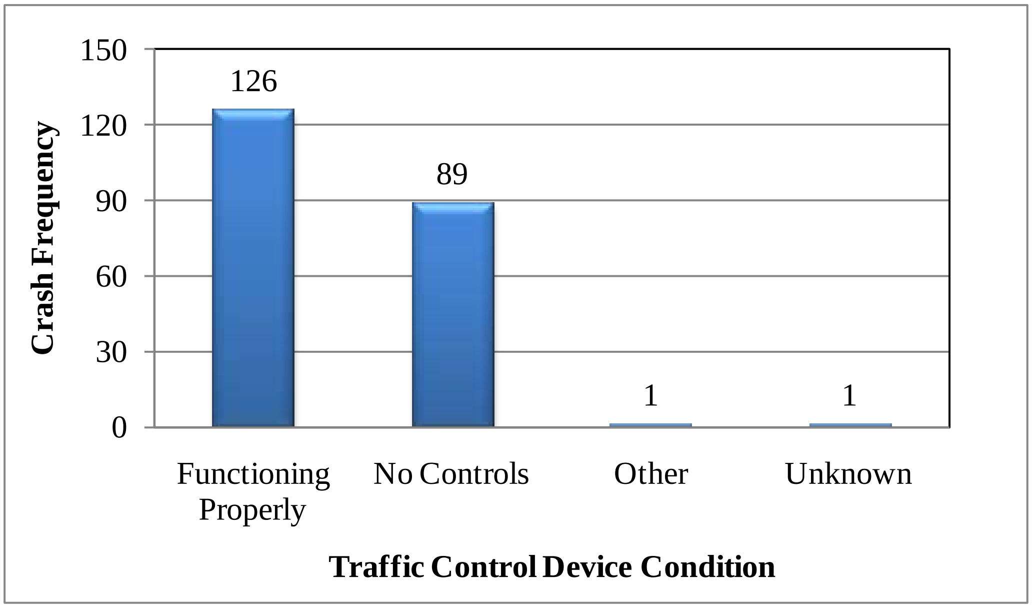


Figure B.10. Traffic control device operating condition for wrong-way crashes.

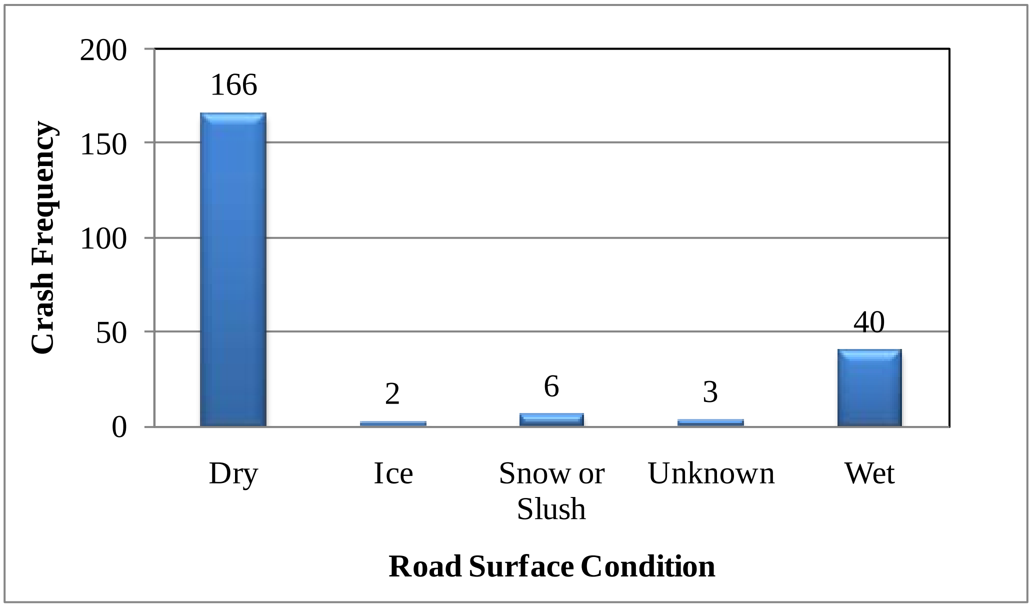


Figure B.11. Road surface condition for wrong-way crashes.

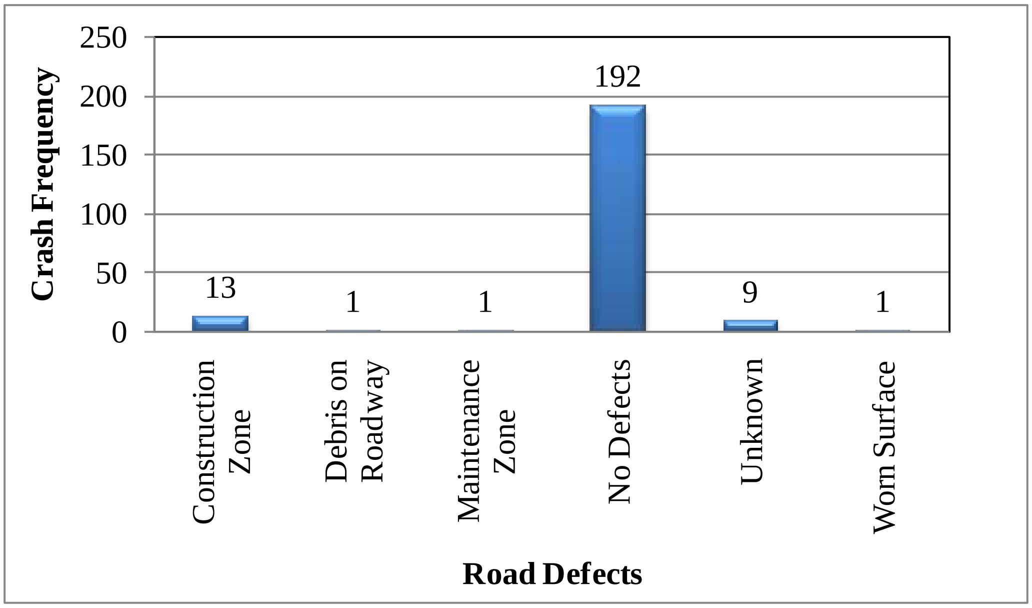


Figure B.12. Road defects–related wrong-way crashes.

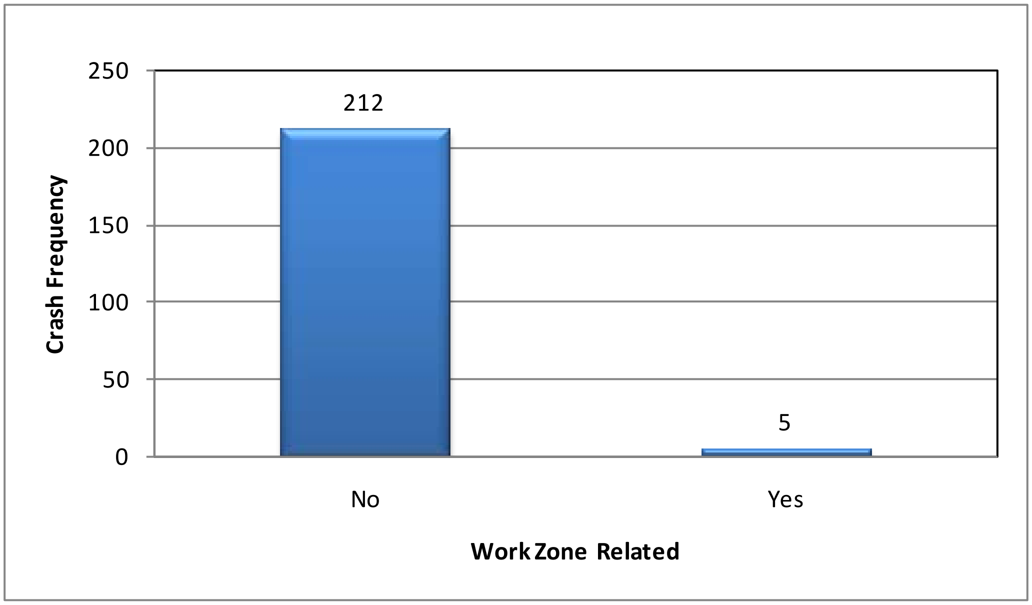


Figure B.13. Work zone–related wrong-way crashes.

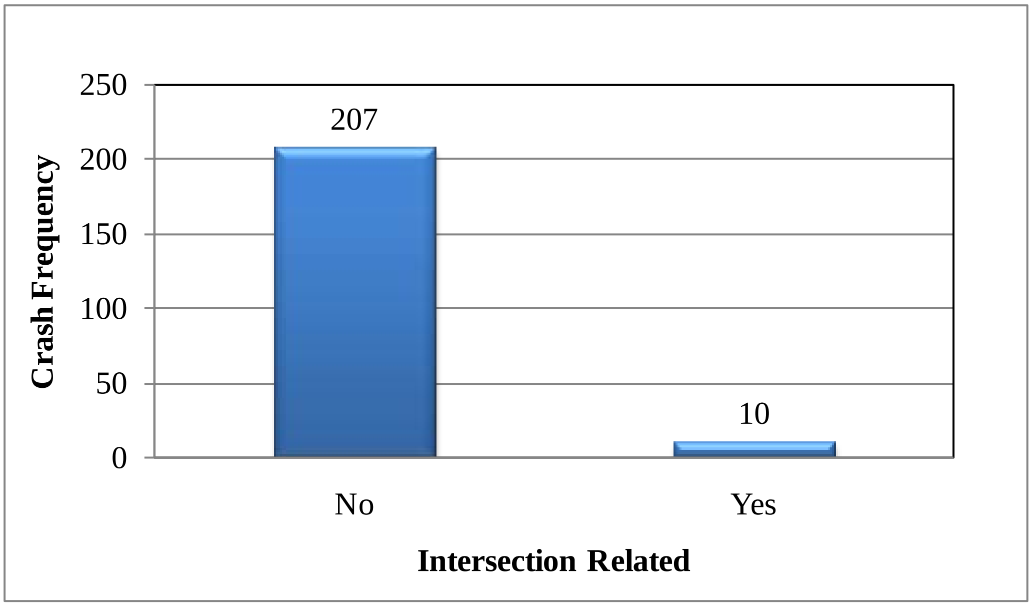


Figure B.14. Relationship between intersections and wrong-way crashes.

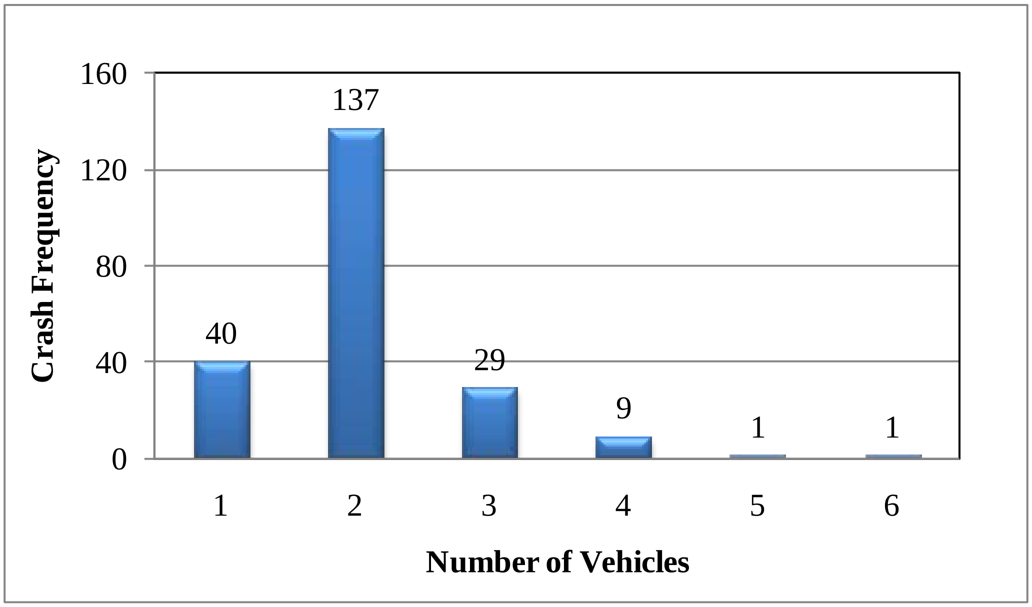


Figure B.15. Number of vehicles involved in wrong-way crashes.

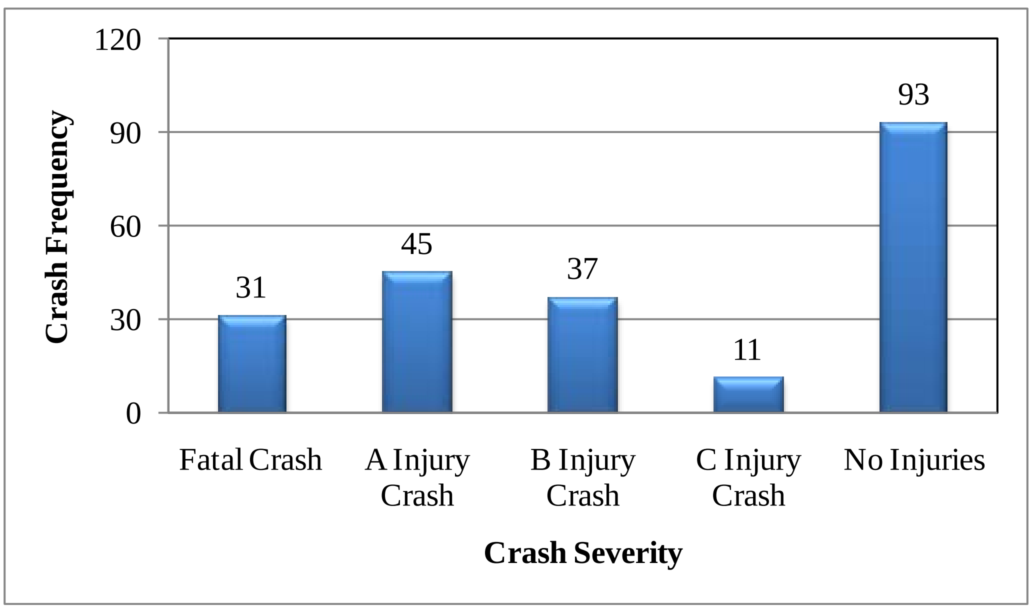


Figure B.16. Wrong-way crash severity.

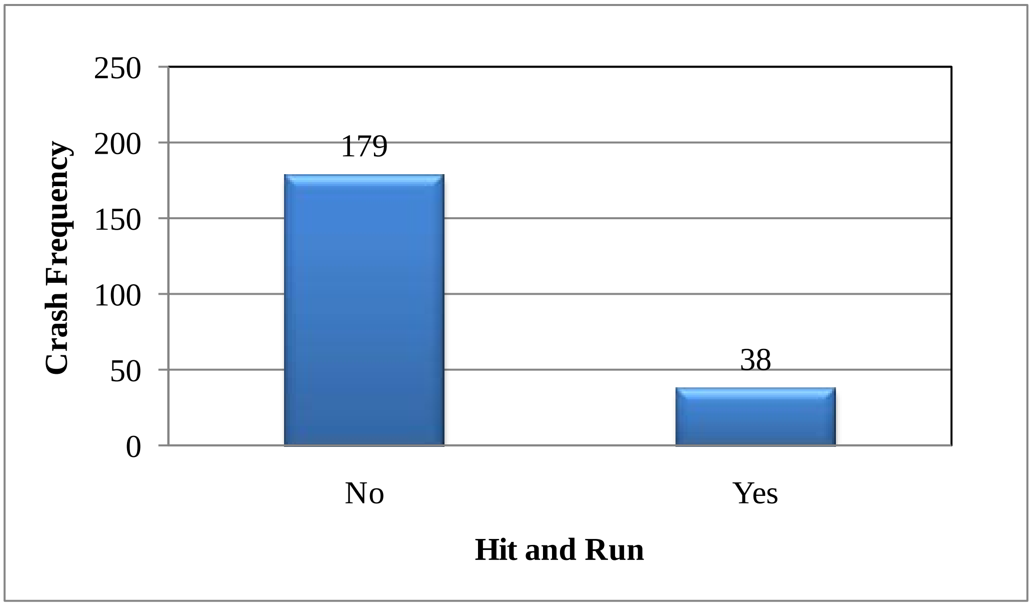


Figure B.17. Hit-and-run for wrong-way crashes.

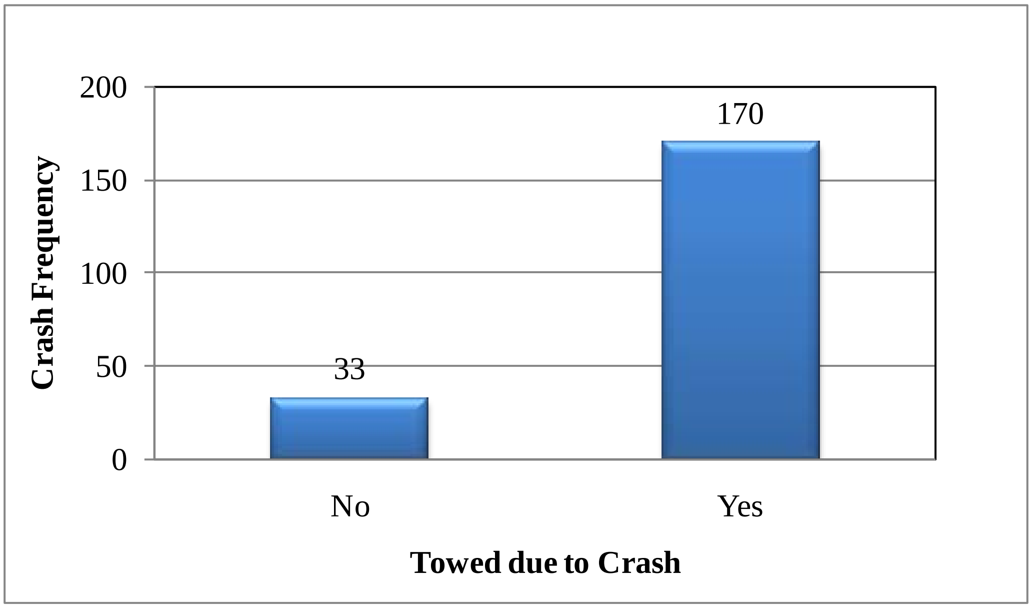


Figure B.18. Towed due to crash for wrong-way crashes.

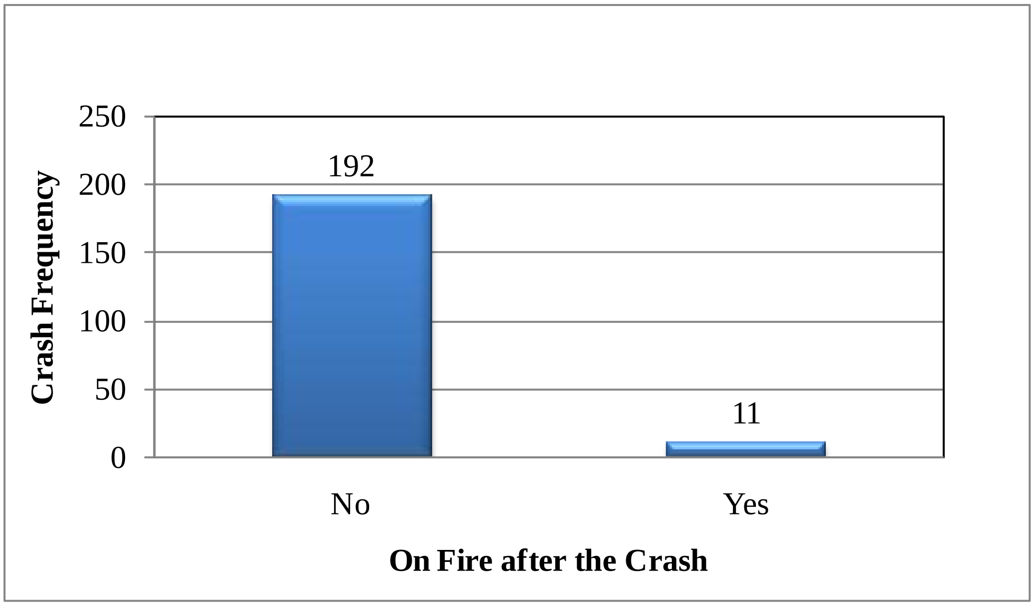


Figure B.19. Number of vehicles on fire after wrong-way crashes.

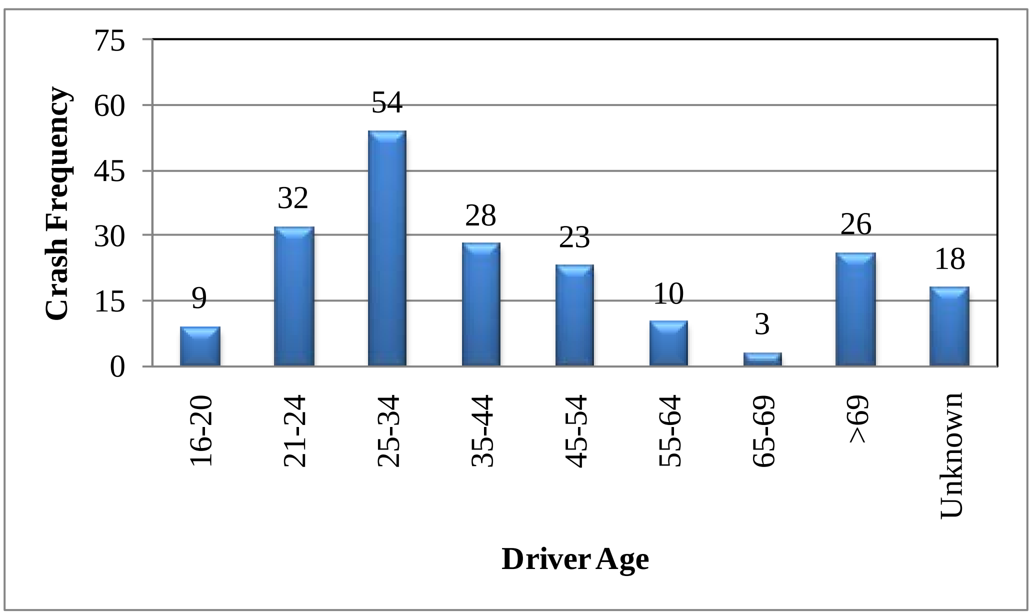


Figure B.20. Wrong-way driver age group.

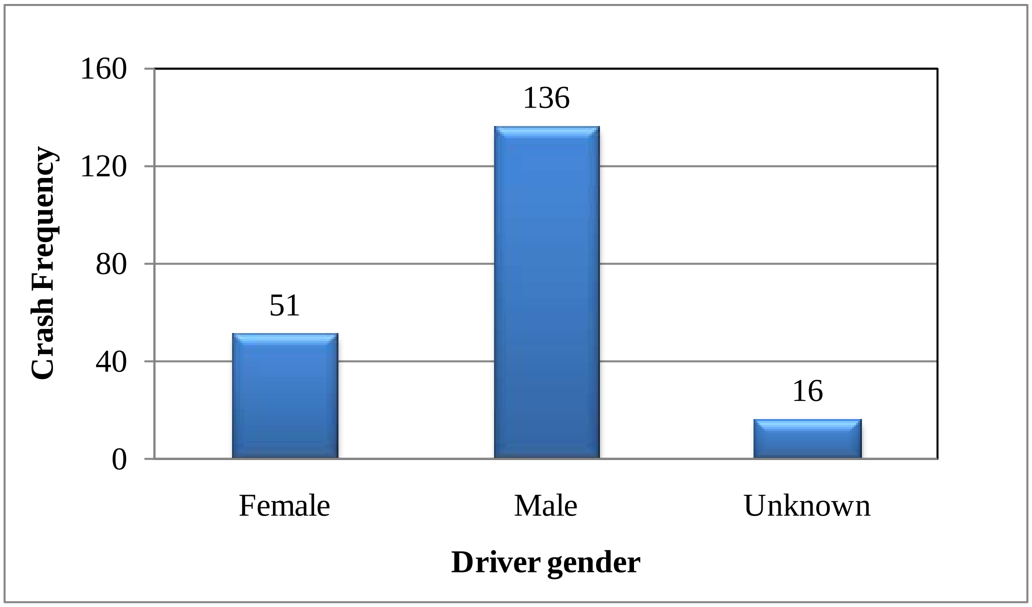


Figure B.21. Wrong-way driver gender distribution.

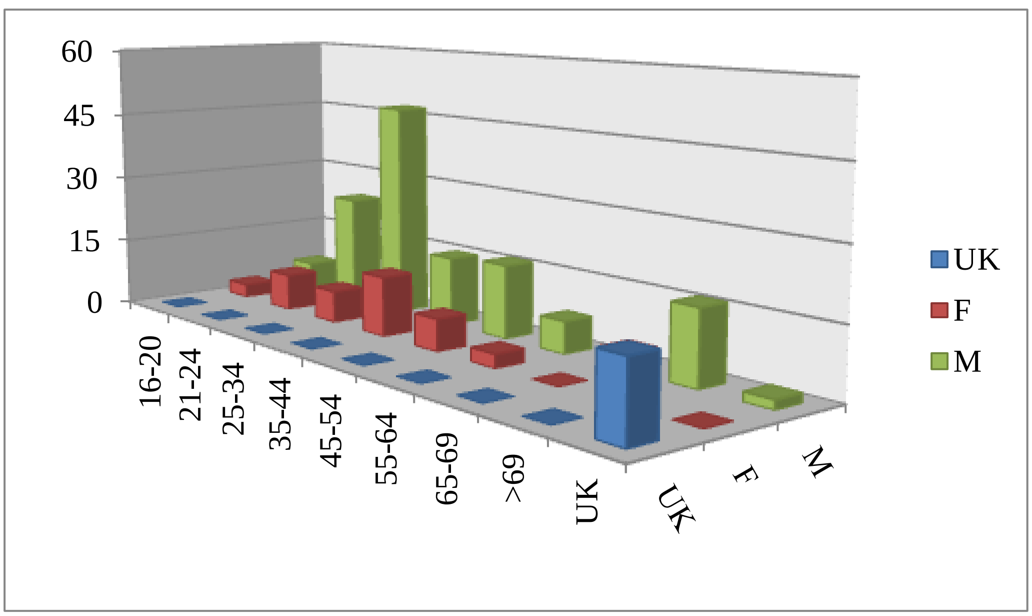


Figure B.22. Relationship between wrong-way driver age group and gender.

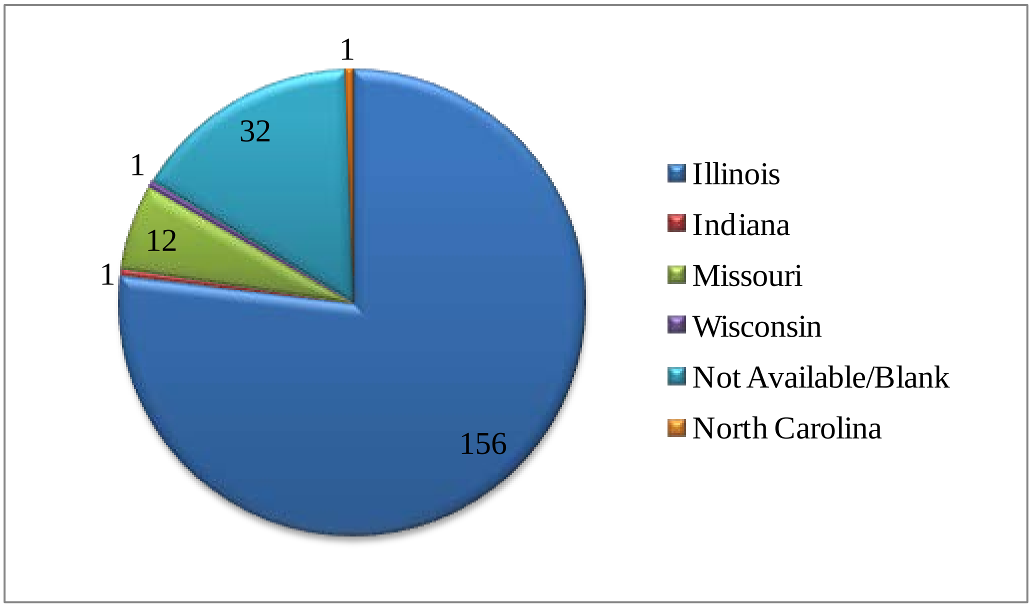


Figure B.23. Licensed state for wrong-way drivers.

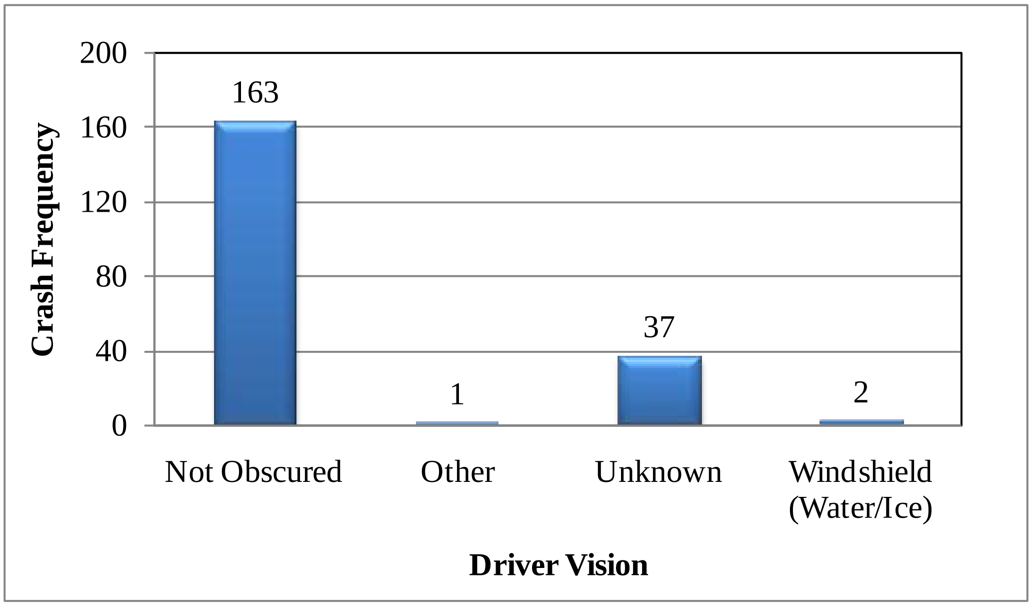


Figure B.24. Wrong-way driver vision.

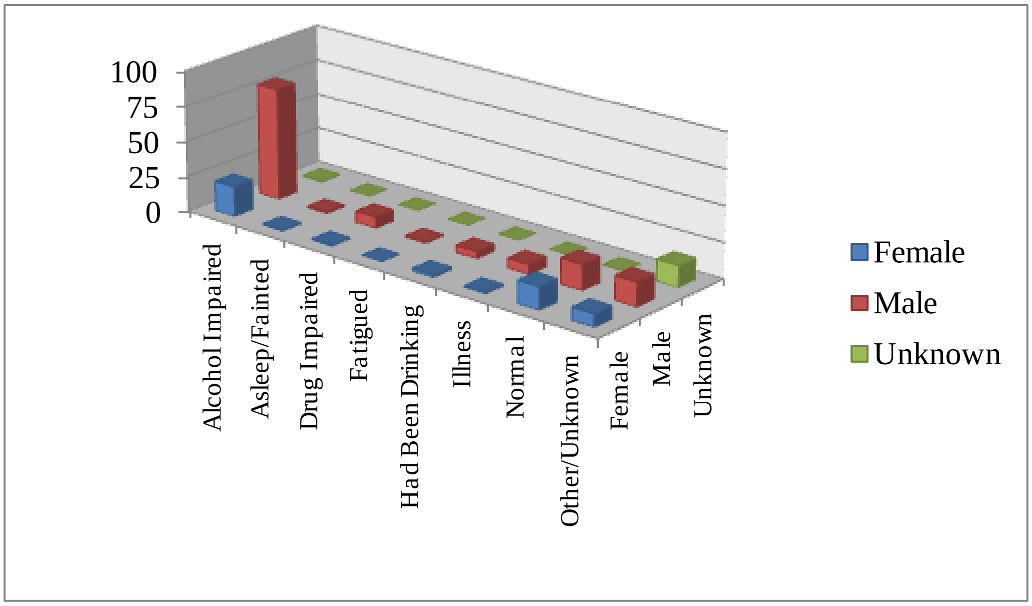


Figure B.25. Relationship between driver gender and condition.

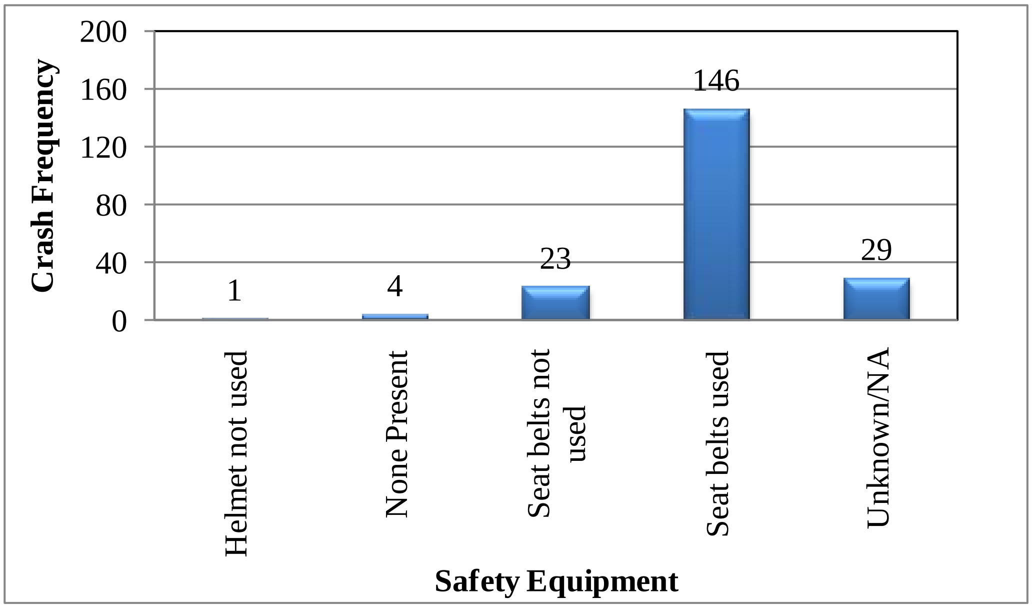


Figure B.26. Safety equipment used by wrong-way drivers.

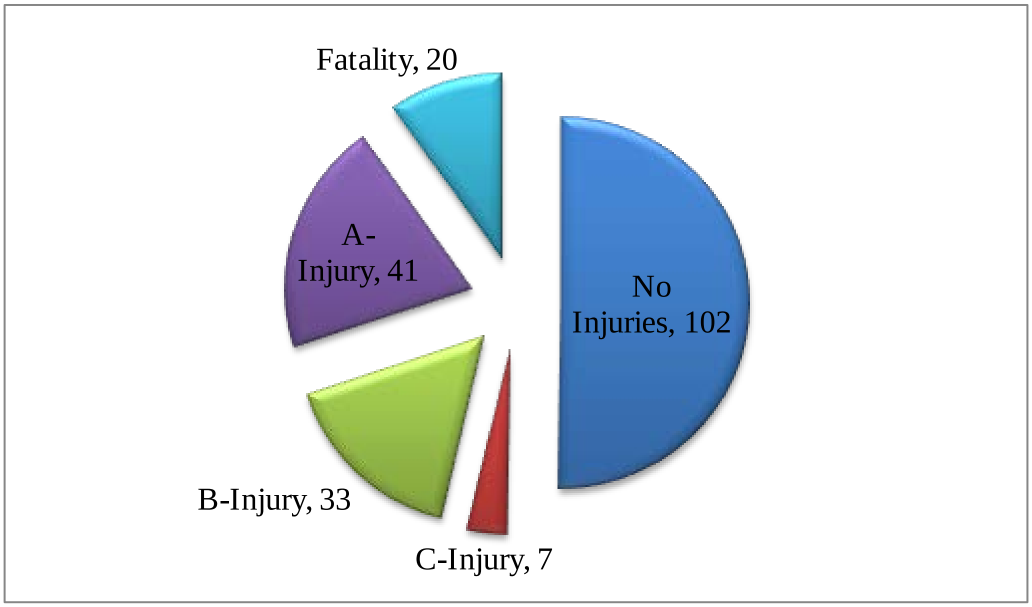


Figure B.27. Injury severity level for wrong-way drivers.

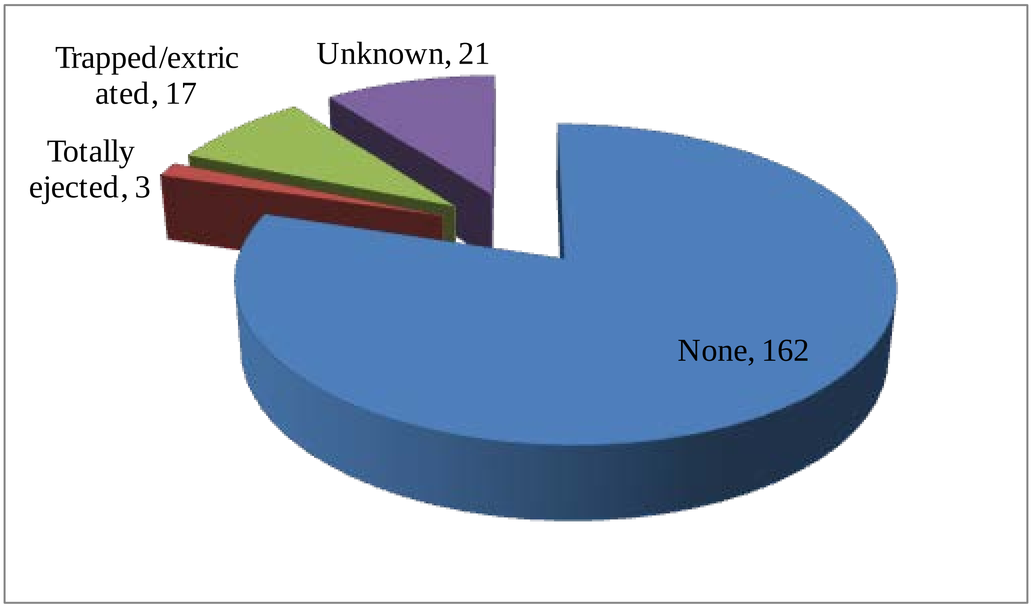


Figure B.28. Ejection results for wrong-way drivers.

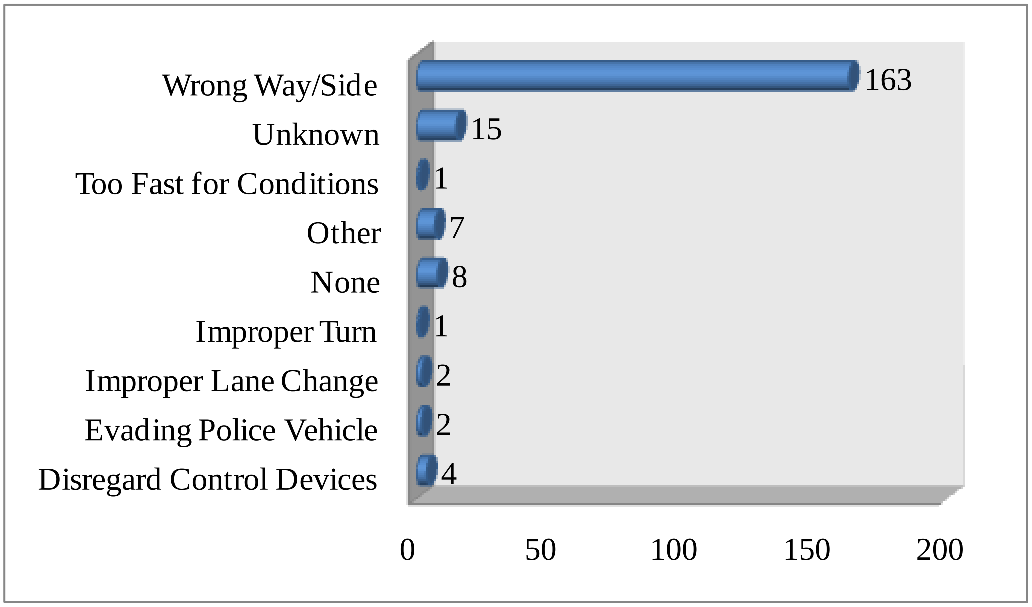


Figure B.29. Driver action for wrong-way drivers.

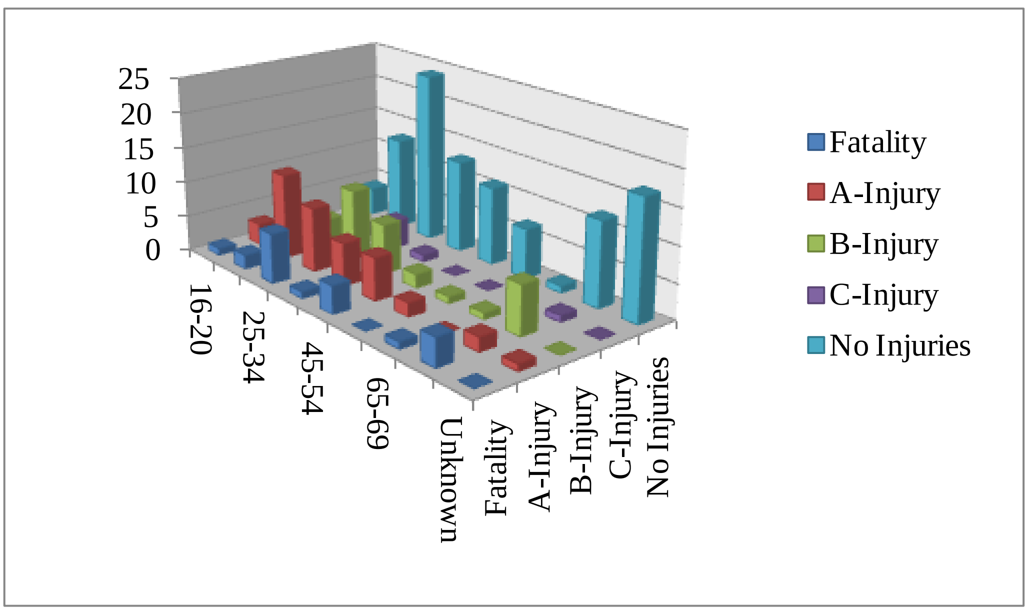


Figure B.30. Relationship between driver injury severity level and driver age group.

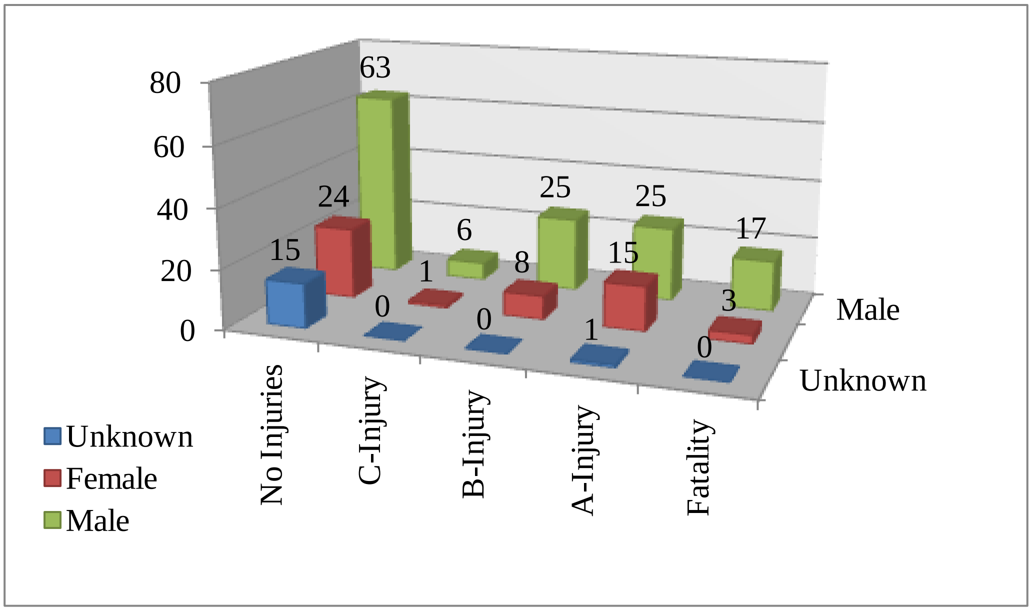


Figure B.31. Relationship between driver injury severity level and driver gender.

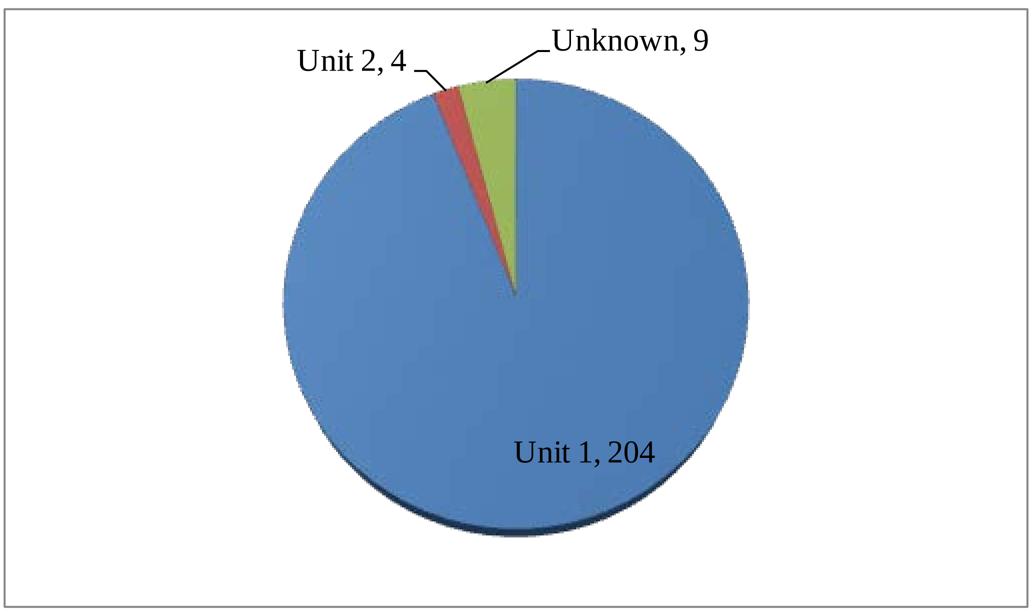


Figure B.32. Wrong-way vehicle distribution.

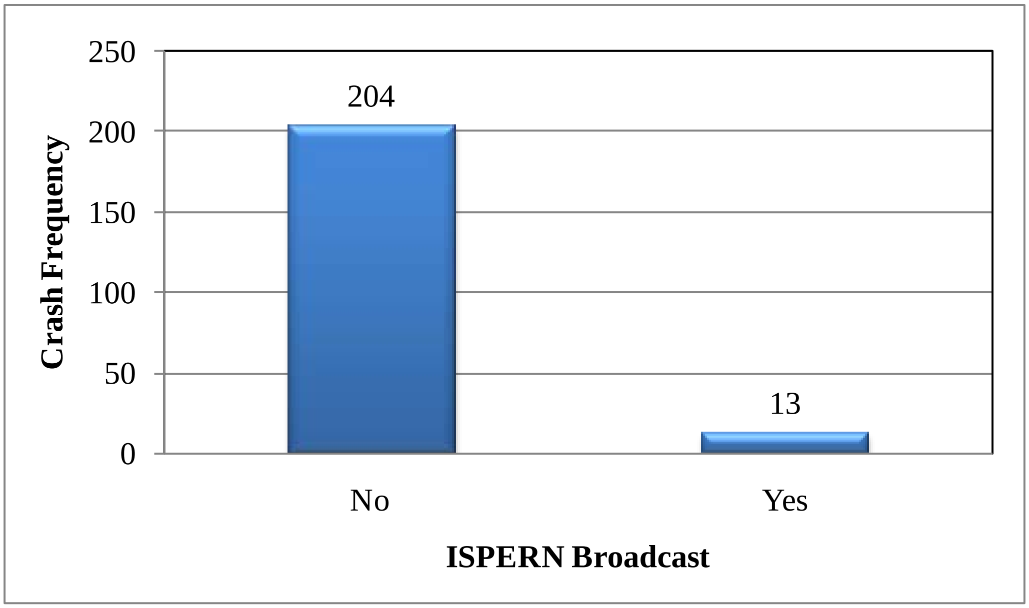


Figure B.33. ISPERN broadcast in wrong-way crashes.

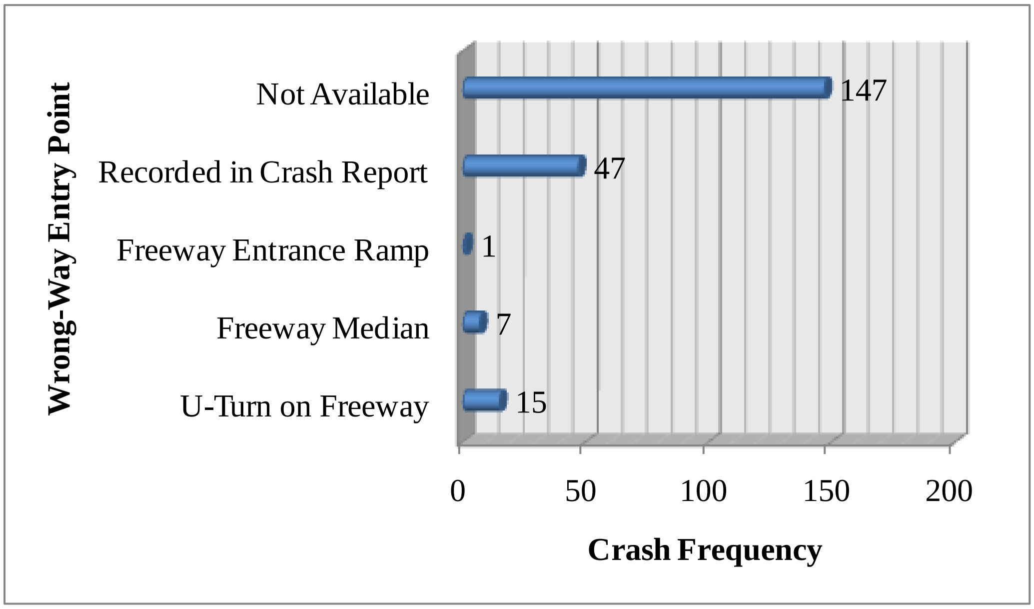


Figure B.34. Entry point type for wrong-way crashes.

APPENDIX C TABLES FOR WRONG-WAY CRASH DATA ANALYSIS

Table C.1. Route Distribution for Wrong-Way Crashes

Route Name	Route Number	Frequency	Category
I-55	9055	42	Interstate
I-94	9094	32	Interstate
I-57	9057	21	Interstate
I-74	9074	17	Interstate
I-64	9064	16	Interstate
I-290	9290	12	Interstate
US 41	1041	11	US Route
I-80	9080	9	Interstate
I-255	9255	8	Interstate
I-270	9270	7	Interstate
I-90	9090	6	Interstate
US 20	1020	5	US Route
I-70	9070	5	Interstate
I-72	9072	3	Interstate
IL 171	5171	3	Illinois Route
E Palatine Road	8182	3	Non-marked Route
IL 3	5003	2	Illinois Route
I-90/I-94	8208	2	Non-marked Route
I-39	9039	2	Interstate
US 51	1051	1	US Route
IL 8	5008	1	Illinois Route
IL 38	5038	1	Illinois Route
IL 394	5394	1	Illinois Route
Elgin–O'Hare Expressway	8220	1	Non-marked Route
I-88	9088	1	Interstate
I-172	9172	1	Interstate
I-180	9180	1	Interstate
I-190	9190	1	Interstate
I-355	9355	1	Interstate
I-474	9474	1	Interstate
Total		**217**	

Table C.2. County Distribution of Wrong-Way Crashes

Ranking	County Name	Frequency	Ranking	County Name	Frequency
1	Cook	82	15	Vermilion	2
2	St. Clair	21	15	Williamson	2
3	Madison	20	25	Adams	1
4	Will	14	25	Bond	1
5	Champaign	6	25	Clark	1
5	Mclean	6	25	Clinton	1
5	Tazewell	6	25	Douglas	1
8	Winnebago	5	25	Effingham	1
9	DuPage	3	25	Fayette	1
9	Lake	3	25	Grundy	1
9	LaSalle	3	25	Kane	1
9	Peoria	3	25	Kankakee	1
9	Sangamon	3	25	Knox	1
9	Union	3	25	Marion	1
15	Franklin	2	25	Marshall	1
15	Iroquois	2	25	Ogle	1
15	Logan	2	25	Pike	1
15	Macon	2	25	Putnam	1
15	Macoupin	2	25	Wayne	1
15	Monroe	2	25	White	1
15	Montgomery	2	25	Whiteside	1
15	Rock Island	2			

Table C.3. City Class for Wrong-Way Crashes

City Class	Crash Frequency
Population under 2,500	10
2,500 to 5,000	5
5,000 to 10,000	10
10,000 to 25,000	24
25,000 to 50,000	20
50,000 and over	17
Chicago	56
Unincorporated	75
Total	**217**

Table C.4. City Distribution of Wrong-Way Crashes

Ranking	City Name	Frequency	Ranking	City Name	Frequency
1	Blank	75	18	Granite City	1
2	Chicago	56	18	Hamel	1
3	East St Louis	7	18	Hennepin	1
4	East Peoria	5	18	Joliet	1
5	Forest Park	4	18	Kankakee	1
5	Rockford	4	18	Lynnwood	1
7	Champaign	3	18	Marion	1
7	Collinsville	3	18	Matteson	1
7	Justice	3	18	Maywood	1
7	Shiloh	3	18	Moline	1
11	Addison	2	18	Normal	1
11	Bolingbrook	2	18	Oakbrook Terrace	1
11	Caseyville	2	18	Peru	1
11	Forest View	2	18	Pesotum	1
11	Highland Park	2	18	Pontoon Beach	1
11	Morton Grove	2	18	Prospect Heights	1
11	Peoria	2	18	Romeoville	1
18	Alton	1	18	Rosemont	1
18	Arcola	1	18	Roxana	1
18	Bethalto	1	18	Schaumburg	1
18	Braidwood	1	18	Sherman	1
18	Calumet City	1	18	Skokie	1
18	Centreville	1	18	Stickney	1
18	Columbia	1	18	Troy	1
18	Decatur	1	18	Urbana	1
18	Downs	1	18	Washington Park	1
18	Elgin	1	18	Wheeling	1
18	Fairmont	1	18	White City	1
18	Fairview Heights	1			

Table C.5. Collision Type for Wrong-Way Crashes

Collision Type	Frequency
Head-On	99
Sideswipe Opposite Direction	47
Fixed Object	31
Rear End	8
Sideswipe Same Direction	8
Overturned	6
Other Non-Collision	5
Other Object	5
Turning	4
Angle	3
Parked Motor Vehicle	1
Total	**217**

Table C.6. Crash Injury Severity for Wrong-Way Crashes

Number of Person Under the Severity Level	Crash					
	Injured					
	Killed	A-Injury	B-Injury	C-Injury	Total Injuries	No Injuries
1	26	36	44	18	63	64
2	1	20	11	3	33	59
3	2	10	7	1	17	13
4	0	0	1	0	7	13
5	2	0	2	0	4	6
6	0	0	1	0	2	1
7	0	0	0	0	0	0
8	0	0	1	0	1	1
51	0	0	0	0	0	1
Subtotal	**44**	**106**	**115**	**27**	**248**	**368**

Table C.7. Crash Severity and Collision Type for Wrong-Way Crashes

Collision Type	Crash Severity Level					
	Fatal	**A-Injury**	**B-Injury**	**C-Injury**	**No Injuries**	**Total**
Head-On	27	32	14	6	20	99
Sideswipe Opposite Direction	3	5	8	2	29	47
Fixed Object	0	4	7	1	19	31
Rear End	0	0	1	1	6	8
Sideswipe Same Direction	0	2	1	0	5	8
Overturned	0	2	2	0	2	6
Other Non-Collision	0	0	2	1	2	5
Other Object	0	0	1	0	4	5
Turning	0	0	1	0	3	4
Angle	1	0	0	0	2	3
Parked Motor Vehicle	0	0	0	0	1	1
Total	**31**	**45**	**37**	**11**	**93**	**217**

Table C.8. Collision Type and Number of Vehicles Involved

Collision Type	# of Vehicles						
	1	**2**	**3**	**4**	**5**	**6**	**Total**
Head-On		75	19	4		1	99
Sideswipe Opposite Direction		40	4	3			47
Fixed Object	28	3					31
Rear End		5	2	1			8
Sideswipe Same Direction		4	2	1	1		8
Overturned	5	1					6
Other Non-Collision	2	3					5
Other Object	5						5
Turning		3	1				4
Angle		2	1				3
Parked Motor Vehicle		1					1
Total	**40**	**137**	**29**	**9**	**1**	**1**	**217**

Table C.9. Contributory Cause for Wrong-Way Crashes

Contributory Cause	Cause 1	Cause 2
Driving on Wrong Side/Wrong Way	118	48
Under Influence of Alcohol/Drugs	55	28
Physical Condition of Driver	13	12
Improper Lane Usage	11	20
Had Been Drinking	5	8
Operating Vehicle in Reckless Manner	4	12
Disregarding Traffic Signals/other Traffic Signs	3	7
Other	2	36
Improper Turning/No Signal	2	2
Driver Skills/Knowledge/Experience	1	19
Failing to Reduce Speed to Avoid Crash	1	11
Exceeding Safe Speed for Conditions	1	2
Following Too Closely	1	2
Weather	0	3
Distraction	0	3
Disregarding Road Markings	0	1
Exceeding Authorized Speed Limit	0	1
Improper Overtaking/Passing	0	1
Road Construction/Maintenance	0	1
Total	**217**	**217**

Table C.10. Number of Vehicles Involved and Crash Severity

Crash Severity	Number of Vehicles						Total
	1	2	3	4	5	6	
Fatal Crash	0	20	10	1	0	0	31
A-Injury Crash	6	24	10	4	0	1	45
B-Injury Crash	9	22	3	2	1	0	37
C-Injury Crash	2	8	0	1	0	0	11
No Injuries	23	63	6	1	0	0	93
Total	**40**	**137**	**29**	**9**	**1**	**1**	**217**

Table C.9. Vehicle Type for Wrong-Way Vehicles

Vehicle Type	Crash Frequency	Percent (%)
Passenger	139	68.5%
Pickup	26	12.8%
SUV	18	8.9%
Van/Mini-Van	12	5.9%
Unknown	4	2.0%
Tractor with Semi-Trailer	2	1.0%
Motorcycle (over 150cc)	1	0.5%
Tractor without Semi-Trailer	1	0.5%
Total	**203**	**100%**

Table C.10. Vehicle Use for Wrong-Way Vehicles

Vehicle Use	Crash Frequency	Percent (%)
Personal	183	90.1%
Unknown/Other	14	6.9%
Commercial/Multi-Unit	3	1.5%
Not in Use	2	1.0%
Taxi/For Hire	1	0.5%
Total	**203**	**100%**

Table C.11. Vehicle Defects for Wrong-Way Vehicles

Vehicle Defects	Crash Frequency	Percent (%)
None	163	80.3%
Unknown/Other	38	18.7%
Brakes	1	0.5%
Signals	1	0.5%
Total	**203**	**100%**

Table C.12. Number of Occupants in Wrong-Way Vehicles

Number of Occupants	Crash Frequency	Total Occupants
1	173	173
2	23	46
3	5	15
4	1	4
5	1	5
Total	**203**	**243**

Table C.13. Vehicle Maneuver for Wrong-Way Crashes

Vehicle Maneuver	Crash Frequency	Percent (%)
Driving Wrong Way	127	62.6%
Straight Ahead	61	30.0%
Other	3	1.5%
Skidding/Control Loss	3	1.5%
U-Turn	3	1.5%
Avoiding Vehicle/Objects	2	1.0%
Slow/Stop in Traffic	2	1.0%
Turning Left	1	0.5%
Unknown	1	0.5%
Total	**203**	**100%**

Table C.14. First Contact for Wrong-Way Crashes

First Contact Code	First Contact	Crash Frequency	Percent (%)
0	None	6	3.0%
1	Front	115	56.7%
2	Right Front Quarter Panel	21	10.3%
3	Right Side Center	4	2.0%
4	Right Back Quarter Panel	2	1.0%
5	Rear	1	0.5%
7	Left Side Center	6	3.0%
8	Left Front Quarter Panel	32	15.8%
10	Under Carriage	1	0.5%
11	Total (all areas)	4	2.0%
99	Unknown	11	5.4%
	Total	**203**	**100%**

Table C.15. Most Harmful Events for Wrong-Way Crashes

Most Harmful Event	Crash Frequency	Percent (%)
Ran Off Roadway	104	51.2%
Motor Vehicle in Traffic	53	26.1%
Blank or No Data	30	14.8%
Other Non-Collision	5	2.5%
Concrete Median Barrier	2	1.0%
Guardrail Face	2	1.0%
Traffic Signal	1	0.5%
Bridge Support	1	0.5%
Ditch/Embankment/Fence	2	1.0%
Hit Parked Vehicle	1	0.5%
Other Fixed Object	1	0.5%
Other Object	1	0.5%
Total	**203**	**100%**

Table C.16. Most Harmful Event Location for Wrong-Way Crashes

Most Harmful Event Location	Crash Frequency	Percent (%)
On Pavement (Roadway)	155	76.4%
No Data or Blank	30	14.8%
Off Pavement, Left	10	4.9%
Off Pavement, Right	7	3.4%
Other	1	0.5%
Total	**203**	**100%**

Table C.17. Events for Wrong-Way Crashes

Event Name	Event 1	Event 2	Event 3	Total
Motor Vehicle in Traffic	155	15	7	177
Ran off Roadway	29	9	5	43
Other Non-Collision	7	0	0	7
Other Object	4	1	0	5
Unknown/No Data/Blank	1	141	185	327
Ditch/Embankment	1	11	0	12
Concrete Median Barrier	1	5	1	7
Guardrail Face	1	2	0	3
Hit Parked Vehicle	1	1	1	3
Other Fixed Object	1	1	1	3
Bridge Support	1	1	0	2
Traffic Signal	1	0	0	1
Overturn	0	7	2	9
Fence	0	2	1	3
Culvert	0	2	0	2
Fire/Explosion	0	2	0	2
Crash Cushion	0	1	0	1
Separation	0	1	0	1
Utility Pole	0	1	0	1
Total	**203**	**203**	**203**	**609**

Table C.18. Location for Wrong-Way Crashes

Location Name	Location 1	Location 2	Location 3	Total
On Pavement (Roadway)	168	23	6	197
Off Pavement, Left	19	16	3	38
Off Pavement, Right	12	19	8	39
Other	3	2	1	6
Blank/No Data/Unknown	1	143	185	329
Total	**203**	**203**	**203**	**609**

Table C.19. Driver Condition for Wrong-Way Drivers

Driver Condition	Crash Frequency	Percent (%)
Alcohol Impaired	101	49.8%
Other/Unknown	41	20.2%
Normal	34	16.7%
Drug Impaired	9	4.4%
Illness	8	3.9%
Had Been Drinking	7	3.4%
Asleep/Fainted	2	1.0%
Fatigued	1	0.5%
Total	**203**	**100%**

Table C.20. BAC Test Results for Wrong-Way Drivers

Driver BAC Test	Crash Frequency	Percent (%)
0%	8	3.9%
0.01%–0.1%	3	1.5%
0.1%–0.2%	29	14.3%
0.2%–0.3%	14	6.9%
0.3%–0.4%	1	0.5%
Test Not Offered	63	31.0%
Test Performed, Results Unknown	29	14.3%
Test Refused	26	12.8%
Unknown/Blank	30	14.8%
Total	**203**	**100%**

Table C.21. Relationship Between Driver Condition and Driver BAC

Driver Condition	Driver BAC										
	0%	0.01%–0.1%	0.1%–0.2%	0.2%–0.3%	0.3%–0.4%	Test Not Offered	Test Performed, Results Unknown	Test Refused	Unknown	Blank	Total
Alcohol Impaired	2	1	28	13	1	3	22	25	5	1	101
Asleep/Fainted	0	0	0	0	0	2					2
Drug Impaired	3	0	1	1	0		1		3		9
Fatigued	0	0	0	0	0	1					1
Had Been Drinking	0	2	0	0	0	2	3				7
Illness	0	0	0	0	0	6			1	1	8
Normal	2	0	0	0	0	26			4	2	34
Other/Unknown	1	0	0	0	0	23	3	1	11	2	41
Total	**8**	**3**	**29**	**14**	**1**	**63**	**29**	**26**	**24**	**6**	**203**

Table C.22. Relationship Between Driver Age and Driver Condition

Driver Condition	Driver Age Group									
	16–20	21–24	25–34	35–44	45–54	55–64	65–69	>69	Unknown	Total
Alcohol Impaired	3	22	42	10	18	3	1	0	2	101
Asleep/Fainted	0	0	0	0	0	1	0	1	0	2
Drug Impaired	1	0	3	1	1	1	1	1	0	9
Fatigued	0	0	1	0	0	0	0	0	0	1
Had Been Drinking	1	3	1	2	0	0	0	0	0	7
Illness	1	0	0	1	2	2	0	2	0	8
Normal	2	4	4	10	1	3	1	9	0	34
Other/Unknown	1	3	3	4	1	0	0	13	16	41
Total	**9**	**32**	**54**	**28**	**23**	**10**	**3**	**26**	**18**	**203**

Table C.23. Air Bag Deployment for Wrong-Way Drivers

Air Bag Deployment	Crash Frequency	Percent (%)
Deployed, Combination	2	1.0%
Deployed, Front	17	8.4%
Deployed, Side	1	0.5%
Deployment Unknown	106	52.2%
Did Not Deploy	7	3.4%
Not Applicable	5	2.5%
With Seat Belt	48	23.6%
Without Seat Belt	17	8.4%
Total	**203**	**100%**

Table C.24. Relationship Between Safety Equipment and Driver Severity Level

	Driver Severity Level					
Safety Equipment	**No Injuries**	**C-Injury**	**B-Injury**	**A-Injury**	**Fatality**	**Total**
Helmet Not Used	0	0	0	0	1	1
None Present	0	0	0	4	0	4
Seat Belts Not Used	4	0	3	9	7	23
Seat Belts Used	79	6	27	24	10	146
Unknown/NA	19	1	3	4	2	29
Total	**102**	**7**	**33**	**41**	**20**	**203**

Table C.25. Relationship Between Driver Condition and Driver Severity Level

	Driver Severity Level					
Driver Condition	**No Injuries**	**C-Injury**	**B-Injury**	**A-Injury**	**Fatality**	**Total**
Alcohol Impaired	47	3	16	24	11	101
Asleep/Fainted	1	0	1	0	0	2
Drug Impaired	2	1	1	0	5	9
Fatigued	1	0	0	0	0	1
Had Been Drinking	3	1	1	2	0	7
Illness	3	0	1	4	0	8
Normal	19	1	6	5	3	34
Other/Unknown	26	1	7	6	1	41
Total	**102**	**7**	**33**	**41**	**20**	**203**

Table C.26. Relationship Between Driver Injury Severity Level and Ejection

Ejection	Driver Severity Level					
	No Injuries	C-Injury	B-Injury	A-Injury	Fatality	Total
None	87	7	28	25	15	162
Totally ejected				2	1	3
Trapped/extricated			4	9	4	17
Unknown	15		1	5		21
Total	**102**	**7**	**33**	**41**	**20**	**203**

Table C.27. Relationship Between Air Bag Deployment and Driver Severity Level

Airbag Deployment	Driver Severity Level					
	No Injuries	C-Injury	B-Injury	A-Injury	Fatality	Total
Deployed (Combination)			1	1		2
Deployed (Front)	8		2	5	2	17
Deployed (Side)	1					1
Deployment Unknown	71	4	9	15	7	106
Did Not Deploy	3		1	2	1	7
Not Applicable	3		2			5
With Seat Belt	15	3	15	10	5	48
Without Seat Belt	1		3	8	5	17
Total	**102**	**7**	**33**	**41**	**20**	**203**

Table C.28. Relationship Between Driver Severity Level and Driver Vision

Driver Vision	Driver Severity Level					
	No Injuries	C-Injury	B-Injury	A-Injury	Fatality	Total
Not Obscured	73	6	30	39	15	163
Other	1	0	0	0	0	1
Unknown	27	1	3	2	4	37
Windshield (Water/Ice)	1	0	0	0	1	2
Total	**102**	**7**	**33**	**41**	**20**	**203**

Table C.29. Relationship Between Driver BAC Test Results and Driver Severity Level

Driver BAC Test	Driver Injury Severity Level					
	No Injuries	C-Injury	B-Injury	A-Injury	Fatality	Total
0%	2	0	0	0	6	8
0.01%–0.1%	1	0	1	1	0	3
0.1%–0.2%	16	0	3	5	5	29
0.2%–0.3%	2	0	1	4	7	14
0.3%–0.4%	0	0	0	0	1	1
Test Not Offered	34	3	13	12	1	63
Test Performed, Results Unknown	5	3	7	14	0	29
Test Refused	19	0	5	2	0	26
Unknown	17	1	3	3	0	24
Blank	6	0	0	0	0	6
Total	**102**	**7**	**33**	**41**	**20**	**203**

Table C.30. Relationship Between Driver Action and Driver Severity Level

Driver Action	Driver Severity Level					
	No Injuries	C-Injury	B-Injury	A-Injury	Fatality	Total
Disregard Control Devices	2	0	1	0	1	4
Evading Police Vehicle	0	0	1	1	0	2
Improper Lane Change	0	0	1	1	0	2
Improper Turn	0	0	0	1	0	1
None	5	1	1	0	1	8
Other	4	0	1	2	0	7
Too Fast for Conditions	1	0	0	0	0	1
Unknown	14	0	0	1	0	15
Wrong Way/Side	76	6	28	35	18	163
Total	**102**	**7**	**33**	**41**	**20**	**203**

Table C.31. Relationship Between Driver Age Group and Crash Severity Level

Driver Age Group	Crash Severity Level					Total
	Fatal	A-Injury	B-Injury	C-Injury	No Injuries	
16–20	2	3	1	0	3	9
21–24	5	13	3	2	9	32
25–34	8	14	9	4	19	54
35–44	2	7	9	1	9	28
45–54	8	2	2	0	11	23
55–64	0	3	2	0	5	10
65–69	1	0	1	0	1	3
>69	5	2	6	1	12	26
Unknown	0	1	4	3	24	32
Total	**31**	**45**	**37**	**11**	**93**	**217**

Table C.32. Relationship Between Driver Gender and Crash Severity Level

Driver Gender	Crash Severity Level					Total
	Fatal	A-Injury	B-Injury	C-Injury	No Injuries	
Male	23	32	25	7	49	136
Female	8	12	8	2	21	51
Unknown	0	1	4	2	23	30
Total	**31**	**45**	**37**	**11**	**93**	**217**

Table C.33. Relationship Between Driver Condition and Crash Severity Level

Driver Condition	Crash Severity Level					Total
	Fatal	A-Injury	B-Injury	C-Injury	No Injuries	
Alcohol Impaired	19	22	18	5	37	101
Other/Unknown	1	8	10	4	32	55
Normal	5	8	4	1	16	34
Drug Impaired	5	1	1	0	2	9
Illness	0	3	2	0	3	8
Had Been Drinking	1	3	1	1	1	7
Asleep/Fainted	0	0	1	0	1	2
Fatigued	0	0	0	0	1	1
Total	**31**	**45**	**37**	**11**	**93**	**217**

Table C.34. Relationship Between Light Condition and Crash Severity Level

Light Condition	Crash Severity Level					
	Fatal	A-Injury	B-Injury	C-Injury	No Injuries	Total
Darkness, Lighted Road	13	22	18	8	40	101
Darkness	14	13	11	2	32	72
Daylight	4	9	6	1	20	40
Dawn	0	1	1	0	1	3
Dusk	0	0	1	0	0	1
Total	**31**	**45**	**37**	**11**	**93**	**217**

Table C.35. Relationship Between Weather and Crash Severity Level

Weather Condition	Crash Severity Level					
	Fatal	A-Injury	B-Injury	C-Injury	No Injuries	Total
Clear	29	36	27	7	75	174
Rain	0	6	5	0	16	27
Snow	1	3	1	2	1	8
Fog/Smoke/Haze	1	0	2	1	0	4
Sleet/Hail	0	0	1	1	0	2
Other	0	0	1	0	0	1
Unknown	0	0	0	0	1	1
Total	**31**	**45**	**37**	**11**	**93**	**217**

Table C.36. Relationship Between Alignment and Crash Severity Level

Road Alignment	Crash Severity Level					
	Fatal	A-Injury	B-Injury	C-Injury	No Injuries	Total
Straight and Level	20	36	30	9	55	150
Straight on Grade	4	4	4	1	3	16
Curve Level	3	3	2	0	6	14
Curve on Grade	2	1	1	0	7	11
Straight on Hillcrest	2	0	0	0	1	3
Curve on Hillcrest	0	0	0	0	3	3
Unknown	0	1	0	1	18	20
Total	**31**	**45**	**37**	**11**	**93**	**217**

Table C.37. Relationship Between Trafficway Description and Crash Severity Level

Trafficway Description	Crash Severity Level					Total
	Fatal	A-Injury	B-Injury	C-Injury	No Injuries	
Divided (median barrier)	20	32	31	6	47	136
Divided (no median barrier)	8	11	4	3	16	42
Unknown	0	1	0	0	18	19
One-Way/Ramp	0	1	2	1	8	12
Not Divided	3	0	0	0	1	4
Other	0	0	0	0	3	3
Alley/Driveway	0	0	0	1	0	1
Total	**31**	**45**	**37**	**11**	**93**	**217**

Table C.38. Relationship Between Roadway Functional Class and Crash Severity Level

Roadway Functional Class Description	Crash Severity Level					Total
	Fatal	A-Injury	B-Injury	C-Injury	No Injuries	
Interstate	26	40	26	9	67	168
Other Principal Arterial	1	3	5	0	12	21
Freeway/Expressway (urban)	2	1	2	2	5	12
Local Road/Street (urban)	1	0	2	0	5	8
Local Road/Street (non-urban)	1	1	2	0	3	7
Minor Arterial (urban)	0	0	0	0	1	1
Total	**31**	**45**	**37**	**11**	**93**	**217**

Table C.39. Relationship Between Vehicle Defects and Crash Severity Level

Vehicle Defects	Crash Severity Level					Total
	Fatal	A-Injury	B-Injury	C-Injury	No Injuries	
None	25	40	32	7	59	163
Unknown	6	4	4	4	33	51
Brakes	0	1	0	0	0	1
Signals	0	0	1	0	0	1
Other	0	0	0	0	1	1
Total	**31**	**45**	**37**	**11**	**93**	**217**

Table C.40. Relationship Between Fire and Crash Severity Level

Fire Indication	Crash Severity Level					
	Fatal	A-Injury	B-Injury	C-Injury	No Injuries	Total
No	29	41	34	10	78	192
Yes	2	4	2	0	3	11
Unknown	0	0	1	1	7	9
Blank	0	0	0	0	5	5
Total	**31**	**45**	**37**	**11**	**93**	**217**

Table C.41. Relationship Between Hazard Material Spill and Crash Severity Level

HazMat Spill	Crash Severity Level					
	Fatal	A-Injury	B-Injury	C-Injury	No Injuries	Total
No	31	45	36	10	81	203
Unknown	0	0	1	1	7	9
Blank	0	0	0	0	5	5
Total	**31**	**45**	**37**	**11**	**93**	**217**

Table C.42. Relationship Between First Contact Point and Crash Severity Level

First Contact	Crash Severity Level					
	Fatal	A-Injury	B-Injury	C-Injury	No Injuries	Total
Front	26	34	17	7	31	115
Left Front Quarter Panel	4	6	8	2	12	32
Unknown/Blank	0	0	4	1	20	25
Right Front Quarter Panel	1	2	3	0	15	21
Left Side Center	0	1	0	0	5	6
None	0	0	2	0	4	6
Total (all areas)	0	2	2	0	0	4
Right Side Center	0	0	1	0	3	4
Right Back Quarter Panel	0	0	0	0	2	2
Rear	0	0	0	0	1	1
Under Carriage	0	0	0	1	0	1
Total	**31**	**45**	**37**	**11**	**93**	**217**

Table C.43. Relationship Between Vehicle Maneuver and Crash Severity Level

Vehicle Maneuver	**Crash Severity Level**					
	Fatal	**A-Injury**	**B-Injury**	**C-Injury**	**No Injuries**	**Total**
Driving Wrong Way	27	23	21	6	50	127
Straight Ahead	4	20	12	2	23	61
Unknown	0	0	1	2	7	10
Blank	0	0	0	0	5	5
Other	0	0	2	1	0	3
Skidding/Control Loss	0	2	0	0	1	3
U-Turn	0	0	1	0	2	3
Slow/Stop in Traffic	0	0	0	0	2	2
Avoiding Vehicle/Objects	0	0	0	0	2	2
Turning Left	0	0	0	0	1	1
Total	**31**	**45**	**37**	**11**	**93**	**217**

Table C.44. Relationship Between Vehicle Type and Crash Severity Level

Vehicle Type	**Crash Severity Level**					
	Fatal	**A-Injury**	**B-Injury**	**C-Injury**	**No Injuries**	**Total**
Passenger	18	30	26	6	59	139
Pickup	9	5	5	0	7	26
SUV	3	5	1	2	7	18
Unknown	0	0	2	2	9	13
Van/Mini-Van	0	4	3	0	5	12
Blank	0	0	0	0	5	5
Tractor with Semitrailer	0	0	0	1	1	2
Tractor without Semitrailer	0	1	0	0	0	1
Motorcycle (over 150cc)	1	0	0	0	0	1
Total	**31**	**45**	**37**	**11**	**93**	**217**

Table C.45. Relationship Between Driver Vision and Crash Severity Level

Driver Vision	Crash Severity Level					
	Fatal	**A-Injury**	**B-Injury**	**C-Injury**	**No Injuries**	**Total**
Not Obscured	26	41	31	6	59	163
Unknown	4	4	6	5	27	46
Blank	0	0	0	0	5	5
Windshield (Water/Ice)	1	0	0	0	1	2
Other	0	0	0	0	1	1
Total	**31**	**45**	**37**	**11**	**93**	**217**

Table C.46. Relationship Between Most Harmful Event and Crash Severity Level

Most Harmful Event	Crash Severity Level					
	Fatal	**A-Injury**	**B-Injury**	**C-Injury**	**No Injuries**	**Total**
Ran Off Roadway	15	23	16	3	47	104
Motor Vehicle in Traffic	16	12	7	4	14	53
Blank	0	3	5	0	14	22
No Data	0	4	2	2	5	13
Unknown	0	0	1	1	7	9
Other Non-Collision	0	1	2	1	1	5
Guardrail Face	0	0	1	0	1	2
Concrete Median Barrier	0	1	1	0	0	2
Ditch/Embankment	0	0	1	0	0	1
Fence	0	0	0	0	1	1
Hit Parked Vehicle	0	0	0	0	1	1
Other Fixed Object	0	0	0	0	1	1
Other Object	0	0	1	0	0	1
Bridge Support	0	1	0	0	0	1
Traffic Signal	0	0	0	0	1	1
Total	**31**	**45**	**37**	**11**	**93**	**217**

Table C.49. Relationship Between Driver Action and Crash Severity Level

	Crash Severity Level					
Driver Action	**Fatal**	**A-Injury**	**B-Injury**	**C-Injury**	**No Injuries**	**Total**
Wrong Way/Side	27	37	29	7	63	163
Unknown	0	1	1	2	20	24
None	3	1	3	1	0	8
Other	0	3	1	1	2	7
Blank	0	0	0	0	5	5
Disregard Control Devices	1	1	1	0	1	4
Evading Police Vehicle	0	1	1	0	0	2
Improper Lane Change	0	1	1	0	0	2
Improper Turn	0	0	0	0	1	1
Too Fast for Conditions	0	0	0	0	1	1
Total	**31**	**45**	**37**	**11**	**93**	**217**

Table C.47. Crash Type for Wrong-Way Crashes

Crash Type	**Crash Frequency**	**Percent (%)**
Wrong-Way Vehicle vs. Right-Way Vehicle(s)	161	74.2%
Wrong-Way Vehicle Only	31	14.3%
Right-Way Vehicle(s) Only	20	9.2%
Wrong-Way Incident	3	1.4%
Wrong-Way Incident after Crash	2	0.9%
Total	**217**	**100%**

Table C.48 Relationship Between Crash Severity Level and ISPERN Broadcast

	Crash Severity Level					
ISPERN	**Fatal**	**A-Injury**	**B-Injury**	**C-Injury**	**No Injury**	**Total**
Yes	4	1	2	1	5	13
No	27	44	35	10	88	204
Total	**31**	**45**	**37**	**11**	**93**	**217**

Table C.49. Wrong-Way Crash Location

Wrong-Way Crash Location	Number of Lanes					Total
	1	2	3	4	5	
Ramp	2	4	1	0	1	8
Left Shoulder	0	2	1	1	0	4
Lane 1	N/A	38	22	2	0	62
Lane 2	N/A	15	14	2	0	31
Lane 3	N/A	N/A	5	2	1	8
Lane 4	N/A	N/A	N/A	4	0	4
Lane 5	N/A	N/A	N/A	N/A	0	0
Right Shoulder	0	3	2	0	0	5
Total	**2**	**62**	**45**	**11**	**2**	**122**

Table C.53. Wrong-Way Entry Point Location

Rank	Route Number	Major Route	Minor Route	Category			Total
				I	II	III	
1	9094	I-94	W Peterson Ave	0	2	3	5
2	1041	US 41	W Belmont Ave	0	2	2	4
3	9055	I-55	St Clair Ave	1	2	0	3
3	9094	I-94	W Foster Ave	1	2	0	3
3	9270	I-270	Riverview Dr.	1	1	1	3
3	9074	I-74	NE Adams St	0	3	0	3
3	1041	US 41	Deerfield Rd	0	2	1	3
3	9074	I-74	W Washington St	0	2	1	3
3	9094	I-94	Dempster St	0	1	2	3
10	9090	I-90	N Central Ave	2	0	0	2
10	1041	US 41	W Fullerton Pkwy	1	1	0	2
10	8182	E Palatine Road	S Milwaukee Ave	1	1	0	2
10	9055	I-55	Lakeview Dr	1	1	0	2
10	9064	I-64	S Bluff Rd	1	1	0	2
10	9074	I-74	Georgetown Rd	1	1	0	2
10	9094	I-94	W North Ave	1	1	0	2
10	9094	I-94	W Touhy Ave	1	1	0	2
10	5255	IL 255	Edwardsville Rd	1	0	1	2
10	9055	I-55	S Damen Ave	1	0	1	2
10	9057	I-57	IL 146	1	0	1	2
10	9064	I-64	N Illinois St	1	0	1	2
10	9074	I-74	N Prospect Ave	1	0	1	2
10	1020	US 20	S Meridian Rd	0	2	0	2

Rank	Route Number	Major Route	Minor Route	Category I	Category II	Category III	Total
10	9055	I-55	IL 111	0	2	0	2
10	9055	I-55	S Central Ave	0	2	0	2
10	9055	I-55	W Coal City Rd	0	2	0	2
10	9057	I-57	S Halsted St	0	2	0	2
10	9080	I-80	E 24th Rd	0	2	0	2
10	9080	I-80	S Briggs St	0	2	0	2
10	9094	I-94	E 87th St	0	2	0	2
10	9270	I-270	W Chain Of Rocks Rd	0	2	0	2
10	9290	I-290	1st Ave	0	2	0	2
10	1020	US 20	11th St	0	1	1	2
10	5171	IL 171	W 95th St	0	1	1	2
10	9055	I-55	Collinsville Rd	0	1	1	2
10	9055	I-55	Fairway Blvd	0	1	1	2
10	9055	I-55	IL 203	0	1	1	2
10	9055	I-55	Lemont Rd	0	1	1	2
10	9055	I-55	Rest Area (SB Near Waggoner)	0	1	1	2
10	9055	I-55	S Bolingbrook Dr	0	1	1	2
10	9055	I-55	S California Ave	0	1	1	2
10	9055	I-55	S Harlem Ave	0	1	1	2
10	9055	I-55	Stuttle Rd	0	1	1	2
10	9057	I-57	2900N Rd	0	1	1	2
10	9057	I-57	W Monee Manhattan Rd	0	1	1	2
10	9064	I-64	IL 203	0	1	1	2
10	9064	I-64	Old Missouri Ave	0	1	1	2
10	9080	I-80	Seneca Rd	0	1	1	2
10	9090	I-90	N Keeler Ave	0	1	1	2
10	9094	I-94	W 35th St	0	1	1	2
10	9094	I-94	W 71st St	0	1	1	2
10	9094	I-94	W Pershing Rd	0	1	1	2
10	9270	I-270	IL 143	0	1	1	2
10	9290	I-290	S Mannheim Rd	0	1	1	2
10	1020	US 20	N Winnebago Rd	0	0	2	2
10	1041	US 41	W Belmont Harbor Dr	0	0	2	2
10	9055	I-55	E Reed Rd	0	0	2	2
10	9055	I-55	Logan County 10	0	0	2	2
10	9055	I-55	N 15th St	0	0	2	2
10	9055	I-55	S Canalport Ave	0	0	2	2
10	9074	I-74	Spalding Ave	0	0	2	2

Rank	Route Number	Major Route	Minor Route	Category I	Category II	Category III	Total
10	9094	I-94	E 79th St	0	0	2	2
10	9290	I-290	S 9th Ave	0	0	2	2
64	1041	US 41	W Bryn Mawr Ave	1	0	0	1
64	1041	US 41	W Irving Park Road	1	0	0	1
64	5003	IL 3	E Broadway	1	0	0	1
64	5038	IL 38	S Villa Ave	1	0	0	1
64	8072	I-72	S Country Fair Dr	1	0	0	1
64	8208	I-90/I-94	N Orleans St	1	0	0	1
64	9055	I-55	E Frontage Rd	1	0	0	1
64	9055	I-55	Edwardsville Rd	1	0	0	1
64	9057	I-57	N Refuge Rd	1	0	0	1
64	9057	I-57	W 99th St	1	0	0	1
64	9064	I-64	IL 242	1	0	0	1
64	9064	I-64	Kingshighway	1	0	0	1
64	9064	I-64	Rest Area (Near Calvin)	1	0	0	1
64	9064	I-64	W Hanover St	1	0	0	1
64	9070	I-70	Pokey Rd	1	0	0	1
64	9070	I-70	W Cumberland Rd	1	0	0	1
64	9074	I-74	7th Ave	1	0	0	1
64	9074	I-74	County Hwy 36	1	0	0	1
64	9074	I-74	N Lincoln Ave	1	0	0	1
64	9074	I-74	N Morton Ave	1	0	0	1
64	9080	I-80	Empress Rd	1	0	0	1
64	9094	I-94	E 103rd St	1	0	0	1
64	9094	I-94	N Orleans St	1	0	0	1
64	9094	I-94	Old Orchard Rd	1	0	0	1
64	9094	I-94	W Addison St	1	0	0	1
64	9094	I-94	W Cermak Rd	1	0	0	1
64	9290	I-290	Biesterfield Rd	1	0	0	1
64	9290	I-290	Des Plaines Ave	1	0	0	1
64	9290	I-290	S 17th Ave	1	0	0	1
64	9290	I-290	S Harlem Ave	1	0	0	1
64	1020	US 20	Montague Rd	0	1	0	1
64	1020	US 20	S State St	0	1	0	1
64	1041	US 41	E 31st St	0	1	0	1
64	1041	US 41	N Marine Dr	0	1	0	1
64	1041	US 41	W Wilson Ave	0	1	0	1
64	1051	US 51	US 51	0	1	0	1

Rank	Route Number	Major Route	Minor Route	Category I	II	III	Total
64	5008	IL 8	SW Washington St	0	1	0	1
64	5171	IL 171	Beverley Ln	0	1	0	1
64	5255	IL 255	Chain Of Rocks Rd	0	1	0	1
64	5255	IL 255	Gateway Commerce Center Dr E	0	1	0	1
64	5255	IL 255	Madison Ave	0	1	0	1
64	5394	IL 394	Glenwood Dyer Rd	0	1	0	1
64	8182	E Palatine Road	S Wolf Rd	0	1	0	1
64	8208	I-90/I-94	N Milwaukee Ave	0	1	0	1
64	8220	Elgin–O'Hare Expy	Wright Blvd	0	1	0	1
64	9039	I-39	County Hwy 2	0	1	0	1
64	9055	I-55	County Hwy 34	0	1	0	1
64	9055	I-55	E 31st St	0	1	0	1
64	9055	I-55	Lincoln Pkwy	0	1	0	1
64	9055	I-55	Lorenz Ave	0	1	0	1
64	9055	I-55	Main St	0	1	0	1
64	9055	I-55	Mississippi Ave	0	1	0	1
64	9055	I-55	New Douglas Rd	0	1	0	1
64	9055	I-55	Pipeline Rd	0	1	0	1
64	9055	I-55	Rest Area (NB Near Romeoville)	0	1	0	1
64	9055	I-55	Rest Area (Near Funks Grove)	0	1	0	1
64	9055	I-55	S Pulaski Rd	0	1	0	1
64	9055	I-55	S Sherman Blvd	0	1	0	1
64	9055	I-55	S State St	0	1	0	1
64	9055	I-55	W 35th St	0	1	0	1
64	9055	I-55	W Bluff Rd	0	1	0	1
64	9055	I-55	Woodlawn Rd	0	1	0	1
64	9057	I-57	Cypress Rd	0	1	0	1
64	9057	I-57	E Court St	0	1	0	1
64	9057	I-57	IL 116	0	1	0	1
64	9057	I-57	IL 133	0	1	0	1
64	9057	I-57	IL 154	0	1	0	1
64	9057	I-57	Rest Area (Near Anna)	0	1	0	1
64	9057	I-57	Rest Area (Near Pesotum)	0	1	0	1
64	9057	I-57	Rest Area (Near Salem)	0	1	0	1
64	9057	I-57	Sauk Trail	0	1	0	1
64	9057	I-57	W Main St	0	1	0	1
64	9064	I-64	Albers Rd	0	1	0	1
64	9064	I-64	N 18th St	0	1	0	1

Rank	Route Number	Major Route	Minor Route	Category I	Category II	Category III	Total
64	9064	I-64	Rest Area (Near Shiloh)	0	1	0	1
64	9064	I-64	State St	0	1	0	1
64	9070	I-70	Rest Area (Near Highland)	0	1	0	1
64	9072	I-72	W Harristown Blvd	0	1	0	1
64	9074	I-74	County Rd 700 N	0	1	0	1
64	9074	I-74	E Caterpillar Trail	0	1	0	1
64	9074	I-74	Knox Hwy 9	0	1	0	1
64	9074	I-74	N Neil St	0	1	0	1
64	9074	I-74	N University St	0	1	0	1
64	9080	I-80	2nd Ave	0	1	0	1
64	9080	I-80	County Hwy 11	0	1	0	1
64	9080	I-80	E 2nd Rd	0	1	0	1
64	9088	I-88	Moline Rd	0	1	0	1
64	9090	I-90	Rest Area (Near Belvidere)	0	1	0	1
64	9090	I-90	S Damen Ave	0	1	0	1
64	9090	I-90	W Lawrence Ave	0	1	0	1
64	9094	I-94	E 25th St	0	1	0	1
64	9094	I-94	N California Ave	0	1	0	1
64	9094	I-94	N Racine Ave	0	1	0	1
64	9094	I-94	Rosecrans Rd	0	1	0	1
64	9094	I-94	W 43rd St	0	1	0	1
64	9094	I-94	W 59th St	0	1	0	1
64	9094	I-94	W 63rd St	0	1	0	1
64	9094	I-94	W 83rd St	0	1	0	1
64	9172	I-172	Payson Rd	0	1	0	1
64	9180	I-180	IL 26	0	1	0	1
64	9190	I-190	N River Rd	0	1	0	1
64	9255	I-255	Horseshoe Lake Rd	0	1	0	1
64	9255	I-255	Koch Rd	0	1	0	1
64	9255	I-255	State St	0	1	0	1
64	9270	I-270	Edwardsville Rd	0	1	0	1
64	9290	I-290	S Central Ave	0	1	0	1
64	9290	I-290	W Algonquin Rd	0	1	0	1
64	9290	I-290	W Lake St	0	1	0	1
64	9290	I-290	W Taylor St	0	1	0	1
64	9355	I-355	W Army Trail Blvd	0	1	0	1
64	9474	I-474	N Maxwell Rd	0	1	0	1
64	1020	US 20	Grace St	0	0	1	1

Rank	Route Number	Major Route	Minor Route	Category I	Category II	Category III	Total
64	1020	US 20	S Main St	0	0	1	1
64	1041	US 41	E Oakwood Blvd	0	0	1	1
64	1041	US 41	Skokie Valley Rd	0	0	1	1
64	1041	US 41	W Lawrence Ave	0	0	1	1
64	1051	US 51	Taylorville Rd	0	0	1	1
64	5171	IL 171	W 87th St	0	0	1	1
64	5255	IL 255	IL 162	0	0	1	1
64	5255	IL 255	New Poag Rd	0	0	1	1
64	5394	IL 394	Torrence Ave	0	0	1	1
64	8182	E Palatine Road	S Wheeling Rd	0	0	1	1
64	8182	E Palatine Road	Sanders Rd	0	0	1	1
64	8208	I-90/I-94	W Randolph St	0	0	1	1
64	8220	Elgin–O'Hare Expy	W Irving Park Rd	0	0	1	1
64	9039	I-39	County Rd 1800N	0	0	1	1
64	9055	I-55	County Highway 44	0	0	1	1
64	9055	I-55	Dixie Rd	0	0	1	1
64	9055	I-55	E 18th Dr	0	0	1	1
64	9055	I-55	E Eames St	0	0	1	1
64	9055	I-55	IL 4	0	0	1	1
64	9055	I-55	Joliet Rd	0	0	1	1
64	9055	I-55	Madison Rd	0	0	1	1
64	9055	I-55	N 22nd Ave	0	0	1	1
64	9055	I-55	N Bluff Rd	0	0	1	1
64	9055	I-55	N Lincoln Pkwy	0	0	1	1
64	9055	I-55	Rest Area (SB Near Romeoville)	0	0	1	1
64	9055	I-55	S 13th St	0	0	1	1
64	9055	I-55	S Cicero Ave	0	0	1	1
64	9055	I-55	S Main St	0	0	1	1
64	9055	I-55	Staunton Rd	0	0	1	1
64	9055	I-55	Towanda Overpass Rd	0	0	1	1
64	9057	I-57	Chebanse Rd	0	0	1	1
64	9057	I-57	E 88th St	0	0	1	1
64	9057	I-57	E McCord St	0	0	1	1
64	9057	I-57	E Southline Rd	0	0	1	1
64	9057	I-57	IL 45	0	0	1	1
64	9057	I-57	North Ave	0	0	1	1
64	9057	I-57	Rest Area (Near Monee)	0	0	1	1
64	9057	I-57	S Schuyler Ave	0	0	1	1

Rank	Route Number	Major Route	Minor Route	Category I	Category II	Category III	Total
64	9057	I-57	Shawnee College Rd	0	0	1	1
64	9057	I-57	W 111th St	0	0	1	1
64	9057	I-57	W Deyoung St	0	0	1	1
64	9064	I-64	Air Mobility Dr	0	0	1	1
64	9064	I-64	E High St	0	0	1	1
64	9064	I-64	Madison Rd	0	0	1	1
64	9064	I-64	S Bluff Rd	0	0	1	1
64	9070	I-70	IL 143	0	0	1	1
64	9072	I-72	Taylorville Rd	0	0	1	1
64	9074	I-74	E Main St	0	0	1	1
64	9074	I-74	N Knoxville Ave	0	0	1	1
64	9074	I-74	NE Greenleaf St	0	0	1	1
64	9074	I-74	Rest Area (Near Goodfield)	0	0	1	1
64	9074	I-74	River Rd	0	0	1	1
64	9074	I-74	S Chestnut St	0	0	1	1
64	9074	I-74	Wendt Ave	0	0	1	1
64	9080	I-80	Division St	0	0	1	1
64	9080	I-80	E 103rd Rd	0	0	1	1
64	9080	I-80	IL 71	0	0	1	1
64	9080	I-80	IL Welcome Center	0	0	1	1
64	9080	I-80	Rest Area (Near Minooka)	0	0	1	1
64	9080	I-80	Richards St	0	0	1	1
64	9080	I-80	W Lincoln Hwy	0	0	1	1
64	9088	I-88	38th Ave N	0	0	1	1
64	9090	I-90	Genoa Rd	0	0	1	1
64	9090	I-90	S Kedzie Ave	0	0	1	1
64	9090	I-90	W Addison St	0	0	1	1
64	9094	I-94	Grand Ave	0	0	1	1
64	9094	I-94	N Cicero Ave	0	0	1	1
64	9094	I-94	S Damen Ave	0	0	1	1
64	9094	I-94	S Wentworth Ave	0	0	1	1
64	9094	I-94	W 75th St	0	0	1	1
64	9094	I-94	W 87th St	0	0	1	1
64	9094	I-94	W Division St	0	0	1	1
64	9094	I-94	W Fullerton Ave	0	0	1	1
64	9094	I-94	W Garfield Blvd	0	0	1	1
64	9094	I-94	W Randolph St	0	0	1	1
64	9172	I-172	Broadway St	0	0	1	1

Rank	Route Number	Major Route	Minor Route	Category I	Category II	Category III	Total
64	9180	I-180	County Rd 875E	0	0	1	1
64	9190	I-190	Bessie Coleman Dr	0	0	1	1
64	9255	I-255	I-64	0	0	1	1
64	9255	I-255	IL 162	0	0	1	1
64	9255	I-255	Telegraph Rd	0	0	1	1
64	9270	I-270	Franko Ln	0	0	1	1
64	9270	I-270	IL 4	0	0	1	1
64	9270	I-270	Lilac Dr	0	0	1	1
64	9290	I-290	N Arlington Heights Rd	0	0	1	1
64	9290	I-290	S Cicero Ave	0	0	1	1
64	9290	I-290	Thorndale Ave	0	0	1	1
64	9290	I-290	W Madison St	0	0	1	1
64	9355	I-355	E North Ave	0	0	1	1
64	9474	I-474	Airport Rd	0	0	1	1
Total				**47**	**147**	**146**	**340**

Table C.50. Wrong-Way Entry Point Distribution

Entry Point Combination	Frequency	Percent (%)
Recorded Only	31	11.7%
1st Possible Entry Only	92	34.7%
2nd Possible Entry Only	100	37.7%
Recorded and 1st Possible Entry	9	3.4%
Recorded and 2nd Possible Entry	5	1.9%
1st and 2nd Possible Entry	27	10.2%
Recorded, 1st and 2nd Possible	1	0.4%
Total	**265**	**100%**

Table C.51. Frequency for Wrong-Way Entry Point

Wrong-Way Entry Frequency					
Total	**I**	**II**	**III**	**Wrong-Way Entry Point**	
5	0	2	3	1	1
4	0	2	2	1	1
3	1	2	0	2	7
	1	1	1	1	
	0	3	0	1	
	0	2	1	2	
	0	1	2	1	
2	2	0	0	1	54
	1	1	0	7	
	1	0	1	5	
	0	2	0	10	
	0	1	1	22	
	0	0	2	9	
1	1	0	0	30	202
	0	1	0	81	
	0	0	1	91	
	Total				**265**

Table C.52. Relationship Between Driver Age and Entry Point Interchange Type

	Age Group								
Interchange Type	16–20	21–24	25–34	35–44	45–54	55–64	>65	Unknown	**Total**
Cloverleaf	1	2	8	1	9	0	4	2	27
Compressed Diamond	5	14	28	10	5	3	10	25	100
Diamond	2	21	18	12	11	5	17	7	93
Directional	0	0	1	1	0	2	0	0	4
Freeway Feeder	1	3	3	1	2	2	0	2	14
Modified Diamond	1	1	2	1	0	2	0	4	11
Partial Cloverleaf	5	5	12	14	4	1	8	7	56
Rest Area	1	5	4	1	2	1	2	0	16
Semi-Directional	0	0	3	0	0	1	0	3	7
SPUI	0	1	1	0	1	0	0	3	6
Trumpet	0	1	3	0	0	1	0	1	6
Total	**16**	**53**	**83**	**41**	**34**	**18**	**41**	**54**	**340**

Table C.53. Relationship Between Driver Gender and Wrong-Way Interchange Type

Interchange Type	Driver Gender			
	Female	**Male**	**Unknown**	**Total**
Cloverleaf	1	24	2	27
Compressed Diamond	18	60	22	100
Diamond	34	52	7	93
Directional	1	3	0	4
Freeway Feeder	1	11	2	14
Modified Diamond	1	6	4	11
Partial Cloverleaf	11	38	7	56
Rest Area	3	13	0	16
Semi-Directional	0	4	3	7
SPUI	0	4	2	6
Trumpet	1	4	1	6
Total	**71**	**219**	**50**	**340**

Table C.54. Relationship Between Driver Condition and Wrong-Way Entry Interchange Type

Interchange Type	Driver Condition								
	Alcohol Impaired	**Asleep / Fainted**	**Drug Impaired**	**Fatigued**	**Had Been Drinking**	**Illness**	**Normal**	**Other/ Unknown**	**Total**
Cloverleaf	16	0	4	0	0	0	2	5	27
Compressed Diamond	42	1	2	0	2	5	18	30	100
Diamond	50	1	1	1	2	2	13	23	93
Directional	4	0	0	0	0	0	0	0	4
Freeway Feeder	6	1	0	0	0	1	3	3	14
Modified Diamond	7	0	1	0	1	0	0	2	11
Partial Cloverleaf	21	0	3	0	4	1	11	16	56
Rest Area	11	0	0	0	0	2	2	1	16
Semi-Directional	4	0	0	0	0	0	0	3	7
SPUI	2	0	0	0	0	1	0	3	6
Trumpet	4	0	0	0	0	1	0	1	6
Total	**167**	**3**	**11**	**1**	**9**	**13**	**49**	**87**	**340**

APPENDIX D CAUSAL TABLES FOR CONTRIBUTING FACTORS

Table D.1. Impairment or Distraction

	Fatal (%)	A-Injury (%)	B-Injury (%)	C-Injury (%)	No Injury (%)	All Crashes (%)
Impairment or Distraction	**13.82**	**15.21**	**13.82**	**2.76**	**21.20**	**66.82**
Under Influence of Alcohol/Drugs	12.44	11.52	10.60	2.30	17.05	53.92
Physical Condition of Driver	1.38	3.69	2.30	0.46	3.69	11.52
Distraction - From Outside Vehicle	0.00	0.00	0.46	0.00	0.46	0.92
Distraction - Operating a Wireless Phone	0.00	0.00	0.46	0.00	0.00	0.46

Table D.2. Injudicious Action

	Fatal (%)	A-Injury (%)	B-injury (%)	C-Injury (%)	No injury (%)	All Crashes (%)
Injudicious Action	**3.23**	**5.99**	**2.76**	**0.92**	**9.22**	**22.12**
Improper Lane Usage	2.30	4.61	0.92	0.92	5.53	14.29
Disregarding Other Traffic Signs	0.92	0.00	0.92	0.00	1.84	3.69
Following Too Closely	0.00	0.46	0.46	0.00	0.46	1.38
Exceeding Safe Speed for Conditions	0.00	0.92	0.00	0.00	0.46	1.38
Disregarding Road Markings	0.00	0.00	0.00	0.00	0.46	0.46
Exceeding Authorized Speed Limit	0.00	0.00	0.46	0.00	0.00	0.46

Table D.3. Behavior or Inexperience

	Fatal (%)	A-Injury (%)	B-injury (%)	C-Injury (%)	No injury (%)	All Crashes (%)
Behavior or Inexperience	**2.30**	**3.23**	**2.76**	**1.38**	**7.37**	**17.05**
Driver Skills/ Knowledge/ Experience	1.38	0.46	1.84	0.46	5.07	9.22
Operating Vehicle in Reckless Manner	0.92	2.76	0.46	0.92	2.30	7.37
Improper Overtaking/Passing	0.00	0.00	0.46	0.00	0.00	0.46

Table D.4. Driver Error or Reaction

	Fatal (%)	A-Injury (%)	B-injury (%)	C-Injury (%)	No injury (%)	All Crashes (%)
Drivers Error or Reaction	**15.67**	**17.51**	**16.59**	**5.53**	**35.48**	**90.78**
Driving on Wrong Side/Wrong Way	12.44	15.67	14.75	3.69	29.95	76.50
Unable to Determine	2.76	0.00	0.46	1.38	2.30	6.91
Failing to Reduce Speed to Avoid Crash	0.46	0.92	1.38	0.46	2.30	5.53
Improper Turning/No Signal	0.00	0.92	0.00	0.00	0.92	1.84

Table D.5. Road Environment

	Fatal (%)	A-Injury (%)	B-injury (%)	C-Injury (%)	No injury (%)	All Crashes (%)
Road environment	**23.04**	**22.58**	**17.50**	**5.07**	**53.00**	
Darkness	12.44	16.13	13.36	4.61	33.18	79.72
Road layout (curve, grade,…)	5.07	2.76	1.38	0.00	8.76	17.97
Weather	0.46	0.00	0.46	0.00	0.46	1.38
Rural	5.07	3.69	2.30	0.46	10.60	22.12

(Note: Several factors may apply to each crash; thus, the sum is greater than 100)

APPENDIX E CONTRIBUTING FACTORS FREQUENCY

Table E.1. Pre-Crash/Human: Fatal Crashes

Fatal Crashes

		Total 31	
Age of driver 1	16-24	7	22.58%
	25-34	8	25.81%
	35-44	2	6.45%
	45-54	8	25.81%
	55-64	0	0.00%
	Above 65	6	19.35%
Gender of driver 1	Male	23	74.19%
	Female	8	25.81%
Driver condition	Alcohol Impaired	19	61.29%
	Drug Impaired	5	16.13%
	Normal	5	16.13%
	Had Been Drinking	1	3.23%
	Other/Unknown	1	3.23%
Driver action	Wrong Way/Side	27	87.10%
	None	3	9.68%

Table E.2. Pre-Crash/Human: A-Injury Crashes

◆A-Injury Crashes

Total 45

Age of driver 1	16-24	16	35.56%
	25-34	14	31.11%
	35-44	7	15.56%
	45-54	2	4.44%
	55-64	3	6.67%
	Above 65	3	6.67%
Gender of driver 1	Male	32	71.11%
	Female	12	26.67%
Driver condition	Alcohol Impaired	22	48.89%
	Normal	9	20.00%
	Other/Unknown	8	17.78%
	Had been drinking	3	6.67%
	Illness	3	6.67%
Driver action	Wrong Way/Side	36	80.00%
	Other/None/Unknown	6	13.33%
	Evading Police Vehicle	1	2.22%
	Improper lane change	1	2.22%

Table E.3. Pre-Crash/Human: B-Injury

◆B-Injury Crashes

Total 37

Age of driver 1	16-24	4	10.81%
	25-34	9	24.32%
	35-44	10	27.03%
	45-54	2	5.41%
	55-64	2	5.41%
	Above 65	10	27.03%
Gender of driver 1	Male	26	70.27%
	Female	8	21.62%
Driver condition	Alcohol Impaired	18	48.65%
	Other/Unknown	9	24.32%
	Normal	5	13.51%
	Illness	2	5.41%
	Asleep/fainted	1	2.70%
	Drug Impaired	1	2.70%
Driver action	Wrong Way/Side	29	78.38%
	None/Other	5	13.51%
	Disregard Control Devices	1	2.70%
	Evading Police Vehicle	1	2.70%

Table E.4. Pre-Crash/Vehicle: Fatal Crashes

Fatal Crashes

		Total 31	
Vehicle 1 Maneuver	Driving Wrong Way	27	87.10%
	Straight Ahead	4	12.90%
Vehicle 1 Type	Passenger	18	58.06%
	Pickup	9	29.03%
	SUV	3	9.68%
	Motorcycle (over 150cc)	1	3.23%
Vehicle 2 Maneuver	Straight Ahead	22	70.97%
	Avoiding Vehicle/Objects	8	25.81%
	Passing/Overtaking	1	3.23%
Vehicle 2 Type	Passenger	12	38.71%
	Tractor with Semi-Trailer	8	25.81%
	Van/Mini-Van	6	19.35%
	Pickup	4	12.90%
	Other	1	3.23%

Table E.5. Pre-Crash/Vehicle: A-Injury Crashes

A-Injury Crashes

		Total 45	
Vehicle 1 Maneuver	Driving Wrong Way	22	48.89%
	Straight Ahead	21	46.67%
	Skidding/Control lost	2	4.44%
Vehicle 1 Type	Passenger	30	66.67%
	Pickup	5	11.11%
	SUV	5	11.11%
	Van/Mini Van	4	8.89%
	Tractor without Semi-Trailer	1	2.22%
Vehicle 2 Maneuver	Straight Ahead	29	74.36%
	Avoiding Vehicle/Objects	8	20.51%
	Passing/Overtaking	2	5.13%
Vehicle 2 Type	Passenger	23	58.97%
	SUV	4	10.26%
	Tractor with Semi-Trailer	4	10.26%
	Pickup	3	7.69%
	Van/Mini-Van	3	7.69%
	Motorcycle	1	2.56%
	Other	1	2.56%

Table E.6. Pre-Crash/Vehicle: B-Injury Crashes

B-Injury Crashes

Total 37

Vehicle 1 Maneuver	Driving Wrong Way	21	56.76%
	Straight Ahead	12	32.43%
	Other	2	5.41%
	Avoiding vehicle	1	2.70%
	U-Turn	1	2.70%
Vehicle 1 Type	Passenger	26	70.27%
	Pickup	5	13.51%
	Van/Mini Van	3	8.11%
	SUV	1	2.70%
	Tractor without Semi-Trailer	1	2.70%
Vehicle 2 Maneuver	Straight Ahead	23	82.14%
	Avoiding Vehicle/Objects	5	17.86%
Vehicle 2 Type	Passenger	17	60.71%
	Tractor with Semi-Trailer	6	21.43%
	Pickup	3	10.71%
	SUV	2	7.14%

Table E.7. Crash/Human: Fatal Crashes

◆Fatal Crashes

		Total	31
Cause 1	Driving on Wrong Side/Wrong Way	25	80.65%
	Improper Lane Usage	3	9.68%
	Under Influence of Alcohol/Drugs	2	6.45%
	Had Been Drinking	1	3.23%
Cause 2	Unable to Determine	6	19.35%
	Under Influence of Alcohol/Drugs	4	12.90%
	Driving Skills/Knowledge/Experience	3	9.68%
	Physical Condition of Driver	3	9.68%
	Disregarding Other Traffic Signs	2	6.45%
	Driving on Wrong Side/Wrong Way	2	6.45%
	Had Been Drinking	2	6.45%
	Improper Lane Usage	2	6.45%
	Operating Vehicle in Reckless Manner	2	6.45%
	NA	2	6.45%
	Failing to Reduce Speed to Avoid Crash	1	3.23%
	No Data	1	3.23%
	Weather	1	3.23%

Table E.8. Crash/Human: A-Injury Crashes

◆A-Injury Crashes

Cause	Factor	Total 45	%
Cause 1	Driving on Wrong Side/Wrong Way	19	42.22%
	Under Influence of Alcohol/Drugs	15	33.33%
	Physical Condition of Driver	4	8.89%
	Improper Lane Usage	2	4.44%
	Operating Vehicle in Reckless Manner	2	4.44%
	Exceeding Safe Speed for Conditions	1	2.22%
	Had Been Drinking	1	2.22%
Cause 2	Driving on Wrong Side/Wrong Way	11	24.44%
	Improper Lane Usage	8	17.78%
	Under Influence of Alcohol/Drugs	6	13.33%
	NA	4	8.89%
	Operating Vehicle in Reckless Manner	4	8.89%
	Physical Condition of Driver	3	6.67%
	Failing to Reduce Speed to Avoid Crash	2	4.44%
	Had Been Drinking	2	4.44%
	Driving Skills/Knowledge/Experience	1	2.22%
	Exceeding Safe Speed for Conditions	1	2.22%
	Following Too Closely	1	2.22%
	Improper Turning/No Signal	1	2.22%

Table E.9. Crash/Human: B-Injury Crashes

B-Injury Crashes

Total 37

Cause 1	Driving on Wrong Side/Wrong Way	16	43.24%
	Under Influence of Alcohol/Drugs	13	35.14%
	Physical Condition of Driver	3	8.11%
	Failing to Reduce Speed to Avoid Crash	1	2.70%
	Following Too Closely	1	2.70%
	Improper Lane Usage	1	2.70%
	NA	1	2.70%
	Operating Vehicle in Reckless Manner	1	2.70%
Cause 2	Driving on Wrong Side/Wrong Way	14	37.84%
	Driving Skills/Knowledge/Experience	4	10.81%
	Had Been Drinking	3	8.11%
	Under Influence of Alcohol/Drugs	3	8.11%
	NA	2	5.41%
	Physical Condition of Driver	2	5.41%
	Disregarding Other Traffic Signs	1	2.70%
	Distraction - From Outside Vehicle	1	2.70%
	Distraction - Operating a Wireless Phone	1	2.70%
	Exceeding Authorized Speed Limit	1	2.70%
	Failing to Reduce Speed to Avoid Crash	1	2.70%
	Improper Lane Usage	1	2.70%
	Road Construction/Maintenance	1	2.70%
	Unable to Determine	1	2.70%
	Weather	1	2.70%

Table E.10. Crash/Vehicle: Fatal Crashes

Fatal Crashes

		Total 31	
Type of crash	Head on	27	87.10%
	Sideswipe opposite direction	3	9.68%
	Angle	1	3.23%
Air Bag	Deployed	20	64.52%
	Deployment Unknown	10	32.26%
	Did Not Deploy	1	3.23%
Safety equipment	Seat belts used	20	64.52%
	Seat belts not used	7	22.58%
	Unknown/NA	2	6.45%
	None Present	1	3.23%
	Helmet not used	1	3.23%

Table E.11. Crash/Vehicle: A-Injury Crashes

A-Injury Crashes

Total 45

Type of crash	Head on	32	71.11%
	Sideswipe opposite direction	7	15.56%
	Fixed object	4	8.89%
	Overturned	2	4.44%
Air Bag	Deployed	26	57.78%
	Deployment Unknown	16	35.56%
	Did Not Deploy	3	6.67%
Safety equipment	Seat belts used	28	62.22%
	Seat belts not used	10	22.22%
	Unknown/NA	4	8.89%
	None Present	3	6.67%

Table E.12. Crash/Vehicle: B-Injury Crashes

B-Injury Crashes

Total 37

Type of crash	Head on	32	71.11%
	Sideswipe opposite direction	7	15.56%
	Fixed object	4	8.89%
	Overturned	2	4.44%
Air Bag	Deployed	17	45.95%
	Deployment Unknown	17	45.95%
	Did Not Deploy	1	2.70%
Safety equipment	Seat belts used	31	83.78%
	Unknown/NA	4	10.81%
	Seat belts not used	2	5.41%

Table E.13. Crash/Roadway: Fatal Crashes

Fatal Crashes

		Total 31	
Roadway surface	Dry	27	87.10%
	Wet	3	9.68%
	Snow or Slush	1	3.23%
Light condition	Darkness	14	45.16%
	Darkness, Lighted Road	13	41.94%
	Daylight	4	12.90%
Weather	Clear	29	93.55%
	Fog/Smoke/Haze	1	3.23%
	Snow	1	3.23%
Construction Zone	No	29	93.55%
	Yes	2	6.45%

Table E.14. Crash/Roadway: A-Injury Crashes

A-Injury Crashes

		Total 45	
Roadway surface	Dry	34	75.56%
	Wet	8	17.78%
	Snow or Slush	3	6.67%
Light condition	Darkness, Lighted Road	22	48.89%
	Darkness	13	28.89%
	Daylight	9	20.00%
	Dawn	1	2.22%
Weather	Clear	36	80.00%
	Rain	6	13.33%
	Snow	3	6.67%
Construction Zone	No defects	42	93.33%
	Construction zone	2	4.44%
	Unknown	1	2.22%

Table E.15. Crash/Roadway: B-Injury Crashes

B-Injury Crashes

	Total	37	
Roadway surface	Dry	28	75.68%
	Wet	9	24.32%
Light condition	Darkness, Lighted Road	18	48.65%
	Darkness	11	29.73%
	Daylight	6	16.22%
	Dawn	1	2.70%
	Dusk	1	2.70%
Weather	Clear	27	72.97%
	Rain	5	13.51%
	Fog/Smoke/Haze	2	5.41%
	Other	1	2.70%
	Sleet/Hail	1	2.70%
	Snow	1	2.70%
Construction Zone	No defects	34	91.89%
	Construction zone	2	5.41%
	Maintenance zone	1	2.70%

Table E.16. Crash Location: Fatal Crashes

31 Fatal Crashes

		Total 31	
Type of area	Urban	20	64.52%
	Rural	11	35.48%
County	MADISON	7	22.58%
	COOK	6	19.35%
	CHAMPAIGN	3	9.68%
	FRANKLIN	2	6.45%
	CLINTON	1	3.23%
	FAYETTE	1	3.23%
	MACOUPIN	1	3.23%
	MARION	1	3.23%
	MCLEAN	1	3.23%
	MONTGOMERY	1	3.23%
	PEORIA	1	3.23%
	ST. CLAIR	1	3.23%
	UNION	1	3.23%
	VERMILION	1	3.23%
	WAYNE	1	3.23%
	WILL	1	3.23%
	WINNEBAGO	1	3.23%

Table E.17. Crash Location: A-Injury Crashes

45 A-Injury Crashes

Type of area	Total 45		
	Urban	37	82.22%
	Rural	8	17.78%

County			
	COOK	17	37.78%
	WILL	7	15.56%
	ST. CLAIR	6	13.33%
	MADISON	2	4.44%
	SANGAMON	2	4.44%
	CHAMPAIGN	1	2.22%
	GRUNDY	1	2.22%
	LASALLE	1	2.22%
	MACON	1	2.22%
	MCLEAN	1	2.22%
	MONROE	1	2.22%
	PEORIA	1	2.22%
	TAZEWELL	1	2.22%
	UNION	1	2.22%
	WHITESIDE	1	2.22%
	WINNEBAGO	1	2.22%

Table E.18. Crash Location: B-Injury Crashes

37 B-Injury Crashes

Total 37

Type of area	Urban	32	86.49%
	Rural	5	13.51%
County	COOK	12	32.43%
	ST. CLAIR	4	10.81%
	LAKE	3	8.11%
	MADISON	3	8.11%
	TAZEWELL	2	5.41%
	WILL	2	5.41%
	CLARK	1	2.70%
	KANE	1	2.70%
	LASALLE	1	2.70%
	LOGAN	1	2.70%
	MCLEAN	1	2.70%
	MONTGOMERY	1	2.70%
	OGLE	1	2.70%
	PEORIA	1	2.70%
	PIKE	1	2.70%
	ROCK ISLAND	1	2.70%
	SANGAMON	1	2.70%

Table E.19. Crash Time

Time			
• Fatal crashes	12AM-1AM	6	19.35%
	1AM-2AM	5	16.13%
	2AM-3AM	4	12.90%
	4AM-5AM	2	6.45%
• A-Injury	3AM-4AM	10	22.22%
	12AM-1AM	6	13.33%
	4AM-5AM	5	11.11%
	6AM-7AM	3	6.67%
	1AM-2AM	2	4.44%
	2AM-3AM	2	4.44%
	5AM-6AM	2	4.44%
• B-Injury	1AM-2AM	7	18.92%
	3AM-4AM	7	18.92%
	2AM-3AM	4	10.81%
	4AM-5AM	3	8.11%

Number killed

- Total number killed: 44
- Average number killed: 1.42 Per fatal crash
- Total number of A-Injury 103
- Average number of A-injury 2.1 Per A-injury crash

APPENDIX F A CHECKLIST FOR FIELD REVIEW

WRONG-WAY ENTRY CHECKLISTFIELD INSPECTION SHEET

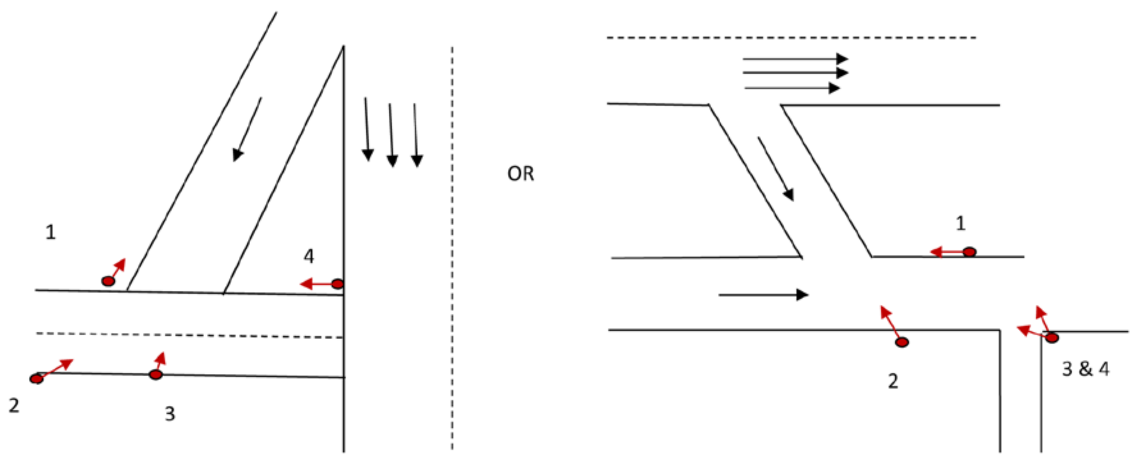
Inspector:		
Route Information:		Date:
Ramp Description:		Time:

SIGN	CHECK IF	YES	NO	COMMENTS
	At least one present			
	In good condition			
	At least one present			
	In good condition			
	Present at location for cross under/over traffic			
	NO RIGHT TURN			
	NO LEFT TURN			
	NO U-TURN			

PAVEMENT MARKNG	CHECK IF	YES	NO	COMMENTS
WRONG-WAY ARROWS	Present			
	Pieces in good condition			
Other Markings	Elephant tracks (turning guide line			
	Stopping lines at end of exit ramp			

GEOMETRC DESIGN FEATURES	CHECK IF	YES	NO	COMMENTS
Raised Curb Median on the crossroad	Present			
	Present			
	Present			
Design to Discourage Wrong-Way Entry	Present			

DESCRIBE ANY CONFUSING ROAD LAYOUT NEAR POSSIBLE WRONG-WAY ENTRY:



APPENDIX G COUNTERMEASURES FOR THE SELECTED 12 INTERCHANGES

Site Specific Countermeasures to Prevent Wrong-Way Driving

Compressed Diamond Interchange

1. **I-94/87th Street**
2. **US 41/W. Belmont Ave.**
3. **I-90/35th Street**
4. **I-57/S. Halsted Street**

Diamond Interchange

5. I-70/IL 111

Partial Cloverleaf Interchange

6. I-94 /W Foster Ave
7. I-94/ W Peterson
8. I-94/Touchy Ave
9. I-90/Cermak (China Town)
10. I-94/ Ohio St.
11. I-64/S. Bluff Rd.

SPUI

12. I-55/S. Damon Ave.

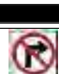
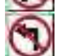
1. I-94/87th Street

Date	Time	Type of injury	Alcohol results	Crash ID	WW Entrance point
1/1/2005	4 AM	C Injury	Alcohol Impaired	50007830	I 94 N off ramp on 87th St.
9/16/2005	11 PM	Property Damage	Unknown	53502506	I94/87th St (U-turn)
10/29/2005	1 AM	B Injury	Alcohol Impaired	54279997	I 94 N off ramp on 87th St.
7/4/2008	3 AM	A Injury	Alcohol Impaired	82372731	I 94 N off ramp on 87th St.
6/15/2008	10 PM	C injury	Alcohol Impaired	82426834	I 94 S off ramp on 87th St.

WRONG-WAY ENTRY CHECKLIST

FIELD INSPECTION SHEET

Inspector:	Alan and Hugo	
Route Information:	I-94/87th St.	Date: 11/23/11
Ramp Description:		Time:1:45

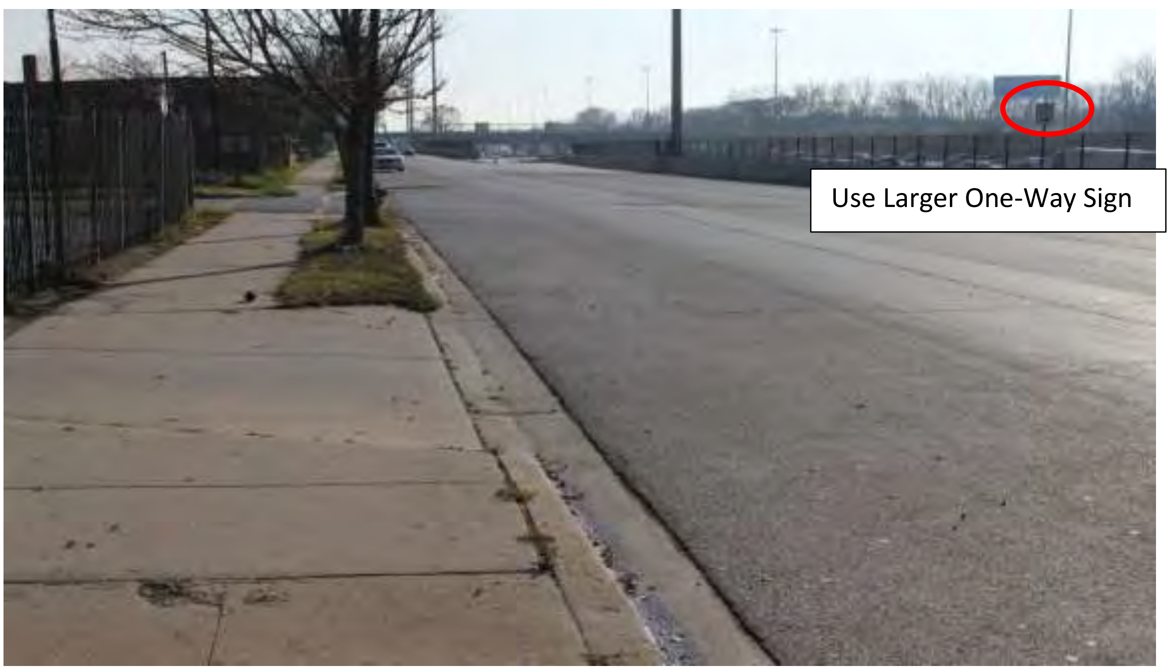
SIGN	CHECK IF	YES	NO	COMMENTS
	At least one present	√		It is located at the end of off-ramp. It should be added at the beginning of one-way street.
	In good condition	√		
	At least one present	√		Wrong-way sign is needed at the one-way street.
	In good condition	√		
	Present at location for cross under/over traffic	√		Very small size Point to wrong direction at 88th street
	NO RIGHT TURN	√		
	NO LEFT TURN	√		
	NO U-TURN		x	

PAVEMENT MARKNG	CHECK IF	YES	NO	COMMENTS
WRONG-WAY ARROWS	Present		x	
	Pieces in good condition		X	
Other Markings	Elephant tracks (turning guide line		X	
	Stopping lines at end of exit ramp		X	

GEOMETRC DESIGN FEATURES	CHECK IF	YES	NO	COMMENTS
Raised Curb Median on the crossroad	Present		X	
	Present		X	
	Present		X	
Design to Discourage	Present		X	

Comments: **Off ramp connects to one way frontage road (3 lanes). More signs should be added along the frontage road, and those driveways and side streets connected to frontage road.**

Potential Counter Measures




Add No-Right-Turn Sign
Use Larger One-Way Sign


Pavement Arrows
Right angle shoulder


STATE
Change to the greens arrow for through traffic


Remove the No-Right-turn at the left corner


Fix the One-Way Sign
ONE WAY
STOP
ONLY


Change this solid line to regular broking line
Exit Street View
Google earth

2. US 41/W. Belmont Ave.

Date	Time	Type of injury	Alcohol results	Crash ID	WW Entrance point
4/25/2004	5 AM	B Injury	Illness	41330648	I 41 N off ramp on Belmont Ave.
9/28/2005	3 AM	Property Damage	Alcohol Impaired	53813564	I 41 N off ramp on Belmont Ave.
12/1/2007	11 PM	Property Damage	Unknown	74837931	I 41 N off ramp on Belmont Ave.
3/24/2009	11 PM	Property Damage	Alcohol Impaired	200901127 535	I 41 S off ramp on Belmont Ave.

WRONG-WAY ENTRY CHECKLIST FIELD INSPECTION SHEET

Inspector:	Hugo, and Jiguang	
Route Information:	41/W Belmont Ave	Date: 11/24
Ramp Description:	Compressed Diamond	Time: 1:45

SIGN	CHECK IF	YES	NO	COMMENTS
	At least one present	√		No located at proper location and angle
	In good condition	√		
	At least one present	√		
	In good condition	√		
	Present at location for cross under/over traffic	x		
	NO RIGHT TURN	x		Need enhanced luminated sign inside the tunnel
	NO LEFT TURN	x		One faded sign
	NO U-TURN		x	

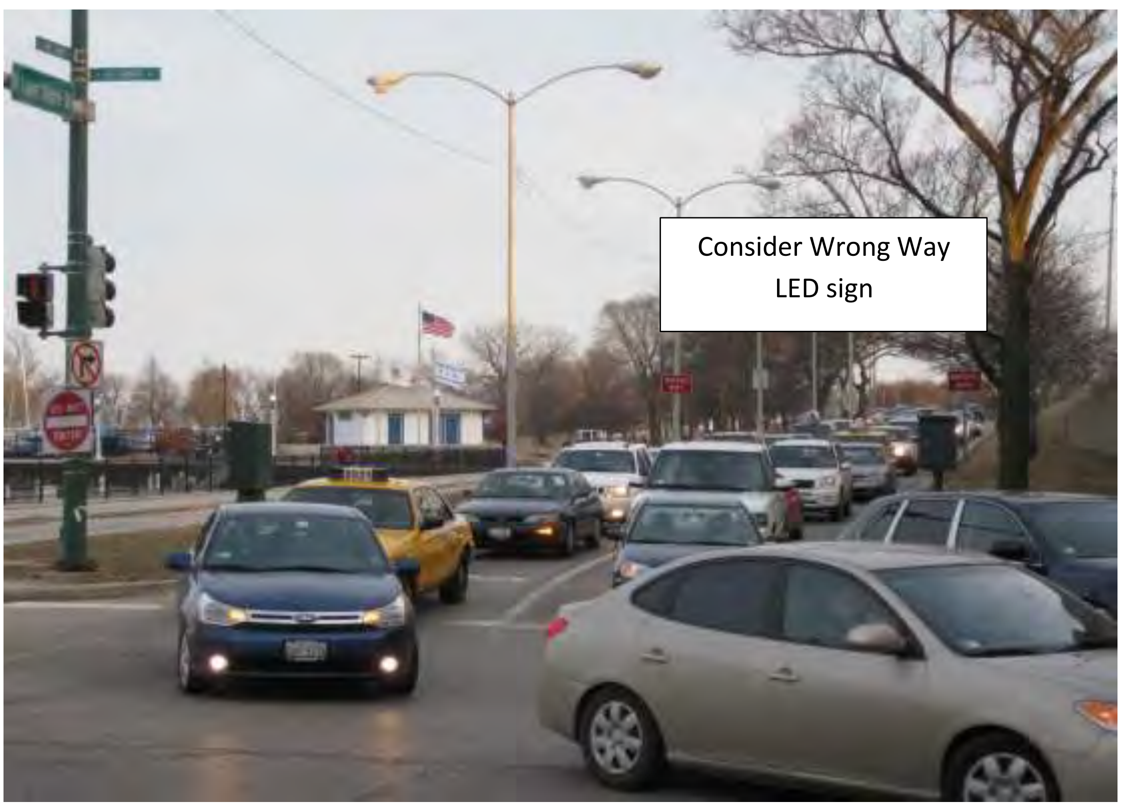
PAVEMENT MARKNG	CHECK IF	YES	NO	COMMENTS
WRONG-WAY ARROWS	Present			
	Pieces in good condition			
Other Markings	Elephant tracks (turning guide line	X		Faded
	Stopping lines at end of exit ramp	√		

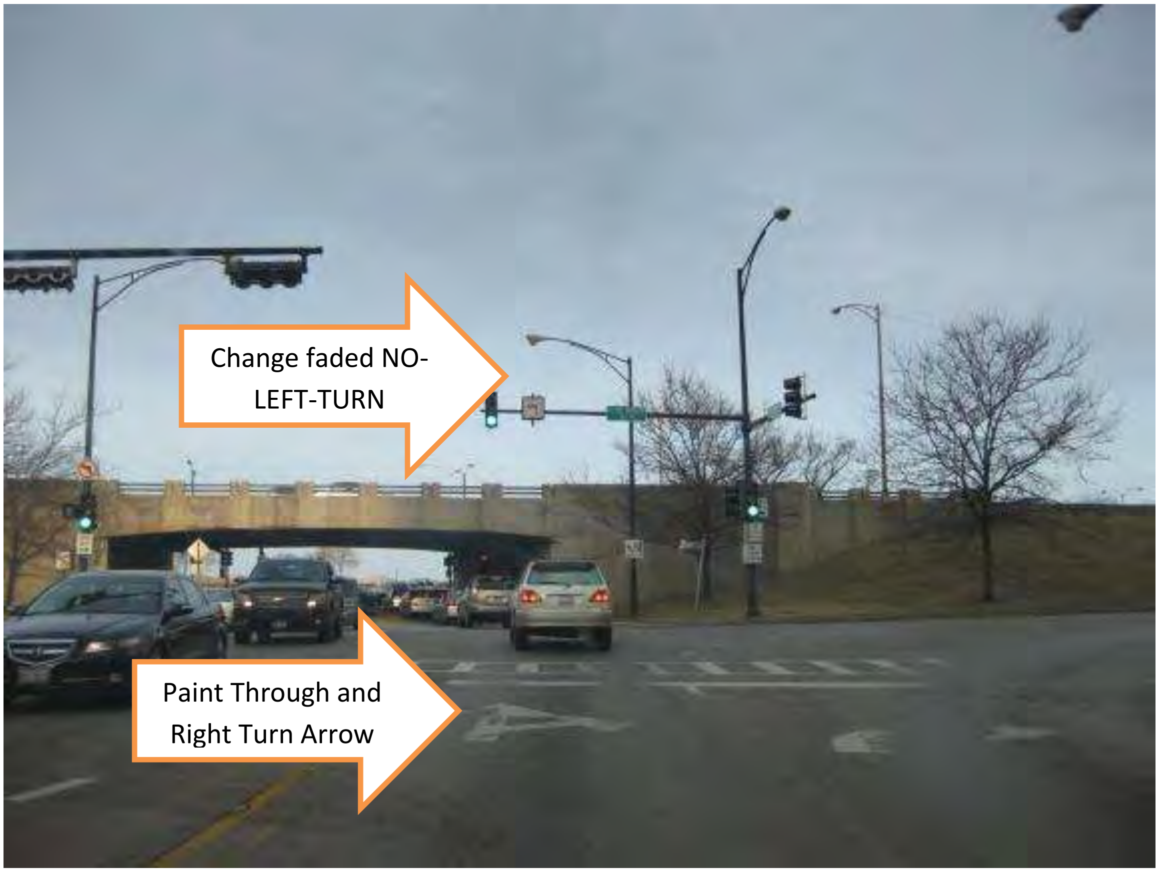
GEOMETRC DESIGN FEATURES	CHECK IF	YES	NO	COMMENTS
Raised Curb Median on the crossroad	Present		x	
	Present			
	Present			
Design to Discourage Wrong-Way Entry	Present	X		Additional signage to show the roadway layout; Pavement markings for through and turning traffic.

Comments: suggest to relocate the Do not Enter sign and use enhanced illuminated sign inside the underpass.

Potential Counter Measures


Replace and lower faded Sign
Rotate the Do Not Enter sign to face the potential WW drivers


Consider Wrong Way LED sign


Change faded NO-LEFT-TURN
Paint Through and Right Turn Arrow


Change faded NO-RIGHT-TURN
BOTH SIDES
North Lake Shore Drive | West Belmont Avenue
Exit Street View
est Belmont Avenue
Google earth


Change faded
NO-RIGHT-TURN
BOTH SIDES

3. I-90/35th Street

Date	Time	Type of injury	Alcohol results	Crash ID	WW Entrance point
3/4/2004	3 AM	Property Damage	Alcohol Impaired	41186206	I 90 S off ramp on 35th St.
3/15/2007	2 AM	Property Damage	Unknown	71163919	I 90 S off ramp on 35th St.
1/11/2009	5 AM	Property Damage	Unknown	200901030599	I 90 N off ramp on 35th St.

WRONG-WAY ENTRY CHECKLIST

FIELD INSPECTION SHEET

Inspector:	Alan and Hugo	
Route Information:	I-94/35th St.	Date: 11/23/11
Ramp Description:		Time: 3:30 PM

SIGN	CHECK IF	YES	NO	COMMENTS
	At least one present	√		
	In good condition	√		
	At least one present	√		
	In good condition	√		
	Present at location for cross under/over traffic		x	One way sign to be used
	NO RIGHT TURN	√		Mounted on over hanging signals
	NO LEFT TURN	√		On the corner, but not in good condition (Faded)
	NO U-TURN			

PAVEMENT MARKNG	CHECK IF	YES	NO	COMMENTS
WRONG-WAY ARROWS	Present		x	
	Pieces in good condition		X	
Other Markings	Elephant tracks (turning guide line		X	
	Stopping lines at end of exit ramp		X	

GEOMETRC DESIGN FEATURES	CHECK IF	YES	NO	COMMENTS
Raised Curb Median on the crossroad	Present		X	
	Present		X	
	Present		X	
Design to Discourage Wrong-Way Entry	Present			

Potential Counter Measures


West 35th Street
Adding One-way Sign
ONLY


Consider the arrow signal light
ONLY


Add one-way sign (both sides of the pole)
USE CROSSWALK
Exit Street View
La Salle Street / West 35th Street


South La Salle Street / West 35th Street, Chicago, Illinois, United States
Address is approximate
Photos
Add Do-not Enter sign and wrong-way sign


ONLY
Exit Street View
Google earth

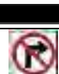

West 35th Street
ONLY
Exit Street View
Google earth

4. I-57/S. Halsted Street

Date	Time	Type of injury	Alcohol results	Crash ID	WW Entrance point
4/11/2007	6 PM	Property Damage	Normal	70758826	I 57 E off ramp on Halsted St.
7/4/2008	3 AM	A injury	Alcohol Impaired	82372731	I 57 E off ramp on Halsted St.
5/18/2009	4 PM	B injury	Normal	200901093 113	I 57 W off ramp on Halsted St.

WRONG-WAY ENTRY CHECKLIST FIELD INSPECTION SHEET

Inspector:	Alan and Hugo	
Route Information:	I-57/S Halsted St.	Date: 11/23/11
Ramp Description:	Compressed Diamond	Time:2:00

SIGN	CHECK IF	YES	NO	COMMENTS
	At least one present	√		
	In good condition	√		
	At least one present	√		More wrong way sign can be added farther way down
	In good condition	√		
	Present at location for cross under/over traffic	√		
	NO RIGHT TURN			
	NO LEFT TURN			
	NO U-TURN			

PAVEMENT MARKNG	CHECK IF	YES	NO	COMMENTS
WRONG-WAY ARROWS	Present		x	
	Pieces in good condition		X	
Other Markings	Elephant tracks (turning guide line		X	
	Stopping lines at end of exit ramp		X	

GEOMETRC DESIGN FEATURES	CHECK IF	YES	NO	COMMENTS
Raised Curb Median on the crossroad	Present		X	
	Present		X	
	Present		X	
Design to Discourage Wrong-Way Entry	Present	√		Right turn only sign. Channelized right turn lanes. Do not enter and one way sign for driveways and one for side streets

Comments: Do Not Enter sign should be added to signalized intersections of one-way frontage road. Wrong way sign should be considered to be added on the one-way frontage road.


Adding Do-Not-Enter Signs and Wrong-Way Sign at the end of the off-ramp
Exit Street View
Google earth


Consider the arrow signal light
South Halsted Street / West 98th Place
87°38'35.08"W, 41°42'53.41"N
ONLY
Exit Street View
Google earth


One Way
STOP
STOP
ONE WAY
STOP
*
Typical Mounting
Google earth


Add Do-Not Enter and Wrong Way Sign
West 99th Street
Google earth

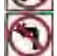
5. I-70/IL 111

Date	Time	Type of injury	Alcohol results	Crash ID	WW Entrance point
9/10/2005	6 AM	B injury	96	53401584	I 70 E off ramp on IL 111
3/26/2006	4 AM	Property damage	--	61367215	I 70 W off ramp on IL 111
7/23/2006	2 AM	Fatal crash 1	24	62477328	I 70 E off ramp on IL 111

WRONG-WAY ENTRY CHECKLIST

FIELD INSPECTION SHEET

Inspector:	H. Zhou, Irene Soria, Alan Ho, Ryan Fries, Balu, M. Williamson, and John 'Bo'	
Route Information:	I-70 / 111	Date: 11/08/11
Ramp Description:		Time:

SIGN	CHECK IF	YES	NO	COMMENTS
	At least one present	√		Angle of visibility is poor
	In good condition	√		
	At least one present	√		
	In good condition	√		
	Present at location for cross under/over traffic	√		
	NO RIGHT TURN		x	
	NO LEFT TURN		x	
	NO U-TURN		x	

PAVEMENT MARKNG	CHECK IF	YES	NO	COMMENTS
WRONG-WAY ARROWS	Present		x	No pavement markings
	Pieces in good condition		x	No stop bar
Other Markings	Elephant tracks (turning guide line		x	Allow pavement markings
	Stopping lines at end of exit ramp		x	

GEOMETRC DESIGN FEATURES	CHECK IF	YES	NO	COMMENTS
Raised Curb Median on the crossroad	Present	√		Left turn is difficult to do.
	Present		x	
	Present	√		
Design to Discourage Wrong-Way Entry	Present	√		Raised median and median extension.


Adjust the angle of Do NOT Enter sign
to face to potential ww drivers


STOP
Add the stop bar and through arrow
on pavement

Table 1 A Summary of Countermeasures for Preventing Wrong-Way Driving at Diamond and Compressed Diamond Interchanges

Countermeasures for Preventing Wrong-Way Manuver at Compressed Diamond & Diamond Interchanges																
		Signage												Pavement Marking		Traffic Lights
		Do-Not Enter				Wrong-Way				One Way		No-Right OR -Left-Turn		Arrow		Green
#	Interchange Name	Left Side	Right Side	Size	Strip	Left Side	Right Side	Size	Strip	Left Side	Right Side	Overhang to traffic Light	To the corner poles	Straight ONLY	Reflective Wrong Way	Change green ball to soild arrow
1	I-94 - 87th Street	X	X	35"X35"	X	X	X	42"X30"	X	X	X	X	X	X	X	X
2	US 41 - W. Belmont Ave	X	X	35"X35"	X	X	X	42"X30"	X	X	X	X	X	X	X	-
3	I-90 - 35th Street	X	X	35"X35"	X	X	X	42"X30"	X	X	X	X	X	X	X	X
4	I-57 - S. Halsted Street	X	X	35"X35"	X	X	X	42"X30"	X	X	X	X	X	X	X	X
5	I-70 - IL 111	X	X	30"x30"	X	X	X	36"x24"	X	-	X	-	-	-	-	
Common countermeasures		**X**	**X**	**35"X35"**	**X**	**X**	**X**	**42"X30"**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
MUTCD SECTION NO.		**2B.37**	**2B.37**	**2B.3**	**2A.21**	**2B.38**	**2B.38**	**2B.3**	**2A.21**	**2B.40**	**2B.40**	**2B.18**	**2B.18**	**2B.41/B**	**2B.41/3C**	**4D.04/2**

Table 2 A Summary of Countermeasures for Preventing Wrong-Way Driving at Partial Cloverleaf Interchanges

#	Interchange Name	Countermeasures for Preventing Wrong-Way Driving at Partial Clover leaf Interchanges																	
		Signage												Pavement Marking					Geometric Design
		Do-Not Enter				Wrong-Way				One Way		No-Right OR -Left-Turn		Arrow			Dotted	Extension	Raised Median
		Left Side	Right Side	Size	Strip	Left Side	Right Side	Size	Strip	Left Side	Right Side	Overhang to traffic Light	To the corner poles	Right Turn only	Straight Only	Reflective Wrong Way	Elephant Track	Double Yellow Line	Adjustment
1	I-94 - W Foster Ave	-	X		X	X	X		X					X			X	X	
2	I-94 - W Peterson	X	X		X	X	X		X					X	X				
3	I-94 - Touchy Ave				X					X		X			X				X
4	I-90 - Cermak (China Town)	X	X	35"X35"	X	X	X	42"X30"	-	X		X					X		X
5	I-90 - Ohio St.	X	X	35"X35"	X	X	X	42"X30"	-	X	X				X				
6	I-64 - S. Bluff Rd.	X	X	35"X35"	X	X	X	42"X30"	X			X					X		X
Common countermeasures		**X**	**X**	**35"X35"**	**X**	**X**	**X**	**42"X30"**	**X**										**X**
MUTCD SECTION NO.		**2B.37**	**2B.37**	**2B.3**	**2A.21**	**2B.38**	**2B.38**	**2B.3**	**2A.21**	**2B.40**	**2B.40**	**2B.18**	**2B.18**	**-**	**2B.41/B**	**2B.41/3C**	**2B-41**	**-**	**-**

6. I-94 /W Foster Ave

Date	Time	Type of injury	Alcohol results	Crash ID	WW Entrance point
2/20/2005	10 PM	A Injury	Unknown	50579119	I 94 N off ramp on W Foster Ave.
8/23/2009	5 AM	Property Damage	Alcohol Impaired	2009012487 29	I 94 N off ramp on W Foster Ave.

WRONG-WAY ENTRY CHECKLIST

FIELD INSPECTION SHEET

Inspector:	Alan and Hugo	
Route Information:	I-94/Foster avenue	Date: 11/23/11
Ramp Description:		Time:1:00

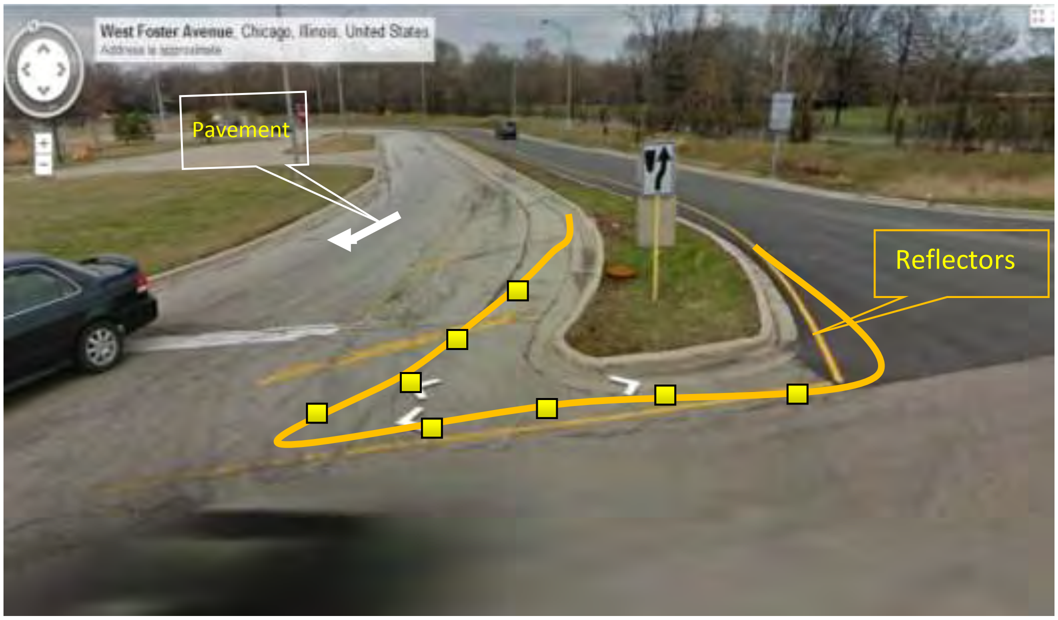
SIGN	CHECK IF	YES	NO	COMMENTS
	At least one present	√		
	In good condition	√		
	At least one present	√		
	In good condition		x	Not straight up
	Present at location for cross under/over traffic			
	NO RIGHT TURN		x	
	NO LEFT TURN		x	
	NO U-TURN		x	

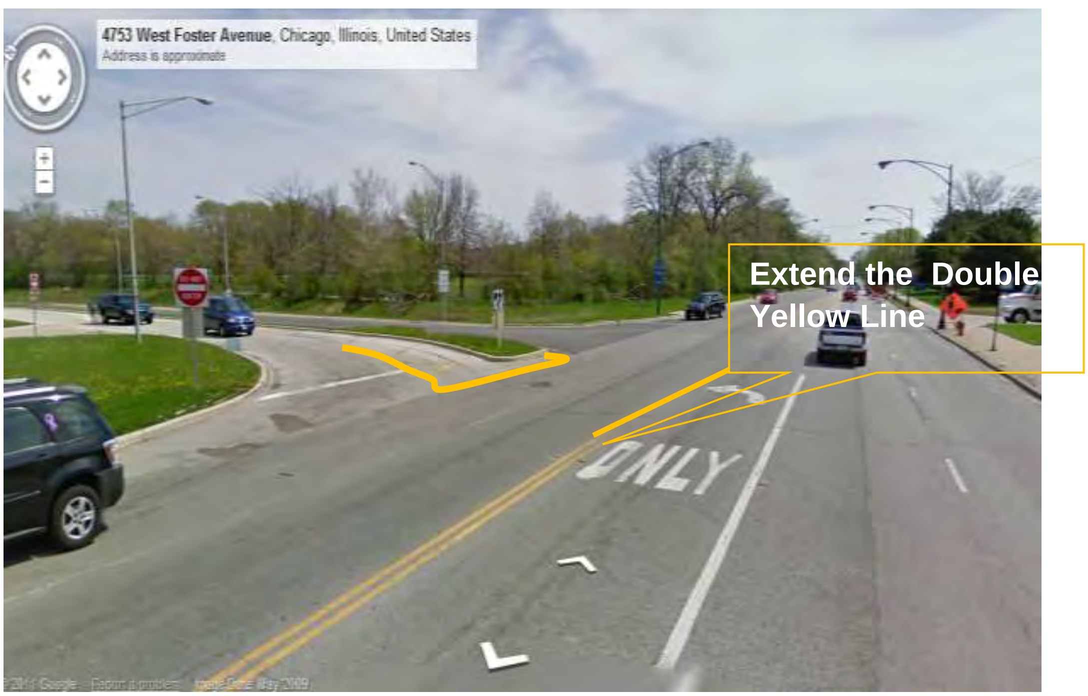
PAVEMENT MARKNG	CHECK IF	YES	NO	COMMENTS
WRONG-WAY ARROWS	Present		x	
	Pieces in good condition		X	
Other Markings	Elephant tracks (turning guide line		X	Double yellow line fade away on foster Ave.
	Stopping lines at end of exit ramp		X	

GEOMETRC DESIGN FEATURES	CHECK IF	YES	NO	COMMENTS
Raised Curb Median on the crossroad	Present		X	Paved area can be used for installing raised curb median
	Present			
	Present	√		
Design to Discourage Wrong-Way Entry	Present		X	

Comments: On and off ramps are very close. No Turn Signage and raised curb median can be used to reduce WW driving incidents.

Potential Countermeasures






4753 West Foster Avenue, Chicago, Illinois, United States
Address is approximate
Enhance Visibility with Red Tape
ONLY


Fix the Wrong-Way Sign

7. I-94/ W Peterson

Date	Time	Type of injury	Alcohol results	Crash ID	WW Entrance point
5/6/2006	3 AM	A Injury	Alcohol Impaired	64043664	I 94 N off ramp on Peterson Ave.
11/27/2008	3 AM	A Injury	Alcohol Impaired	84194687	I 94 N off ramp on Peterson Ave.
1/7/2009	11 AM	Fatal 1	Drug Impaired	96092994	I 94 N off ramp on W Touhy Ave.
8/23/2009	5 AM	Property Damage	Alcohol Impaired	200901248729	I 94 N off ramp on Peterson Ave.

WRONG-WAY ENTRY CHECKLIST
FIELD INSPECTION SHEET

Inspector:	Alan and Hugo	
Route Information:	I-94/Peterson	Date: 11/23/11
Ramp Description:	Parco 3	Time:11:00

SIGN	CHECK IF	YES	NO	COMMENTS
	At least one present	√		
	In good condition	√		
	At least one present	√		
	In good condition	√		
	Present at location for cross under/over traffic		x	Don't needed for partial clover leaf
	NO RIGHT TURN		x	
	NO LEFT TURN		x	
	NO U-TURN		x	

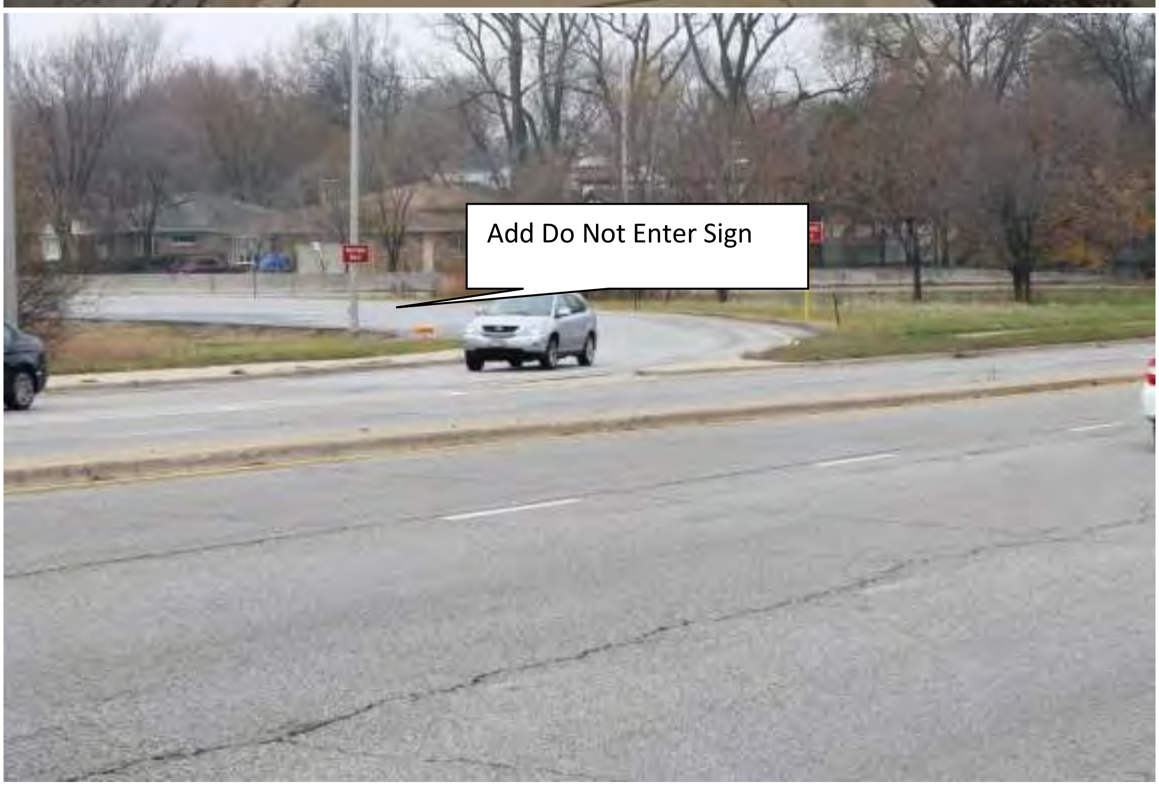
PAVEMENT MARKNG	CHECK IF	YES	NO	COMMENTS
WRONG-WAY ARROWS	Present		x	
	Pieces in good condition		X	
Other Markings	Elephant tracks (turning guide line		X	
	Stopping lines at end of exit ramp		X	No need for free flow clover leaf interchange

GEOMETRC DESIGN FEATURES	CHECK IF	YES	NO	COMMENTS
Raised Curb Median on the crossroad	Present	√		
	Present		X	
	Present		X	
Design to Discourage Wrong-Way Entry	Present	√		Raised curb median to eliminate any potential left turn WW entry

Comments: Short sight distance on ramp to I 94W (driver's view blocked by building, very short right turn lane). Some drivers missed the entrance might try to turn at the next off ramp, assuming it is a diamond interchange

Potential Countermeasures


Short Sight Distance for the On-Ramp Traffic
EAST
WEST
94
94


Add Do Not Enter Sign

8. I-94/Touchy Ave

WRONG-WAY ENTRY CHECKLIST

FIELD INSPECTION SHEET

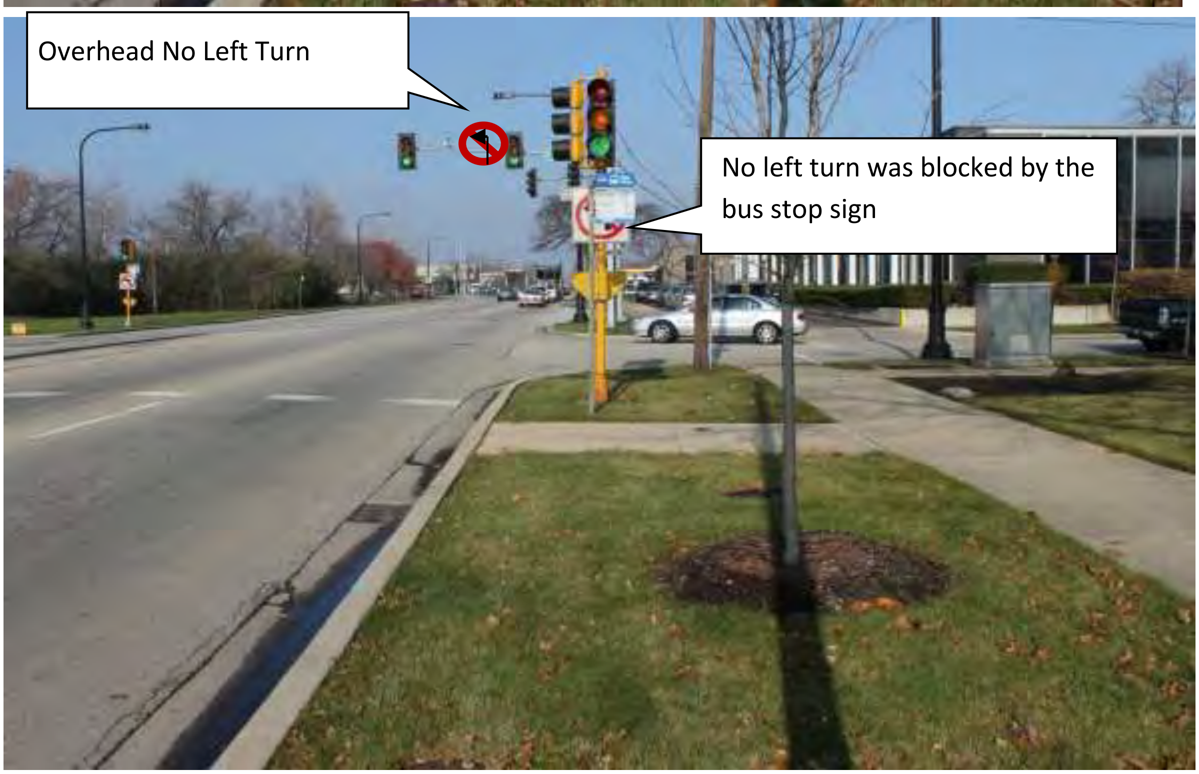
Inspector:	Alan and Hugo	
Route Information:	I-94/Touchy (W Peterson)	Date: 11/23/11
Ramp Description:	Off ramp	Time:12:00

SIGN	CHECK IF	YES	NO	COMMENTS
	At least one present	√		
	In good condition	√		
	At least one present	√		
	In good condition		x	Add more wrong-way sign along off ramp
	Present at location for cross under/over traffic		x	Very small size for the one-way street wrong direction at 88th street
	NO RIGHT TURN	√		
	NO LEFT TURN	√		One was blocked by bus stop
	NO U-TURN		x	

PAVEMENT MARKNG	CHECK IF	YES	NO	COMMENTS
WRONG-WAY ARROWS	Present		x	
	Pieces in good condition		X	
Other Markings	Elephant tracks (turning guide line			
	Stopping lines at end of exit ramp	√		

GEOMETRC DESIGN FEATURES	CHECK IF	YES	NO	COMMENTS
Raised Curb Median on the crossroad	Present		X	Paved island to add raised curb median
	Present		X	
	Present		X	
Design to Discourage Wrong-Way Entry	Present	X		Triangle island

Potential Countermeasures

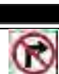
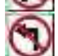


9. I-90/Cermak (China Town)

WRONG-WAY ENTRY CHECKLIST

FIELD INSPECTION SHEET

Inspector:	Hugo and Jiguang	
Route Information:	I-90/94/Chinatown	Date: 11/25
Ramp Description:	Partial Cloverleaf	Time:10:45

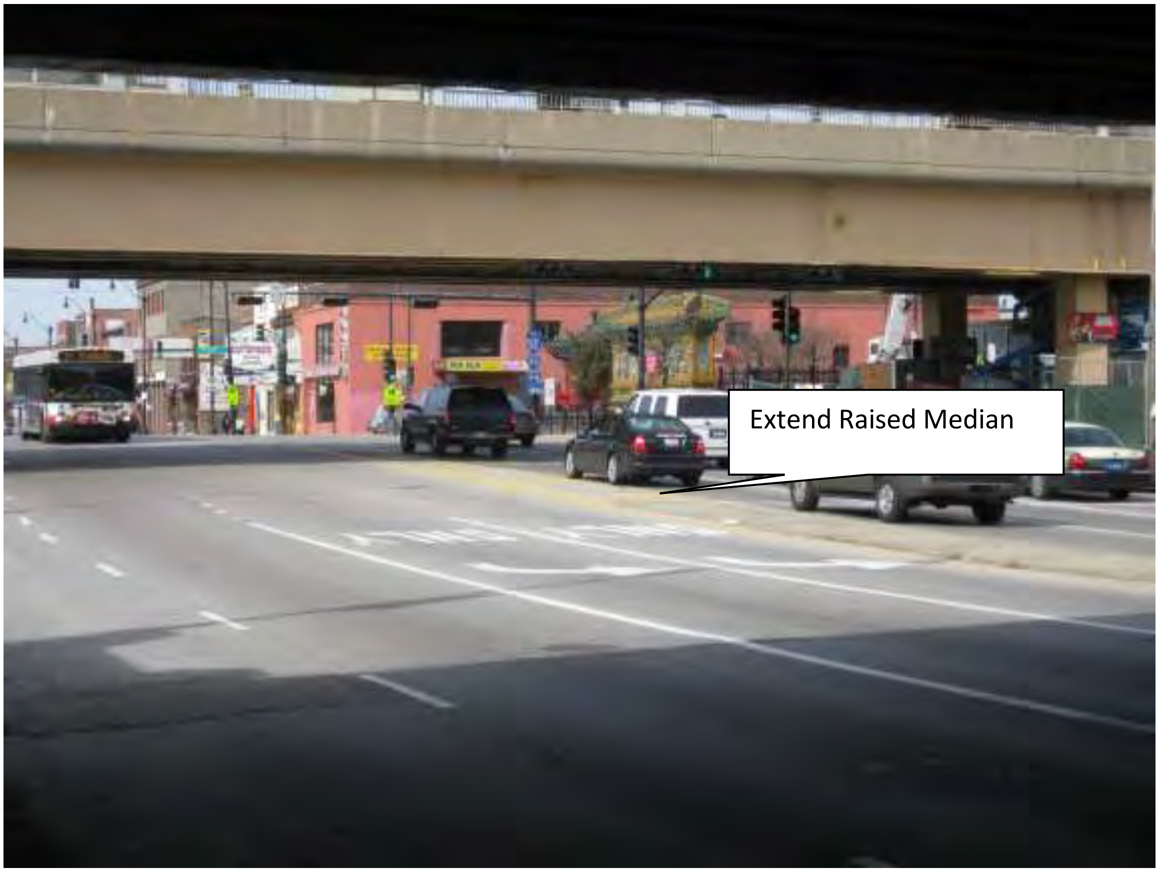
SIGN	CHECK IF	YES	NO	COMMENTS
	At least one present	√		A bigger sign needed for wide cross section
	In good condition	√		
	At least one present	√		
	In good condition	√		
	Present at location for cross under/over traffic			
	NO RIGHT TURN		x	
	NO LEFT TURN		x	
	NO U-TURN		x	

PAVEMENT MARKNG	CHECK IF	YES	NO	COMMENTS
WRONG-WAY ARROWS	Present			
	Pieces in good condition			
Other Markings	Elephant tracks (turning guide line		X	Need to guide traffic made the large turning
	Stopping lines at end of exit ramp	√		

GEOMETRC DESIGN FEATURES	CHECK IF	YES	NO	COMMENTS
Raised Curb Median on the crossroad	Present		X	Extend the raised curb median to restrict WW movements
	Present			
	Present			
Design to Discourage Wrong-Way Entry	Present			Additional signage for roadway layout

Comments: suggest to extend the raised curb median, use large size “Do Not Enter” sign, and install pavement marking to guide large turning movements.

Potential Countermeasures


Extend Raised Median


Good Lighting! Consider
LED Wrong-Way Sign

10. I-94/ Ohio St.

WRONG-WAY ENTRY CHECKLIST

FIELD INSPECTION SHEET

Inspector:	Hugo and Jiguang	
Route Information:	I-94/Ohio St.	Date: 11/25
Ramp Description:	Partial Cloverleaf	Time: 2:15

SIGN	CHECK IF	YES	NO	COMMENTS
	At least one present	√		Need an oversized sign for the wide cross section
	In good condition	√		
	At least one present	√		Need an enhanced sign for the wide cross section
	In good condition	√		
	Present at location for cross under/over traffic	X		
	NO RIGHT TURN			
	NO LEFT TURN	X		
	NO U-TURN		x	

PAVEMENT MARKNG	CHECK IF	YES	NO	COMMENTS
WRONG-WAY ARROWS	Present			
	Pieces in good condition			
Other Markings	Elephant tracks (turning guide line		X	Need to guide traffic from two-way to one way street transition
	Stopping lines at end of exit ramp	√		

GEOMETRC DESIGN FEATURES	CHECK IF	YES	NO	COMMENTS
Raised Curb Median on the crossroad	Present		X	Install raised median
	Present			
	Present			
Design to Discourage Wrong-Way Entry	Present			Additional overhead Do NOT Enter Sign Oversize Wrong-way sign used

Comments: Suggest to redesign the transition area from two-way to one-way street. Install raised median. Corner signal head is confusing to drivers.

Potential Countermeasures

11. I-64/S. Bluff Rd.

Date	Time	Type of injury	Alcohol results	Crash ID	WW Entrance point
9/23/2005	9 AM	C injury	96	53628657	I 64 off ramp South on IL 157
3/9/2006	2 AM	B injury	96	61360285	I 64 off ramp north on IL 157
4/21/2007	5 AM	Property damage	Drug impaired	70797980	I 64 off ramp South on IL 157

WRONG-WAY ENTRY CHECKLIST

FIELD INSPECTION SHEET

Inspector:	Irene Soria, H Zhou, M. Williams, R. Fries, and A. Ho	
Route Information:	I-64/ S bluff road	Date: 11/08/11
Ramp Description:		Time:

SIGN	CHECK IF	YES	NO	COMMENTS
	At least one present	√		3 entry points confusing for left turns
	In good condition	√		Not on both sides
	At least one present	√		For right turns if 4 miss the right turn only lane may
	In good condition	√		Not on both sides
	Present at location for cross under/over traffic		x	
	NO RIGHT TURN		x	
	NO LEFT TURN		x	
	NO U-TURN		x	

PAVEMENT MARKNG	CHECK IF	YES	NO	COMMENTS
WRONG-WAY ARROWS	Present		X	They don't use a through arrows
	Pieces in good condition		X	Include pavement markings
Other Markings	Elephant tracks (turning guide line		x	Stop bars & arrows
	Stopping lines at end of exit ramp	√		Use the reflective tape for pavement markings

GEOMETRC DESIGN FEATURES	CHECK IF	YES	NO	COMMENTS
Raised Curb Median on the crossroad	Present			
	Present			
	Present	√		
Design to Discourage Wrong-Way Entry	Present			

Comments:

- Remove the raised medians for right, through and left turn lanes of I-64 and Bluff south exit ramp
- Provide overhead DO NOT ENTER signs
- Elephant tracks need to be provided to guide traffic to both WB and EB on-ramps (MUTCD 2009 2B-41 & fig 3B-13)
- Recommend to have DO NOT ENTER sign followed by WRONG WAY on both sides of the road way clearly demarcating the wrong way for the drivers
- Use larger size WRONG-WAY and DO NOT ENTER signs for multi-lane off-ramps.
- DO NOT ENTER sign mounted on red post to increase nighttime visibility

Potential Countermeasures

12. I-55/S. Damon Ave.

Date	Time	Type of injury	Alcohol results	Crash ID	WW Entrance point
12/25/2004	7 PM	C Injury	Normal	45470762	I 55 W off ramp on S Damon Ave.
01/01/2006	6 AM	C Injury	Unknown	60541372	I 55 W off ramp on S Damon Ave.
11/22/2007	4 AM	C Injury	Alcohol Impaired	74225152	I 55 E off ramp on S Damon Ave.
11/25/2009	3 AM	Property Damage	Unknown	200901373072	I 55 E off ramp on S Damon Ave.

WRONG-WAY ENTRY CHECKLIST

FIELD INSPECTION SHEET

Inspector:	Alan, Hugo, and Jiguang	
Route Information:	I-55/Damon	Date: 11/23 and 24
Ramp Description:	SPUI	Time:1:45

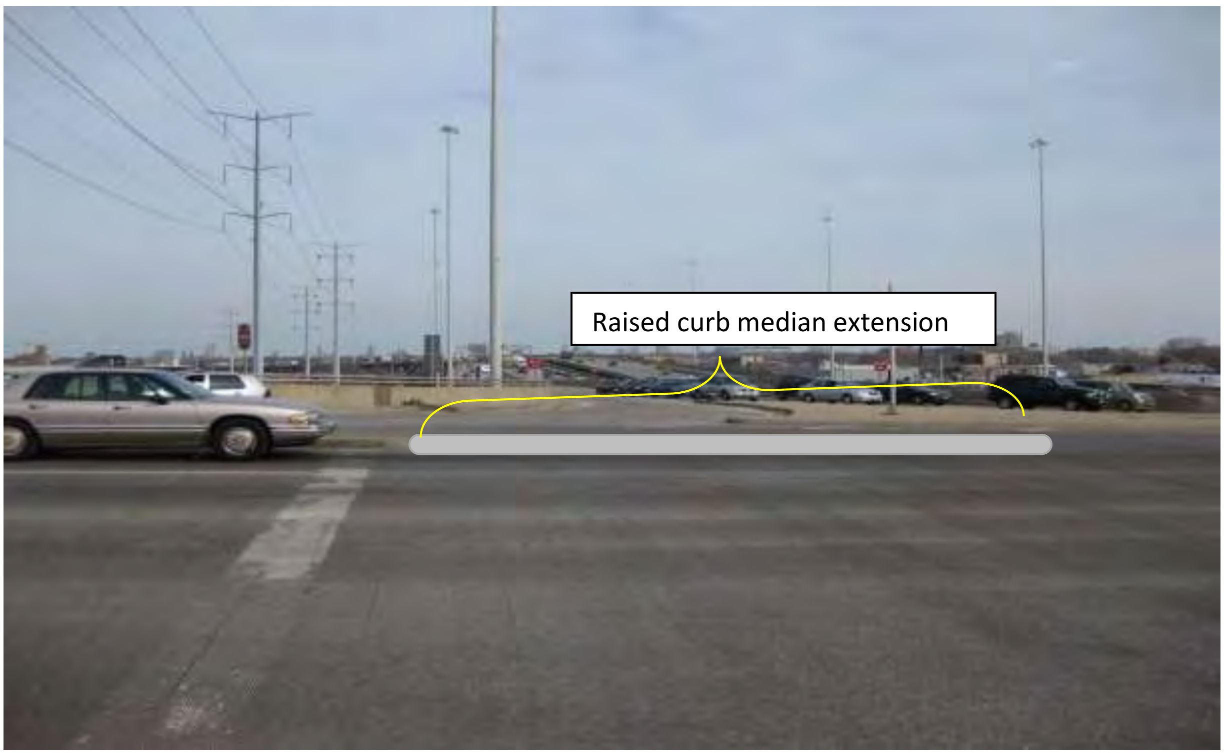
SIGN	CHECK IF	YES	NO	COMMENTS
	At least one present	√		Suggest to add on both sides
	In good condition	√		
	At least one present	√		
	In good condition	√		
	Present at location for cross under/over traffic		x	
	NO RIGHT TURN		x	
	NO LEFT TURN		x	
	NO U-TURN		x	

PAVEMENT MARKNG	CHECK IF	YES	NO	COMMENTS
WRONG-WAY ARROWS	Present			
	Pieces in good condition			
Other Markings	Elephant tracks (turning guide line		X	Need to guide traffic made the large turning
	Stopping lines at end of exit ramp	√		

GEOMETRC DESIGN FEATURES	CHECK IF	YES	NO	COMMENTS
Raised Curb Median on the crossroad	Present			
	Present			
	Present			
Design to Discourage Wrong-Way Entry	Present			Triangle Island Right turn only lane

Comments: suggest to use signal arrow for through traffic, and enhanced elephant tracts pavement marking to guide large turning movements.

Potential Countermeasures




Raised curb median extension
87°40'31.60"W 41°50'13.89"N
W 31st Pl
© 2012 Google

Appendix G

MUTCD 2009-Related Standards and Guidance

Section 1A.04 Placement and Operation of Traffic Control Devices

Guidance:

01 Placement of a traffic control device should be within the road user's view so that adequate visibility is provided. To aid in conveying the proper meaning, the traffic control device should be appropriately positioned with respect to the location, object, or situation to which it applies. The location and legibility of the traffic control device should be such that a road user has adequate time to make the proper response in both day and night conditions.

02 Traffic control devices should be placed and operated in a uniform and consistent manner.

03 Unnecessary traffic control devices should be removed. The fact that a device is in good physical condition should not be a basis for deferring needed removal or change.

Section 2B.37 DO NOT ENTER Sign (R5-1)

R5-1

Standard:

01 The DO NOT ENTER (R5-1) sign (see Figure 2B-11) shall be used where traffic is prohibited from entering a restricted roadway.

Guidance:

02 The DO NOT ENTER sign, if used, should be placed directly in view of a road user at the point where a road user could wrongly enter a divided highway, one-way roadway, or ramp (see Figure 2B-12). The sign should be mounted on the right-hand side of the roadway, facing traffic that might enter the roadway or ramp in the wrong direction.

03 If the DO NOT ENTER sign would be visible to traffic to which it does not apply, the sign should be turned away from, or shielded from, the view of that traffic.

Option:

04 The DO NOT ENTER sign may be installed where it is necessary to emphasize the one-way traffic movement on a ramp or turning lane.

05 A second DO NOT ENTER sign on the left-hand side of the roadway may be used, particularly where traffic approaches from an intersecting roadway (see Figure 2B-12).

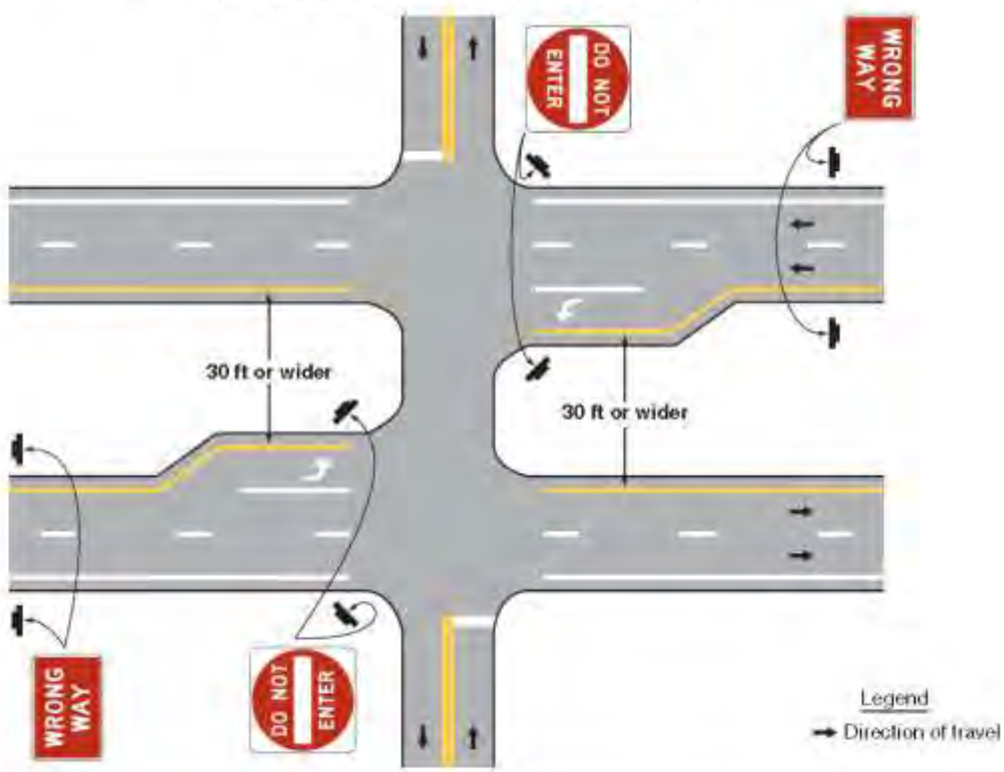
Support:

06 Section 2B.41 contains information regarding an optional lower mounting height for DO NOT ENTER signs that are located along an exit ramp facing a road user who is traveling in the wrong direction.

Figure 2B-11. Selective Exclusion Signs

* An optional word message sign is shown in the "Standard Highway Signs and Markings" book

Figure 2B-12. Locations of Wrong-Way Signing for Divided Highways with Median Widths of 30 Feet or Wider



Section 2B.38 WRONG WAY Sign (R5-1a)
Option:
01 The WRONG WAY (R5-1a) sign (see Figure 2B-11) may be used as a supplement to the DO NOT ENTER sign where an exit ramp intersects a crossroad or a crossroad intersects a one-way roadway in a manner that does not physically discourage or prevent wrong-way entry (see Figure 2B-12).

R5-1a

Guidance:
02 *If used, the WRONG WAY sign should be placed at a location along the exit ramp or the one-way roadway farther from the crossroad than the DO NOT ENTER sign (see Section 2B.41).*
Support:
03 *Section 2B.41 contains information regarding an optional lower mounting height for WRONG WAY signs that are located along an exit ramp facing a road user who is traveling in the wrong direction.*

Section 2B.40 ONE WAY Signs (R6-1, R6-2)
Standard:
01 **Except as provided in Paragraph 6, the ONE WAY (R6-1 or R6-2) sign (see Figure 2B-13) shall be used to indicate streets or roadways upon which vehicular traffic is allowed to travel in one direction only.**

R6-1

02 **ONE WAY signs shall be placed parallel to the one-way street at all alleys and roadways that intersect one-way roadways as shown in Figure 2B-14.**
03 **At an intersection with a divided highway that has a median width at the intersection itself of 30 feet or more, ONE WAY signs shall be placed, visible to each crossroad approach, on the near right and far left corners of each intersection with the directional roadways (see Figure 2B-15).**
04 **At an intersection with a divided highway that has a median width at the intersection itself of less than 30 feet, Keep Right (R4-7) signs and/or ONE WAY signs shall be installed (see Figures 2B-16 and 2B-17).**
If Keep Right signs are installed, they shall be placed as close as practical to the approach ends of the medians and shall be visible to traffic on the divided highway and each crossroad approach. If ONE WAY signs are installed, they shall be placed on the near right and far left corners of the intersection and shall be visible to each crossroad approach.

Typical Mounting

Option:
05 At an intersection with a divided highway that has a median width at the intersection itself of less than 30 feet, ONE WAY signs may also be placed on the far right corner of the intersection as shown in Figures 2B-16 and 2B-17.
06 ONE WAY signs may be omitted on the one-way roadways of divided highways, where the design of interchanges indicates the direction of traffic on the separate roadways.

Figure 2B-13. ONE WAY and Divided Highway Crossing Signs

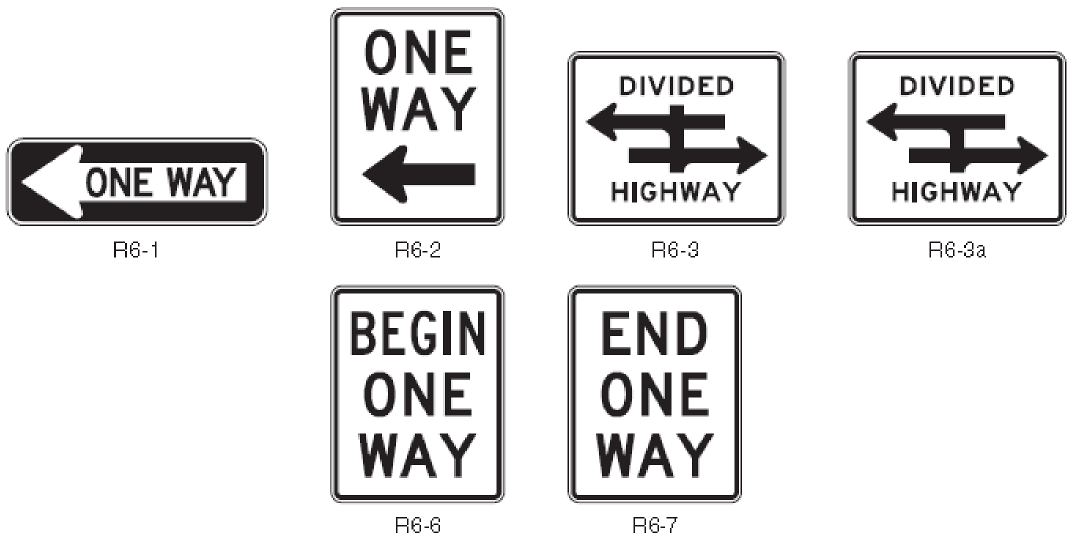


Figure 2B-14. Locations of ONE WAY Signs

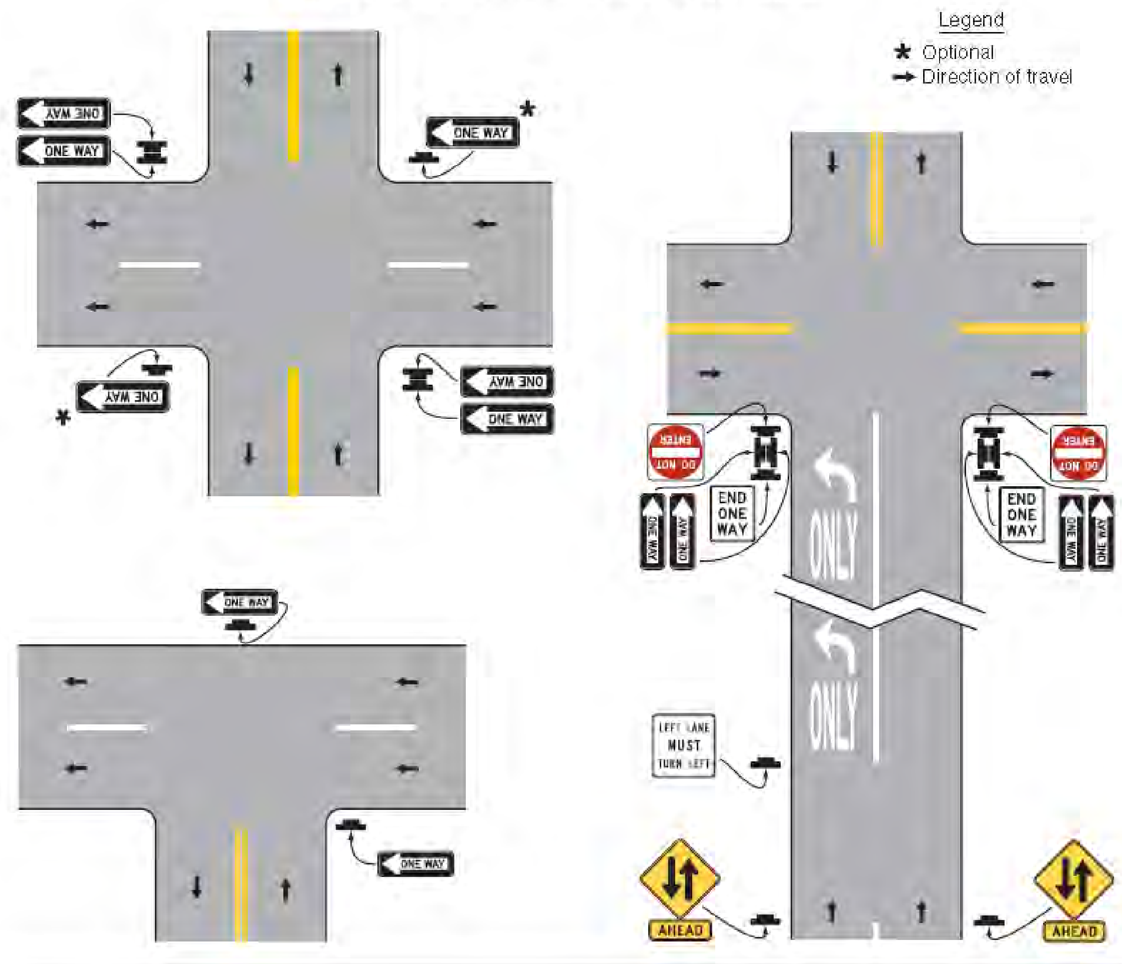
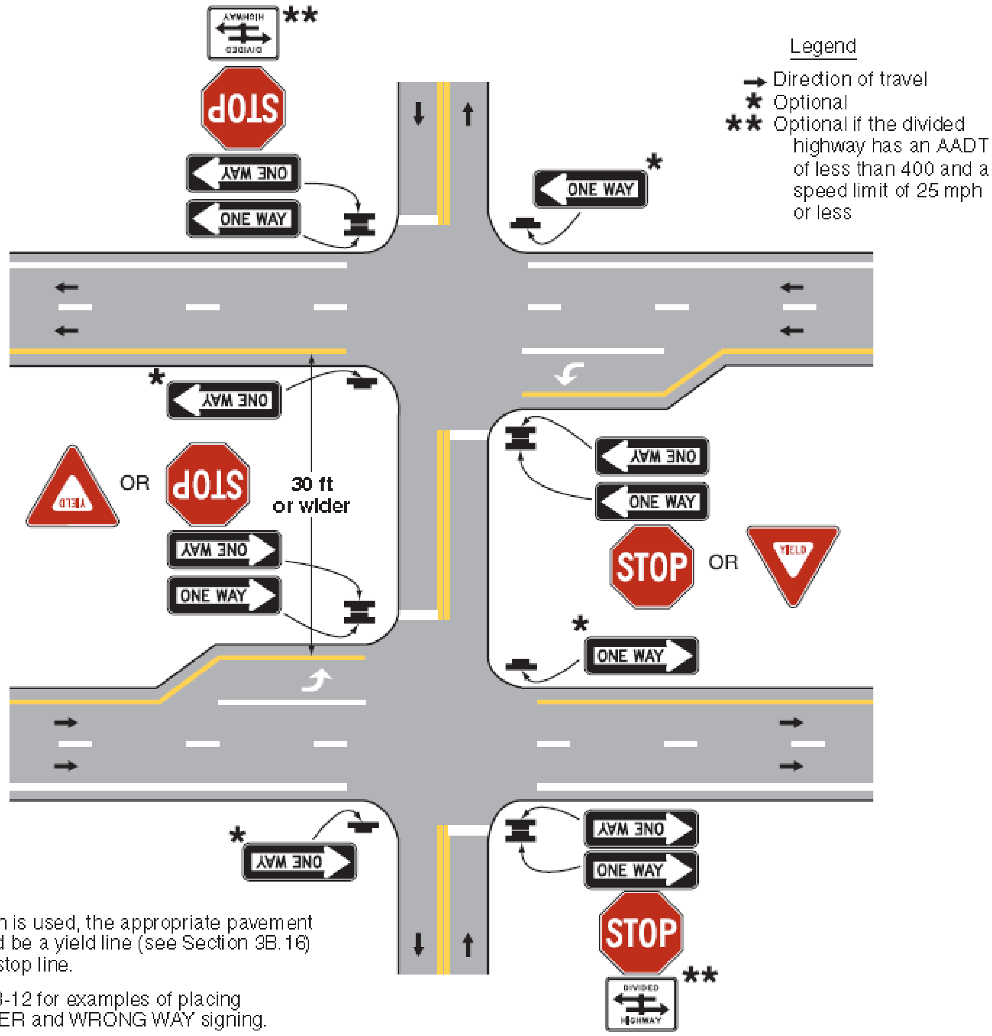


Figure 2B-15. ONE WAY Signing for Divided Highways with Median Widths of 30 Feet or Wider



Notes:

If a YIELD sign is used, the appropriate pavement marking would be a yield line (see Section 3B.16) rather than a stop line.

See Figure 2B-12 for examples of placing DO NOT ENTER and WRONG WAY signing.

Figure 2B-16. ONE WAY Signing for Divided Highways with Median Widths Narrower Than 30 Feet

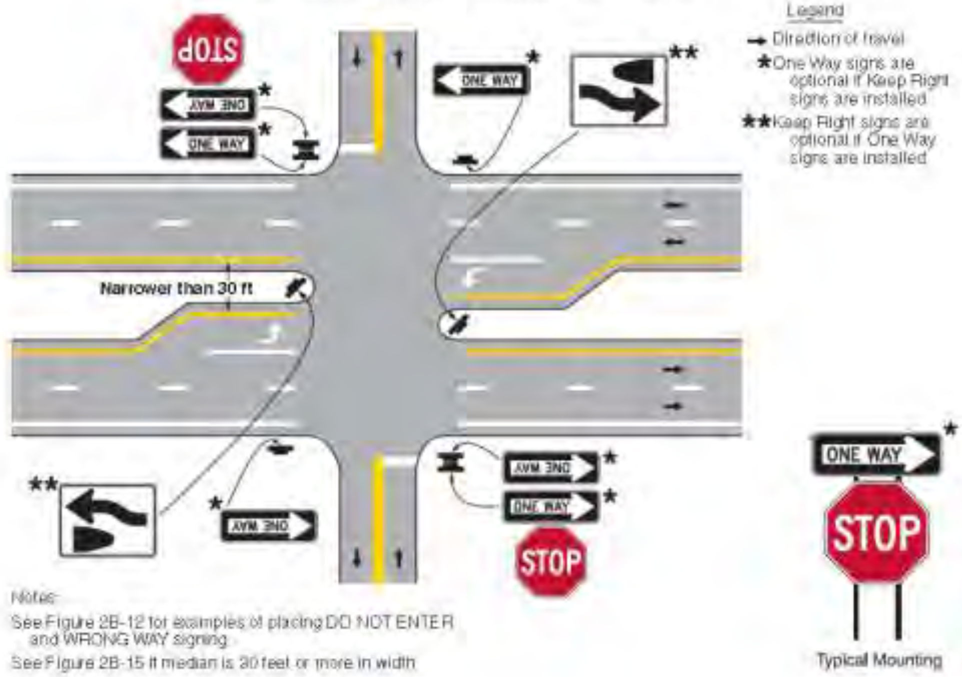
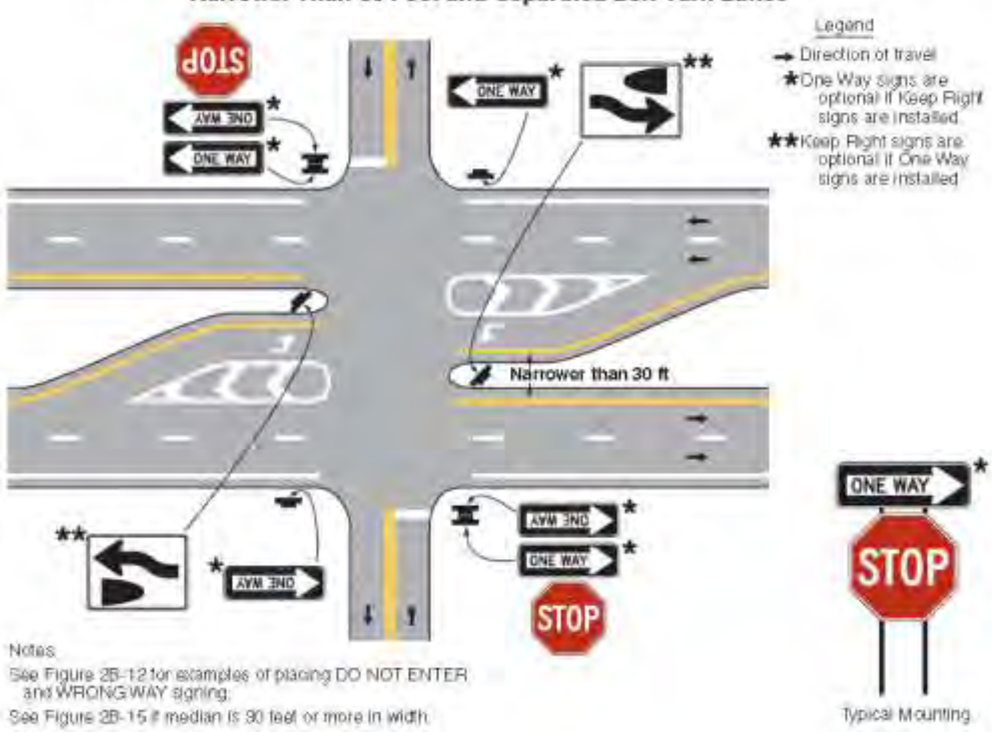


Figure 2B-17. ONE WAY Signing for Divided Highways with Median Widths Narrower Than 30 Feet and Separated Left-Turn Lanes



Section 2B.41 Wrong-Way Traffic Control at Interchange Ramps
Standard:
01 **At interchange exit ramp terminals where the ramp intersects a crossroad in such a manner that wrong-way entry could inadvertently be made, the following signs shall be used (see Figure 2B-18):**
A. At least one ONE WAY sign for each direction of travel on the crossroad shall be placed where the exit ramp intersects the crossroad.
B. At least one DO NOT ENTER sign shall be conspicuously placed near the downstream end of the exit ramp in positions appropriate for full view of a road user starting to enter wrongly from the crossroad.
C. At least one WRONG WAY sign shall be placed on the exit ramp facing a road user traveling in the wrong direction.
Guidance:
02 *In addition, the following pavement markings should be used (see Figure 2B-18):*
A. On two-lane paved crossroads at interchanges, double solid yellow lines should be used as a center line for an adequate distance on both sides approaching the ramp intersections.
B. Where crossroad channelization or ramp geometrics do not make wrong-way movements difficult, a lane-use arrow should be placed in each lane of an exit ramp near the crossroad terminal where it will be clearly visible to a potential wrong-way road user.

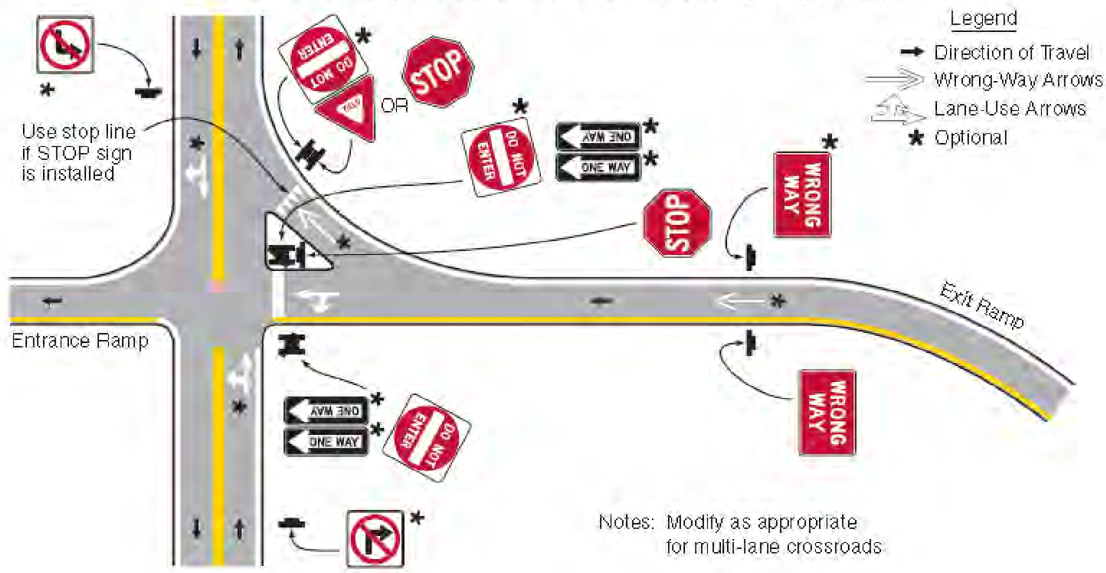
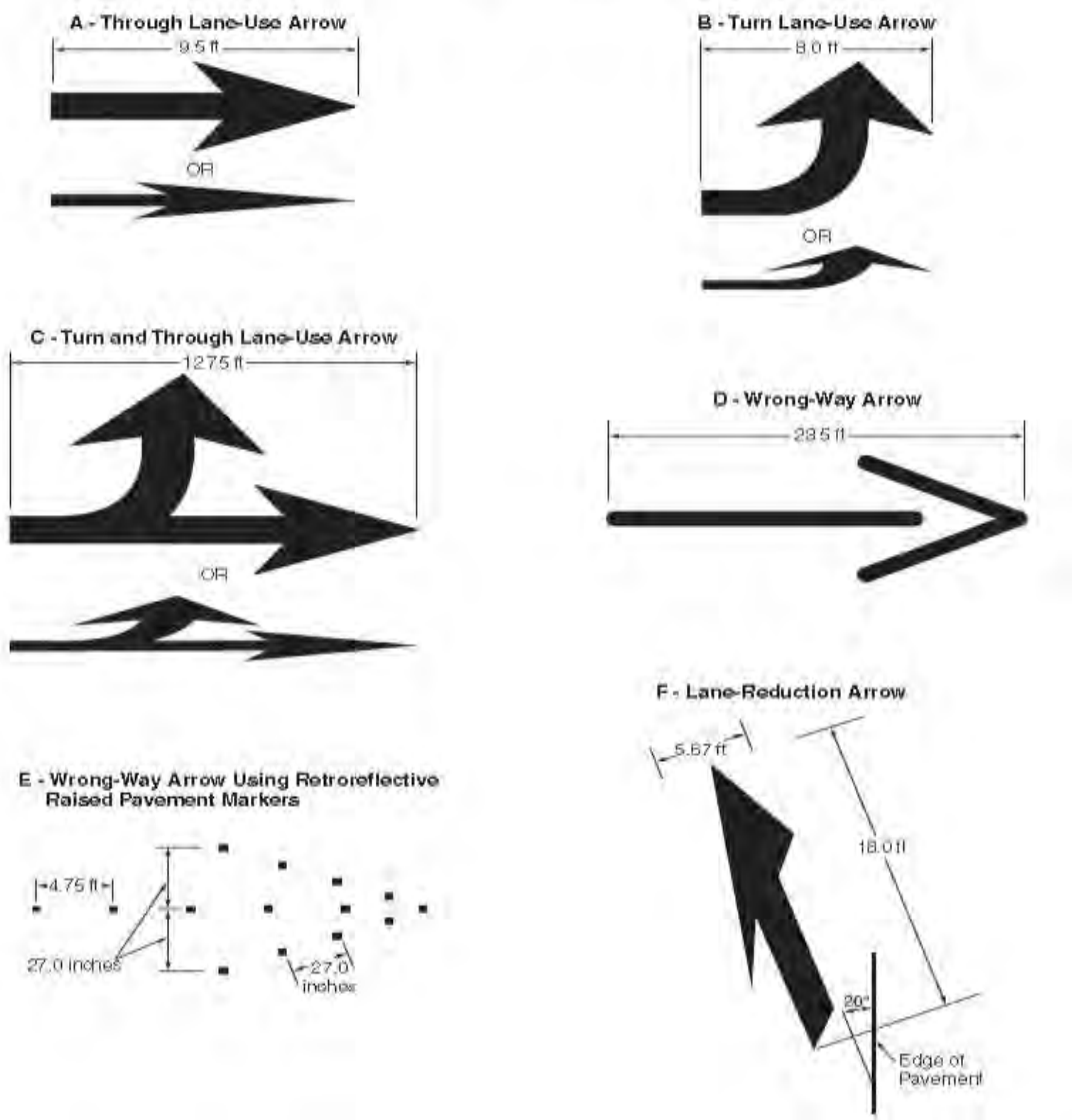


Figure 2B-18. Example of Application of Regulatory Signing and Pavement Markings at an Exit Ramp Termination to Deter Wrong-Way Entry

Option:
03 The following traffic control devices may be used to supplement the signs and pavement markings described in Paragraphs 1 and 2:
A. Additional ONE WAY signs may be placed, especially on two-lane rural crossroads, appropriately in advance of the ramp intersection to supplement the required ONE WAY sign(s).
B. Additional WRONG WAY signs may be used.
C. Slender, elongated wrong-way arrow pavement markings (see Figure 3B-24) intended primarily to warn wrong-way road users that they are traveling in the wrong direction may be placed upstream from the ramp terminus (see Figure 2B-18) to indicate the correct direction of traffic flow. Wrong-way arrow pavement markings may also be placed on the exit ramp at appropriate locations near the crossroad junction to indicate wrong-way movement. The wrong-way arrow markings may consist of pavement markings or bidirectional red-and-white raised pavement markers or other units that show red to wrong-way road users and white to other road users (see Figure 3B-24).
D. Lane-use arrow pavement markings may be placed on the exit ramp and crossroad near their intersection to indicate the permissive direction of flow.
E. Freeway entrance signs (see Section 2D.46) may be used.
Guidance:
04 On interchange entrance ramps where the ramp merges with the through roadway and the design of the interchange does not clearly make evident the direction of traffic on the separate roadways or ramps, a ONE WAY sign visible to traffic on the entrance ramp and through roadway should be placed on each side of the through roadway near the entrance ramp merging point as illustrated in Figure 2B-19.
Option:
05 At locations where engineering judgment determines that a special need exists, other standard warning or prohibitive methods and devices may be used as a deterrent to the wrong-way movement.
06 Where there are no parked cars, pedestrian activity or other obstructions such as snow or vegetation, and if an engineering study indicates that a lower mounting height would address wrong-way movements on freeway or expressway exit ramps, a DO NOT ENTER sign(s) and/or a WRONG WAY sign(s) that is located along the exit ramp facing a road user who is traveling in the wrong direction may be installed at a minimum mounting height of 3 feet, measured vertically from the bottom of the sign to the elevation of the near edge of the pavement.
Support:
07 Section 2B.41 contains further information on signing to avoid wrong-way movements at at-grade intersections on expressways.

Figure 3B-24. Examples of Standard Arrows for Pavement Markings



Section 2A.21 Posts and Mountings
Standard:
01 Sign posts, foundations, and mountings shall be so constructed as to hold signs in a proper and permanent position, and to resist swaying in the wind or displacement by vandalism.
Support:
02 The latest edition of AASHTO's "Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals" contains additional information regarding posts and mounting (see Page i for AASHTO's address).
Option:
03 Where engineering judgment indicates a need to draw attention to the sign during nighttime conditions, a strip of retroreflective material may be used on regulatory and warning sign supports.
Standard:
04 If a strip of retroreflective material is used on the sign support, it shall be at least 2 inches in width, it shall be placed for the full length of the support from the sign to within 2 feet above the edge of the roadway, and its color shall match the background color of the sign, except that the color of the strip for the YIELD and DO NOT ENTER signs shall be red.

…………………………………………………………….

Section 2B.03 Size of Regulatory Signs
Standard:
01 ***Except as provided in Section 2A.11, the sizes for regulatory signs shall be as shown in Table 2B-1.***
Support:
02 *Section 2A.11 contains information regarding the applicability of the various columns in Table 2B-1.*
Standard:
03 ***Except as provided in Paragraphs 4 and 5, the minimum sizes for regulatory signs facing traffic on multi-lane conventional roads shall be as shown in the Multi-lane column of Table 2B-1.***
Option:
04 *Where the posted speed limit is 35 mph or less on a multi-lane highway or street, other than for a STOP sign, the minimum size shown in the Single Lane column in Table 2B-1 may be used.*
05 *Where a regulatory sign, other than a STOP sign, is placed on the left-hand side of a multi-lane roadway in addition to the installation of the same regulatory sign on the right-hand side or the roadway, the size shown in the Single Lane column in Table 2B-1 may be used for both the sign on the right-hand side and the sign on the left-hand side of the roadway.*
Standard:
06 ***A minimum size of 36 x 36 inches shall be used for STOP signs that face multi-lane approaches.***

Table 2B-1. Regulatory Sign and Plaque Sizes (Sheet 2 of 4)

Sign or Plaque	Sign Designation	Section	Conventional Road		Expressway	Freeway	Minimum	Oversized
			Single Lane	Multi-Lane				
Do Not Pass	R4-1	2B.28	24 x 30	24 x 30	36 x 48	48 x 60	18 x 24	36 x 48
Pass With Care	R4-2	2B.29	24 x 30	24 x 30	36 x 48	48 x 60	18 x 24	36 x 48
Slower Traffic Keep Right	R4-3	2B.30	24 x 30	24 x 30	36 x 48	48 x 60	18 x 24	36 x 48
Trucks Use Right Lane	R4-5	2B.31	24 x 30	24 x 30	36 x 48	48 x 60	—	36 x 48
Keep Right	R4-7,7a,7b	2B.32	24 x 30	24 x 30	36 x 48	48 x 60	18 x 24	36 x 48
Narrow Keep Right	R4-7c	2B.32	18 x 30	18 x 30	—	—	—	—
Keep Left	R4-8,8a,8b	2B.32	24 x 30	24 x 30	36 x 48	48 x 60	18 x 24	35 x 48
Narrow Keep Left	R4-8c	2B.32	18 x 30	18 x 30	—	—	—	—
Stay in Lane	R4-9	2B.33	24 x 30	24 x 30	36 x 48	48 x 60	18 x 24	35 x 48
Runaway Vehicles Only	R4-10	2B.34	48 x 48	48 x 48	—	—	—	—
Slow Vehicles with XX or More Following Vehicles Must Use Turn-Out	R4-12	2B.35	42 x 24	42 x 24	—	—	—	—
Slow Vehicles Must Use Turn-Out Ahead	R4-13	2B.35	42 x 24	42 x 24	—	—	—	—
Slow Vehicles Must Turn Out	R4-14	2B.35	30 x 42	30 x 42	—	—	—	—
Keep Right Except to Pass	R4-16	2B.30	24 x 30	24 x 30	36 x 48	48 x 60	18 x 24	35 x 48
Do Not Drive on Shoulder	R4-17	2B.35	24 x 30	24 x 30	36 x 48	48 x 60	18 x 24	35 x 48
Do Not Pass on Shoulder	R4-18	2B.35	24 x 30	24 x 30	36 x 48	48 x 60	18 x 24	35 x 48
Do Not Enter	R5-1	2B.37	30 x 30*	36 x 36	36 x 36	48 x 48	—	36 x 36
Wrong Way	R5-1a	2B.38	36 x 24*	42 x 30	36 x 24*	42 x 30	30 x 18*	42 x 30
No Trucks	R5-2,2a	2B.39	24 x 24	24 x 24	30 x 30	36 x 36	—	36 x 36
No Motor Vehicles	R5-3	2B.39	24 x 24	24 x 24	—	—	24 x 24	—
No Commercial Vehicles	R5-4	2B.39	24 x 30	24 x 30	36 x 48	36 x 48	—	—
No Vehicles with Lugs	R5-5	2B.39	24 x 30	24 x 30	36 x 48	48 x 60	—	—
No Bicycles	R5-6	2B.39	24 x 24	24 x 24	30 x 30	36 x 36	24 x 24	48 x 48
No Non-Motorized Traffic	R5-7	2B.39	30 x 24	30 x 24	42 x 24	48 x 30	—	42 x 24
No Motor-Driven Cycles	R5-8	2B.39	30 x 24	30 x 24	42 x 24	48 x 30	—	42 x 24
No Pedestrians, Bicycles, Motor-Driven Cycles	R5-10a	2B.39	30 x 36	30 x 36	—	—	—	—
No Pedestrians or Bicycles	R5-10b	2B.39	30 x 18	30 x 18	—	—	—	—
No Pedestrians	R5-10c	2B.39	24 x 12	24 x 12	—	—	—	—
Authorized Vehicles Only	R5-11	2B.39	30 x 24	30 x 24	—	—	—	—
One Way	R6-1	2B.40	36 x 12*	54 x 18	54 x 18	54 x 18	—	54 x 18
One Way	R6-2	2B.40	24 x 30*	30 x 36	36 x 48	48 x 60	18 x 24*	36 x 48
Divided Highway Crossing	R6-3,3a	2B.42	30 x 24	30 x 24	36 x 30	—	—	36 x 30

Do Not Enter	R5-1	2B.37	30 x 30*	36 x 36	36 x 36	48 x 48	—	36 x 36
Wrong Way	R5-1a	2B.38	36 x 24*	42 x 30	36 x 24*	42 x 30	30 x 18*	42 x 30

One Way	R6-1	2B.40	36 x 12*	54 x 18	54 x 18	54 x 18	—	54 x 18
One Way	R6-2	2B.40	24 x 30*	30 x 36	36 x 48	48 x 60	18 x 24*	36 x 48

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Section 4D.04 Meaning of Vehicular Signal Indications

Support:

01 The "Uniform Vehicle Code" (see Section 1A.11) is the primary source for the standards for the meaning of vehicular signal indications to both vehicle operators and pedestrians as provided in this Section, and the standards for the meaning of separate pedestrian signal head indications as provided in Section 4E.02.

02 The physical area that is defined as being "within the intersection" is dependent upon the conditions that are described in the definition of intersection in Section 1A.13.

Standard:

03 The following meanings shall be given to highway traffic signal indications for vehicles and pedestrians:

A. Steady green signal indications shall have the following meanings:

1. Vehicular traffic facing a CIRCULAR GREEN signal indication is permitted to proceed straight through or turn right or left or make a U-turn movement except as such movement is modified by lane-use signs, turn prohibition signs, lane markings, roadway design, separate turn signal indications, or other traffic control devices.
Such vehicular traffic, including vehicles turning right or left or making a U-turn movement, shall yield the right-of-way to:
(a) Pedestrians lawfully within an associated crosswalk, and
(b) Other vehicles lawfully within the intersection.
In addition, vehicular traffic turning left or making a U-turn movement to the left shall yield the right-of-way to other vehicles approaching from the opposite direction so closely as to constitute an immediate hazard during the time when such turning vehicle is moving across or within the intersection.
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2. Vehicular traffic facing a GREEN ARROW signal indication, displayed alone or in combination with another signal indication, is permitted to cautiously enter the intersection only to make the movement indicated by such arrow, or such other movement as is permitted by other signal indications displayed at the same time.
Such vehicular traffic, including vehicles turning right or left or making a U-turn movement, shall yield the right-of-way to:
(a) Pedestrians lawfully within an associated crosswalk, and (b) Other vehicles lawfully within the intersection.
3. Pedestrians facing a CIRCULAR GREEN signal indication, unless otherwise directed by a pedestrian signal indication or other traffic control device, are permitted to proceed across the roadway within any marked or unmarked associated crosswalk. The pedestrian shall yield the right-of-way to vehicles lawfully within the intersection or so close as to create an immediate hazard at the time that the green signal indication is first displayed.
4. Pedestrians facing a GREEN ARROW signal indication, unless otherwise directed by a pedestrian signal indication or other traffic control device, shall not cross the roadway.
B. Steady yellow signal indications shall have the following meanings:
1. Vehicular traffic facing a steady CIRCULAR YELLOW signal indication is thereby warned that the related green movement or the related flashing arrow movement is being terminated or that a steady red signal indication will be displayed immediately thereafter when vehicular traffic shall not enter the intersection. The rules set forth concerning vehicular operation under the movement(s) being terminated shall continue to apply while the steady CIRCULAR YELLOW signal indication is displayed.
2. Vehicular traffic facing a steady YELLOW ARROW signal indication is thereby warned that the related GREEN ARROW movement or the related flashing arrow movement is being terminated. The rules set forth concerning vehicular operation under the movement(s) being terminated shall continue to apply while the steady YELLOW ARROW signal indication is displayed.
3. Pedestrians facing a steady CIRCULAR YELLOW or YELLOW ARROW signal indication, unless otherwise directed by a pedestrian signal indication or other traffic control device shall not start to cross the roadway.
C. Steady red signal indications shall have the following meanings:
1. Vehicular traffic facing a steady CIRCULAR RED signal indication, unless entering the intersection to make another movement permitted by another signal indication, shall stop at a clearly marked stop line; but if there is no stop line, traffic shall stop before entering the crosswalk on the near side of the intersection; or if there is no crosswalk, then before entering the intersection; and shall remain stopped until a signal indication to proceed is displayed, or as provided below.

Except when a traffic control device is in place prohibiting a turn on red or a steady RED ARROW signal indication is displayed, vehicular traffic facing a steady CIRCULAR RED signal indication is permitted to enter the intersection to turn right, or to turn left from a one-way street into a one-way street, after stopping. The right to proceed with the turn shall be subject to the rules applicable after making a stop at a STOP sign.

2. Vehicular traffic facing a steady RED ARROW signal indication shall not enter the intersection to make the movement indicated by the arrow and, unless entering the intersection to make another movement permitted by another signal indication, shall stop at a clearly marked stop line; but if there is no stop line, before entering the crosswalk on the near side of the intersection; or if there is no crosswalk, then before entering the intersection; and shall remain stopped until a signal indication or other traffic control device permitting the movement indicated by such RED ARROW is displayed.

When a traffic control device is in place permitting a turn on a steady RED ARROW signal indication, vehicular traffic facing a steady RED ARROW signal indication is permitted to enter the intersection to make the movement indicated by the arrow signal indication, after stopping.

The right to proceed with the turn shall be limited to the direction indicated by the arrow and shall be subject to the rules applicable after making a stop at a STOP sign.

3. Unless otherwise directed by a pedestrian signal indication or other traffic control device, pedestrians facing a steady CIRCULAR RED or steady RED ARROW signal indication shall not enter the roadway.

D. A flashing green signal indication has no meaning and shall not be used.

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E. Flashing yellow signal indications shall have the following meanings:

1. Vehicular traffic, on an approach to an intersection, facing a flashing CIRCULAR YELLOW signal indication is permitted to cautiously enter the intersection to proceed straight through or turn right or left or make a U-turn except as such movement is modified by lane-use signs, turn prohibition signs, lane markings, roadway design, separate turn signal indications, or other traffic control devices.

Such vehicular traffic, including vehicles turning right or left or making a U-turn, shall yield the right-of-way to:

(a) Pedestrians lawfully within an associated crosswalk, and

(b) Other vehicles lawfully within the intersection.

In addition, vehicular traffic turning left or making a U-turn to the left shall yield the right-of way to other vehicles approaching from the opposite direction so closely as to constitute an immediate hazard during the time when such turning vehicle is moving across or within the intersection.

2. Vehicular traffic, on an approach to an intersection, facing a flashing YELLOW ARROW signal indication, displayed alone or in combination with another signal indication, is permitted to cautiously enter the intersection only to make the movement indicated by such arrow, or other such movement as is permitted by other signal indications displayed at the same time.

Such vehicular traffic, including vehicles turning right or left or making a U-turn, shall yield the right-of-way to:

(a) Pedestrians lawfully within an associated crosswalk, and

(b) Other vehicles lawfully within the intersection.

In addition, vehicular traffic turning left or making a U-turn to the left shall yield the right-of-way to other vehicles approaching from the opposite direction so closely as to constitute an immediate hazard during the time when such turning vehicle is moving across or within the intersection.

3. Pedestrians facing any flashing yellow signal indication at an intersection, unless otherwise directed by a pedestrian signal indication or other traffic control device, are permitted to proceed across the roadway within any marked or unmarked associated crosswalk. Pedestrians shall yield the right-of-way to vehicles lawfully within the intersection at the time that the flashing yellow signal indication is first displayed.
4. When a flashing CIRCULAR YELLOW signal indication(s) is displayed as a beacon (see Chapter 4L) to supplement another traffic control device, road users are notified that there is a need to pay extra attention to the message contained thereon or that the regulatory or warning requirements of the other traffic control device, which might not be applicable at all times, are currently applicable.
F. Flashing red signal indications shall have the following meanings:
1. Vehicular traffic, on an approach to an intersection, facing a flashing CIRCULAR RED signal indication shall stop at a clearly marked stop line; but if there is no stop line, before entering the crosswalk on the near side of the intersection; or if there is no crosswalk, at the point nearest the intersecting roadway where the driver has a view of approaching traffic on the intersecting roadway before entering the intersection. The right to proceed shall be subject to the rules applicable after making a stop at a STOP sign.
2. Vehicular traffic, on an approach to an intersection, facing a flashing RED ARROW signal indication if intending to turn in the direction indicated by the arrow shall stop at a clearly marked stop line; but if there is no stop line, before entering the crosswalk on the near side of the intersection; or if there is no crosswalk, at the point nearest the intersecting roadway where the driver has a view of approaching traffic on the intersecting roadway before entering the intersection. The right to proceed with the turn shall be limited to the direction indicated by the arrow and shall be subject to the rules applicable after making a stop at a STOP sign.
3. Pedestrians facing any flashing red signal indication at an intersection, unless otherwise directed by a pedestrian signal indication or other traffic control device, are permitted to proceed across the roadway within any marked or unmarked associated crosswalk. Pedestrians shall yield the right-of-way to vehicles lawfully within the intersection at the time that the flashing red signal indication is first displayed.
4. When a flashing CIRCULAR RED signal indication(s) is displayed as a beacon (see Chapter 4L) to supplement another traffic control device, road users are notified that there is a need to pay extra attention to the message contained thereon or that the regulatory requirements of the other traffic control device, which might not be applicable at all times, are currently applicable. Use of this signal indication shall be limited to supplementing STOP (R1-1), DO NOT ENTER (R5-1), or WRONG WAY (R5-1a) signs, and to applications where compliance with the supplemented traffic control device requires a stop at a designated point.

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Section 2B.18 Movement Prohibition Signs (R3-1 through R3-4, R3-18, and R3-27)
Standard:
01 **Except as provided in Paragraphs 11 and 13, where specific movements are prohibited, Movement**
Prohibition signs shall be installed.
Guidance:
02 *Movement Prohibition signs should be placed where they will be most easily seen by road users who might be intending to make the movement.*
03 *If No Right Turn (R3-1) signs (see Figure 2B-4) are used, at least one should be placed either over the roadway or at a right-hand corner of the intersection.*

04 If No Left Turn (R3-2) signs (see Figure 2B-4) are used, at least one should be placed over the roadway, at the far left-hand corner of the intersection, on a median, or in conjunction with the STOP sign or YIELD sign located on the near right-hand corner.

Figure 2B-4. Movement Prohibition and Lane Control Signs and Plaques

* The diamond symbol may be used instead of the "HOV" word message. The minimum vehicle occupancy level may vary, such as 2+, 3+, 4+. The words "LANE" or "ONLY" may be used with this sign when appropriate.

05 Except as provided in Item C of Paragraph 9 for signalized locations, if NO TURNS (R3-3) signs (see Figure 2B-4) are used, two signs should be used, one at a location specified for a No Right Turn sign and one at a location specified for a No Left Turn sign.

06 If No U-Turn (R3-4) signs (see Figure 2B-4) or combination No U-Turn/No Left Turn (R3-18) signs (see Figure 2B-4) are used, at least one should be used at a location specified for No Left Turn signs.

Option:

07 If both left turns and U-turns are prohibited, the combination No U-Turn/No Left Turn (R3-18) sign (see Figure 2B-4) may be used instead of separate R3-2 and R3-4 signs.

Guidance:

08 *If No Straight Through (R3-27) signs (see Figure 2B-4) are used, at least one should be placed either over the roadway or at a location where it can be seen by road users who might be intending to travel straight through the intersection.*
09 *If turn prohibition signs are installed in conjunction with traffic control signals:*
A. The No Right Turn sign should be installed adjacent to a signal face viewed by road users in the right-hand lane.
B. The No Left Turn (or No U-Turn or combination No U-Turn/No Left Turn) sign should be installed adjacent to a signal face viewed by road users in the left-hand lane.
C. A NO TURNS sign should be placed adjacent to a signal face viewed by all road users on that approach, or two signs should be used.
Option:
10 If turn prohibition signs are installed in conjunction with traffic control signals, an additional Movement Prohibition sign may be post-mounted to supplement the sign mounted overhead.
11 Where ONE WAY signs are used (see Section 2B.40), No Left Turn and No Right Turn signs may be omitted.
12 When the movement restriction applies during certain time periods only, the following Movement Prohibition signing alternatives may be used and are listed in order of preference:
A. Changeable message signs, especially at signalized intersections.
B. Permanently mounted signs incorporating a supplementary legend showing the hours and days during which the prohibition is applicable.
C. Portable signs, installed by proper authority, located off the roadway at each corner of the intersection.
The portable signs are only to be used during the time that the movement prohibition is applicable.
13 Movement Prohibition signs may be omitted at a ramp entrance to an expressway or a channelized intersection where the design is such as to indicate clearly the one-way traffic movement on the ramp or turning lane.
Standard:
14 **The No Left Turn (R3-2) sign, the No U-Turn (R3-4) sign, and the combination No U-Turn/No Left Turn (R3-18) sign shall not be used at approaches to roundabouts to prohibit drivers from turning left onto the circulatory roadway of a roundabout.**
Support:
15 At roundabouts, the use of R3-2, R3-4, or R3-18 signs to prohibit left turns onto the circulatory roadway might confuse drivers about the possible legal turning movements around the roundabout. Roundabout Directional Arrow (R6-4 series) signs (see Section 2B.43) and/or ONE WAY (R6-1R or R6-2R) signs are the appropriate signs to indicate the travel direction within a roundabout.