Keeping Drivers Right:
Iowa's Low-Cost Strategy to Prevent Wrong-Way Entries

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Abstract

Wrong-way driving (WWD) crashes, though infrequent, carry a high risk of fatal and severe outcomes. The Iowa Department of Transportation (Iowa DOT) identified recurring WWD movements at partial cloverleaf (Parclo B) interchanges and implemented a series of low-cost, human-factor-based signing and marking countermeasures. The "gateway treatment" approach emphasized driver guidance through enhanced "Do Not Enter" and "Keep Right" signing and improved pavement markings. Evaluation across multiple sites showed an 88 percent reduction in WWD events per month and no crashes at treated locations since implementation. The results demonstrate that simple, data-driven strategies can deliver substantial safety benefits and serve as a practical model for other agencies addressing WWD risks.

Introduction

Over the last decade, Willy Sorenson, a longtime Iowa Department of Transportation (Iowa DOT) Traffic and Safety Engineer, has become one of the leading voices in understanding and preventing wrong-way driving (WWD).

What began as a personal initiative, a single engineer tracking a handful of puzzling wrong-way entries on one corridor, slowly grew into a statewide effort built on curiosity, persistence, and a willingness to test every idea that might make a difference. Mr. Sorenson evaluated nearly every WWD detection technology available, pored over crashes and near misses, and partnered with colleagues across disciplines to uncover patterns hidden in the data.

Wrong-way driving remains one of the most difficult roadway safety challenges to grasp. WWD events are rare, unpredictable, and scattered across the entire network. They can happen anywhere, at any time, for reasons that are often impossible to pinpoint, making them feel like finding a needle in a haystack the size of a state. Because of this unpredictability, it is neither practical nor cost-effective to deploy advanced ITS detection systems everywhere.

Yet the rarity of WWD events does not diminish their danger. A single wrong-way entry can lead to catastrophic head-on collisions, and some roadway configurations quietly raise the odds that a driver will make a path-choice error. Understanding how geometry, signage, pavement markings, and even lighting contribute to these mistakes is essential for identifying where physical changes can truly make a difference.

This combination of rare events, dispersed locations, severe consequences, and subtle human-factor triggers underscores why agencies need strategies that can detect patterns, prioritize locations, and apply practical, affordable countermeasures. This paper tells the story of how the Iowa DOT moved beyond standard guidance to develop a low-cost, human-centered approach that has dramatically reduced wrong-way entries across the state.

Statewide Screening and Site Prioritization

By the time the Iowa DOT began digging into its wrong-way driving (WWD) records, one thing had already become clear: the data alone did not tell the full story. Since 2010, the agency had been cataloging WWD events by frequency, location, and crash history, but the patterns were incomplete, and many incidents were not reported. Others were recorded only after a near miss or a driver's panicked call to 911. Understanding "when, where, and why" quickly proved far more complicated than the numbers suggested.

As the team reviewed national practices, they found a variety of ranking systems used by other agencies. Each offered pieces of the puzzle, but none fully captured the nuances the Iowa DOT saw in its own system. If Iowa was going to truly understand where the highest risks existed, it needed a way to see the network through a new lens—one that blended data, geometry, and human factors.

With this in mind, the DOT developed a modified scoring system to evaluate 129 interchanges and thirty-six at-grade intersections across the state. Rather than relying on a single metric, the system weighed six factors together: the number of wrong-way crashes, mainline traffic volume, side-road volume, interchange type, the number of non-crash WWD events, and whether the site was urban or rural. When the scoring was complete, a clearer picture emerged. Iowa's interchanges are clustered into three main configuration types: at-grade intersections, standard diamonds, and folded diamonds, each with its own tendencies and risks.

Among them, the folded diamond (or partial cloverleaf) interchanges stood out. Their geometry, turning paths, and visual cues created just enough opportunity for a driver to make the wrong choice at the wrong moment. These were the locations where small errors could turn into serious consequences.

This paper focuses on the Iowa DOT's efforts to understand and mitigate WWD at these folded diamond interchanges, where thoughtful design changes could have the greatest impact.

Problem Definition and Context

Geometry and Driver Behavior at Parclo Interchanges

Among Iowa's many interchange designs, the folded diamond, also known as a partial cloverleaf or "Parclo," presents a unique set of challenges for drivers. These interchanges appear frequently across the state, and although they function well under typical conditions, their geometry can create moments of hesitation or confusion, particularly for drivers who are unfamiliar with the area.

A Parclo interchange consists of several ramps, each identified by a letter and arranged to connect the major roadway with the minor road in a compact looping pattern. These partial

cloverleaf ramps, known as Parclos, are labelled by letter designation. Figure 1 provides an example. The aerial view highlights the intended travel paths, and the accompanying photograph shows how those same movements appear from the driver's perspective. The photo (left) also shows the typical signage provided up through roughly 2013, with an additional R5-1A not shown.

Mr. Sorenson refers to the inherent risk for drivers making wrong-way movements as "Parclo A is OK, but Parclo B is Bad". In practice, this means that the configuration of the "A" ramps tends to guide drivers correctly with little confusion, while the "B" ramps, depending on turning angles, sight distance, and driver conditions, appear more susceptible to wrong-way entries and fatal consequences.

Understanding how these geometric factors influence driver behavior became a critical step in identifying where low-cost treatments could provide meaningful improvements.

Figure 1. Typical Folded Diamond interchange. Aerial image source: Story County Assessor. Photo Source: Google StreetView (2013)

Observed Wrong-Way Driving Trends

When Iowa DOT reviewed ten years of data from 55 Parclo interchanges, a clear pattern emerged. Over that period, 36 wrong-way crashes were recorded, and most were the result of simple driver mistakes rather than intentional or reckless behavior. In many cases, drivers overlooked or misunderstood the cues intended to guide them into the correct lane. Figure 2 illustrates this with three examples where a driver failed to stay to the right, passing by standard signs and pavement marking arrows that were in place but did not prevent the wrong-way entry.

Figure 2. Images of wrong-way drivers at 3 Parclo B ramp locations

Gateway Treatment Concept and Design

The Iowa DOT set out to develop treatments that were simple, affordable, and grounded in human factors, rather than relying on costly Intelligent Transportation System (ITS) technologies. Their first step was to revisit the standard signing and pavement marking practices already in place. The goal was to strengthen the visual cues that guide drivers to stay on the correct path and to create a clear sense of a gateway at the decision point, where a wrong-way movement could occur.

Enhanced Signing and Pavement Marking Details

To begin addressing the persistent wrong-way entries on Parclo B ramps, the team examined the standard signing shown on the left side of Figure 3. This signing typically included the R4-7 "Keep Right" symbol sign, the R5-1 "Do Not Enter", and the R5-1a "Wrong Way" sign, which is not shown in the image.

As the team explored options to better influence driver decisions, they developed the idea of creating a visual red "Do Not Enter" gateway that would be perceived by the driver about to go the wrong direction while still providing a clear and intuitive path for drivers to keep right. To support this concept, the team positioned the signing at the same point as the R4-7 "Keep Right" sign so that drivers were presented with a strong and unified set of cues. They also enhanced the pavement markings by widening the gore area and adding horizontal pavement marking lane arrows in each lane.

Figure 3 shows an example of these enhanced gateway treatments on the right, compared with the standard signing arrangement on the left. Some additional signs are not shown in the images but were part of the treatment package.

Figure 3. Same location showing before and after, where the standard Parclo B signage is shown on the left and the enhanced gateway treatment is shown on the right.

Implementation Approach and Cost Summary

In 2021, the Iowa DOT implemented gateway treatments at 43 of the 55 Parclo B interchanges identified statewide. Each location required an investment of roughly five thousand dollars, which is only a small portion of the cost of advanced ITS detection and warning systems. The treatments were installed efficiently, with minimal impact on traffic, and relied solely on standard signing and pavement marking materials that maintenance crews already use daily. Each enhancement included the following elements:

- Dual R5-1 "Do Not Enter" Signs: These were placed side by side at the ramp entrance to create a strong visual gateway and provide a clear and immediate cue to discourage wrong-way entry.
- Pavement Markings: Directional arrows were added along with a wider gore median.

Evaluation and Results

The effectiveness of the gateway treatments was assessed using a combination of field-based observations and a review of crash and event data.

Methodology

During the summer of 2021, the Iowa DOT installed cameras capable of detecting wrong-way driving at seven Parclo B ramp locations scheduled to receive the gateway treatment. The cameras operated continuously, capturing wrong-way movements both before and after installation. Each recorded event was reviewed in detail and categorized, and any movements associated with work zones, emergency responders, or law enforcement activity were excluded from the analysis to ensure accuracy. Figure 4 presents a map of the seven study locations. The red arrows indicate the wrong-way movements that were detected by the cameras and included in the evaluation.

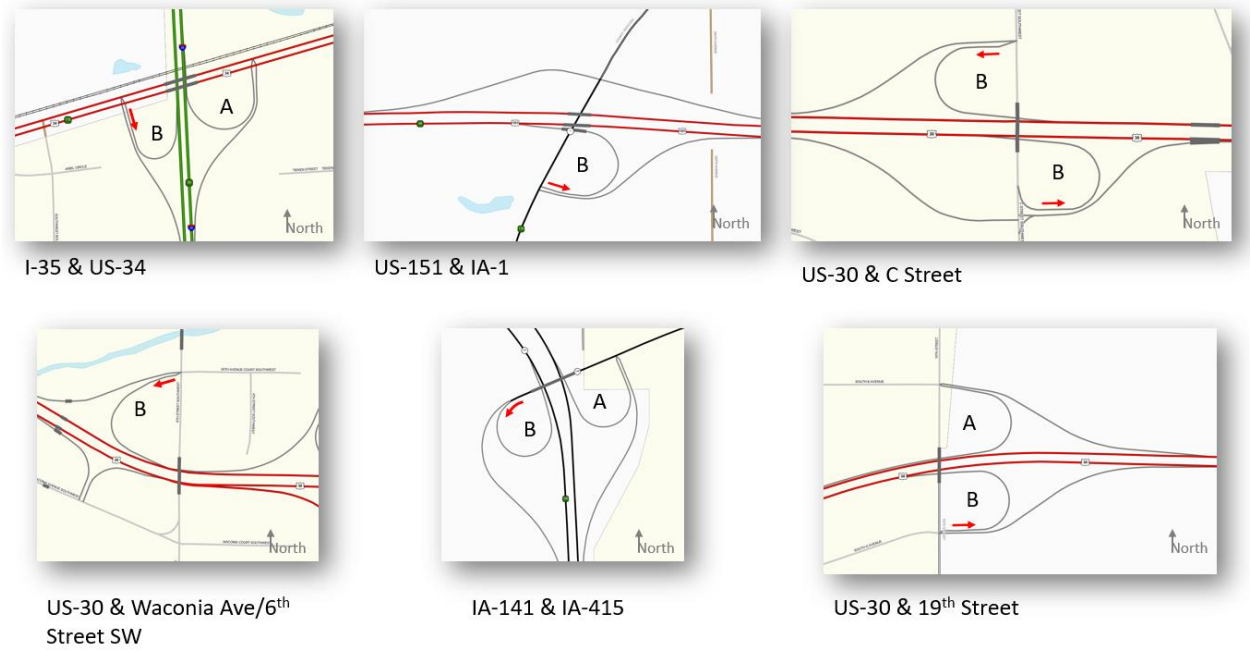

Figure 4. WWD camera locations used in the before-and-after analysis.

Results

The wrong-way events recorded by the cameras were used to compare conditions before and after installation of the gateway treatments at each study location. The summary of these observations, reported through July 13, 2025, is provided in Table 1.

Table 1. WWD events before and after the installation of the gateway treatments as of July 13, 2025

Interchange Location	Type	Camera	# Months Before Treatment	# WWD Events Before Treatment	# Months After Treatment	# WWD Events After Treatment
I-35 & US-34	Parc-Lo "AB"	WWD55	1	1	29	0
US-151 & IA-1	Parc-Lo "B"	WWD04	1	1	13	1
US-30 & C St (WB Exit loop)	Parc-Lo "B"	WWD18	2	1	38	4
US-30 & C St (EB Exit Loop)	Parc-Lo "B"	WWD19	2	0	38	0
US-30 & Waconia Ave/6TH St SW	Parc-Lo "AB"	WWD09	3	4	37	8
IA-141 & IA-415	Parc-Lo "AB"	WWD40	1	2	38	4
US-30 & 19th St	Parc-Lo "AB"	WWD62	6	1	43	1

Findings and Interpretation

While having only one month of “before” data is not ideal from an analytical standpoint, many agency studies lack comparable data either before or after implementation. In this case, the Iowa DOT demonstrated considerable foresight by installing wrong-way detection cameras in advance of the gateway treatments, creating an opportunity for a meaningful before-and-after comparison that is rarely possible in real-world field conditions. The authors acknowledge the study limitations due to the brief before installation monitoring period, the site and exposure variations, and a lack of control sites. Even with these constraints, an aggregate comparison provides a clear indication of the treatment’s effectiveness.

Across all monitored locations, the gateway treatments resulted in a reduction of approximately 88 percent in the average number of WWD events per month based on the following:

- Before Treatment: 0.63 WWD events per month (10 WWD events over 16 months)
- After Treatment: 0.08 WWD events per month (18 WWD events over 236 months)

To determine whether this reduction was statistically significant, a Poisson rate ratio test was conducted. The analysis compared the total number of WWD events and the total observation time before and after installation at all sites. The post-treatment event rate of 0.08 events per month was roughly 12 percent of the pre-treatment rate of 0.63 events per month, representing an 88 percent decrease. The estimated rate ratio of 0.12, with a 95 percent confidence interval of 0.07 to 0.21, was highly statistically significant ($p < 0.001$).

These results provide strong statistical evidence that the gateway treatments meaningfully reduce wrong-way events across the study locations. The findings reinforce the value of these treatments as a practical and cost-effective safety countermeasure supported by data and field performance.

Ongoing Refinements and Lessons Learned

As Mr. Sorenson shared the gateway treatment concepts with staff and with non-technical audiences, he became increasingly interested in understanding why wrong-way decisions occur in the first place. The R4-7 "Keep Right" symbol sign emerged as a key point of curiosity. He wanted to know how quickly and accurately people recognized its meaning compared with the R4-7b "Keep Right" word legend sign.

To explore this question, he incorporated an informal "pop quiz" into his presentations over several years, using the two slides shown in Figure 5. The process was simple. He first displayed Slide 1 and asked the audience to identify the meaning of the symbol sign, offering no hints or guidance. He then revealed Slide 2 and again asked for responses, allowing participants to answer freely before any explanation was provided.

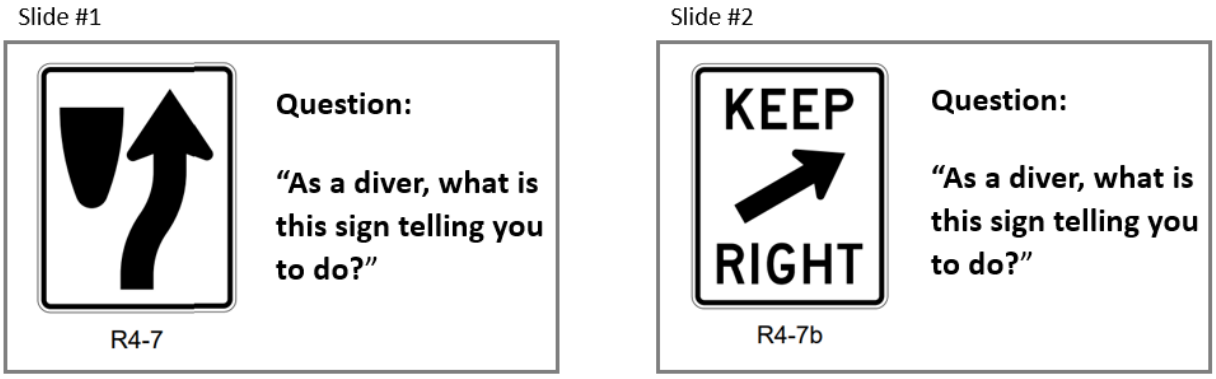

Figure 5. Slides that were used to gather input on the meaning of each sign.

Although the exercise was not a formal study, the responses revealed a consistent pattern. Many participants hesitated when interpreting the R4-7 symbol sign. Their answers were often hesitant, unsure, and sometimes creative but incorrect. In contrast, the R4-7b word legend sign was

immediately understood. Responses were quick, confident, and with a few people adding “duh” to their answer.

This insight prompted the Iowa DOT to replace the R4-7 symbol sign with the R4-7b word legend at most Parclo B locations. Records indicating the exact timing of each replacement were not available, but the observations clearly influenced the evolution of the Parclo B treatment, as shown in Figure 6.

Future enhancements under consideration include:

- Rumble strips: Suggested as a tactile and audible deterrent for vehicles drifting toward incorrect entry paths.
- Channelization islands/raised pavement markers: Potential additions to further emphasize correct routing.

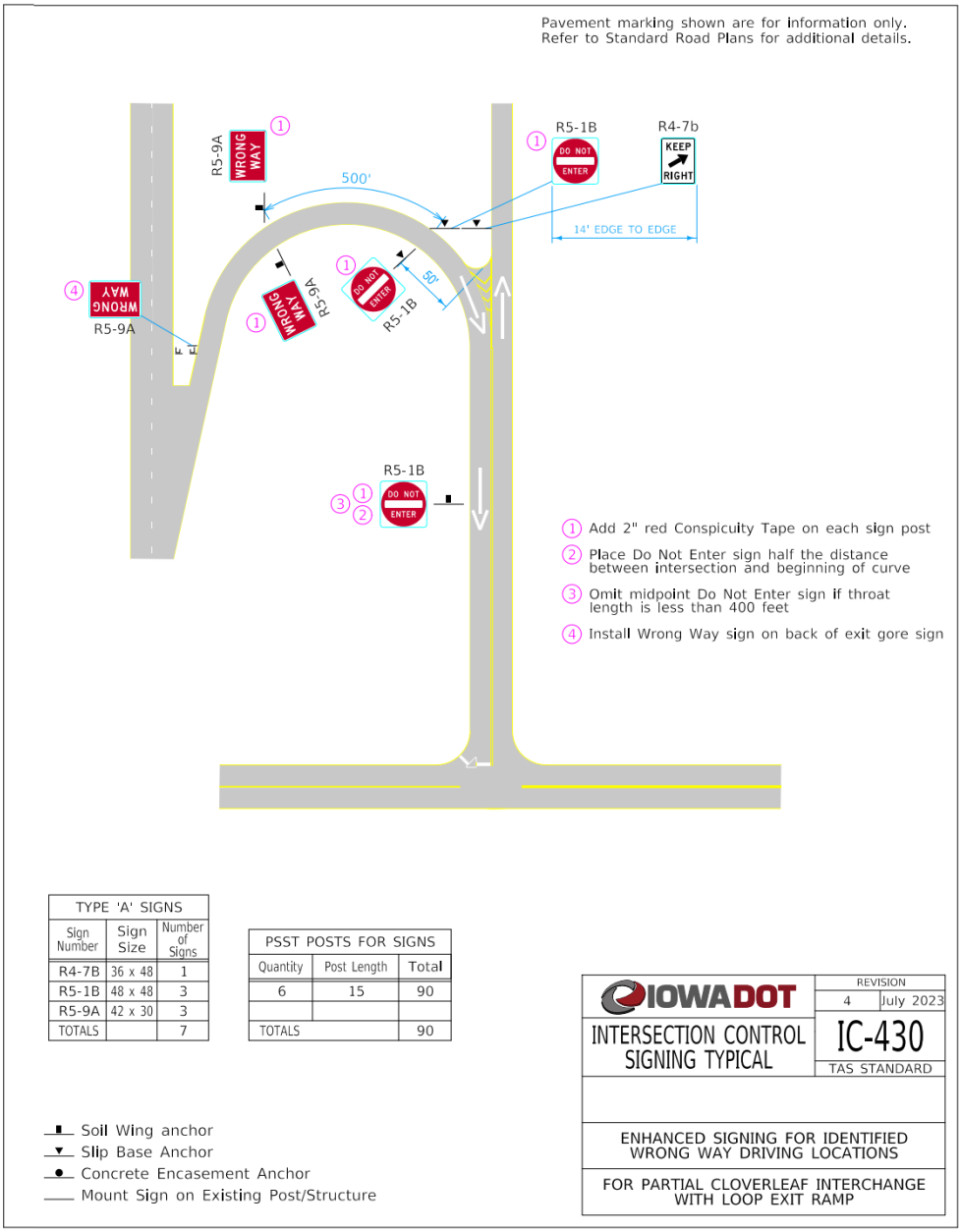

Figure 6. Gateway treatment details

Emerging Technology

The Institute for Transportation (InTrans) at Iowa State University has advanced a new method for identifying wrong-way driving patterns across the state by combining roadway network data with connected vehicle (CV) trajectory data at a three-second resolution. This approach examines statewide vehicle paths at three-second resolution and compares each trajectory to the roadway direction of travel for every segment. Although connected vehicle data represent only a subset of all drivers, the method provides a valuable window into wrong-way movements that have not been available through traditional crash reports or occasional field observations. It

reveals when and where they recognize their mistakes and where and how they self-correct, if at all.

Figure 7 highlights an example from one location where, on two different occasions, eastbound drivers on a minor road turned too quickly, ending up as a WWD on the I-80 exit ramp instead of on their desired road (256th Street).

This data-driven methodology offers new insights into wrong-way driver behavior and gives the Iowa DOT the ability to monitor their entire roadway network with far greater context and precision than was possible in the past.

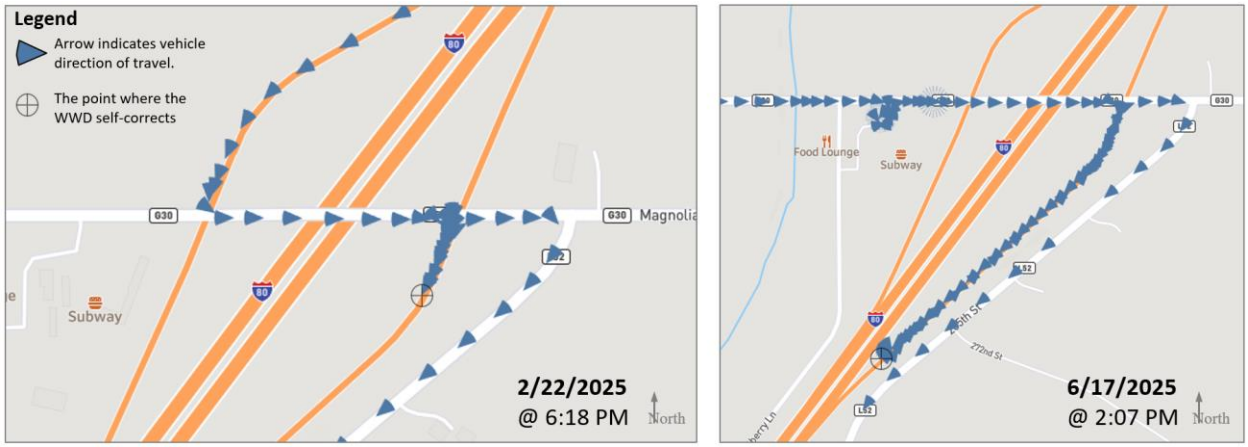

Figure 7. Detection of two wrong-way driving incidents at the same location using InTrans CV data-based methodology.

Conclusion and Implications

The Iowa DOT's experience shows that simple and thoughtful countermeasures rooted in human factors can produce significant improvements in roadway safety. Through close observation, ongoing refinement, and careful field evaluation, the agency achieved an eighty-eight percent reduction in wrong-way entries at Parclo B ramps. It is also notable that no wrong-way driving crashes have been documented at the treated locations since the treatments were installed.

This work demonstrates that even small, thoughtful improvements can reshape driver behavior and reduce the risk of severe crashes statewide.