Wisconsin Department of Transportation

WIS 75 Intersection Screening & Project Development Process

SAFETY DATA CASE STUDY

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16. Abstract This case study presents a safety analysis conducted by the Wisconsin Department of Transportation (WisDOT) at the intersection of State Highway 75 (WIS 75) and Plank Road (County Road A) in Racine County, WI. WisDOT proactively identified key safety needs early in the project development process and used a data-driven approach to evaluate the safety effects of potential alternatives. The corridor is scheduled for resurfacing in 2023, and through the network screening process, WisDOT identified an opportunity to develop a Highway Safety Improvement Program-related project in conjunction with routine maintenance. WisDOT's diagnosis process reviewed recent crash history for potential contributing factors (e.g., driver behavior, sight distance, curvature, intersection geometry, etc.) and underscored the need to reduce failure-to-yield crashes. A preliminary intersection control evaluation eliminated infeasible alternatives early in the process and highlighted appropriate alternatives for further analysis. WisDOT applied State-calibrated safety performance functions in the Interactive Highway Safety Design Model software to predict crashes for each alternative and used State-approved crash modification factors where applicable. With these results, the economic appraisal step highlighted the most cost-effective alternative for this particular location. The State of the Practice methods and tools applied at each step in the process allowed WisDOT to thoroughly evaluate a safety need on its public road network as part of an institutional and readily repeatable planning process.			
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Acronyms

Acronym	Description
AADT	annual average daily traffic
AASHTO	American Association of State Highway and Transportation Officials
BCR	benefit/cost ratio
CMF	crash modification factor
FHWA	Federal Highway Administration
HSIP	Highway Safety Improvement Program
HSM	Highway Safety Manual
ICE	intersection control evaluation
IHSDM	Interactive Highway Safety Design Model
LOSS	level of service of safety
SPF	safety performance function
WI	Wisconsin
WisDOT	Wisconsin Department of Transportation

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Executive Summary

This case study presents a safety analysis conducted by the Wisconsin Department of Transportation (WisDOT) at the intersection of State Highway 75 (WIS 75) and Plank Road (County Road A) in Racine County, WI. WisDOT proactively identified key safety needs early in the project development process and used a data-driven approach to evaluate the safety effects of potential alternatives. The corridor is scheduled for resurfacing in 2023, and through the network screening process, WisDOT identified an opportunity to develop a Highway Safety Improvement Program-related project in conjunction with routine maintenance. WisDOT's diagnosis process reviewed recent crash history for potential contributing factors (e.g., driver behavior, sight distance, curvature, intersection geometry, etc.) and underscored the need to reduce failure-to-yield crashes. A preliminary intersection control evaluation eliminated infeasible alternatives early in the process and highlighted appropriate alternatives for further analysis. WisDOT applied State-calibrated safety performance functions in the Interactive Highway Safety Design Model software to predict crashes for each alternative and used State-approved crash modification factors where applicable. With these results, the economic appraisal step highlighted the most cost-effective alternative for this particular location. The State of the Practice methods and tools applied at each step in the process allowed WisDOT to thoroughly evaluate a safety need on its public road network as part of an institutional and readily repeatable planning process.

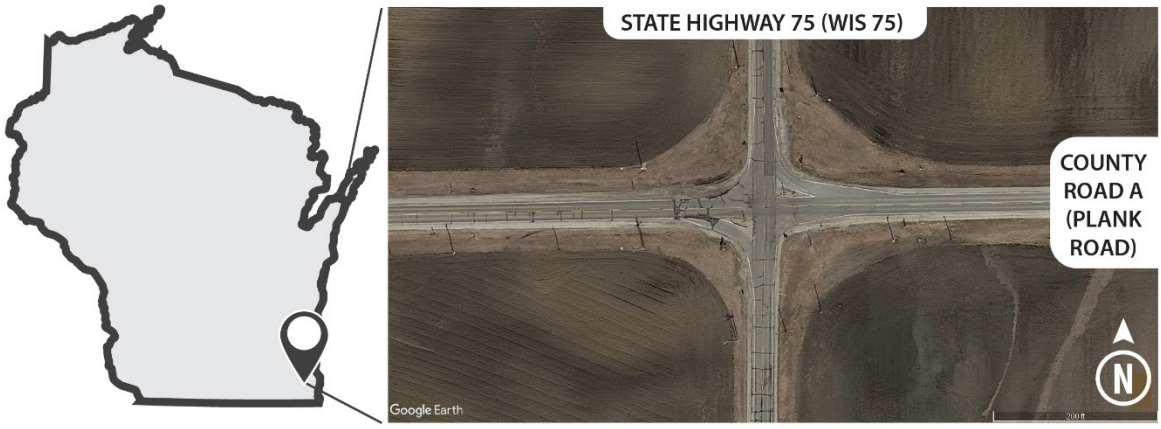
Introduction

The Transportation Research Board's Safety Performance and Analysis (ACS20) User Liaison Subcommittee has an ongoing initiative focused on practical application of the American Association of State Highway and Transportation Officials (AASHTO) Highway Safety Manual (HSM) (i.e., "using the HSM in the real world"). The Federal Highway Administration (FHWA) administers the HSM Implementation Pooled Fund, which includes 22 States focused on projects to help further HSM implementation. Development of HSM case studies will assist practitioners in performing data-driven safety analysis using the methods described in the HSM. The primary purpose of the HSM case studies is to highlight noteworthy applications of HSM methods, focus on common challenges, and feature agencies that overcame those challenges. These case studies serve as a source of lessons learned and noteworthy practices to help guide practitioners applying the HSM.

Background

This case study presents a safety analysis conducted by the Wisconsin Department of Transportation (WisDOT) at the intersection of State Highway 75 (WIS 75) and County Road A (Plank Road) in Racine County, WI (figure 1). WisDOT proactively identified key safety needs early in the project development process and used a data-driven approach to evaluate the safety effects of potential alternatives. This comprehensive, institutionalized use of the HSM showcases the direct application of research into practice, as well as a variety of tools that help improve safety-related decision-making. Each step highlights practical examples of the HSM in the planning process:

- WisDOT used customized screening tools to apply State-calibrated safety performance functions (SPFs) and rate intersections according to a level of service of safety (LOSS) methodology based on expected and observed crash frequency.
- Based on this screening process, WisDOT identified an intersection with a demonstrated safety need and investigated the recent crash history to diagnose crash contributing factors.
- Based on these findings, WisDOT identified suitable potential alternatives to the traffic control devices already in place.
- WisDOT applied the Interactive Highway Safety Design Model (IHSDM) software to evaluate these potential alternatives and assess predicted crashes.
- With predicted outcomes based on several alternatives, WisDOT used IHSDM's Economic Analysis module to identify the most cost-effective alternative to improve safety at the candidate intersection.



Note: The white labels were added by the authors to delineate the project bounds.

Figure 1. Graphic. WIS 75/County Road A project location.

Purpose and Need

WisDOT has a resurfacing project planned in 2023 for WIS 75 in the Town of Dover, WI. In 2019, through the State's network screening process, WisDOT identified the intersection of WIS 75 and County Road A as a location with a high potential for safety improvement. Further investigation into crash history revealed contributing circumstances that could potentially be addressed during routine maintenance in 2023, including traffic control compliance and high posted speed limits on all approaches (55 miles per hour). This application of data-driven safety analysis in the planning process allowed WisDOT to develop a Highway Safety Improvement Program (HSIP) project in conjunction with routine resurfacing.

Project Description

- **Sponsoring agency:** WisDOT.
- **Project location:** Dover, WI.
- **Project bounds and length of project:** Intersection of State Highway 75 (WIS 75) and County Road A (Plank Road).
- **Facility type(s):** Four-leg, two-way stop-controlled intersection with 2-lane major collectors on all legs.
- **Area type:** Rural, flat terrain.
- **Project status (as of spring 2021):** Analysis completed; construction anticipated in 2023.

Safety Performance Analysis

WisDOT's analysis covered several chapters from Part B (Chapters 4, 5, 6, and 7) and Part C of the HSM to identify sites with a safety need, diagnose the location-specific issues, select appropriate countermeasures, and produce a cost-effective solution (AASHTO, 2010). This section provides an overview of the safety analysis methods, proposed alternatives, and final results.

Analysis Overview

Prior to selecting countermeasures and assessing future performance, WisDOT conducted network screening and applied a diagnostic process to identify issues and focus on relevant solutions.

Network Screening

WisDOT assessed the entire WIS 75 resurfacing project corridor for safety needs using two Sate-specific tools:

1. The MetaManager tool screens segments using crash rates (although WisDOT plans to develop SPFs for segment network screening in the future).
2. The Intersection Network Screening Spreadsheet screens intersections using LOSS for both total crashes and fatal and injury crashes.

The Intersection Network Screening Spreadsheet applies a LOSS analysis criterion to each intersection and assigns a value between one, indicating a low potential for crash reduction, and four, indicating a high potential for crash reduction (figure 2). LOSS compares the relative safety performance of a

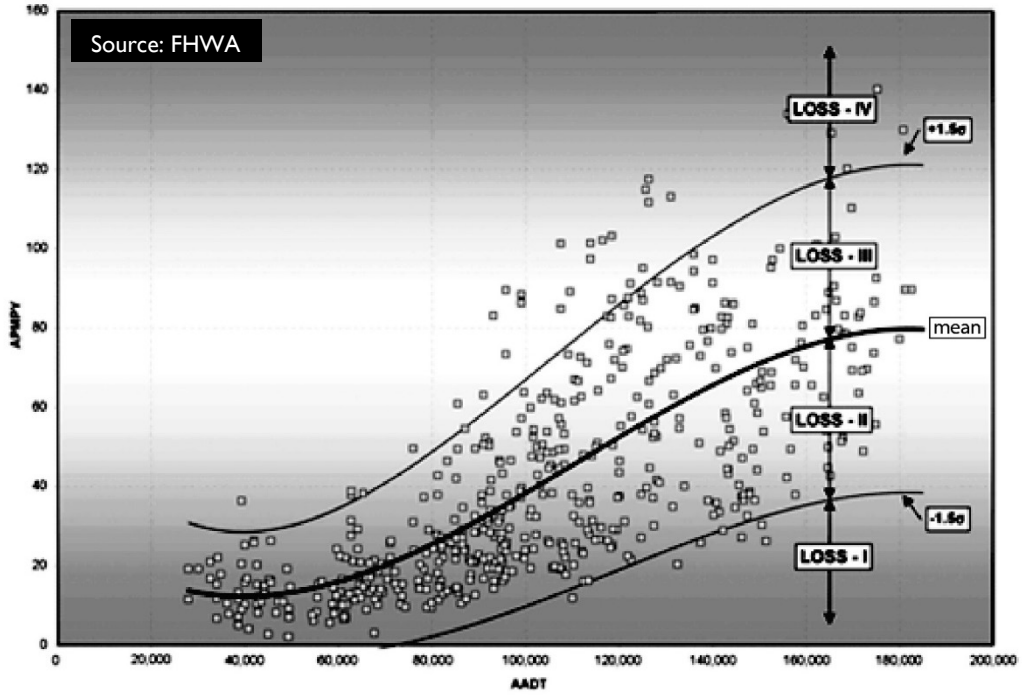


Figure 2. Graphic. Example distribution of sites by LOSS (Source: FHWA, 2011).

location (i.e., observed crash frequency) to its expected safety performance based on State-calibrated SPFs. A LOSS value of four indicates that the location observed a crash frequency in excess of 1.5 standard deviations above the mean. This elevated rating illustrates the magnitude of a potential safety issue at a given location.

The intersection of WIS 75 and County Road A received a LOSS IV rating based on this network screening approach. The crash rate at the WIS 75/County Road A intersection between 2014 and 2019 was relatively high compared to similar locations (3.7 crashes per million entering vehicles) with nearly 50 percent of all crashes resulting in an injury. There were no fatalities during the study period.

Diagnosis

During the analysis period, the intersection was two-way stop-controlled with stop signs present on the east/west approaches (County Road A); the east/west approaches also had flashing beacons and "Traffic on WIS 75 Does Not Stop" signs installed in addition to the stop signs. There were no stop bars present on County Road A. A detailed investigation into the crash history did not reveal any significant geometric issues. However, it did highlight an important trend with respect to vehicles on County Road A (i.e., the stop-controlled approaches) failing to yield to through traffic on WIS 75 (i.e., no traffic control present). Most failure to yield-related crashes (fifteen of nineteen) involved vehicles making a complete stop on the east/west County Road A approaches before proceeding into the intersection and colliding with north/south traffic. Only four of nineteen crashes involved vehicles running the stop sign without coming to a stop (figure 3).

Based on the relationship of the observed crash history, driver behavior, and traffic control devices present, WisDOT conducted an alternatives analysis using IHSDM to evaluate several different traffic control alternatives.

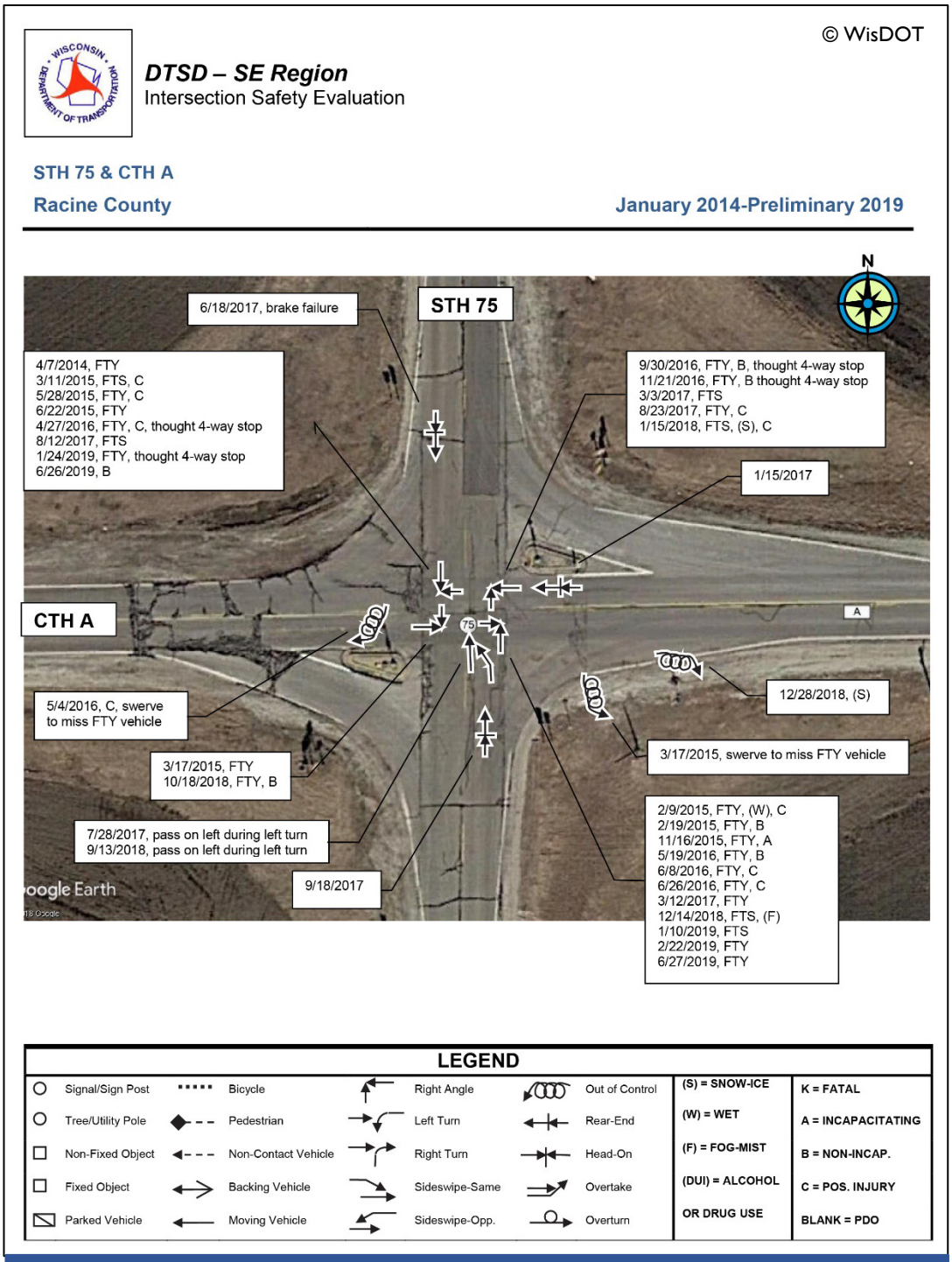


Figure 3. Graphic. WIS 75 crash diagram.

Crash Prediction Analysis & Results

WisDOT used IHSDM (version 15.0) to predict crashes at the study intersection over a 10-year period between 2025 and 2034. Historic traffic count data were very limited for the study area; the last turning movement count at the intersection occurred in 1999. WisDOT collected tube counts near the intersection in 2011, and the results closely aligned with the 1999 turning movement count volumes. Given the timing of the safety analysis study (May 2020), the State's Safer-at-Home order made new data collection unreliable for typical expected conditions. However, since the available data sources were generally consistent, average daily traffic was generally low (1,900 to 2,200 vehicles per day on all approaches), and the area had not experienced any significant development, WisDOT believed the 1999 data to be a reasonable estimate for the purposes of the IHSDM analysis. WisDOT used forecast growth rates to grow the base year (2020) traffic volumes to yield design year (2045) volumes (0.18% on WIS 75 and 0.29% on County Road A).

Countermeasure Selection

WisDOT conducted a preliminary intersection control evaluation (ICE) to assess potential design impacts and eliminate infeasible alternatives early in the planning process. WisDOT used traffic warrants for all-way stop controls, traffic signals, and roundabouts to refine the potential list of traffic control alternatives. Although WisDOT estimated that all three options would have additional capacity through 2045, the traffic counts did not meet traffic signal warrants. As a result, WisDOT only considered all-way stop control and roundabout alternatives to compare to the existing two-way stop control base alternative:

- For the two-way stop control base alternative, WisDOT used State-calibrated models (i.e., HSM models with a State-specific calibration factor on Wisconsin data) derived from Chapter 10 of the HSM (*Rural Two-Lane Two-Way Roads*) to predict crashes per year (AASHTO, 2010).
- To derive a prediction for an all-way stop control alternative, WisDOT applied a State-approved crash modification factor (CMF) of 0.52 to the base alternative predicted crashes (i.e., a 48 percent reduction in crashes of all severities; CMF ID #315).
    - This reflected an anticipated safety benefit of converting the two-way stop control to an all-way stop control.
- For the four-leg, single lane roundabout alternative, WisDOT used roundabout-specific SPFs to predict future crashes (Ferguson et al., 2018).

Table 1 documents the predicted crash results by severity for each alternative. The existing two-way stop control base alternative predicted the highest number of total crashes, as well as the highest number of fatal and serious injury crashes. The all-way stop control alternative predicted the fewest number of total crashes, while the roundabout predicted the fewest number of fatal and serious injury crashes over the study period.

Table 1. Predicted crashes for each traffic control alternative (2025-2034).

Alternative	Fatal (K) Crashes	Incapacitating Injury (A) Crashes	Non-Incapacitating Injury (B) Crashes	Possible Injury (C) Crashes	No Injury (O) Crashes	Total Crashes
Rural Two-Lane Two-Way Stop Control Intersection	0.13	0.49	1.38	1.22	7.29	10.50
Rural Two-Lane All-Way Stop Control Intersection	0.07	0.25	0.72	0.63	3.79	5.46
Roundabout with 4 Legs and a Single Circulating Lane	0.02	0.17	1.07	0.97	7.78	10.01

Economic Appraisal

Based on the alternatives analysis results, WisDOT conducted an economic analysis using State-specific crash costs that compared the expected benefits associated with predicted crashes reduced to the total cost of the traffic control treatment. For instance, WisDOT could compare a baseline, no-change alternative (e.g., two-way stop control) that would lead to $2 million in predicted future crash costs during the study period to a new traffic control alternative (e.g., a roundabout) that would lead to $500,000 in predicted future crash costs. In this scenario, the new traffic control alternative, the roundabout, is expected to result in $1.5 million in crash-related cost savings or benefits relative to the existing condition.

This analysis allowed WisDOT to develop a benefit/cost ratio (BCR) for each alternative (table 2). Based on this review, WisDOT determined that an all-way stop control alternative is expected to be the most cost-effective treatment (BCR = 13.67). Conversely, a roundabout is not expected to produce economic benefits (i.e., dollar value of expected crashes reduced) that outweigh the economic costs (i.e., costs associated with construction and maintenance of the project) due to the cost of right-of-way acquisition and construction.

Table 2. Economic analysis results for each traffic control alternative (2025-2034).

Alternative	Present Value of Crash Cost	Net Present Value of Benefits (B)	Net Present Value of Costs (C)	Present Value of Net Benefit (B-C)	BCR
Rural Two-Lane Two-Way Stop Control Intersection	$1,905,772.99	n/a	n/a	n/a	n/a
Rural Two-Lane All-Way Stop Control Intersection	$991,001.96	$914,771.04	$66,940.00	$ 847,831.04	13.67
Roundabout with 4 Legs and a Single Circulating Lane	$596,685.42	$1,309,087.57	$1,727,840.00	-$418,752.43	0.76

Documentation and Use of Analysis Results

WisDOT documented its process, analysis, and findings in a formal safety certification document and associated ICE memorandum. These documents conform to the State's Facilities Development Manual and methodically present the intersection evaluation process, including existing conditions, crash history, IHSDM outputs, conceptual designs and associated costs, and final recommendations. It also lists potential caveats and considerations for future implementation. For instance, the documentation notes that although the all-way stop control alternative is the most cost-effective and readily-implementable solution, compliance is a notable concern for the corridor. WisDOT would also need to alert drivers to the new traffic control if an all-way stop were installed. Conversely, although a roundabout would not be the most cost-effective solution, it would remove most concerns around compliance and would inherently alert drivers to operational changes. The document recommends that an all-way stop should be applied as an interim solution, but it should not be a permanent solution; a roundabout should be strongly considered in future HSIP project evaluations.

Challenges and Opportunities

In addition to concerns over driver compliance with regulatory and advisory signage, WisDOT noted considerable complexity associated with applying SPFs to compare intersection alternatives. WisDOT targeted the WIS 75/County Road A intersection as a result of the high number of severe injury and angle crashes; this was well above average for comparable facilities. However, when evaluating alternatives, WisDOT and the HSM methodology recommends using a calibrated or State-specific SPF to determine predicted performance and calculate potential benefits. This means that WisDOT's predictions treat the study intersection according to the average performance for similar locations around the State. Although this is the State of the Practice approach, it may not reflect local nuances that led to the high frequency of crashes in recent years. Furthermore, due to the significant changes in traffic control between alternatives, WisDOT was not able to apply the Empirical-Bayes methodology to crash prediction. This challenge highlights the importance of the diagnosis process. Although WisDOT continues to consider a roundabout as a more permanent solution to potential safety concerns, the

agency is able to produce targeted interim solutions in a timely manner that suit the scale of the safety issue.

Conclusions and Lessons Learned

The WIS 75 and County Road A intersection evaluation is a practical example of how data-driven safety analysis can be incorporated into the planning process. The corridor is scheduled for resurfacing in 2023, and through the network screening process, WisDOT identified an opportunity to develop an HSIP project in conjunction with routine maintenance. WisDOT's diagnosis process reviewed recent crash history for potential contributing factors (e.g., driver behavior, sight distance, curvature, intersection geometry, etc.) and underscored the need to reduce failure-to-yield crashes. The ICE evaluation eliminated infeasible alternatives (e.g., a traffic signal) early in the process and highlighted appropriate alternatives for further analysis. WisDOT applied State-calibrated SPFs in the IHSDM software to predict crashes for a baseline alternative and roundabout alternative, and the project team applied a State-approved CMF to the baseline alternative to determine predicted crashes for the all-way stop alternative. The economic appraisal produced the BCR and highlighted the most cost-effective alternative for this particular location. The State of the Practice methods and tools applied at each step in the process allowed WisDOT to thoroughly evaluate a safety need on its public road network as part of an institutional and readily repeatable planning process.

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Contact

Wisconsin Department of Transportation

Kevin M. Scopoline, Traffic Operations and Analysis Engineer

KevinM.Scopoline@dot.wi.gov