OUR TEAM – THE PROACTIVE BADGERS

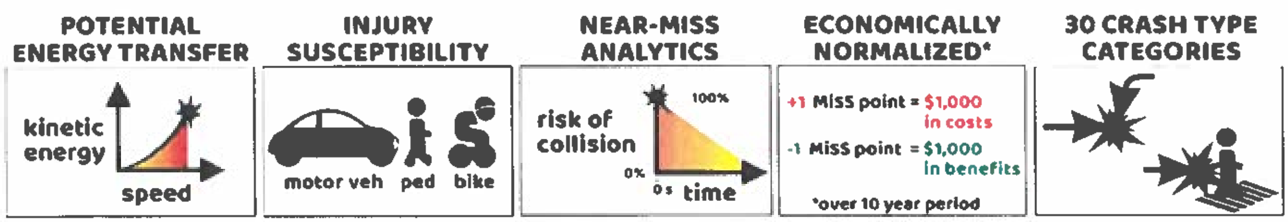
Thank you for the opportunity to participate in this competition! Our team consists of four alumni from the University of Wisconsin – Madison. In an ode to our alma mater and the proactive safety analysis our team is proposing, we decided a fitting name to call ourselves would be: The Proactive Badgers.

The Proactive Badgers includes John R. Campbell, IV, PE, RSP2I and Christian R. Sternke, PE, RSP1 from the firm Traffic Analysis & Design, Inc. (TADI) in Cedarburg, WI, Kevin Scopoline, PE, from the Wisconsin Department of Transportation (WisDOT), and Ahnaray Bizjak, PE, from the City of Janesville, WI. Between the four of us, we bring 40+ years of safety engineering experience to the project.

Our combination of public and private engineering experience is a strength of our team as we viewed the project from different perspectives. Our collaboration led to solutions that we vetted from multiple viewpoints including the feasibility to adapt, transfer, and implement the proposed methodology in identifying constructible, low-cost safety solutions.

THE MiSS METHOD

The methodology proposed is grounded in science and is built upon principles proven to impact the severity outcomes of injuries in crashes. The method uses a metric we have named the Multimodal Intersection Severity Score (MiSS) and incorporates potential energy transfer, injury susceptibility based on crash type and mode, and near-miss analytics. MiSS is also economically normalized and categorized into crash type categories for expediting the diagnosis of issues and the prioritization of improvements.



MiSS is a point scoring system that is a summation of observed near-miss events. MiSS is calculated by the following equation for total intersection scores and then is subdivided into 30 crash type categories:

$$\text{MiSS} = \sum \frac{F_v^{2} * F_{inj} * \frac{1}{3}F_{type}(3 - PET)}{F_{econ}}$$

multimodal intersection severity score

F_v = energy factor (velocity in mph of fastest vehicle involved in near-miss event)

F_{inj} = injury susceptibility weighting factor
- 2.5 ped/bike (vulnerable user)
- 1.3 motor vehicle (left-turn angle, right-angle, and right-turn angle crashes)
- 1.0 motor vehicle (all other crashes)

F_{type} = crash-type weighting factor for near-miss analytics
- 15 near-side vulnerable user
- 4 right-angle and all other vulnerable user crash types
- 2.5 left-turn angle
- 1 all other motor vehicle crash types

PET = post encroachment time (seconds)

F_{econ} = economic normalization factor (converts 1 MiSS point to $1,000 comprehensive cost or $1,000 crash reduction benefit, over a 10 year period)

Potential Energy Transfer (f_v)

Speed is a critical component in the severity outcomes of crashes. To account for potential energy transfer, we developed a factor based on the kinetic energy equation: K.E. = ½ mass * velocity^2. The potential energy factor in the MiSS method is the square of the conflict speed (i.e., velocity) of the fastest moving vehicle in a near-miss event. Our team discussed several concepts for incorporating potential energy and this methodology offers an understandable concept that is simple to extract from the data. We chose to focus on the conflict speed of the fastest moving vehicle because majority of potential energy transfer in the crash types MiSS uses is created by the fastest moving vehicle. The concept also adheres to the exponential relationship between speed and energy, which we felt was important to incorporate because the kinetic energy quadruples every time the velocity doubles.

Injury Susceptibility (f_{inj})

Crash type and mode of travel play substantial roles in the risk of injury or death in crashes. A priority for our team was to account for the additional injury and fatality risks pedestrians, bicyclists, and occupants of vehicles in certain crash types are subjected to. To accomplish this, our team researched and analyzed the severity outcomes of different crash types and developed an injury susceptibility weighting methodology that incorporates crash type and mode of travel.

For the injury susceptibility weighting factor, our team used data from the state of Wisconsin. We used Wisconsin data because we had access to it and the state's overall population is similar to that of Washington State (within 25%). We analyzed data for 94,560 crashes at intersections on Wisconsin's local road network for five years (2015-2019) and calculated the average comprehensive cost of different crash types. Several crash types had similar average comprehensive costs enabling a consolidated weighting scale shown in the table below.[1]

Crash Type by Mode	Average Comprehesive Cost*		(f_{inj}) Weight
Pedestrian/Bicyclist (vulnerable user)	$	160,000	2.5
Angle (left-turn, right-angle, right-turn angle)	$	82,000	1.3
Miscellaneous Motor Vehicle	$	64,000	1

* Based on 94,560 crashes at local road intersections in Wisconsin using FHWA comprehensive crash costs https://safety.fhwa.dot.gov/hsip/resources/fhwasa09029/sec4.cfm

Near-Miss Analytics (f_{type})

The incorporation of near-miss data into the MiSS method was of undeniable importance given the purpose of the competition. Our team's inclusion of near-miss analytics was an iterative and much-discussed process that led to a sound methodology we are confident using. The near-miss component of the MiSS method correlates crash frequency, crash type, and near-miss parameters. Additional details include:

- Near-miss data was filtered:
  - Near-misses that have post-encroachment time (PET) >3 seconds were removed. To encompass nearly all road users and conditions, a time of 3 seconds was used as the cut-off value for PET. This kept the data set contained to critical conflicts and minor conflicts since they are of most concern.[2]
  - Near-misses where the vulnerable user crossed the conflict point after the motor vehicle were removed from the analysis as we concluded this type of near-miss was less indicative of a potential crash.

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[1] Herbel, S., L. Laing, and C. McGovern. *Highway Safety Improvement Program Manual*. US Department of Transportation, Federal Highway Administration, Office of Safety, 2010.

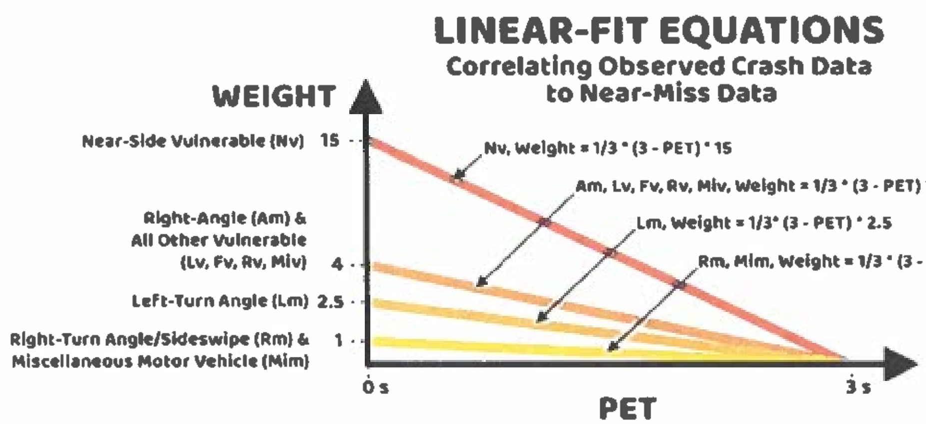
[2] *Video-based Network-wide Conflict Analysis to Support Vision Zero in Bellevue (WA) United States*. Conflict Analysis Report. City of Bellevue, Transoft Solutions, 2020.

- Near-misses where a turning motor vehicle crossed the conflict point after a through motor vehicle were also removed from the analysis (for example, a left-turn near-miss where the vehicle turned after the conflicting thru vehicle had passed was removed).
- Filtering was performed using Microsoft Excel coding techniques.

➢ Near-miss data was correlated to observed crash data, then categorized by crash type:

- The observed crash frequency for each of the MiSS crash types was compared to the near-miss data for those crash types (99 crashes were correlated to 2,536 near-misses).
- Linear relationships were used to weight near-misses with shorter PETs more heavily than near-misses with longer PETs. While this component of safety analytics is relatively new and not as thoroughly researched as observed crash data analytics, our team decided linearly fit equations were explainable and would effectively weigh higher-risk events more heavily than lower-risk events.

During our analysis, we found that crash type does impact the relationship between crash frequency and near-miss data. The resulting solution was linearly fit equations (via sum of least squares technique) for specific crash type categories (defined in graphic on page 5). Several categories were consolidated because they had similar correlations. Other categories, such as near-side near-misses with vulnerable users (Nv), stood out on their own as higher-risk events. We attempted further consolidations within the MiSS method, but concluded it compromised the accuracy of the results. Thus, the following near-miss weighting equations were applied in the MiSS method.



Economic Normalization (f_{econ})

When evaluating potential improvements, the MiSS points are reduced/increased based on the crash modification factors for those improvements. This provides an instantaneous estimate of the potential benefit of various crash mitigation solutions.

For this project, the economic normalization factor was calculated by using the previously discussed data set of 94,560 local roadway intersection crashes. Applying the FHWA comprehensive costs to that dataset yielded an average comprehensive crash cost of $80,000. This cost was correlated to the observed crashes at the six intersections in the competition, the unadjusted sum of MISS points, and an adjustment to be representative of a 10-year period. The resulting economic adjustment factor, as calculated for this project, is shown below:

99 applicable crashes in 5 yrs * $80,000 =	**$7,920,000**
Unadjusted sum of MiSS points at 6 intersections	**÷ 909,118**
Comprehensive Cost Per Unadjusted MiSS point =	**$8.71**
x 2 (to adjust to 10 years) =	**$17.42**

$$f_{econ} = \frac{\$1,000}{\$17.42} = 57.4$$

To illustrate an example of how the economic normalization simplifies crash reduction benefit estimates, let us assume intersection A has a MiSS of 600. Improvement Z has a crash modification factor (CMF) of 0.8. Applying the CMF to the MiSS of 600 (600 * 0.8) yields an expected future safety performance of 480 MiSS points. This is a 120-point reduction and is equivalent to $120,000 in potential crash reduction benefits over a 10-year period (120 MISS points * $1,000).

30 Crash Type Categories

Crash type is an invaluable piece of information and the MiSS method is fundamentally built around it. With near-miss data, crash type would be more accurately named "potential crash type" but for the sake of simplicity, we refer to this component as "crash type". Crash type was incorporated into MiSS with two objectives in mind. The first objective was to diagnosis safety issues. The second objective was to identify and prioritize solutions.

Based on our team's extensive experience diagnosing safety issues and prioritizing safety improvements, we identified the specific crash types we could focus on with MiSS. The criteria used to develop a crash type categorical system included the following:

1. Categories must consider motor vehicles, pedestrians, and bicyclists.
2. Crash types must be consistently viewable from the video footage. For example, rear-end near-misses on the approaches are often beyond the viewable area and thus not included.
3. Single vehicle collisions with stationary objects were excluded from the analysis.
4. Crash type categories must be named in a consistent, understandable manner that is adaptable and transferable to other intersection configurations.

The crash type categorization proposed includes 30 specific crash type categories for a typical 4-leg intersection, 16 categories for a 3-leg intersection, and is adaptable/transferable to other intersection configurations. However, because a vast majority of intersections are 3- or 4-legged, the base methodology is expected to function at most locations without categorical adjustments.

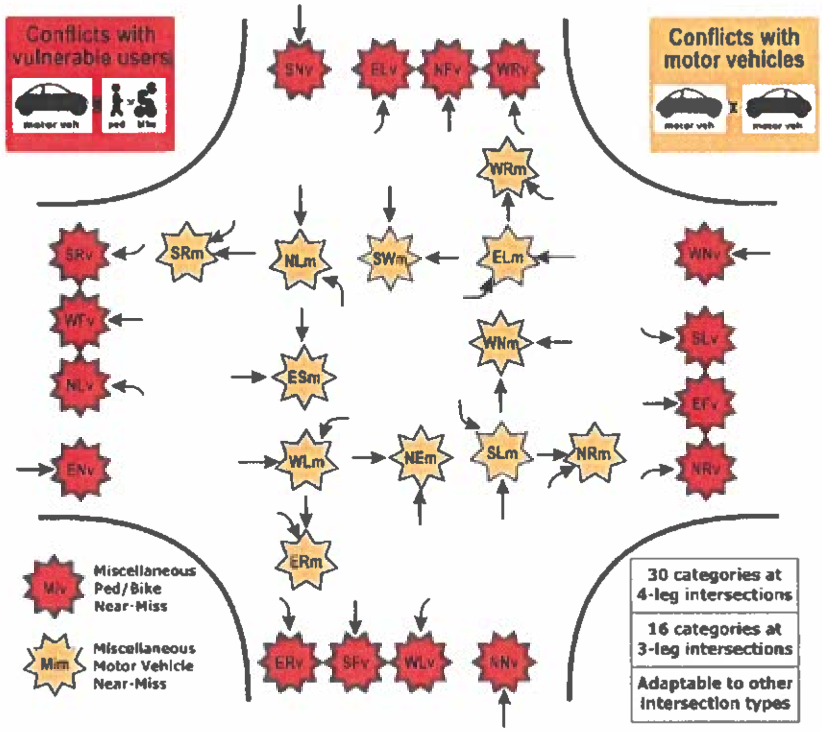
Vulnerable User (Ped/Bike) Crash Type Categories

Seventeen (17) of the crash type categories are specifically for pedestrians and bicyclists and are labeled as "vulnerable user" categories. This includes four (4) categories on each approach leg, and a miscellaneous category for near-misses within the intersection that did not fit within a designated category. Careful consideration was given to the selection of these categories as the system is designed to help diagnose specific issues. For example, left-turning traffic and right-turning traffic both commonly pose safety threats to crosswalk users, however, the solutions for mitigating those threats are often different. Thus, the MiSS method enables identification of specific issues so targeted solutions can be implemented (e.g., installing a high-visibility crosswalk on one intersection leg).

Motor Vehicle Crash Type Categories

The remaining 13 crash type categories are for near-miss collisions between two motor vehicles. The three main crash type categories are left-turn angle, right-angle, and right-turn angle/sideswipe. There is also a miscellaneous category for motor vehicle near-misses occurring within the intersection but not within one of these categories. As with the vulnerable user crash types, these specific crash types were chosen as they can lead to focused diagnosis and targeted solutions.

CRASH TYPE CATEGORIES



HSM ROADWAY SAFETY MANAGEMENT PROCESS USING MiSS

The Roadway Safety Management (RSM) process in the Highway Safety Manual outlines six steps for roadway safety management.[3] The MiSS method is compatible with all six steps of the process. The MiSS method was applied to the competition's intersections for the first five steps of the RSM process. The last step of the process, safety effectiveness evaluation, was not performed in this study. However, our team feels the MiSS method would be extremely valuable in safety effectiveness evaluation as it provides safety performance evaluations without waiting 3-5 years for crashes to occur.

Step #1: Screening Results

The MiSS method was applied to the observed near-miss data at the six intersections in the competition. The top three intersections each had more than 4,000 MiSS points as shown in the upcoming full-page results table. The top three also scored substantially higher than the bottom three. Thus, the top three intersections were further evaluated using the RSM diagnosis, countermeasure selection, economic appraisal, and prioritization steps. Spoiler alert – the targeted safety analysis MiSS provides also helped find highly effective low-cost improvement options at two of the lower ranked intersections.

Step #2: Diagnosis Results

An advantage of the MiSS method is it enables big-picture evaluations as well as targeted, granular evaluations. This is exemplified in the results table where general crash type categories (all directions) are shown as well as the MiSS point totals for specific, directional crash type categories. The crash types shaded blue with white text were identified as crash types of interest based on the MiSS evaluation. Five crash types evaluated for improvements were in overall ped/bike or general categories. The other nine crash types evaluated highlight the ability of MiSS to target specific, directional crash types.

[3] AASHTO. Highway Safety Manual. Washington, D.C., American Association of State Transportation Officials. (2010)

SCREENING AND DIAGNOSIS RESULTS

TOP 3

Crash types evaluated for improvements

Overall

	Rank #1	Rank #2	Rank #3	Rank #4	Rank #5	Rank #6
Σ(MiSS)	4,399	4,315	4,212	1,291	874	749
Ped/Bike	784	214	138	266	256	547

General Crash Type Categories

Int #4 112th Avenue NE and NE 8th Street		Int #1 124th Avenue NE and NE 8th Street		Int #3 148th Avenue SE and SE 22nd Street		Int #5 100th Avenue and Main Street		Int #2 116th Avenue NE and Northup Way		Int #6 Bellevue Way NE and NE 8th Street	
Symbol	Σ(MiSS)	Symbol	Σ(MiSS)	Symbol	Σ(MiSS)	Symbol	Σ(MiSS)	Symbol	Σ(MiSS)	Symbol	Σ(MiSS)
Am	3,252	Lm	3,436	Lm	3,593	Lm	684	Lm	617	Rv	256
Rv	677	Am	344	Am	270	Am	263	Miv	224	Nv	253
Lm	294	Rm	192	Rm	175	Miv	121	Lv	19	Lm	78
Nv	85	Rv	134	Miv	57	Nv	91	Rv	10	Mim	54
Mim	54	Mim	129	Nv	38	Mim	60	Nv	3	Am	46
Lv	23	Nv	38	Mim	36	Rv	48	Fv	0	Lv	33
Rm	14	Lv	27	Rv	22	Rm	17	Am	0	Rm	24
Fv	0	Fv	13	Fv	11	Lv	7	Rm	0	Miv	3
Miv	0	Miv	1	Lv	10	Fv	0	Mim	0	Fv	2
Σ(MiSS)	4,399	Σ(MiSS)	4,315	Σ(MiSS)	4,212	Σ(MiSS)	1,291	Σ(MiSS)	874	Σ(MiSS)	749

Specific Crash Type Categories

Directional crash types

30 categories at typical 4-legged intersections

Vulnerable user categories

Enables targeted low-cost solutions

Int #4 112th Avenue NE and NE 8th Street		Int #1 124th Avenue NE and NE 8th Street		Int #3 148th Avenue SE and SE 22nd Street		Int #5 100th Avenue and Main Street		Int #2 116th Avenue NE and Northup Way		Int #6 Bellevue Way NE and NE 8th Street	
Symbol	Σ(MiSS)	Symbol	Σ(MiSS)	Symbol	Σ(MiSS)	Symbol	Σ(MiSS)	Symbol	Σ(MiSS)	Symbol	Σ(MiSS)
SWm	2,126	ELm	1,463	SLm	2,287	SLm	634	WLm	617	WNv	142
ESm	1,116	WLm	1,456	NLm	1,110	SWm	156	Miv	224	NRv	101
ERv	618	SLm	357	SWm	220	Miv	121	WLv	19	WRv	99
SLm	180	ESm	192	WLm	175	WNm	72	ERv	10	SLm	63
WLm	95	NLm	160	ERm	169	Mim	60	ENv	3	ENv	63
NNv	85	NEm	140	Miv	57	SNv	53	SNv	0	ERv	55
SRv	59	Mim	129	WNv	38	ELm	41	ELv	0	Mim	54
Mim	54	NRm	113	Mim	36	NNv	35	NFv	0	ESm	46
WLv	23	SRm	78	WNm	30	WRv	34	WRv	0	NNv	42
NLm	19	SRv	51	ELm	21	ESm	33	WNv	0	SLv	24
SRm	14	WRv	43	ESm	19	ERv	14	SLv	0	WRm	14
WNm	10	NRv	37	SFv	11	WRm	14	EFv	0	WLm	9
SNv	0	SLv	24	ERv	10	WLm	9	NRv	0	SRm	7
ELv	0	SNv	23	WRv	9	ELv	7	NNv	0	WLv	6
NFv	0	ENv	16	NLv	8	WNv	3	SFv	0	SNv	5
WRv	0	WFv	13	NRm	6	NEm	2	NLv	0	ELm	4
WNv	0	SWm	11	NRv	2	NRm	2	WFv	0	Miv	3
SLv	0	ELv	3	ELv	2	SRm	2	SRv	0	ERm	3
EFv	0	ERv	3	SRv	1	ERm	0	NLm	0	ELv	2
NRv	0	ERm	2	NEm	1	NFv	0	ELm	0	SFv	2
SFv	0	WNm	1	SNv	0	SLv	0	SLm	0	SRv	1
ENv	0	Miv	1	NFv	0	EFv	0	SWm	0	NLm	1
NLv	0	NLv	0	SLv	0	NRv	0	WNm	0	SWm	0
WFv	0	NFv	0	EFv	0	WLv	0	NEm	0	NFv	0
ELm	0	WNv	0	NNv	0	SFv	0	ESm	0	EFv	0
NEm	0	EFv	0	WLv	0	ENv	0	SRm	0	NLv	0
WRm	0	NNv	0	ENv	0	NLv	0	WRm	0	WFv	0
NRm	0	WLv	0	WFv	0	WFv	0	NRm	0	WNm	0
ERm	0	SFv	0	SRm	0	SRv	0	ERm	0	NEm	0
Miv	0	WRm	0	WRm	0	NLm	0	Mim	0	NRm	0
Σ(MiSS)	4,399	Σ(MiSS)	4,315	Σ(MiSS)	4,212	Σ(MiSS)	1,291	Σ(MiSS)	874	Σ(MiSS)	749

General Symbol	Description
Nv	Near-Side Vulnerable User
Lv	Left-Turn Vulnerable User
Fv	Far-Side Vulnerable User
Rv	Right-Turn Vulnerable User
Miv	Miscellaneous Vulnerable User
Am	Right-Angle Motor Vehicle
Lm	Left-Turn Motor Vehicle
Rm	Right-Turn Motor Vehicle
Mim	Miscellaneous Motor Vehicle

Specific Symbol	Description
SNv	Southbound Near-Side Vulnerable User
ELv	Eastbound Left-Turn Vulnerable User
NFv	Northbound Far-Side Vulnerable User
WRv	Westbound Right-Turn Vulnerable User
WNv	Westbound Near-Side Vulnerable User
SLv	Southbound Left-Turn Vulnerable User
EFv	Eastbound Far-Side Vulnerable User
NRv	Northbound Right-Turn Vulnerable User
NNv	Northbound Near-Side Vulnerable User
WLv	Westbound Left-Turn Vulnerable User

Specific Crash Types Continued....

Specific Symbol	Description
SFv	Southbound Far-Side Vulnerable User
ERv	Eastbound Right-Turn Vulnerable User
ENv	Eastbound Near-Side Vulnerable User
NLv	Northbound Left-Turn Vulnerable User
WFv	Westbound Far-Side Vulnerable User
SRv	Southbound Right-Turn Vulnerable User
Miv	Miscellaneous Vulnerable User
NLm	Northbound Left-Turn Angle with Southbound Thru Motor Vehicle
ELm	Eastbound Left-Turn Angle with Westbound Thru Motor Vehicle
SLm	Southbound Left-Turn Angle with Northbound Thru Motor Vehicle
WLm	Westbound Left-Turn Angle with Eastbound Thru Motor Vehicle
SWm	Southbound Thru Right-Angle with Westbound Thru Motor Vehicle
WNm	Westbound Thru Right-Angle with Northbound Thru Motor Vehicle
NEm	Northbound Thru Right-Angle with Eastbound Thru, Motor Vehicle
ESm	Eastbound Thru Right-Angle with Southbound Thru, Motor Vehicle
SRm	Southbound Right-Turn Angle/Sideswipe with Westbound Thru, Motor Vehicle
WRm	Westbound Right-Turn Angle/Sideswipe with Northbound Thru, Motor Vehicle
NRm	Northbound Right-Turn Angle/Sideswipe with Eastbound Thru, Motor Vehicle
ERm	Eastbound Right-Turn Angle/Sideswipe with Southbound Thru, Motor Vehicle
Mim	Miscellaneous Motor Vehicle

Specifying directional crash types enabled targeted, low-cost solutions at top-ranked intersections. But it also enabled MiSS to be used to identify opportunities for cost-effective improvements at lower ranked intersections. As such, we included diagnosis results for all six intersections and highlighted three opportunities to investigate safety at intersections ranked #4, #5, and #6, respectively.

Step #3 Countermeasure Selection

Diagnosis of specific crash types led to investigation of possible causes of those crashes. With this data, the project team explored various countermeasures to mitigate the general and specific crash types identified in the diagnosis stage (shaded blue with white text). After countermeasures were identified, our team used the Crash Modification Factors Clearinghouse (http://www.cmfclearinghouse.org/) to find crash modification factors to quantify the benefit (or crash reduction potential) of implementing the selected countermeasure at the specific crash locations.[4]

Step #4 Economic Appraisal

Next, economic analysis was used to help identify cost-effective safety improvements using a benefit-cost ratio over a 10-year period of potential crash reduction. Inflation and discount rates were not included in this exercise but could be, if desired, incorporated in the (f_{econ}) factor.

Crash reduction benefits were calculated by applying applicable CMFs to improvements to estimate the number of MiSS points reduced, then multiplying by $1,000 to convert to crash reduction benefits.

We estimated the costs of various improvements based on our experience with implementing such improvements. For improvements that involved a potential change to traffic signal timing, we assumed a minimum cost of $5,000 to conduct a traffic study and determine new timings. We also considered the lifespan of the improvements. For example, high-visibility crosswalks may need to be repainted several times in the benefit period of 10 years. Our costs reflect estimates of such maintenance.

Step #5 Prioritization

Merging the countermeasures evaluated with the expected crash reduction benefits resulted in a list of potential solutions, prioritized by their benefit-cost ratio. Many of the benefit-cost ratios are very favorable and there are two main reasons for this. First, the benefits are based on comprehensive crash costs rather than just economic loss. Secondly, many of the improvements are very low-cost and have, with the help of MiSS, been applied to address specific crash types and locations (e.g., a high-visibility crosswalk on one specific leg of an intersection).

Intersection	Crash Type	Improvement	Existing Σ(MiSS)	CMF	CMF SOURCE	New Σ(MiSS)	10yr Benefit	Cost	B/C Ratio	Rec.
112th Ave NE and NE 8th St	All	retroreflective backplates	4,399	0.85	ID#[illegible]	3,739	$ 659,848	$ 12,000	55.0	✓
	ERv	high-visibility crosswalk on south leg	618	0.60	ID#[illegible]	371	$ 247,017	$ 5,000	49.4	✓
	SWm	near-side traffic signal display on WB approach	2,126	0.71	ID#[illegible]	1,509	$ 616,419	$ 30,000	20.5	✓
	Ped/Bike	leading pedestrian interval all legs	784	0.87	ID#[illegible]	682	$ 101,953	$ 7,500	13.6	
	Ped/Bike	high-visibility crosswalks all legs	784	0.60	ID#[illegible]	471	$ 313,702	$ 25,000	12.5	
	ERv	prohibit EB right-turns on red	618	0.87	ID#[illegible]	537	$ 80,280	$ 7,000	11.5	✓
	ESm	near-side traffic signal display on EB approach & stop	1,116	0.71	ID#[illegible]	793	$ 323,713	$ 35,000	9.2	✓
124th Ave NE and NE 8th St	ELm	protected-only left-turn phasing EB plus storage	1,463	0.01	ID#333	15	$1,448,013	$ 7,500	193.1	✓
	WLm	protected-only left-turn phasing WB plus storage	1,456	0.01	ID#333	15	$1,441,492	$ 7,500	192.2	✓
	ELm	improve left-turn offset	1,463	0.66	ID#[illegible]	965	$ 497,298	$250,000	2.0	
	WLm	improve left-turn offset	1,456	0.66	ID#[illegible]	961	$ 495,058	$250,000	2.0	
148th Ave SE and SE 22nd St	SLm	protected-only left-turn phasing SB	2,287	0.01	ID#333	23	$2,264,475	$ 7,500	301.9	✓
	NLm	protected-only left-turn phasing NB	1,110	0.01	ID#333	11	$1,098,669	$ 7,500	146.5	✓
	SLm	protected-only left-turn phasing SB + ~150' storage	2,287	0.01	ID#333	23	$2,264,475	$125,000	18.1	
	NLm	protected-only left-turn phasing NB + ~150' storage	1,110	0.01	ID#333	11	$1,098,669	$125,000	8.8	
	SLm	improve left-turn offset	2,287	0.66	ID#[illegible]	1,510	$ 777,699	$150,000	5.2	
	NLm	improve left-turn offset	1,110	0.66	ID#[illegible]	732	$ 377,321	$150,000	2.5	
116th Ave NE and Northup Way	WLm	protected-only left-turn phasing WB plus storage	617	0.01	ID#333	6	$ 610,991	$ 7,500	81.5	✓
Bellevue Way NE and NE 8th St	Ped/Bike	leading pedestrian interval all legs	547	0.87	ID#[illegible]	476	$ 71,085	$ 7,500	9.5	✓
	Ped/Bike	high-visibility crosswalks all legs	547	0.60	ID#[illegible]	328	$ 218,723	$ 25,000	8.7	✓

[4] Crash Modification Factors (CMF) Clearinghouse. Federal Highway Administration. Available online at: www.cmfclearinghouse.org <Accessed April 15, 2021>

Improvement Recommendations

The purpose of the prioritization table is to be a guide for discussing improvement options with the city. The city can provide additional context to the decision-making process (e.g., improvements are already planned as part of a project, etc.). Based on the information available to us, our recommendations for safety improvements have checkmarks on the last column of the prioritization table.

Other Opportunities Identified by MiSS at Lower Ranking Intersections:

- Consider high-visibility crosswalks and/or leading pedestrian interval at the intersection of Bellevue Way NE and NE 8th Street (73% of the MiSS points were from conflicts with ped/bikes)
- Consider WB protected-only left-turn operations at 118th Avenue NE and Northup Way
- Consider reviewing video at the intersection of 116th Avenue NE and Northup Way to determine what is causing the southbound left-turn near-miss conflicts.

Step #6: Safety Effectiveness Evaluation

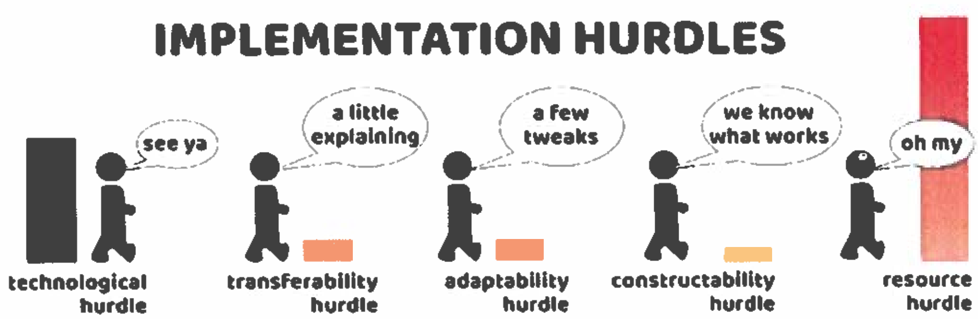
Lastly, while this competition did not center around the safety effectiveness evaluation step of the RSM, The Proactive Badgers have concluded that near-miss analytics and the MiSS method could be extremely useful in step #6 of the RSM. Why wait for 3-5 years of crash data after making an improvement when you can get virtually instantaneous evaluation results with MiSS?

IMPLEMENTATION

To evaluate transferability of MiSS, our team focused on how the method could be implemented across multiple jurisdictions. We used a multi-faceted approach to identify, comprehend, and address implementation hurdles that may exist for utilizing this method. More specifically, our team contacted several transportation professionals throughout North America to discuss the MiSS concept and the barriers that may exist for collecting and using near-miss crash data as a proactive approach to roadway safety management. The following transportation professionals were consulted:

- Karyn Ryg Robles, AICP, MPA, Director of Transportation, Village of Schaumburg, IL
- John Riehl, Chief Transportation Management Section, Gaithersburg, MD
- Tanya Davis and Sam Trax, PE, Supervisor Road Safety & Transportation, Halifax, Nova Scotia
- Eric Lom, PE, City Traffic Engineer, City of Appleton, WI

A resonating theme from our discussions was an overall lack of resources to collect, review, analyze, or implement safety projects. For jurisdictions to embrace this type of methodology, they must be convinced that it is a simple, straightforward, and worthwhile investment to dedicate their limited resources towards. Our team has successfully designed MiSS to address these hurdles, take advantage of technological advancements, be transferable and adaptable, and lead to low-cost constructible solutions across jurisdictions. The following illustration summarizes the hurdles and the scale of such hurdles. Each hurdle is discussed in more detail in the subsequent text.



Technological

Technology continues to strengthen the transportation industry's ability to adapt to real-time traffic scenarios and look beyond traditional means of analysis. The integration and presence of this technology varies widely from jurisdiction to jurisdiction. But the technology to collect high-resolution video surveillance and track the trajectories of vehicles and non-motorists already exists no matter where you are in that continuum. Some jurisdictions, such as Halifax, are already exploring the use of vehicle-tracking and near-miss data as surrogates for safety analysis. A few years ago, the technological hurdle was high. But given that the technology exists and there are multiple companies with the capability of creating and analyzing the trajectories of vehicles and non-motorists, we considered the technological hurdle one that has been crossed.

Transferability

The MiSS method our team developed is transferable and can be replicated by other jurisdictions. Compared to the advanced analytics and algorithms involved in creating vehicle trajectories (which are performed behind the scenes), the MiSS method is implementable using tools such as Microsoft Excel. The MiSS calculation was designed to be simple, straightforward, and highly transferable. It was developed using a 4-step process:

- Step 1. Establish crash type categories (see graphic on page 5)
- Step 2. Use logic statements to assign a crash type and filter near-miss events (see page 4)
- Step 3. Use the MiSS formula to calculate a MiSS value for each remaining near-miss event
- Step 4. Sum the MiSS values for each crash type category

Adaptability

The MiSS method is highly adaptable. For every intersection, the crash type categories and labels can be adjusted and established to reflect the existing conditions of the intersection including roundabouts, any number of approaches, and the actual orientation of the intersection. Since most intersections are 3- or 4-legged, MiSS is directly applicable to a vast majority of locations. Additionally, the factors in the MiSS equation are calibratable based on further research or local conditions.

Constructability

Our team had differing opinions on how to interpret constructability; therefore, two interpretations are discussed. The first interpretation is the constructability of a near-miss analytics system using the MiSS method. The second interpretation is the constructability of the safety improvements MiSS helped identify. For either interpretation, MiSS offers constructible solutions. Presuming sufficient resources are provided, the technology needed to implement MiSS already exists and the MiSS method is adaptable, transferable, and programmable into analytical systems. Regarding the second interpretation, the targeted low-cost safety improvements identified by the MiSS method are constructible, implementable solutions expected to provide high returns on investment.

Resources

The biggest hurdle for jurisdictions is a lack of resources and competing priorities. The lack of resources included staff, equipment, funding, and the on-going maintenance and troubleshooting associated with maintaining their technology. There were also concerns related to shared jurisdictional boundaries and challenges associated with working between multiple jurisdictions, especially with a new safety evaluation methodology.

In recognition of these limitations, our team developed a method to identify and prioritize safety improvements that can be implemented proactively. The MiSS method identifies and prioritizes locations that have the highest potential for crash-avoidance of severe and injury-prone crashes. This prioritization is critical to allow transportation professionals the opportunity to explain the value of these safety improvement investments at a given location. MiSS is a valuable method to justify these safety improvements to the public and elected officials.

ADDITIONAL NOTES ABOUT THE MISS METHOD

The Proactive Badgers carefully considered many aspects of the MiSS method. To help illustrate the depth of analysis and thought behind the MiSS method, please see the summary below regarding additional thoughts about MiSS.

- Crash types that typically occur upstream of intersections, such as rear-ends and sideswipes were specifically excluded from this submittal due to inconsistent video footage of all approach legs. MiSS is adaptable to include those crash types and others in future studies if more comprehensive video footage of approaches is provided. We specifically sought to focus on the near-miss crash types that were observable and potentially mitigatable.
- The energy factor, the injury susceptibility factor, the crash type factor for near-miss analytics, and the economic normalization factor are all able to be calibrated to match future research and/or local conditions. Our team used the observed crash and near-miss data from six intersections and correlated it to the comprehensive costs based on a dataset of 94,560 Wisconsin local road intersection crashes. More robust databases of near-miss data and state or jurisdictional specific economic or comprehensive cost data could be used.
- Near-miss technology and the MiSS method opens the door for science-based safety evaluations of temporary or pilot solutions in which waiting 3-5 years for crash data is not possible. Temporary infrastructure has been used to test improvements such as curb bumpouts or refuge islands. However, the ability to evaluate the safety performance of temporary installments with a science-based approach was lacking and could now be performed by the MiSS method.

FINAL THOUGHTS

Our team enjoyed developing the Multimodal Intersection Severity Score (MiSS) and all the vetting, calculating, conversating, testing, exhibit preparation, and writing involved with this submittal. Our hope is that we showed compelling evidence that a scientific approach to near-miss analytics can be understandable, transferable, adaptable, and lead to low-cost, constructible solutions. We also strove to illustrate that the main hurdle for branching this analysis to more jurisdictions is not a technology hurdle, nor is it a methodological hurdle, but is a resource hurdle. For many jurisdictions to do safety analysis, let alone proactive predictive analysis using advanced technologies, resources are the biggest hurdle. Grant or federal aid money, if it became available on a widespread basis for this type of work, would make collecting and analyzing near-miss data substantially more feasible for many jurisdictions.

Furthermore, we hope it was clearly illustrated that pedestrian and bicyclists can specifically be accounted for in the MiSS method and that the crash type categories enabled targeted solutions. Given the transferability of MiSS to virtually any intersection with near-miss data, we feel strongly that MiSS can identify cost-effective improvement options at top-ranking intersections, but also for targeted solutions for specific crash types at lower ranking intersections. Aside from prioritization of projects, MiSS can provide safety effectiveness evaluations (step #6 of the RSM) without waiting 3-5 years for crash data to accumulate. Thank you for the opportunity to develop and share the MiSS method!