

Designing Intersections Using a Safe System Approach



Picture Source: MnDOT

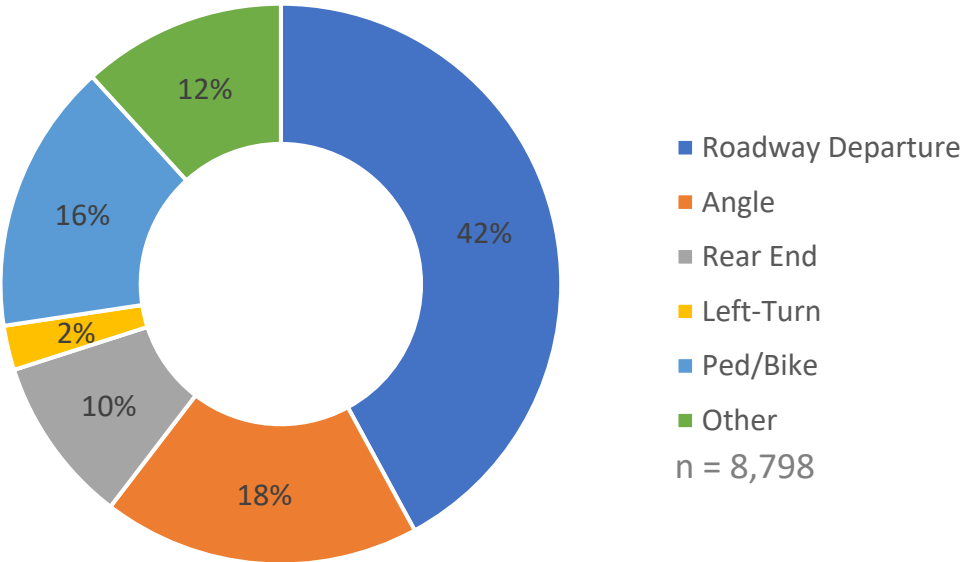
Victor Lund, P.E., PTOE
Traffic Engineer
St. Louis County, MN
Minnesota TZD Conference, November 14, 2023



MINNESOTA

Snapshot of the Problem in Minnesota

2017-2021
Serious Crashes on All Roads in Minnesota
By Crash Type



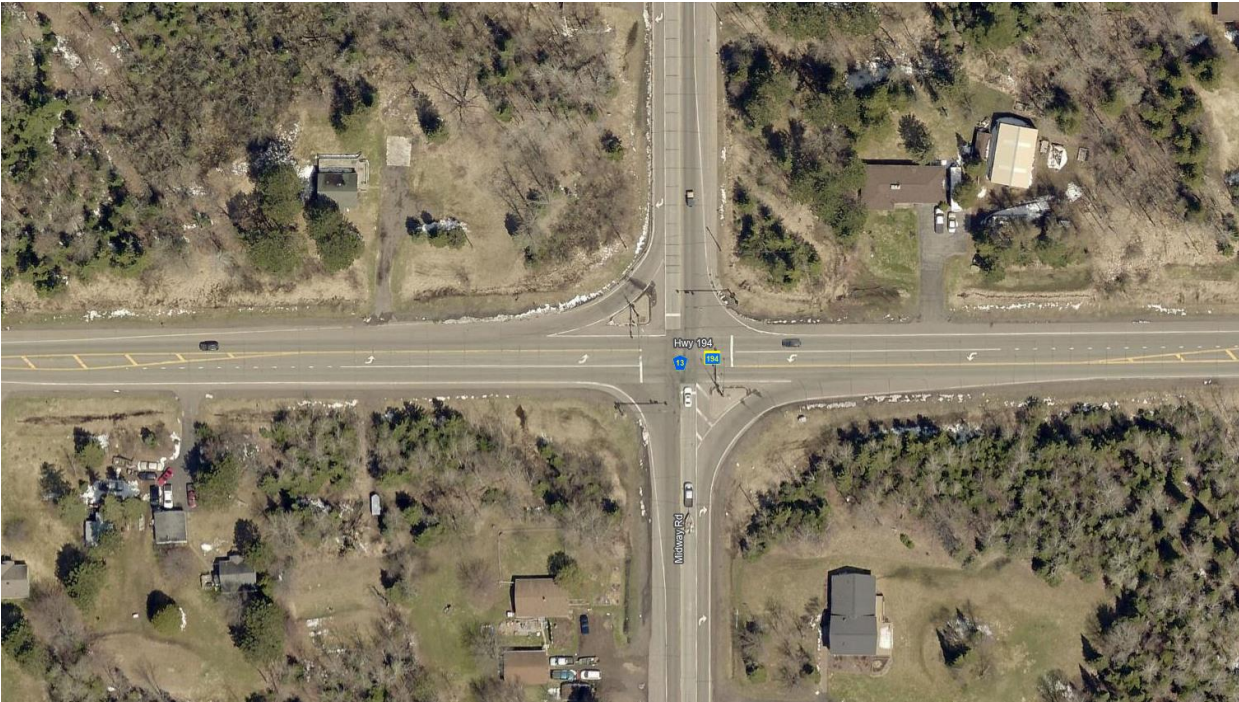
- Roadway departure type crashes generate the most serious crashes.
- Roadway departure and angle type crashes represent 60% of all serious crashes.

Intersection Case #1



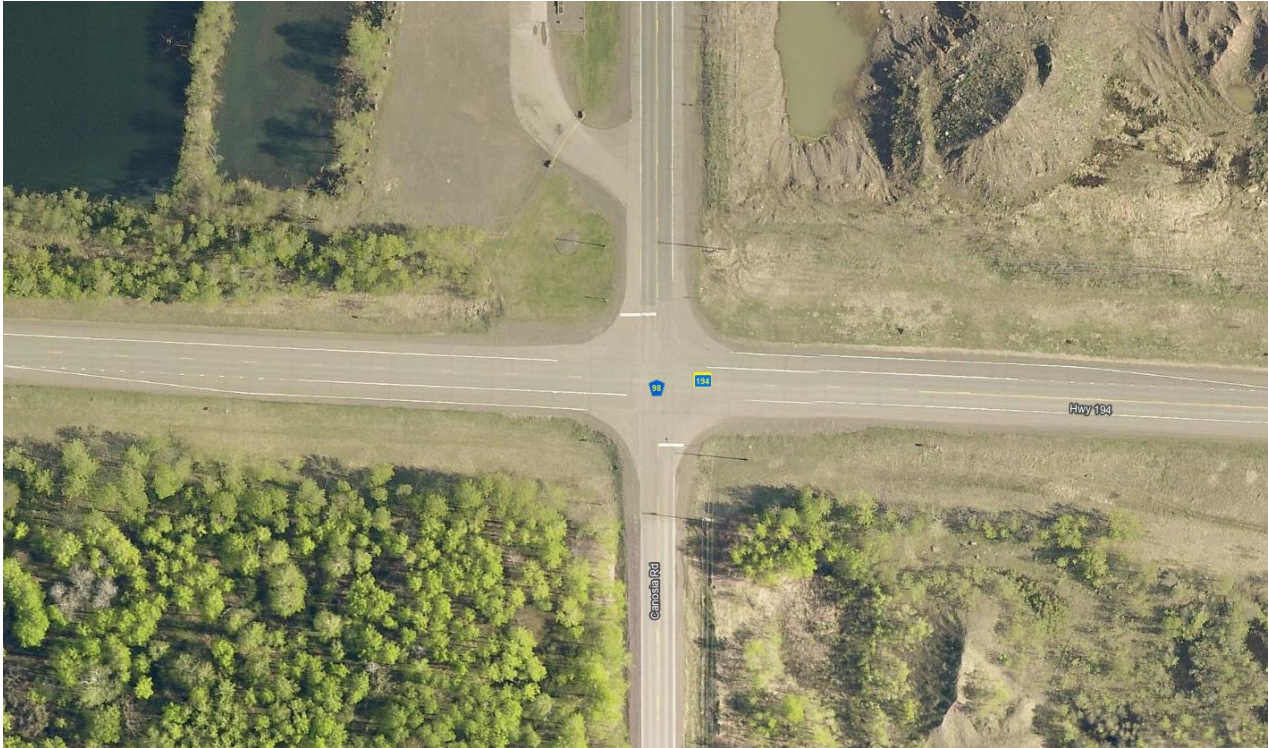
- Intersection of US 169 and 4th Ave SE (CSAH 67) in Chisholm, MN.
- Generally, meets design standards.
- Control type is in accordance with the MUTCD. Side-street STOP control.
- Experienced 2 fatal crashes in 2021. Both drivers pulled out into the intersection from CSAH 67 after stopping and were hit by a westbound vehicle on the “near side” of the intersection.

Intersection Case #2



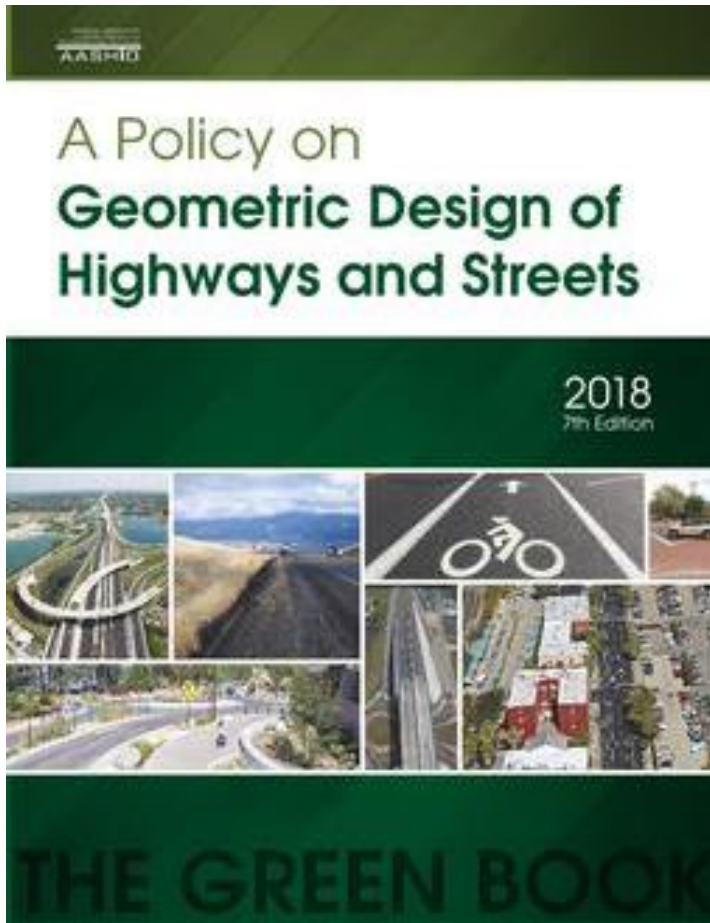
- Intersection of MNTD 194 and Midway Rd (CSAH 13) in Hermantown, MN.
- Generally, meets design standards.
- Traffic signal system installed in 1997 in response to a fatal crash.
- Experienced a fatal crash in 2015. Driver ran the red light.

Intersection Case #3

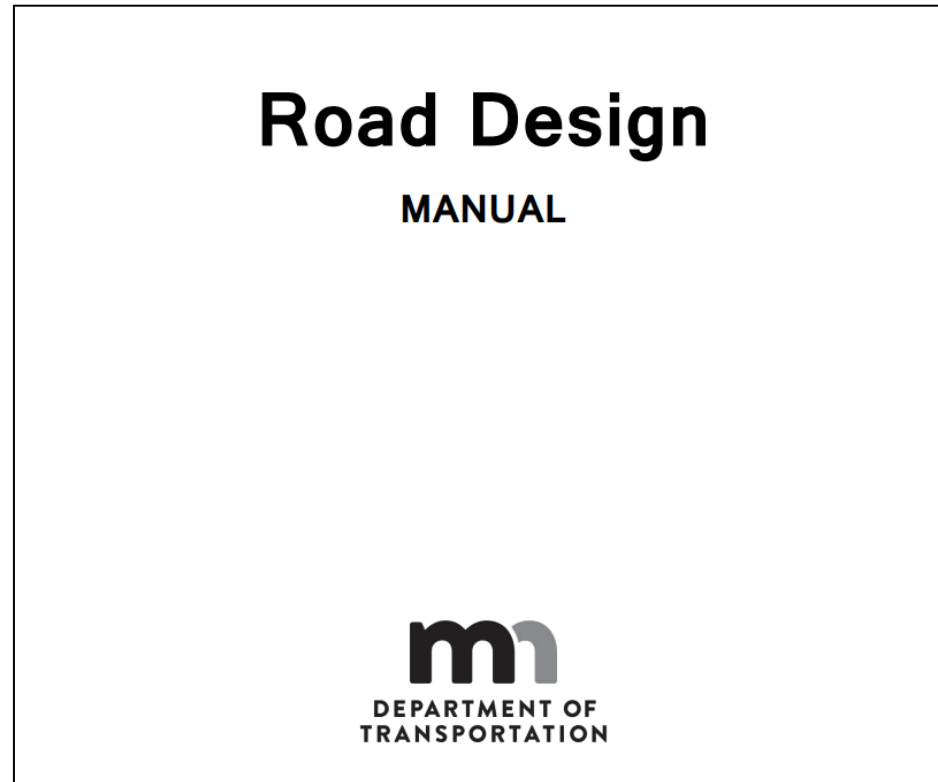


- Intersection of MNTN 194 and Canosia Rd (CSAH 98) near Hermantown, MN.
- Generally, meets design standards.
- Control type is in accordance with the MUTCD. Side-street STOP control.
- Experienced a fatal crash in 2022. Westbound vehicle waiting to turn left from MNTN 194 with other vehicles stopped behind. Trailing westbound vehicle tried to pass on the left to avoid hitting the stopped vehicles and overturned hitting on oncoming vehicle killing the driver.

Design Philosophy Questions

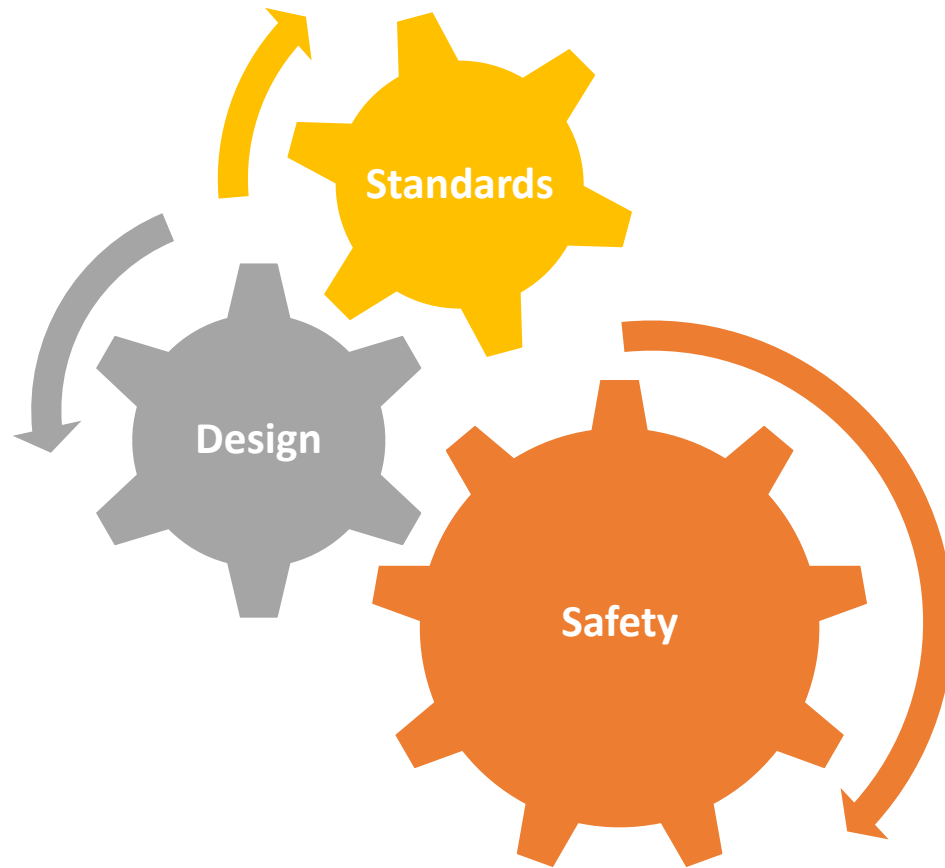


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= Safe Design?

Design Philosophy Questions

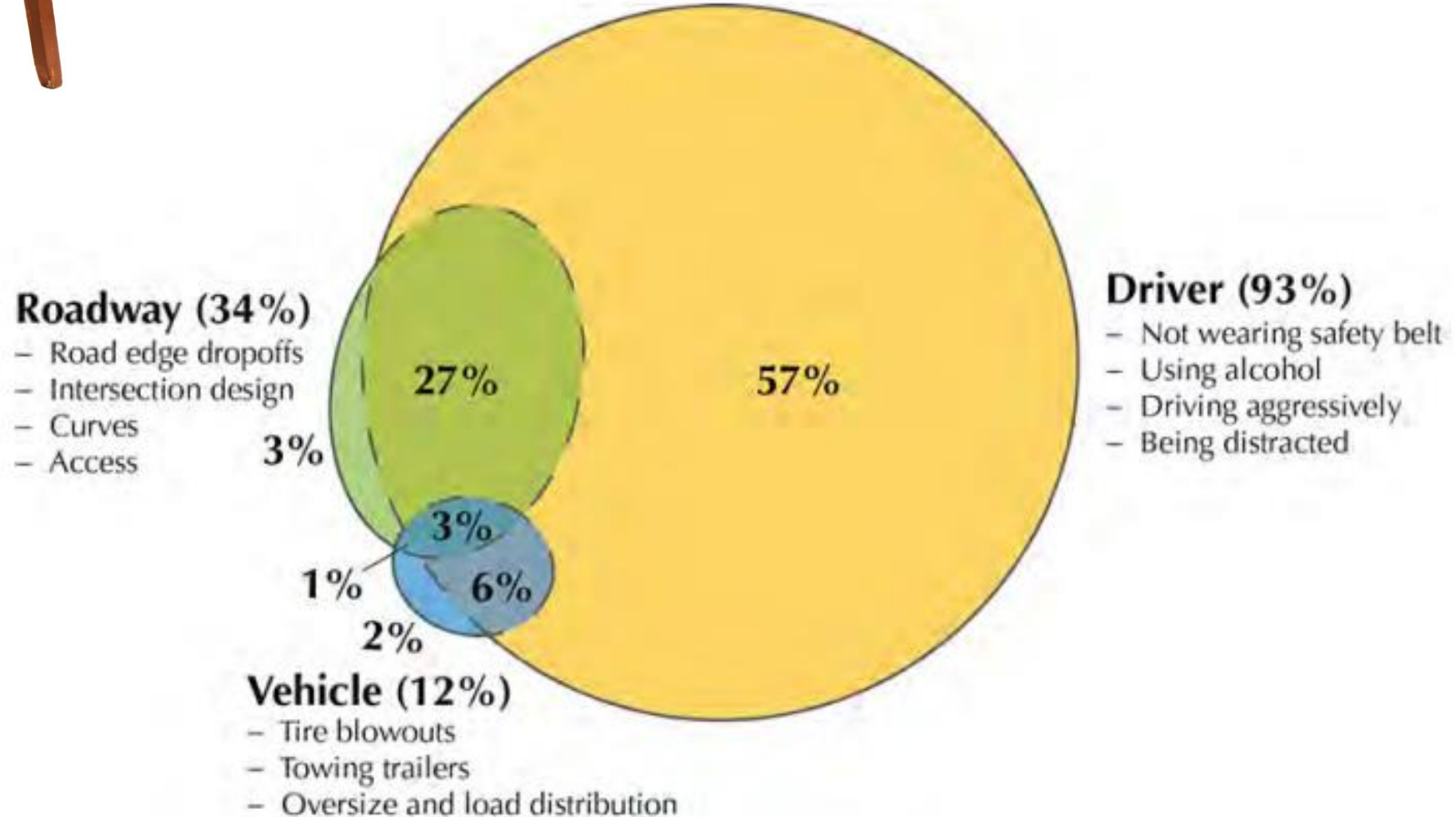


- Do design standards (minimums) equal maximum safety?
- If we are not achieving desired safety performance, what are the implications (if any) for design standards?
- Is there a missing gear between standards and design?



Crash Causation Factors

In this example, roadways are the sole contributing factor in 3% of crashes and the roadway and driver interaction is the factor in 27% of crashes.



The Role of Perceptual and Cognitive Filters in Observed Behavior, Kåre Rumar, 1985

Safe System Approach: What is it?

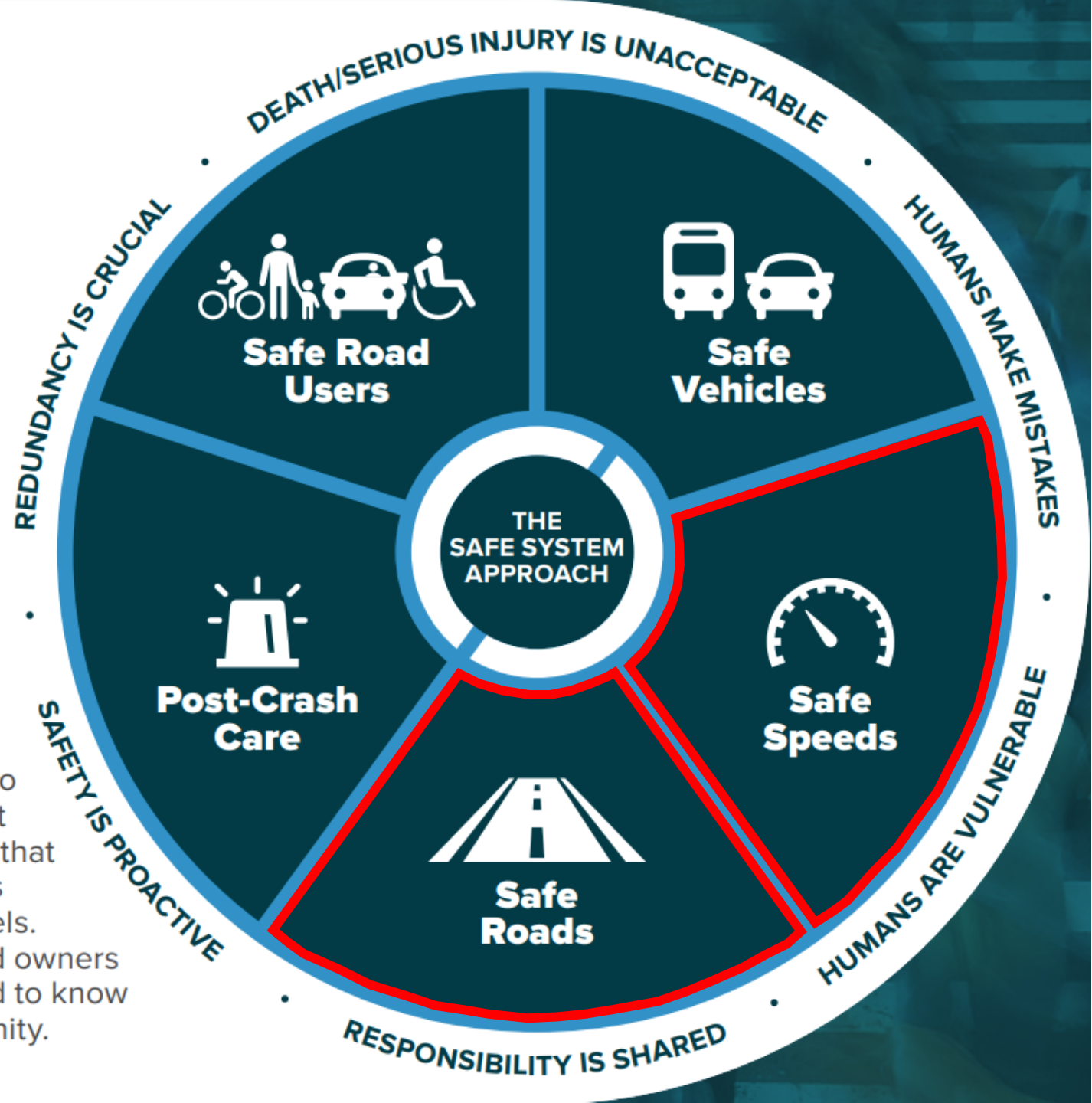
- <https://vimeo.com/346982825>

THE SAFE SYSTEM

APPROACH

Zero is our goal. A Safe System is how we will get there.

Imagine a world where nobody has to die from vehicle crashes. The Safe System approach aims to eliminate fatal & serious injuries for all road users. It does so through a holistic view of the road system that first anticipates human mistakes and second keeps impact energy on the human body at tolerable levels. Safety is an ethical imperative of the designers and owners of the transportation system. Here's what you need to know to bring the Safe System approach to your community.





Safe Road Users

The Safe System approach addresses the safety of all road users, including those who walk, bike, drive, ride transit, and travel by other modes.



Safe Vehicles

Vehicles are designed and regulated to minimize the occurrence and severity of collisions using safety measures that incorporate the latest technology.



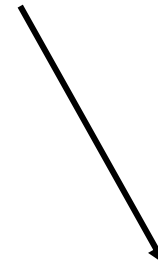
Safe Speeds

Humans are unlikely to survive high-speed crashes. Reducing speeds can accommodate human injury tolerances in three ways: reducing impact forces, providing additional time for drivers to stop, and improving visibility.



Safe Roads

Designing to accommodate human mistakes and injury tolerances can greatly reduce the severity of crashes that do occur. Examples include physically separating people traveling at different speeds, providing dedicated times for different users to move through a space, and alerting users to hazards and other road users.



Post-Crash Care

When a person is injured in a collision, they rely on emergency first responders to quickly locate them, stabilize their injury, and transport them to medical facilities. Post-crash care also includes forensic analysis at the crash site, traffic incident management, and other activities.

Vehicles will be operated by people for the foreseeable future.

Consider operating speeds through intersections. Can the operating speeds be reduced through geometry?

Focus on opportunities to remove intersection conflict points. Could an alternative type intersection reduce conflict points?



Resolution
of the

Board of County Commissioners

St. Louis County, Minnesota

Adopted on: September 13, 2016 Resolution No. 16-569

Offered by Commissioner: Boyle

**Implementation of the County Road Safety Plan and other Highway Safety Strategies
on the St. Louis County Road System**

WHEREAS, The first priority listed in the St. Louis County Public Works Department mission statement is safety; and

WHEREAS, St. Louis County believes that traffic-related deaths on St. Louis County Roads are unacceptable and is supportive of and active in the Minnesota Toward Zero Deaths partnership; and

WHEREAS, St. Louis County has been recognized by the Minnesota Department of Transportation as a champion of implementing its County Road Safety Plan with its investment of \$3.8 million in highway safety projects between 2009 and 2015 on St. Louis County Roads; and

WHEREAS, As a result of the cumulative efforts of educators, enforcement, engineering and emergency response professionals, there has been a 57 percent reduction in serious crashes on St. Louis County Roads between the years of 2003 and 2015; and

WHEREAS, St. Louis County plans to invest \$6.2 million in additional highway safety projects between 2016 and 2020 to further reduce serious crashes on County Roads; and

WHEREAS, St. Louis County intends to update its County Road Safety Plan in cooperation with the Minnesota Department of Transportation to identify additional highway safety strategies;

THEREFORE, BE IT RESOLVED, That the St. Louis County Board of Commissioners fully supports the efforts of the Public Works Department to continue the implementation of the County Road Safety Plan and other highway safety strategies through multiple funding sources on St. Louis County Roads;

RESOLVED FURTHER, That the St. Louis County Board authorizes the Public Works Director/Highway Engineer to apply for and accept highway safety related grants from federal, state and other sources that are consistent with implementation of the County Road Safety Plan.

Commissioner Boyle moved the adoption of the Resolution and it was declared adopted upon the following vote:
Yeas – Commissioners Jewell, Boyle, Dahlberg, Rukavina, Stauber, Nelson and Chair Raukar – 7
Nays – None

STATE OF MINNESOTA
Office of County Auditor, ss.
County of St. Louis

I, DONALD DICKLICH, Auditor of the County of St. Louis, do hereby certify that I have compared the foregoing with the original resolution filed in my office on the 13th day of September, A.D. 2016, and that this is a true and correct copy.

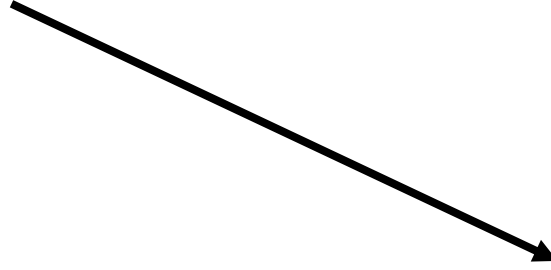
WITNESS MY HAND AND SEAL OF OFFICE at Duluth, Minnesota, this 13th day of September, A.D., 2016.

DONALD DICKLICH, COUNTY AUDITOR

By

Deputy Auditor/Clerk of the County Board

Principle: Death/Serious Injury is Unacceptable



WHEREAS, The first priority listed in the St. Louis County Public Works Department mission statement is safety; and

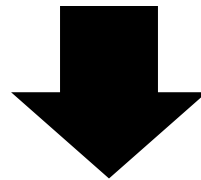
WHEREAS, St. Louis County believes that traffic-related deaths on St. Louis County Roads are unacceptable and is supportive of and active in the Minnesota Toward Zero Deaths partnership; and

Lesson: Promote and elevate the culture of a safe system within your agency or firm.

Principle: Humans Make Mistakes

- Problem:

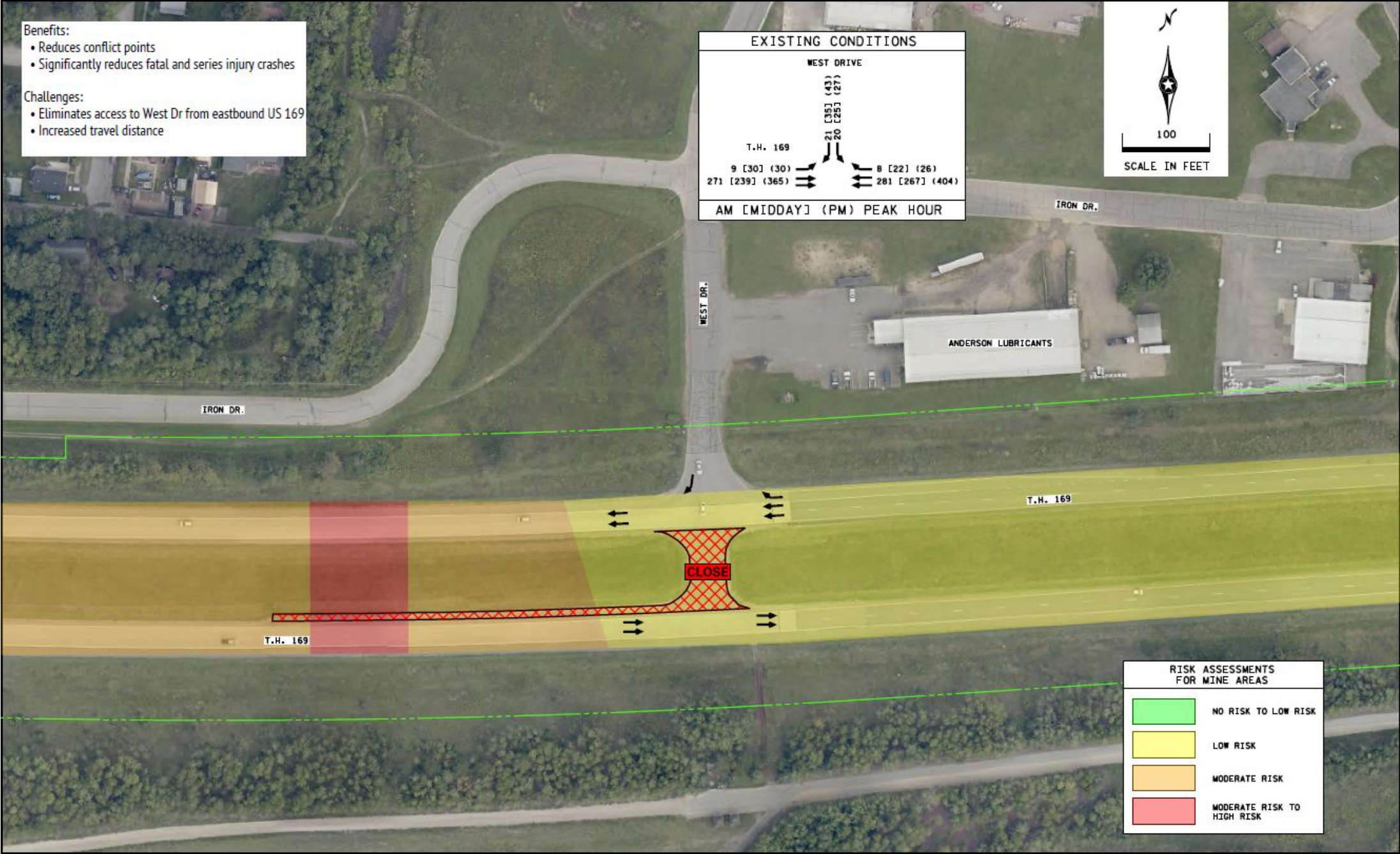
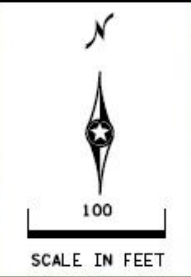
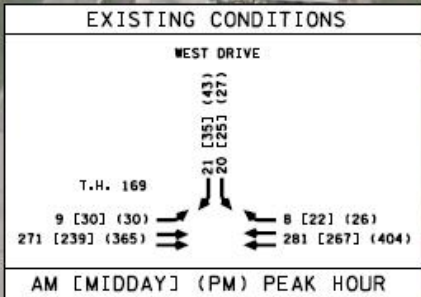
- If given the opportunity, drivers will avail themselves by placing themselves and others in an unsafe or high-risk position within an intersection.



- Lesson:

- An absence of crash history does not equate to “safe” intersections. Look for opportunities to proactively reduce risk or exposure.

- Benefits:**
- Reduces conflict points
 - Significantly reduces fatal and series injury crashes
- Challenges:**
- Eliminates access to West Dr from eastbound US 169
 - Increased travel distance



RISK ASSESSMENTS FOR MINE AREAS

	NO RISK TO LOW RISK
	LOW RISK
	MODERATE RISK
	MODERATE RISK TO HIGH RISK

NO	DATE	BY	CHKD	APPR	REVISION

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

Print Name _____

Date 10/5/2022 License # _____

DRAWN BY _____

DESIGNED BY _____

CHECKED BY _____



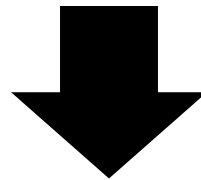
MINNESOTA STATE PROJECT NO.
6935-99
(T.H. 169)

MINNESOTA DEPARTMENT OF TRANSPORTATION

T.H. 169 AND WEST DRIVE
CONCEPT 2.1
RIGHT-IN, RIGHT-OUT

Principle: Humans Are Vulnerable

- Problem:
 - The human body was not designed to withstand traumatic forces experienced in a crash.



- Lesson:
 - Angle type crashes tend result in serious crashes. Reduce or eliminate right-angle conflict points.

Principle: Humans Are Vulnerable

Intersection of US 53 and CSAH 7 (Industrial Rd)						
Conflict Points			All Crashes		Fatal/Injury Crashes	
Type	Number	Percent	Frequency	Percent	Frequency	Percent
Right-Angle	8	27%	4	80%	3	100%
Turning	12	40%	1	20%	0	0%
Merge/Diverge	10	33%	0	0%	0	0%
Total	30		5		3	

Principle: Humans Are Vulnerable

Intersection of MNTH 33 and CSAH 7 (Industrial Rd)						
Conflict Points			All Crashes		Fatal/Injury Crashes	
Type	Number	Percent	Frequency	Percent	Frequency	Percent
Right-Angle	8	27%	5	100%	2	100%
Turning	12	40%	0	0%	0	0%
Merge/Diverge	10	33%	0	0%	0	0%
Total	30		5		2	

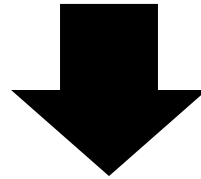
Principle: Humans Are Vulnerable

Intersection of US 169 and CSAH 137 (Spirit Lake Rd)						
Conflict Points			All Crashes		Fatal/Injury Crashes	
Type	Number	Percent	Frequency	Percent	Frequency	Percent
Right-Angle	8	27%	9	100%	6	100%
Turning	12	40%	0	0%	0	0%
Merge/Diverge	10	33%	0	0%	0	0%
Total	30		9		6	

Principle: Responsibility is Shared

- Problem:

- There is a need to create a safe system culture in the transportation engineering profession.



- Lesson:

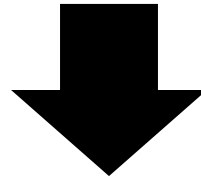
- Need champions to promote a safe system culture for both public agencies and private firms.
- Public agencies should prioritize intersection safety improvements in a programmatic way. Make a concerted effort to treat X intersections in the next Y years.
- Private firms should intentionally incorporate a safe systems approach into the designs for their clients (e.g. intersections within a housing development or new access/intersection on a public road).

Principle: Responsibility is Shared

- St. Louis County and MnDOT have been working in a much more cooperative and deliberative way.
- St. Louis County's approach to prioritizing and programming intersection safety projects.
 - Intersections identified as high-risk in the County Road Safety Plan.
 - Intersections with a high-crash history (greater than the critical rate).
 - Trunk Highway (TH) at County State Aid Highway (CSAH) intersections.
 - CSAH at CSAH intersections.
- St. Louis County's vision for the decade of the 2020s...
 - The "decade of the J-turn".
- This changes the relationship between the "agency" and the "public".

Principle: Safety is Proactive

- Problem:
 - We don't need to wait for crash events in order to act.



- Lesson:
 - Which is it? Crashes = Risk, No Crashes = No Risk OR No Crashes ≠ No Risk.
 - Leverage a Systemic and Systematic approach to prioritizing intersection safety investments.

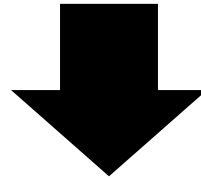
Principle: Safety is Proactive

- St. Louis County and MnDOT have worked closely to complete Intersection Control Evaluation (ICE) reports.
- An ICE provides an engineering-driven process to identify the best intersection control based on a variety of factors. Adds context to the problem and provides value to the recommendation.
- Support funding requests for the recommended projects.

Principle: Redundancy is Critical

- Problem:

- Crashes will still occur even under a “Safe System”.



- Lesson:

- Focus on pushing the crash severity distribution (“curve”) to the lower severity end of the spectrum.
- Promote trade-offs between high severity and low severity conflict points.

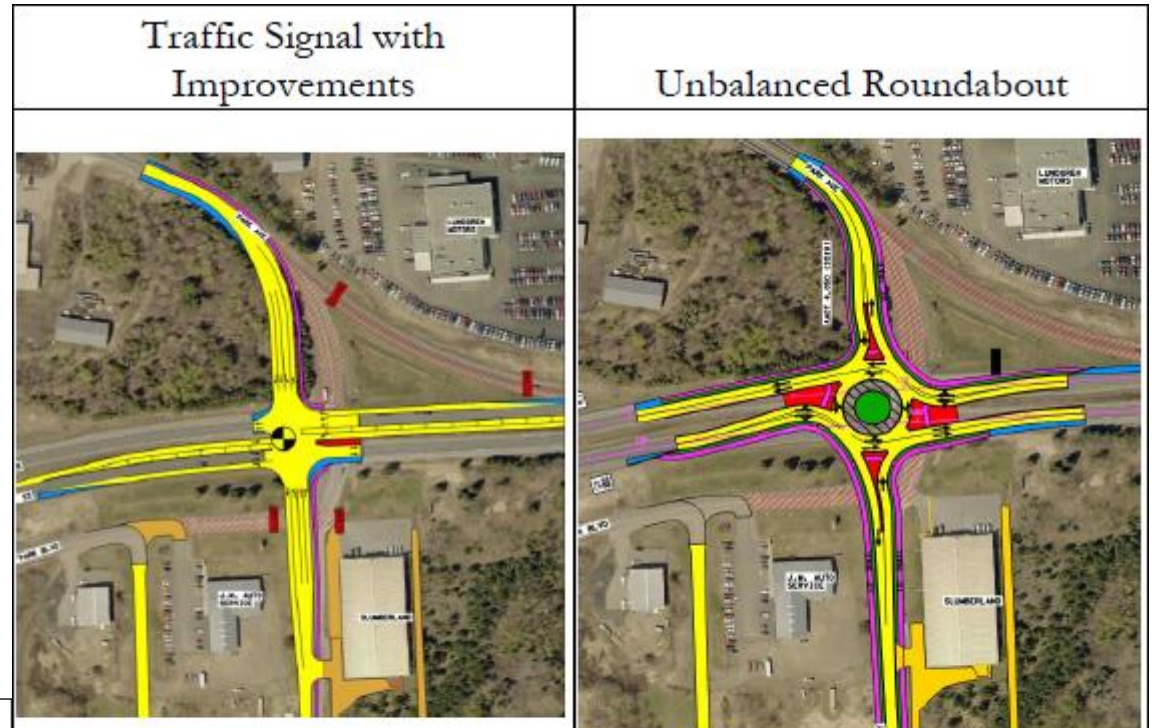
Principle: Redundancy is Critical

Traffic Control Device	Crash Rate	Fatal and Serious Injury Crash Rate
Urban Thru-Stop	0.18	0.33
Rural Thru-Stop	0.25	1.05
Signal - Low Volume/Low Speed	0.52	0.42
All-Way Stop	0.35	0.57
Single Lane Roundabout	0.32	0.31
Signal - High Volume/Low Speed	0.70	0.76
Signal - High Volume/High Speed	0.45	0.48
Unbalanced Roundabout	0.76	0.15
Dual Lane Roundabout	2.18	0.00
All Roundabouts	0.51	0.24

Source: A Study of Traffic Safety at Roundabouts in Minnesota, MnDOT

Which Alternative is Best?

Evaluation Criteria	Traffic Signal with Improvements	Unbalanced Roundabout
Improves Overall Intersection Safety	Moderate Improvement	Moderate Improvement
Conflict Points	32	16
20-Year Crash Costs *1	\$5.2 M	\$6.0M



Source: US 53 at Progress Pkwy Intersection Control Evaluation Report

Recent Examples

Continuous Green-T Intersection

Intersection of Rice Lake Rd (CSAH 4) and Airport Rd, Duluth, MN (2016)



Continuous Green-T Intersections

- Total crashes are reduced by 6%
- Fatal and Injury Crashes are reduced by 11%
- Rear-End, Angle and Sideswipe Crashes are reduced by 17%

Source: Safety Evaluation of Continuous Green T Intersections, FHWA-HRT-16-036, 2016

Recent Examples

Single Lane Roundabout

Intersection of MNTH 194 and Midway Rd (CSAH 13), Hermantown, MN (2022)



Single Lane Roundabouts

- “K” crashes are reduced by 89%
- “A” crashes are reduced by 83%
- Right-Angle crashes are reduced by 68%

Source: A Study of the Traffic Safety at Roundabouts in Minnesota, 2017, MnDOT

Recent Examples

J-Turn

Intersection of US 53 and MNTH 194/Lindahl Rd, Hermantown, MN (2022)



J-Turn (Reduced Conflict Intersection)

- “K” angle crashes are reduced by 100%
- “K” crashes are reduced by 69%
- “A” angle crashes are reduced by 100%
- “A” crashes are reduced by 69%
- Right-Angle crashes are reduced by 70%

Source: Traffic Safety Evaluation at Reduced Conflict Intersections in Minnesota, 2021, MnDOT

Recent Examples

J-Turn

Intersection of US 169 and Spirit Lake Rd (CSAH 137), Mountain Iron, MN (2022)



J-Turn (Reduced Conflict Intersection)

- “K” angle crashes are reduced by 100%
- “K” crashes are reduced by 69%
- “A” angle crashes are reduced by 100%
- “A” crashes are reduced by 69%
- Right-Angle crashes are reduced by 70%

Source: Traffic Safety Evaluation at Reduced Conflict Intersections in Minnesota, 2021, MnDOT

Pedestrian Considerations



Pedestrian and Bicycle Safety Performance at Roundabouts

- 57% lower pedestrian crash rate contrasted with comparable intersections
- 3% lower bicycle crash rate contrasted with comparable intersections

Source: An Addendum to "A Study of the Traffic Safety at Roundabouts in Minnesota", 2018, MnDOT

Lessons Learned

- Intersection conflict points are king.
- Consider speed reduction through geometry.
- Don't lose focus of intersection context.
- Design standards do not necessarily equal safe intersections.
- Focus on a programmatic improvements across a regional transportation network.
- Leverage Intersection Control Evaluation (ICE) studies. They help float good ideas to the surface and get funding.
- You will likely encounter resistance. Don't run from it and don't dismiss it. Rather, work through it with your eye focused on a safer intersection.

Questions?

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