Integrating Conflict Modeling into Microsimulation

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MN Toward Zero Deaths Conference

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Predicting Future Safety for Projects

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Crash Analysis Techniques

- Critical Crash Rate
- Crash Modification Factors (CMFs)
- Predicted Crashes / Safety Performance Functions
- FHWA ISAT Tool
- AASHTO Safety Analyst
- Engineering Judgement

System Average, 2015 Section Toolkit - Green Sheet

Three Years of Crash Data	Non-Junction Crashes (NJ)				All Crashes (ALL)			
	CR_NJ	SR_NJ	FR_NJ	FAR_NJ	CR_ALL	SR_ALL	FR_ALL	FAR_ALL
Rural 2-lane : ADT∈[0,1499]	0.40	0.71	1.05	2.70	0.60	1.03	1.65	3.72
Rural 2-lane : ADT∈[1500,4999]	0.31	0.51	0.78	1.55	0.53	0.87	1.14	2.43
Rural 2-lane : ADT∈[5000,7999]	0.31	0.49	0.66	1.49	0.61	0.97	1.26	2.63
Rural 2-lane : ADT∈[8000,∞)	0.37	0.56	0.65	1.19	0.77	1.16	1.00	2.13
Rural Freeway	0.49	0.65	0.24	0.69	0.60	0.81	0.28	0.78
Rural Expressway	0.36	0.52	0.25	0.75	0.69	1.02	0.59	1.61

Five Years of Crash Data	Non-Junction Crashes (NJ)				All Crashes (ALL)			
	CR_NJ	SR_NJ	FR_NJ	FAR_NJ	CR_ALL	SR_ALL	FR_ALL	FAR_ALL
Rural 2-lane : ADT∈[0,1499]	0.40	0.72	1.00	2.76	0.61	1.07	1.50	3.97
Rural 2-lane : ADT∈[1500,4999]	0.31	0.51	0.75	1.61	0.53	0.87	1.14	2.53
Rural 2-lane : ADT∈[5000,7999]	0.30	0.48	0.58	1.37	0.60	0.96	0.98	2.42
Rural 2-lane : ADT∈[8000,∞)	0.35	0.53	0.60	1.13	0.76	1.15	0.87	1.97
Rural Freeway	0.45	0.61	0.21	0.65	0.56	0.76	0.23	0.75
Rural Expressway	0.34	0.50	0.24	0.70	0.66	0.98	0.56	1.60
Rural 4-lane Divided	0.29	0.44	0.20	0.61	0.87	1.28	0.51	1.78

Ten Years of Crash Data	Non-Junction Crashes (NJ)				All Crashes (ALL)			
	CR_NJ	SR_NJ	FR_NJ	FAR_NJ	CR_ALL	SR_ALL	FR_ALL	FAR_ALL
Rural 2-lane : ADT∈[0,1499]	0.41	0.74	1.04	2.65	0.66	1.15	1.60	4.03
Rural 2-lane : ADT∈[1500,4999]	0.32	0.53	0.72	1.61	0.57	0.93	1.06	2.61
Rural 2-lane : ADT∈[5000,7999]	0.31	0.50	0.58	1.45	0.62	1.01	1.07	2.62
Rural 2-lane : ADT∈[8000,∞)	0.34	0.52	0.52	1.03	0.75	1.14	0.82	1.98
Rural Freeway	0.42	0.59	0.26	0.72	0.55	0.77	0.31	0.86
Rural Expressway	0.34	0.50	0.28	0.76	0.68	1.02	0.63	1.79
Rural 4-lane Divided	0.28	0.42	0.23	0.76	0.87	1.32	0.61	2.10

CR = Crash Rate
SR = Severity Rate (Type A-K crashes)
FR = Fatality Rate (Type K crashes)
FAR = Fatal (K) and incapacitating injury (A) crash rate / Severe Crash Rate

Crash Values (2015)	Per crash
Fatal (Type K)	$10,700,000
Injury Type A	$570,000
Injury Type B	$170,000
Injury Type C	$84,000
Property damage only	$7,600

CRASH MODIFICATION FACTORS CLEARINGHOUSE

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SPF Functions and Screening

- 1) Network Screening
  - Compare observed crash rate versus similar segments or intersections
- 2) Countermeasure Comparison
  - Use a CMF to estimate reduction in crashes
- 3) Project Evaluation
  - Conduct a before/after study to validate or update CMF Factors.

	Junction and Non-Junction Crashes			
2018 through 2022 Crashes	**F+A Crashes**	**Total Crashes**	**F+A Average Crash Density**	**Average Crash Density**
Rural 2-Lane AADT 1-1499	237	2,846	0.01	0.16
Rural 2-Lane AADT 1500-4999	471	8,166	2.60	0.45
Rural 2-Lane AADT 5000-7999	161	3,043	2.64	0.50
Rural 2-Lane AADT 8000+	77	1,778	2.43	0.56
Rural 4-Lane Undivided	5	213	1.18	0.50
Rural 4-Lane Divided	13	631	1.76	0.86
Rural Expressway	205	7,582	1.33	0.49
Rural Freeway	151	11,005	0.72	0.53
Urban 2-Lane AADT 1-1499	21	258	6.77	0.83
Urban 2-Lane AADT 1500-4999	76	2,409	2.74	0.87
Urban 2-Lane AADT 5000-7999	67	2,695	2.74	1.10
Urban 2-Lane AADT 8000+	114	6,142	2.27	1.22
Urban 4-Lane Undivided	74	4,043	3.76	2.05
Urban 4-Lane Divided	209	12,117	3.23	1.87
Urban Expressway	255	13,530	1.85	0.98
Urban Freeway	415	58,189	0.66	0.93

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CMF Data Overload

Countermeasure: Conversion of intersection into single-lane roundabout

Compare	CMF	CRF(%)	Quality	Crash Type	Crash Severity	Area Type	Reference	Comments
☐	0.41	59	★★★★★	All	All	Rural	JENSEN, S. U., 2017	This CMF is for all crashes at...[READ MORE]
☐	0.52	48	★★★★★	All	All	All	JENSEN, S. U., 2017	This CMF is for all crashes at...[READ MORE]
☐	0.75	25	★★★★★	All	All	All	JENSEN, S. U., 2017	This CMF is for all crashes at...[READ MORE]
☐	0.53	47	★★★★★	All	All	Rural	JENSEN, S. U., 2017	This CMF is for all crashes at...[READ MORE]
☐	0.85	15	★★★★★	All	All	Urban	JENSEN, S. U., 2017	This CMF is for all crashes at...[READ MORE]
☐	1.34	-34	★★★★★	All	All	Urban	JENSEN, S. U., 2017	This CMF is for all crashes at...[READ MORE]
☐	0.78	22	★★★★★	All	All	Rural	JENSEN, S. U., 2017	This CMF is for all crashes at...[READ MORE]

- Single Lane Roundabout

$0.41 < x < 1.34$

Countermeasure: Install J-Turn intersection

Compare	CMF	CRF(%)	Quality	Crash Type	Crash Severity	Area Type	Reference	Comments
☐	0.877	12.3	★★☆☆☆	All	All		Leuer and Fleming, 2016	The study used crashes within ... [read more]
☐	0.56	44	★★★☆☆	All	All	Rural	Inman and Haas, 2012	Although the empirical Bayes method ... [read more]
☐	0.54	46	★★★☆☆	All	All	Rural	Hummer et al., 2010	This CMF was obtained from ... [read more]
☐	0.652	34.8	★★★★☆	All	All	Rural	Edara et al., 2013	
☐	0.39	60.57	★★☆☆☆	All	All	Not specified	Hochstein et al., 2009	

- J-turns/RCI Intersection

$0.39 < x < 0.87$

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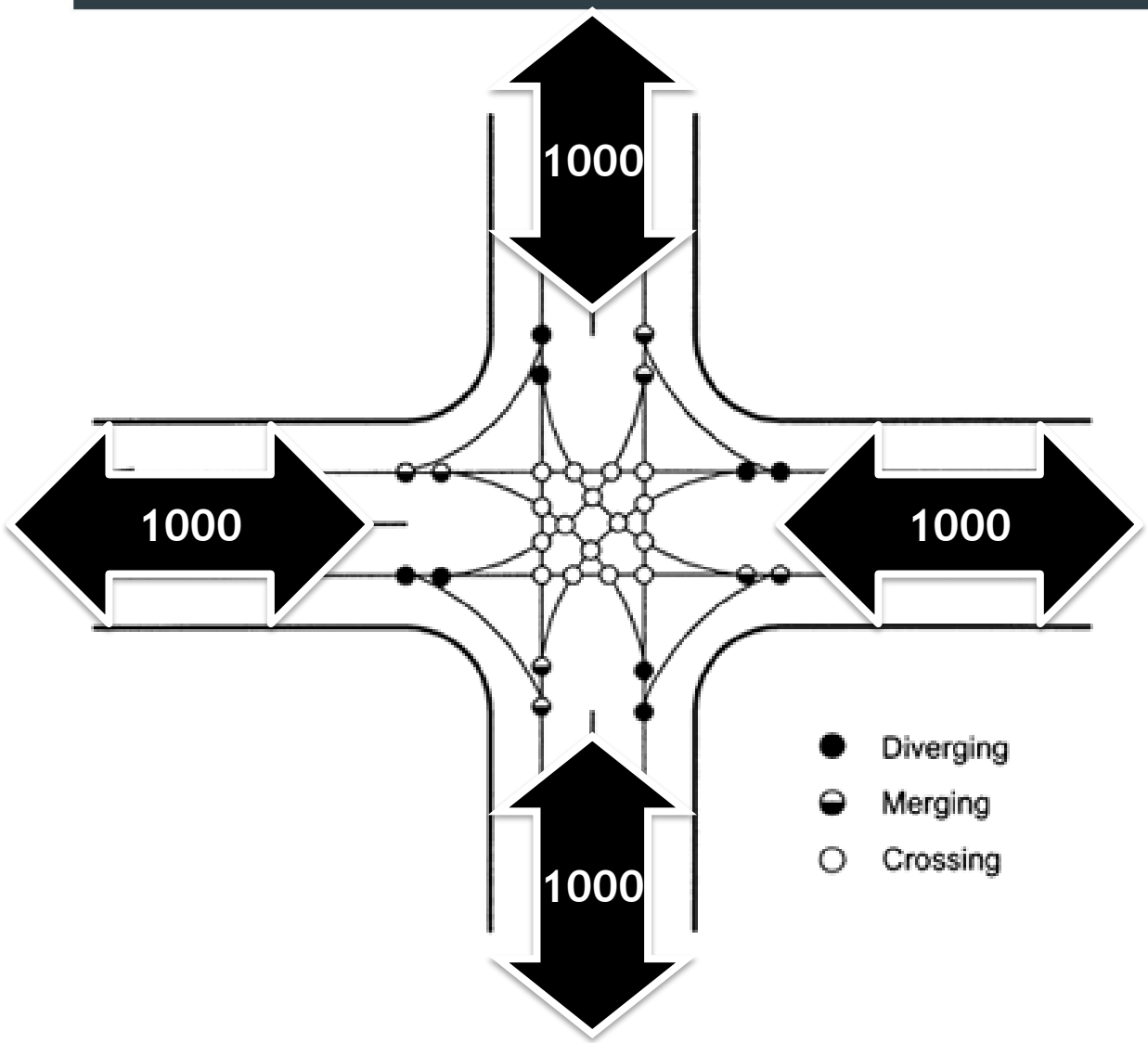
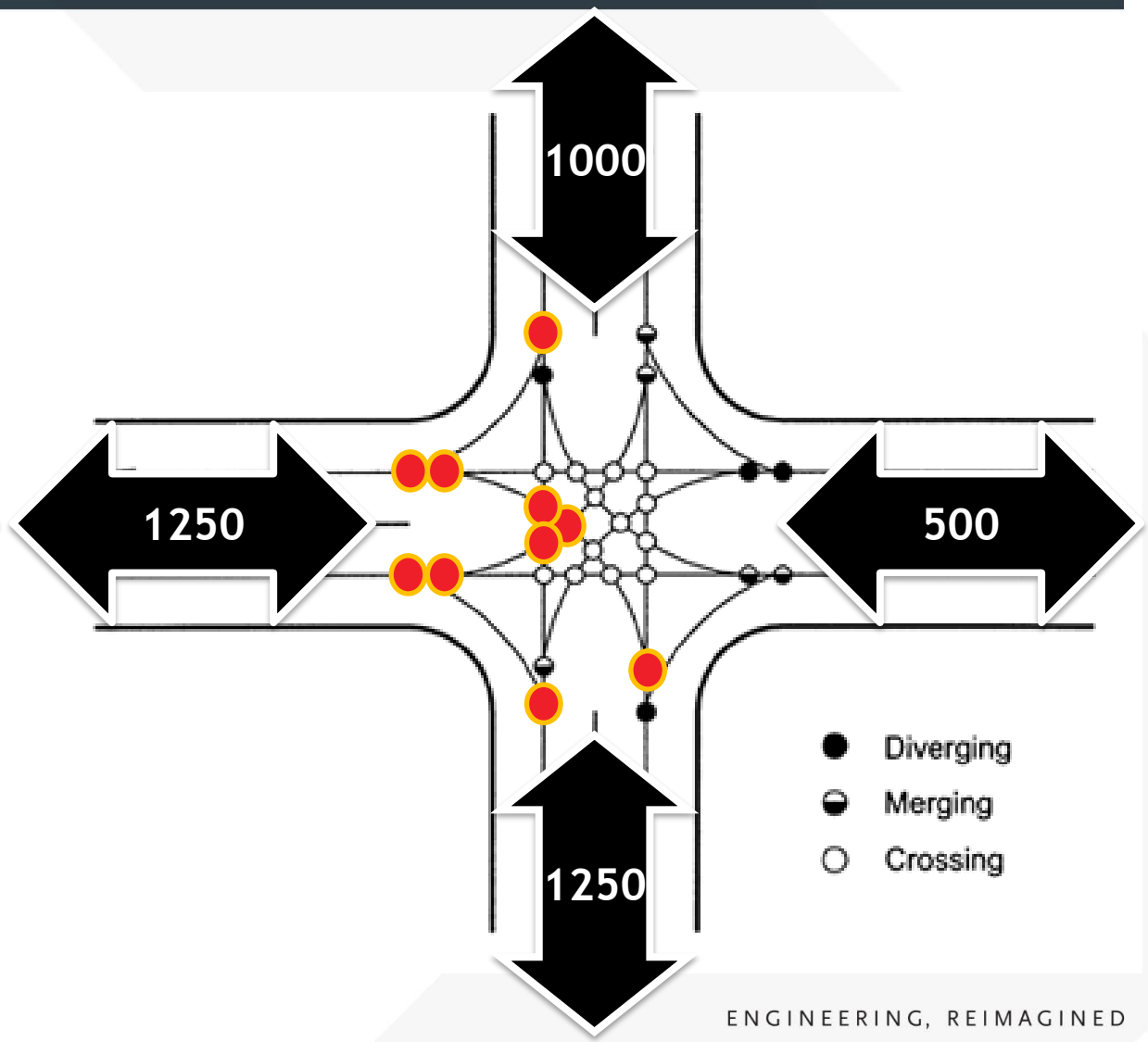
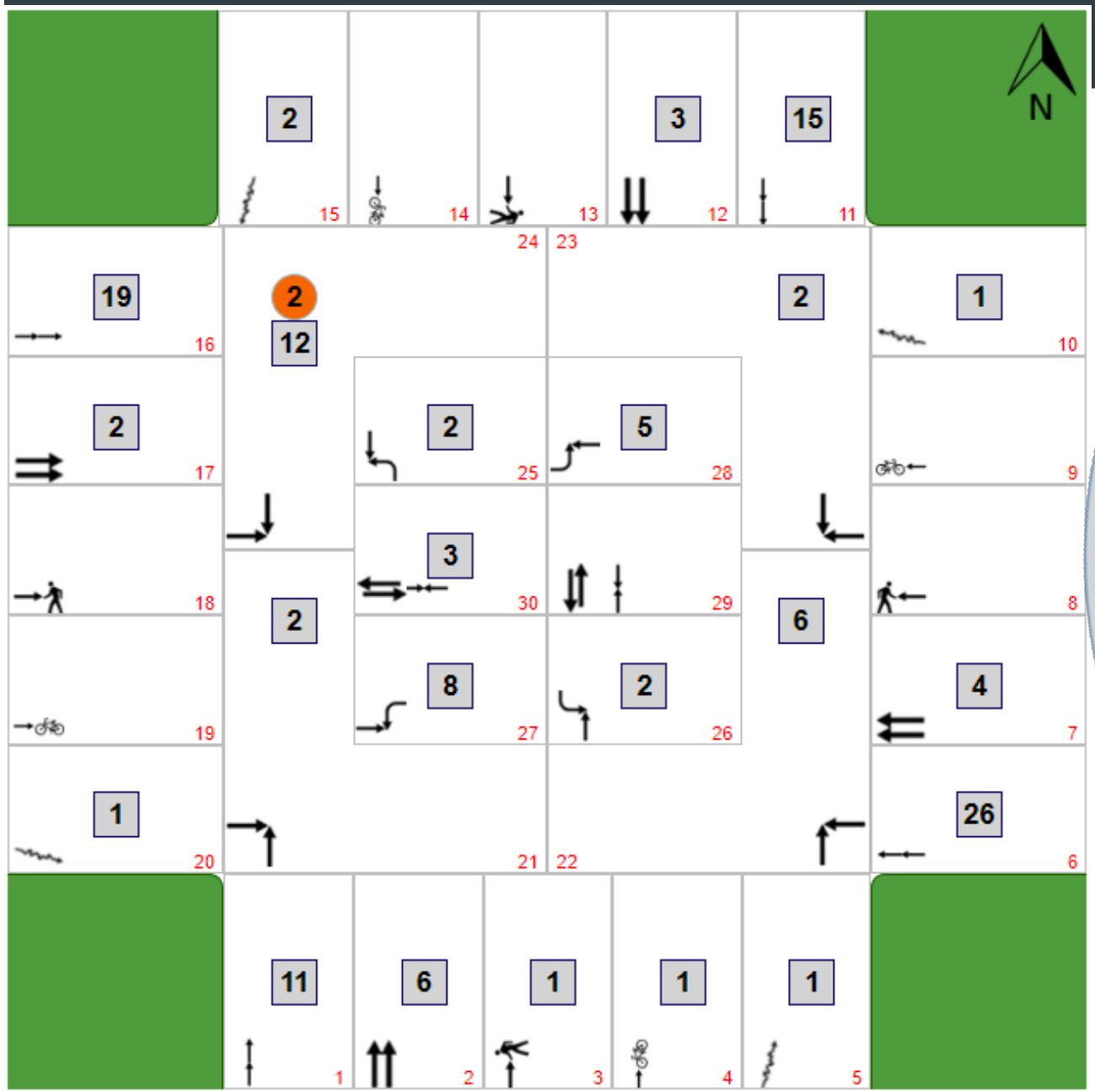
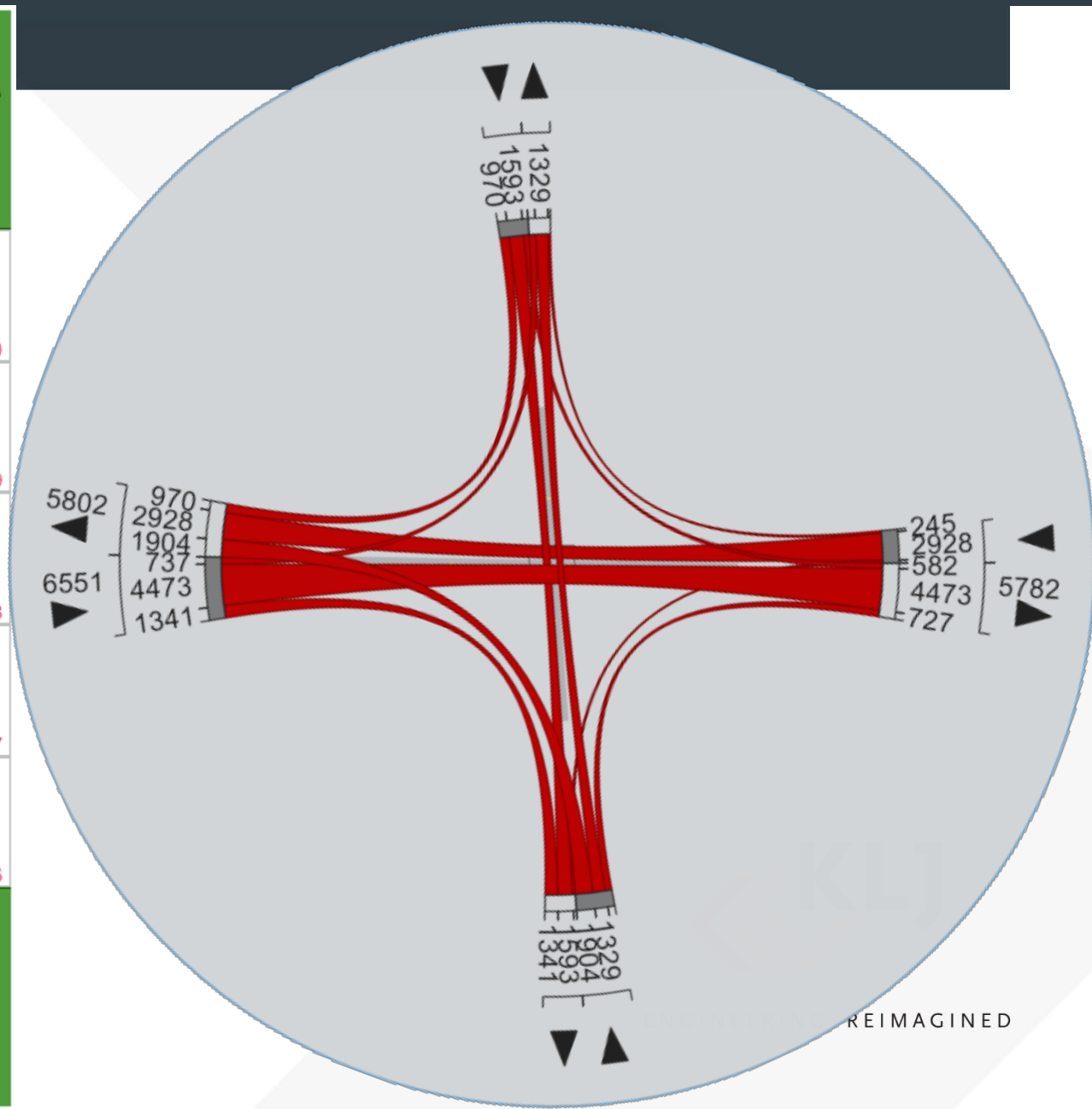
Conflict Points Are Not Created Equally



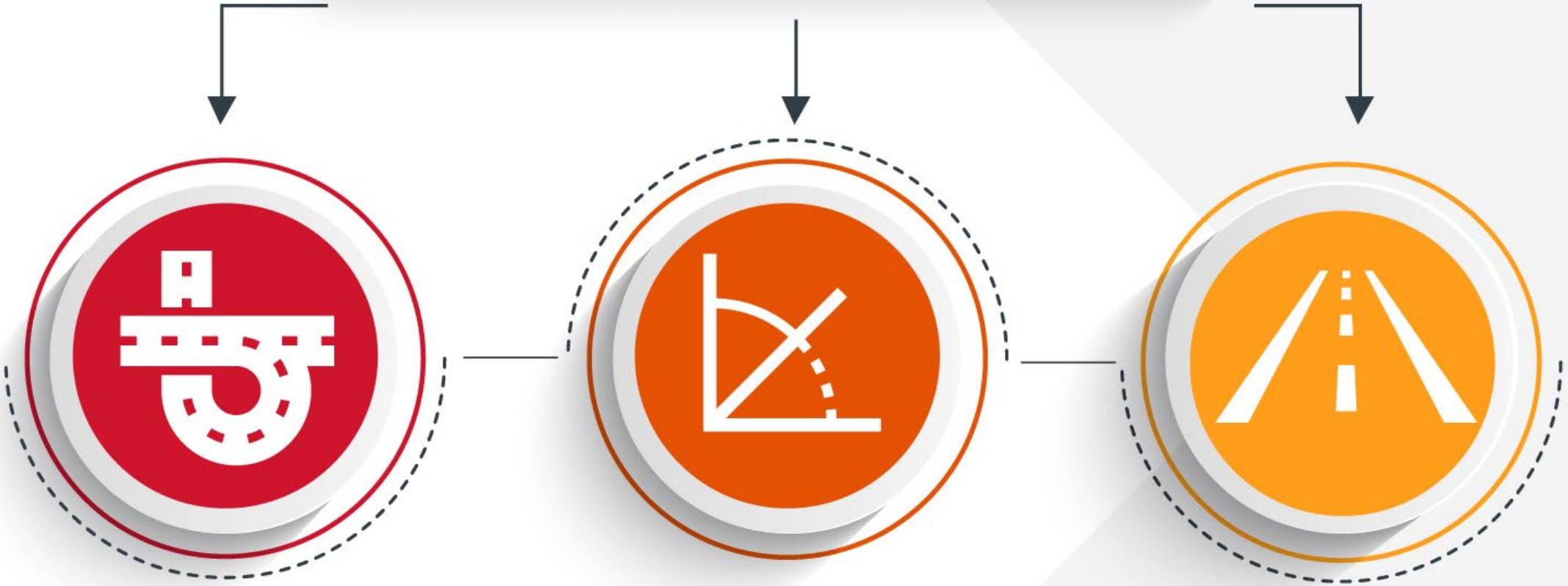


US 14 and CSAH 36 – Rochester, MN



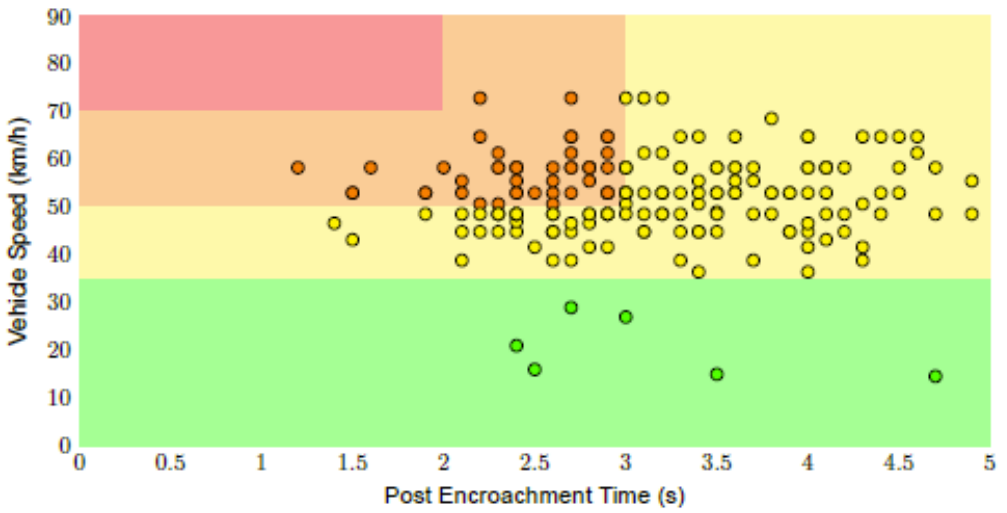


SSAM MODELING APPROACH



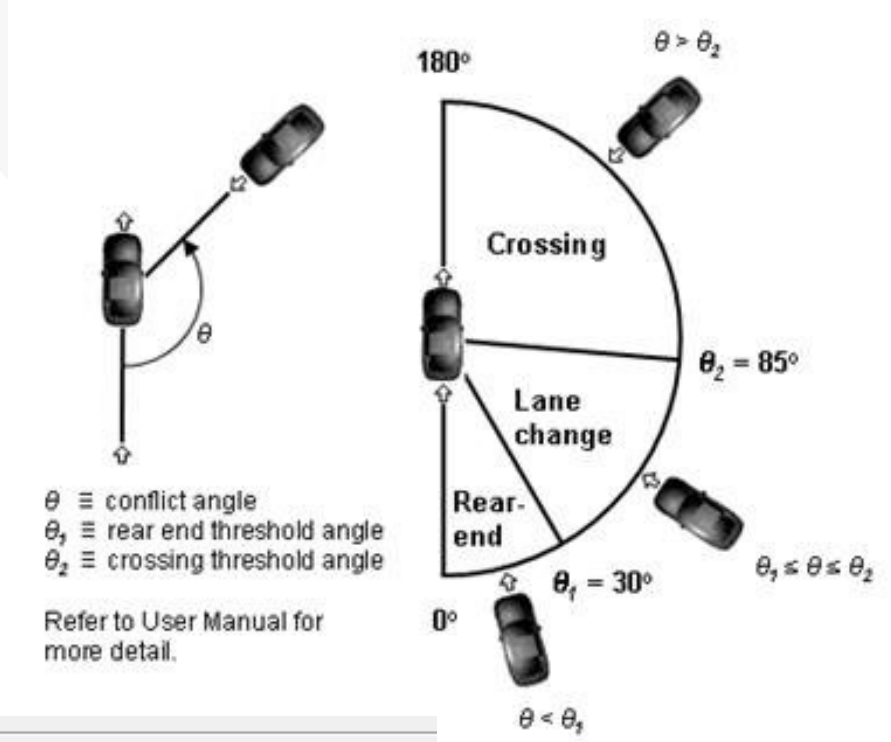
MicroTraffic Surrogate Safety

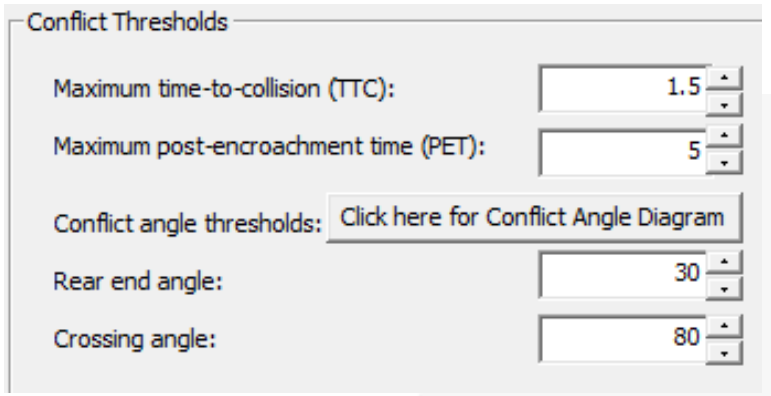
- Quantify Existing Near Miss Data
- Artificial Intelligence Identifies Vehicle Trajectories



SSAM Conflict Basics

- Conflict Type
  - Crossing
  - Lane Change
  - Rear End
- Severity
  - Time to Collision (TTC)
- Vehicle Type
  - Ped/Bike/Transit Analysis





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SSAM Basic Model Validation

- Study Compared SSAM to 11 Intersection and Interchange Designs
- Conflict to Crash Ratio of 20,000:1
- Similar Correlation with Existing Crash Data when PET is calibrated

$$\frac{Crashes}{Year} = 0.119 * \left(\frac{Conflicts}{Hour}\right)^{1.419}$$

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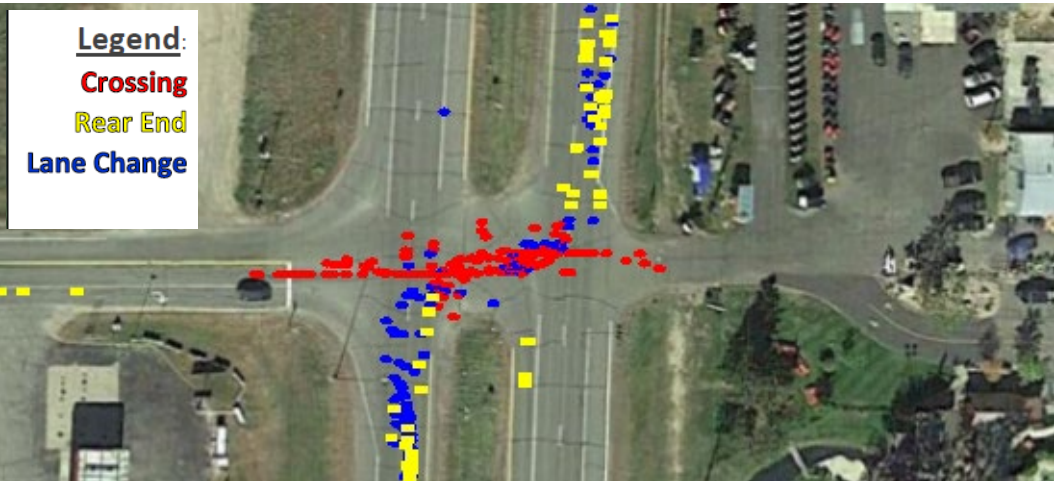
SSAM Model Existing CROSSING Validation

TH 371 - Brainerd



$$\frac{3.0\ Crashes}{Year} = 0.119 * (\frac{136\ Conflicts}{14\ Hour})^{1.419}$$

Actual 3.2 Crashes/Year!

Hwy 197 - Bemidji

$$\frac{20.4\ Crashes}{Year} = 0.119 * (\frac{900\ Conflicts}{24\ Hour})^{1.419}$$

Actual 19 Crashes/Year!

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SSAM PROJECT EXAMPLES

Bemidji, MN – MN 197

- 45 crashes costing the community $1.6M per year
- 40-70 seconds of peak hour delay at unsignalized locations (Projected 2040)
- Over 100 businesses are served by this corridor, generating 70,000 trips each day

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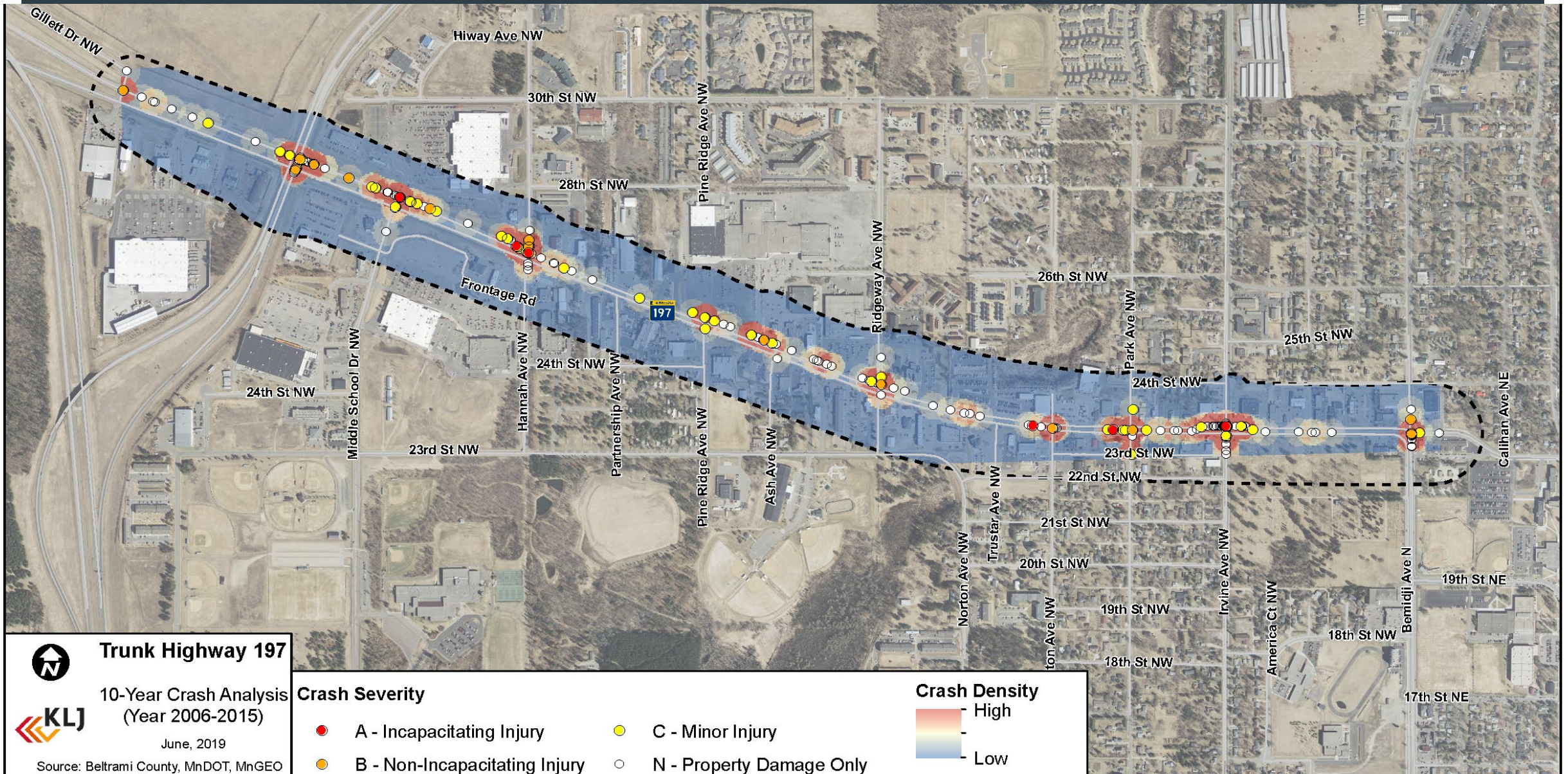
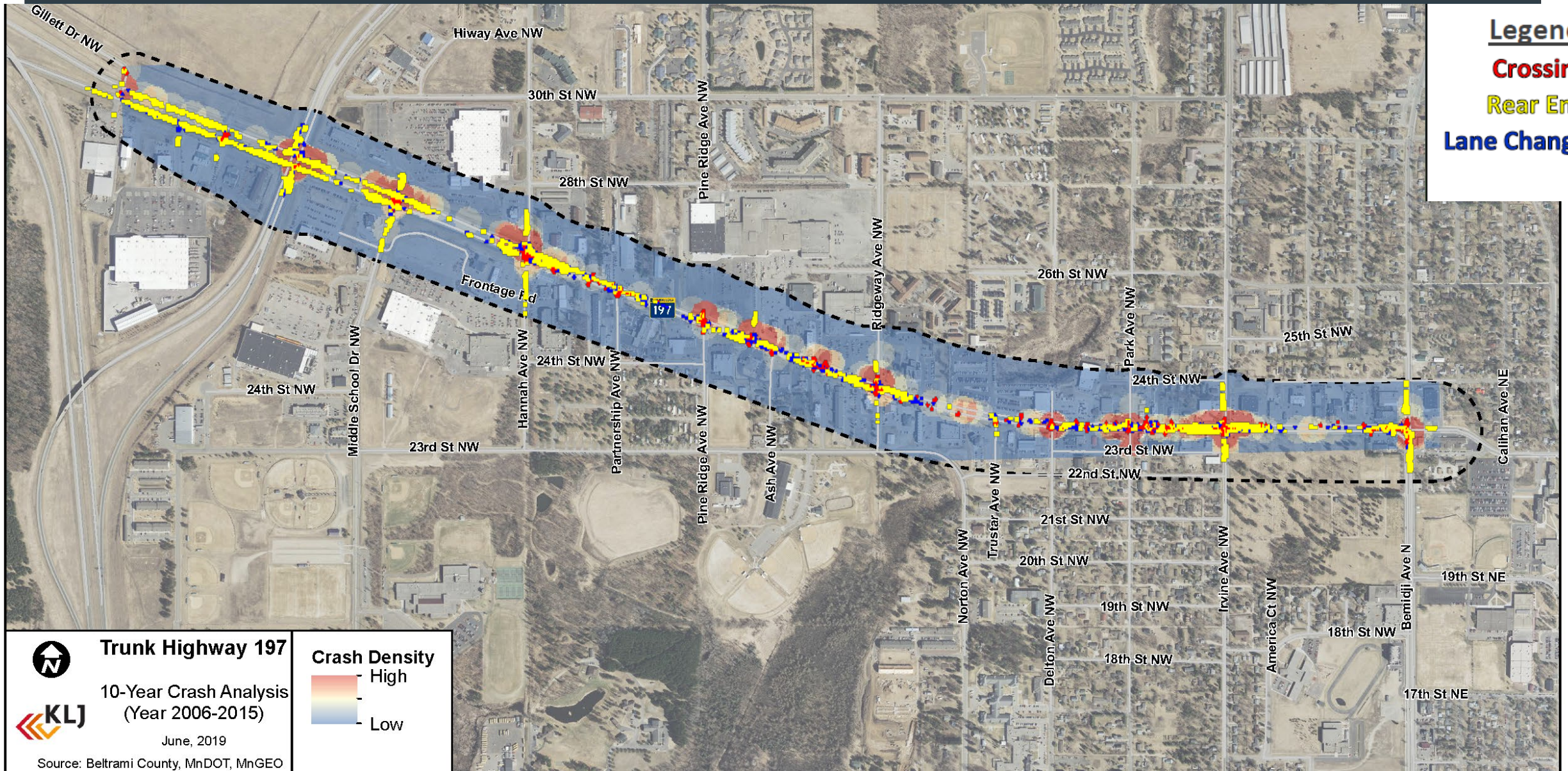
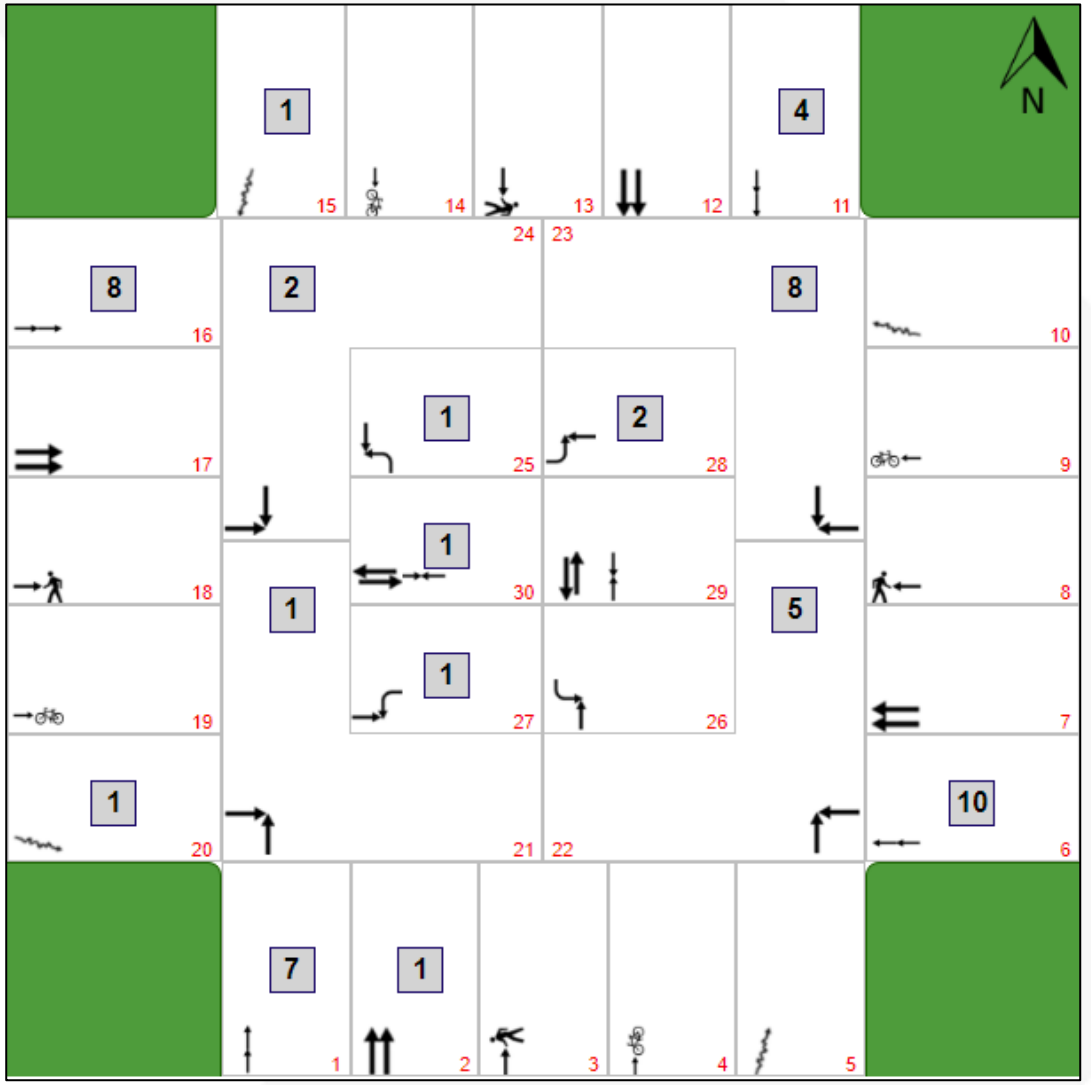
Existing Crash Heatmap



Existing SSAM Crash Data Heatmap



MN 197 and US 71 – Calibrating Data



MN 197 Existing Conflict Analysis

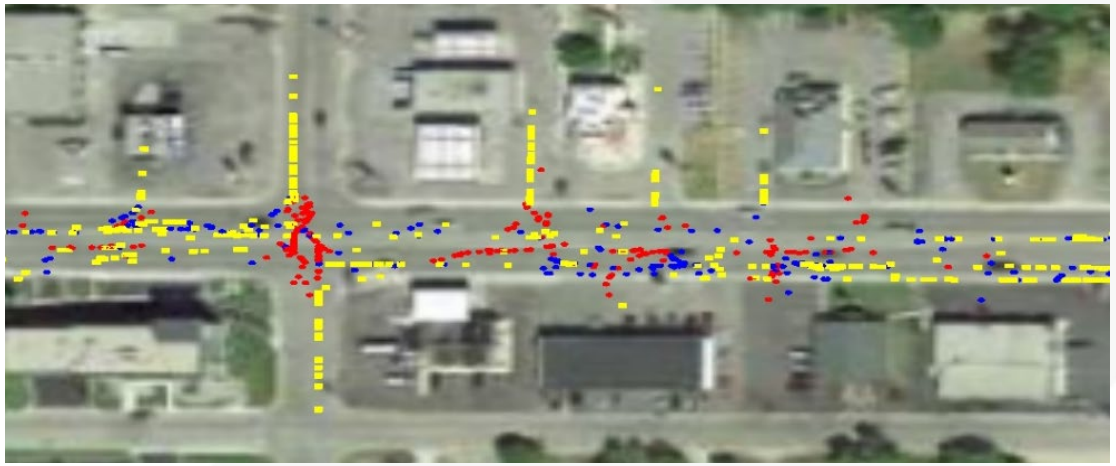
- Crossing Conflicts (26%)
  - Permissive Movements During Peaks
- Rear End Conflicts (46%)
  - Signalized Intersections
- Lane Change Conflicts (28%)
  - 5-Lane Sections
- Traffic Growth
  - 25% in 2040
  - 40% in 2040 Summer Rec

Scenario	Conflict Type			
	Crossing	Rear End	Lane Change	Total
Existing Conditions	-	-	-	-
2040 No Build	+56%	+79%	+50%	+65%
2040 Summer Rec	+120%	+144%	+97%	+125%

Hwy 197 and US 71

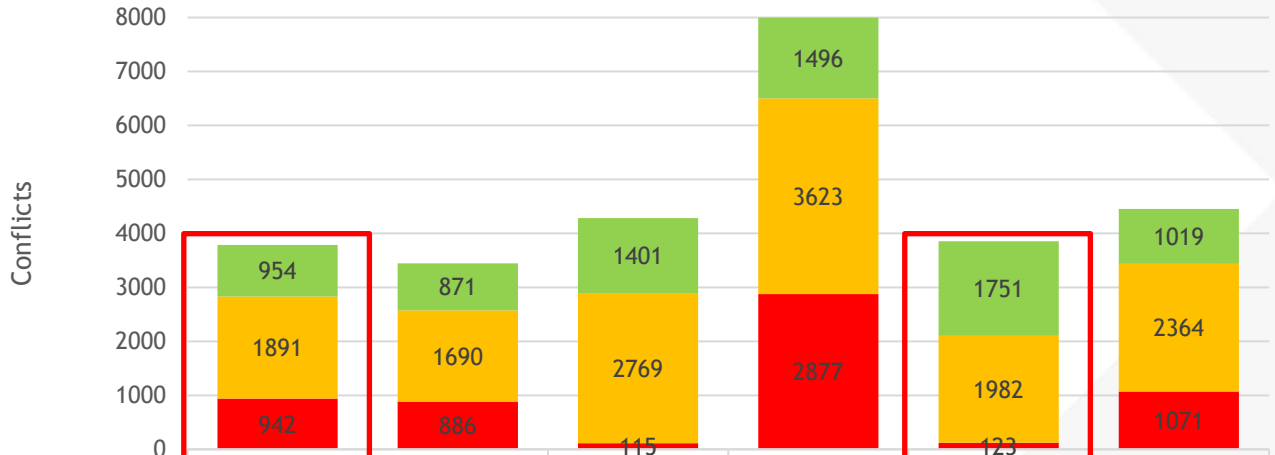
Hwy 197 and Irvine Avenue

Hwy 197 and Park Avenue and 5-Lane Section



MN 197 Alternatives Conflict Analysis

- SSAM Results
  - Total Crashes: +2%
  - Severe Crashes: -87%
- MnDOT RAB Results
  - Total Crashes: +43%
  - Severe Crashes: -78%



	No Build	Alt 1 Signals	Alt 2 RABs	Alt 3 Hybrid / 3-Lane	Alt 4 Updated RABs	Access Consolidation
Lane Change	954	871	1401	1496	1751	1019
Rear End	1891	1690	2769	3623	1982	2364
Crossing	942	886	115	2877	123	1071

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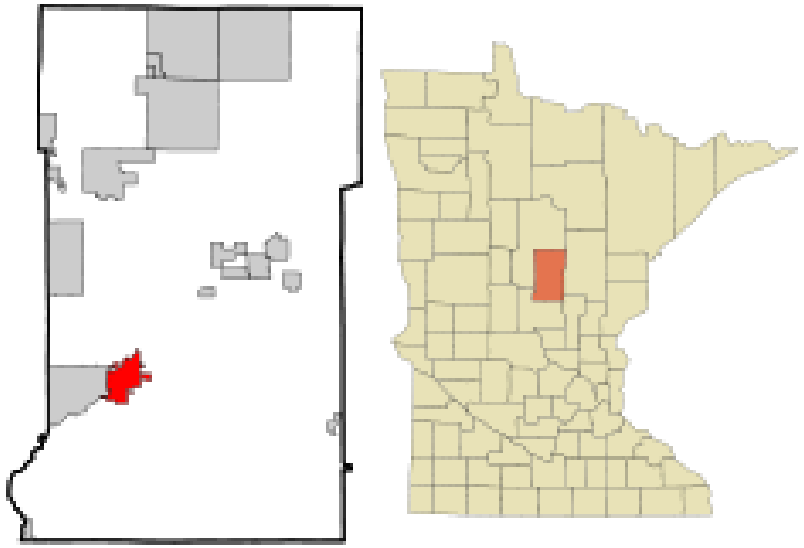
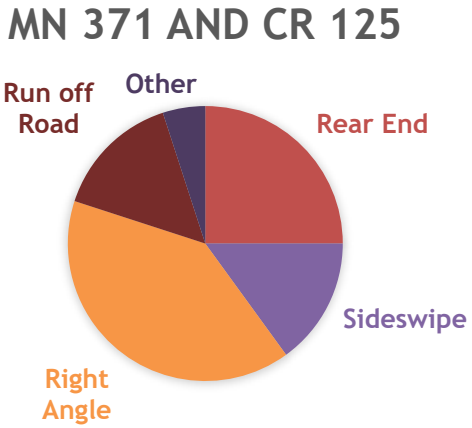
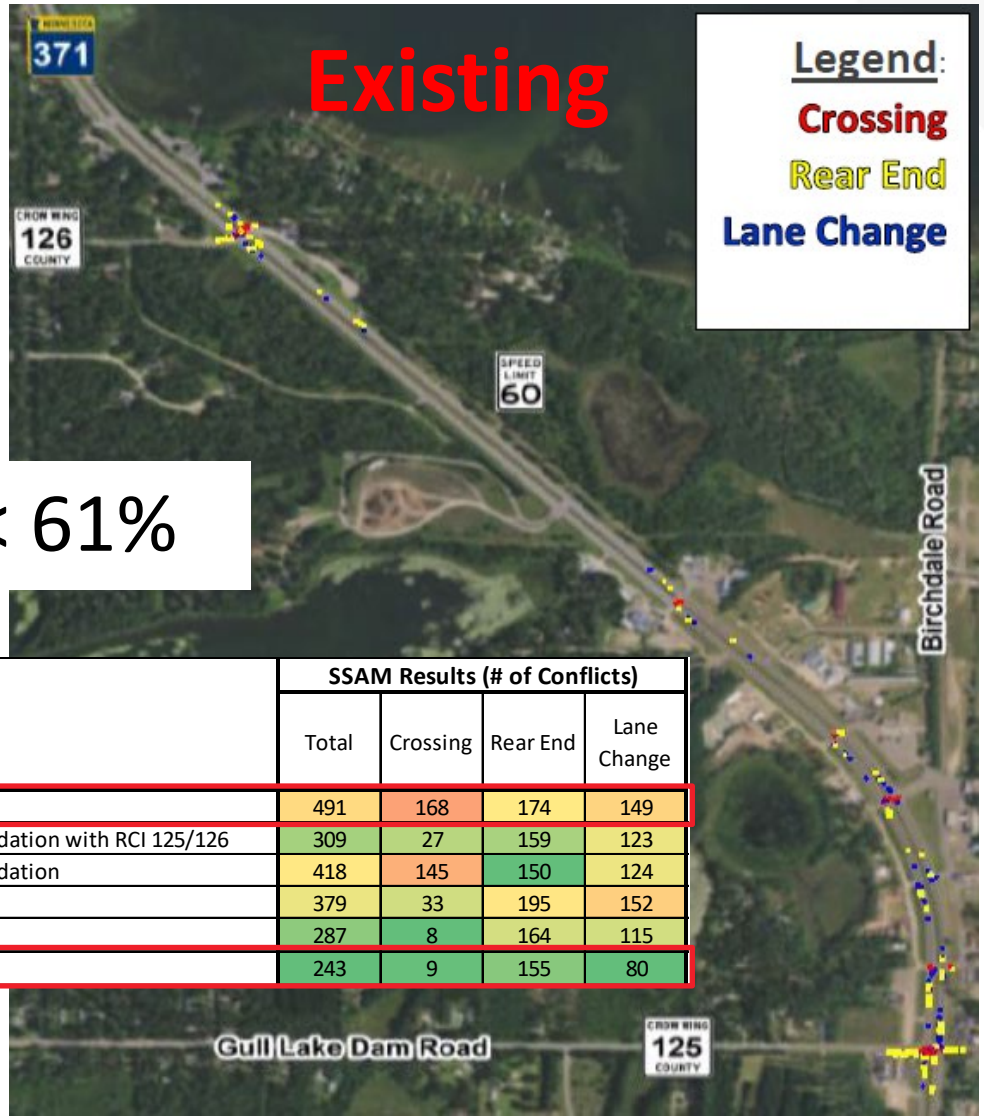
Brainerd, MN - MN 371

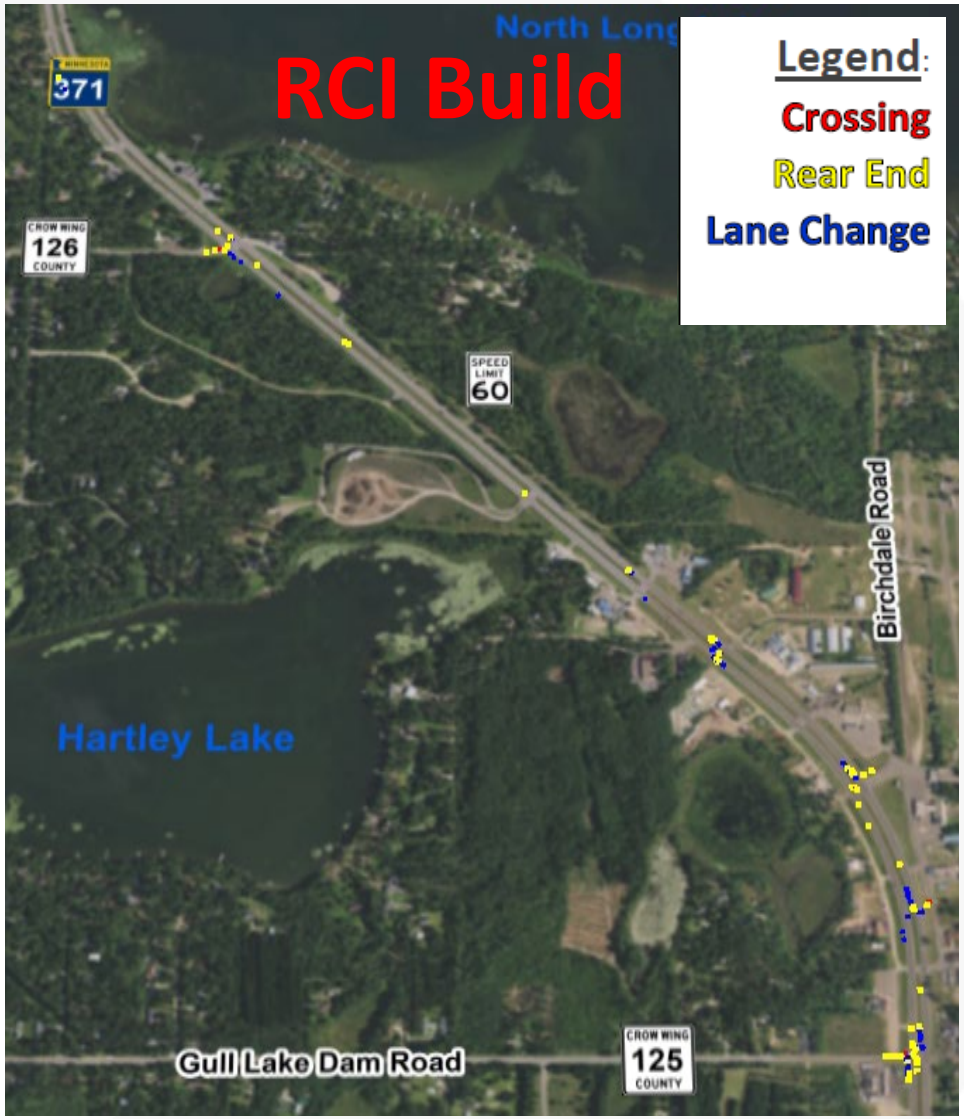
- Access Management Study
- Event/Recreation Traffic
- Critical Crashes at 125/126
- Traffic Signals Unwarranted





MN 371 - Existing vs RCI Build Conflicts



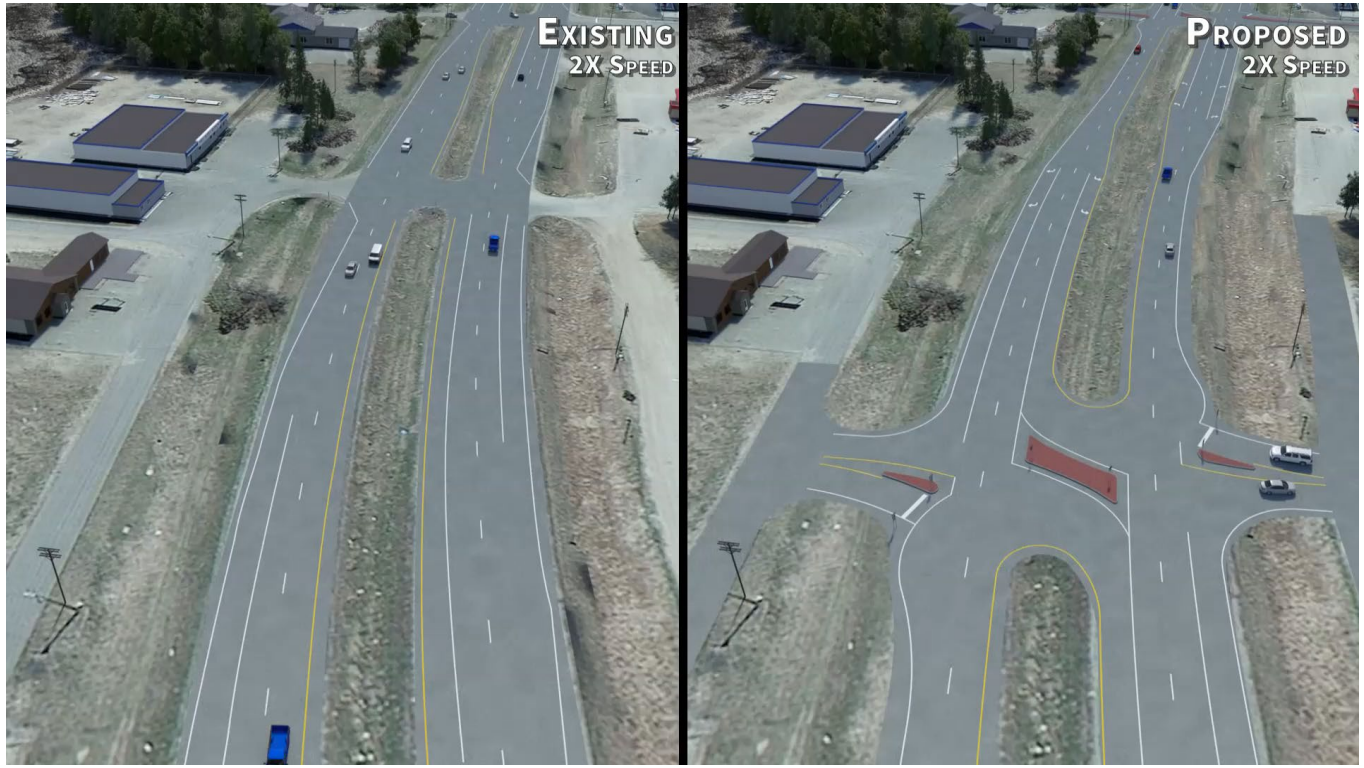


13% < **49%** < 61%

Alternative	SSAM Results (# of Conflicts)			
	Total	Crossing	Rear End	Lane Change
2037 NoBuild Weekday 14 Hour	491	168	174	149
2037 Weekday 14 hour - Build Access Consolidation with RCI 125/126	309	27	159	123
2037 Weekday 14 hour - Build Access Consolidation	418	145	150	124
2037 Weekday 14 hour - Build RCUT Max	379	33	195	152
2037 Weekday 14 hour - Build RCUT Min	287	8	164	115
2037 Weekday 14 hour - Build RCUT MnDOT	243	9	155	80

MN 371 Corridor in Brainerd, MN

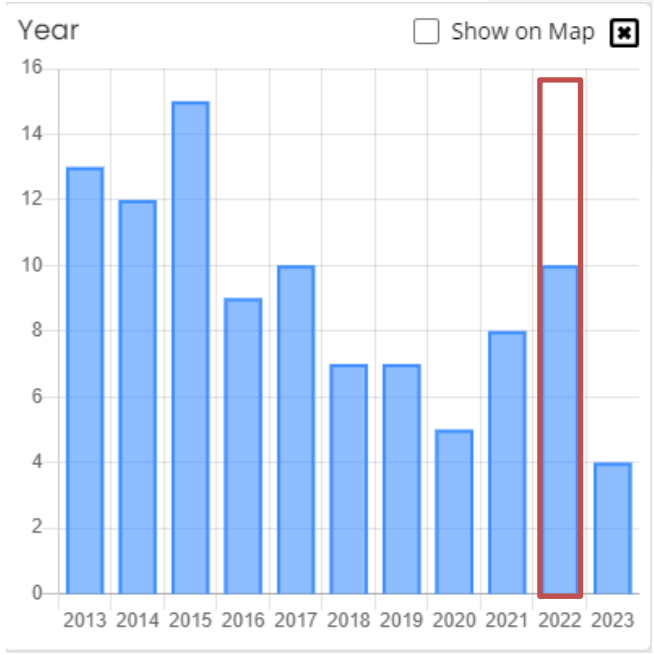
- Constructed three new J-turns
- -95% in Crossing Conflicts
- -90% in Rear-Ends vs. Signal Traffic Control



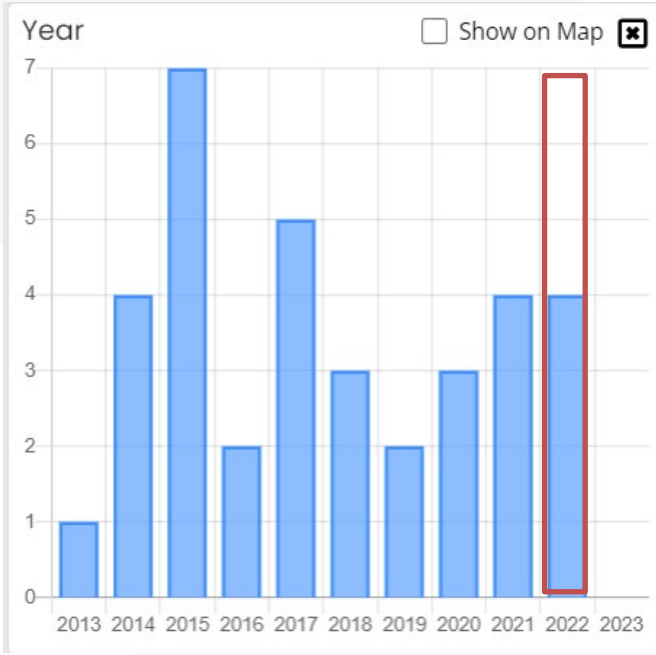
MN 371 Before and After

- 12 Months of After Data
  - No Right-Angle or Rear-End Crashes
    - 1 Multi-Vehicle Sideswipe
    - 1 Driver using SBU Turn
  - 2 Single Vehicle crashes
    - 1 Alcohol Related Fatal

Total Crashes



Angle Crashes



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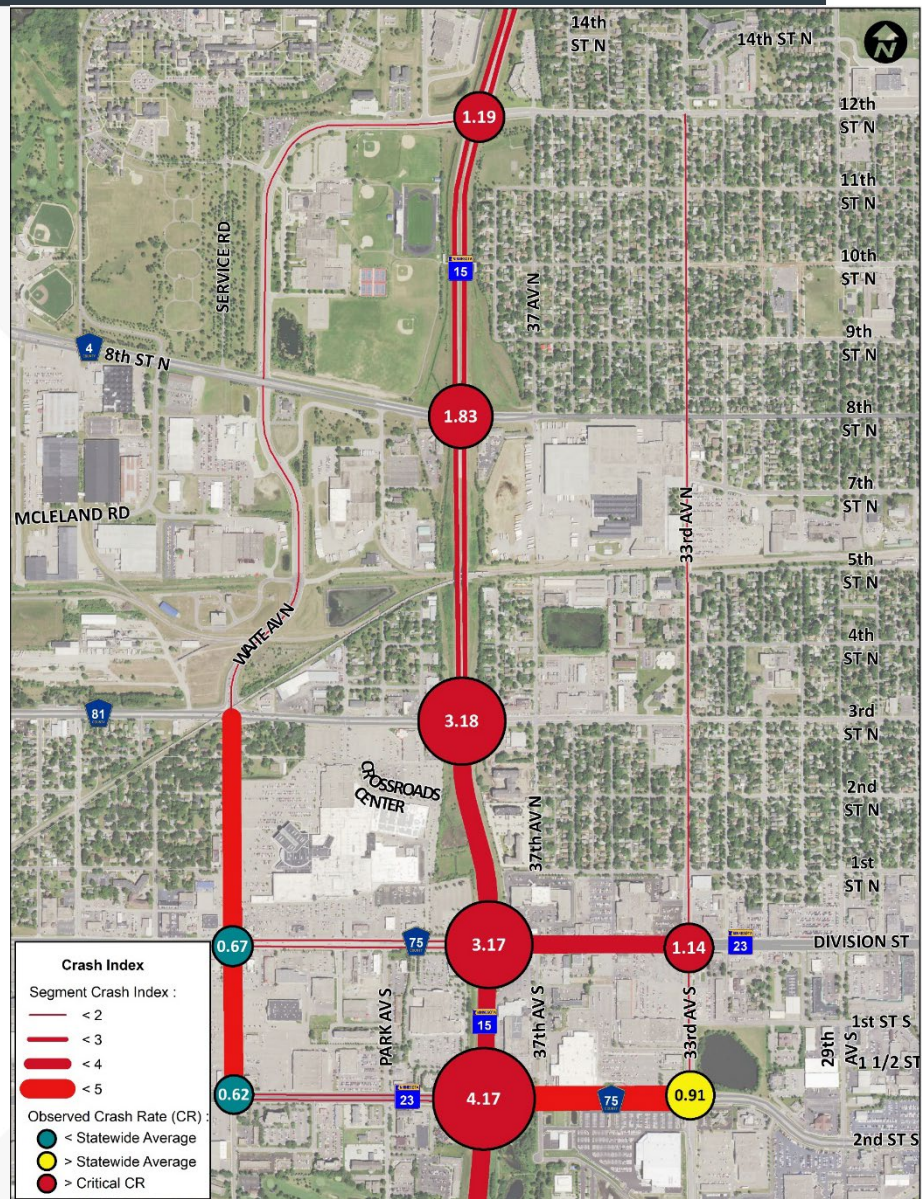
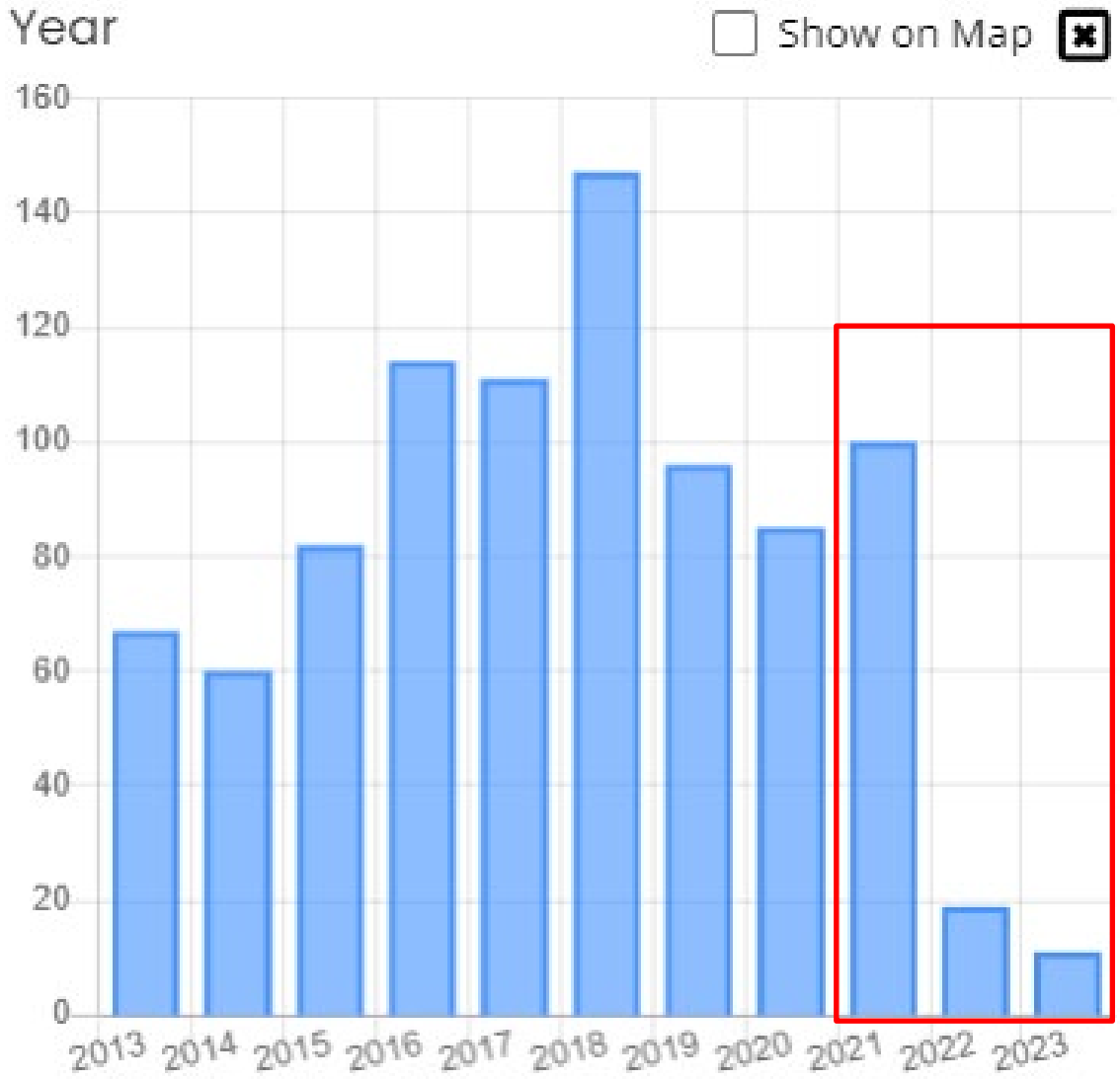
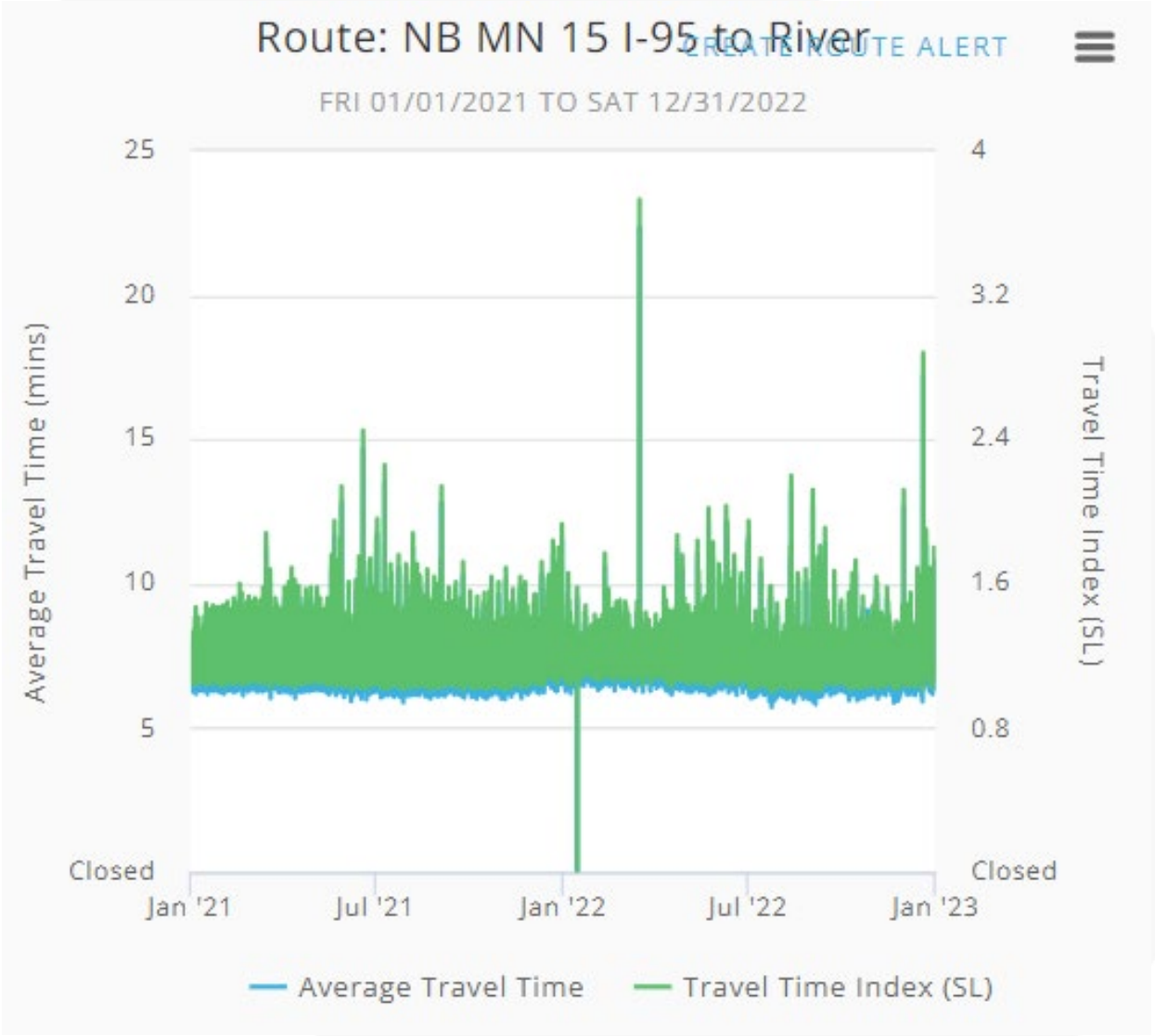
Case Study #3: MN 15 – St Cloud, MN

- State Highway 15 At-Grade vs Interchange Study
- Urban 4-lane (5 Signals), High Speed, 75% Rear End Crashes
- 3 of Top 5 (#5,#6,#10) highest crash intersections in Minnesota
- Evaluation included Node, Network, Travel Times, and SSAM
- Needed short-, mid-, and long-term implementation plan

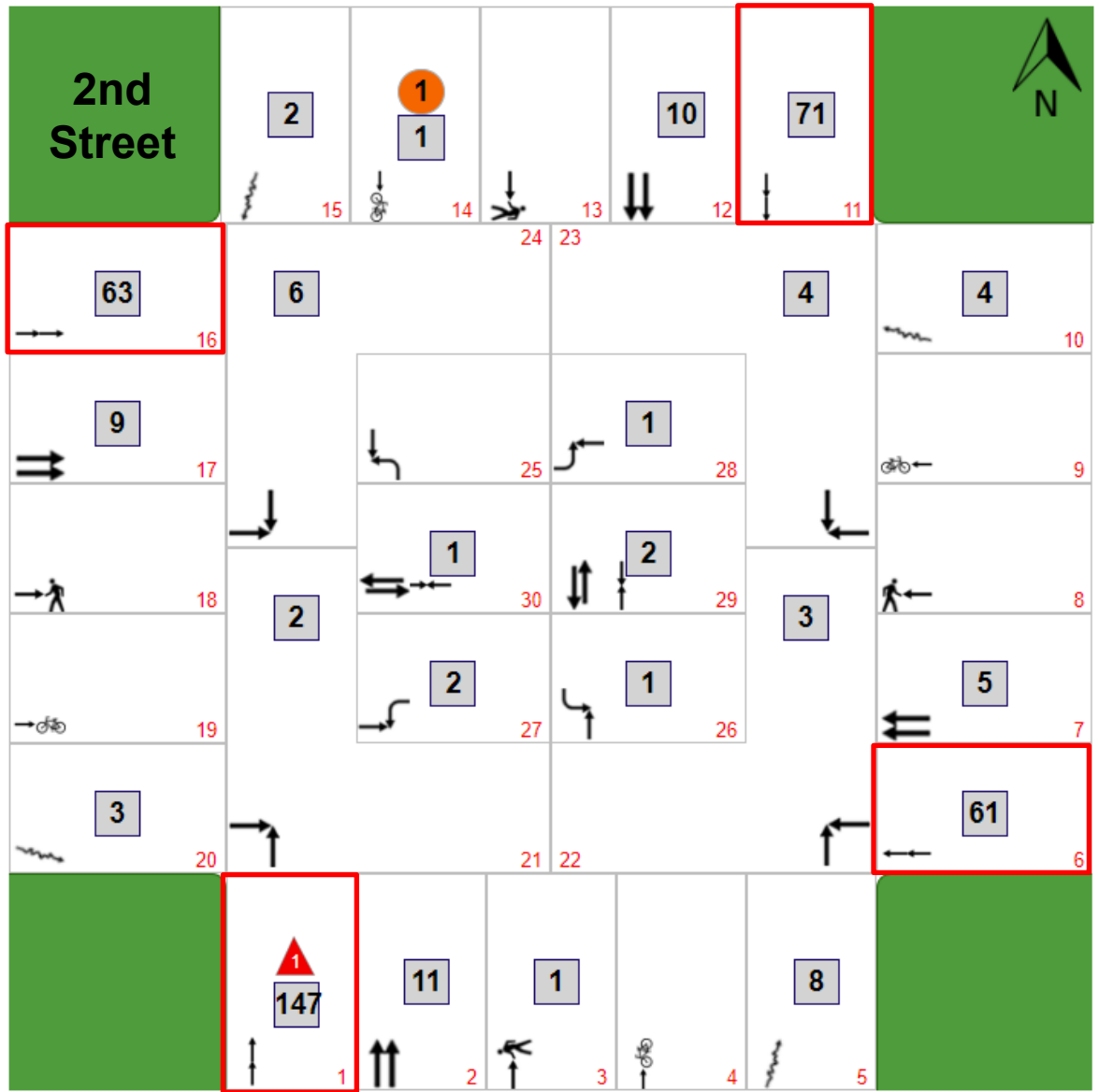


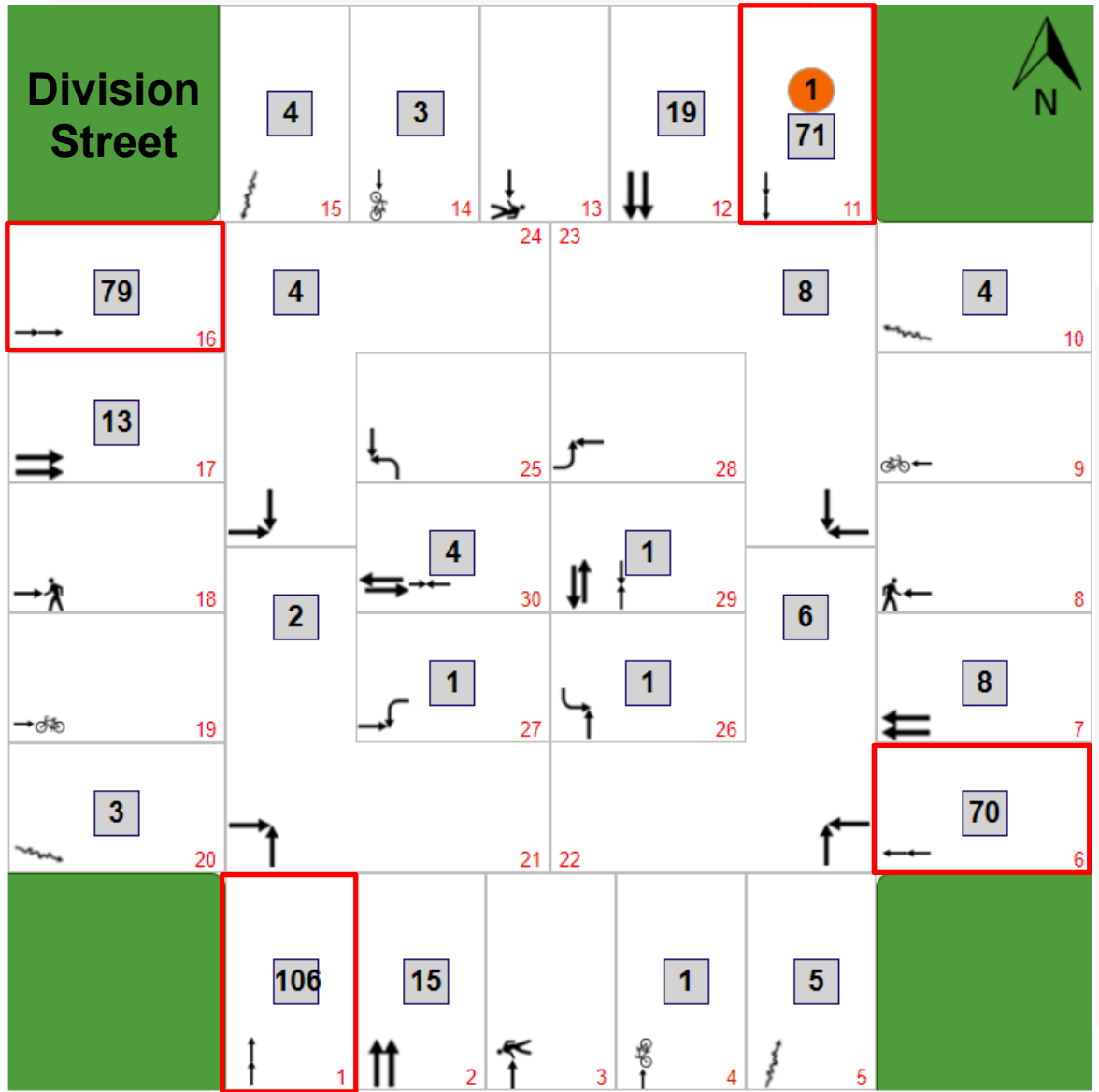
MN 15 Crashes and Congestion



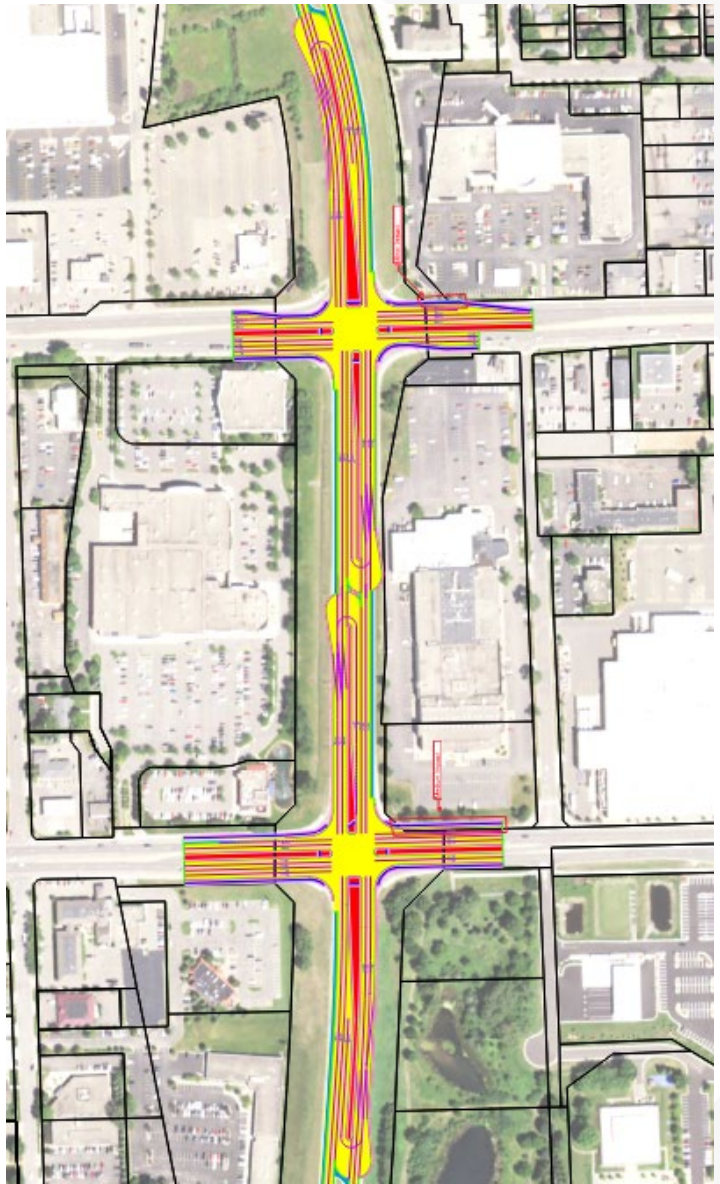


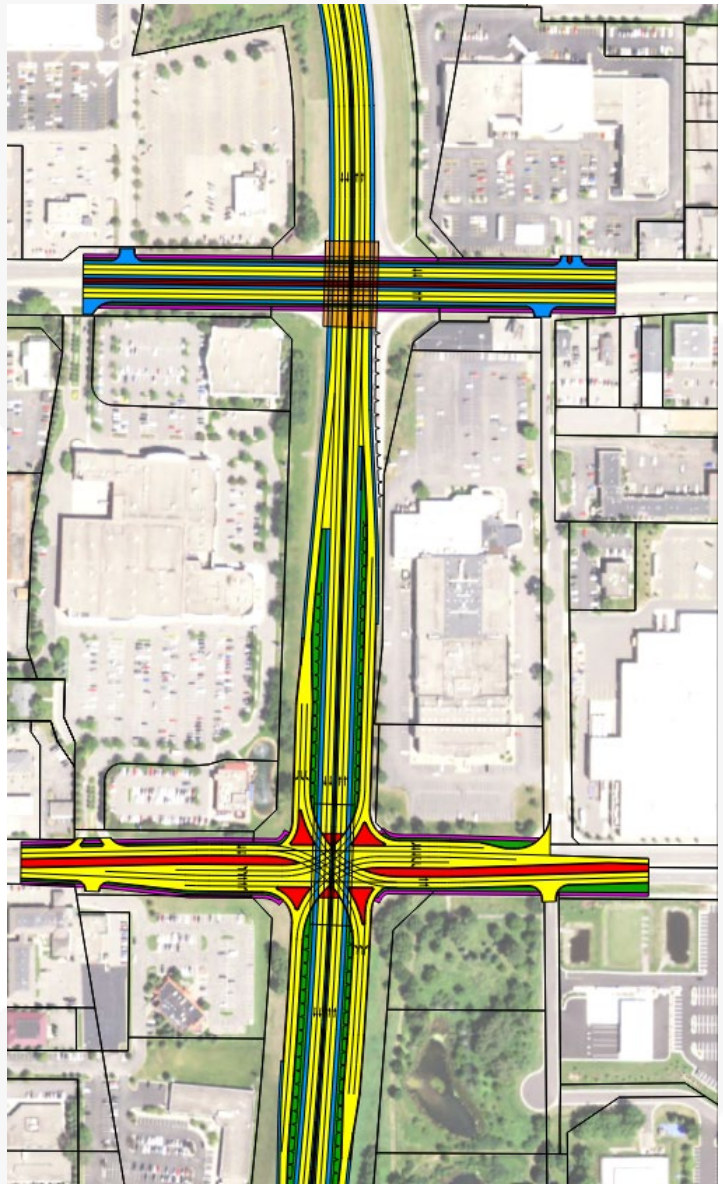
MN 15 at MN 23 Intersections





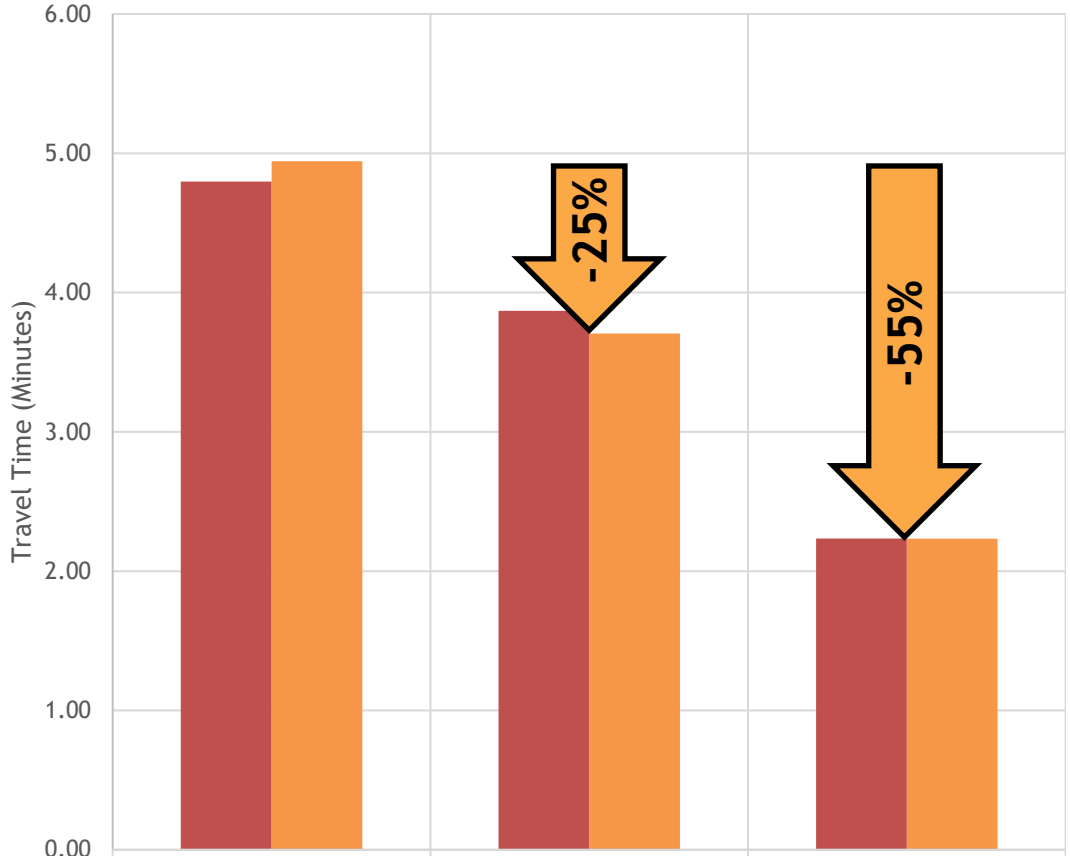
MN 15 SSAM Existing Vs Interchange





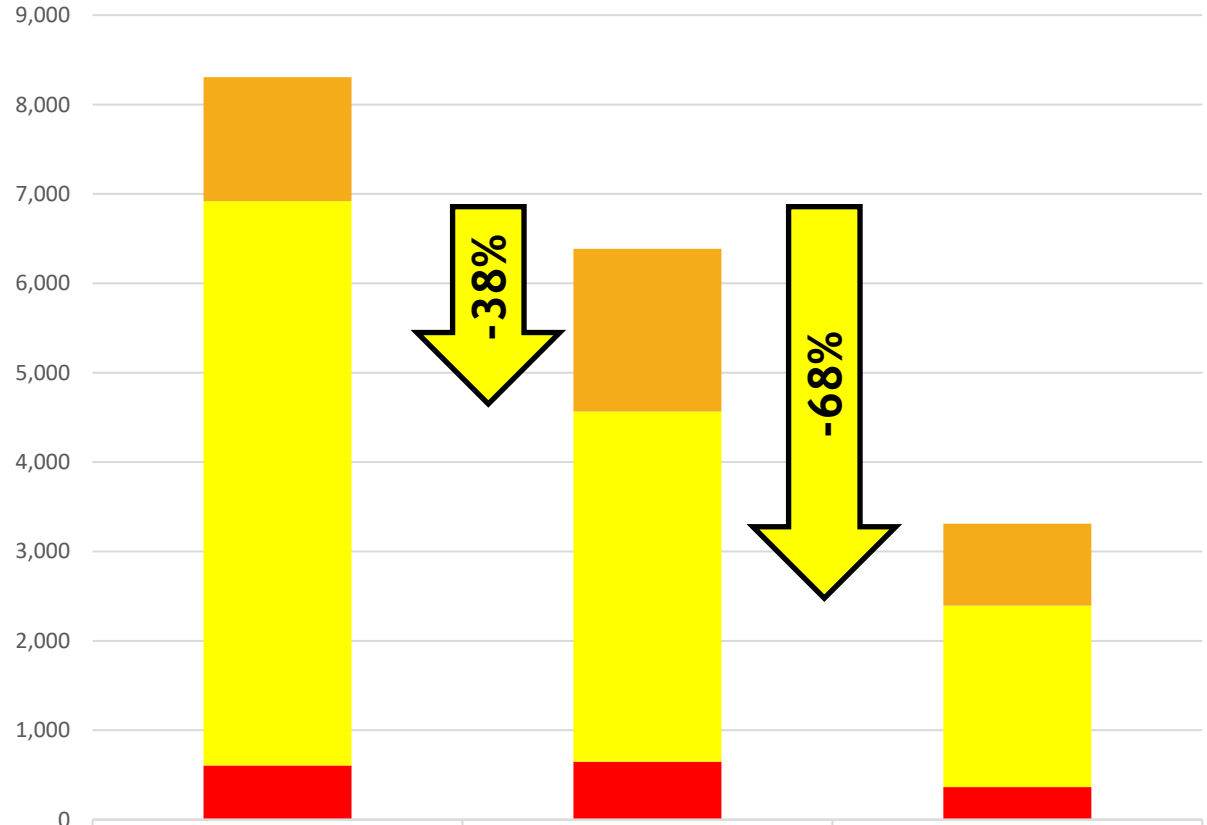
MN 15 Alternative Comparison

MN 15 85th Percentile Travel Times



	2045 Balanced No Build	2045 Balanced Alt E MUT	2045 Balanced Alt I2 Spaced SPUI
NB 85th Percentile	4.80	3.87	2.23
SB 85th Percentile	4.94	3.71	2.23

MN 15 Daily Conflicts



	2045 No Build	(E1) MUT	(H2) Spacing Focused Freeway - SPUI
Merging	1,388	1,820	917
Rear End	6,312	3,917	2,030
Crossing	607	649	365

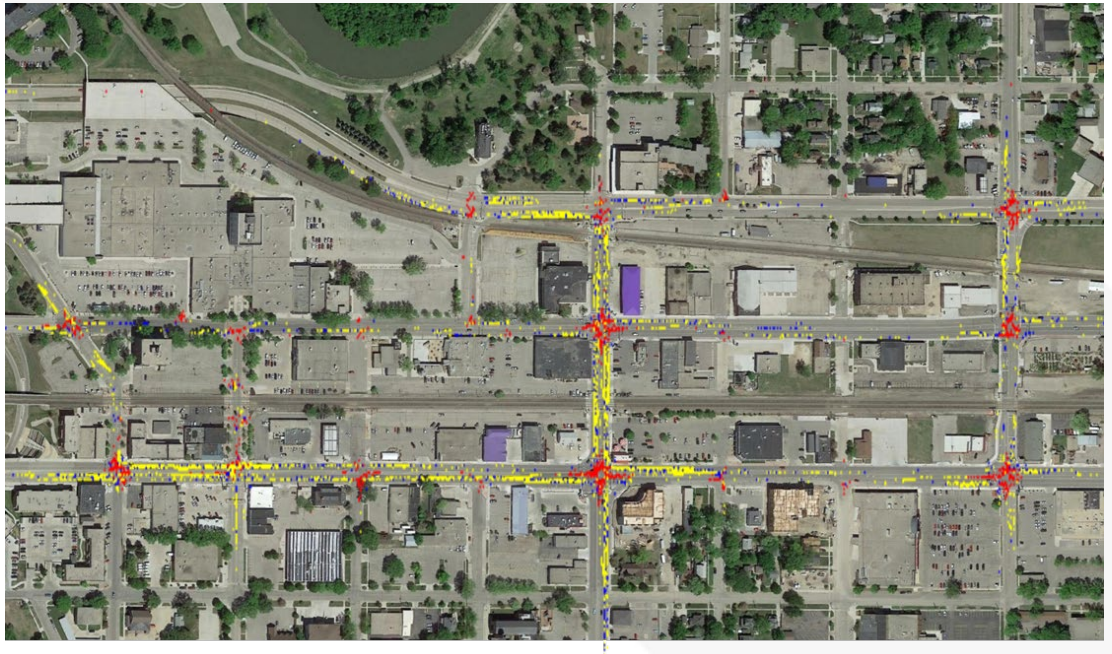
SSAM Uses Summary

Where to Use SSAM?

- Corridor Studies/Access Management
- Reduced Conflict Alternatives

How to Use SSAM?

- Specifically Address Intersection Crash Patterns
- 24-hour Modeling Further Calibrates Results
- Integrate Volume Scenarios To Further Assess Safety



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