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Performance Based Practical Design/Data Driven Safety Analysis

Module 1 – What is DDSA

Session Starts at 10 am

Welcome

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Instructors

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Agenda

- Welcome
- Intro from MDOT to set the stage
- Intro to DDSA - What is DDSA; HSM vs traditional safety analysis vs systemic
- Intro to DDSA – examples
- Break
- The HSM - What is the HSM and how it works, HSM performance measures, and examples
- HSM examples
- Wrap-up

Intro from MDOT

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Introduction to DDSA

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What is DDSA?

Data **D**riven

Safety **A**nalysis

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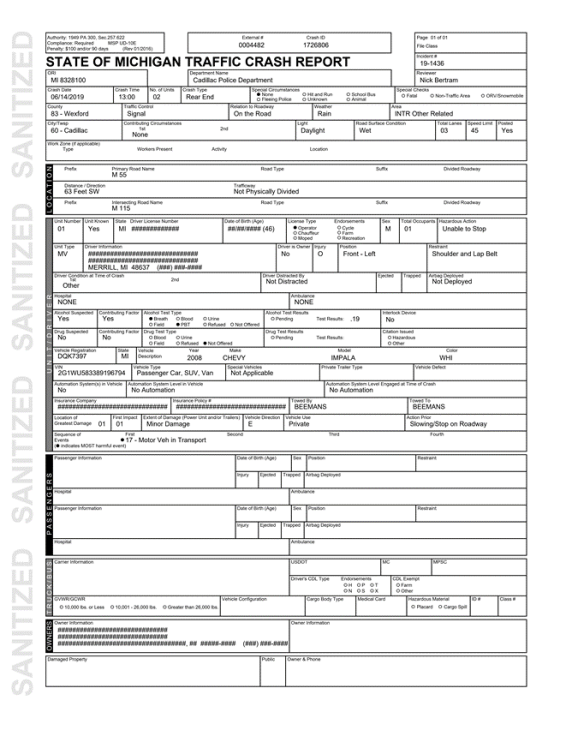
What is DDSA?

Using tools to analyze crash and roadway data to predict the safety impacts of highway projects allows agencies to target investments with more confidence and reduce severe crashes on the roadways.

Source: FHWA

Safety Data Analysis


STATE OF MICHIGAN TRAFFIC CRASH REPORT

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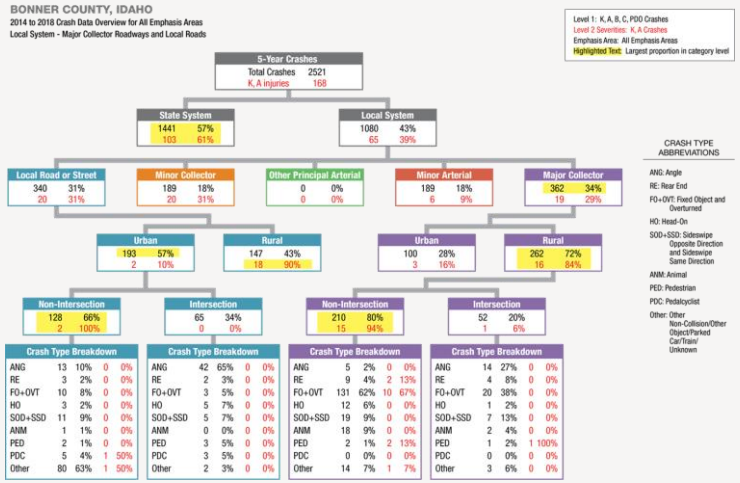
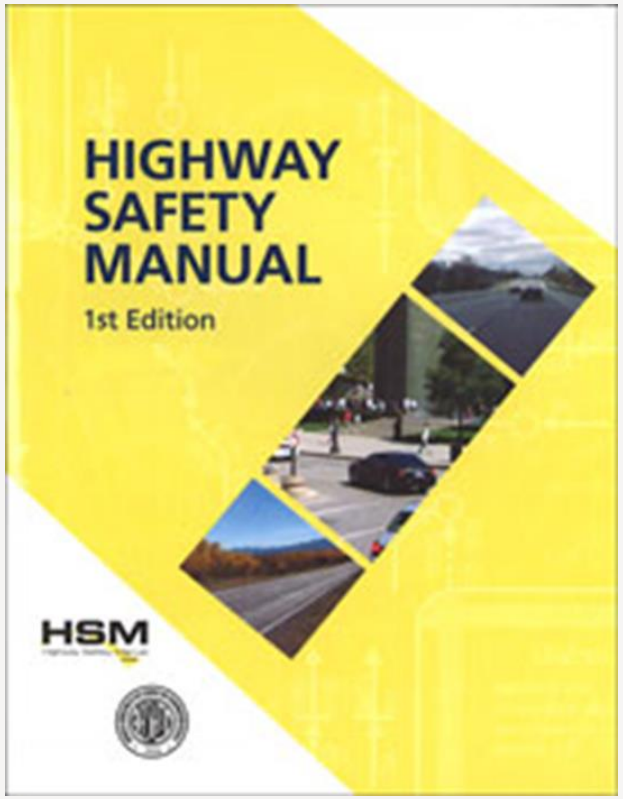
Crash Data Collection



Spot vs. Systemic



Predictive/HSM

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Crash Data Collection

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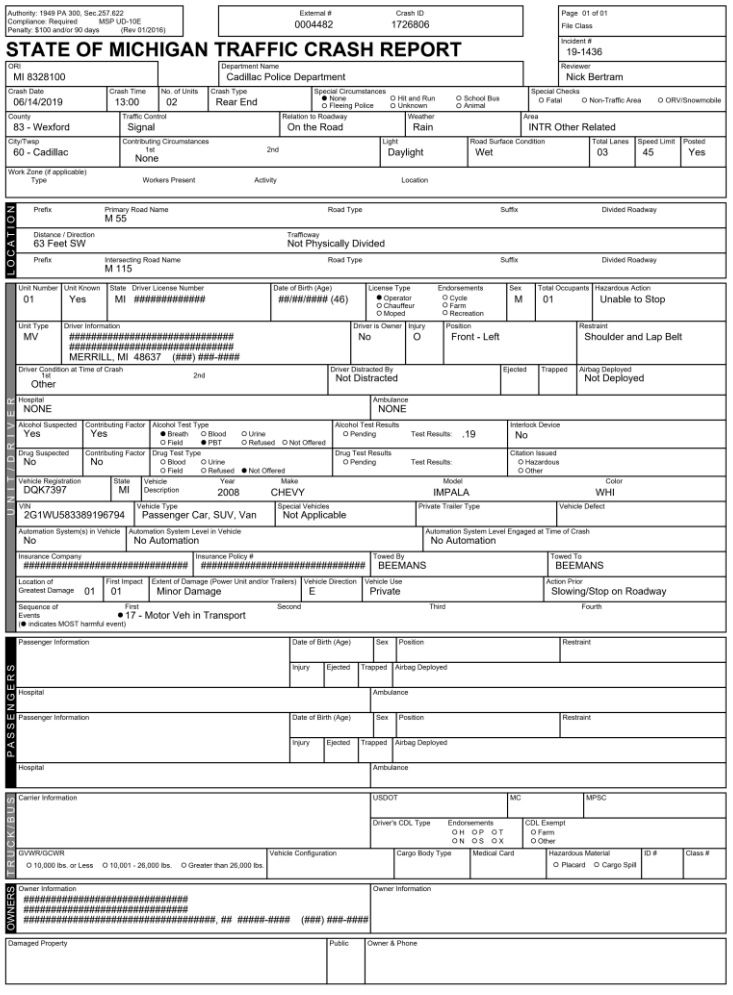
Crash Data Collection



Authority: 1949 PA 300, Sec.257.622 Compliance: Required MSP UD-10E Penalty: $100 and/or 90 days (Rev 01/2016)

External # 0004482 Crash ID 1726806

Page 01 of 01 File Class

Incident # 19-1436

STATE OF MICHIGAN TRAFFIC CRASH REPORT

ORI: MI 8328100 | Department Name: Cadillac Police Department | Reviewer: Nick Bertram

Crash Date	Crash Time	No. of Units	Crash Type	Special Circumstances	Special Checks
06/14/2019	13:00	02	Rear End	● None O Fleeing Police O Hit and Run O Unknown O School Bus O Animal	O Fatal O Non-Traffic Area O ORV/Snowmobile

County	Traffic Control	Relation to Roadway	Weather	Area
83 - Wexford	Signal	On the Road	Rain	INTR Other Related

City/Twsp	Contributing Circumstances 1st / 2nd	Light	Road Surface Condition	Total Lanes	Speed Limit	Posted
60 - Cadillac	None	Daylight	Wet	03	45	Yes

Work Zone (if applicable) Type / Workers Present / Activity / Location

LOCATION

Prefix	Primary Road Name	Road Type	Suffix	Divided Roadway
	M 55			

Distance / Direction: 63 Feet SW | Trafficway: Not Physically Divided

Prefix	Intersecting Road Name	Road Type	Suffix	Divided Roadway
	M 115			

UNIT # 1 (DRIVER)

Unit Number	Unit Known	State	Driver License Number	Date of Birth (Age)	License Type	Endorsements	Sex	Total Occupants	Hazardous Action
01	Yes	MI	############	##/##/#### (46)	● Operator O Chauffeur O Moped	O Cycle O Farm O Recreation	M	01	Unable to Stop

Unit Type	Driver Information	Driver is Owner	Injury	Position	Restraint
MV	############################ ############################ MERRILL, MI 48637 (###) ###-####	No	O	Front - Left	Shoulder and Lap Belt

Driver Condition at Time of Crash 1st / 2nd	Driver Distracted By	Ejected	Trapped	Airbag Deployed
Other	Not Distracted			Not Deployed

Hospital	Ambulance
NONE	NONE

Alcohol Suspected	Contributing Factor	Alcohol Test Type	Alcohol Test Results	Interlock Device
Yes	Yes	● Breath O Blood O Urine O Field ● PBT O Refused O Not Offered	O Pending Test Results: .19	No

Drug Suspected	Contributing Factor	Drug Test Type	Drug Test Results	Citation Issued
No	No	O Blood O Urine O Field O Refused ● Not Offered	O Pending Test Results:	O Hazardous O Other

Vehicle Registration	State	Vehicle Description	Year	Make	Model	Color
DQK7397	MI		2008	CHEVY	IMPALA	WHI

VIN	Vehicle Type	Special Vehicles	Private Trailer Type	Vehicle Defect
2G1WU583389196794	Passenger Car, SUV, Van	Not Applicable		

Automation System(s) in Vehicle	Automation System Level in Vehicle	Automation System Level Engaged at Time of Crash
No	No Automation	No Automation

Insurance Company	Insurance Policy #	Towed By	Towed To
############################	############################	BEEMANS	BEEMANS

Location of Greatest Damage	First Impact	Extent of Damage (Power Unit and/or Trailers)	Vehicle Direction	Vehicle Use	Action Prior
01	01	Minor Damage	E	Private	Slowing/Stop on Roadway

Sequence of Events (● indicates MOST harmful event): First: ● 17 - Motor Veh in Transport / Second / Third / Fourth

PASSENGERS

Passenger Information	Date of Birth (Age)	Sex	Position	Restraint	Injury	Ejected	Trapped	Airbag Deployed	Hospital	Ambulance

FREIGHT BUS

Carrier Information	USDOT	MC	MPSC

Driver's CDL Type / Endorsements: O H O P O T O N O S O X | CDL Exempt: O Farm O Other

GVWR/GCWR	Vehicle Configuration	Cargo Body Type	Medical Card	Hazardous Material	ID #	Class #
O 10,000 lbs. or Less O 10,001 - 26,000 lbs. O Greater than 26,000 lbs.				O Placard O Cargo Spill		

OWNERS

Owner Information	Owner Information
############################ ############################ ############################, ## #####-#### (###) ###-####	

Damaged Property	Public	Owner & Phone

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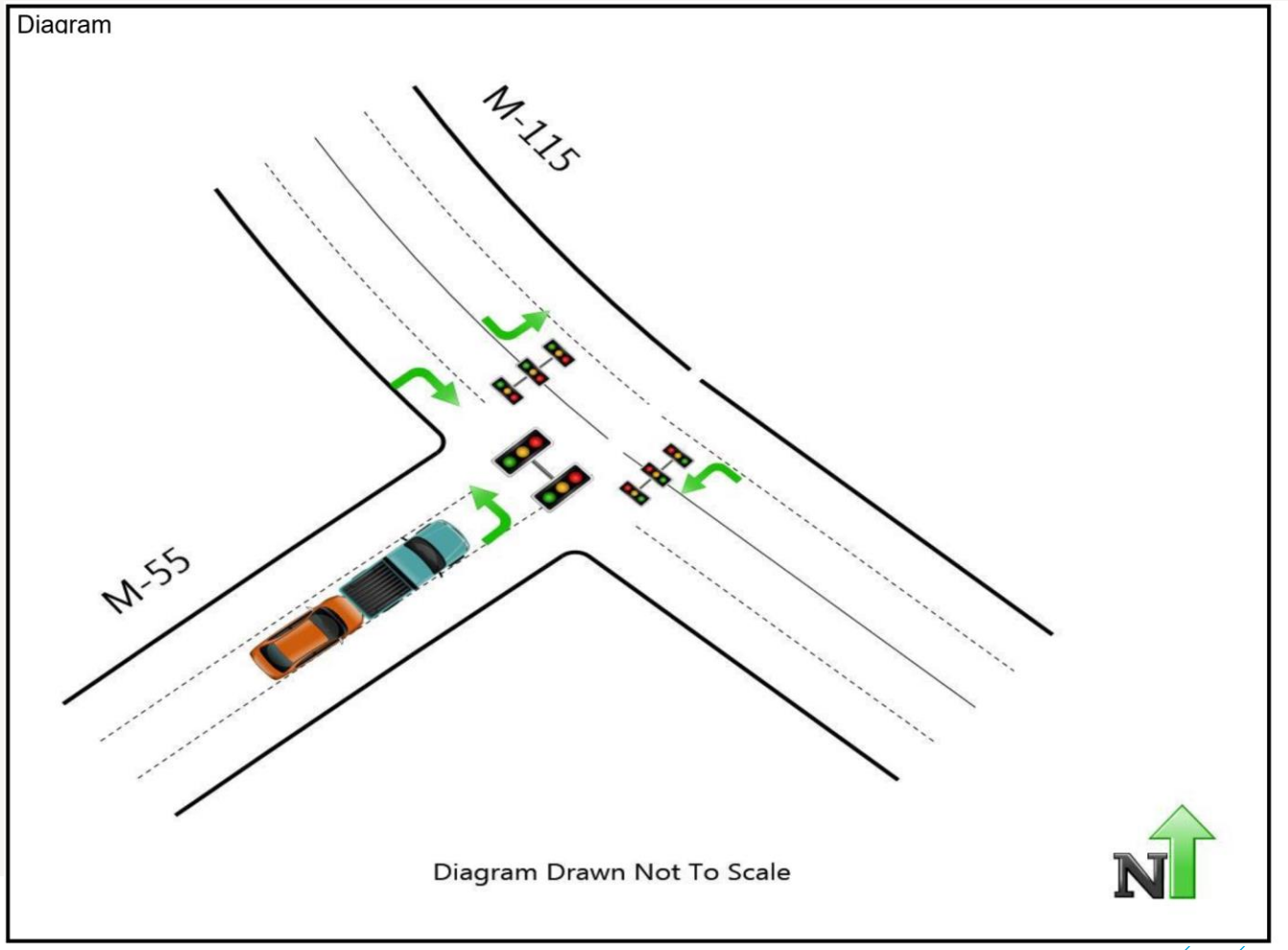
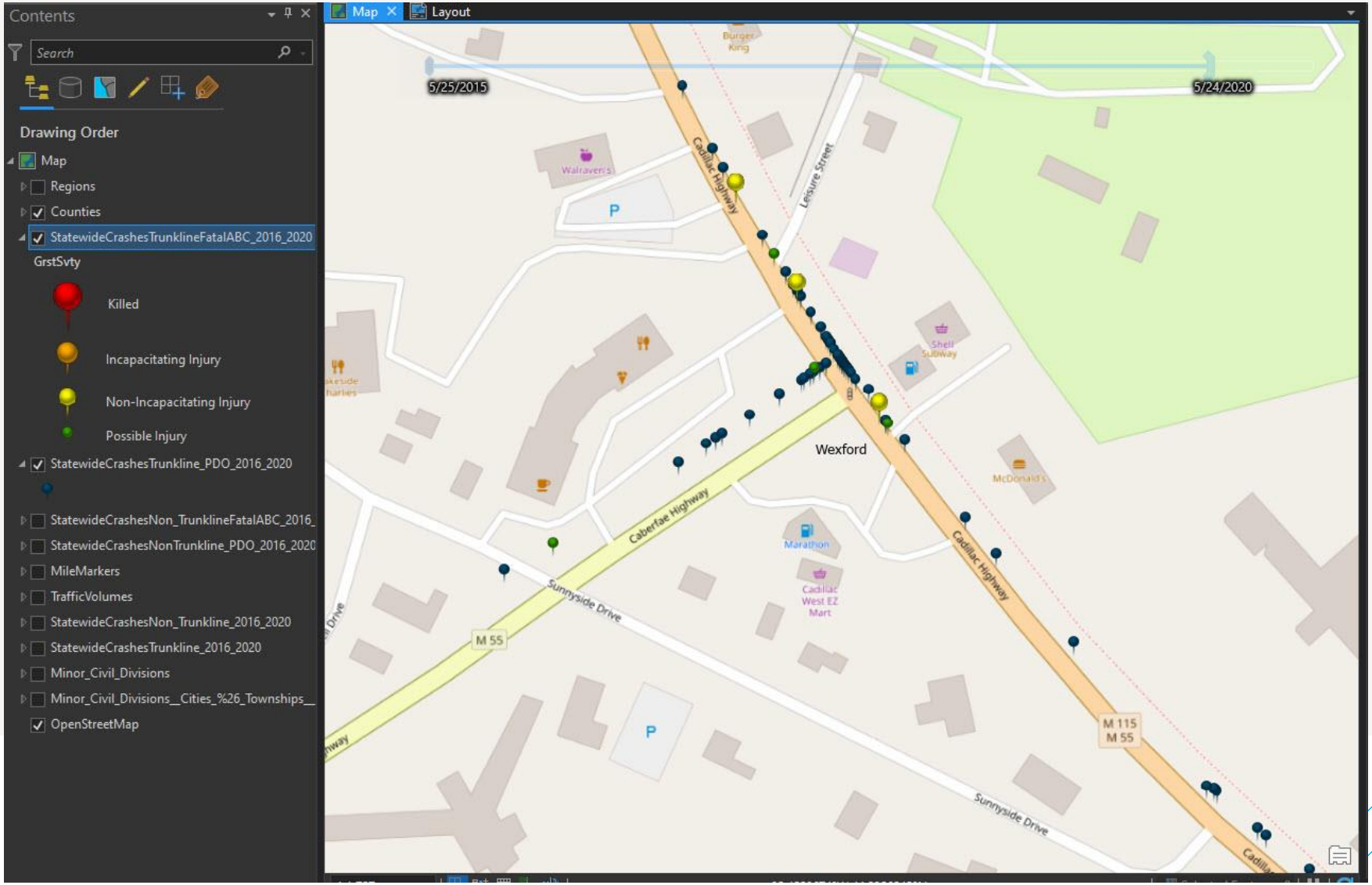


Source: MichiganCrashFacts.org

Crash Data Collection



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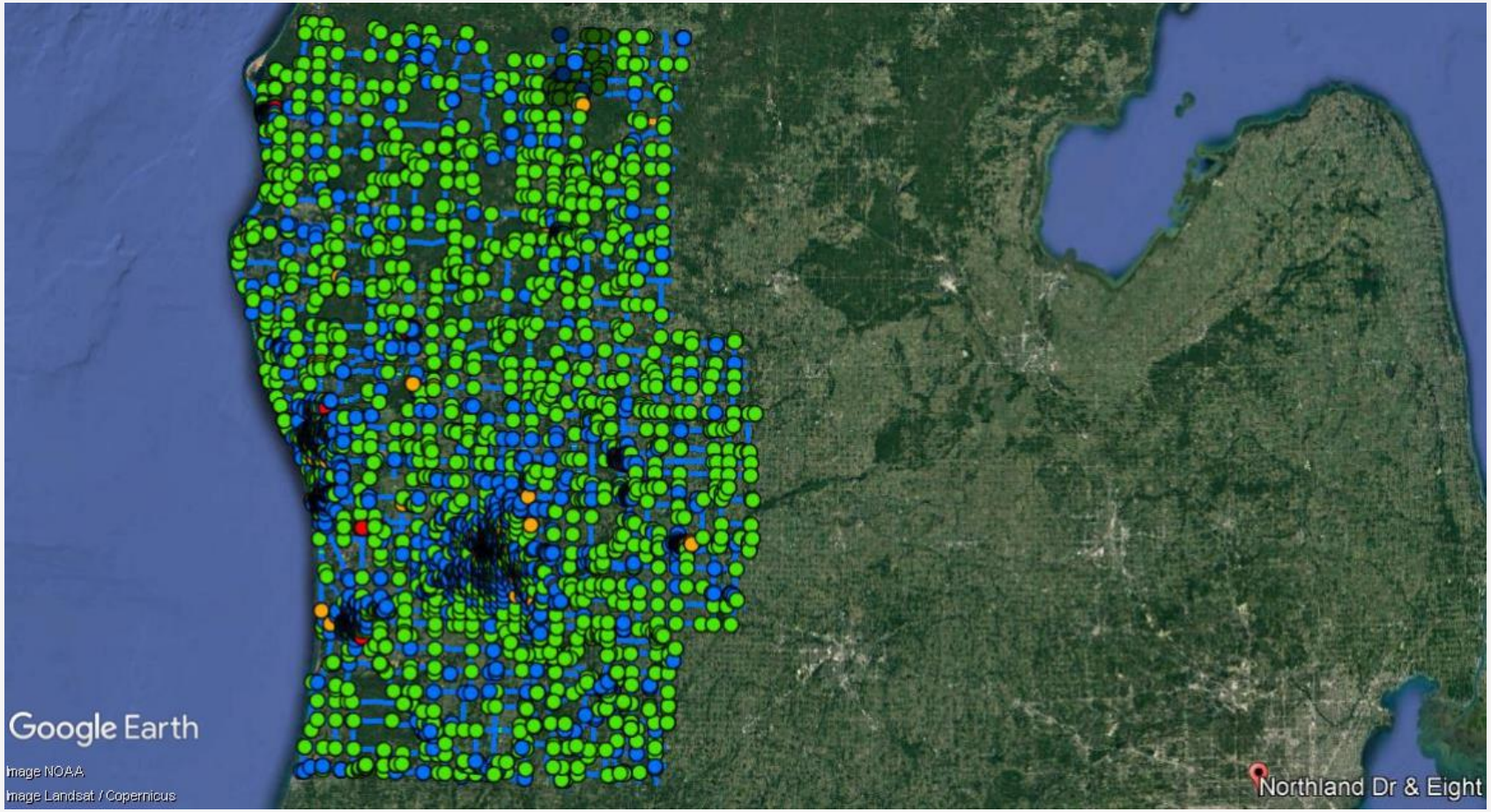
Crash Data Collection



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Spot vs. Systemic

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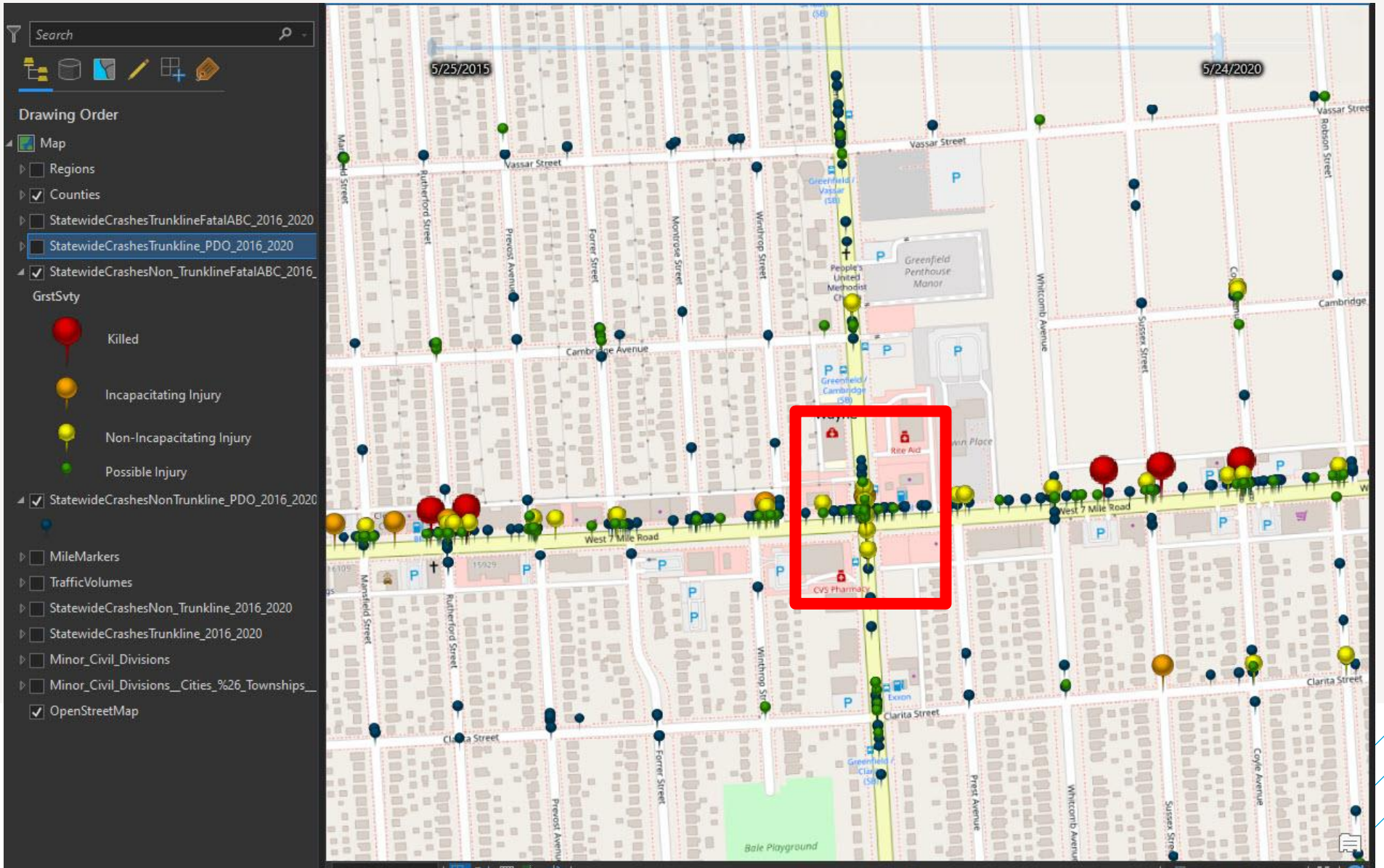
Clusters of Traffic Crashes



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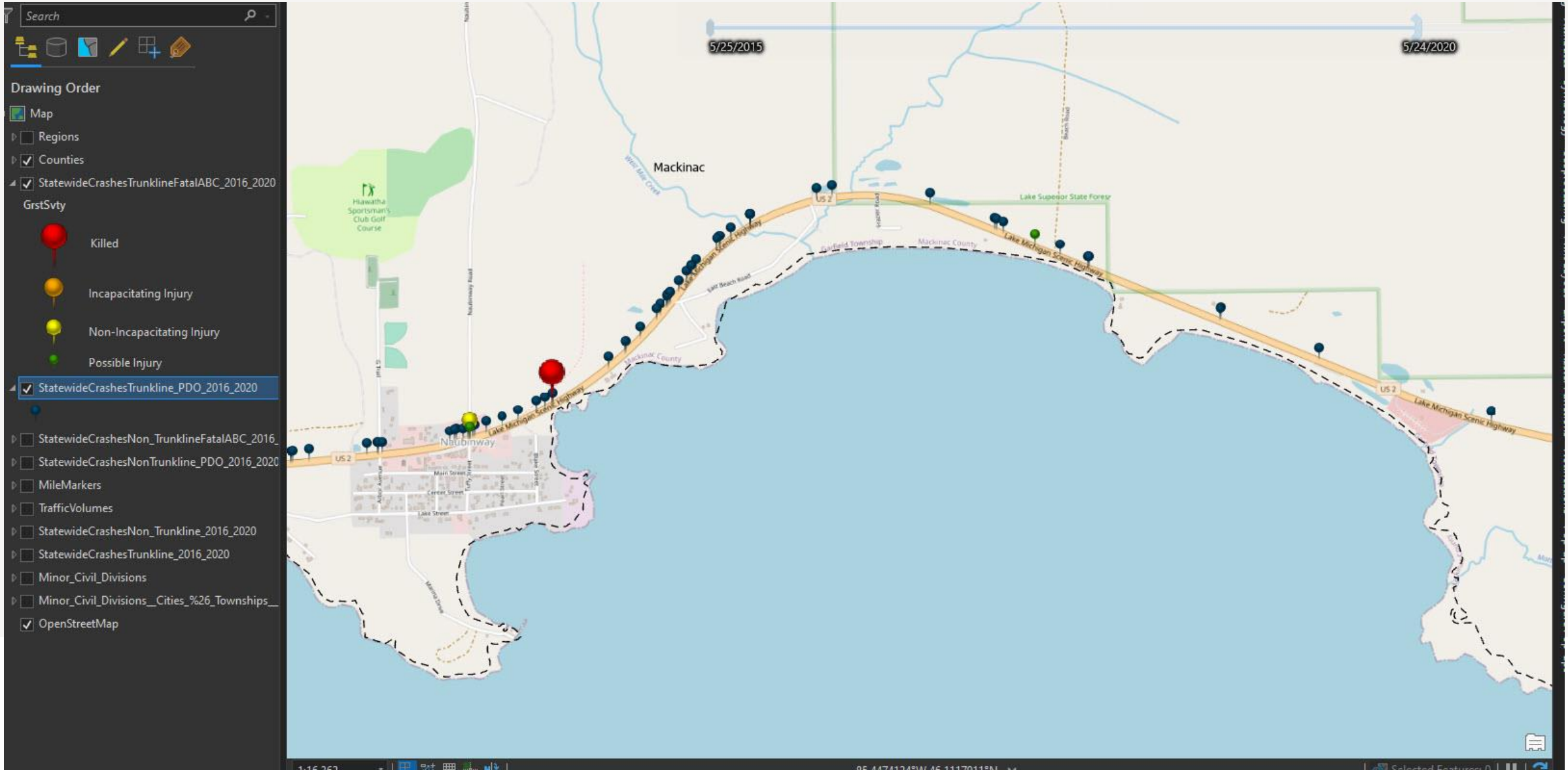
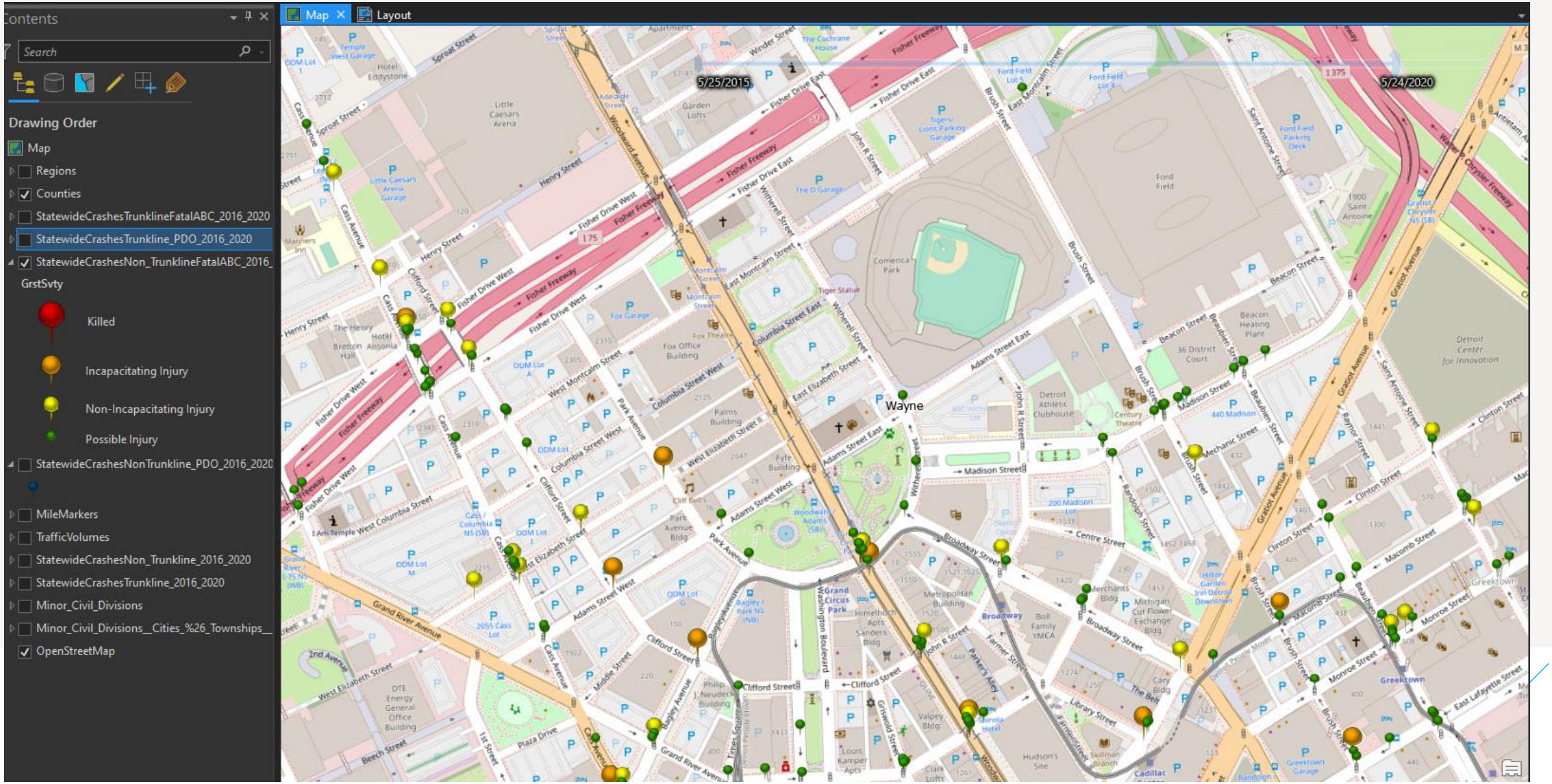
Distributed Traffic Crashes



Distributed Traffic Crashes

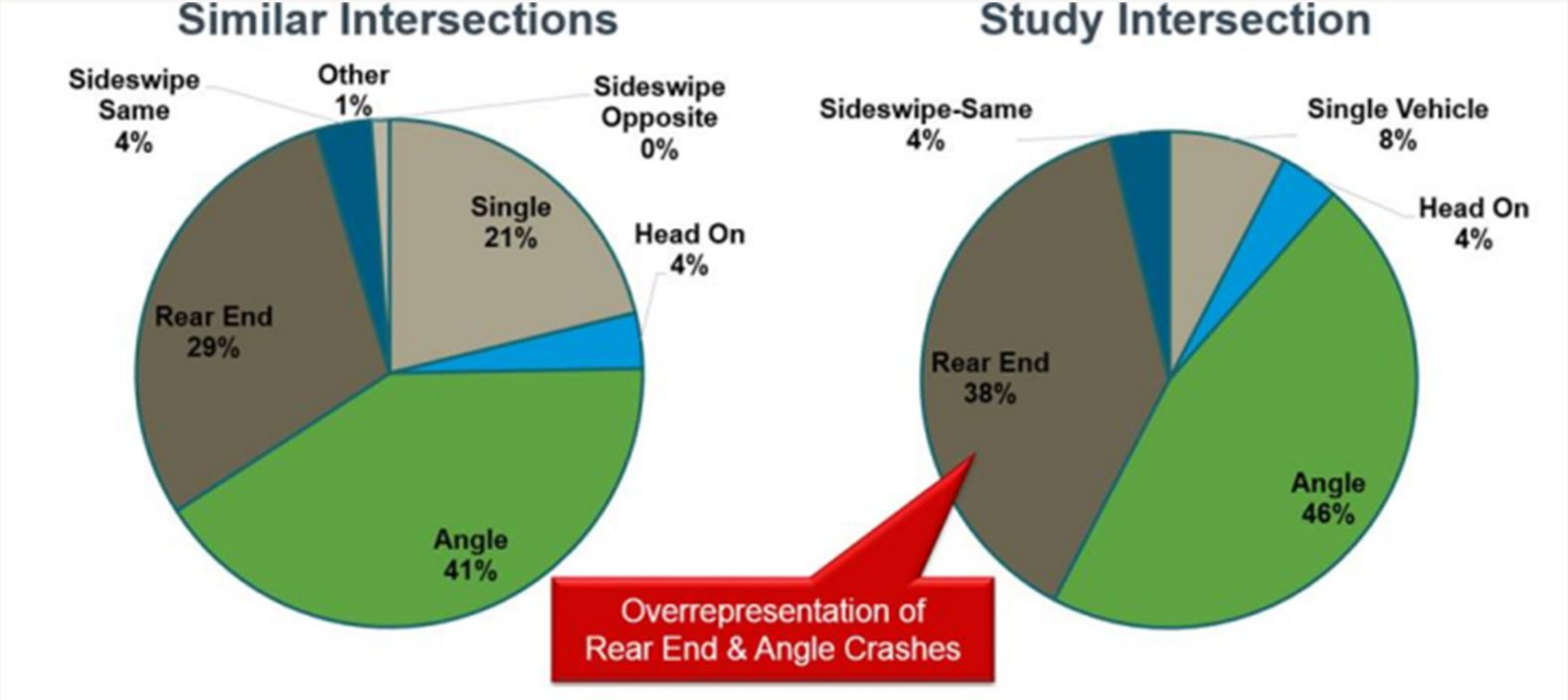


Spot vs. Systemic

Clusters of Crashes → Spot

Distributed Crashes → Systemic

Spot Analysis



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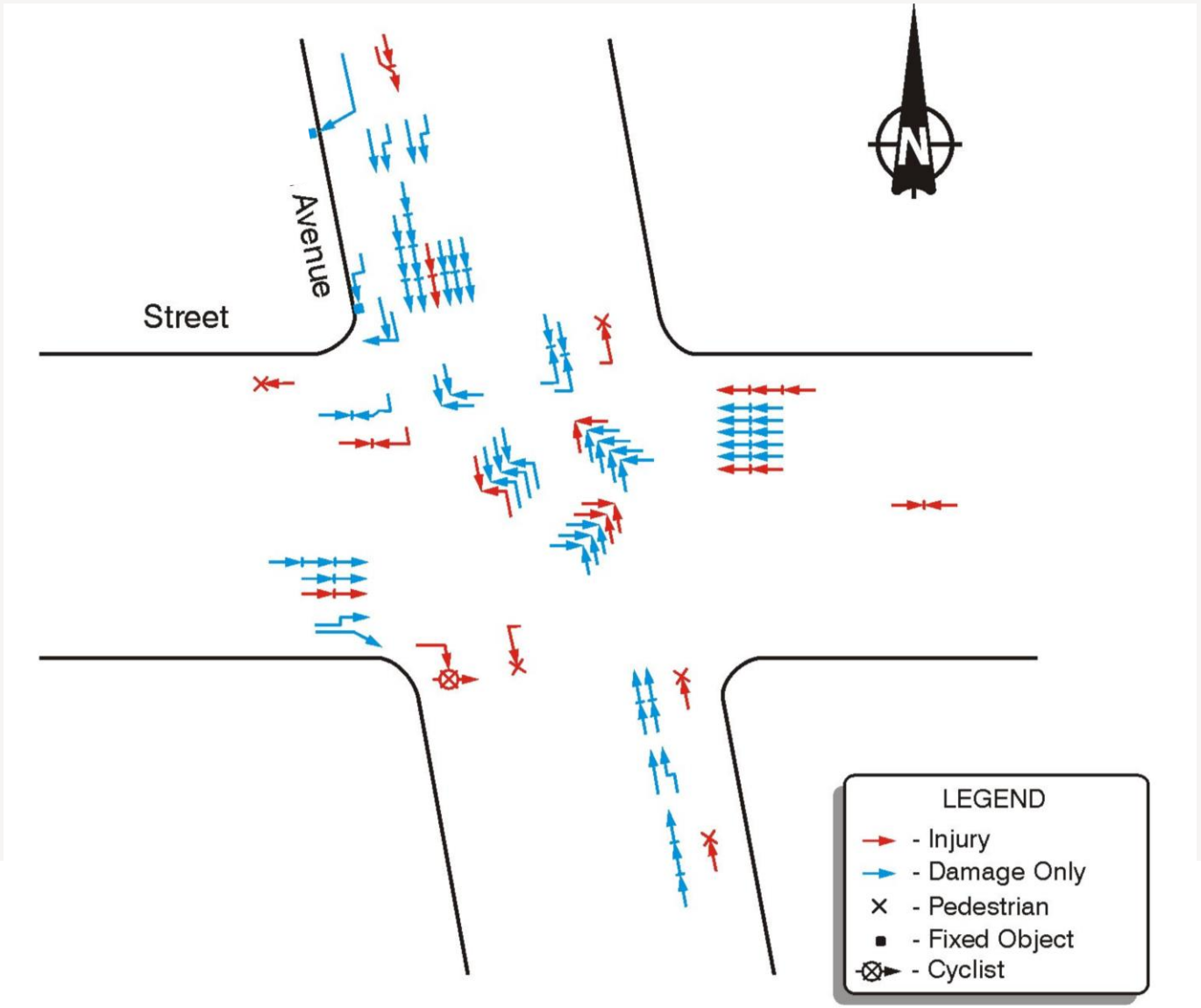
Spot Analysis

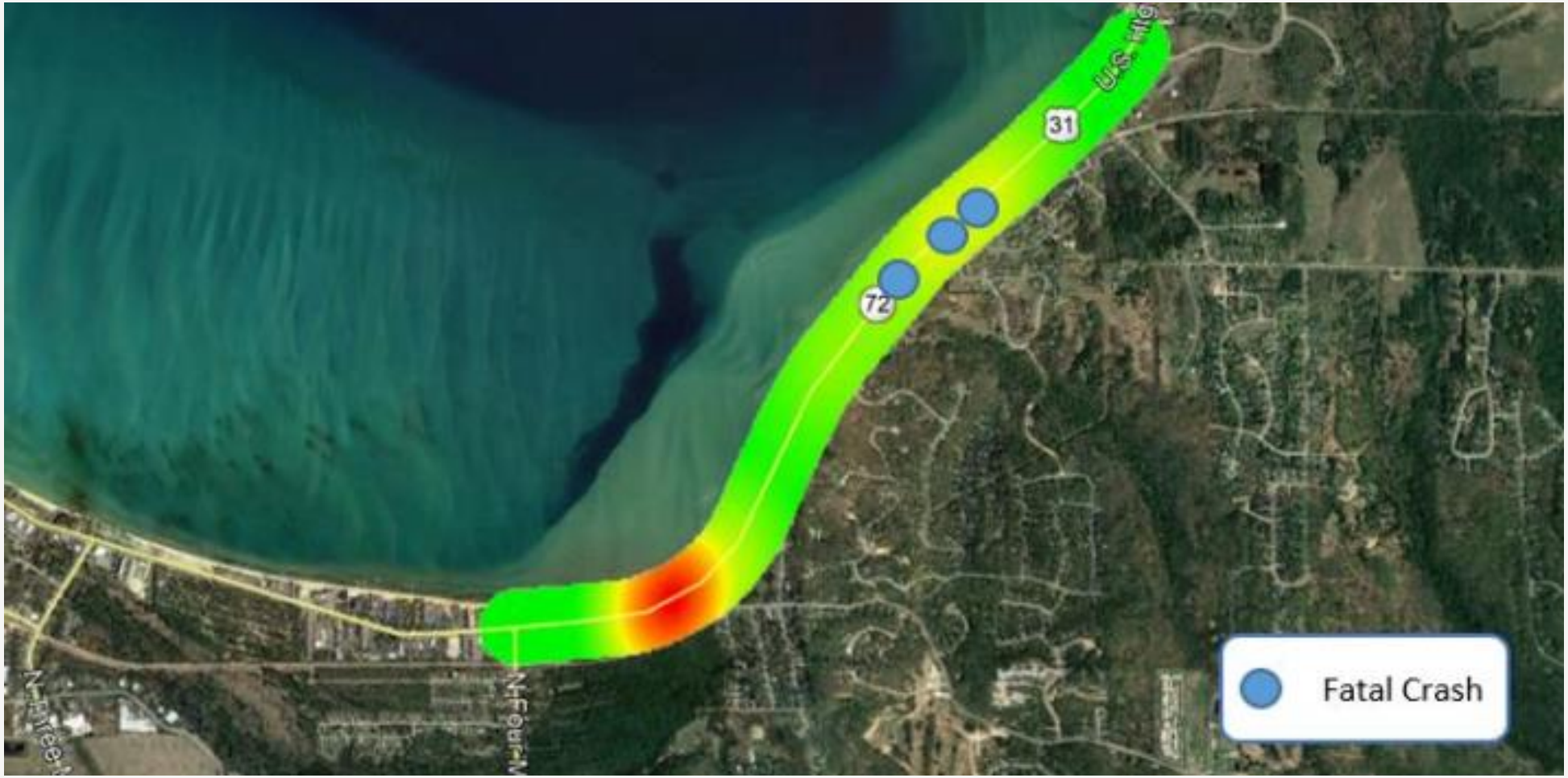
Intersection Details		Traffic Volumes		Traffic Crashes			Crash Type Distribution					
Minor	Configuration	Major	Minor	FI	PDO	TOT	Single	Head On	Angle	Rear End	S.S. Same	S.S. Opp.
Minor 1	Three Leg Stop	17,600	2,500	3	6	9	56%	0%	33%	11%	0%	0%
Minor 2	Three Leg Stop	17,600	2,500	3	7	10	10%	20%	40%	20%	10%	0%
Minor 3	Three Leg Stop	17,600	2,500	6	7	13	8%	0%	77%	15%	0%	0%
Minor 4	Four Leg Signal	20,250	5,650	27	58	85	4%	2%	31%	56%	4%	4%
Minor 5	Three Leg Stop	19,900	1,250	1	5	6	0%	33%	33%	17%	0%	17%
Minor 6	Four Leg Signal	19,050	7,640	13	75	88	3%	2%	35%	50%	9%	0%
Minor 7	Four Leg Stop	18,200	800	2	17	19	5%	0%	68%	11%	11%	5%
Minor 8	Four Leg Stop	18,200	1,250	11	26	37	3%	3%	78%	11%	5%	0%
All Corridor Intersections		**18,550**	**3,011**	**66**	**201**	**267**	**6%**	**3%**	**44%**	**39%**	**6%**	**2%**

Spot Analysis – Collision Diagram



- Rear-end
- Head-on
- Left/Right Rear-end
- Sideswipe Same Direction
- Sideswipe Opposite Direction
- Angle
- Left-turn Head-on
- Left/Right Turn
- Left/Right Crossing
- Single Vehicle
- Fixed Object

Spot Analysis



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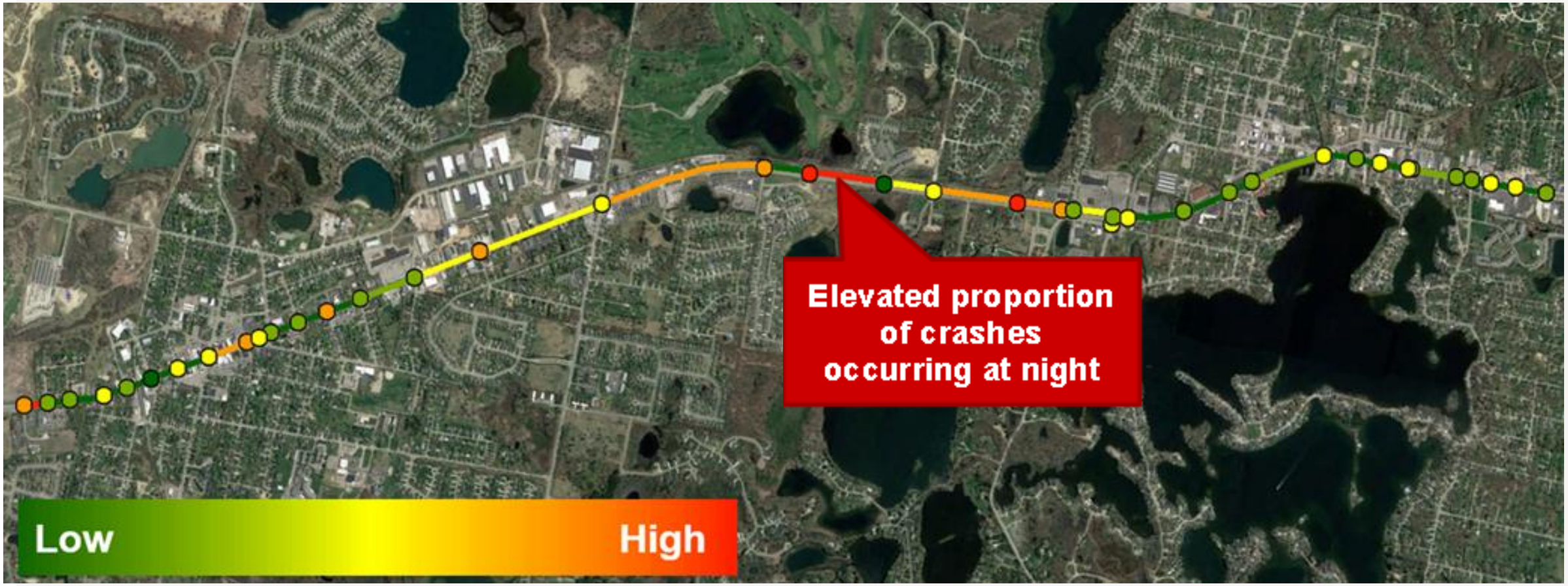
Spot Analysis



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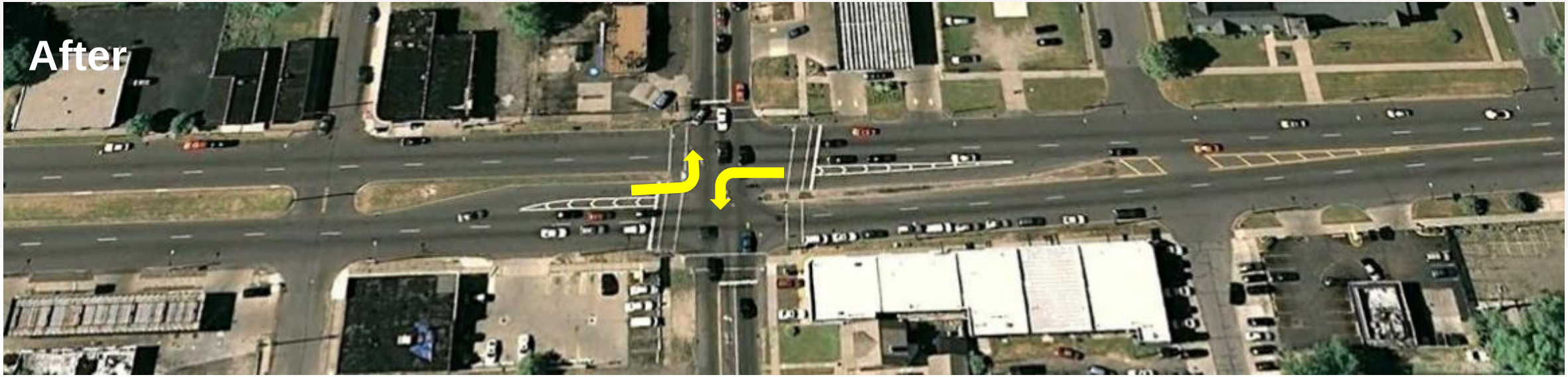
Example Spot Improvement



Example Spot Improvement

Systemic Analysis

Table 4: Percentage Distribution of Lane Departure Crashes by County, 2010-2014

Location	Crashes	Fatalities	A-injuries	K&A
Alger	34%	100%	63%	69%
Baraga	24%	100%	54%	61%
Chippewa	27%	67%	58%	59%
Delta	16%	40%	50%	49%
Dickinson	14%	75%	41%	45%
Gogebic	32%	50%	58%	57%
Houghton	25%	82%	47%	51%
Iron	23%	60%	54%	55%
Keweenaw	40%	100%	57%	64%
Luce	26%	71%	71%	71%
Mackinac	30%	70%	60%	61%
Marquette	24%	33%	41%	40%
Menominee	18%	58%	53%	54%
Ontonagon	20%	50%	52%	52%
Schoolcraft	23%	100%	63%	68%
Upper Peninsula	**23%**	**62%**	**53%**	**54%**

Systemic Analysis - Comparisons

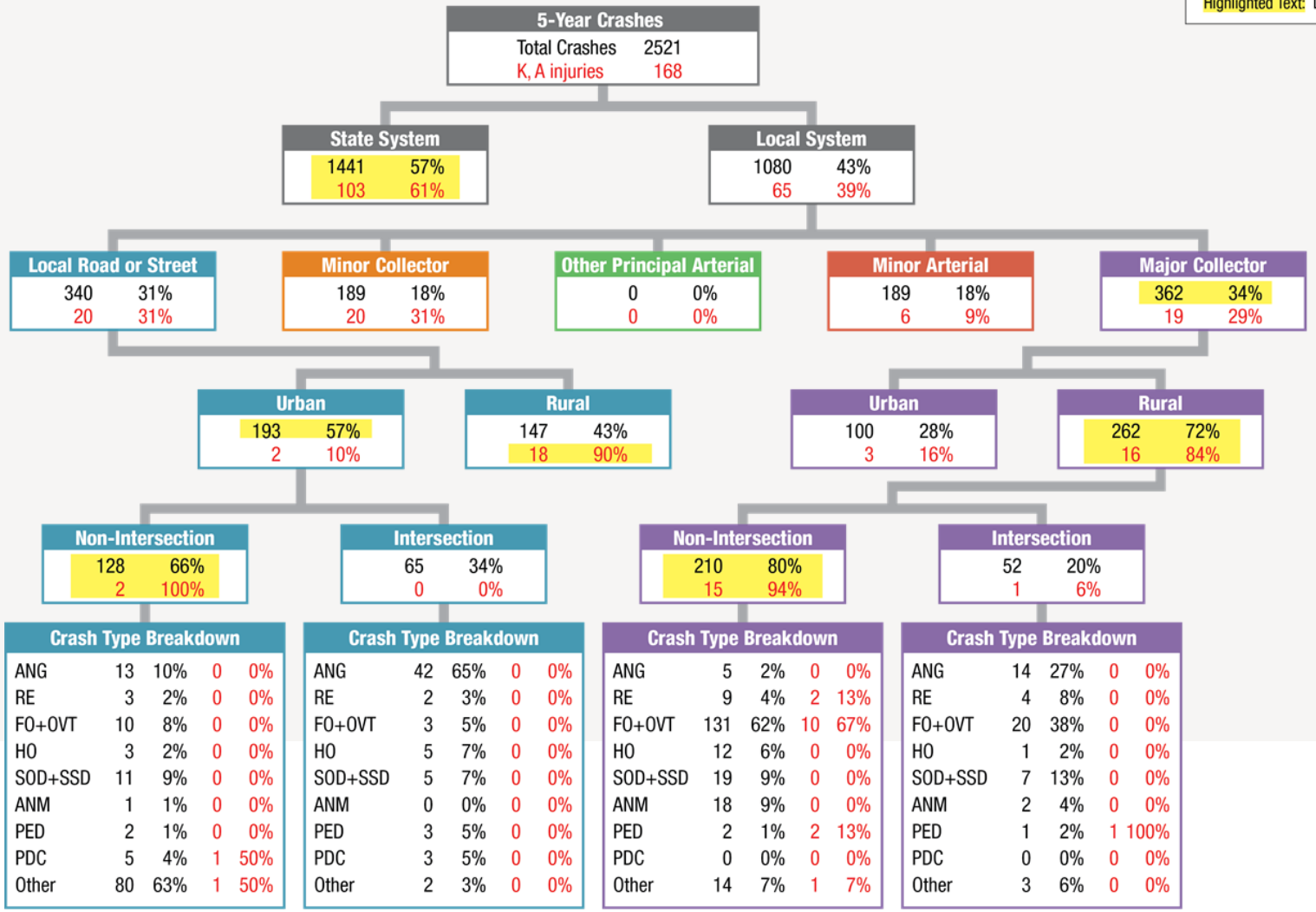
Fatal and Severe Injury Crashes (2007-2011) Percent by Jurisdiction								
Emphasis Area	**Statewide 114,592 mi**		**State 15,486 mi**		**County 19,938 mi**		**City, Town, Village 76,735 mi**	
Total Fatal/Serious Injury	100%	63,443	31%	19,819	10%	6,572	45%	28,597
Pedestrian	19%	11,786	9%	1,860	6%	421	28%	8,122
Bicycle	5%	3,390	3%	518	3%	187	8%	2,414
Heavy Vehicle	5%	3,123	6%	1,266	4%	234	4%	1,051
Road Departure	26%	16,668	30%	5,985	44%	2,892	18%	5,128
Intersection	41%	25,791	25%	5,033	30%	1,957	64%	18,270
Head-on and Sideswipe	5%	3,071	7%	1,439	7%	490	3%	887

Systemic Analysis – Crash Tree

BONNER COUNTY, IDAHO

2014 to 2018 Crash Data Overview for All Emphasis Areas
Local System - Major Collector Roadways and Local Roads

Level 1: K, A, B, C, PDO Crashes
Level 2 Severities: K, A Crashes
Emphasis Area: All Emphasis Areas
Highlighted Text: Largest proportion in category level



CRASH TYPE ABBREVIATIONS

- ANG: Angle
- RE: Rear End
- FO+OVT: Fixed Object and Overturned
- HO: Head-On
- SOD+SSD: Sideswipe Opposite Direction and Sideswipe Same Direction
- ANM: Animal
- PED: Pedestrian
- PDC: Pedalcyclist
- Other: Other Non-Collision/Other Object/Parked Car/Train/ Unknown

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Systemic Improvements –Rumble Strips

Systemic Improvements - Delineation

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Systemic Strategies

Lane Departure

1. Re-grading side slopes to 1:4, or flatter, to eliminate the need for guardrail

2. Guardrail improvements (SWA Funding eligible only)

3. Fixed object removal including clear zone widening, tree removal

4. Extending or modifying culvert ends to eliminate a fixed-objects in the clear zone

5. High-friction surface treatment (multi-location throughout Region)

6. Installing impact attenuators where one does not currently exist

7. Installing delineators as laid out in Standard Plan R-127

8. Installing channelization: quick curb, access management (right in/right out, etc.)

9. Installing curve warning signs: chevrons, target arrows with reflective sign post strips

10. Eliminate edge drop-offs/rutting using Safety Edge installation

11. Construct centerline or shoulder rumble or mumble strips including widening shoulders to accommodate installation

12. Widen shoulders to decrease lane departure crashes

Systemic Strategies

Intersections

1. Improvements to sight vision corners: tree/shrub removal, minimal site grading

2. Reflective sign post strips for horizontal alignment signs and /or stop, stop ahead, yield, or yield ahead signs.

3. Signing treatments for All Way Stop and Cross Traffic Does Not Stop Conditions as per SIGN-145-A

Pedestrians

1. Road Diets- Restriping only with no pavement overlays or reconstruction. (Form 1629 still needs to be followed)

2. Pedestrian Refuge Islands

3. Special Emphasis Pedestrian Crosswalk Markings as per PAVE-945

4. Rectangular Rapid Flashing Beacon (RRFB) – Approval per the Crosswalk Guidance Document

5. Pedestrian Hybrid Beacon (PHB) – Approval per the Crosswalk Guidance Document

6. Gateway Treatment as per the R1-6 User Guide

Five Minute Break

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Predictive Analysis/HSM

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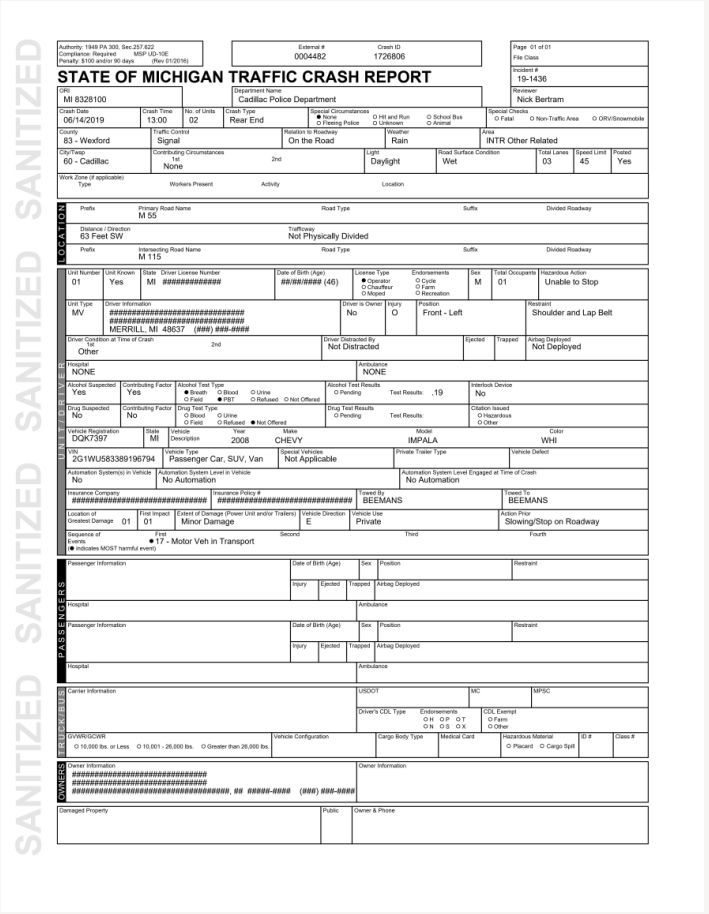
Issues with Traditional Crash Analysis

HSM Addresses:

- Quality & accuracy
- Reporting thresholds
- Frequency-severity
- Differences between jurisdictions
- Randomness and change



SANITIZED

STATE OF MICHIGAN TRAFFIC CRASH REPORT

External # 0004482 Crash ID 1726806

ORI MI 8328100 Department Name Cadillac Police Department Incident # 19-1436

Crash Date 06/14/2019 Crash Time 13:00 No. of Units 02 Crash Type Rear End

County 83 - Wexford Traffic Control Signal Relation to Roadway On the Road Weather Rain Area INTR Other Related

City/Twp 60 - Cadillac Contributing Circumstances 1st None Light Daylight Road Surface Condition Wet Total Lanes 03 Speed Limit 45 Posted Yes

LOCATION

Primary Road Name M 55 Distance / Direction 63 Feet SW Trafficway Not Physically Divided

Intersecting Road Name M 115

UNIT / DRIVER

Unit Number 01 Unit Known Yes State MI Driver License Number ########## Date of Birth (Age) ######## (46) License Type Operator Endorsements Sex M Total Occupants 01 Hazardous Action Unable to Stop

Unit Type MV Driver Information ########## MERRILL, MI 48637 (###) ###-#### Driver is Owner No Injury O Position Front - Left Restraint Shoulder and Lap Belt

Driver Condition at Time of Crash 1st Other Driver Distracted By Not Distracted Airbag Deployed Not Deployed

Hospital NONE Ambulance NONE

Alcohol Suspected Yes Contributing Factor Yes Alcohol Test Type Breath Alcohol Test Results Pending Test Results: .19 Interlock Device No

Drug Suspected No Contributing Factor No Drug Test Type Not Offered Drug Test Results Pending Citation Issued

Vehicle Registration DQK7397 State MI Vehicle Description Year 2008 Make CHEVY Model IMPALA Color WHI

VIN 2G1WU583389196794 Vehicle Type Passenger Car, SUV, Van Special Vehicles Not Applicable Private Trailer Type Vehicle Defect

Automation System(s) in Vehicle No Automation System Level in Vehicle No Automation Automation System Level Engaged at Time of Crash No Automation

Insurance Company ########## Insurance Policy # ########## Towed By BEEMANS Towed To BEEMANS

Location of Greatest Damage 01 First Impact 01 Extent of Damage (Power Unit and/or Trailers) Minor Damage Vehicle Direction E Vehicle Use Private Action Prior Slowing/Stop on Roadway

Sequence of Events First 17 - Motor Veh in Transport Second Third Fourth

PASSENGERS

Passenger Information Date of Birth (Age) Sex Position Restraint Injury Ejected Trapped Airbag Deployed Hospital Ambulance

Passenger Information Date of Birth (Age) Sex Position Restraint Injury Ejected Trapped Airbag Deployed Hospital Ambulance

TRUCK/BUS

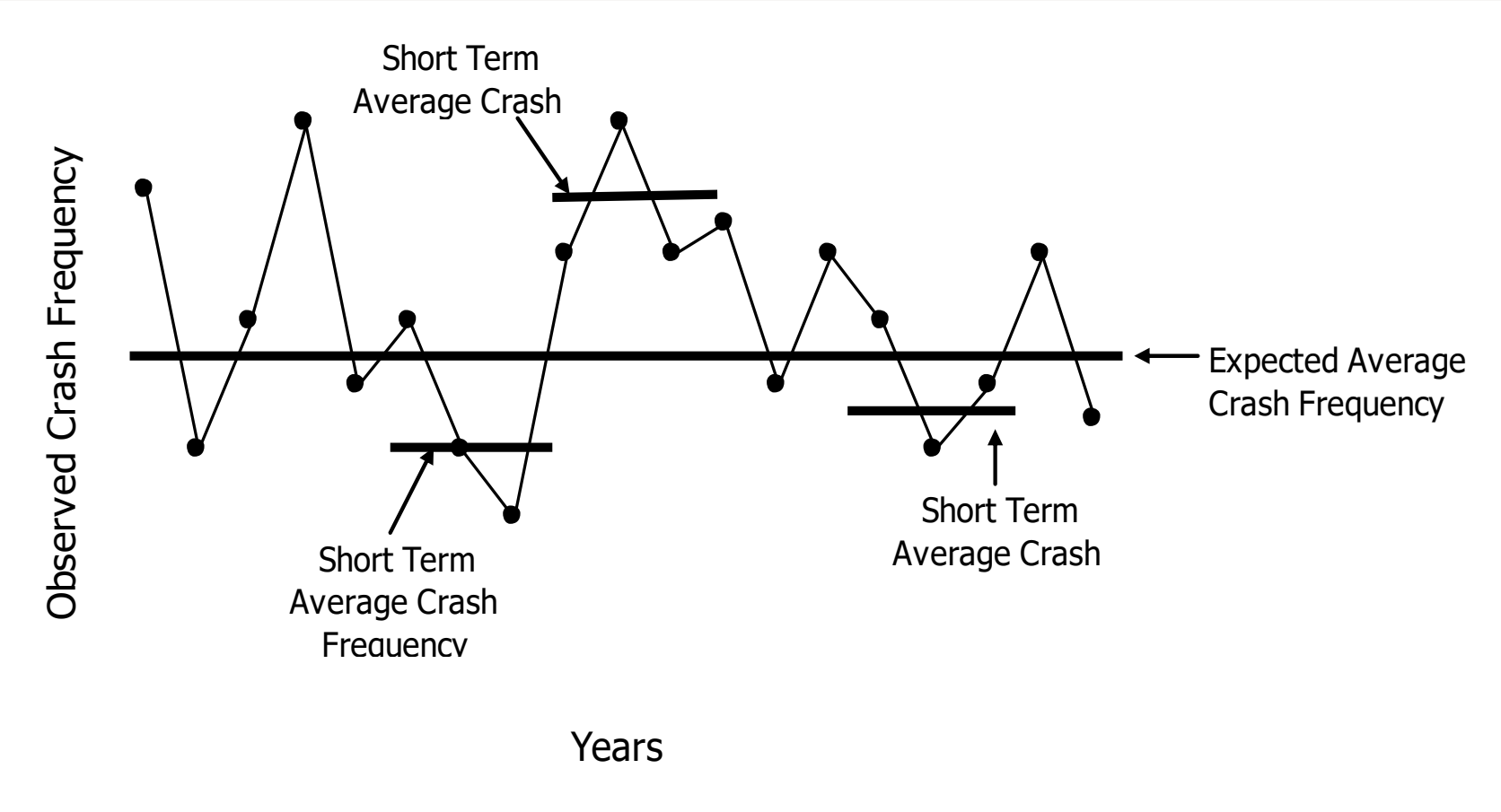
Carrier Information USDOT MC MPSC Driver's CDL Type Endorsements CDL Exempt GVWR/GCWR Vehicle Configuration Cargo Body Type Medical Card Hazardous Material ID # Class #

OWNER

Owner Information ########## ########## ##########, ## #####-#### (###) ###-#### Owner Information

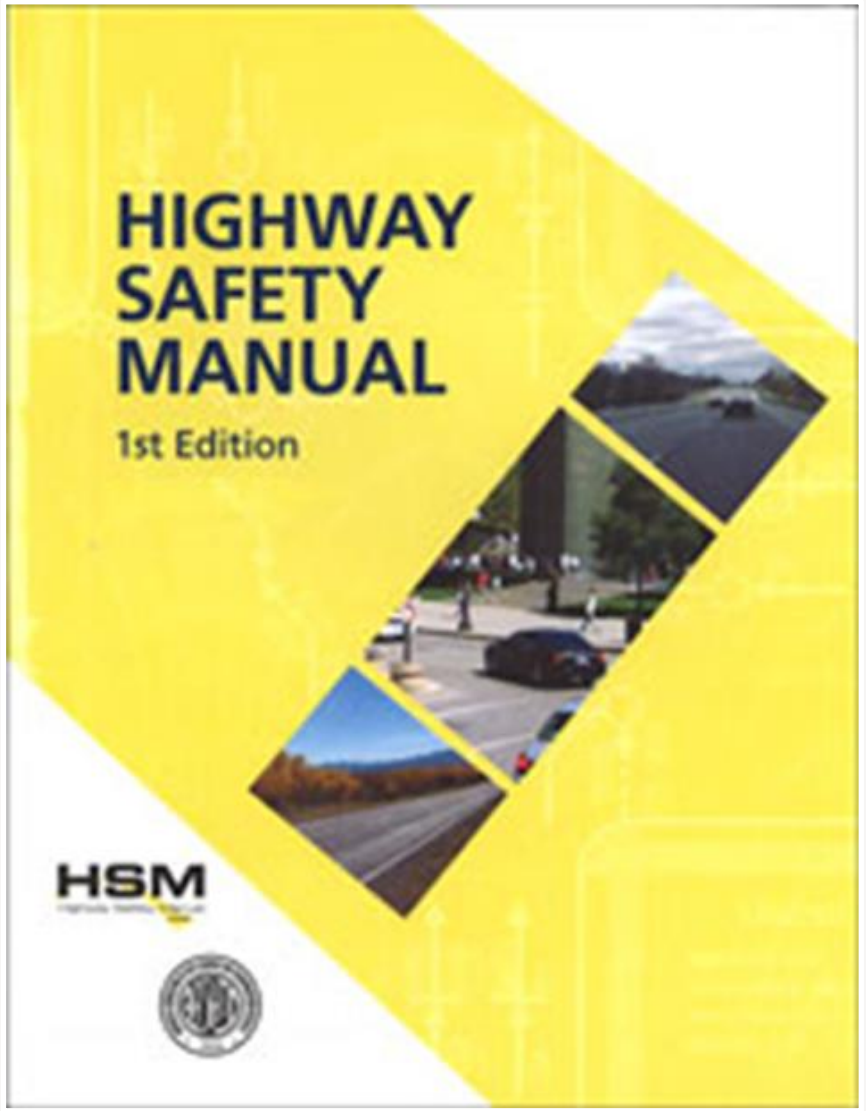
Damaged Property Public Owner & Phone

Natural Variability in Crash Frequency

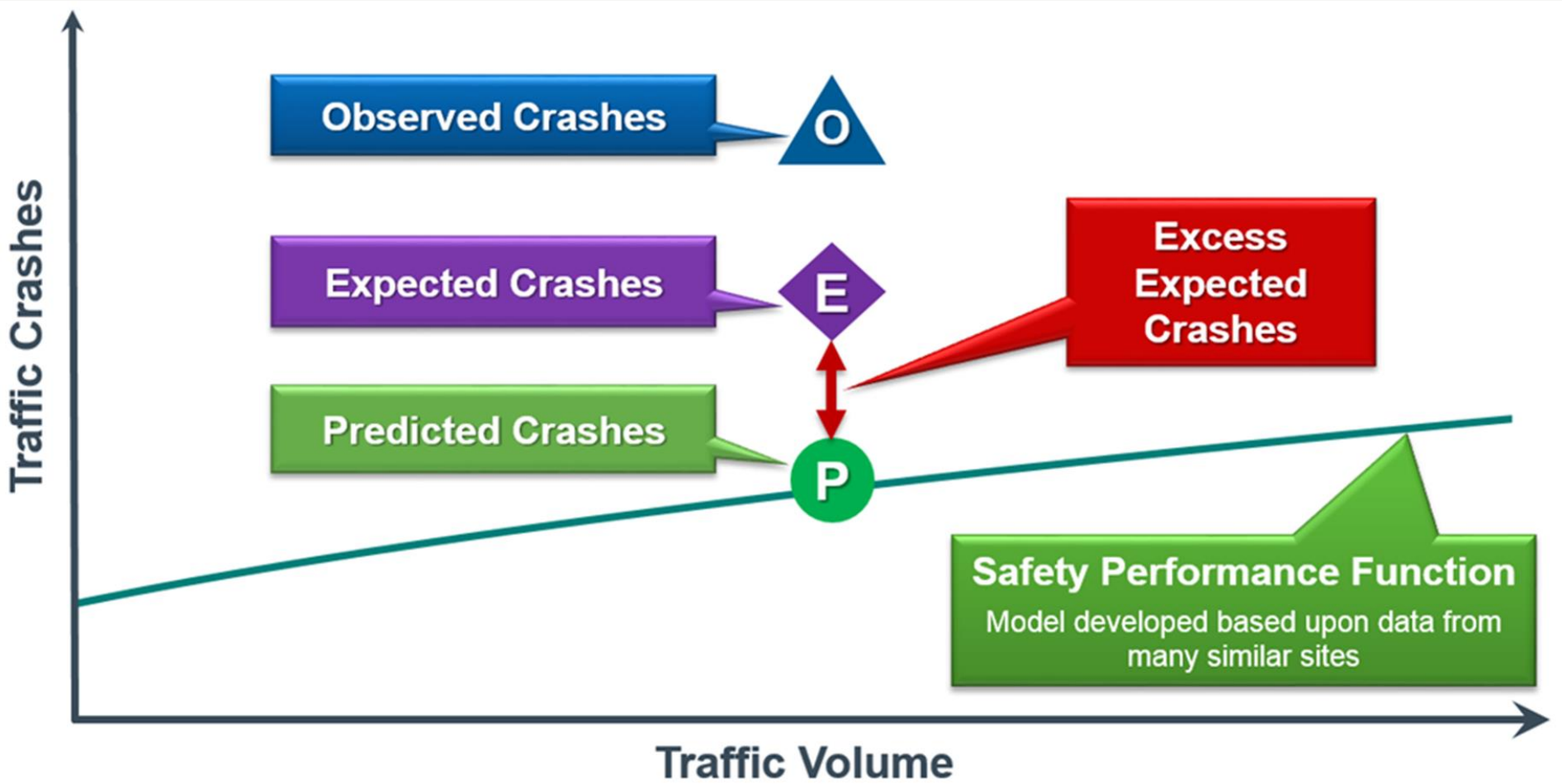


Highway Safety Manual

- Predictive modeling (safety performance functions)
- Network screening
- Scenario analysis



HSM Performance Measures



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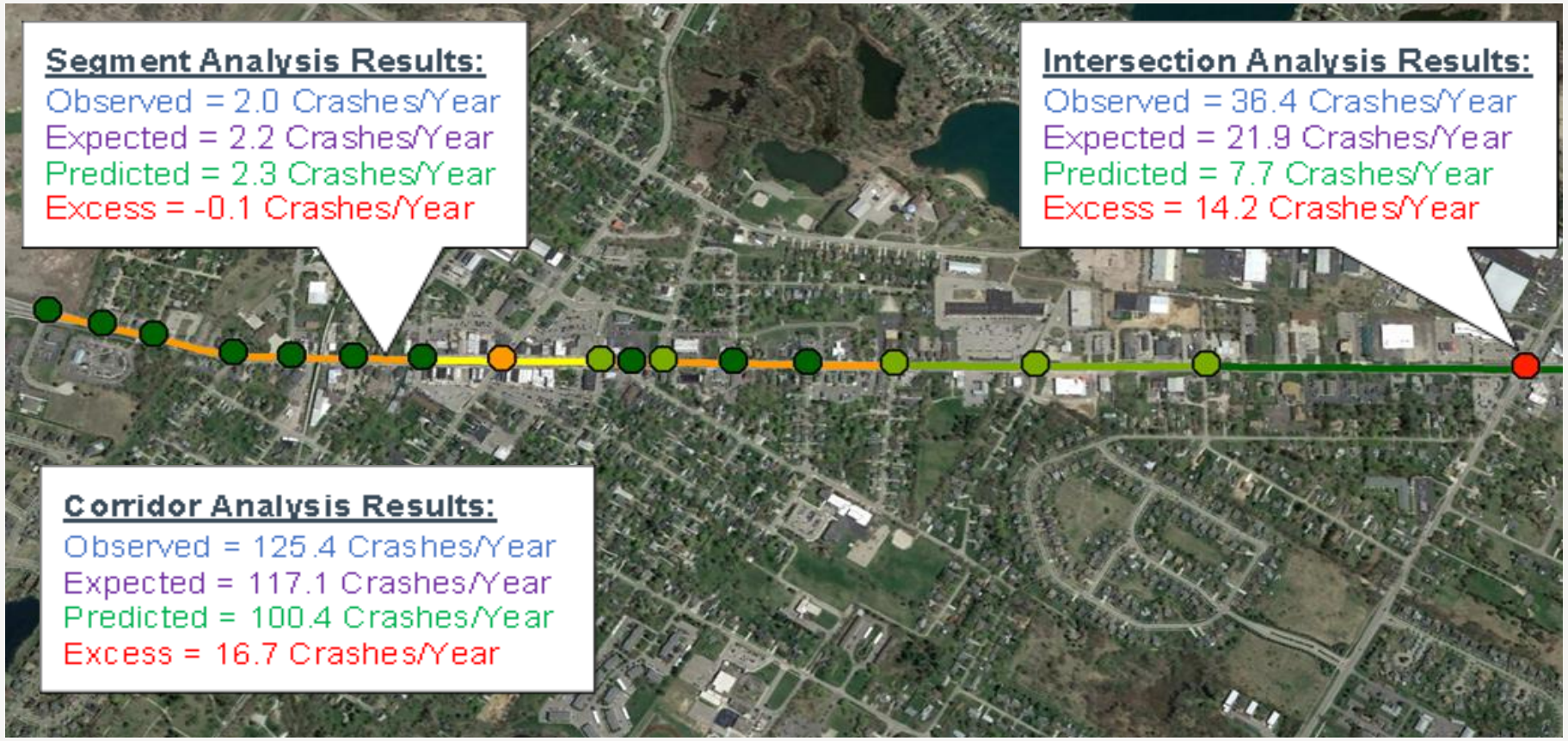
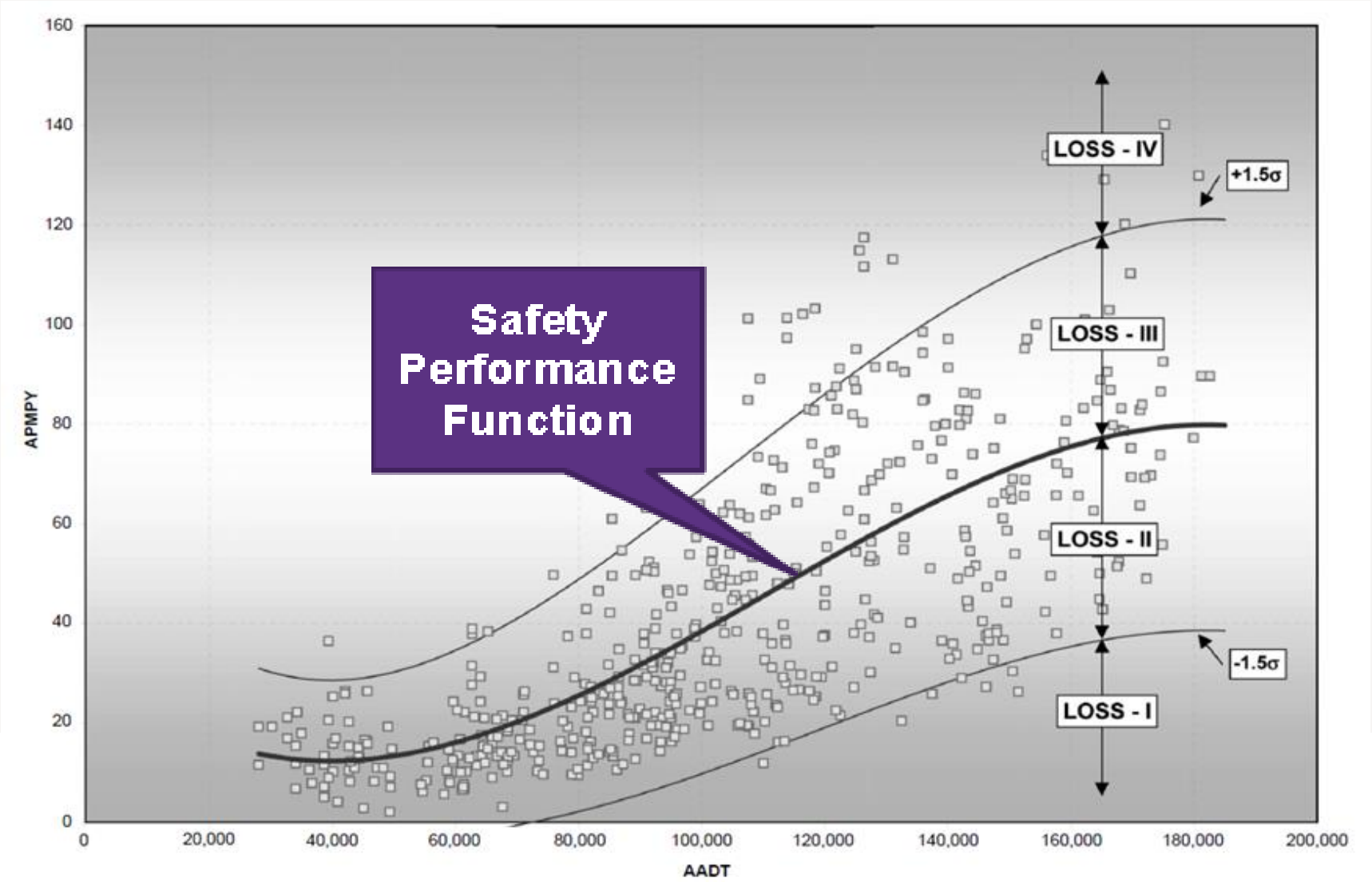
HSM Analysis



Level of Service Safety



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Level of Service Safety

LOSS Category	Category Description
I	Indicates a low potential for crash reduction
II	Indicates a low to moderate potential for crash reduction
III	Indicates a moderate to high potential for crash reduction
IV	Indicates a high potential for crash reduction

Applying DDSA on MDOT Projects

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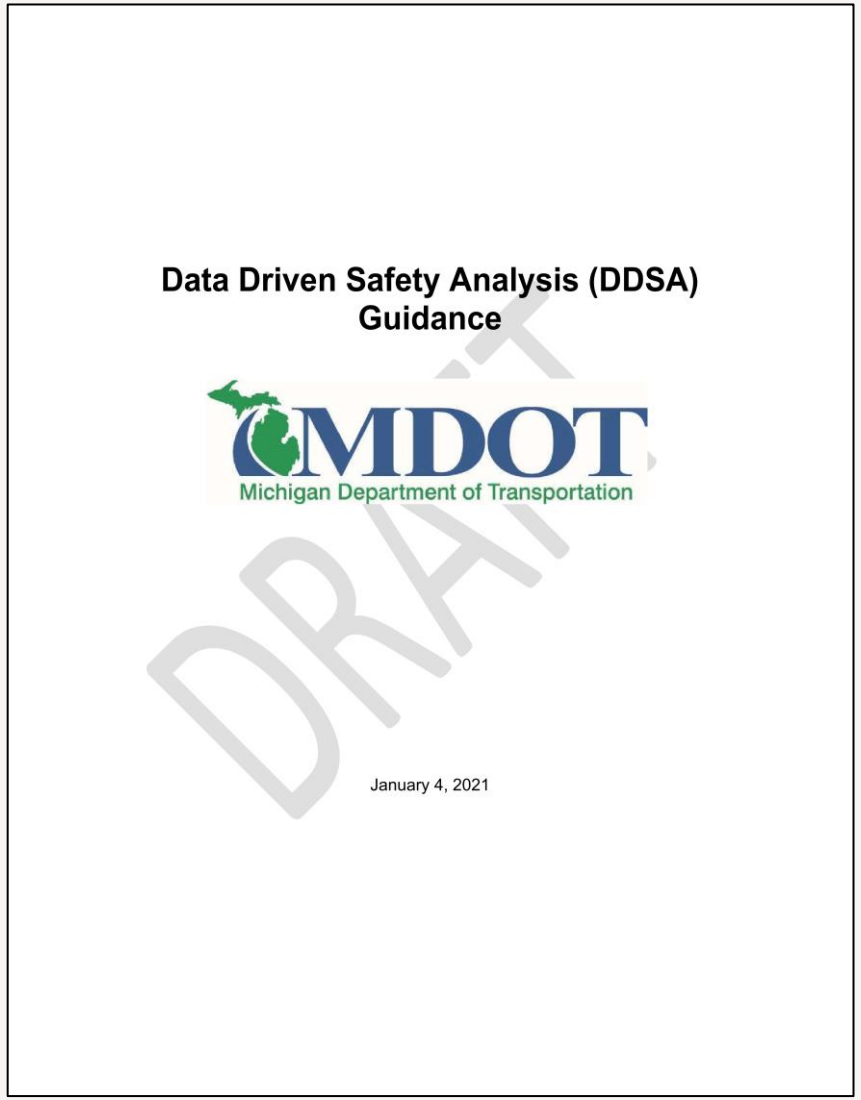
MDOT DDSA Guidance

Areas of Application

- Project development safety analysis
- Design Exceptions/Design Variances
- Alternative analysis as part of National Environmental Policy Act (NEPA)
- Interstate Access Requests
- Performance Based Practical Design (PBPD)



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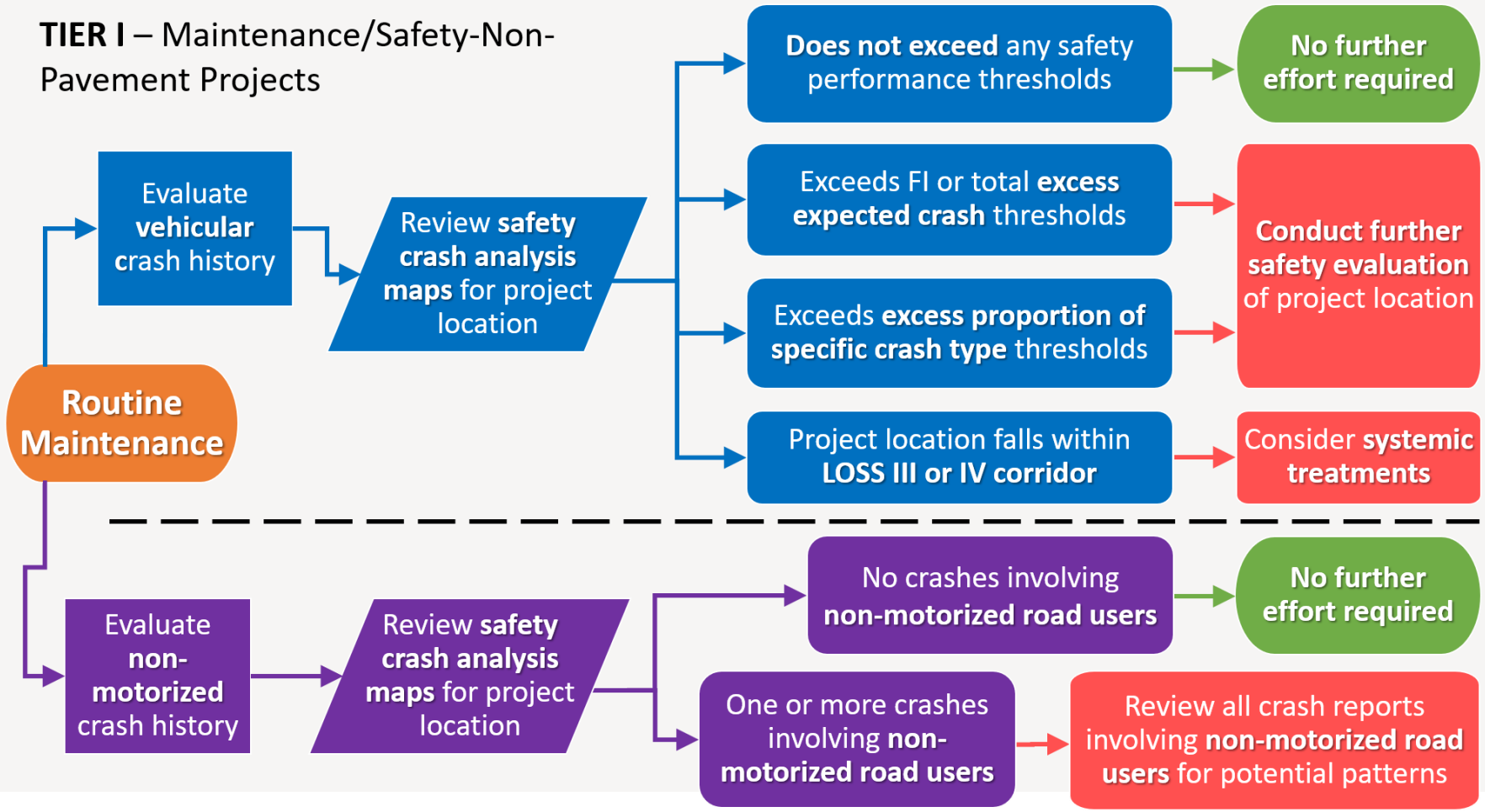
Tier I – Maintenance/Safety Non-Pavement



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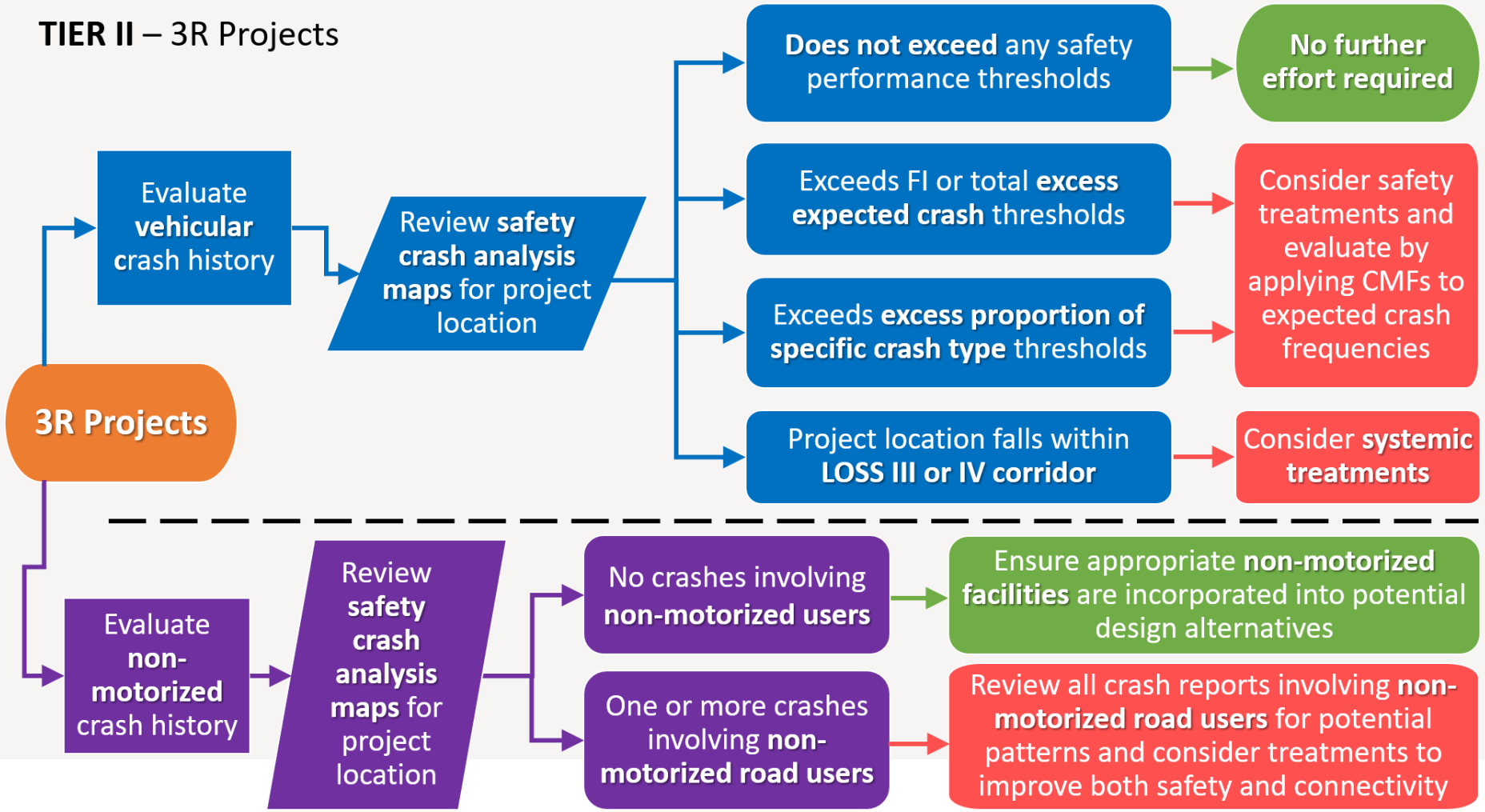
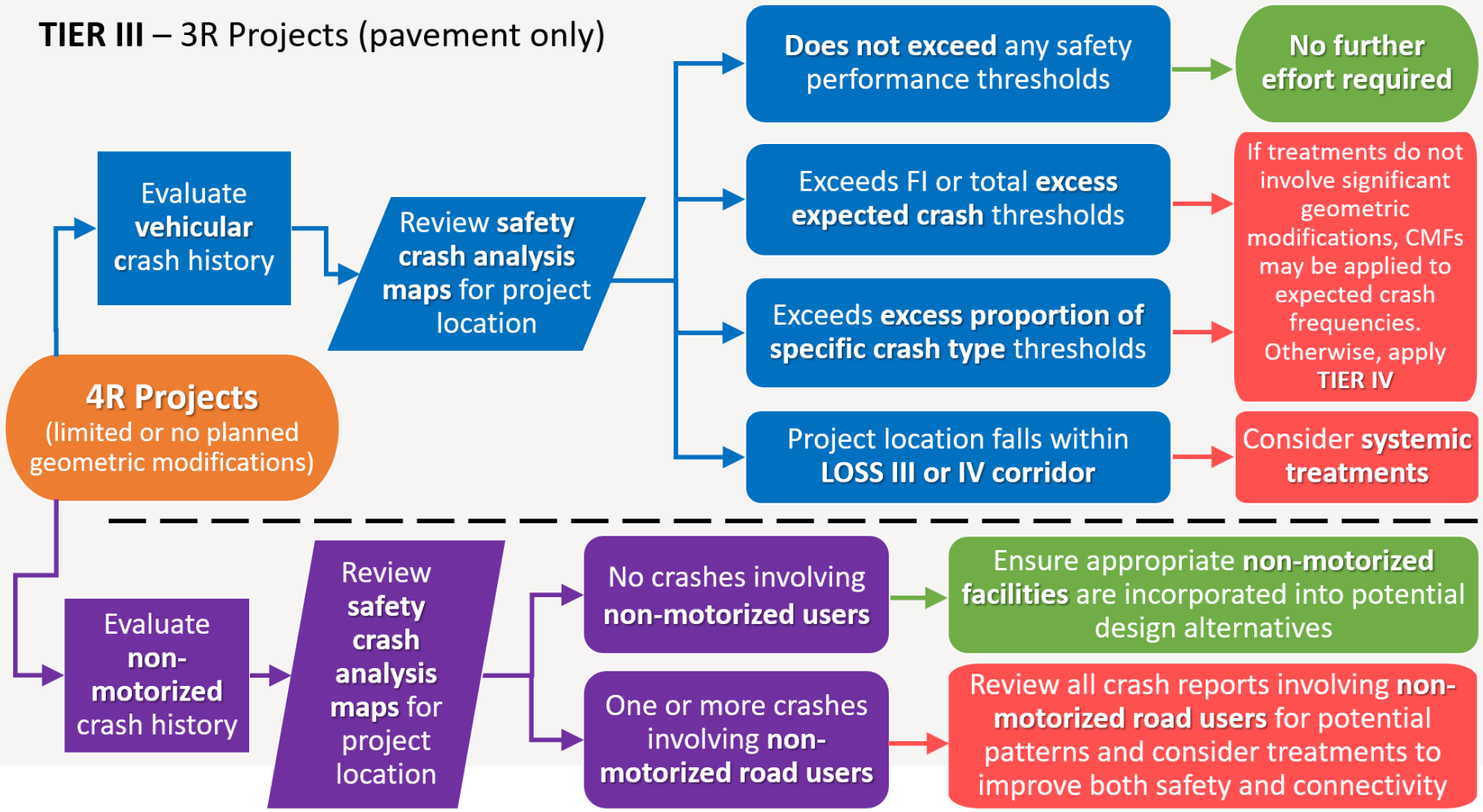
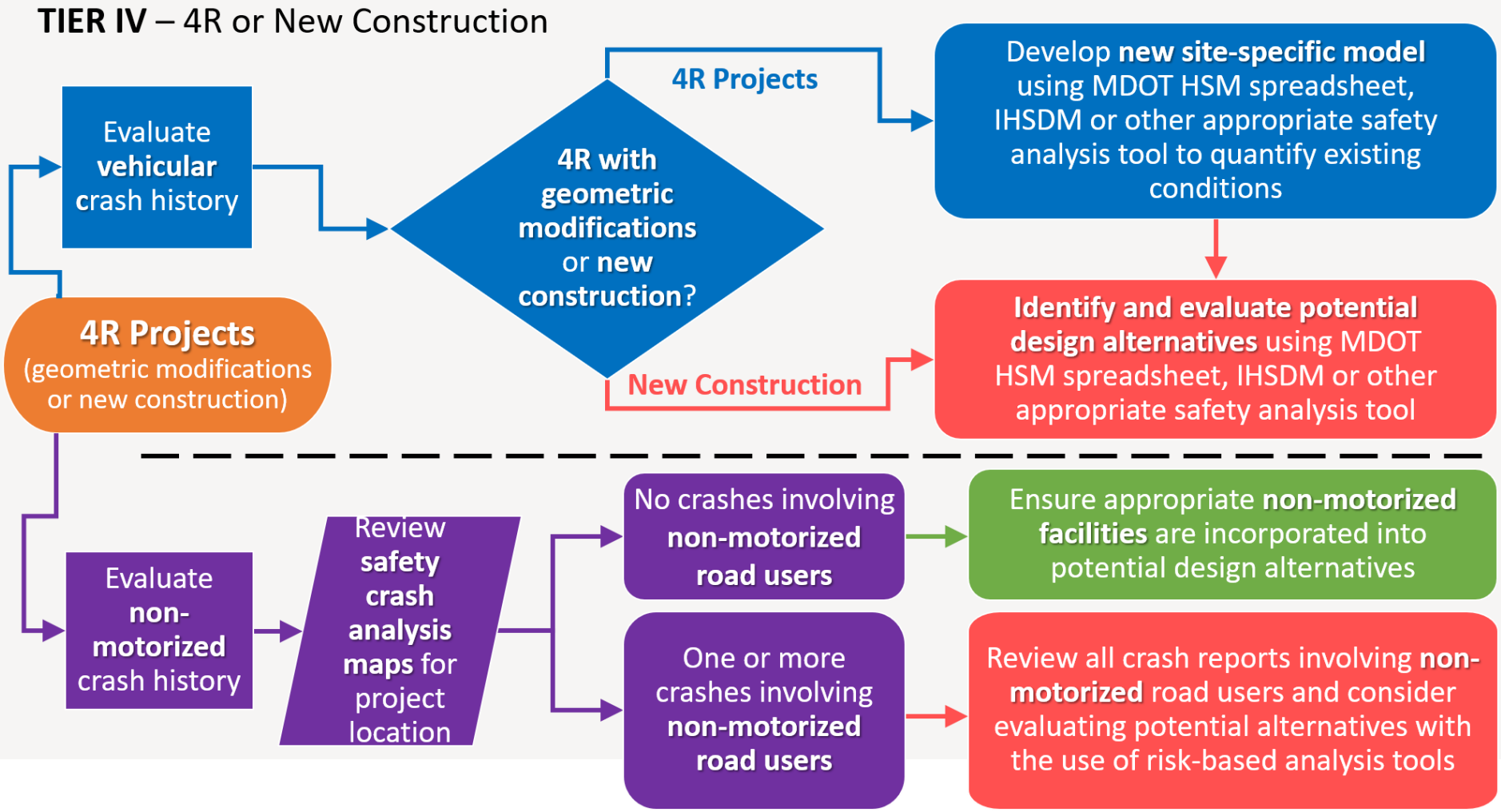
Tier II – 3R Projects



Tier III – 3R (pavement only)



Tier IV – 4R or New Construction



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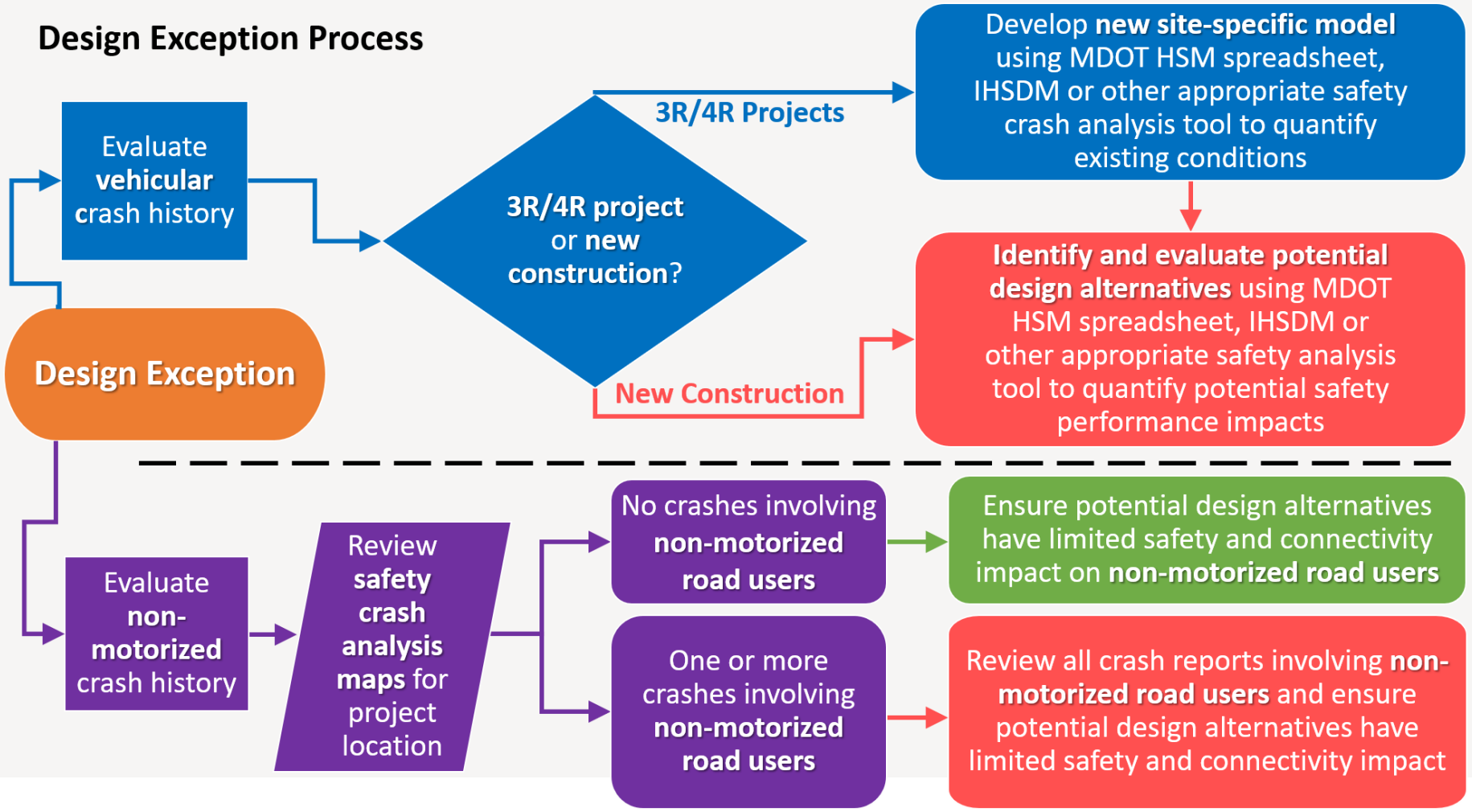
Design Exception Process



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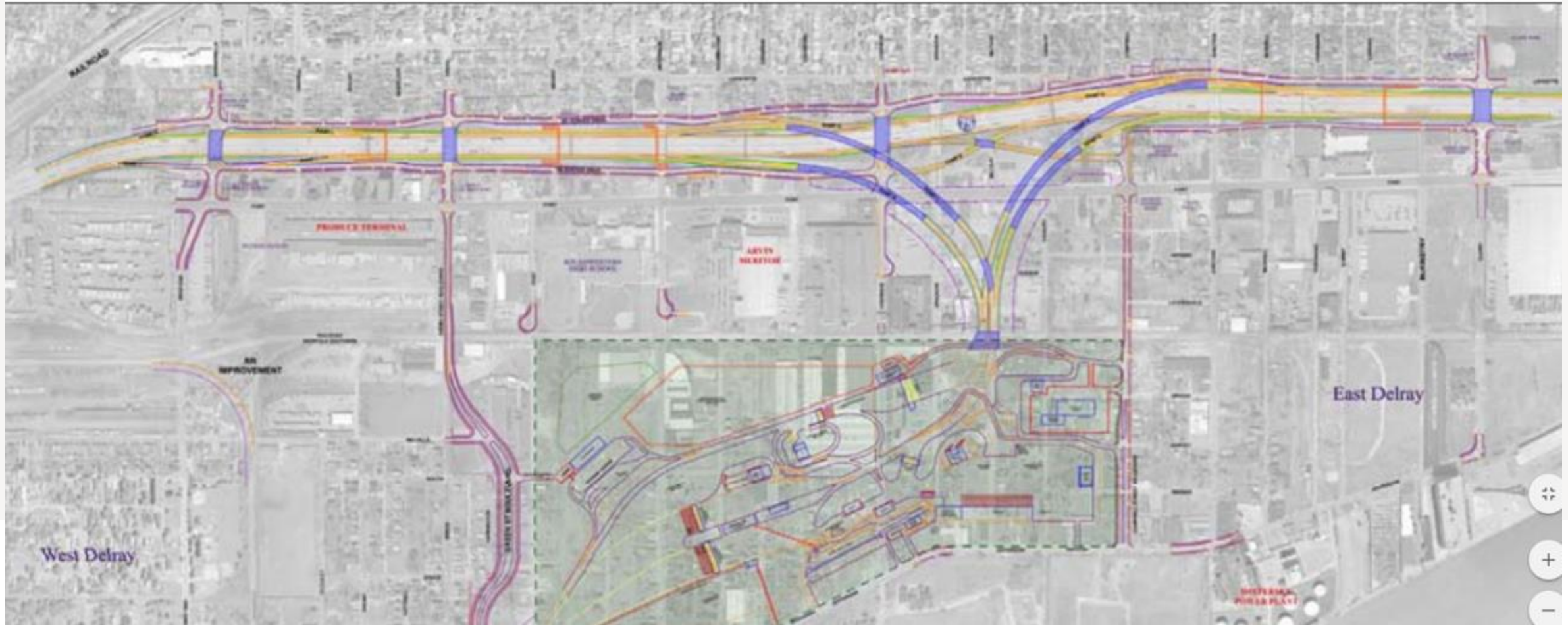
Upgrade to Existing vs. New Construction

Figure 2-15
Preferred Alternative
Detroit River International Crossing Study



Upgrade to Existing vs. New Construction

Project Type	Type of Improvement	HSM Performance Measure
Maintenance	Upgrade to existing	Excess expected crashes
3R	Upgrade to existing	Excess expected crashes
3R (Pavement)	Upgrade to existing	Excess expected crashes
4R	New construction	Predicted crashes
Design exception	Upgrade to existing	Excess expected crashes
Design exception	New construction	Predicted crashes

Case Studies

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Case Study – US-31 in Grand Traverse County

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Case Study – US-31 in Grand Traverse County

HSM Analysis for Intersections

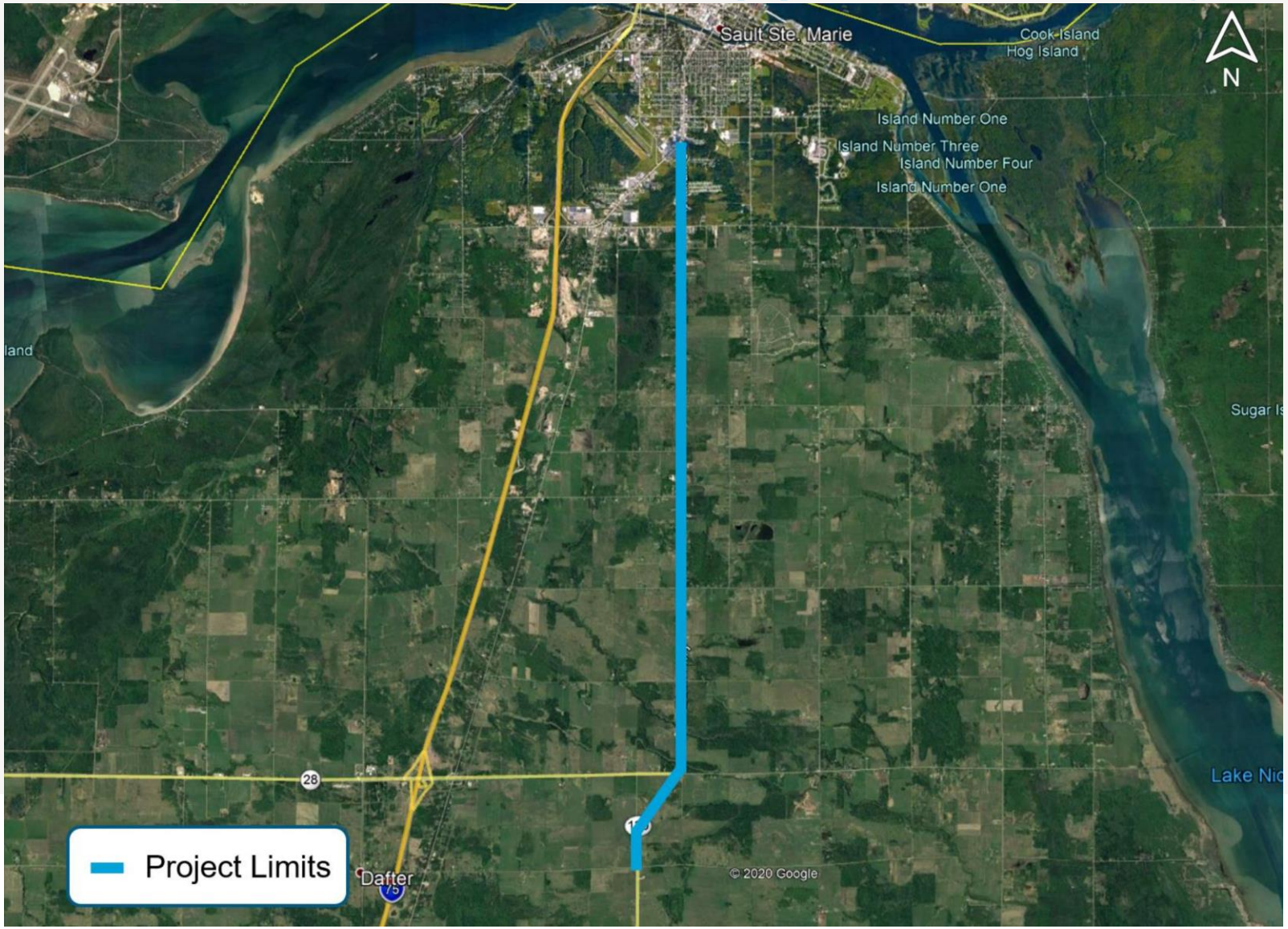
Intersection		Predicted Crashes			Expected Crashes			Excess Crashes per Year		
Major	Minor	FI	PDO	Total	FI	PDO	Total	FI	PDO	Tot
US-31	Five Mile Road	0.54	2.22	2.75	0.12	3.54	3.66	-0.42	1.32	0.91
US-31	Holiday Road	0.10	1.27	1.37	0.47	6.99	7.46	0.37	5.72	6.09
Overall		**0.64**	**3.49**	**4.12**	**0.59**	**10.53**	**11.12**	**-0.05**	**7.04**	**7.00**

Case Study – US-31 in Grand Traverse County

HSM Analysis for Segments

Section		Predicted Crashes			Expected Crashes			Excess Crashes per Year		
Road	Cross-Section	FI	PDO	Total	FI	PDO	Total	FI	PDO	Tot
US-31	Four-Lane Multi-Vehicle	5.58	33.48	39.06	2.59	7.38	9.97	-2.99	-26.1	-29.09
US-31	Five-Lane Multi-Vehicle	5.46	21.6	27.06	1.46	6.17	7.63	-4	-15.43	-19.43
US-31	Four-Lane Single Vehicle	0.72	7.41	8.13	0.88	8.90	9.78	0.16	1.49	1.65
US-31	Five-Lane Single-Vehicle	0.57	3.58	4.25	0.78	7.23	8.01	0.21	3.55	3.76
Overall		**12.33**	**66.17**	**78.5**	**5.71**	**29.68**	**35.39**	**-6.62**	**-36.49**	**-43.11**

Case Study – M-129 in Chippewa County



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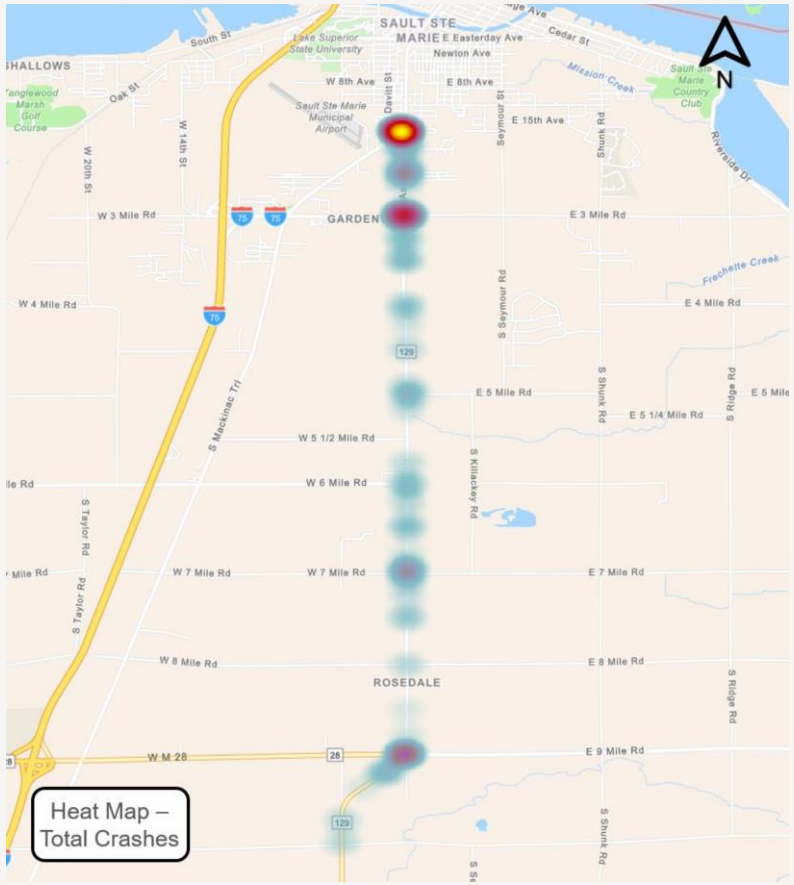
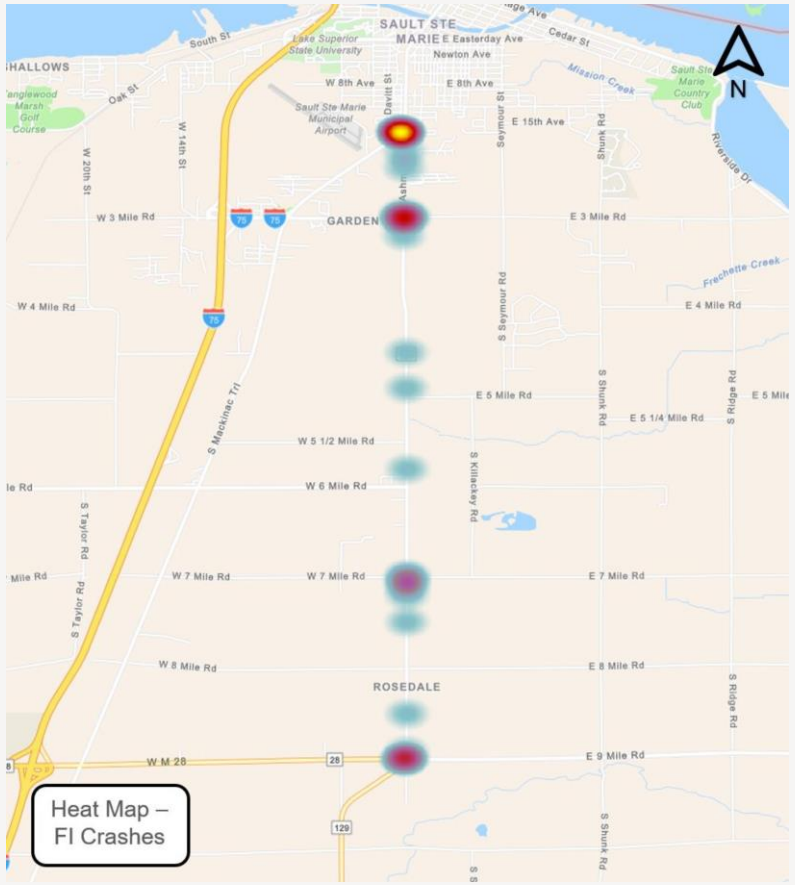
Case Study – M-129 in Chippewa County





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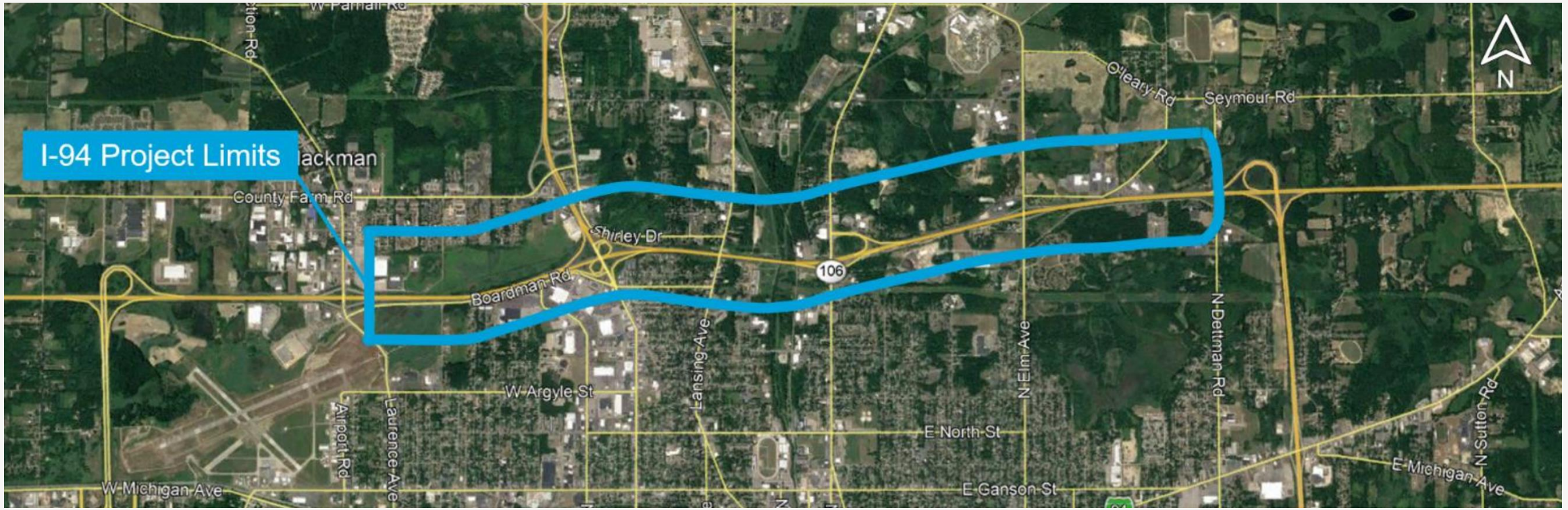
Case Study – M-129 in Chippewa County

Location		Predicted Crashes			Expected Crashes			Excess Expected		
		FI	PDO	TOT	FI	PDO	TOT	FI	PDO	TOT
M-129 (10 Mile Rd to 3 Mile Rd)	Segment	1.84	5.42	7.26	1.46	3.12	4.58	-0.38	-2.3	-2.68
M-129 (3 Mile Rd to I-75BS)	Segment	1.45	8.35	9.8	0.67	1.22	1.89	-0.78	-7.13	-7.91
M-129 & M-28	Intersection	0.07	0.34	0.41	0.06	0.22	0.28	-0.01	-0.12	-0.13
M-129 & 6 Mile Rd	Intersection	0.26	1.06	1.32	0.17	0.45	0.62	-0.09	-0.61	-0.7
M-129 & 5 Mile Rd	Intersection	0.08	0.41	0.49	0.07	0.28	0.35	-0.01	-0.13	-0.14
M-129 & 3 Mile Rd	Intersection	0.16	0.52	0.68	0.12	0.26	0.38	-0.04	-0.26	-0.3
M-129 & I-75BS	Intersection	1.15	4.27	5.42	0.67	1.58	2.25	-0.48	-2.69	-3.17
TOTAL		**5.01**	**20.37**	**25.38**	**3.22**	**7.13**	**10.35**	**-1.79**	**-13.24**	**-15.03**

Case Study – I-94 in Jackson



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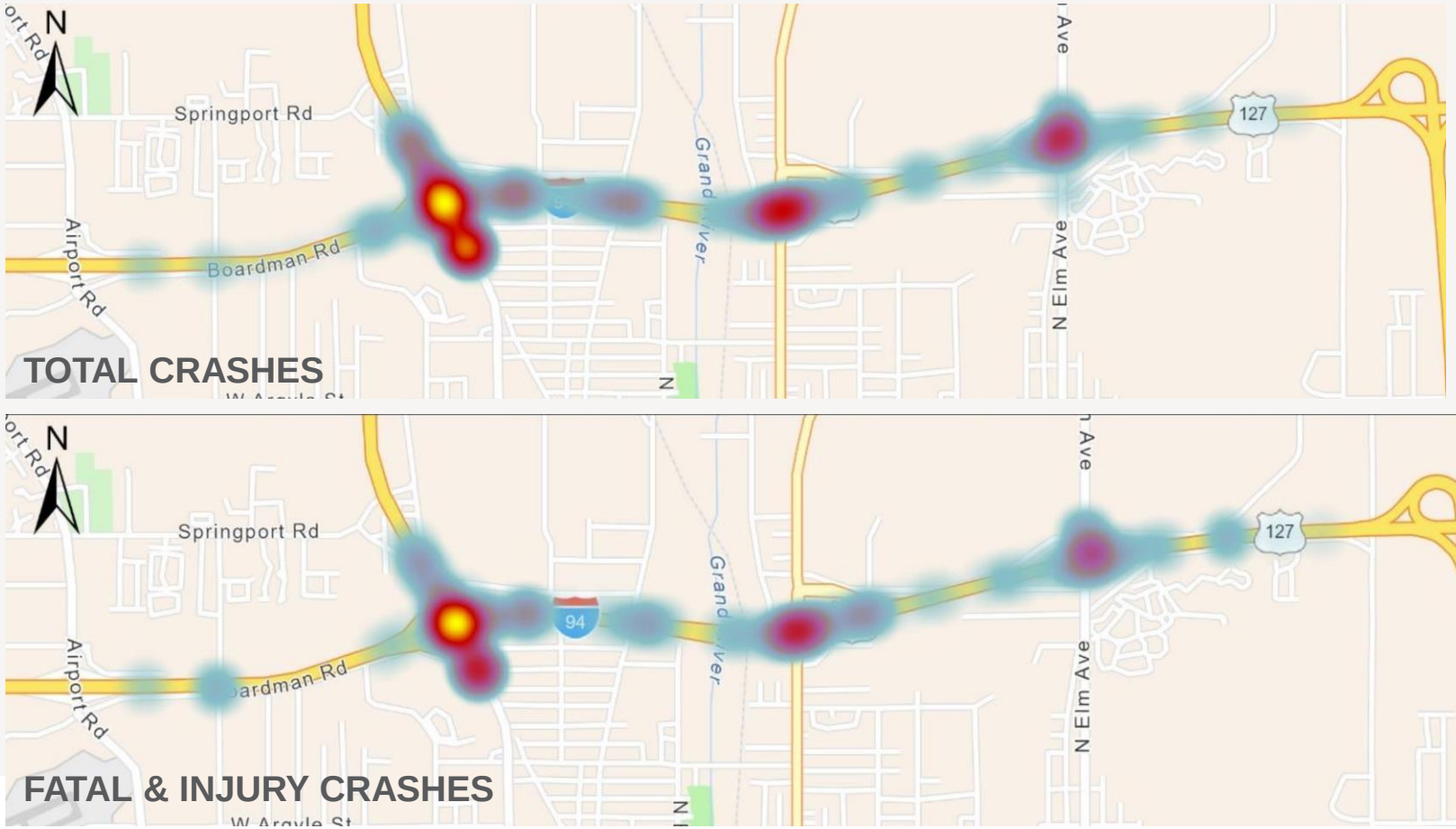
Case Study – I-94 in Jackson



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Case Study – I-94 in Jackson

Location		Predicted crashes without treatment			Predicted crashes with treatment			Change in predicted crashes		
		FI	PDO	TOT	FI	PDO	TOT	FI	PDO	TOT
I-94	Segment	49.22	91.89	141.11	37.80	62.30	100.10	11.42	29.59	41.01
US-127	Segment	7.12	12.21	19.33	10.59	17.29	27.88	-3.47	-5.08	-8.55
US-127/US-127BR/M-50 to EB I-94	Ramp	0.84	1.27	2.11	0.49	0.97	1.46	0.35	0.30	0.65
WB I-94 to US-127	Ramp	0.57	1.01	1.58	0.66	1.04	1.70	-0.09	-0.03	-0.12
US-127/US-127BR/M-50 to EB I-94	Ramp	0.43	0.60	1.03	0.22	0.35	0.57	0.21	0.25	0.46
EB I-94 to US-127BR/M-50	Ramp	0.30	0.40	0.70	0.14	0.20	0.34	0.16	0.20	0.36
EB I-94 to Elm Ave	Ramp	0.05	0.05	0.10	0.09	0.12	0.21	-0.04	-0.07	-0.11
Elm Ave to EB I-94	Ramp	0.09	0.10	0.19	0.10	0.15	0.25	-0.01	-0.05	-0.06
WB I-94 to Elm Ave	Ramp	0.06	0.09	0.15	0.11	0.14	0.25	-0.05	-0.05	-0.10
Elm Ave to WB I-94	Ramp	0.02	0.04	0.06	0.05	0.06	0.11	-0.03	-0.02	-0.05
Elm Ave & Carmen Dr	Intersection	0.65	1.97	2.62	0.18	0.47	0.65	0.47	1.50	1.97
Elm Ave & Rosehill Rd/Seymour Rd	Intersection	1.41	4.07	5.48	0.56	1.55	2.11	0.85	2.52	3.37
Elm Ave & Barrett Ln/Blake Rd	Intersection	0.18	0.47	0.65	0.65	1.97	2.62	-0.47	-1.50	-1.97
TOTAL		**60.94**	**114.17**	**175.11**	**51.64**	**86.61**	**138.25**	**9.30**	**27.56**	**36.86**

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