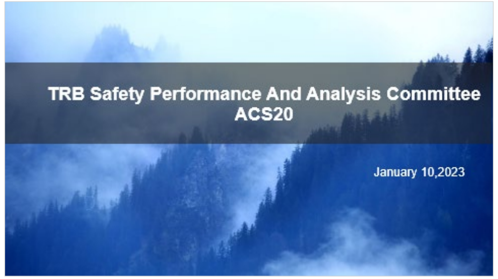
TRB Safety Performance And Analysis Committee ACS20

January 10,2023

Welcome and Introductions

Sign In Form

Agenda



NCHRP 17-100
Leveraging Artificial Intelligence and Big Data to Enhance Safety Analysis
2024 TRB Annual Meeting Safety Performance and Analysis (ACS20) - Wednesday

NCHRP 17-109
Crash Modification Factors for Automated Traffic Signal Performance Measures
2024 TRB Annual Meeting Safety Performance and Analysis (ACS20) - Wednesday

NCHRP 22-49
The Effect of Vehicle Mix on Crash Frequency and Crash Severity
2024 TRB Annual Meeting Safety Performance and Analysis (ACS20) - Wednesday

FHWA Global Benchmarking Study Report on Pedestrian Safety on Urban Arterials

Committee Paper Awards

Update on Second Edition of AASHTO Highway Safety Manual

NCHRP 17-71A
Proposed AASHTO Highway Safety Manual, Second Edition

HSM Implementation Pooled Fund Study Research: Exploring the Validity of Combining Predictive Methods

AASHTOWare Safety Crash Prediction Update

Announcements

Open Floor

Presentations on Safety Related NCHRP Research

NCHRP 17-100
Leveraging Artificial Intelligence and Big Data to Enhance Safety Analysis

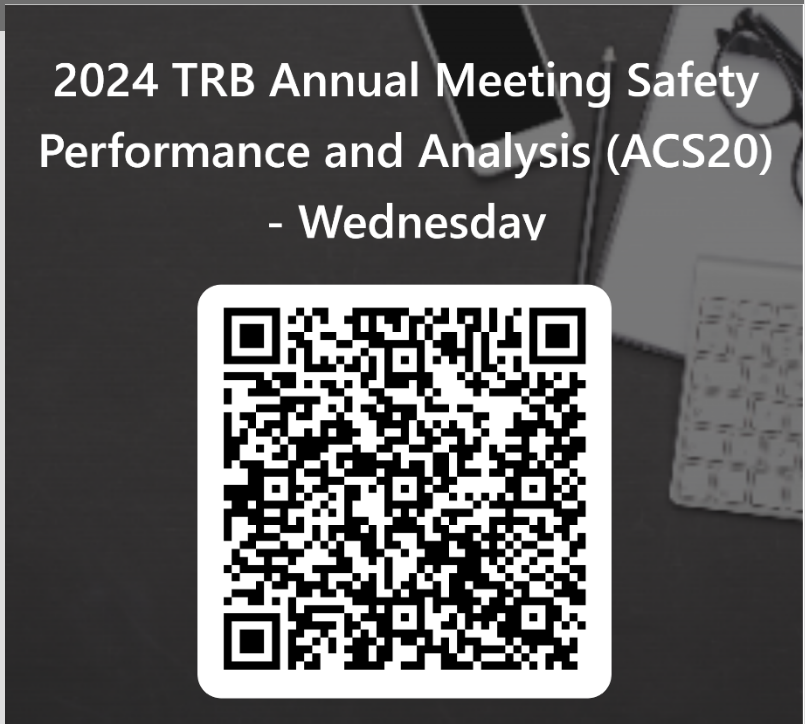
NCHRP 17-100
Leveraging Artificial Intelligence and Big Data to Enhance Safety Analysis

progress report

ACS20 Safety Performance and Analysis Committee meeting
Jan 10, 2024

Shuyi Yin, Dr. Yinhai Wang
on behalf of the NCHRP 17-100 Research Team

NCHRP 17-109
Crash Modification Factors for Automated Traffic Signal Performance Measures



DATE **01/10/2024**

UPDATE ON NCHRP 17-109: CMFS FOR ATSPMS

TRB ACS 20 SAFETY PERFORMANCE AND ANALYSIS COMMITTEE MEETING

BURAK CESME, PHD

KITTELSON & ASSOCIATES

DISCLAIMER

- This presentation is part of the National Cooperative Highway Research Program (NCHRP) Project 17-109. Data reported are work in progress. Contents of this research may have not been reviewed by the NCHRP project panel and nor do they constitute a standard, specification, or regulation. Any opinions and conclusions expressed or implied are those of the individuals and organizations who are performing the research and are not necessarily those of TRB; the National Academies of Sciences, Engineering, and Medicine; the FHWA; or NCHRP sponsors.

Introductions

- **Research Team**
  - Burak Cesme (PI)
  - James Bonneson
  - Nemanja Dobrota
  - Bastian Schroeder
  - Shannon Warchol
  - Laura Zhao
  - Chris Day
  - Anuj Sharma
  - Jonathan Wood

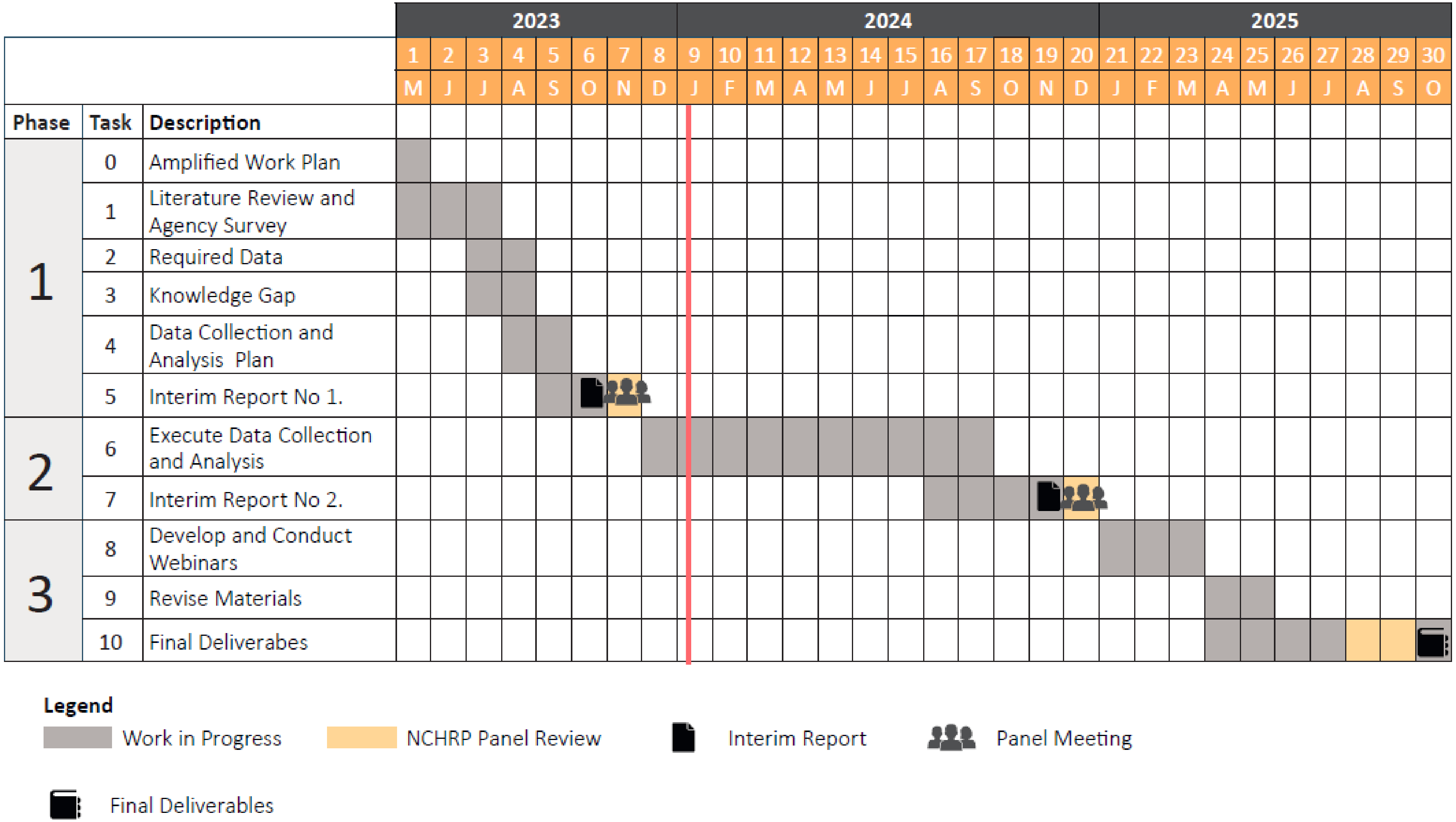
- **Senior Program Officer**
  - Roberto Barcena

- **Project Panel**
  - Mark Taylor (chair)
  - Jay Grossman
  - Khalid Jamil
  - Venkat Nallamothu
  - Stacie Phillips
  - Sunil Taori
  - Di Zhu
  - Woon Kim
  - Kelly Hardy

Research Objectives

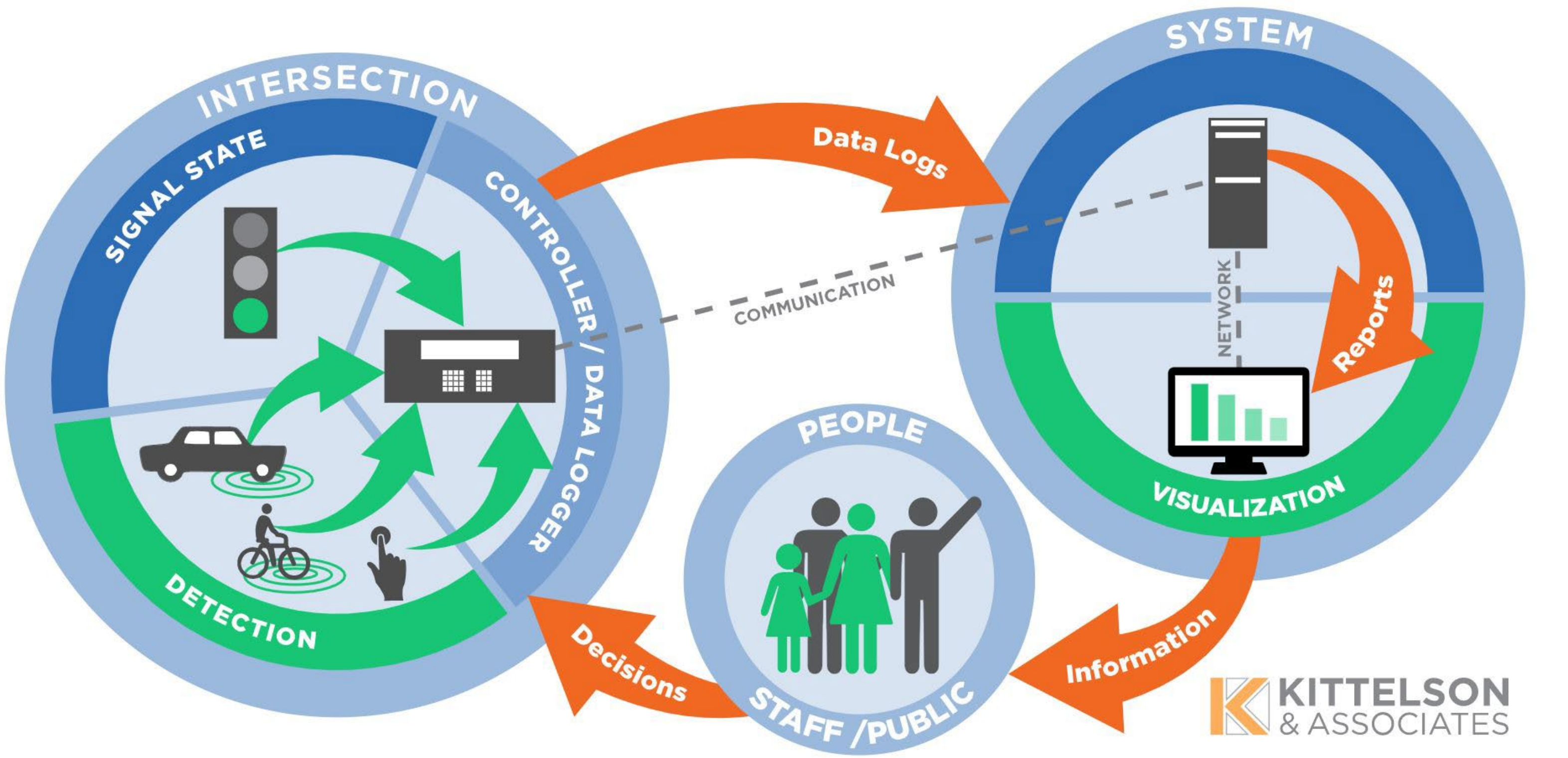
- The objectives of this research are to
  i. Develop crash modification factors (CMFs) for automated traffic signal performance measures (ATSPM) signal timing for all modes and various conflict types and levels of severity
  ii. Estimate potential return on investment on ATSPM deployments to facilitate ATSPM implementation

Project Schedule



Key Definitions and Terms

- Automated Traffic Signal Performance Measures (ATSPMs)

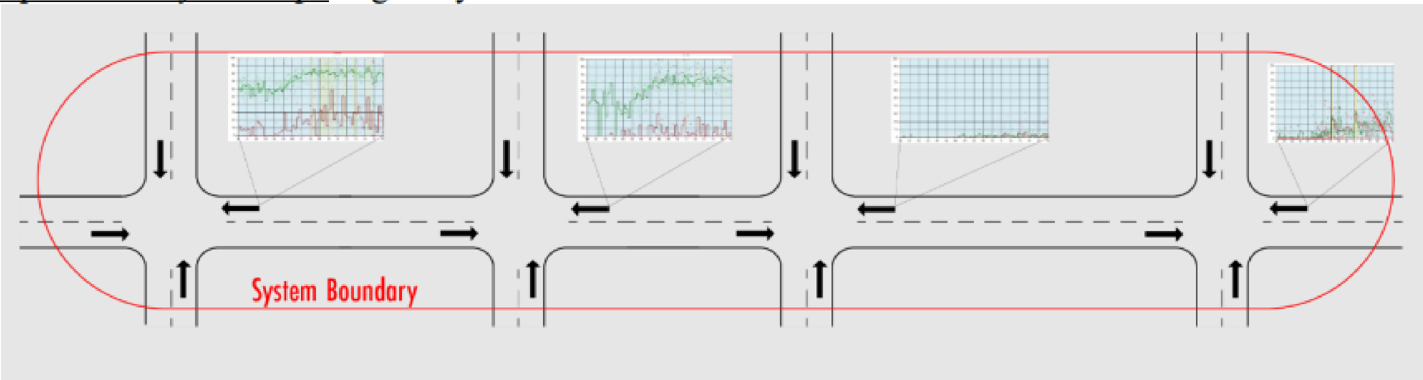


Key Definitions and Terms

- ***Case A CMF***: *Overall evaluation of ATSPM-based systems*

Components

<u>Spatial Analysis Scope</u>: signal system



<u>Example Application Scenarios</u>

1. Predict safety effect of conversion from traditional approach to ATSPM-based system
2. Predict safety effect of change in time interval between ATSPM-based timing adjustments

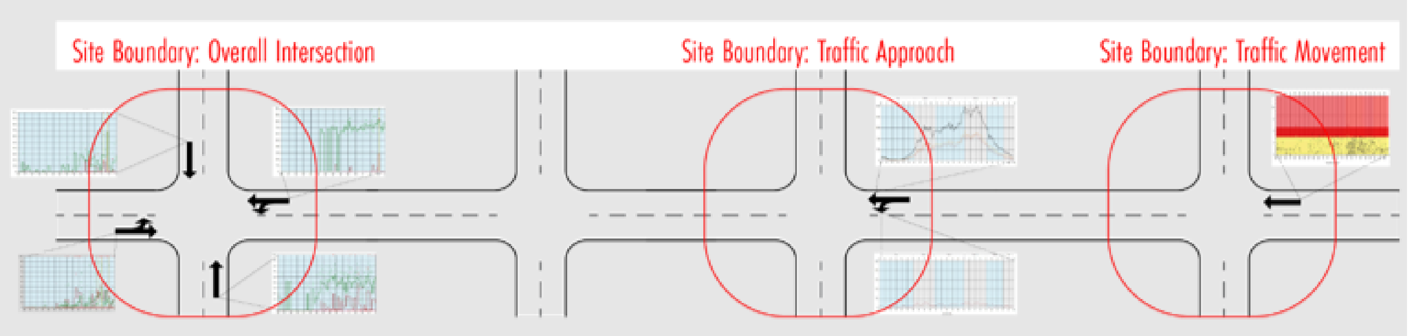
Research Objective: *Compute Case A CMF as a function of intersection characteristics (e.g., signal spacing, speed limit, traffic volume) and ATSPM-system characteristics (e.g., detection scheme, signal timing change frequency using ATSPM reports)*

Key Definitions and Terms

- ***Case B CMF**: Site-based evaluation of individual ATSPM reports*

Components

<u>Spatial Analysis Scope</u>: one, two, …, or all sites in a signal system where a site is an intersection traffic movement, intersection approach lanes, or overall intersection.



<u>Example Application Scenarios</u>

1. Compute safety effect of a reported change in value or level of one or more ATSPMs at one or more sites in system (as may occur after a change to signal timing or operation).

***Research Objective:** Compute Case B CMF <u>for each prioritized knowledge gap</u> that describes the association between the target metric and traffic safety (e.g., average platoon ratio for Percent Arrivals on Green; percent of large gaps for Left Turn Gap Analysis)*

Prioritization of ATSPM Knowledge Gaps for Case B CMFs

Recommendations for Prioritization

Performance Measure	Safety Impact	Agency Interest	Data Availability	Inclusion in Phase II CMF Development
Flash status	Direct	Medium	Low	Maybe
Phase termination (gap-out, max-out, force-off frequency)	Indirect	High	High	Yes (combined as one study)
Split monitor				
Split failures (green and red occupancy ratios)				
Estimated queue length	Indirect	Low	Low	No
Oversaturation severity index	Indirect	Low	Low	No
Pedestrian phase actuation and service	Indirect	Low	Low	No
Estimated pedestrian delay	Indirect	Medium	Medium	Maybe
Estimated pedestrian conflicts	Direct	Medium	Low	Maybe
Yellow and red actuations	Direct	Medium	Medium	Yes (combined as one study)
Red-light-running occurrences				
Preemption details (percent false calls, preempt time)	Indirect	Medium	Low	No
Progression quality (arrivals on green/red, platoon ratio)	Indirect	High	High	Yes (combined as one study)
Purdue coordination diagram				
Cyclic flow profile	Indirect	Low	Low	No
Offset adjustment diagram	Indirect	Medium	Low	No
Travel time and average speed	Indirect	Low	Low	No
Time-space diagram	Indirect	Low	Low	No
Left-turn gap analysis (gaps/cycle, percent large gaps)	Direct	High	Medium	Yes
Timing and Actuation	Indirect	Medium	Medium	No

Data Requirements and Initial Study Designs

Study Designs and Data Needs

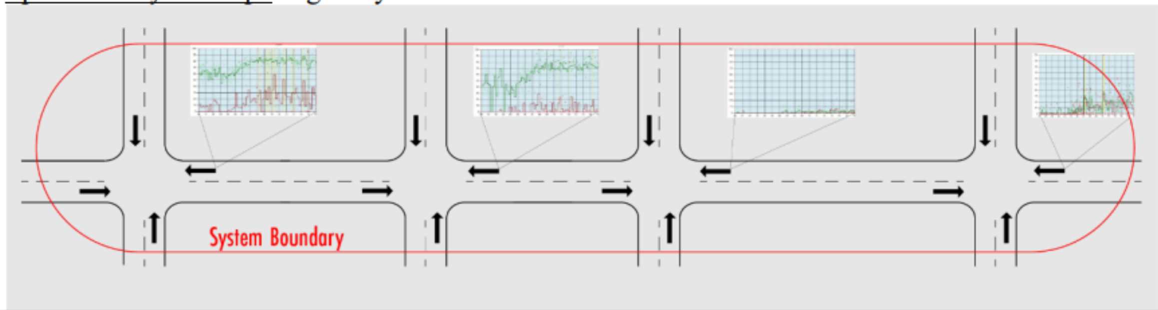
- Study designs developed to identify initial data needs and the methodology followed to develop CMFs in Phase II
  - ***A1. Use of ATSPMs to Manage a Signal System***
  - ***B1. Percent Arrivals on Green***
  - ***B2. Yellow and Red Actuation***
  - ***B3. Split Failure***
  - ***B4. Left Turn Gap Analysis***
- Each study designs follows the same format
  - Study objectives, method, and scope
  - Analysis scale
  - Required data and sources
  - CMF development and application (for case B CMFs)

Study Design A1. Use of ATSPMs to Manage a Signal System

- Set of 8 CMFs that describe the association between ***ATSPM deployment*** and ***safety***
  - 2 crash severity (fatal/injury combined, property damage crashes only)
  - 2 traffic periods (peak hours, non-peak hours)
  - 2 site types (signalized intersections, segments)
- A ***before-and-after study method*** from 6 arterials (3 to 15 signals) for which ATSPMs are currently being used
- For the "before" period, at least 3 consecutive years of crash data
- For the "after" period, at least 1 year of crash data
- Non-ATSPM-operated arterials will be used as ***comparison sites***

Components

Spatial Analysis Scope: signal system



Example Application Scenarios

1. Predict safety effect of conversion from traditional approach to ATSPM-based system
2. Predict safety effect of change in time interval between ATSPM-based timing adjustments

Study Design A1. Signal Related Crashes

CMF	Travel Mode	Crash Severity	Analysis Period	Variable Category	Variables [a]
1	All modes	Fatal and injury	Peak traffic hours / week	Crash characteristics	• Signal-related crashes in signal system during analysis period
				Exposure	• Time duration (= analysis period hours / [7 × 24]) • Count of signalized intersections in signal system • Analysis period AADT (= AADT x proportion AADT during analysis period hours / 7), (can be computed as a segment-length weighted average)[b]
				Key independent	• Signal timing change frequency in analysis period • Proportion of time out-of-service in analysis period • Proportion of signals in system with ATSPM
				Other independent	• Median type • Number of through lanes • Proportion of signalized intersections with major-road left-turn bays • Posted speed limit on major road
2	All modes	PDO	Same as CMF 1	Same as CMF 1	Same as CMF 1
3	All modes	Fatal and injury	Non-peak traffic hours / week	Same as CMF 1	Same as CMF 1
4	All modes	PDO	Same as CMF 3	Same as CMF 1	Same as CMF 1

[a] – All variables are recorded separately for each year of the evaluation time period (i.e., one observation per year).
[b] – Where available, count data obtained from the ATPSM reports will be used instead of the AADT for exposure.

Study Design A1. Non-Signal Related Crashes

CMF	Travel Mode	Crash Severity	Analysis Period	Variable Category	Variables [a]
5	All modes	Fatal and injury	Peak traffic hours / week	Crash characteristics	Non-signal-related crashes in signal system during analysis period
				Exposure	• Time duration (= analysis period hours / [7 × 24]) • Total effective length of segments in system (= total system length – 700 ft for each signal) • Analysis period AADT (= AADT x proportion AADT during analysis period hours / 7), (can be computed as a segment-length weighted average)
				Independent	Same as CMF 1
6	All modes	PDO	Same as CMF 5	Same as CMF 5	Same as CMF 5
7	All modes	Fatal and injury	Non-peak traffic hours / week	Same as CMF 5	Same as CMF 5
8	All modes	PDO	Same as CMF 7	Same as CMF 5	Same as CMF 5

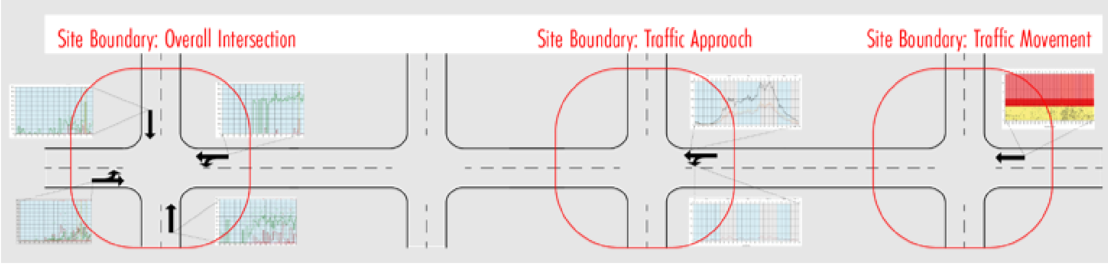
[a] – All variables are recorded separately for each year of the evaluation time period (i.e., one observation per year).

Study Design B4. Left Turn Gap Analysis

- Set of 8 CMFs that describe the association between the availability of ***left turning gaps*** and ***safety***
  - 2 crash severity (fatal/injury combined, property damage crashes only)
  - 2 traffic periods (peak hours, non-peak hours)
  - 2 crash types (left turn related, non-left turn related)
- The ***percent of time in each cycle consisting of large gaps*** will be used as an indicator of left-turn gap availability
- A ***cross-sectional study method*** from at least 50 signalized intersection approaches with permitted only left turns and ATSPMs
- At least 3 consecutive years of crash data and ATSPM data for each approach

Components

Spatial Analysis Scope: one, two, ..., or all sites in a signal system where a site is an intersection traffic movement, intersection approach lanes, or overall intersection.



Example Application Scenarios

1. Compute safety effect of a reported change in value or level of one or more ATSPMs at one or more sites in system (as may occur after a change to signal timing or operation).

Study Design B4. Left Turn Related Crashes

CMF	Travel Mode	Crash Severity	Analysis Period	Variable Category	Variables [a]
1	All modes	Fatal and injury	Peak traffic hours / week	Crash characteristics	• Left-turn-related crashes on the approach during analysis period
				Exposure	• Evaluation time period, in years (ETP) • Analysis period duration, in hours per week (APD) • Analysis period AADT [b] for approach opposing the subject left-turn movement • Analysis period AADT [b] for subject permitted left-turn movement
				Key independent	• Average percent of time in each cycle consisting of large gaps (PTG) • Average cycle length (C)
				Other independent	• Median type • Number of through lanes on the approach • Presence of a left-turn bay • Posted speed limit on approach
2	All modes	PDO	Same as CMF 1	Same as CMF 1	Same as CMF 1
3	All modes	Fatal and injury	Non-peak traffic hours / week	Same as CMF 1	Same as CMF 1
4	All modes	PDO	Same as CMF 3	Same as CMF 1	Same as CMF 1

[a] – All variables are recorded separately for each year of the evaluation time period (i.e., one observation per year).

[b] – Where available, count data obtained from the ATPSM reports will be used instead of the AADT for exposure.

Study Design B4. Non-Left Turn Related Crashes

CMF	Travel Mode	Crash Severity	Analysis Period	Variable Category	Variables [a]
5	All modes	Fatal and injury	Peak traffic hours / week	Crash characteristics	• Non-left-turn-related crashes on the approach during analysis period
				All others	Same as CMF 1
6	All modes	PDO	Same as CMF 5	Same as CMF 5	Same as CMF 5
7	All modes	Fatal and injury	Non-peak traffic hours / week	Same as CMF 5	Same as CMF 5
8	All modes	PDO	Same as CMF 7	Same as CMF 5	Same as CMF 5

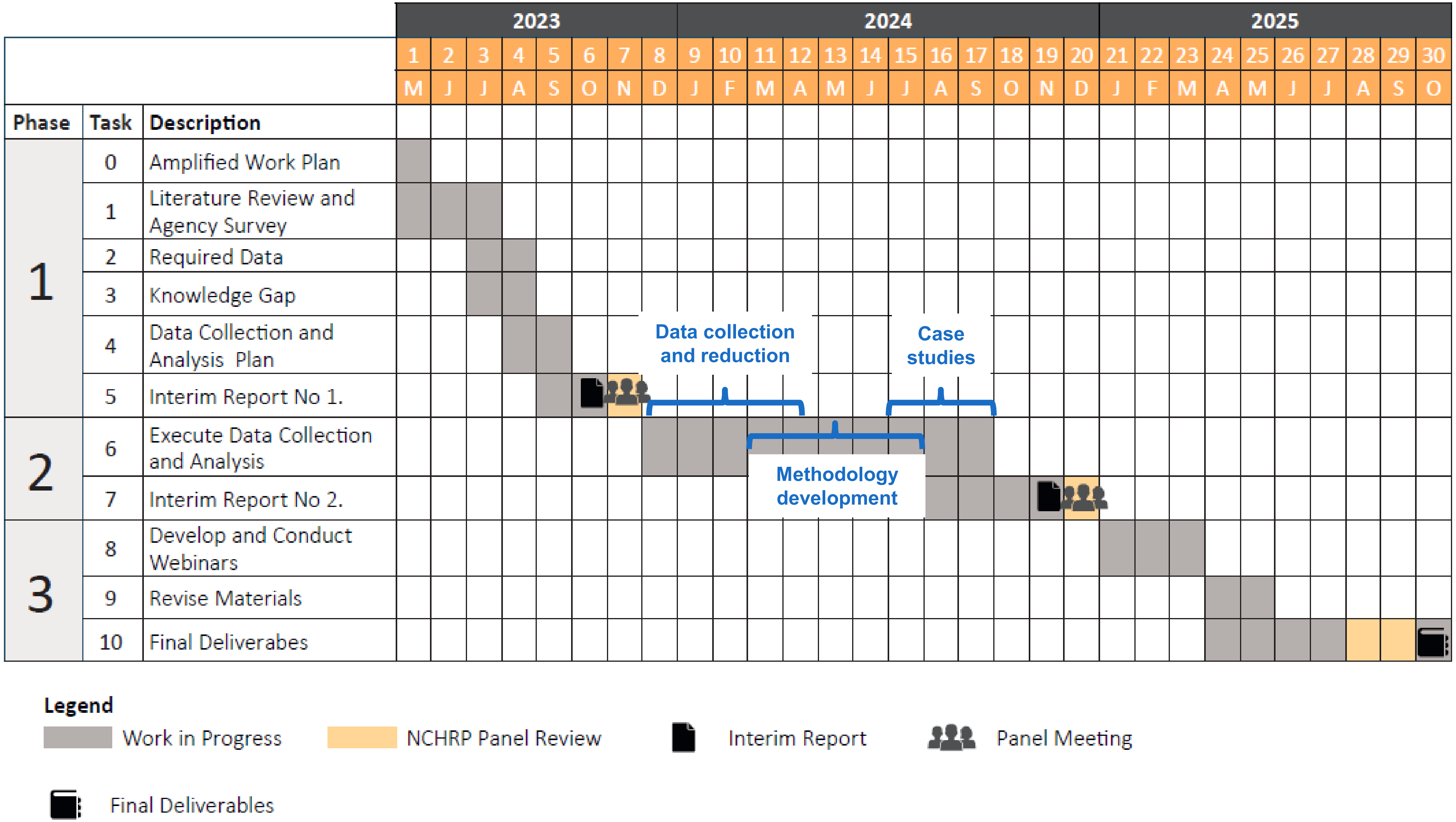
[a] – All variables are recorded separately for each year of the evaluation time period (i.e., one observation per year).

Phase II Tasks and Schedule

Phase II Work Plan by Task

- Task 6. Develop Methodology for Evaluating the Safety Effects of ATSPM-Based Signal Timing
  - Collect and reduce data following the data collection plan developed in Phase I (after approved by the Panel)
  - Develop methodology for case A and case B CMFs as well as standalone application spreadsheets
  - Develop case studies for case A CMFs along with the benefit-cost analysis
- Task 7. Prepare Interim Report No. 2
  - Prepare Interim Report No. 2
  - Meet with the Panel

Phase II Schedule



Questions?

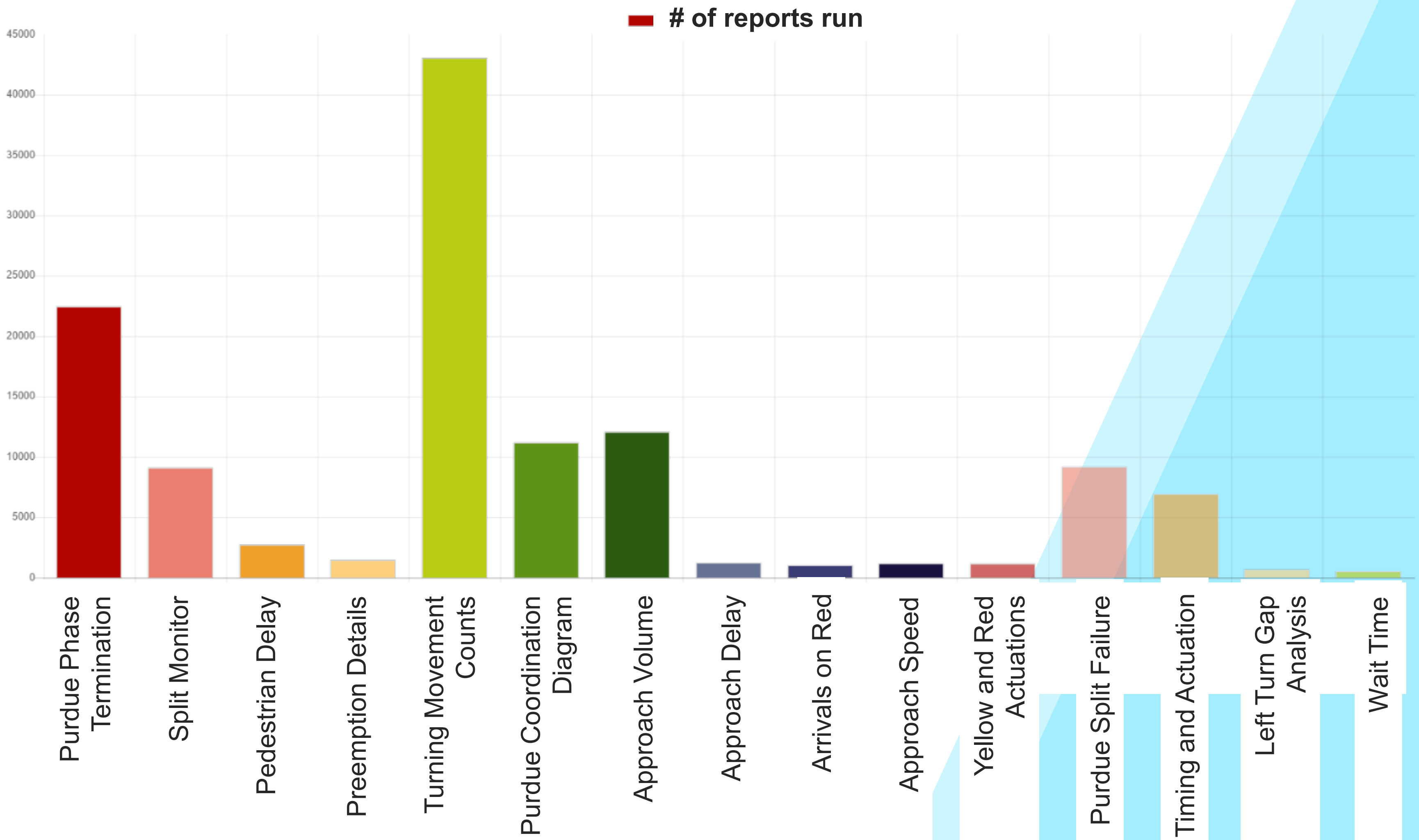
Prioritize Knowledge Gaps

- Case B CMFs prioritization considers the following:
  - Potential safety impact of the ATSPM report
  - The availability of high-quality data/sites to address the research gap
  - Practitioner's need and interest in Case B CMFs for specific ATSPM reports

Performance Measure Name [a]	Safety Impact	Source		
		Day et al., 2014	Nevers et al., 2020	Bassett et al., 2021
1. Communication status			X	
2. Flash status	**Direct**		**X**	
3. Power failures			X	
4. Detection system status		X	X	
5. Vehicle volumes		X	X	X
6. Phase termination (gap-out, max-out, force-off frequency)	Indirect	X	X	X
7. Split monitor	Indirect	X	X	X
8. Split failures (green and red occupancy ratios)	Indirect	X	X	X
9. Estimated vehicle delay		X	X [b]	X
10. Estimated queue length	Indirect	X	X [c]	
11. Oversaturation severity index	Indirect		X	
12. Pedestrian volumes			X	
13. Pedestrian phase actuation and service	Indirect	X	X	X
14. Estimated pedestrian delay	Indirect		X	X
15. Estimated pedestrian conflicts	**Direct**	**X**	**X**	
16. Yellow and red actuations	**Direct**		**X**	**X**
17. Red-light-running occurrences	**Direct**		**X**	**X**
18. Effective cycle length		X	X	
19. Progression quality (arrivals on green/red, platoon ratio)	Indirect	X	X	X
20. Purdue coordination diagram	Indirect	X	X	X
21. Cyclic flow profile	Indirect		X	
22. Offset adjustment diagram	Indirect		X	
23. Travel time and average speed	Indirect		X	X
24. Time-space diagram	Indirect		X	
25. Preemption details (percent false calls, preempt time)	Indirect	X	X	X
26. Priority details (request duration, number of requests)		X	X	
27. Left-turn gap analysis (gaps/cycle, percent large gaps)	**Direct**			**X**
28. Timing and Actuation	Indirect			

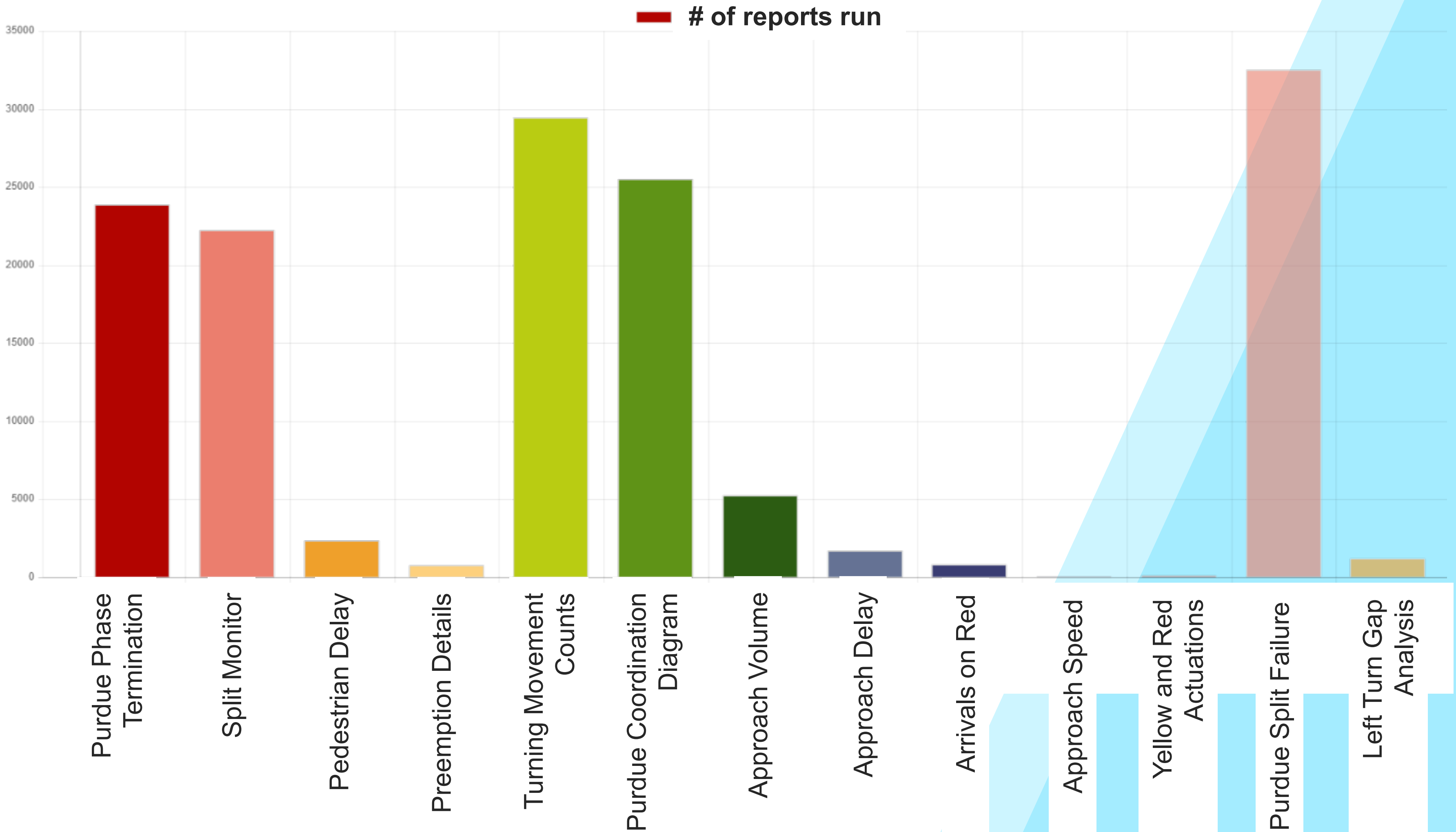
Practitioner Interest in ATSPM Reports

- Chart usage statistics from Utah DOT using 2022 data



Practitioner Interest in ATSPM Reports

- Chart usage statistics from Georgia DOT using 2022 data



NCHRP 22-49
The Effect of Vehicle Mix on Crash Frequency and Crash Severity

NCHRP 22-49

The Effect of Vehicle Mix on Crash Frequency and Crash Severity

NCHRP 22-49 Presentation
Committee on Safety Performance and Analysis (ACS 20)
2024 TRB Annual Meeting

Project Team

Project Team	Team Members
UCF UNIVERSITY OF CENTRAL FLORIDA	Naveen Eluru (Principal Investigator) Tanmoy Bhowmik Shahrior Pervaz Dewan Ashraful Parvez Lauren Hoover Mohamed Abdel-Aty
UCONN UNIVERSITY OF CONNECTICUT	Kai Wang (Co-Principal Investigator) John N. Ivan Shanshan Zhao Manmohan Joshi

Program Officer and Panel Members

Camille Crichton-Sumners (**Senior Program Officer**)
Randy (Brad) Bradley II, FDOT (**Chair**)
Larbi Hanni, TxDOT
William Paille, BSC Group
Jeffrey Pulver, Maine DOT
Karla Rodrigues Silva, City of Gainsville
Ida Van Schalkwyk, Washington DOT
Jonathan Wood, Iowa State University
Carol Tan, FHWA liaison

Outline

Project Background and Objectives

Key Research Elements

- Facility Selection
- Datasets
- Model Frameworks
- Recommended Models by Facility

Project Tasks

Key Deliverables

Project Background and Objectives

Project Background

- Currently, Highway Safety Manual (HSM) does not account for the influence of vehicle mix information while modeling crash frequency and severity

- However, recent research efforts show a substantial impact of vehicle mix on crashes

- Thus, the incorporation of vehicle mix would improve crash predictive methods and assist in better use of the limited funds and resources

Project Objectives (from RFP)

Objective 1

Develop methods to quantify the effect of vehicle mix on crash frequency and severity for various facility types

Objective 2

Develop a spreadsheet tool for practitioners to quantify the effect of vehicle mix on safety performance

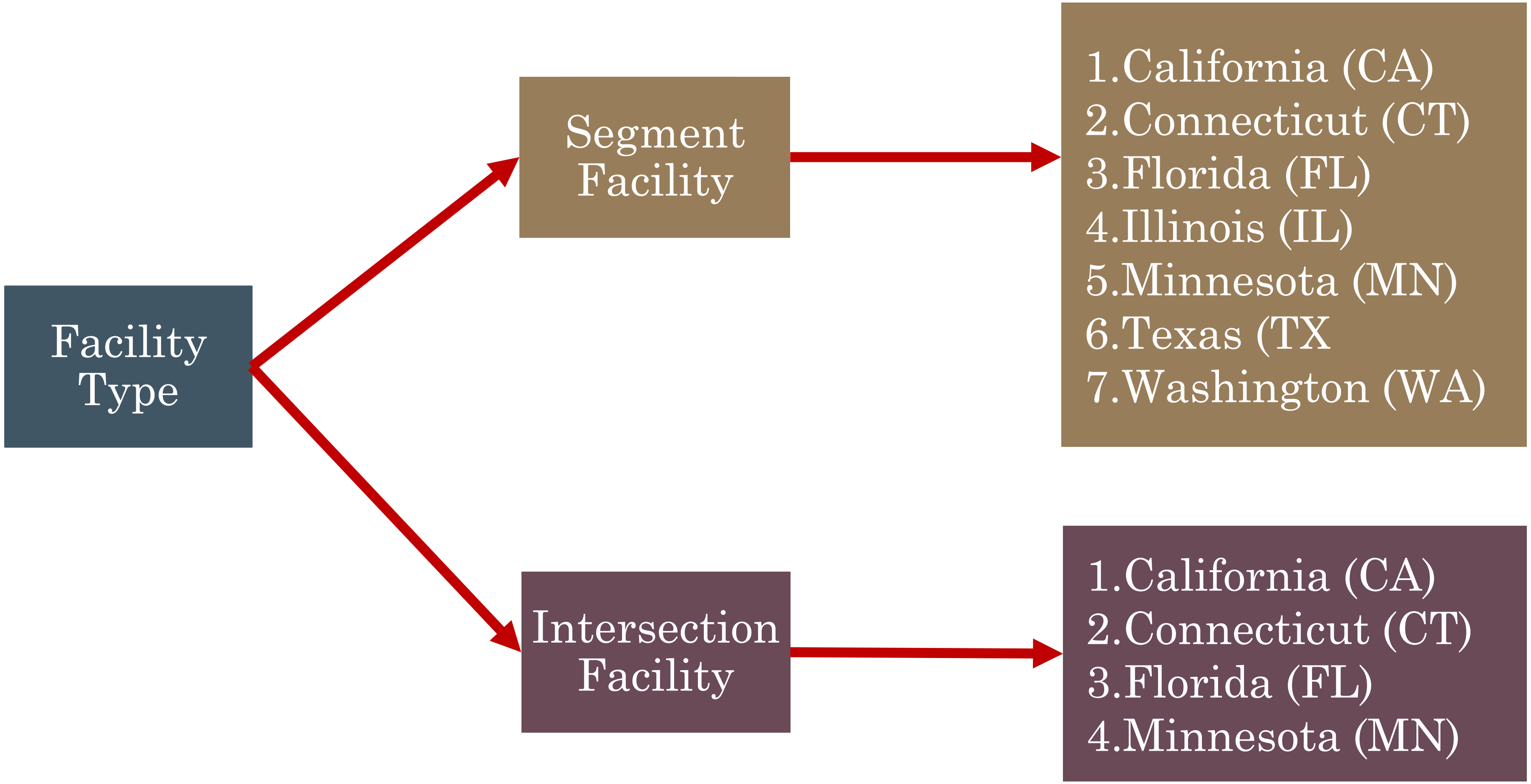
Key Research Elements

Facility Selection

Facility Selection

- First, the team focused on the **facilities** that are covered in the first edition of the **HSM**
  - rural two-lane two-way roadways, rural multilane highways, urban/suburban arterials, freeway segments and intersections
- Each facility is **further categorized** into multiple categories based on different variables (*number of lanes, presence of median*).
- Estimating models for **all the facilities** will require **substantial amount of time and effort**
  - Vehicle mix might not vary across locations
- The research team focused on **major facilities** based on **total and heavy vehicle crashes.**

Facility Selection: States



Facility Selection: Detailed Classification

Facility Type

- **Segment Facility**
  - 1. CA
  - 2. CT
  - 3. FL
  - 4. IL
  - 5. MN
  - 6. TX
  - 7. WA

Limited Access Facilities:
1. Urban 4-LD
2. Urban 6-LD
3. Urban 8-LD
4. Urban 10-LD
5. Rural 4-LD
6. Rural 6-LD
7. Rural 8-LD

Arterials:
1. Urban 2-LUD
2. Urban 3-L
3. Urban 4-LUD
4. Urban 4-LD
5. Urban 5-L
6. Rural 2-LUD
7. Rural 3-L
8. Rural 4-LUD
9. Rural 4-LD
10. Rural 5-L

- **Intersection Facility**
  - 1. CA
  - 2. CT
  - 3. FL
  - 4. MN

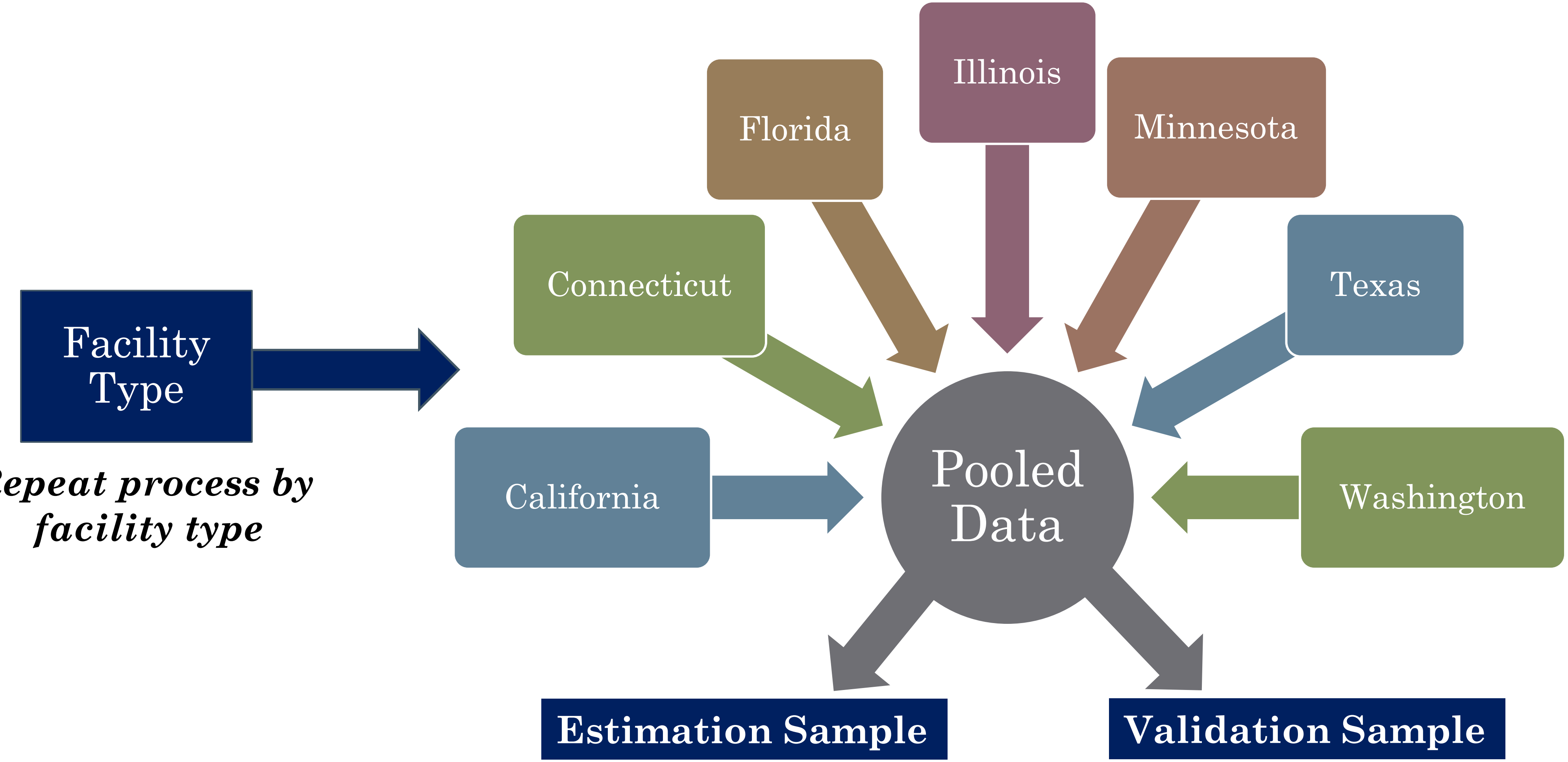
STOP Controlled:
1. Urban 3-leg
2. Urban 4-leg
3. Rural 3-leg
4. Rural 4-leg

Signalized:
1. Urban 3-leg
2. Urban 4-leg
3. Rural 4-leg

24 Facilities

Datasets

Model Estimation on Pooled Datasets



Repeat process by facility type

Variables

Variable Assessment

- Independent Variables
  - **HSM** aligned variables
    - **Roadway Characteristics**
      - Lane width, median width, shoulder width
    - **Traffic Characteristics**
      - AADT, major AADT, minor AADT
  - New **vehicle mix** variables
    - *Coarser Level*: %truck, %major road truck, %minor road truck
    - *Finer Level*: %truck types (single unit, double unit etc.)

Vehicle Mix Data Availability

State	Vehicle Mix Data Availability	Vehicle Classification		Data Used for Models	Source
		Coarse	Fine		
HSIS States					
California	Available	Car	--	Observed	CDOT
		Truck	Two axle, three axle, four axle, five axle		
Illinois	Available	Car	--	Observed	IDOT
		Truck	Single unit, multi-unit		
Minnesota	Available	Car	--	Observed	MNDOT
		Truck	Single unit, combination unit truck		
Washington	Available	Car	--	Observed	WSDOT
		Truck	Single unit, double unit and triple unit		
Non-HSIS States					
Connecticut	Not Available	Car	--	Generated	**QIE technique**
		Truck	--		
Florida	Available	Car	--	Observed	FDOT
		Truck	--		
Texas	Available	Car	--	Observed	TXDOT
		Truck	Single unit, combination truck		

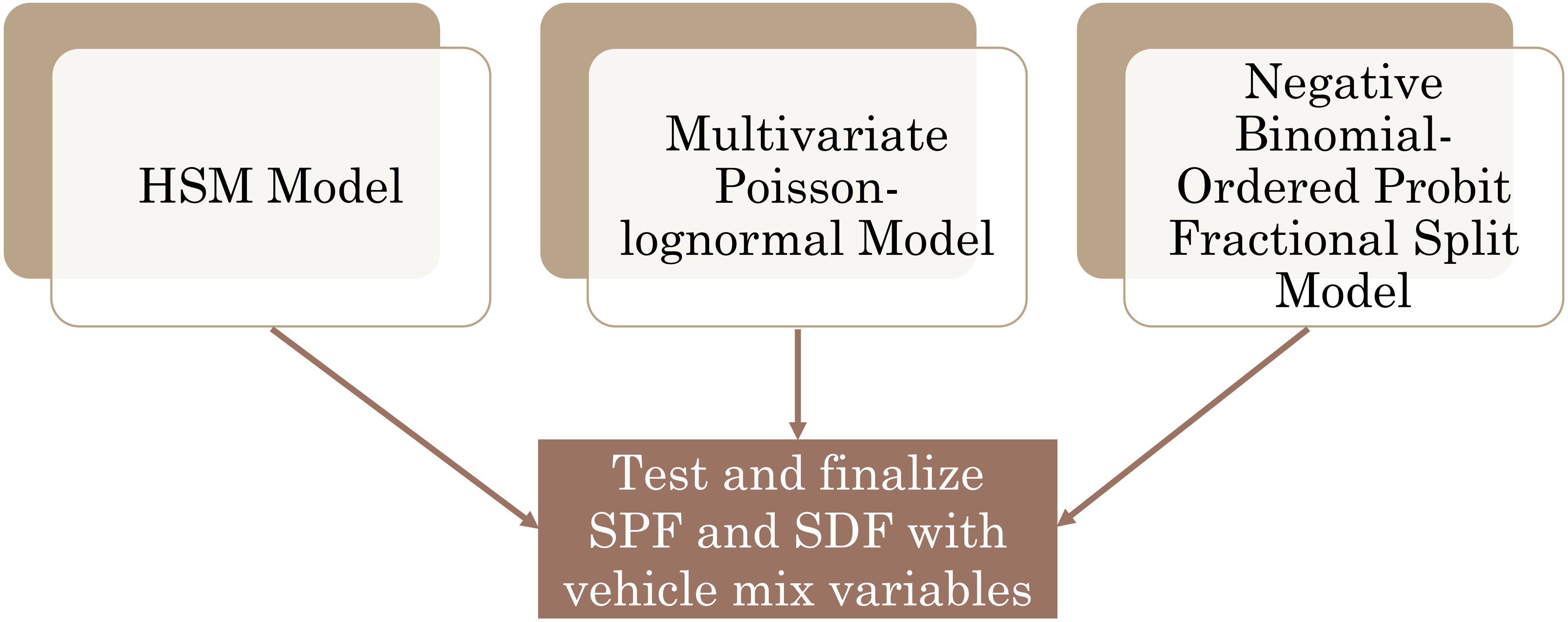
Model Estimation with Truck Data

- Based on data availability, we used following variables as **vehicle mix** data
  - **%truck:** Truck AADT*100/AADT
  - **%SUT:** Single unit truck AADT*100/AADT
  - **%major road truck:** Truck AADT in major road*100/major road AADT
  - **%major road truck:** Truck AADT in minor road*100/minor road AADT

- To consider **additional forms** of truck traffic affecting crash counts
  - We tested for the impact of trucks in locations with high truck volume
    - These are locations with **truck proportion >= 85th Percentile of truck traffic proportion** for the facility type
    - For Rural Arterial 2 Lane Undivided (RA2LUD) segments, the high truck 85th percentile value was 20%.

Model Frameworks and Selection

Model Frameworks



Multivariate Count Method

ID	Total Crash	PDO	Injury	Fatal
1	10	6	4	0
2	12	6	5	1
3	8	5	2	1
4	4	0	3	1

Crash counts by severity level

Develop Multivariate Poisson Log-normal (MVPLN) model for crash severity levels at each facility type

Count Fractional Split Method

ID	Total Crash	PDO	Injury	Fatal	PDO	Injury	Fatal
1	10	6	4	0	0.6	0.4	0
2	12	6	5	1	0.5	0.42	0.08
3	8	5	2	1	0.63	0.25	0.12
4	4	0	3	1	0	0.75	**0.25**

NB Model

Ordered Fractional Split Model

Predicted Total Crash Counts

X

Predicted Severity Counts

Predicted Severity Proportions

Illustration for RA4LUD

NB-OPFS Model Result (RA4LUD)

Variable Names	NB Model Component	OPFS Model Component
	Estimates	Estimates
Constant	-4.560	--
Threshold Parameters		
Threshold between O-C	--	-0.299
Threshold between C-B	--	0.154
Threshold between B-A	--	0.804
Threshold between A-K	--	1.365
Roadway Characteristics		
Ln (Segment Length, Miles)	1.000	0.036
Lane width (≤12 feet)		
LW>12	-0.237	--
Outside shoulder width (base: ≥6 feet)		
OSW<6	-0.161	--
Shoulder type (base: paved)		
Unpaved	0.236	--
Speed limit (base: 41-55 mph)		
SL≤40	--	-0.223
SL>55	-0.247	--

90% Significance level

5 years of crash data

NB-OPFS Model Result (RA4LUD)

Variable Names	NB Model Component	OPFS Model Component
	Estimates	Estimates
Traffic Characteristics		
Ln (AADT)	0.651	-0.068
Ln(AADT)*Indicator for AADT≤10,000	0.029	--
Ln(AADT)*Indicator for AADT≤14,000	-0.038	--
%Truck	-0.030	--
%SUT	-0.100	--
State Indicators	(Base: CA, CT, FL, TX, WA)	(Base: CA, CT, FL, MN, TX)
State-Illinois	1.250	-0.470
State-Minnesota	-0.542	--
State-Washington	--	-0.290

90% Significance level

5 years of crash data

CA = California
CT = Connecticut
FL = Florida
MN = Minnesota
TX = Texas
WA = Washington

HSM Highway Safety Manual

NCHRP NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

MVPLN Model Result (RA4LUD)

Variable Names	O	C	B	A	K
Constant	-5.697	-6.921	-5.772	-7.210	-8.030
Roadway Characteristics					
Lane width (base: ≤12 feet)					
LW>12	-0.401	-0.398	-0.619	-0.424	--
Outside shoulder width (base: ≥6 feet)					
OSW<6	0.227	--	0.262	--	--
Speed limit (base: 41-55 mph)					
SL≤40	--	--	-0.665	--	--
SL>55	-0.268	-0.265	--	--	1.027
Traffic Characteristics					
Ln (AADT)	0.611	0.568	0.440	0.459	0.418
%Truck	-0.026	-0.032	-0.040	--	-0.052
%SUT	-0.111	-0.096	-0.074	--	--
HTZ (base: Indicator for <85th percentile of truck percentage)	-0.476	--	--	-0.581	0.77
State Indicators (base: CA, CT, FL, TX)					
State- Illinois	1.574	--	1.280	1.874	--
State- Minnesota	-0.443	--	--	-1.654	--
State- Washington	1.204	1.135	--	--	--

90% Significance level

5 years of crash data

CA = California
CT = Connecticut
FL = Florida
TX = Texas

MVPLN Model Result (RA4LUD)

Variable Names	O	C	B	A	K
Variance-Covariance Matrix	O	C	B	A	K
O	2.436	2.314	2.223	2.027	1.553
C		2.375	2.169	1.950	1.506
B			2.244	1.949	1.496
A				1.914	1.386
K					1.222
Pearson Correlation Coefficients	O	C	B	A	K
O	-	0.962	0.951	0.939	0.900
C		-	0.940	0.915	0.884
B			-	0.940	0.903
A				-	0.906
K					-

Model Selection

- **Use of mean square error and predictive error**
  - We employed two different measures of fit:
    - Mean Absolute Deviation (MAD)

$$\text{MAD} = mean\,|\hat{y}_i - y_i|$$

    - Mean Squared Prediction Error (MSPE)

$$\text{MSPE} = mean\,(\hat{y}_i - y_i)^2$$

where
$\hat{y}_i$ = Predicted crashes,
y_i = Observed crashes, at space i over a period of time.

- **The smaller the value, the better the model predicts observed crashes.**

Measures of Fit (RA4LUD)

Goodness of fit		Model	O	C	B	A	K	Total
Estimation Sample	MAD	HSM	1.376	0.286	0.293	0.118	0.052	2.000
		NB-OLFS	1.316	0.301	0.303	0.132	0.061	1.810
		MVPLN	1.484	0.323	0.330	0.166	0.060	2.042
	MSPE	HSM	22.539	0.862	2.295	0.376	0.078	65.808
		NB-OLFS	11.008	0.467	0.446	0.112	0.037	19.488
		MVPLN	16.066	0.575	0.521	0.142	0.036	28.099
Validation Sample	MAD	HSM	1.379	0.288	0.309	0.130	0.054	1.996
		NB-OLFS	1.319	0.294	0.324	0.138	0.064	1.839
		MVPLN	1.473	0.316	0.350	0.172	0.064	2.043
	MSPE	HSM	20.442	0.779	1.168	0.238	0.058	43.399
		NB-OLFS	9.841	0.405	0.535	0.116	0.045	17.359
		MVPLN	12.201	0.412	0.601	0.142	0.045	21.098

Model Selection Process

- For each facility type: 3 Models
  - HSM
  - Multivariate Poisson Lognormal
  - Negative Binomial Fractional Split

- For each model: **2 Performance measures**
  - MAD
  - MSPE

- MAD and MSPE
  - **2 samples**: estimation and validation
  - For all **5 severity (KABCO) categories**

Model Selection Process

- For each facility type: 3 Models
  - HSM
  - Multivariate Poisson Lognormal
  - Negative Binomial Fractional Split
- For each model: **2 Performance measures**
  - MAD
  - MSPE
- MAD and MSPE
  - **2 samples**: estimation and validation
  - For all **5 severity (KABCO) categories**

- Identifying the **"best"** model is **challenging**
- **20 dimensions** are compared (2*2*5)
- It is unlikely: single model **outperforms** across all 20 measures

Model Selection Process

- We considered **2 approaches**
  - The first approach employs **total crash frequency** – model that performs better in predicting **total crash counts** for both samples (estimation and validation)
  - The second approach employs a **scoring process** where the models that perform well for the severity levels are awarded a point and the score for each model **across the severity** levels is aggregated.
- The **final selection** is considered based on **2 approaches**

Model Selection Process

- **Total crash approach**
  - Identified the model that provides the lowest MAD and MSPE (summation of estimation and validation) with respect to total crash frequency.

Facility	Measures	Models	Total Estimation	Total Validation	Total for Count	Top Performing Model
RA4LUD	MAD	HSM	2.000	1.996	3.996	NB-OPFS
		NB-OPFS	1.810	1.839	3.649	
		MVPLN	2.042	2.043	4.085	
	MSPE	HSM	65.808	43.399	109.207	NB-OPFS
		NB-OPFS	19.488	17.359	36.847	
		MVPLN	28.099	21.098	49.197	

Model Selection Process

- **Severity level scoring approach**
  - For MAD and MSPE
    - Assigned a value of 1 for top performing model for each severity category while a value of 0 for other models
    - Assigned 1 for models with similar performance (difference in the value <10%)

Facility	Measures	Models	Value					Score				
			O	C	B	A	K	O	C	B	A	K
RA4LUD	MAD	HSM	1.38	0.29	0.29	0.12	0.05	1	1	1	1	1
		NB-OPFS	1.32	0.30	0.30	0.13	0.06	1	1	1	0	0
		MVPLN	1.48	0.32	0.33	0.17	0.06	0	0	0	0	0
	MSPE	HSM	22.54	0.86	2.30	0.38	0.08	0	0	0	0	0
		NB-OPFS	11.01	0.47	0.45	0.11	0.04	1	1	1	1	1
		MVPLN	16.07	0.58	0.52	0.14	0.04	0	0	0	0	1

Model Selection Process

- **Severity level scoring approach**
  - For MAD and MSPE
    - Total score is the sum of the score across severity categories
    - The higher the total score, the better the model
    - The score are generated considering **both estimation and validation sample**

Facility	Measures	Models	Score O	Score C	Score B	Score A	Score K	Total Score	Top Performing Model
RA4LUD	MAD	HSM	2	2	2	2	2	<u>10</u>	HSM
		NB-OPFS	2	2	1	1	0	7	
		MVPLN	0	0	0	0	1	1	
	MSPE	HSM	0	0	0	0	0	0	NB-OPFS
		NB-OPFS	2	2	2	2	2	<u>10</u>	
		MVPLN	0	0	0	1	2	3	

HSM Highway Safety Manual

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Model Selection Process

- **Combine two scoring approach**
  - The final model selection is obtained based on the combination of two approaches

Facility	Measures	Total crash approach	Severity level scoring approach	Final Selection
RA4LUD	MAD	NB-OPFS	HSM	NB-OPFS
	MSPE	NB-OPFS	NB-OPFS	

Final Model Selection by Facility Group

Model Recommendations for Segment Facilities

Facility Group	Facility	Selected for Facility	Recommended for Facility Group
Urban Limited Access	Urban 4-lane divided (ULA4LD)	NB-OPFS	NB-OPFS
	Urban 6-lane divided (ULA6LD)	HSM	HSM
	Urban 8-lane divided (ULA8LD)	HSM	
	Urban 10-lane divided (ULA10LD)	HSM	
Rural Limited Access	Rural 4-lane divided (RLA4LD)	HSM	HSM
	Rural 6-lane divided (RLA6LD)	HSM	
	Rural 8-lane divided (RLA8LD)	HSM	
Urban Arterials	Urban 2-lane undivided (UA2LUD)	NB-OPFS	NB-OPFS
	Urban 3-lane (UA3L)	NB-OPFS/HSM	
	Urban 5-lane (UA5L)	HSM	
	Urban 4-lane undivided (UA4LUD)	NB-OPFS	
	Urban 4-lane divided (UA4LD)	NB-OPFS	
Rural Arterials	Rural 2-lane undivided (RA2LUD)	NB-OPFS	NB-OPFS
	Rural 3-lane (RA3L)	NB-OPFS	
	Rural 5-lane (RA5L)	MVPLN	
	Rural 4-lane undivided (RA4LUD)	NB-OPFS	
	Rural 4-lane divided (RA4LD)	NB-OPFS	

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Model Recommendations for Intersection Facilities

Facility Group	Facility	Selected for Facility	Recommended for Facility Group
Urban Intersections	Urban 3-leg STOP controlled (U3ST)	NB-OPFS/MVPLN	MVPLN
	Urban 4-leg STOP controlled (U4ST)	MVPLN	
	Urban 3-leg signalized (U3SG)	MVPLN	
	Urban 4-leg signalized (U4SG)	MVPLN	
Rural Intersections	Rural 3-leg STOP controlled (R3ST)	NB-OPFS	NB-OPFS
	Rural 4-leg STOP controlled (R4ST)	NB-OPFS/MVPLN	
	Rural 4-leg signalized (R4SG)	NB-OPFS	

Model Recommendations for Segment Facilities

Facility Group	Facility	Recommended for Facility Group
Urban Limited Access	Urban 4-lane divided (ULA4LD)	NB-OPFS
	Urban 6-lane divided (ULA6LD)	HSM
	Urban 8-lane divided (ULA8LD)	
	Urban 10-lane divided (ULA10LD)	
Rural Limited Access	Rural 4-lane divided (RLA4LD)	HSM
	Rural 6-lane divided (RLA6LD)	
	Rural 8-lane divided (RLA8LD)	
Urban Arterials	Urban 2-lane undivided (UA2LUD)	NB-OPFS
	Urban 3-lane (UA3L)	
	Urban 5-lane (UA5L)	
	Urban 4-lane undivided (UA4LUD)	
	Urban 4-lane divided (UA4LD)	
Rural Arterials	Rural 2-lane undivided (RA2LUD)	NB-OPFS
	Rural 3-lane (RA3L)	
	Rural 5-lane (RA5L)	
	Rural 4-lane undivided (RA4LUD)	
	Rural 4-lane divided (RA4LD)	

Model Recommendations for Intersection Facilities

Facility Group	Facility	Recommended for Facility Group
Urban Intersections	Urban 3-leg STOP controlled (U3ST)	MVPLN
	Urban 4-leg STOP controlled (U4ST)	
	Urban 3-leg signalized (U3SG)	
	Urban 4-leg signalized (U4SG)	
Rural Intersections	Rural 3-leg STOP controlled (R3ST)	NB-OPFS
	Rural 4-leg STOP controlled (R4ST)	
	Rural 4-leg signalized (R4SG)	

Project Tasks

Project Tasks Completed

Phase I
Task 1: Prepare a **technical report** that summarizes **literature** review, **data availability**, **analytical approaches** and develops a **framework** for incorporating vehicle mix in frequency and severity models
Task 2: Develop a detailed **work plan** with **data sources**, selected **facility types**, **data processing** and **analysis approaches**, **validation** metrics and **spreadsheet** development
Task 3: Prepare and submit an **interim report**

Project Tasks Completed

Phase II
Task 4: **Apply** the **proposed framework** by processing the data, **estimating and validating models** by facility type and **examining model performance**
Task 5: Develop a **spreadsheet tool** clearly outlining the methodology and application guidance
Task 6: Use **practical examples**, to test and illustrate the spreadsheet tool
Task 7: Prepare an **instruction guide** and a **quick start guide** for facilitating **adoption** of the developed models

Project Tasks Completed

Phase II
Task 8: Provide a **virtual demonstration** for the **NCHRP Panel** as well as a final presentation to sponsoring committees including coordination with NCHRP and AASHTO Committee on Highway Traffic Safety
Task 9: Prepare an accessible report with **guidelines for future HSM adoption**
Task 10: Prepare **draft final** deliverables
Task 11: Prepare **documentation and guidance** summarizing the **research effort**, **future recommendations**, **spreadsheet tools**, to enhance state DOTs' procedures for updating crash frequency and severity models and a **TR News article**

Key Project Deliverables

Final Report

Excel Spreadsheet Tools

Final Report

Project NCHRP 22-49

The Effect of Vehicle Mix on Crash Frequency and Crash Severity

FINAL DRAFT DELIVERABLE

Prepared for NCHRP
Transportation Research Board
of
The National Academies of Sciences, Engineering, and Medicine

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES
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Report Prepared by
Naveen Eluru, Tanmoy Bhowmik, Shahrior Pervaz, Dewan Ashraful Parvez, Lauren Hoover, Mohamed Abdel-Aty, Kai Wang, John N. Ivan, Shanshan Zhao, Manmohan Joshi

University of Central Florida, Orlando, FL
University of Connecticut, Storrs Mansfield, CT
June 2023

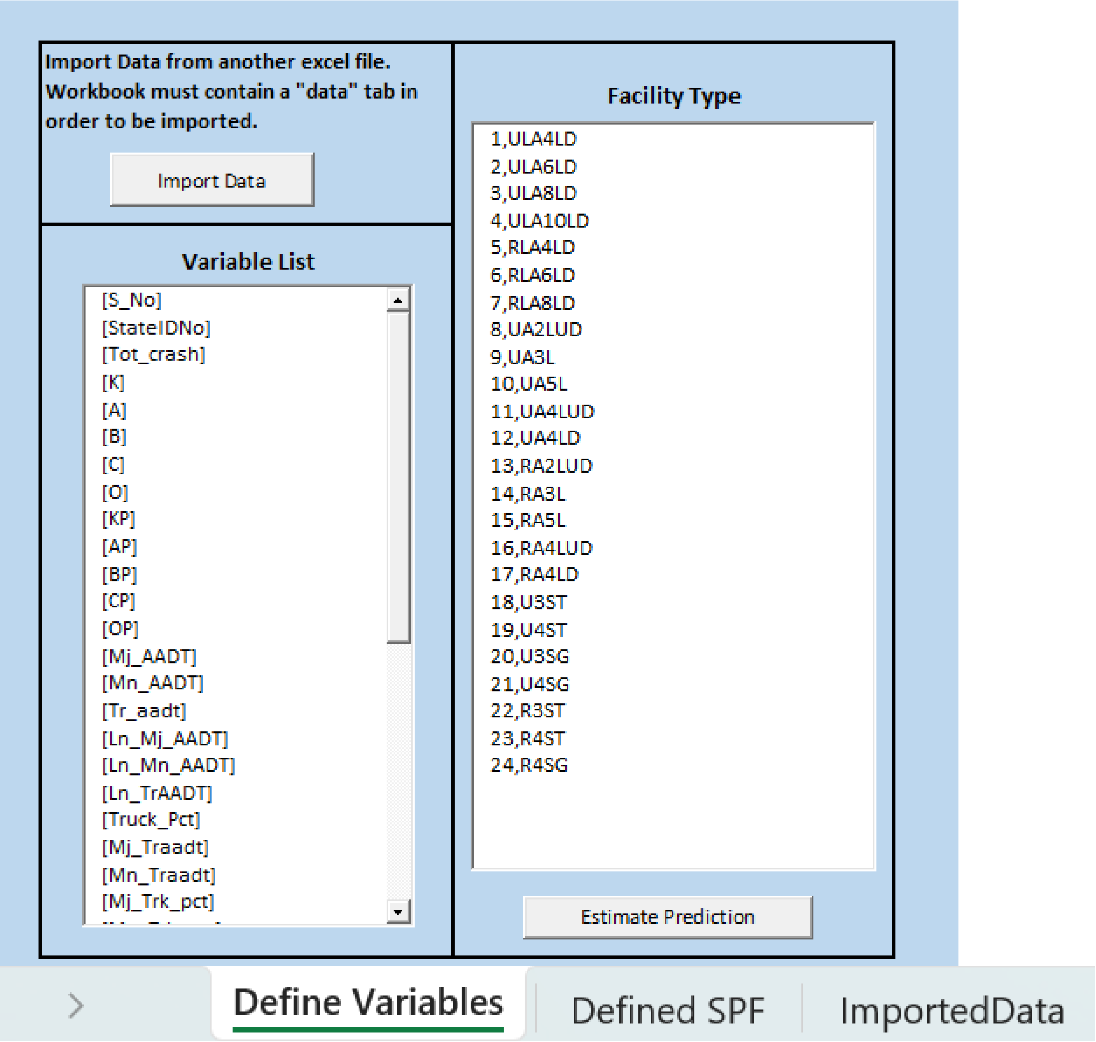
- Documented the research completed in this project.
- Chapters are:
  - Chapter 1: Introduction
  - Chapter 2: Literature Review
  - Chapter 3: Data Description
  - Chapter 4: Methodology
  - Chapter 5: Model Selection and Facility Specific Recommendations
  - Chapter 6: Recommended Model Parameters
  - Chapter 7: Conclusions

Excel Spreadsheet Tools

- To aid the practitioners in implementing the new models the research team developed three excel spreadsheet tools including:
  - **22-49 Spreadsheet Tool without Calibration,**
  - **22-49 Spreadsheet Tool with Calibration, and**
  - **22-49 Data Input and Prediction Tool**

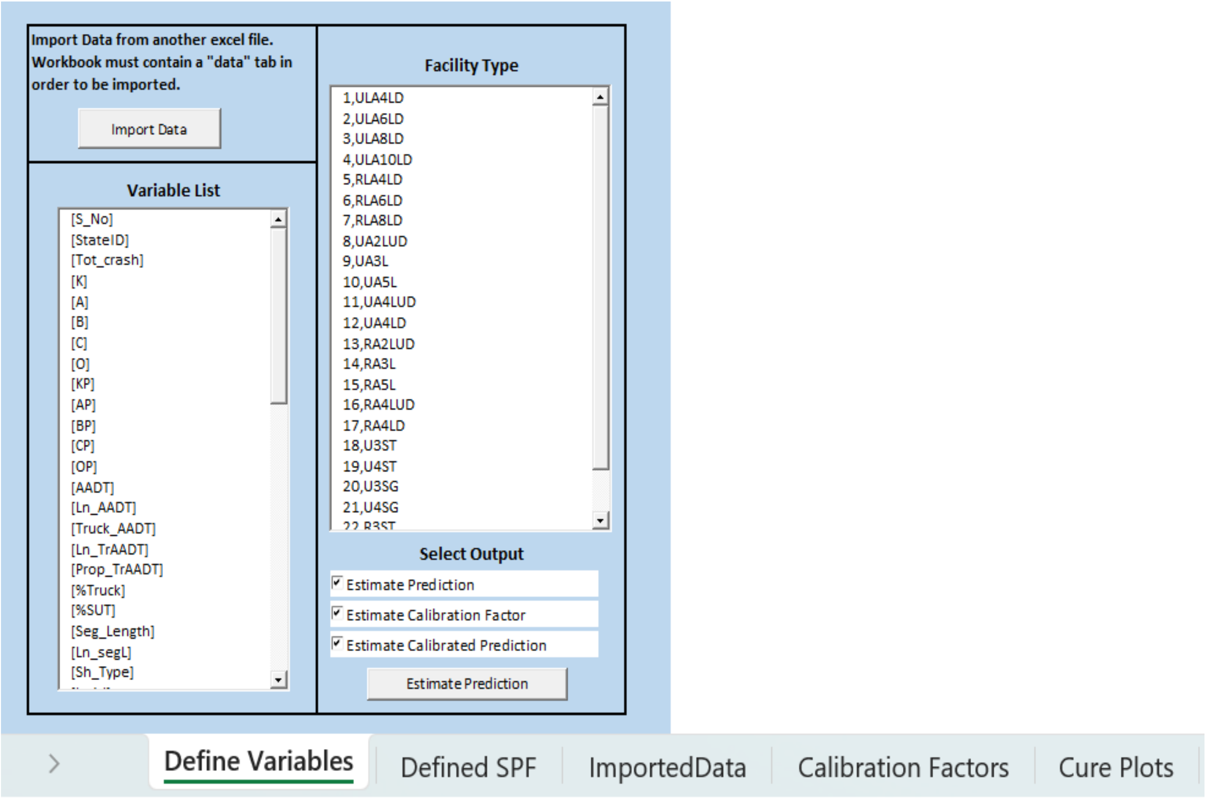
Excel Spreadsheet Tools

- **22-49 Spreadsheet Tool without Calibration:**
  - Provides predictions for the user provided data directly without considering calibration.



Excel Spreadsheet Tools

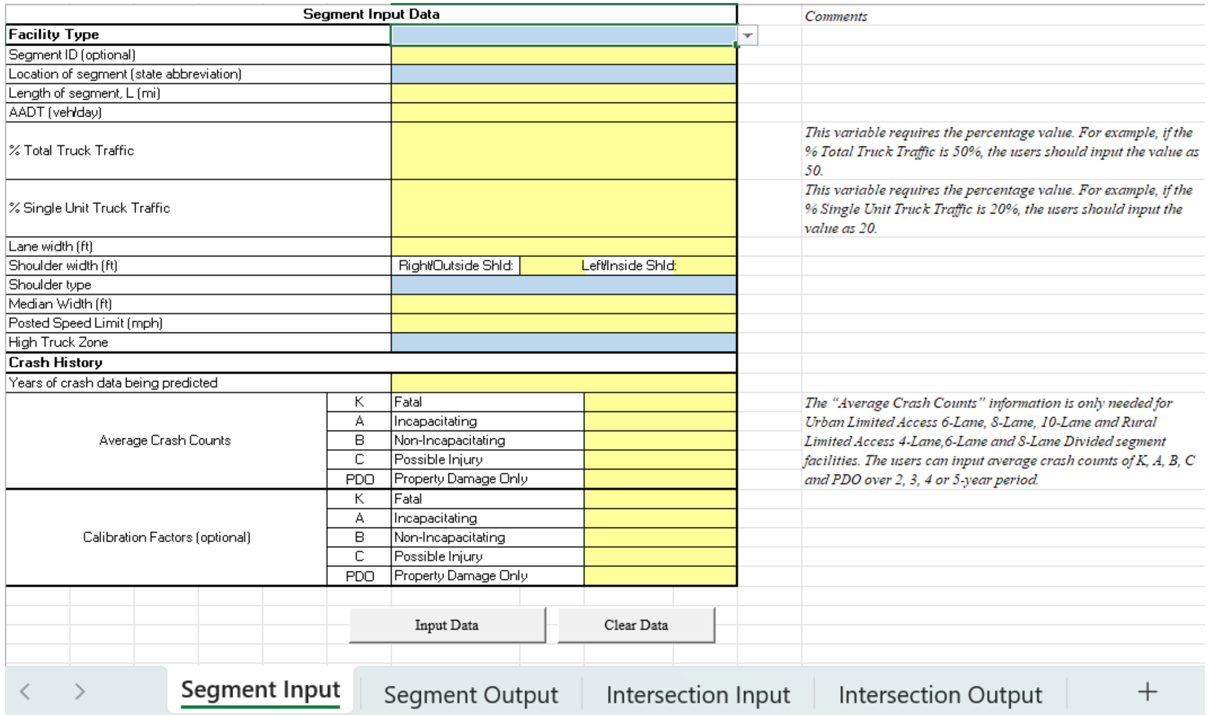
- ❑ **22-49 Spreadsheet Tool with Calibration:**
  - ➢ Provides predictions for the user provided data while modifying the predictions considering calibration.



Excel Spreadsheet Tools

❑ **22-49 Data Input and Prediction Tool:**

➢Provides practitioners a tool to undertake crash frequency and severity analysis at a facility resolution (segment and intersection).



Guidelines to Use Spreadsheet Tools

Spreadsheet Tool User Guidelines

The step-by-step guidelines to use spreadsheet tools has been submitted.

Guidelines contains detailed instructions for three developed tools.

Project NCHRP 22-49: The Effect of Vehicle Mix on Crash Frequency and Crash Severity

Spreadsheet Tool User Guidelines

NCHRP
Transportation Research Board
of
The National Academies of Sciences, Engineering, and Medicine

Project Implementation and Future HSM Adoption

NCHRP Project 22-49

The Effect of Vehicle Mix on Crash Frequency and Crash Severity

Technical Memorandum

Implementation of Research Findings and Products

Prepared for NCHRP
Transportation Research Board
of
The National Academies of Sciences, Engineering, and Medicine

Report Prepared by
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University of Central Florida, Orlando, FL
University of Connecticut, Storrs Mansfield, CT
October 2023

NCHRP Project 22-49
The Effect of Vehicle Mix on Crash Frequency and Crash Severity

Inclusion of Research Results into Future Editions of the Highway Safety Manual

Prepared for NCHRP
Transportation Research Board
of
The National Academies of Sciences, Engineering, and Medicine

Report Prepared by
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University of Central Florida, Orlando, FL
University of Connecticut, Storrs Mansfield, CT
October 2023

Thank you

Calibration of NB-OPFS Model

- Models were developed considering 7 States for segment facilities (CA, CT, FL, IL, MN, TX, WA), and 4 States for intersection facilities (CA, CT, FL, MN)

- **Calibration is recommended for other states**

  Calibration factor for severity S,

$$C_{NB-OPFS,S} = \frac{\Sigma_{allsites}(observed\ crashes\ for\ the\ severity\ level\ S\ )}{\Sigma_{allsites}(predicted\ crashes\ for\ the\ severity\ level\ S\ )}$$

  Calibrated predicted crashes for severity S,

$$C_{crash,S} = P_{crash,S} * C_{NB-OPFS}$$

where $P_{crash,S}$ = predicted number of crashes for severity level S

HSM Highway Safety Manual

NCHRP NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Calibration of MVPLN Model

- Models were developed considering 7 States for segment facilities (CA, CT, FL, IL, MN, TX, WA), and 4 States for intersection facilities (CA, CT, FL, MN)

- **Calibration is recommended for other states**

  Calibration factor for severity S,

$$C_{\mathrm{MVPLN},S} = \frac{\Sigma_{allsites}(observed\ crashes\ for\ the\ severity\ level\ S\ )}{\Sigma_{allsites}(predicted\ crashes\ for\ the\ severity\ level\ S\ )}$$

  Calibrated predicted crashes for severity S,

$$C_{crash,S} = P_{crash,S} * C_{MVPLN}$$

where $P_{crash,S}$ = predicted number of crashes for severity level S

FHWA Global Benchmarking Study Report on Pedestrian Safety on Urban Arterials

Improving Pedestrian Safety on Urban Arterials: Learning from Australasia

U.S. DOT Federal Highway Administration

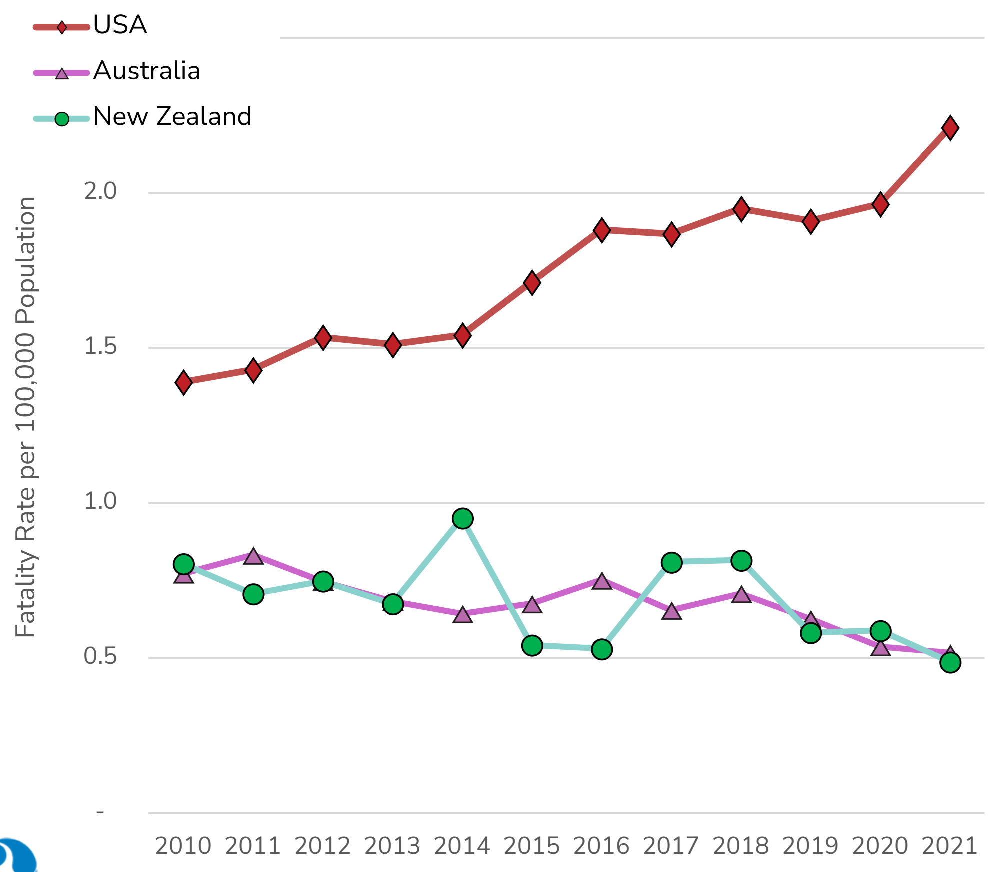
Office of International Programs

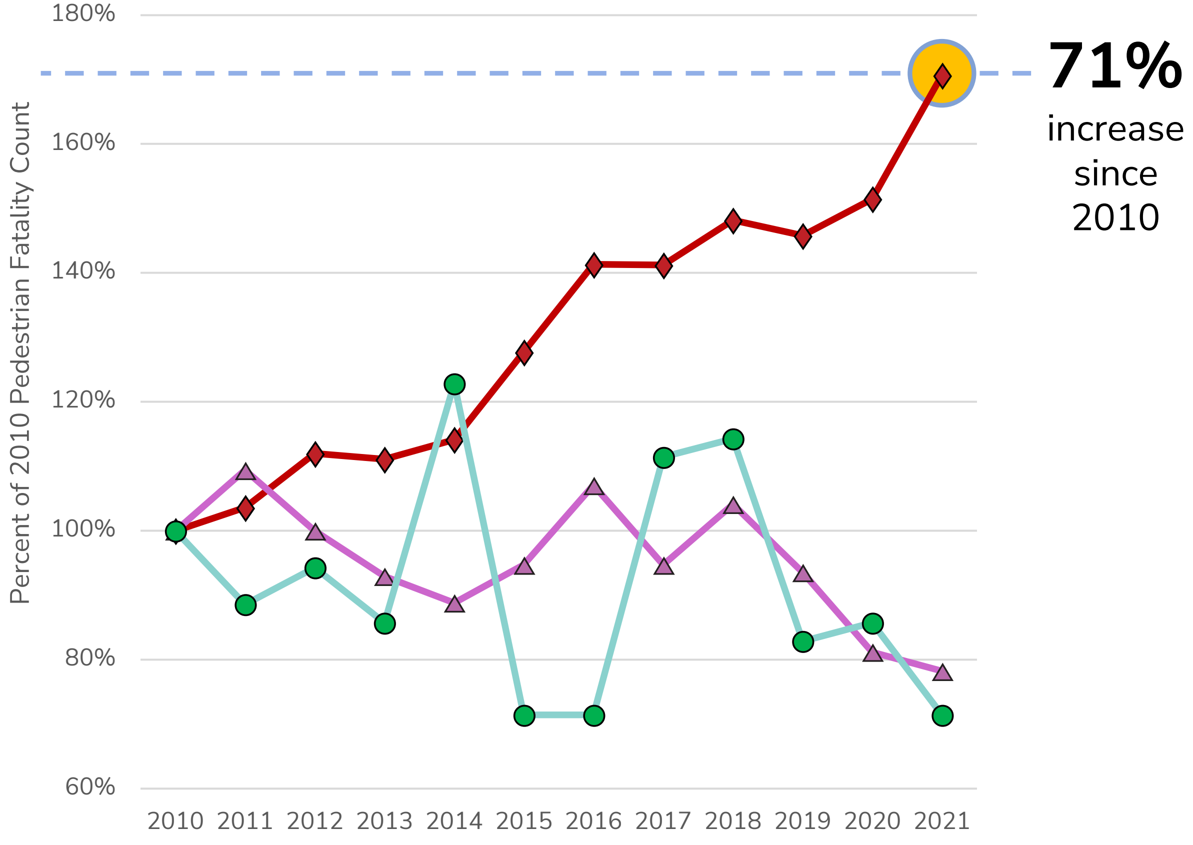
January 2024

Source: USDOT/Getty

U.S. Department of Transportation
Federal Highway Administration
Office of International Programs

Pedestrian Fatality Trends 2010 – 2021





U.S. Department of Transportation
Federal Highway Administration
Office of International Programs

Data Source: ITF and FARS

Special Guests… this week only!

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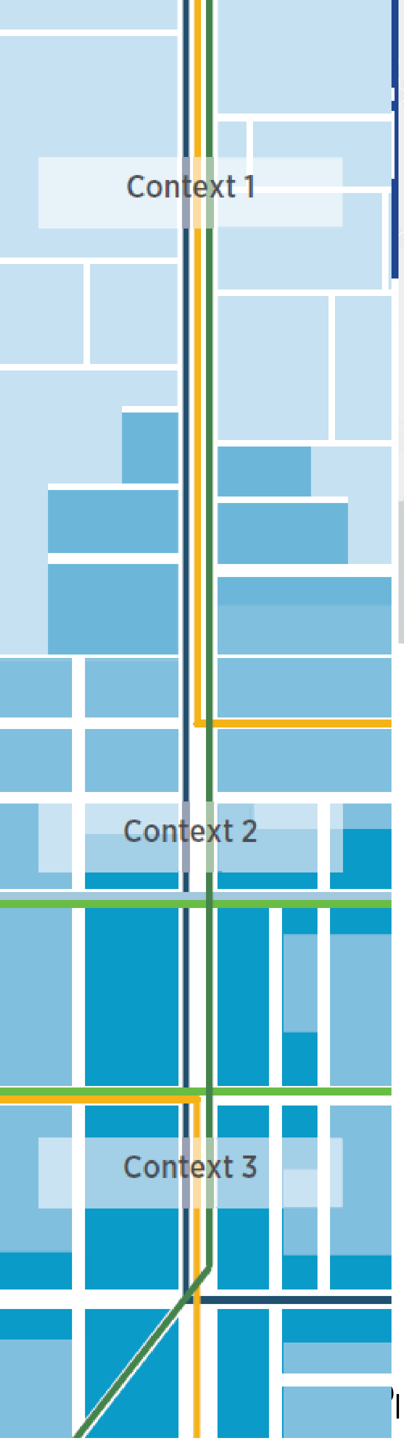
in coordination with:

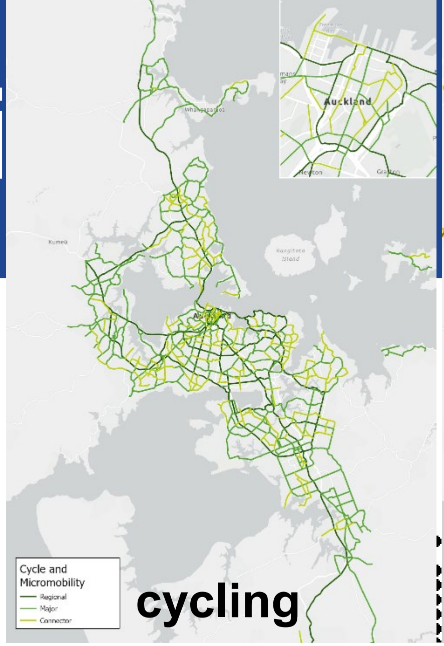
Te Kāwanatanga o Aotearoa
New Zealand Government

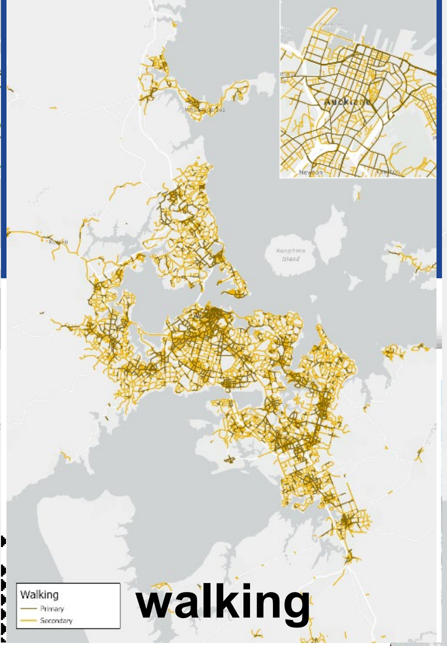
WAKA KOTAHI
NZ TRANSPORT AGENCY

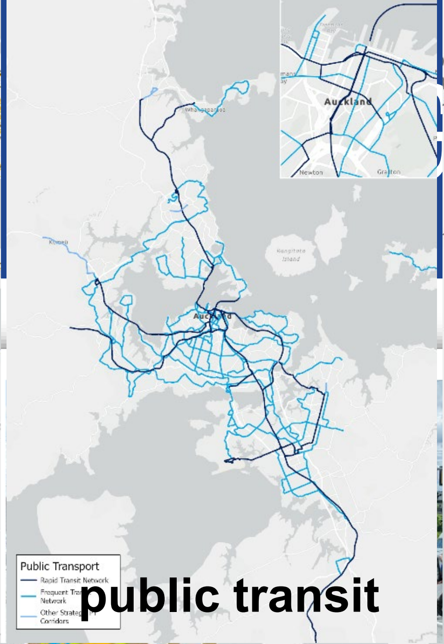
Auckland Transport

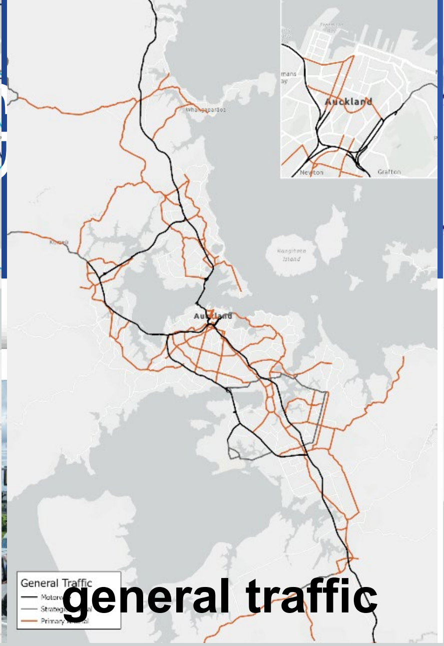
U.S. Department of Transportation
Federal Highway Administration
Office of International Programs

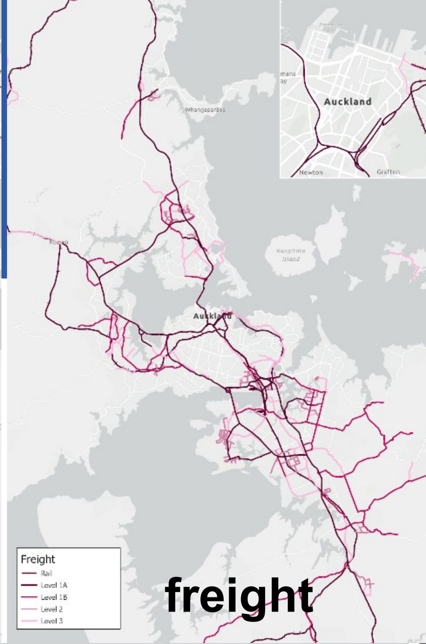

Context 1
Context 2
Context 3

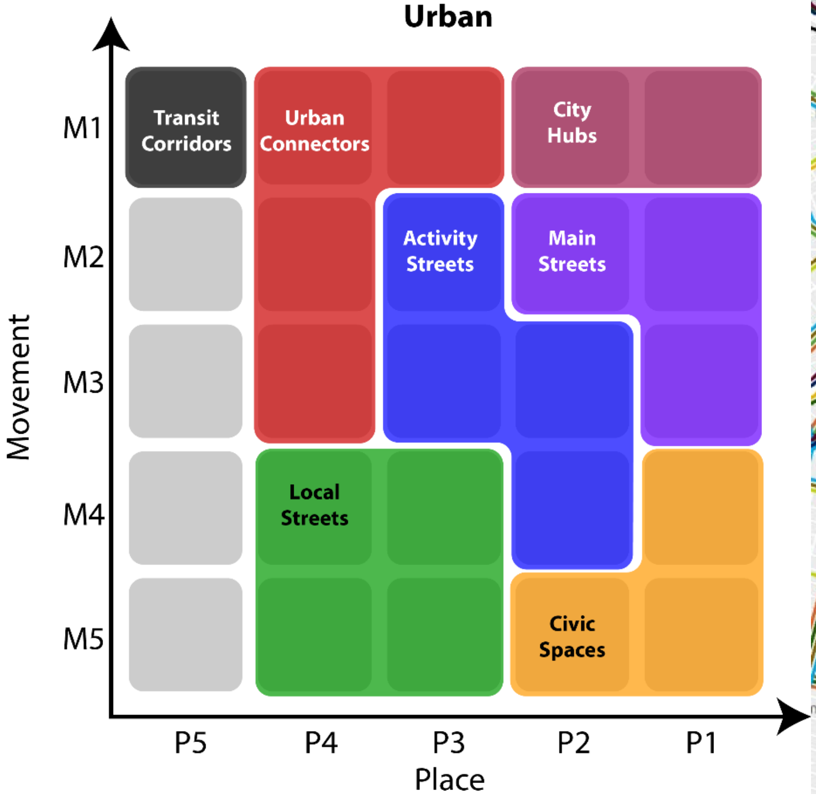

Auckland
Cycle and Micromobility
cycling

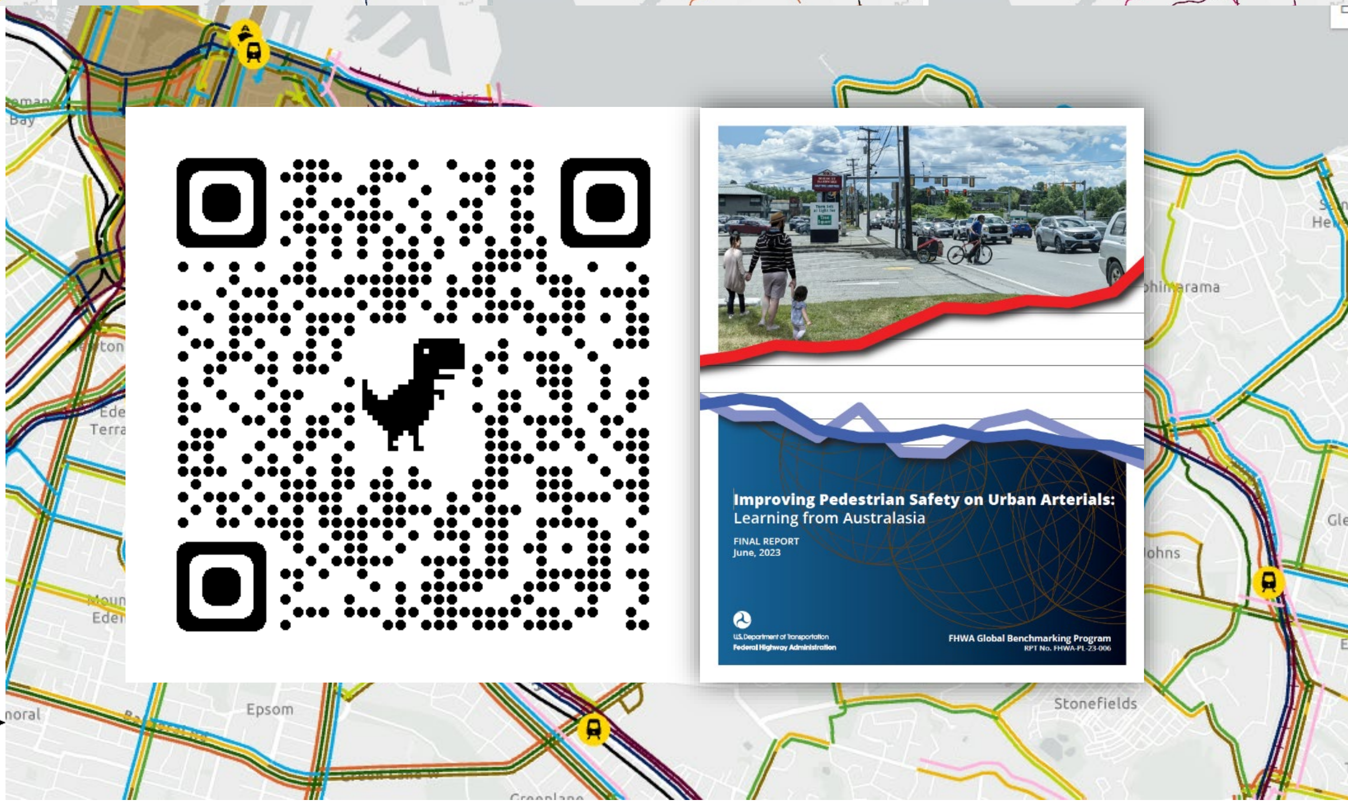

Walking
walking


Auckland
Public Transport
public transit


Auckland
General Traffic
general traffic


Auckland
Freight
freight


Urban
Movement
M1
M2
M3
M4
M5
Transit Corridors
Urban Connectors
City Hubs
Activity Streets
Main Streets
Local Streets
Civic Spaces
P5
P4
P3
P2
P1
Place

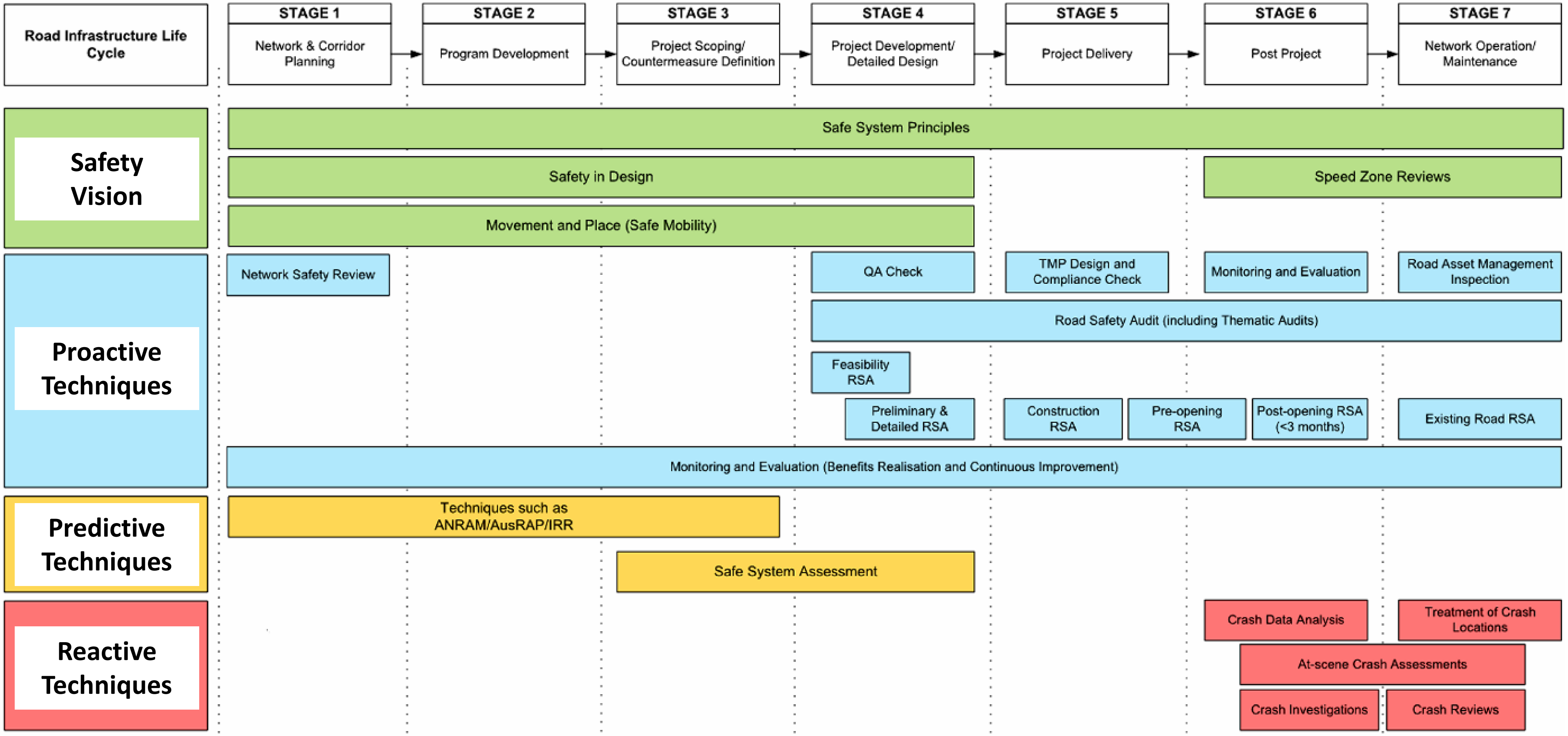

Epsom
Stonefields
Improving Pedestrian Safety on Urban Arterials: Learning from Australasia
FINAL REPORT
June, 2023
U.S. Department of Transportation
Federal Highway Administration
FHWA Global Benchmarking Program

Systemic Safety Integration – RSAs as a PROCESS

Systemic Approach

Span all stages of the project lifecycle:

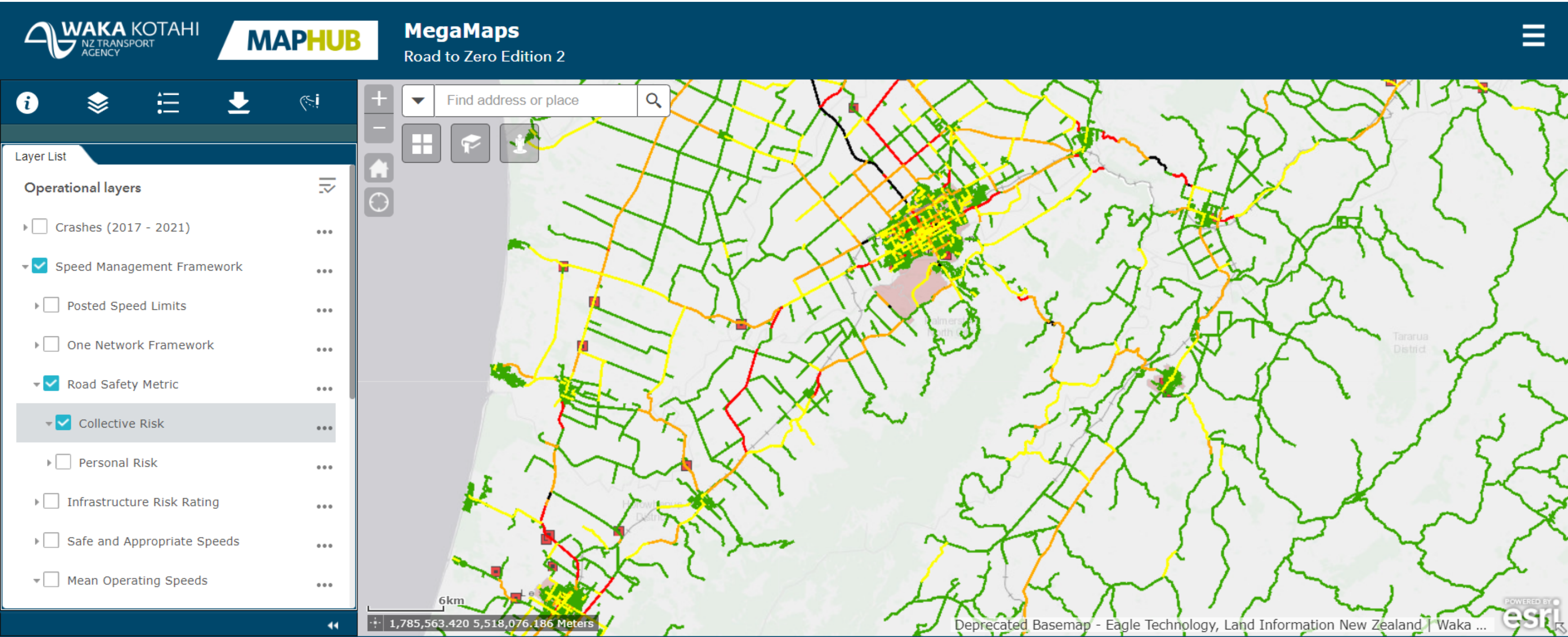
1. Network / corridor-scale planning
2. Programming
3. Scoping / developing countermeasures
4. Project development / detailed design
5. Project delivery
6. Post project
7. Network operation / maintenance



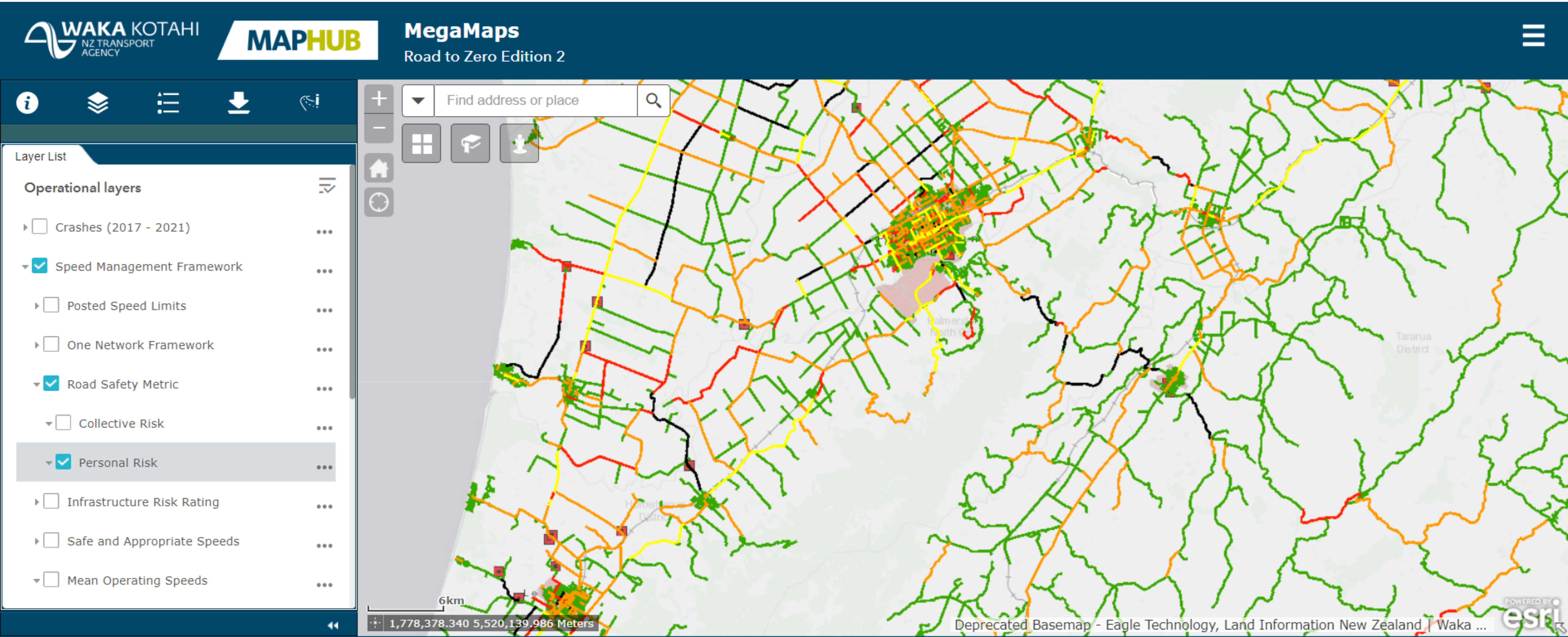
U.S. Department of Transportation
Federal Highway Administration
Office of International Programs

Source: Austroads Managing Road Safety Audits

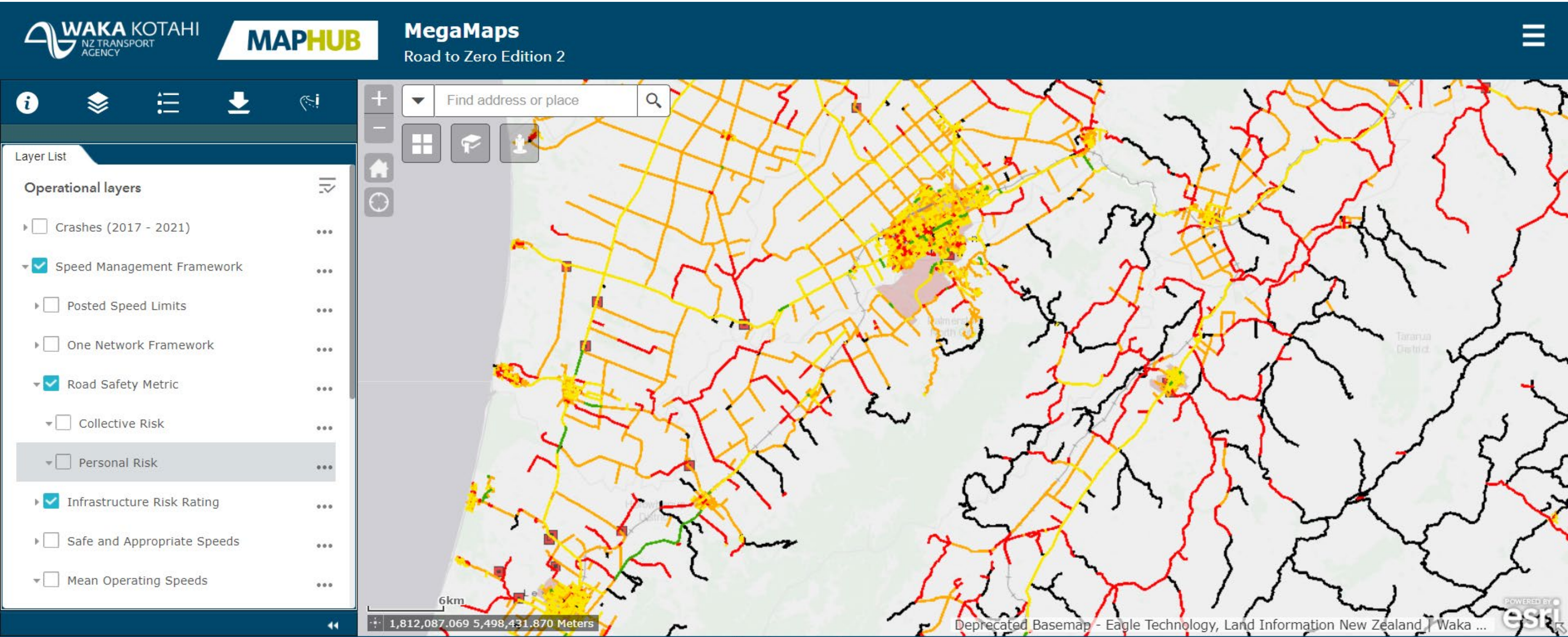
Collective Risk Map - Crashes



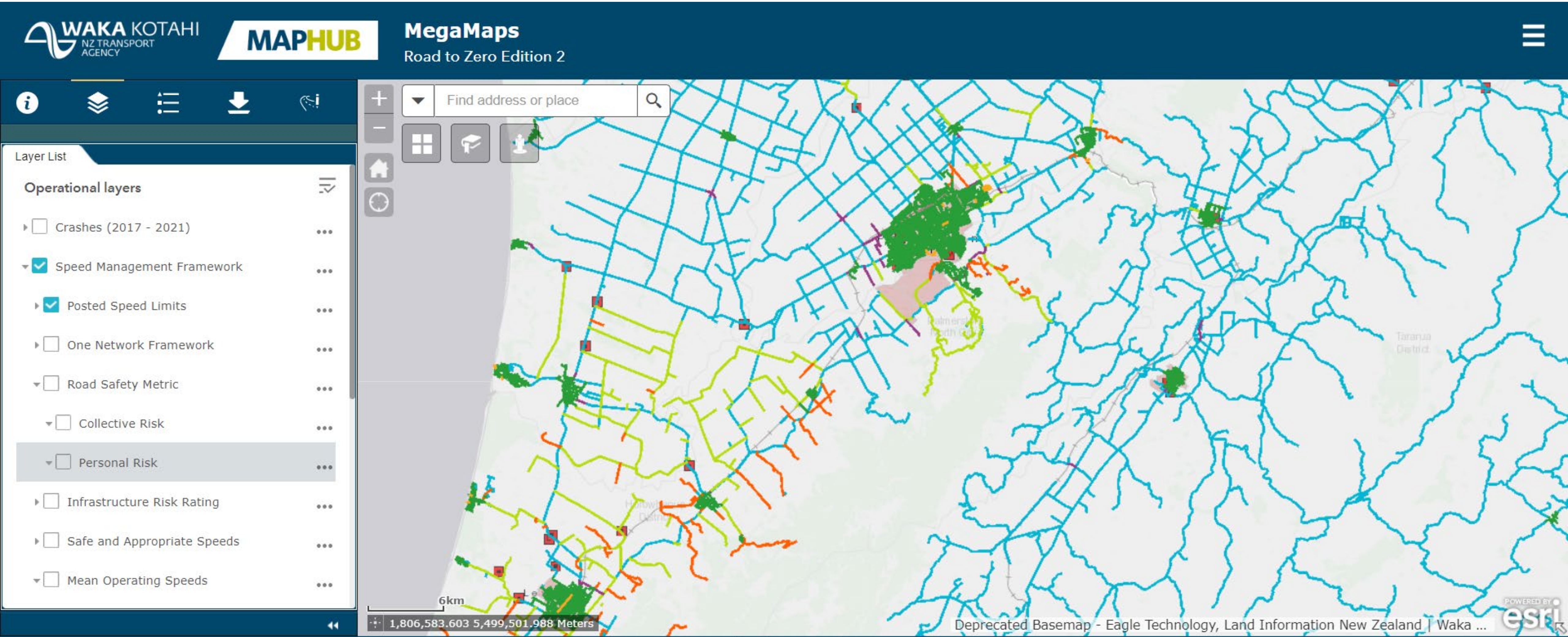
Personal Risk – Crashes Normalized to Volume



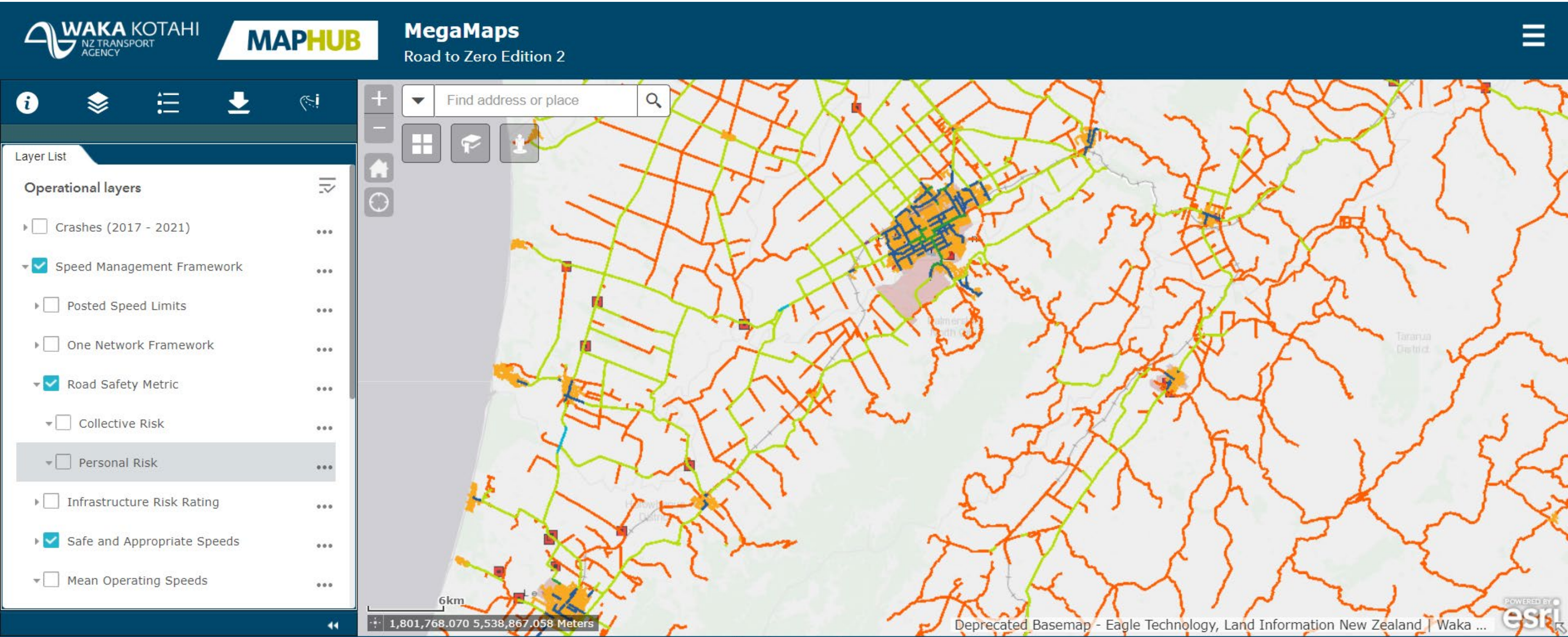
Infrastructure Risk Rating



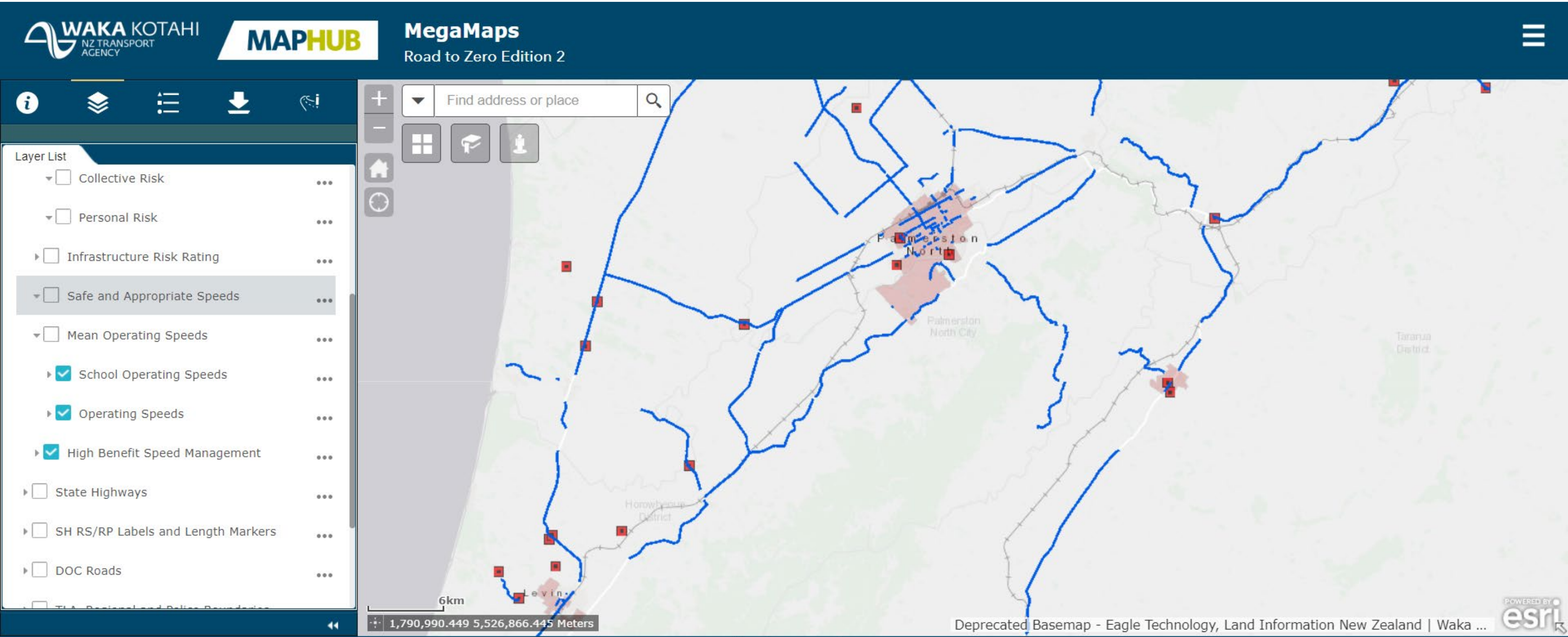
Existing (Posted) Speed Limits



Safe and Appropriate Speed Target



High Benefit Speed Management Segments



Gap-analysis (intersections)

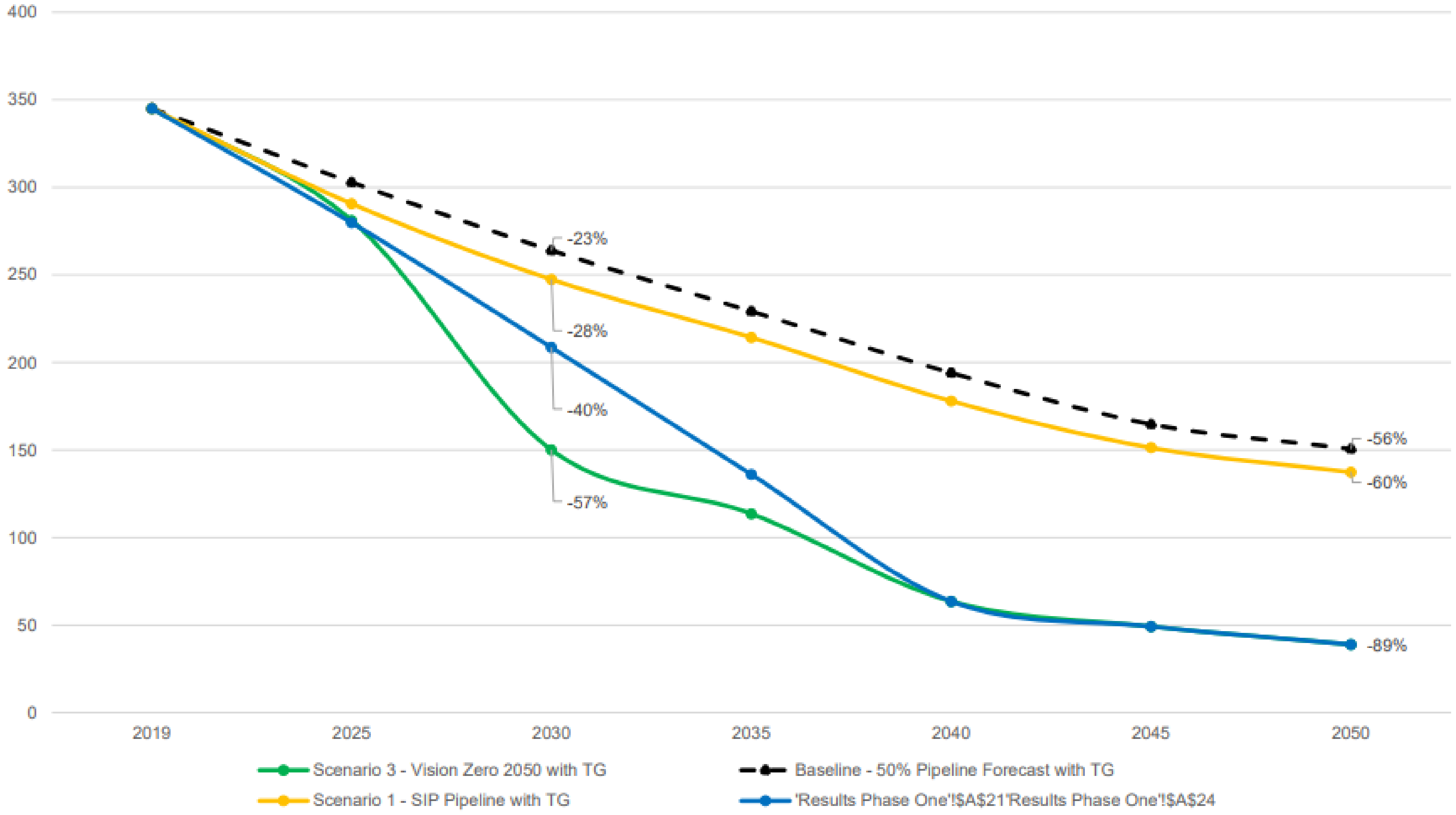
Gap between existing network and 2050 end-state

Car occupants

M&P Rural			**Rural Connectors**			**Interregional Connectors & Rural Connectors**		
M&P Urban	**Activity streets, Main streets**	**Urban Connectors**		**Transit Corridors**				
	40 km/h	**50 km/h**	**60 km/h**	**70-80 km/h**	**90 km/h**	**100 km/h**	**110 km/h**	**120 km/h**
Grade separation								
Left in/left out with acceleration lane								N/A
Roundabout (1-2 lane depending on radius)	22	1275	34	113	1	65	1	N/A
Signalised intersection with RSIP							N/A	N/A
Signalised intersection (NOT PART OF END STATE E	68	1086	165	91	0	15	N/A	N/A
Priority with RISP/chicane								N/A
Priority (with continous speed)	793	54039	852	3884	14	20568	8	N/A
Left in/left out								N/A

1331	Safe System aligned
56165	Acceptable with a 5-star vehicle
1018	Potentially high energy crash, but lower overall risk. Not acceptable but not nessecarily not priority
24580	High energy, not acceptable

Phase One - Baseline and Scenarios 1-3



Lives saved to 2050 compared to Baseline:

Scenario 1: 411

Scenario 2: 2,434
Scenario 3: 2,831

Linking Classification to Design Standards

Main streets						
	Transit way	Transit boulevard	Transit street	Arterial high street	High-activity mall	Connector avenue
General						
Place contexts	Urban and Suburban	Urban Centre, Urban and Suburban	Urban Centre, Urban and Suburban	Urban Centre, Urban and Suburban	Urban Centre, Urban and Suburban	Urban Centre, Urban and Suburban
Land uses	Various urban land uses	Mixed uses	Medium to high density mixed uses	Mixed uses	Medium to high density mixed uses	Mixed uses
Built form frontages	Set back secondary frontages	Active retail frontages or other frontages set back	Active retail frontages or other frontages set back	Active retail frontages	Active retail frontages	Active retail frontages or other frontages set back
Access to properties	Option for direct pedestrian access to frontages, primary direct access to properties from adjacent streets	Direct pedestrian access to frontages with vehicle access to rear of properties	Direct pedestrian access to frontages with vehicle access to rear of properties	Direct pedestrian access to frontages with vehicle access to rear of properties	Direct pedestrian access to frontages with vehicle access to rear of properties	Direct
Posted speed (km/h)	60-90	60-70	30-40	40-50	30-50	40-60
Design speed (km/h)	60-100	60-80				
Active transport						
Level of active transport seperation from motor vehicles	Separated	Separated	Separated	Separated	Separated	Separated
Environment						
Tree canopy cover target[2]	Apply local council tree canopy targets	Apply local council tree canopy targets	Apply local council tree canopy targets	Apply local council tree canopy targets	Apply local council tree canopy targets	Apply local council tree canopy targets
Intersections						
Intersection type	At grade or separated	At grade	At grade	At grade	At grade	At grade
Kerb extensions at intersections and crossings	Where appropriate	Where appropriate	Required	Required	Required	Required
Continuous footpaths/ threshold paint on low volume side streets[3]	Use with caution	Use with caution	Use with caution	Required	Required	Required
Vehicles						
Buses	Yes	Yes	Yes	Yes	Where appropriate	Yes
Can check vehicle swept path cross the centreline at intersections?	No	No	Yes	No	Yes	No
Parallel car parking lane	n/a	Permitted	Use with caution	Use with caution	n/a	Permitted
Sight distance[4]	Greater than 50m	Greater than 50m	–	45	–	–

Source: Transport for New South Wales

Example of a Safe System Assessment Matrix Score

SH3 / SH54 Intersection – Existing Intersection

Table 4.3: Safe System matrix for Safe Roads and Roadsides and Safe Speeds

	ROR	HO	INT	OTHER	PED	CYC	M/C	
Exposure	3/4	3/4	3/4	3/4	1/4	2/4	3/4	
Likelihood	3/4	3/4	4/4	2/4	0/4	1/4	2/4	
Severity	3/4	4/4	4/4	2/4	4/4	4/4	4/4	
Product	27/64	36/64	48/64	12/64	0/64	8/64	24/64	159/448

U.S. Department of Transportation
Federal Highway Administration
Office of International Programs

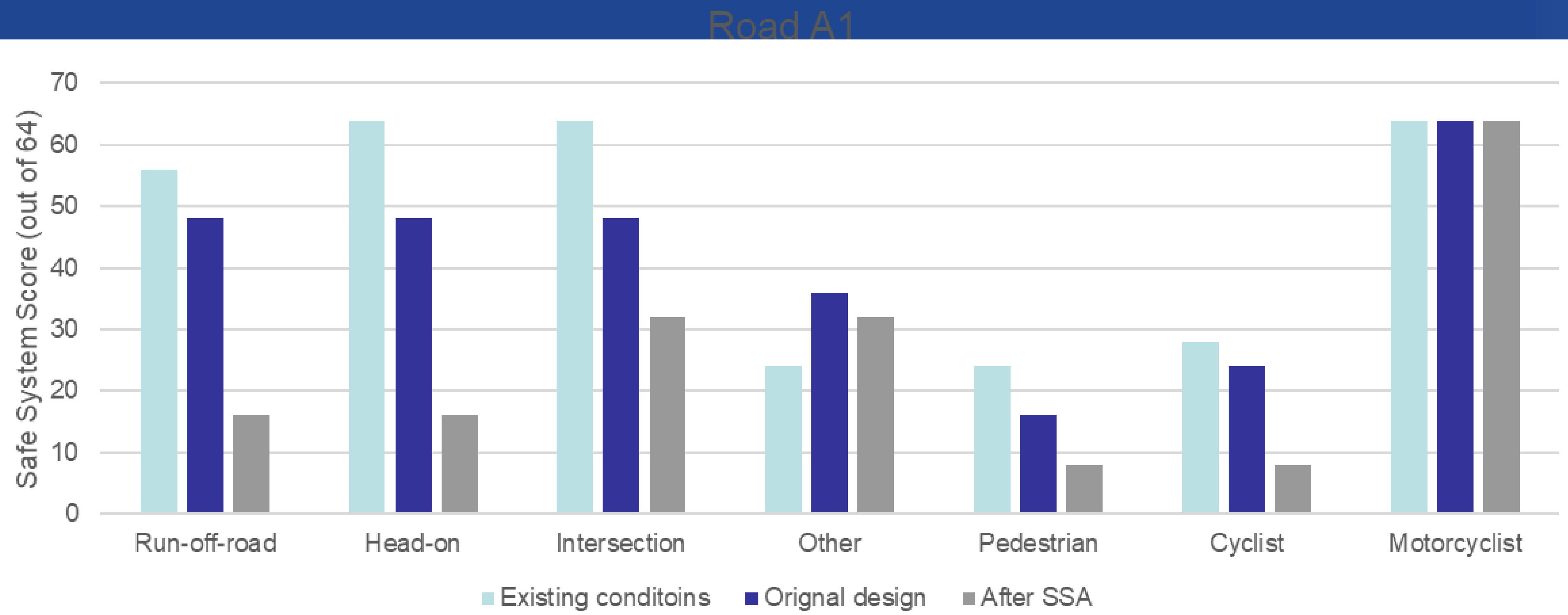
Example of a Safe System Assessment Matrix Score

SH3 / SH54 Intersection – Roundabout Option

Table 4.3: Safe System matrix for Safe Roads and Roadsides and Safe Speeds

	ROR	HO	INT	OTHER	PED	CYC	M/C	
Exposure	3/4	3/4	3/4	3/4	1/4	2/4	3/4	
Likelihood	3/4	1/4	2/4	1/4	0/4	2/4	2/4	
Severity	2/4	1/4	1/4	1/4	2/4	1/4	1/4	
Product	12/64	3/64	6/64	3/64	0/64	4/64	6/64	34/448

Safe System Assessments from Vic Roads



		Safe System Assessment Score	improvement	Estimated Cost
	Existing conditions	**324** / 448		-
	Original design	**284** / 448	12%	$130M
	After Safe System Assessment	**176** / 448	45% (38% improvement from original design)	$130M

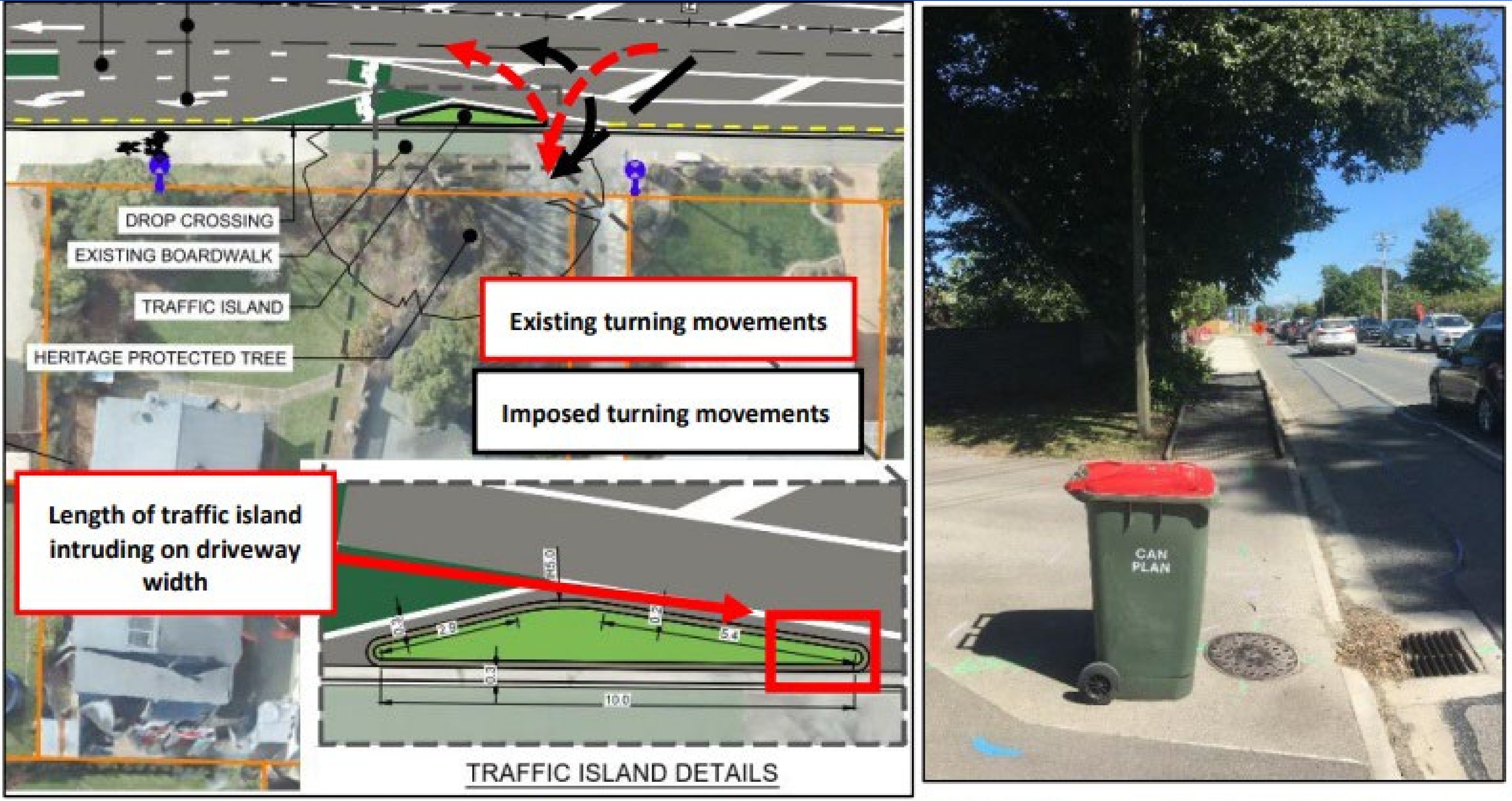


Figure 2.1: Proposed traffic island cycle diversion area (left) compared to existing arrangement (right).

Frequency Rating: Crashes are likely to be Occassional	**Severity Rating:** Death or serious injury is Likely

Designer Response: Point 1 – Island length will be reduced to eliminate the restriction for vehicles entering and exiting out of 387/389 Lower Queen Street. Point 2 – Berryfield Drive is expected to accommodate 12,000 vehicles per day and therefore we envisage that this lane will be highly utilised. Reducing the stacking length of this lane will reduce the level of service and exacerbate the risk of vehicles encroaching onto the through lane during peak times. No change recommended. Point 3 – A single through/left turn lane will be very wide and encourage high speeds along Lower Queen Street. The reason for the island is to discourage left turning vehicles entering the left turn lane into Berryfield Drive early. No change recommended. Point 4 – Agreed, we will include a note in the next set of drawings to replace this sump grate.

Safety Engineer: Agree with the SAT that the island may force an awkward and uncomfortable manoeuvre for cyclists, particularly for less confident cyclists opting to use the exit ramp and shared path. Also agree with the designer that a physical deterrent is needed to prevent left turn vehicles from using the cycle lane and road width as an extended left turn lane. Designer to consider a physical island and or safe hit bollards as a cycle lane buffer instead of the drawn island.

Client Decision: Designer to consider a physical island and or something similar to safe hit bollards as a cycle lane buffer instead of the drawn island. My preference is not to use safe hit posts

Action Taken: Click here to enter text.

Study Team

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in coordination with:

Pedestrian and Bicycle Information Center

NACTO

AASHTO

U.S. Department of Transportation
Federal Highway Administration
Office of International Programs

Help us advance these findings in the U.S.

Shari Schaftlein | Director, Office of Human Environment
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Source: USDOT/Getty

Movement and Place

A shift in focus to people, place, and movement

Putting people, place and movement at the heart of planning & investment

- Consider the role roads and streets play as **Places (destinations in their own right)** as well as movement corridors
- Consider the **current function** and **future function of the network**
- Classify **modal networks** for multi-modal network planning, including 'off-road' routes
- Shift the emphasis to the **movement of people and goods,** rather than vehicles

Break Time

Committee Paper Awards

TRB 2024 ACS20 Best Paper Award

Thanks to the Award Committee

- Raul Avelar, Insurance Institute for Highway Safety
- Daniel Carter, North Carolina Department of Transportation
- Vikash Gayah, Pennsylvania State University
- Srinivas Geedipally, Texas A&M Transportation Institute
- Juan Medina, University of Utah
- Peter Savolainen, Michigan State University
- Michael Pawlovich, South Dakota State University
- Jonathan Wood, Iowa State University
- George Yannis, National Technical University of Athens

TRB 2024 ACS20
Best Paper Award (cont.)

- Three finalists selected over course of review process

- Evaluation Criteria:
  - Contribution to the Field
  - Quality of Research
  - Breadth of Applicability
  - Readability

TRB 2024 ACS20
Best Paper Award (cont.)

- This year's winner is……..

- Title:
  - "A Comparative Sensitivity Analysis on Intersection Crash Prediction Models by Control Type: Highway Safety Manual Approach"

- Authors:
  - Seyedehsan Dadvar, Ph.D.
  - Michael A. Dimaiuta, M.S.
  - In-Kyu Lim, Ph.D.

Doctoral Student Research in Transportation Safety Podium Session

Doctoral Student Research

Overview

- AED60 - Statistical Methods & ACS20 - Safety Performance Analysis Committees continue to sponsor a special session that highlights work by Ph.D. students who are nearing the completion of their doctoral research on transportation safety.
- Format
  - 11 presenters
  - 3-minute presentations from each person
  - Posters that provide greater detail

Lectern Session 2124: **Doctoral Student Research in Transportation Safety: A Lectern-Poster Session**

Mon., Jan. 8, 1:30 PM - 3:15 PM | Convention Center, Salon B

Peter Savolainen, Michigan State University, presiding

Doctoral Student Research (cont.)

The Process

1. Students submit, via e-mail, an abstract that summarizes their research. A template is provided for their use. Submission occurs after, and separate from, the TRB call.
2. Students copy their faculty advisor on the e-mail to allow for confirmation of the anticipated graduation date. Priority is given to students who are nearest to graduation.
3. A group of volunteers from AED60 and ACS20 reviews and rates the abstracts. Selections are made after consultation with committee chairs.
4. The event is held during the TRB Annual Meeting and a group of volunteers rate the presentations, culminating in a Best Presentation Award.

Doctoral Student Research (cont.)

Thanks to this year’s volunteers who assisted with abstract review!

- Natalia Barbour, University of Central Florida
- Daniel Carter, North Carolina Department of Transportation
- Rajesh Chahuan, Sardar Vallabhbhai National Institute of Technology
- Grigorios Fountas, Aristotle University of Thessaloniki
- Salvador Hernandez, Oregon State University
- Silvia Varotto, École Nationale des Travaux Publics de l'État (ENTPE)
- Ken Wu, National Chiao Tung University
- Xingjing Xu, University of Florida
- Xilei Zhao, University of Florida

Doctoral Student Research (cont.)

Thanks to this year’s numerous volunteers who served as judges!

Doctoral Student Research (cont.)

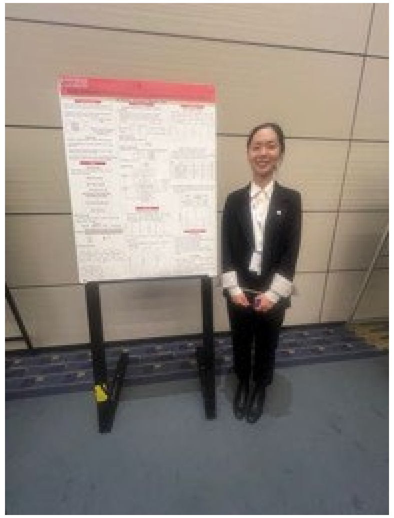
This Year's Presenters and Topics

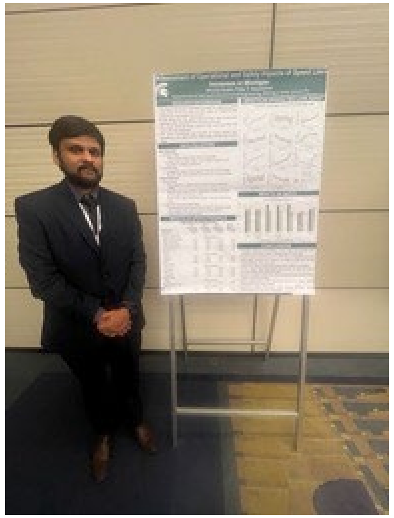
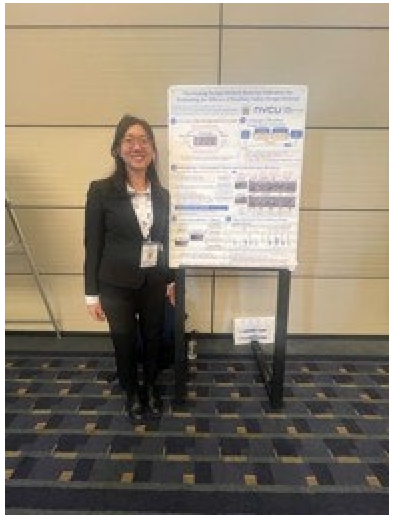
Name	University	Presentation Title
Abdul Rashid Kanda Mussah	University of Missouri - Columbia	Spatial Big Data Analysis and Artificial Intelligence Applications for Transportation Safety and Network Systems Optimization
Akshay Gupta	Indian Institute of Technology - Roorkee	Enhancing High-Speed Road Safety: Insights from Advanced LiDAR-Based Driver Behavior Analysis
Eva Michelaraki	National Technical University of Athens	Interactions between Road Environment and Driver State for the Identification of Safety Critical Conditions
Maroa Mumtarin	Iowa State University	Short-term Network Screening and Crash Hotspot Detection
Nana Kankam Gyimah	North Carolina Agricultural & Technical State University	NCAT12-DET: A New Benchmark Dataset for Surface Defect Detection and a Comparative Study
Nischal Gupta	Michigan State University	Assessment of Operational, Safety, and Behavioral Impacts of Speed Limit Increases
Panagiotis G. Tzouras	National Technical University of Athens	Methodologies for the Integrated Analysis and Assessment of Shared-space Urban Roads
Tong Lin	National Yang Ming Chiao Tung University	Developing Design-Related-Behavior Indicators for Evaluating the Efficacy of Roadway Safety Design Element - A Case Study for the Design of an Exclusive Left-turn Lane in Taiwan
Vamsi Krishna Bandaru	Purdue University	Multi LiDAR Tracking for Identifying Safety Relevant Events
Vinayaraj V. S.	Indian Institute of Technology - Bombay	Development of Safety Performance Measures and Modeling Crash Risk for Urban Roundabouts in Heterogeneous Traffic Conditions
Ye Dong	Iowa State University	Evaluation of Lane Keeping Systems and Automatic Emergency Braking Systems

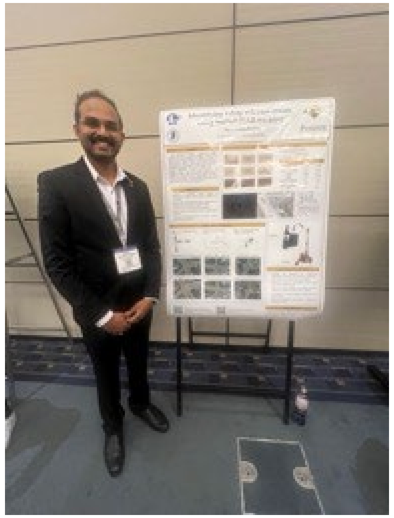
Doctoral Student Research (cont.)

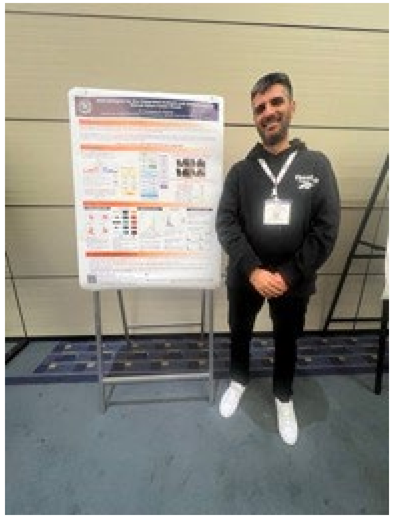
The Session









Doctoral Student Research (cont.)
Best Presentation Award

- Evaluation Criteria:
  - Quality of Lectern Presentation
  - Quality of Research Poster
  - Technical Knowledge
  - Contribution to State-of-Art/Practice

Doctoral Student Research (cont.)
Best Presentation Award

- Presenter – Abdul Rashid Kanda Mussah, University of Missouri – Columbia
- Title – “Spatial Big Data Analysis and Artificial Intelligence Applications for Transportation Safety and Network Systems Optimization”

Update on Second Edition of AASHTO Highway Safety Manual

NCHRP 17-71A
Proposed AASHTO Highway Safety Manual, Second Edition

NCHRP Project 17-71A

Proposed AASHTO Highway Safety Manual, Second Edition

ACS20 Annual Meeting
2024

Texas A&M Transportation Institute

HDR

Exponent®

Harwood Road Safety, LLC

Mr. Brelend C. Gowan

Ogle Research, LLC

Agenda

- Project objective and scope
- Structure of HSM2
- Update of activities since 2023 midyear meeting
- Single state calibration and sensitivity analysis
- Overview of Part C pedestrian and bicycle SPFs
- Remaining activities and schedule
- Questions
- AASHTO update

Project Objective and Scope

Project Objective

- Complete work initiated as part of NCHRP Project 17-71 to develop and prepare a proposed HSM2 in a format suitable for adoption as an AASHTO publication
  - Proposed HSM2 will synthesize and incorporate relevant ongoing and completed research including completed NCHRP Project 17-71 deliverables, related documents, and user feedback to expand the scope and quality of HSM2 to increase application and improve its usability

Structure of HSM2

HSM
Highway Safety Manual
AASHTO

Outline of HSM2

HSM2 (Ch.)	HSM1 (Ch.)	Chapter Title
		Preface
1	1	Introduction and Overview to the Highway Safety Manual
Part A- Fundamentals		
		Introduction to Part A
2	3	Road Safety Principles
3	2	Human Factors
4		**Pedestrians and Bicyclists (NEW)**
Part B – Roadway Safety Management Process		
		Introduction to Part B
5		**Areawide Approach to Roadway Safety Management (NEW)**
6	4	Network Screening
7	5	Diagnosis
8	6	Countermeasure Selection
9	7	Economic Appraisal
10	8	Project Prioritization
11	9	Countermeasure Effectiveness Evaluation
12		**Systemic Approach to Roadway Safety Management (NEW)**
Part C – Predictive Method		
		Introduction to Part C
13		**General Concepts for Applying the Part C Predictive Methods (NEW)**
14	10	Predictive Method for Rural Two-Lane, Two-Way Roads
15	11	Predictive Method for Rural Multilane Highways
16	12	Predictive Method for Urban and Suburban Arterials
17	18	Predictive Method for Directional Freeway Segments
18	19	Predictive Method for Ramps
Part D – Crash Modification Factors		
		Introduction to Part D
19		**Selecting CMFs (NEW)**
20		**Applying CMFs (NEW)**
		Glossary (Applicable to all Parts)

Update of Activities Since 2023 Midyear Meeting

Recent Activities

- Revised draft chapters (Version 1) in response to review comments and submitted Version 2 for review
  - Reviewers of Version 1 draft chapters included:
    - Panel members
    - AASHTO HSM Steering Committee Members
    - Select AASHTO/TRB volunteers
  - Addressed individual comments within chapters
  - Addressed consistency across chapters
  - Addressed single state calibration with Part C chapters

Recent Activities

- Draft chapters (Version 2) were reviewed by panel members, AASHTO HSM Steering Committee, and select SMEs
  - Research Team received comments in mid November 2023
  - Research Team met in-person on November 28th & 29th with the project panel and external reviewers to discuss and resolve substantive comments
  - Some reviews are still being conducted
  - Jacobs' Team reviewed the comments and established suggested priorities (e.g., high, medium, and low) for the comments to be addressed

Recent Activities

- Research Team has been working on Part C Sample Problems
  - Chapter 14. (Rural Two-Lane) recently completed
  - Chapter 15. (Rural Multilane) soon to be completed
  - Chapters 13 (General Concepts), 16 (Urban/Suburban Arterials), and 17 (Directional Freeways) to be completed

Part C
Single State Calibration
and
Sensitivity Analysis

Single-State Calibration

- Single-state calibration for many of the Part C models was performed in NCHRP Project 17-72
- Conducted sensitivity analysis in which we plotted:
  - Original models from the underlying research projects
  - Calibrated models using single-state calibration from Project 17-72
- Comparisons were made between the plotted models to assess whether:
  - The models make sense in absolute terms
  - The models make sense relative to one another
  - The original or calibrated models should be used

Sensitivity Analysis

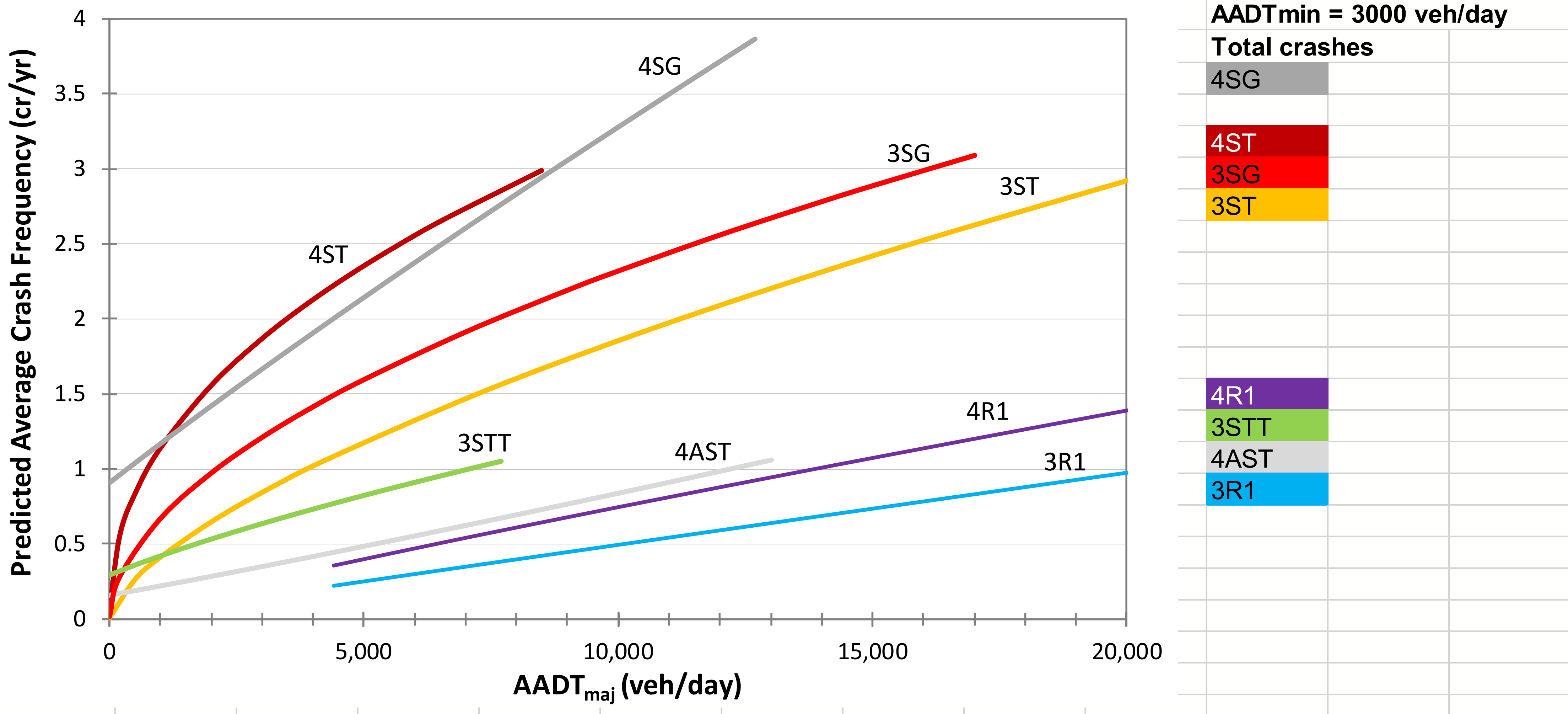
- Every candidate HSM2 Part C model was plotted:
  - Crash frequency vs. AADT for roadway segments
  - Crash frequency vs. major-road AADT for intersections for separate curves for various representative values of minor-road AADT

- Comparisons were made:
  - Total vs. KABC vs. PDO models
  - Multiple-vehicle vs. single-vehicle crashes, where relevant

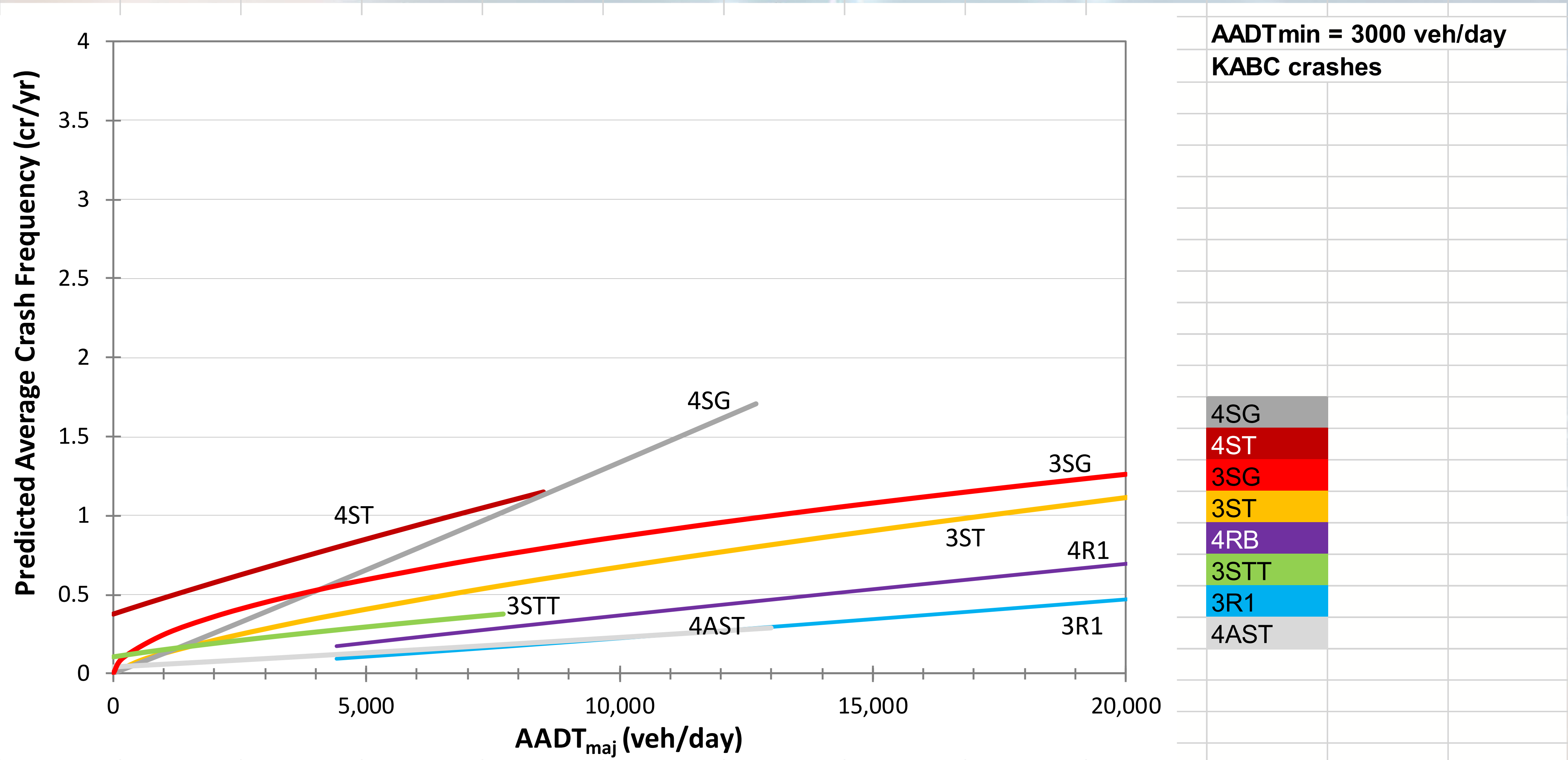
Sensitivity Analysis

- Issues identified:
  - Most (but not all) roundabout models predicted more crashes than comparable signalized and minor-road stop-controlled intersections
  - One all-way stop-controlled intersection model predicted more crashes than comparable signalized or minor-road stop-controlled intersections
- Adjustments to roundabout and all-way stop-controlled intersection models were made using appropriate CMFs (from the CMF clearinghouse)
- After some final checks, the final SPFs were selected for Chapters 14, 15, and 16

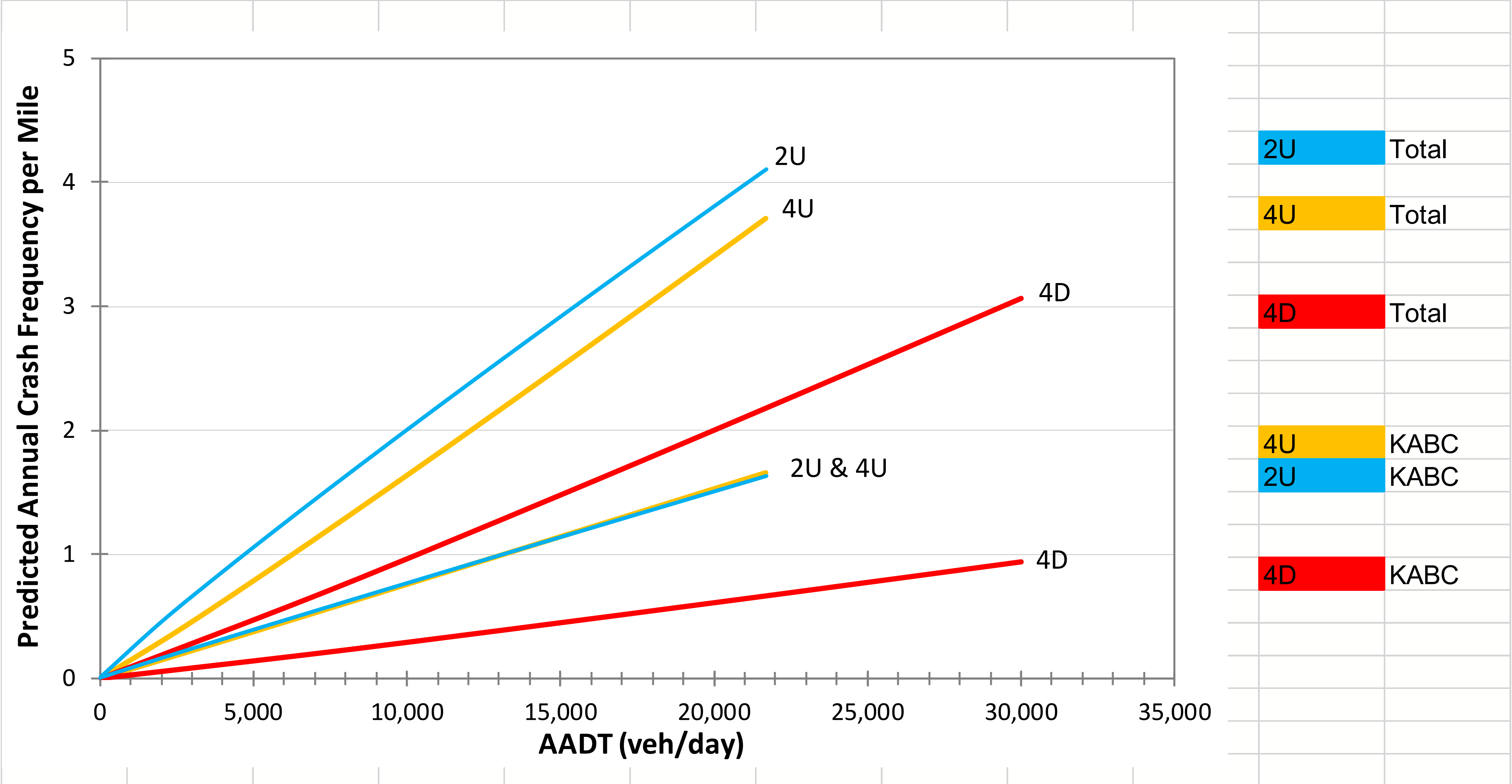
Ch 14. Rural 2-Lane (Intersections) Total Crashes



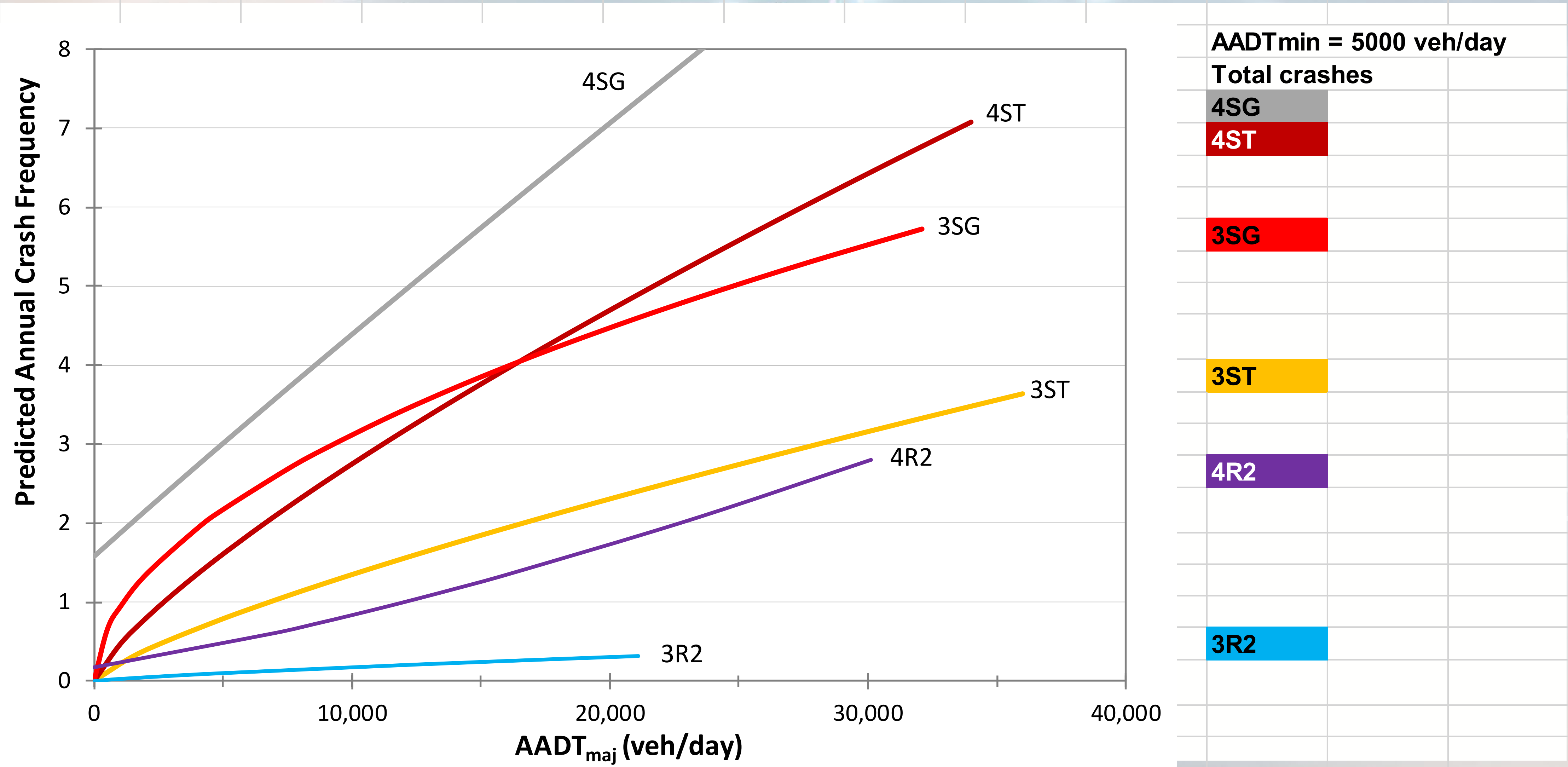
Ch 14. Rural 2-Lane (Intersections) KABC Crashes



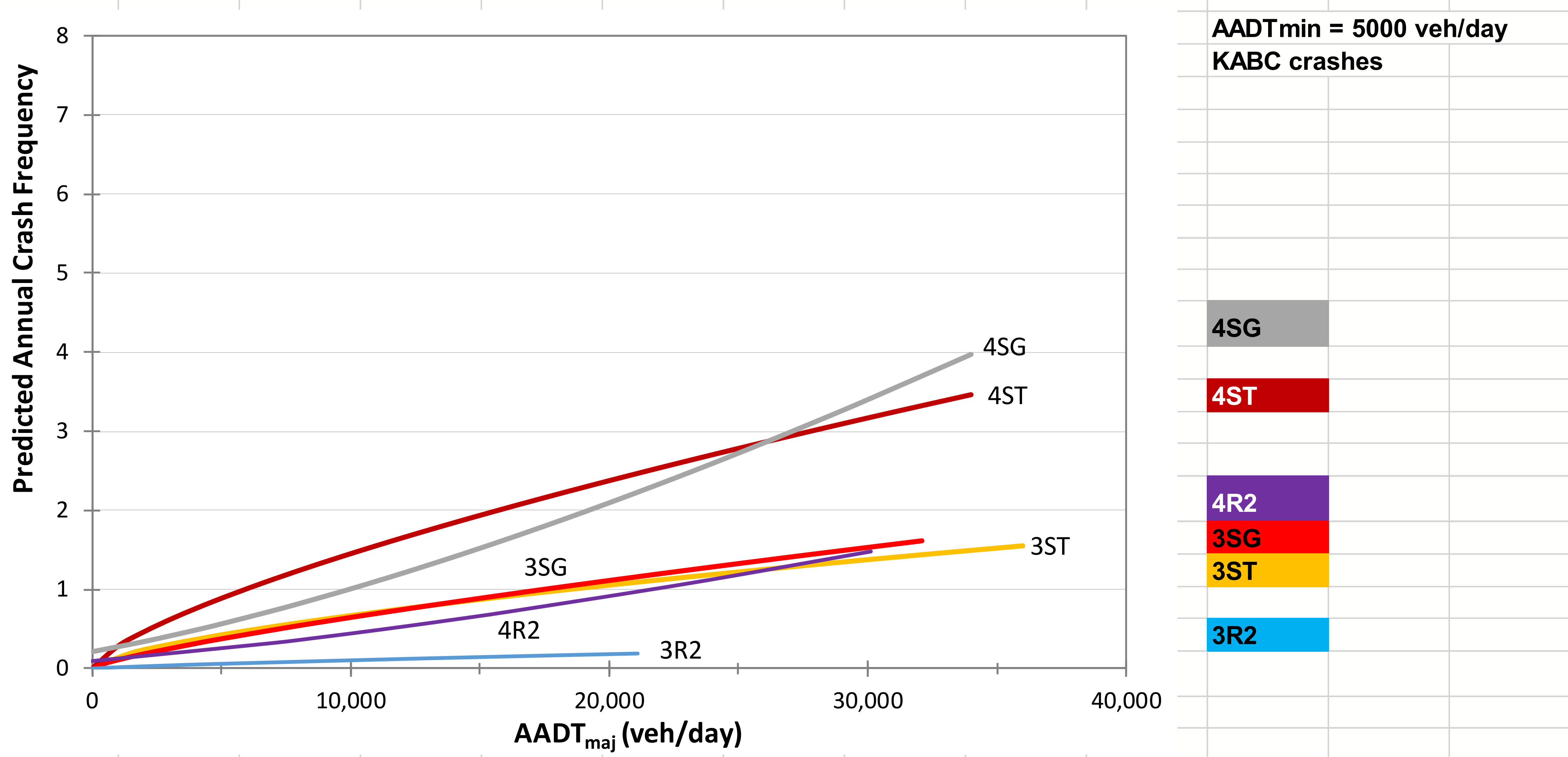
Ch 14. Rural 2-Lane & Ch 15. Rural Multilane (Segments) Total & KABC Crashes



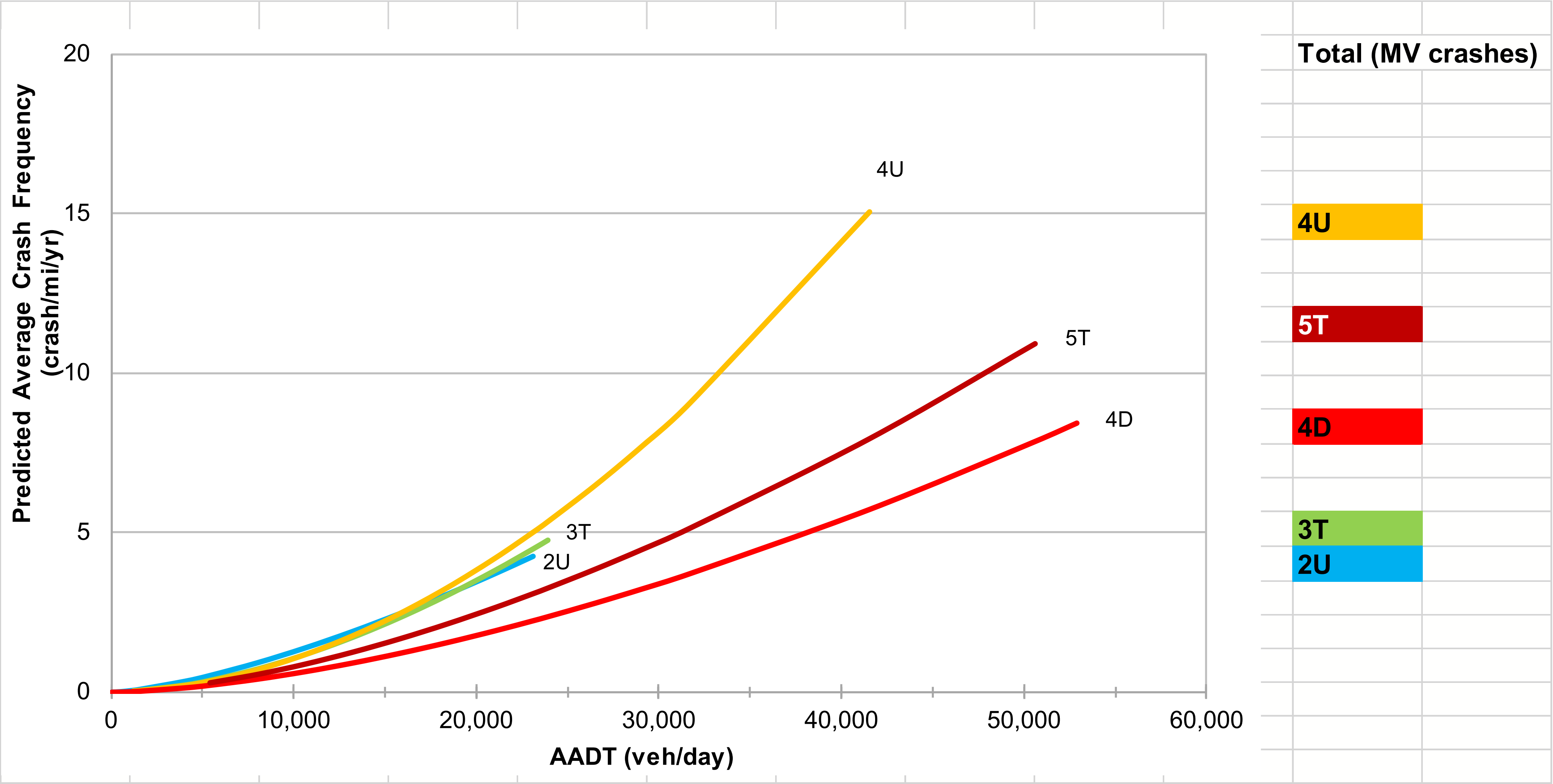
Ch 15. Rural Multilane (Intersections) Total Crashes



Ch 15. Rural Multilane (Intersections) KABC Crashes



Ch 16. Urban and Suburban Arterials (Segments) Total Multiple-Vehicle Crashes



Calibration and/or Development of Jurisdiction-Specific SPFs

- The need to calibrate Part C SPFs to local conditions or develop jurisdiction-specific SPFs cannot be stressed strong enough!!!

Overview of
Part C Crash Prediction Methods
for
Pedestrian and Bicycle
Collisions

Crash Prediction Methods – Pedestrian and Bicycle Collisions

- Crash prediction models were adapted for U.S. application in NCHRP Project 17-84 based on models originally developed by:
  - International Road Assessment Program (iRAP)
  - U.S. Road Assessment Program (usRAP)
- The Project 17-84 pedestrian and bicycle crash prediction models will be used in the following HSM2 chapters:
  - Chapter 14 – Predictive Method for Rural Two-Lane, Two-Way Roads
  - Chapter 15 – Predictive Method for Rural Multilane Highways
  - Chapter 16 – Predictive Method for Urban and Suburban Arterials

Crash Prediction Models from NCHRP Project 17-84

Pedestrians

- Pedestrian movements along the road – left side
- Pedestrian movements along the road – right side
- Pedestrian crossing movements – midblock
- Pedestrian crossing movements – intersections

Bicycles

- Bicycle movements along the road
- Bicycle movements through intersections

General Form of Pedestrian and Bicycle Crash Prediction Methods

N = Crash Likelihood Factors x Crash Severity Factors x
Motor Vehicle Speed Factor x Motor Vehicle Volume (AADT) Factor x
Peak-Hour Pedestrian or Bicycle Volume Factor x Calibration Factor

NOTES ON CALIBRATION FACTORS:

- Method has already been calibrated to typical U.S. conditions
- Method may be further calibrated to local conditions by individual agencies

Crash Likelihood and Crash Severity Factors

Crash Likelihood Factors

- Factors related to the likelihood that motor vehicles will run off the road (and, therefore, might potentially strike a pedestrian or a bicyclist)
- Factors related to the direct effects of pedestrian or bicycle facilities

Crash Severity Factors

- Factors related to the direct effects of pedestrian or bicycle facilities

Factors for Direct Effects of Pedestrian Facilities

Presence/absence of sidewalk

- separation distance from traveled way to sidewalk

Presence and width of paved shoulder

Presence of informal path

Type of pedestrian crossing facility:

- grade separated vs. at-grade facilities
- signalized vs. unsignalized crossings
- crossings with and without median refuge areas
- marked vs. unmarked

Advance visibility of crossing

Number of traffic lanes to be crossed

Pedestrian fencing

Type of median present

Type of intersection present

School zone crossing

- flashing beacon/active warning
- static signs or markings

Factors for Direct Effects of Bicycle Facilities

Type of bicycle facility

- separated bicycle path (with or without barrier separation from motor vehicles)
- dedicated bicycle lane on roadway
- extra wide outside lane

Presence and width of paved shoulder

Interaction with pedestrian crossing facility type

Quantitative Results Available from Crash Prediction Method

Pedestrians

No. of fatal (K) crashes
No. of A injury crashes
No. of B injury crashes
No. of C injury crashes
No. of pedestrians fatally injured
No. of pedestrians with A injuries
No. of pedestrians with B injuries
No. of pedestrians with C injuries

Bicyclists

No. of fatal (K) crashes
No. of A injury crashes
No. of B injury crashes
No. of C injury crashes
No. of bicyclists fatally injured
No. of bicyclists with A injuries
No. of bicyclists with B injuries
No. of bicyclists with C injuries

Remaining Major Activities and Schedule

Schedule

Planned Date	Activities
12/2023 – 1/2024	Prepare and submit draft sample problems for HSM2 Part C predictive chapters.
2/2024	Conduct virtual workshop to discuss and resolve comments on the Part C sample problems.
2/21/2024	Prepare and submit draft project deliverables, including: • Project report • Summary presentation • Implementation plan
5/21/2024	Prepare and submit revised final project deliverables, including: • The proposed HSM2, in an electronic format suitable for transmittal to AASHTO for balloting and eventual publication • Project report • Summary presentation • Implementation plan

Questions

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American Association of State Highway and Transportation Officials
AASHTO

AASHTO Highway Safety Manual Update

Stephen Read, Virginia DOT

TRB Annual Meeting

ACS20 Meeting

January 10th, 2024

Publication Timeline

American Association of State Highway and Transportation Officials
AASHTO

NCHRP Project

AASHTO Review and Balloting
Steering Committee; Committee on Safety; workgroups from other AASHTO Committees

AASHTO Publication
Editing, technical queries, layout, printing, links

June 2024

Dec. 2024

June 2025

Comprehensive Review Summary

- Panel and External Reviewers
- **Comprehensive Review**
  - Active Transportation Review
  - Term Consistency
  - Content Consistency
  - Accuracy and Relevancy of Sample Problems

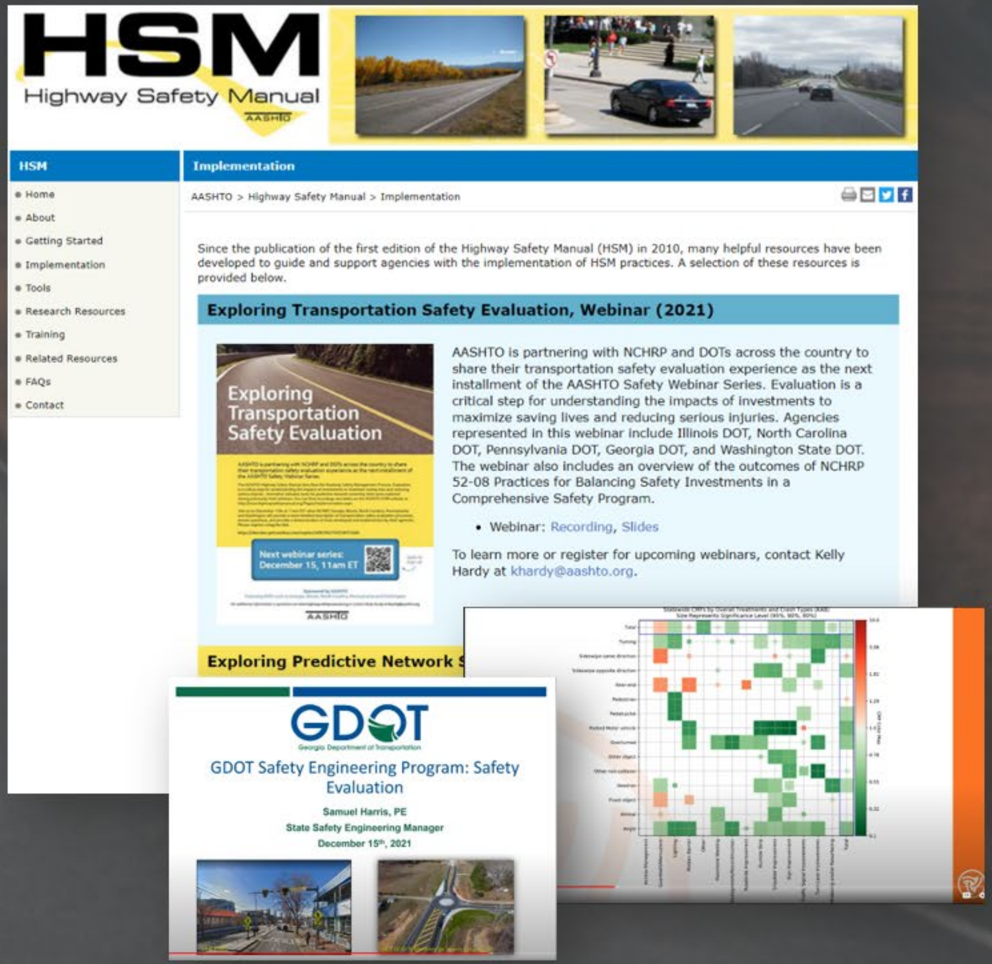
Related Efforts

- **Practical Applications**
  - Ongoing discussions around practical applications of HSM methods
  - Guiding future research to improve adoption, consistency
- **Part C Model Tools**
  - Researching advanced tools and software to perform analyses with more complex models and applications

HSM Application Webinars

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
AASHTO

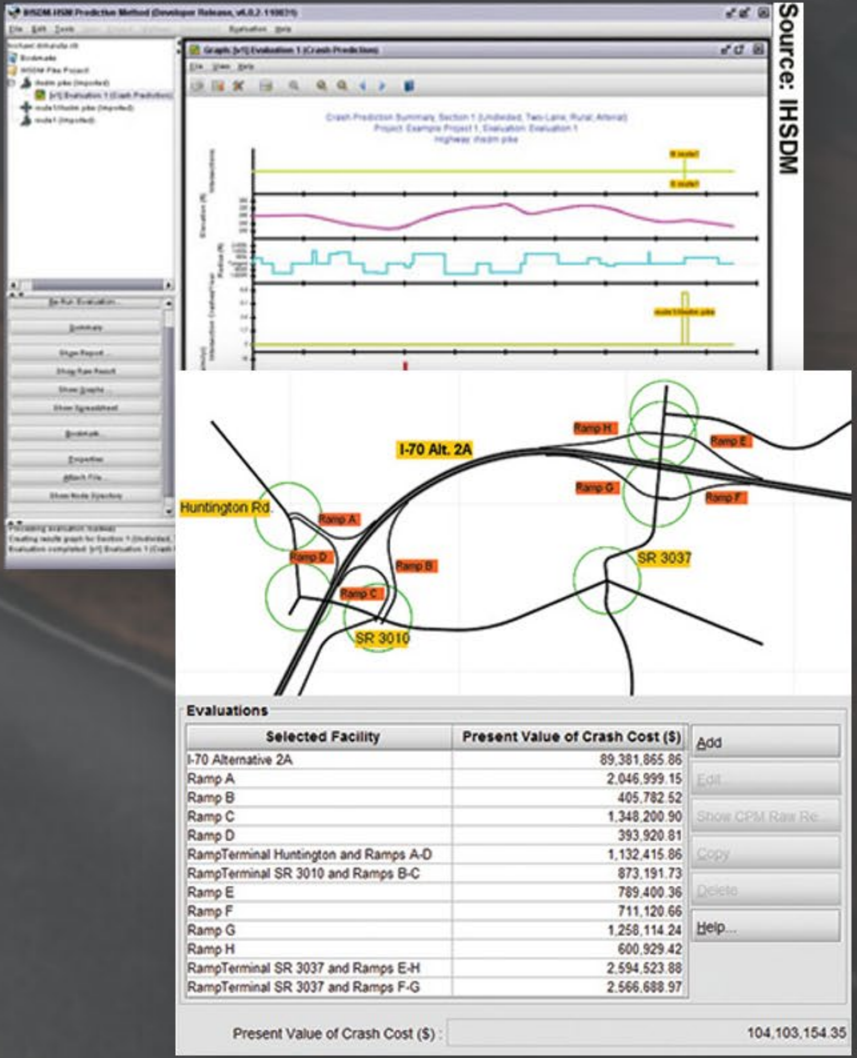
- AASHTO sponsors periodic webinars on HSM methods and research
- Recent and upcoming webinars include:
  - Transportation Safety Evaluation
  - Predictive Network Screening Tools
  - Applications of recently completed research



American Association of State Highway and Transportation Officials
AASHTO

Interactive Highway Safety Design Model (IHSDM)

- FHWA standalone software tool for predictive crash analysis and visualization
- Includes all predictive models in HSM1 and the supplement, with additional research updates from HSM2
- Sunsetting in 2024 but will still be available

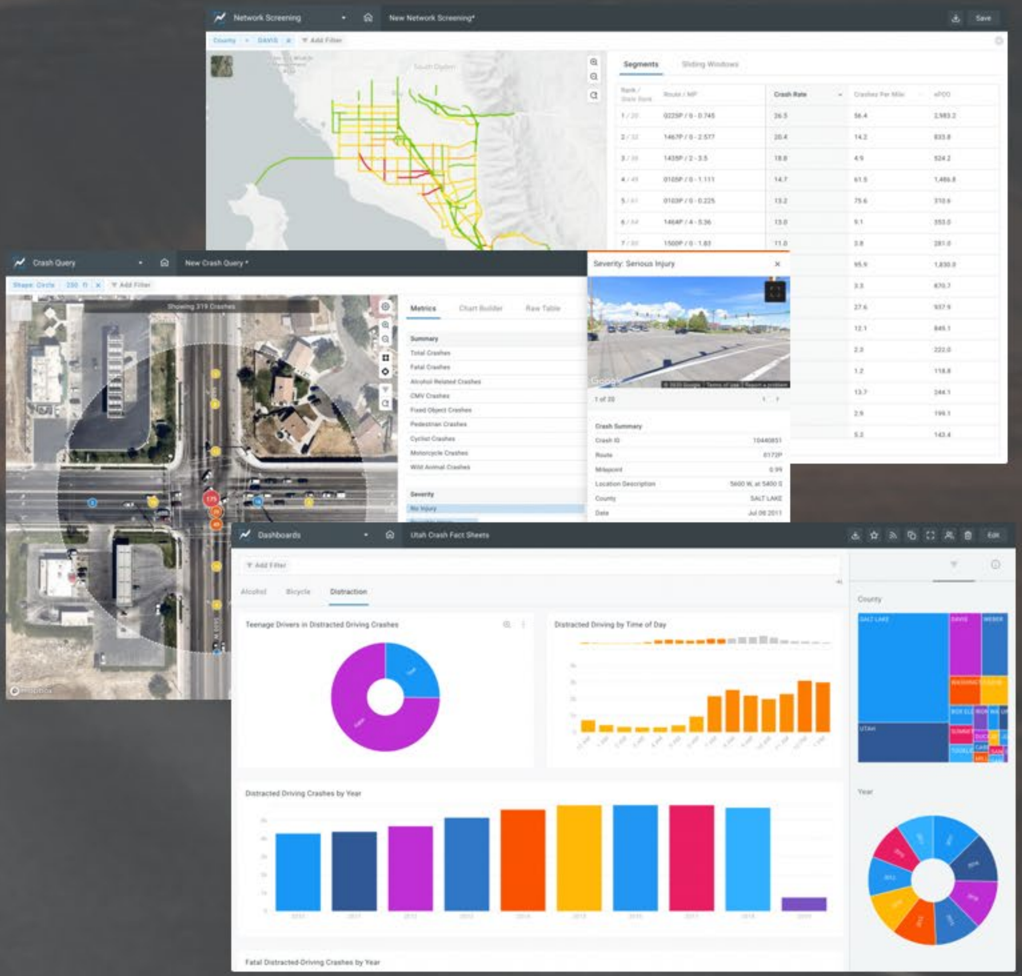


Source: IHSDM

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
AASHTO

AASHTOWare Safety

- Web-based safety analysis suite powered by Numetric
  - Supersedes SafetyAnalyst
  - Annual cost is context-dependent
- Includes modules for segment, intersection, and trend analysis
- Features for network screening, crash querying, SPF development, visualization, and more
- Learn more at https://numetric.com/



HSM2 Implementation Needs

- **Active Transportation (Bicycle/Pedestrian Analysis)**
  - Need spreadsheet/software for streamlined implementation or standalone analyses

- **Discussion**
  - Any other needs identified?

Contact Information

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
AASHTO

- Website for updates and additional information
  - www.highwaysafetymanual.org
- Questions? Contact Kelly Hardy
  - highwaysafetymanual@aashto.org

American Association of State Highway and Transportation Officials
AASHTO

Questions?

Thank you for your attention.

For more information, please contact
Kelly Hardy at highwaysafetymanual@aashto.org

HSM Implementation Pooled Fund Study Research: Exploring the Validity of Combining Predictive Methods

Applications of Data Driven Safety Analysis

Exploring the Validity of Combining Predictive Methods

Scott Himes, PhD, PE

vhb

Acknowledgements

- HSM Implementation Pooled Fund Study
- Matt Hinshaw, FHWA
- Derek Troyer, FHWA
- Jerry Roche, FHWA
- Bonnie Polin, MassDOT
- Dan Carter, NCDOT
- Kevin Scopoline, WisDOT

Research Questions

- HSM promotes Empirical Bayes (EB) method for analyzing project alternatives
  - HSM supplement clarifies EB method cannot be used for any alternatives if it is not applicable for all alternatives
  - This has led agencies to avoid EB method in general, including “future no-build” scenarios
  - Considering only predicted crash frequency treats locations as “average” locations
- Task 2 research questions
  - Is there an effective approach to consistently and reliably incorporate observed crash history?
  - What is the appropriate traffic volume (projected versus existing) for alternative analysis?
  - What role does calibration play in safety analysis?

Literature Review and Case Study Summary

- There is a demonstrated need for understanding potential biases, including when and how to use historic crash data when evaluating alternatives
  - Site specific attributes may contribute to higher crash counts, which may not be accounted for in predicted crash frequency which is a measure of "average"
  - Examples highlighted that higher crash counts, or higher proportion of severe crashes can hold over time (i.e., may not necessarily be regression-to-mean)
- There is no clear guidance on when historic crash data may no longer be applicable and may introduce bias when employing EB method
- There is a demonstrated need for a consistent and reliable approach for conducting project alternatives analysis

Literature Review and Case Study Summary

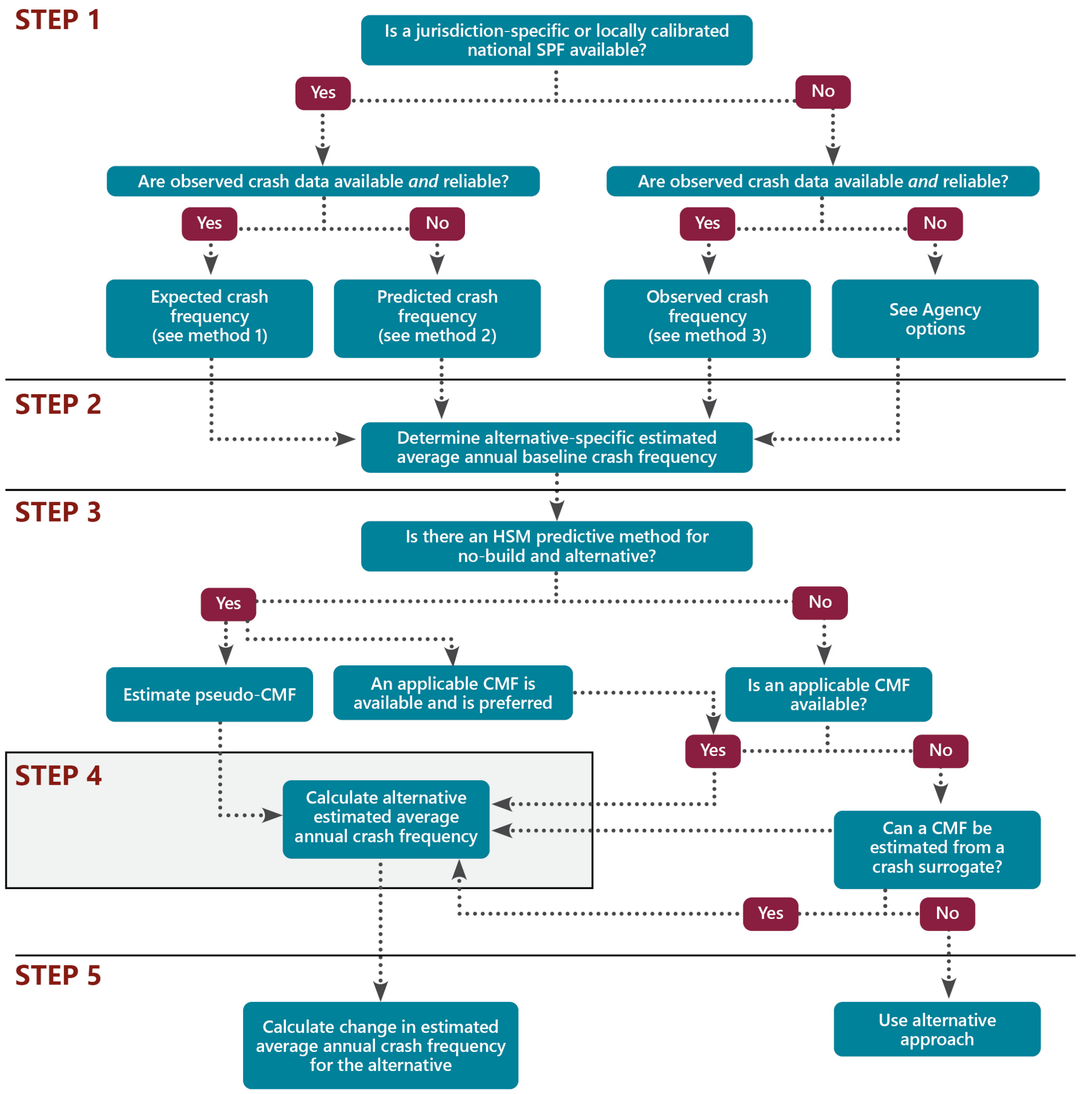
- Project alternatives analysis should consider alternative-specific traffic volumes and should consider the spatial and temporal impacts of the project alternative
- The HSM single-State calibration is a useful concept for estimating predicted crash frequency and severity for alternatives when facility types change
- However, State calibration efforts have shown that the HSM single-State calibration may not provide valid relationships from State to State
- Additionally, the single-State calibration may not capture the interactive influences of traffic volumes and geometric characteristics
- Jurisdiction-specific calibrations and utilizing calibration functions can support improved decision-making particularly when considering project alternatives of different facility types

A Combined Method for Alternatives Analysis

- Project team explored reliability of methods for comparing project alternatives
  - Comparing expected crash frequency with observed or predicted crash frequency results in bias
  - Comparing predicted crash frequencies based on SPFs (and treating them as average locations) may result in a loss of information responsible for unique outcomes
  - There appears to be a disconnect when using baseline crash frequency and CMFs when comparing to using expected crash frequencies for project alternatives
- An approach, using baseline crash frequency and a relative assessment in estimated change in safety performance, is recommended for project alternatives analysis
  - Does not conflict with utilization of HSM Parts C or D
  - Allows the analyst to use the most reliable method available for assessing baseline measure
  - Provides for fair attribution of CMFs relative to Part C predictive method

Project Alternative Analysis Approach

1. Establish baseline estimated average crash frequency for future no-build condition
2. Determine alternative-specific baseline average crash frequency
3. Identify the applicable method for estimating the safety effectiveness of project alternatives
4. Calculate the project alternative estimated crash frequency
5. Calculate expected change in crash frequency



Step 1: Baseline Average Crash Frequency

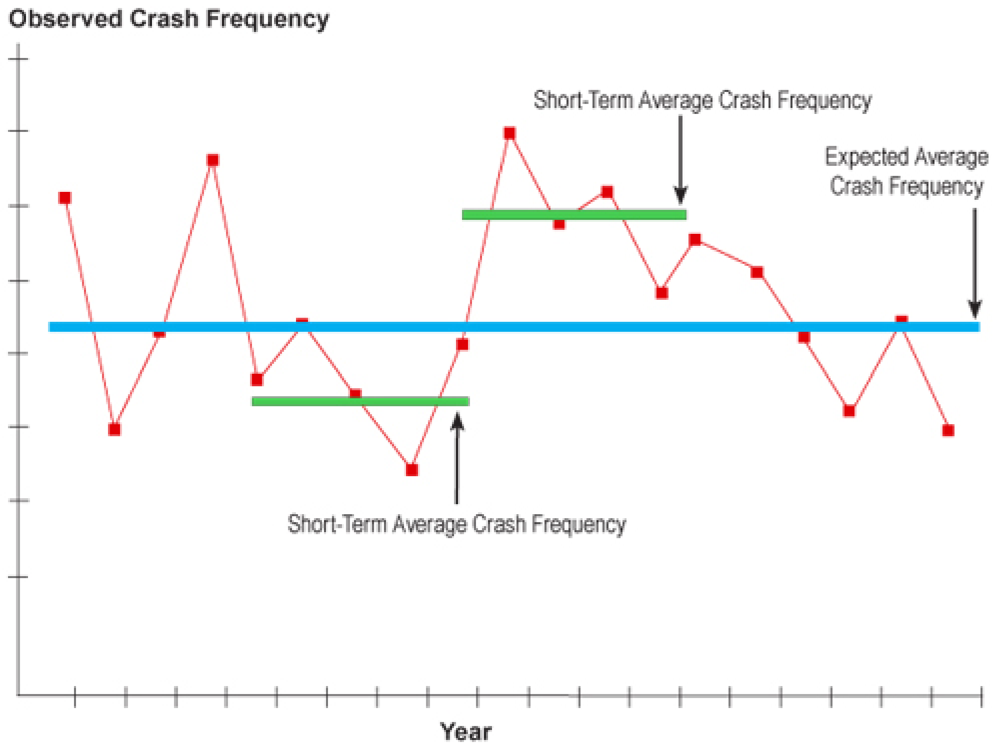
Establish baseline estimated average crash frequency for future no-build condition

a) Expected crash frequency

b) Predicted crash frequency

c) Observed crash frequency

d) Identify other options



Step 1: Identify Other Options

- At least two years of reliable observed crash data may not be available
- Locally calibrated SPFs or jurisdiction-specific SPFs may not be available
- Example options
  - Use one year of crash data if available
  - Identify a group of similar locations with reliable crash data
  - Use a predictive method for a similar facility type if available

Step 2: Alternative-Specific Baseline

- No-build condition may not serve as an applicable baseline for a project alternative
  - Example: Existing three-leg signalized intersection for a Continuous Green-T
  - An alternative-specific baseline (three-leg signalized intersection) may be required
- Alternative may require adjustment to baseline crash frequency if design year traffic volume differs
  - CMF may account for difference in traffic volume already
  - Example: road diet CMF may already account for change in traffic volume
- In most cases no adjustment is needed and results of Step 1 are used for Step 2

Step 3: Safety Effectiveness of Alternatives

- Several options exist for assessing project alternatives
- Each option has advantages and limitations
- Options are not considered as a hierarchy
  - Application of preferred CMFs
  - Application of pseudo-CMF
  - Application of safety surrogates

Step 3: Application of Preferred CMFs

- CMFs represent the relative effects of proposed countermeasures or enhancements
- HSM and CMF Clearinghouse contain CMFs to serve this purpose; however, context, crash type, and crash severity should be considered
- State agencies have developed preferred lists for consistent application
- HSM AFs can be applied together for multiple countermeasures
- NCHRP Report 991 should be considered when combining independent CMFs
- CMFs may not provide nuance for the complexity of proposed improvements
  - Example: CMF for widening rural two-lane to multilane roadway may be one CMF
  - Practitioner may wish to further consider the balance of median width, inside shoulder width, lane width, and outside shoulder width on safety performance

Step 3: Application of Pseudo-CMFs

- Relative comparison of predicted crash frequency from no-build to alternative

$$CMF_{pseudo} = \frac{N_{Alternative}}{N_{NoBuild}}$$

- May involve geometric changes within a facility type

$$CMF_{PM1} = \frac{AF_{i,A} \times \ldots \times AF_{n,A}}{AF_{i,NB} \times \ldots \times AF_{n,NB}}$$

- May involve geometric changes and traffic volume difference within a facility type

$$CMF_{PM2} = \frac{AADT_A^{\beta} \times AF_{i,A} \times \ldots \times AF_{n,A}}{AADT_{NB}^{\beta} \times AF_{i,NB} \times \ldots \times AF_{n,NB}}$$

- May involve a change in facility type

$$CMF_{pseudo} = \frac{N_{Alternative}}{N_{NoBuild}}$$

Step 3: Application of Pseudo-CMFs

- Allows for more nuanced assessment of geometric changes
- Allows for use of the predictive method when a CMF may not exist
- Assumes the predictive method for different facility types can be compared
  - Local calibration or jurisdiction-specific for all SPFs considered is required
  - Assumes single-State calibration is valid and applicable to jurisdiction if HSM models are directly applied

Step 4: Alternative Estimated Annual Crash Frequency

- Project alternative-specific estimated annual crash frequency

$$N_{estimated\ ,design\ ,alternative} = N_{baseline\ ,design\ ,alternative} \times CMF_{alternative}$$

- Can be compared to baseline crash frequency for the no-build condition or to other alternatives in the design year

Step 5: Change in Estimated Annual Crash Frequency

- Calculate the change in estimated annual crash frequency from the baseline in the design year under no-build conditions

$$N_{change,design,alternative} = N_{baseline,design} - N_{estimated,design,alterantive}$$

Summary

- Recommended approach provides consistent method for project alternatives analysis
- Flexible to demands of analysis and availability of evaluation methods
- Recommended approach prioritizes using EB method, when data are available
- Consistent application of relative effects of safety improvements
- Additionally, historic crash data confined to no-build condition, removing question of applicability after changes are made
- Can be accomplished without local calibration, but calibration is recommended
- Flexible to incorporate alternative-specific traffic volumes
- More research is needed to identify the extent to which local calibration supports assessment of alternatives across facility types compared to a single-State calibration

Questions?

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AASHTOWare Safety Crash Prediction Update

Alternative Design: A Tool to Support HSM 2 (Part C) and Green Book v8

Danny Anderson, Numetric
January, 2024

Outline of Presentation

- Why a new tool?
- Why now?
- Criteria for success
- Overview of the application

Why a New Tool?

Current Approaches:

- **IHSDM**
- **FHWA Spreadsheets**
- **Consultant made spreadsheets**
- **Consultants doing manual calculations**

Findings:

- Lack of Implementation
  - Only two states reported using the IHSDM consistently
  - Only one state (Wisconsin) included its use in their DOT policy
- Not Impacting Safety
  - Most reports were being completed after designers had completed their designs and created these reports to satisfy requirements, not to influence the design
  - Seen as a Safety Requirement, not design

Why a New Tool?

Current Approaches:

- **IHSDM**
- **FHWA Spreadsheets**
- **Consultant made spreadsheets**
- **Consultants doing manual calculations**

Findings:

- Usability Issues
  - Inputting data manually was the most time consuming part of the process
  - When a user made a change, they didn't know the impact that change had on the safety of the project until the entire report was complete
  - Unable to do multiple proposals in the same report

Why Now?

Feedback:

- Part C in HSM 1, struggled to get adopted nationwide. Part C will only become more complex in HSM 2.
- Green Book v8 will require designers to show comprehensive data, showing the impact of safety in their designs.
- States using the IHSDM are looking for a replacement.

Sunsetting and New Versions:

- **The IHSDM is now sunset**
- **HSM 2 - Begins balloting end of 2024**
- **Green Book v8 - Begins balloting end of 2024**

Criteria for Success

Adoption

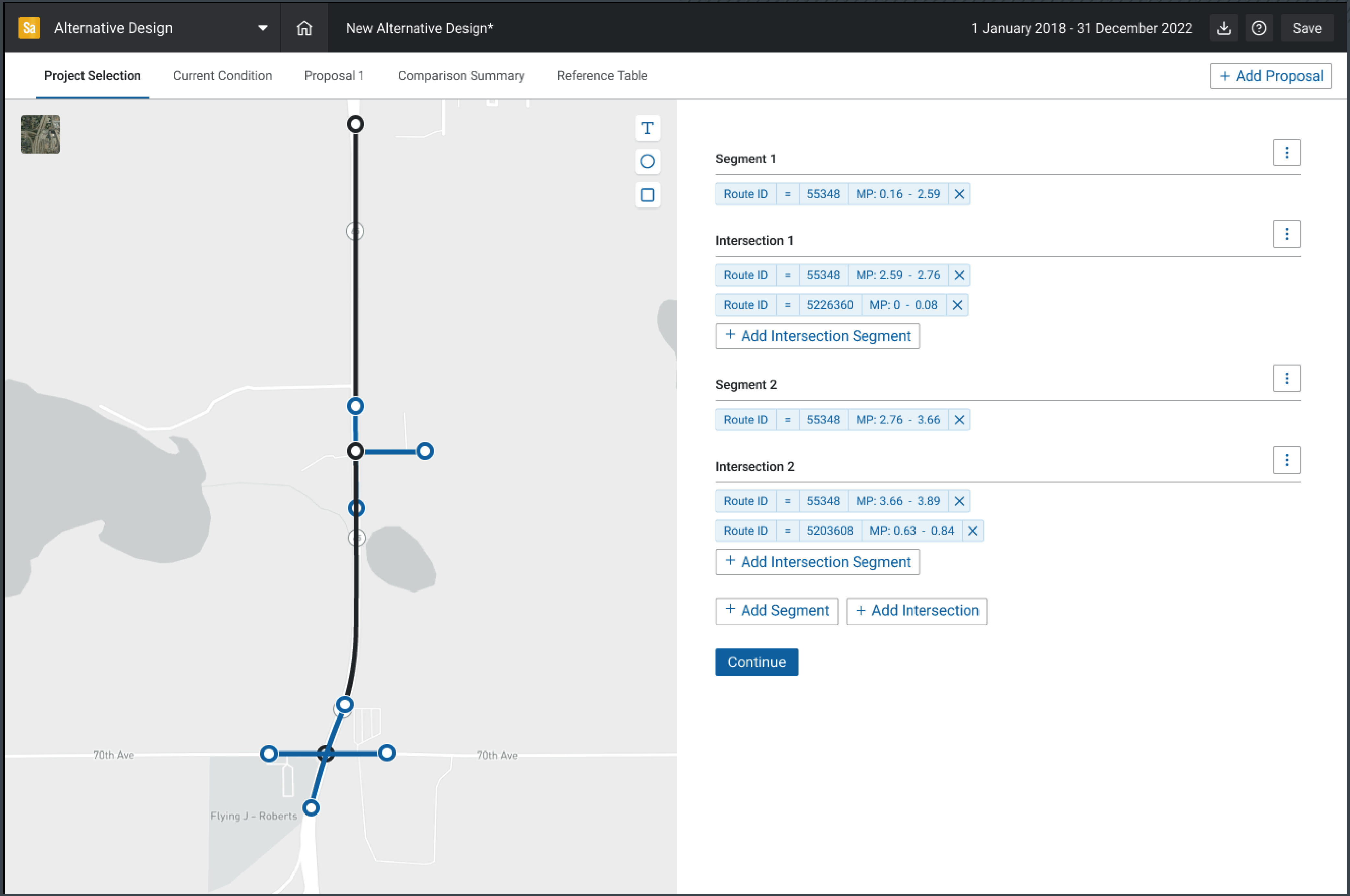
- This tool must be included in DOT policy
- This tool must be used by the designers creating the designs BEFORE work begins on the project
- This tool cannot be a Safety only tool, the must be adopted by Geometric Design and/or Planning
- This tool needs to make Part C a powerful tool to increase safety for all states

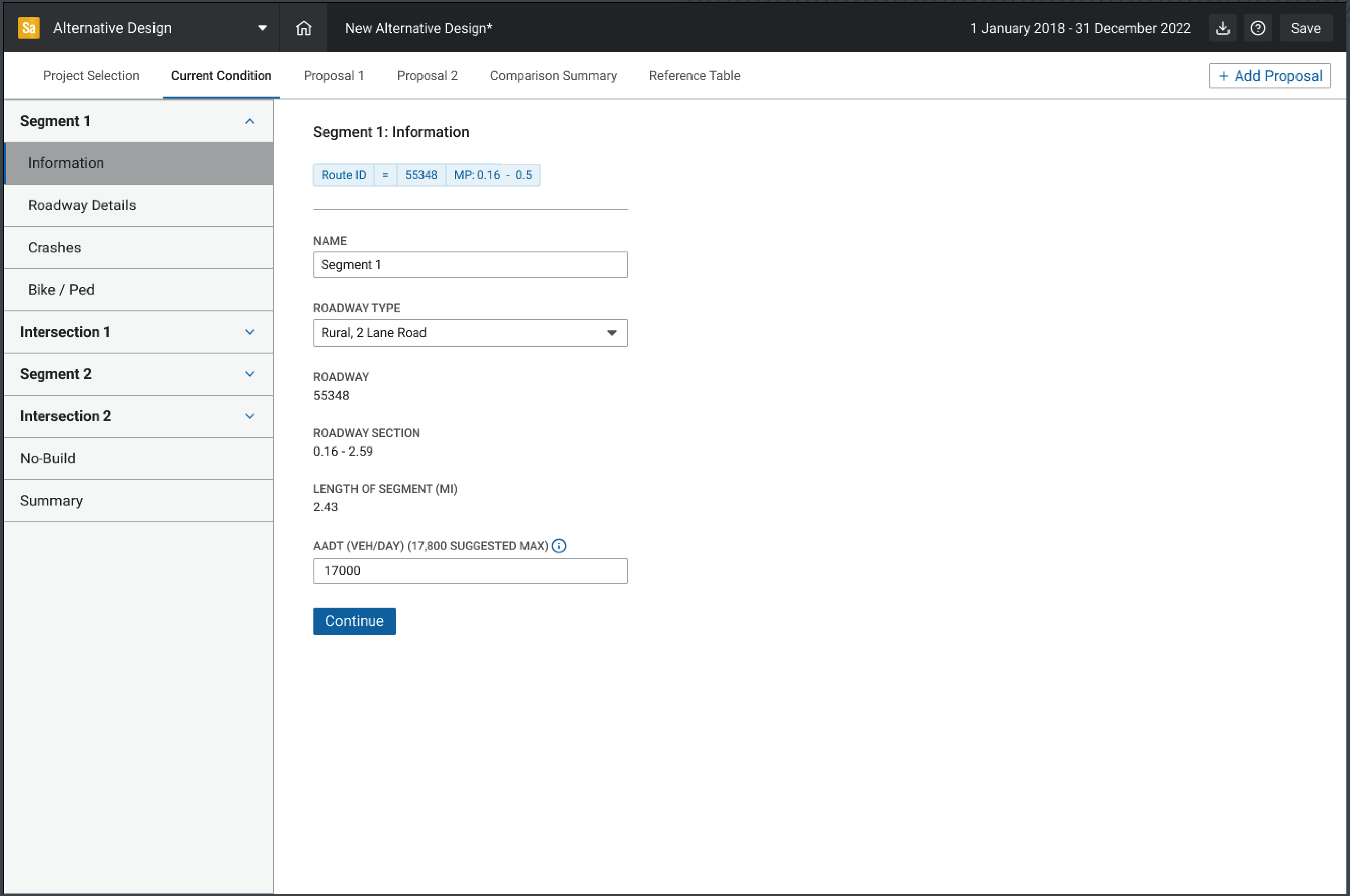
Timelines:

- **HSM Part I modules: August 2024**
- **HSM Part II modules: Q1/Q2 2025**

Demo

Questions?


Alternative Design
New Alternative Design*
1 January 2018 - 31 December 2022
Save
Project Selection
Current Condition
Proposal 1
Comparison Summary
Reference Table
+ Add Proposal
70th Ave
70th Ave
Flying J – Roberts
Segment 1
Route ID = 55348 MP: 0.16 - 2.59
Intersection 1
Route ID = 55348 MP: 2.59 - 2.76
Route ID = 5226360 MP: 0 - 0.08
+ Add Intersection Segment
Segment 2
Route ID = 55348 MP: 2.76 - 3.66
Intersection 2
Route ID = 55348 MP: 3.66 - 3.89
Route ID = 5203608 MP: 0.63 - 0.84
+ Add Intersection Segment
+ Add Segment
+ Add Intersection
Continue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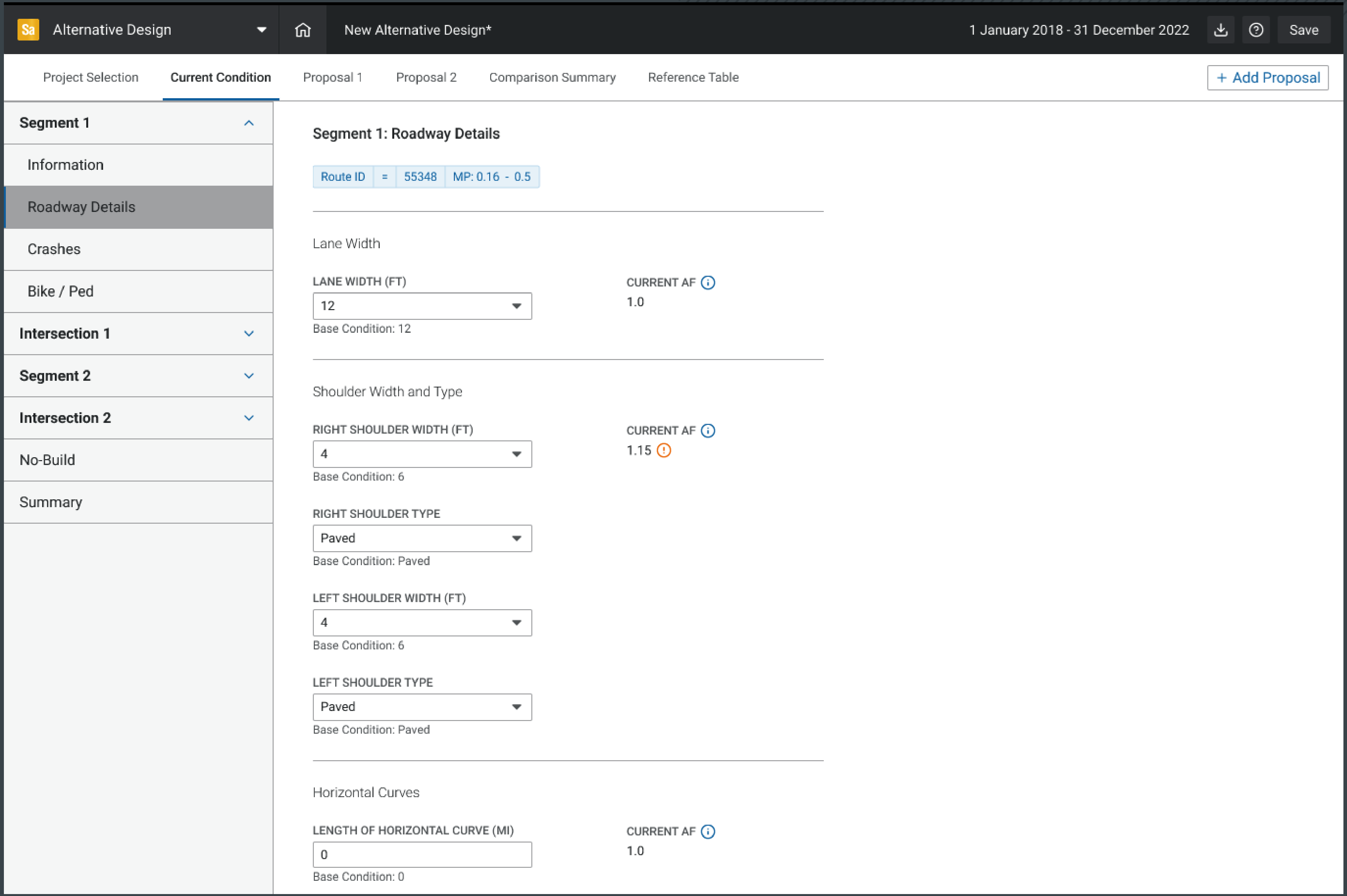
Alternative Design
New Alternative Design*
1 January 2018 - 31 December 2022
Save
Project Selection
Current Condition
Proposal 1
Proposal 2
Comparison Summary
Reference Table
+ Add Proposal
Segment 1
Information
Roadway Details
Crashes
Bike / Ped
Intersection 1
Segment 2
Intersection 2
No-Build
Summary
Segment 1: Information
Route ID = 55348 MP: 0.16 - 0.5
NAME
Segment 1
ROADWAY TYPE
Rural, 2 Lane Road
ROADWAY
55348
ROADWAY SECTION
0.16 - 2.59
LENGTH OF SEGMENT (MI)
2.43
AADT (VEH/DAY) (17,800 SUGGESTED MAX)
17000
Continue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Alternative Design
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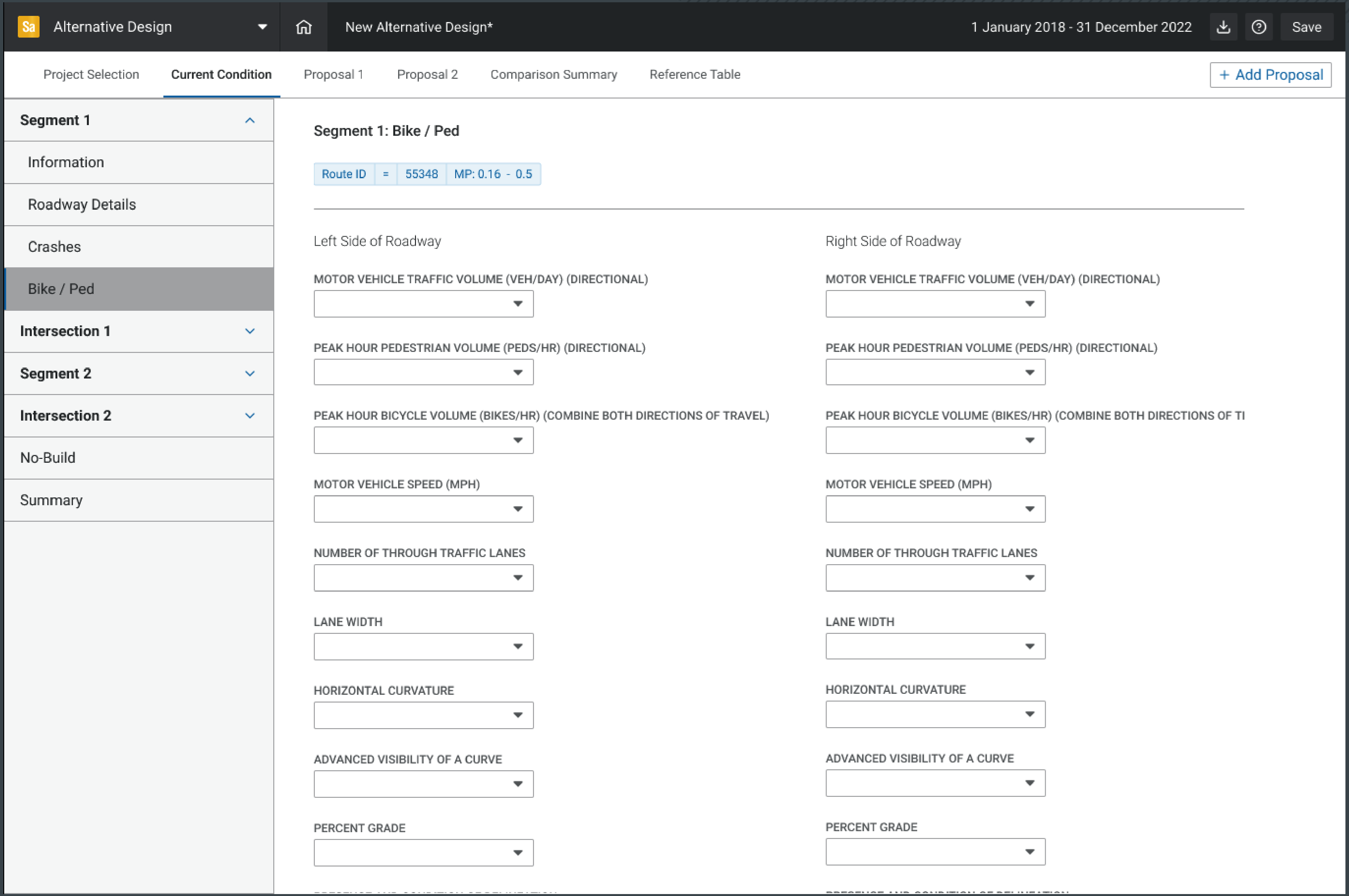
1 January 2018 - 31 December 2022
Save
Project Selection
Current Condition
Proposal 1
Proposal 2
Comparison Summary
Reference Table
+ Add Proposal
Segment 1
Information
Roadway Details
Crashes
Bike / Ped
Intersection 1
Segment 2
Intersection 2
No-Build
Summary
Segment 1: Roadway Details
Route ID = 55348 MP: 0.16 - 0.5
Lane Width
LANE WIDTH (FT)
12
Base Condition: 12
CURRENT AF
1.0
Shoulder Width and Type
RIGHT SHOULDER WIDTH (FT)
4
Base Condition: 6
CURRENT AF
1.15
RIGHT SHOULDER TYPE
Paved
Base Condition: Paved
LEFT SHOULDER WIDTH (FT)
4
Base Condition: 6
LEFT SHOULDER TYPE
Paved
Base Condition: Paved
Horizontal Curves
LENGTH OF HORIZONTAL CURVE (MI)
0
Base Condition: 0
CURRENT AF
1.0


Alternative Design
New Alternative Design*
1 January 2018 - 31 December 2022
Save
Project Selection
Current Condition
Proposal 1
Proposal 2
Comparison Summary
Reference Table
+ Add Proposal
Segment 1
Information
Roadway Details
Crashes
Bike / Ped
Intersection 1
Segment 2
Intersection 2
No-Build
Summary
Segment 1: Bike / Ped
Route ID = 55348 MP: 0.16 - 0.5
Left Side of Roadway
Right Side of Roadway
MOTOR VEHICLE TRAFFIC VOLUME (VEH/DAY) (DIRECTIONAL)
PEAK HOUR PEDESTRIAN VOLUME (PEDS/HR) (DIRECTIONAL)
PEAK HOUR BICYCLE VOLUME (BIKES/HR) (COMBINE BOTH DIRECTIONS OF TRAVEL)
MOTOR VEHICLE SPEED (MPH)
NUMBER OF THROUGH TRAFFIC LANES
LANE WIDTH
HORIZONTAL CURVATURE
ADVANCED VISIBILITY OF A CURVE
PERCENT GRADE
MOTOR VEHICLE TRAFFIC VOLUME (VEH/DAY) (DIRECTIONAL)
PEAK HOUR PEDESTRIAN VOLUME (PEDS/HR) (DIRECTIONAL)
PEAK HOUR BICYCLE VOLUME (BIKES/HR) (COMBINE BOTH DIRECTIONS OF TI
MOTOR VEHICLE SPEED (MPH)
NUMBER OF THROUGH TRAFFIC LANES
LANE WIDTH
HORIZONTAL CURVATURE
ADVANCED VISIBILITY OF A CURVE
PERCENT GRADE

Sa Alternative Design | New Alternative Design* | 1 January 2018 - 31 December 2022 | Save

Project Selection | Current Condition | Proposal 1 | Proposal 2 | Comparison Summary | Reference Table | + Add Proposal

Segment 1

- Information
- Roadway Details
- Crashes
- Bike / Ped

Intersection 1

Segment 2

Intersection 2

No-Build

Summary

No-Build

INCLUDE AADT GROWTH

- (•) Yes
- ( ) No

YEARS

5

ANNUAL AADT GROWTH RATE (%)

3.5

Continue

Sa Alternative Design

New Alternative Design*

1 January 2018 - 31 December 2022

Save

Project Selection | Current Condition | **Wider Shoulders (and then some) Proposal** | Proposal 2 | Comparison Summary | Reference Table

+ Add Proposal

- **Information**
- Segment 1
- Intersection 1
- Segment 2
- Intersection 2
- Cost
- Summary

Information

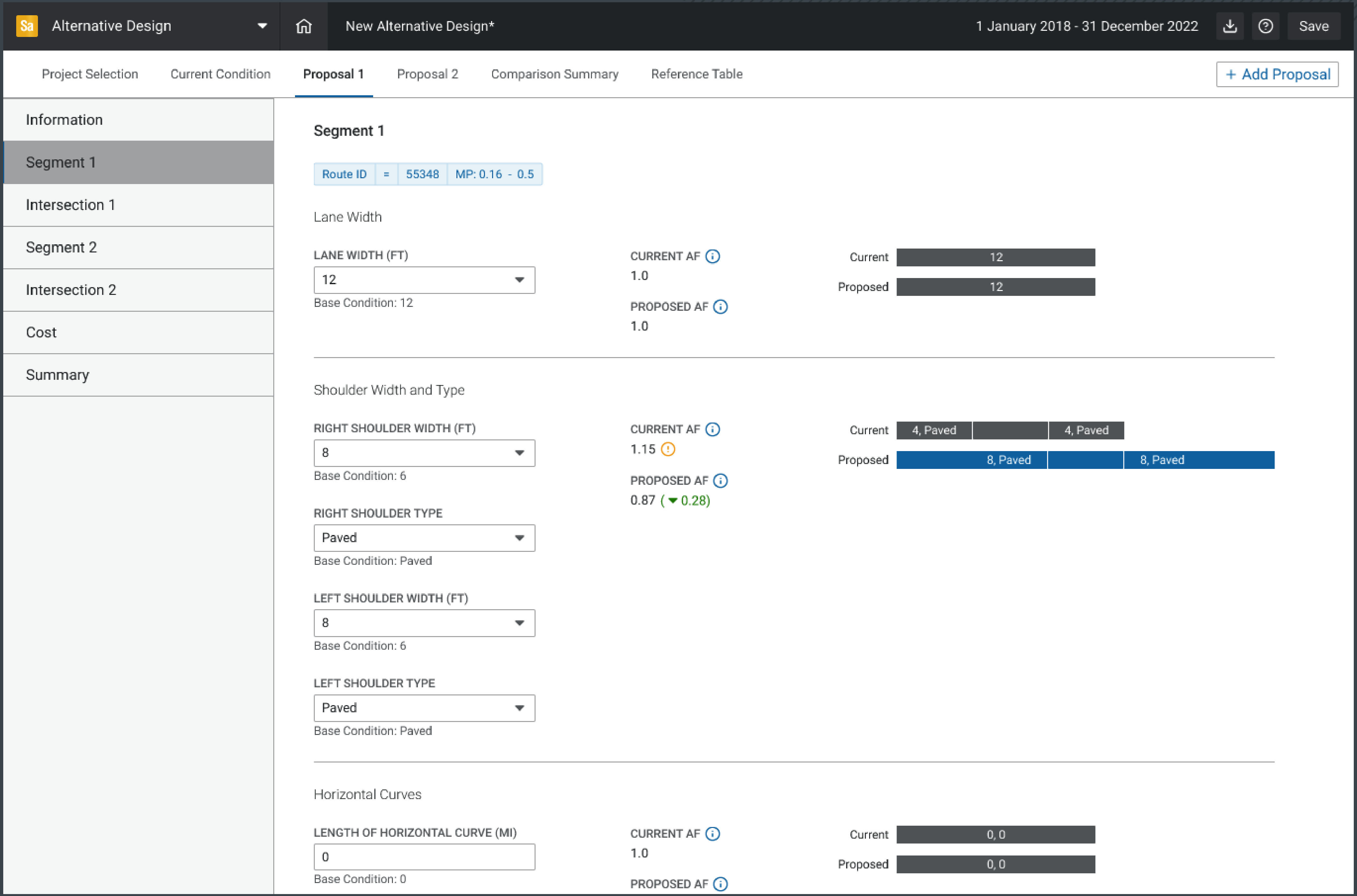
PROPOSAL NAME

Wider Shoulders (and then some) Proposal

PROPOSAL NOTES (5,000 CHARACTER MAX)

Continue

Remove Proposal


Sa
Alternative Design
New Alternative Design*
1 January 2018 - 31 December 2022
Save
Project Selection
Current Condition
Proposal 1
Proposal 2
Comparison Summary
Reference Table
+ Add Proposal
Information
Segment 1
Intersection 1
Segment 2
Intersection 2
Cost
Summary
Segment 1
Route ID = 55348 MP: 0.16 - 0.5
Lane Width
LANE WIDTH (FT)
12
Base Condition: 12
CURRENT AF
1.0
PROPOSED AF
1.0
Current 12
Proposed 12
Shoulder Width and Type
RIGHT SHOULDER WIDTH (FT)
8
Base Condition: 6
RIGHT SHOULDER TYPE
Paved
Base Condition: Paved
LEFT SHOULDER WIDTH (FT)
8
Base Condition: 6
LEFT SHOULDER TYPE
Paved
Base Condition: Paved
CURRENT AF
1.15
PROPOSED AF
0.87 (0.28)
Current 4, Paved 4, Paved
Proposed 8, Paved 8, Paved
Horizontal Curves
LENGTH OF HORIZONTAL CURVE (MI)
0
Base Condition: 0
CURRENT AF
1.0
PROPOSED AF
Current 0, 0
Proposed 0, 0

Sa Alternative Design | New Alternative Design* | 1 January 2018 - 31 December 2022 | Save

Project Selection | Current Condition | **Proposal 1** | Proposal 2 | Comparison Summary | Reference Table | + Add Proposal

- Information
- Segment 1
- Intersection 1
- Segment 2
- Intersection 2
- Cost
- Summary

Cost

Total Benefit	Total Project Cost	Total Benefit Cost Ratio
$861,823	$73,000	19.47

Shoulder Width and Type

Left Shoulder: 4 ft, Paved
Right Shoulder: 4 ft, Paved
→
Left Shoulder: 8 ft, Paved
Right Shoulder: 8 ft, Paved

CONSTRUCTION COST
50000

MAINTENANCE COST
0

SERVICE LIFE (YEARS)
20

Shoulder Width and Type Changes	
Benefit	$76,078
Project Cost	$50,000
Benefit Cost Ratio	1.52
Annual Cost Savings	$5,003
Annual Crash Reduction	0.29

Roadside Design

5 → 3

CONSTRUCTION COST
1000

MAINTENANCE COST
1000

SERVICE LIFE (YEARS)
5

Roadside Design Changes	
Benefit	$0
Project Cost	$2,000
Benefit Cost Ratio	0.00
Annual Cost Savings	$0
Annual Crash Reduction	0.00

Alternative Design

New Alternative Design*

1 January 2018 - 31 December 2022

Save

Project Selection | Current Condition | **Proposal 1** | Proposal 2 | Comparison Summary | Reference Table

+ Add Proposal

- Information
- Segment 1
- Intersection 1
- Segment 2
- Intersection 2
- Cost
- Summary

Summary

TOTAL COMBINED PROPOSED AF
1.03

By Segment/Intersection

SEGMENT 1 AF
1.08

INTERSECTION 1 AF
1.00

SEGMENT 2 AF
1.00

INTERSECTION 1 AF
1.00

By Crash Severity

FATAL (K) AF
1.00

SUSPECTED SERIOUS INJURY (A) AF
1.08

SUSPECTED MINOR INJURY (B) AF
1.00

POSSIBLE INJURY (C) AF
1.08

PROPERTY DAMAGE ONLY (O) AF
1.08

Continue

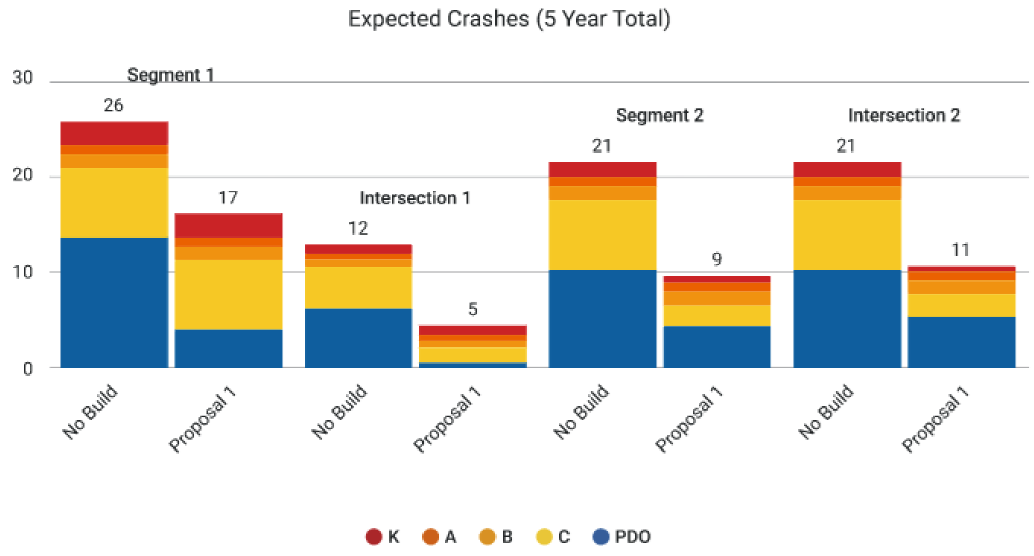


Table 10-5: Default Distribution for Crash Severity Level at Rural Two-Lane Two-Way Intersections plus Locally-Derived Values

Note: HSM -Provided values based on HSIS data for California (2002-2006). *optional values

	HSM-Provided Values			Locally-Derived Values		
Collision Type	**3ST**	**4ST**	**4SG**	**3ST**	**4ST**	**4SG**
Fatal	1.7	1.8	0.9	4.0*	17.0*	*
Incapacitating Injury	4.0	4.3	2.1	4.0*	17.0*	*
Non-incapacitating Injury	16.6	16.2	10.5	4.0*	17.0*	*
Possible Injury	19.2	20.8	20.5	4.0*	17.0*	*
Total Fatal + Injury	41.5	43.1	34.0	4.0	17.0	0.0
Property Damage Only	58.5	56.9	66.0	96.0	83.0	100.0
Total	**1.00**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table 10-8: AF for Lane Width on Roadway Segments by AADT

Note: The collision types related to lane width to which this CMF applies include single-vehicle run-off-the-road and multiple-vehicle head-on, opposite-direction sideswipe, and same-direction sideswipe crashes.

Lane Width (ft)	**AADT (veh/day) < 400**	**AADT (veh/day) 400 to 2000**	**AADT (veh/day) > 2000**
9	1.05	5.71	1.50
9.5	1.04	4.82	1.40
10	1.02	3.93	1.30
10.5	1.02	2.68	1.18
11	1.01	1.43	1.05
11.5	1.01	1.21	1.03
12	1.00	1.00	1.00

Announcements

Upcoming Events

2024 Midyear Meeting

- 13th National Conference on Access Management
- Boston, MA
- June 24-26, Sheraton Boston Hotel

Upcoming Events

- 2nd International Roadside Safety Conference,
  - June 23-26, 2024 – Orlando, FL

- 2024 Road Safety & Simulation Conference,
  - October 28-31, 2024 – Lexington, KY

Open Floor


See you tomorrow morning at 9:00 am EST
in the Liberty Salon JK (M4)