Minnesota Walks Safely Together: Examining Statewide Roadway Risk Factors in Context

Sonja Piper, PE | MnDOT Office of Traffic Engineering

Jessica Schoner, PhD | Toole Design Group

DEPARTMENT OF TRANSPORTATION

TOOLE DESIGN

Website: mndot.gov/trafficeng/index.html
Photo Source: Toole Design Group

Presentation Overview

- Purpose, Context, and Approach
- Data Sources
- Systemic Pedestrian Safety Analysis
  - Descriptive and SPACE analysis
  - Crash Types and Crash Trees
- Next Steps and Implementation
- Conclusion and Resources

Photo source: Toole Design Group

Purpose

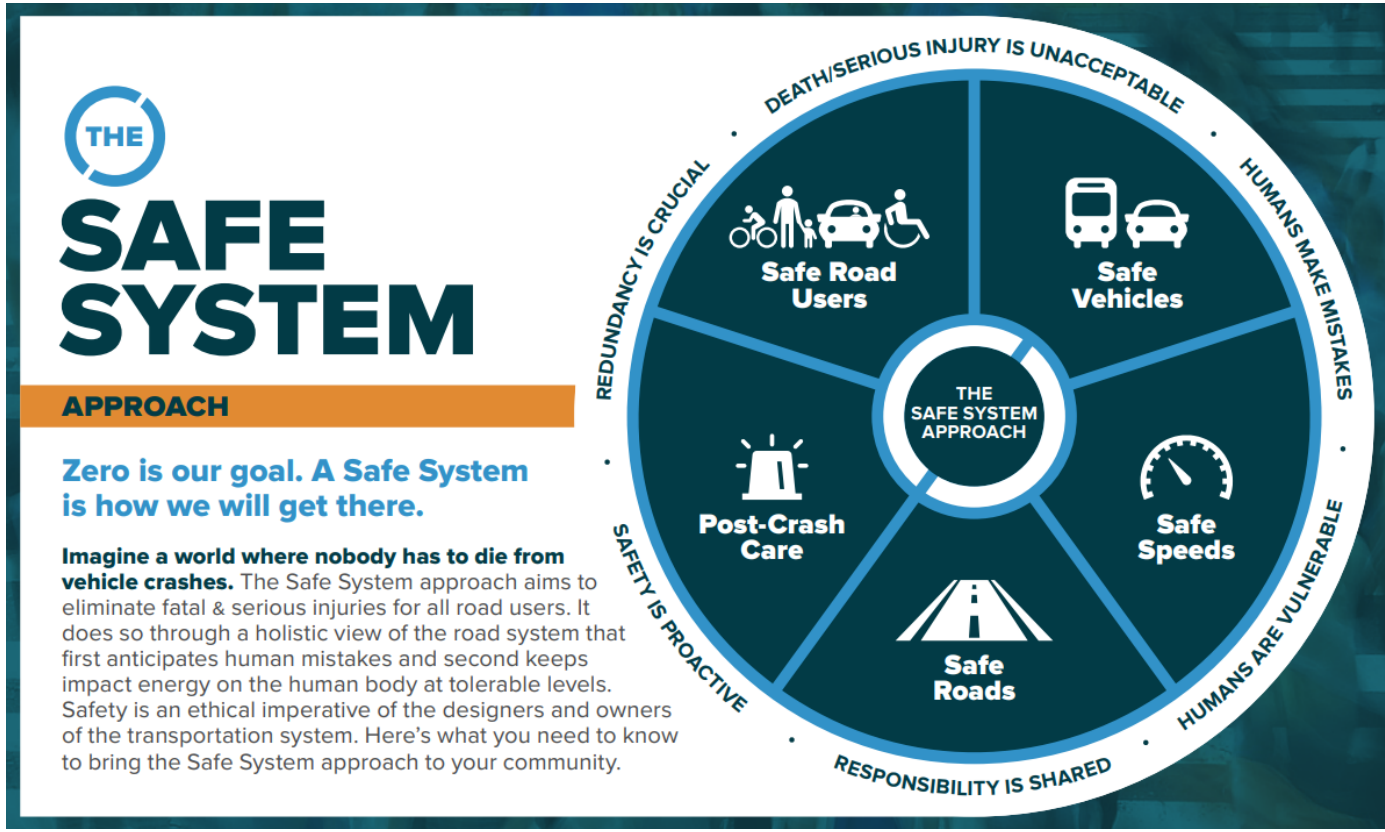
- Study Goal: Understand underlying systemic and environmental risk factors for pedestrian deaths and injuries
- Approach: Merge multiple existing statewide sources and analyze them in conjunction to better understand and explain pedestrian crashes

Photo source: Toole Design Group

Context: FHWA Approach

The FHWA Safe System Approach

- People make mistakes
- Human bodies are vulnerable
- Deaths or serious injuries are not acceptable
- Redundant safety measures create layers of safety
- **Infrastructure is key**
  - Influences user behavior
  - Alters crash dynamics



Graphic source: FHWA, 2020

Approach

- This study is exclusively focused on pedestrian crashes
  - Bicycle crashes and other non-motorized crashes may be analyzed in a future study
- Collected, inventoried, and consolidated data for systemic analysis:
  - Crash reports,
  - Roadway attributes, and
  - Land use characteristics

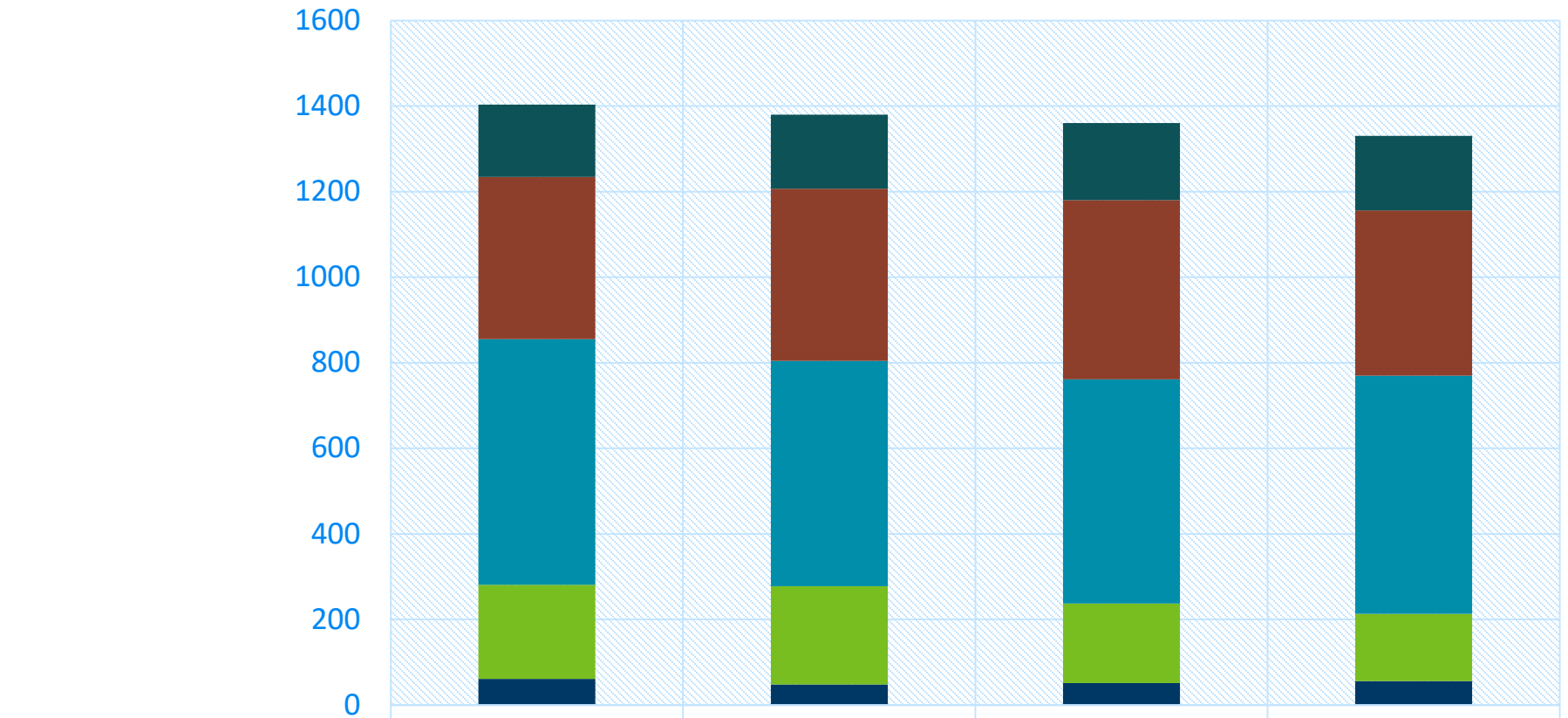
Photo source: Toole Design Group

Crash Data in Minnesota

- Crash data come from police reports aggregated by the Minnesota Department of Public Safety and shared with MnDOT.
- Study dataset: 2016-2019. DPS previously overhauled crash reporting system.
- Roadway and contextual data can be joined to crash data spatially to enrich our understanding of crash dynamics and context.
    - *Some roadway variables are ONLY available for certain types or subsets of roadways*

Year-to-Year Crash Data

- Year-to-year changes do not necessarily indicate a meaningful trend.
- Need to pool the data across several years to understand broader patterns.



	2016	2017	2018	2019
Property Damage Only (O)	169	173	180	174
Possible Injury (C)	379	403	419	386
Minor Injury (B)	574	526	524	557
Serious Injury (A)	220	230	186	157
Fatal (K)	61	48	51	56

Contextual Data Joined to Crashes

LRS	TAMS	ADA	HERE	**SPACE**	Additional Datasets

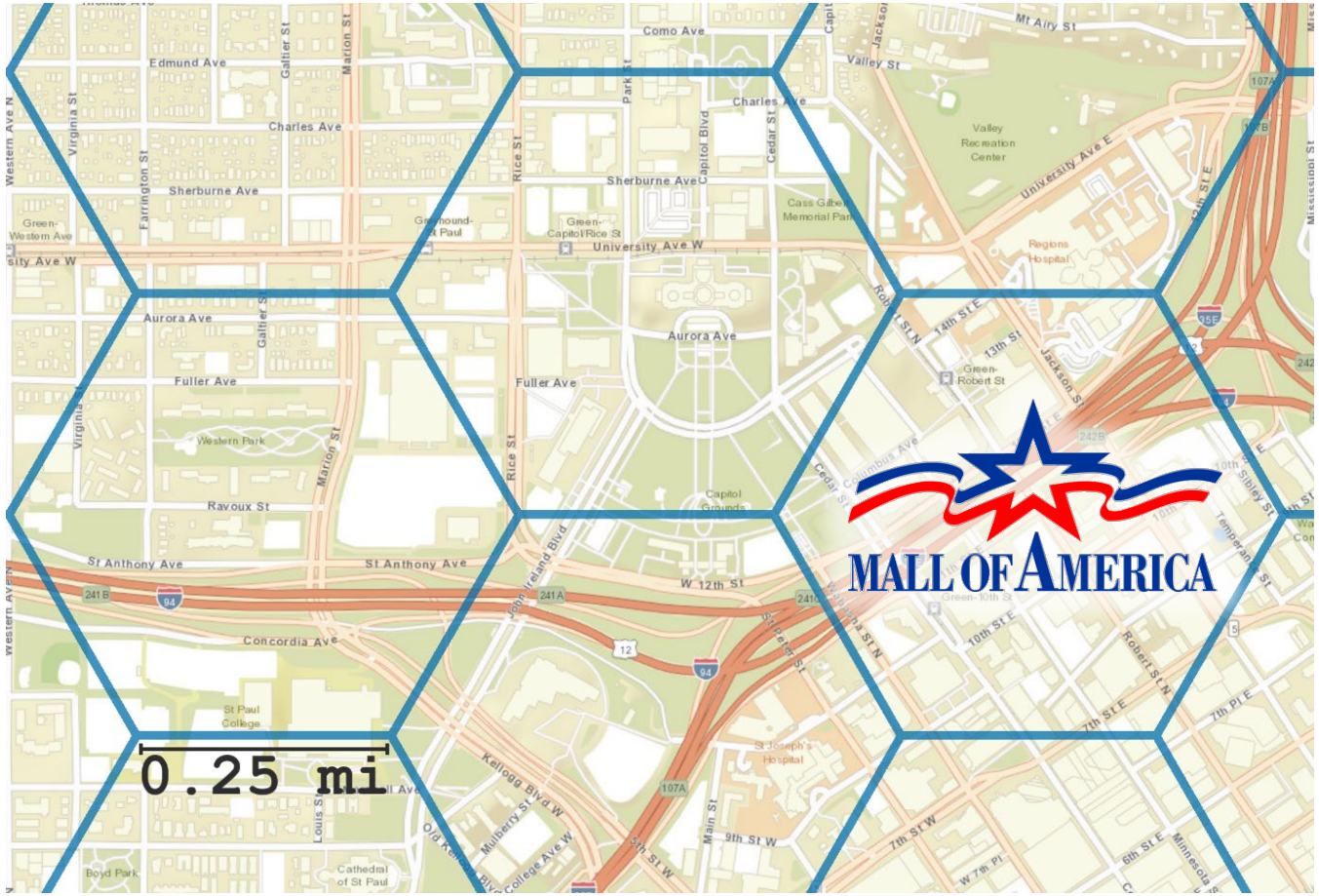
• Lanes, AADT, functional class, shoulders, parking
• Mostly Trunk Highways
  • AADT in more locations
	• Pavement messages and markings, signals, signs
	• Only for assets owned by MnDOT
	  • Trunk highways outside largest cities
		• Curb ramps, accessible pedestrian signals, sidewalk widths
		• Only for assets owned by MnDOT
		• No information about where data not present
		  • e.g., doesn't catalog where sidewalks *aren't*
			• Vendor data, including approximate speeds, point destinations, and other features
			• Statewide coverage, but with varying accuracy
				• 19 factors about demographics, land use, and roadway infrastructure selected for relevance to ped/bike
				• Statewide coverage measured in ½ mile hexagons
					• Signal spreadsheet from MnDOT
					• Intersection polygon dataset from MnDOT
					• US Census / American Community Survey

SPACE - Suitability of the Pedestrian And Cyclist Environment Data Components

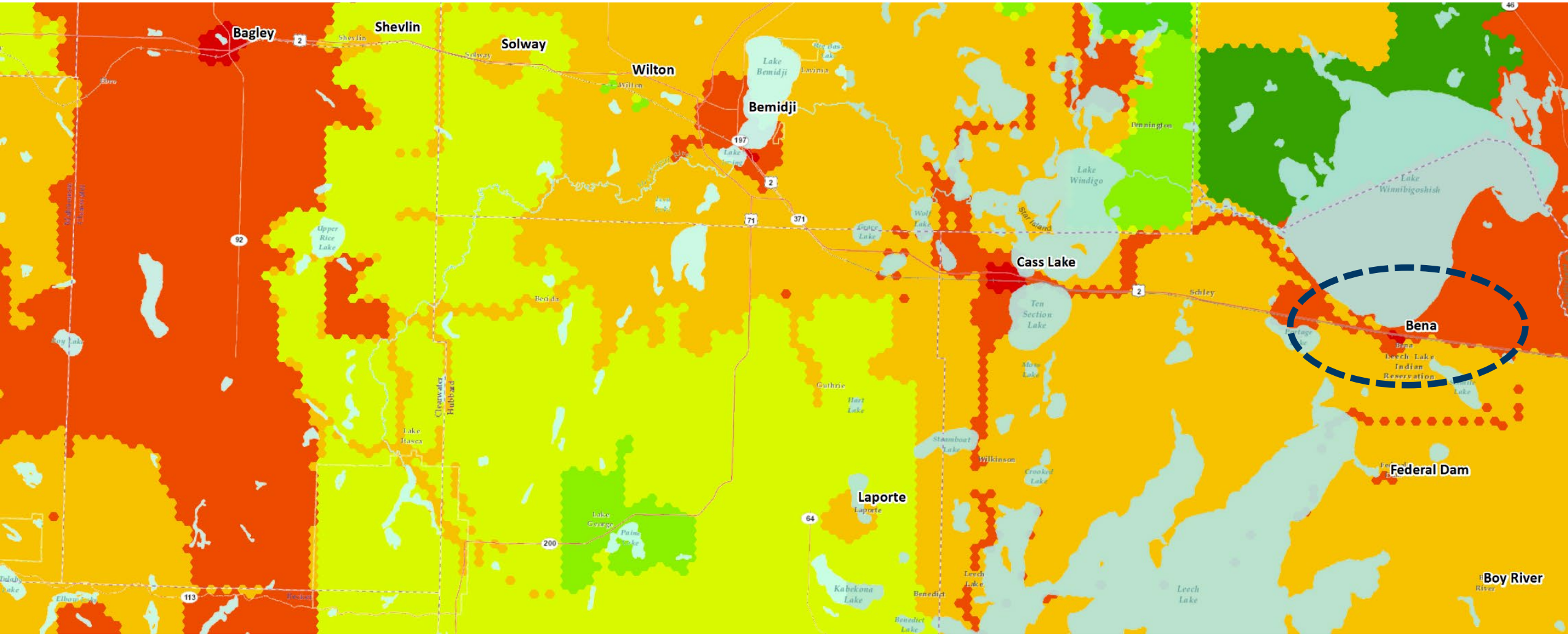
Priority Populations	Percent of population **AGE 5-17** > average	Existing & Latent Demand	Percent of workers **COMMUTING 15 MIN** or less > average
	Percent of population **AGE 65+** > average		Percent of workers **COMMUTING BY TRANSIT** > 0%
	Percent of population **FOREIGN BORN** > average		Percent of workers **COMMUTING BY WALKING** > 0%
	Percent of population **NATIVE AMERICAN** > average		Percent of workers **COMMUTING BY BICYCLE** > 0%
	Percent of population with **DISABILITY** > average		Percent of workers with **NO ACCESS TO A VEHICLE** > 0%
Environmental Justice	"Area of concern" by MPCA **ENVIRONMENTAL JUSTICE**	Trip Generators	≥ 25% population within half-mile of **SUPERMARKET**
	UNEMPLOYMENT rate ≥ average		Within 1-mile of K-12 **SCHOOL**
	Percent of population in **POVERTY IN URBAN** area ≥ 25%		Within 500 feet of **BUS STOP**
Risk	**HIGH RISK** trunk highway intersection for non-motorists		Within an **URBAN** area
	19 factors		Contains a state **BICYCLE TRAIL**

SPACE Standardized Grid

- The data sources that go into SCORE are diverse; the geographies do not always align.
- To solve this issue, MnDOT used a standard shape, in this case hexagons. This is for the following reasons:
  - Circles ideal: but they do not tessellate
  - Regular, simple shape
  - Identifies contours
  - No quirky angle issues
- Each hexagon is approximately 104 acres (1/2-mile diameter) and is calculated for the entire state.



SPACE Output - Bemidji, MN

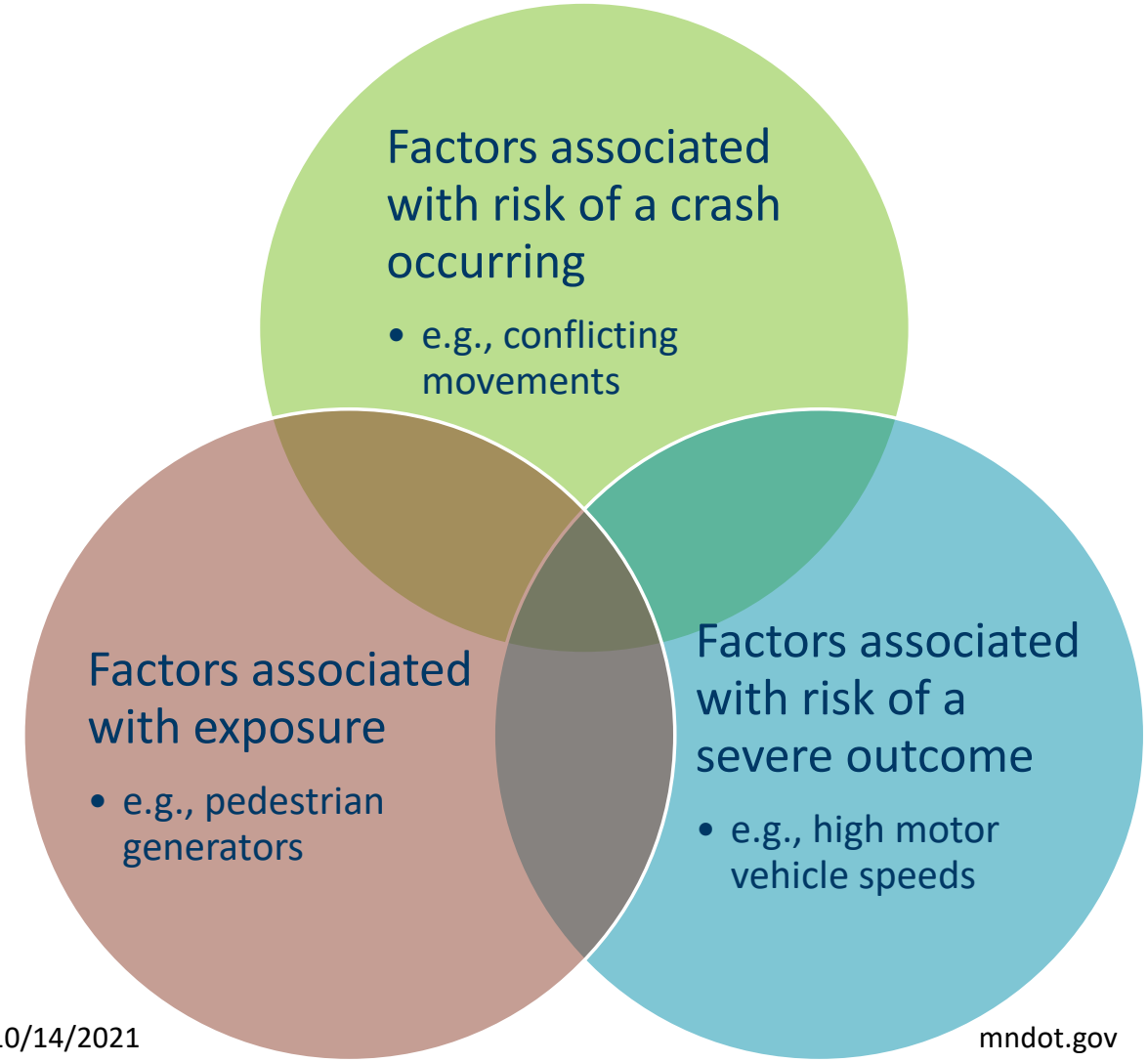


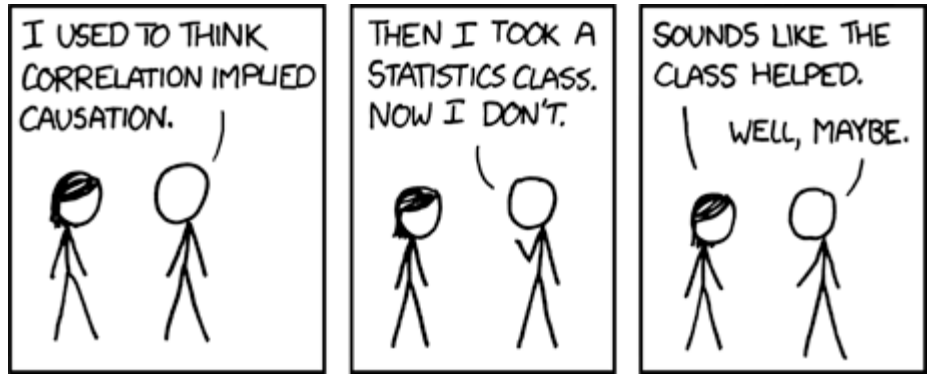
Descriptive Analysis Results

- Crashes by SPACE score
- Crashes by underlying SPACE input data – race, poverty status, reservations, and other attributes
- Crashes by location type and roadway type
- Note: different categories of severity analyzed, depending on data coverage, analysis type, and sample size

	Grouping 1 (Used for SPACE score analysis and Crash Trees)	Grouping 2 (Used for roadway attributes descriptive analysis)
Severe	Fatal (K) + Injury A ●	Fatal (K) + Injury A/B ●
Non-Severe	Injury B/C + PDO	Injury C + PDO

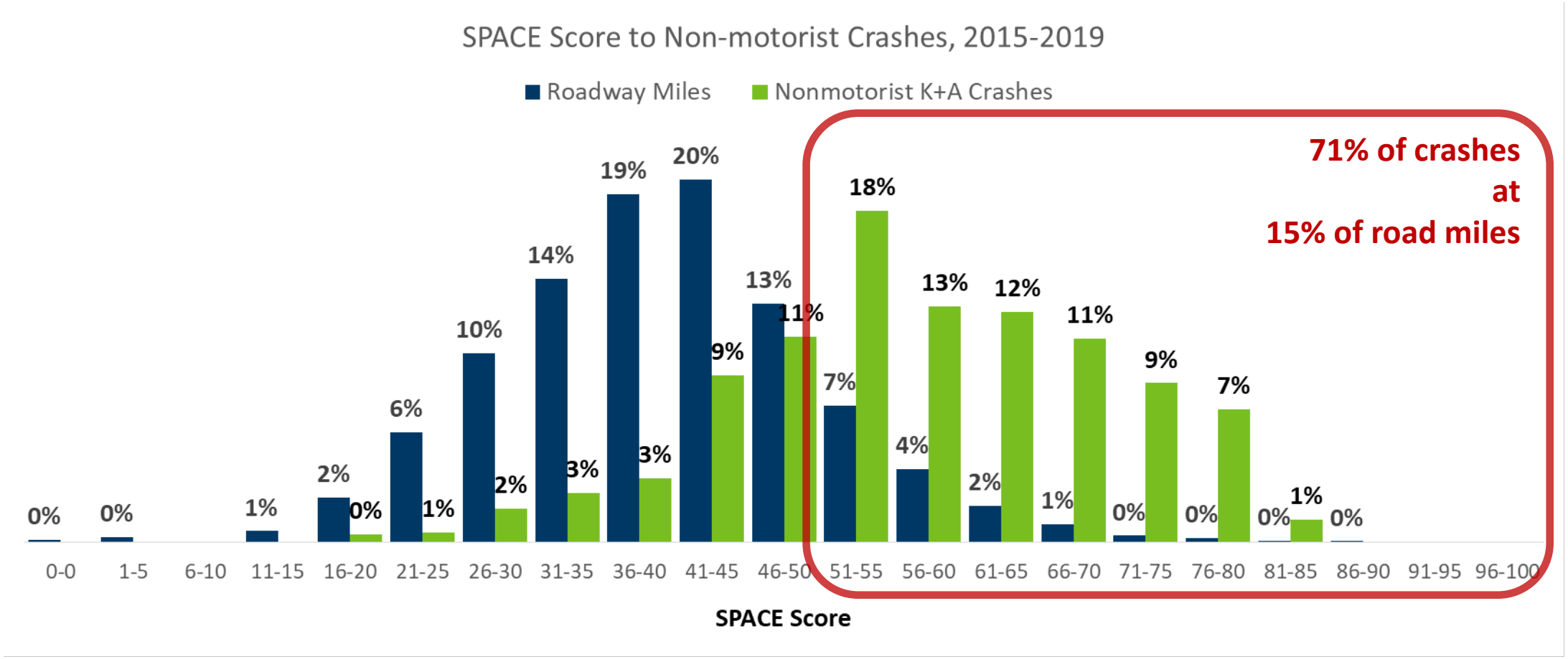
Pedestrian Risk Factors: Correlation vs Causation





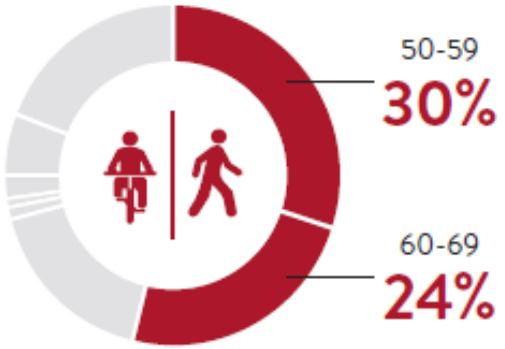
https://xkcd.com/552/

MnDOT's Analysis – SPACE Score as a Risk Factor for Peds + Bikes



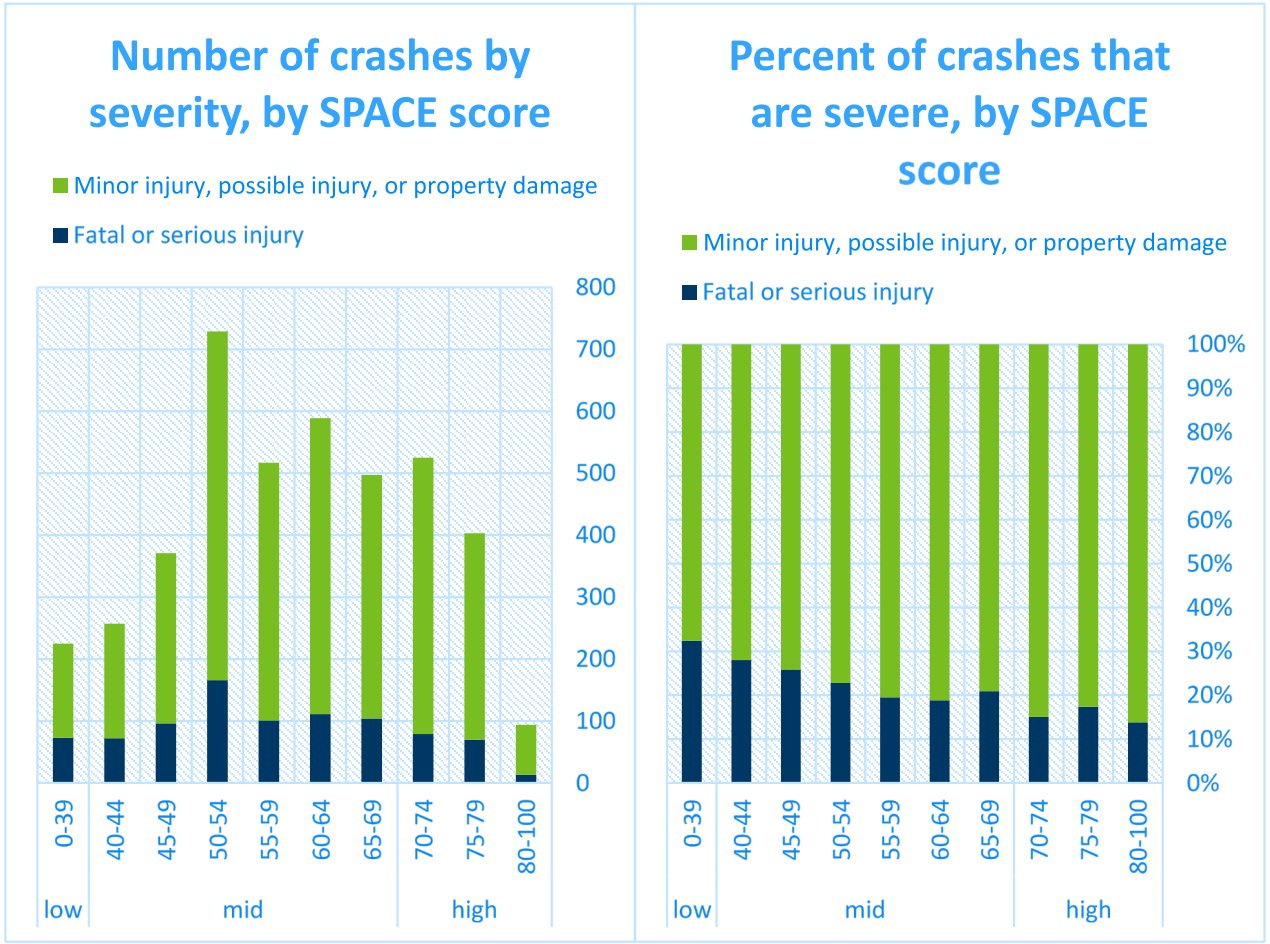
Pedestrian Crashes by SPACE Score and Severity

- Higher numbers of crashes occurred in areas with mid-range SPACE scores.
- The percentage of high-severity crashes did not follow this pattern.



More than half

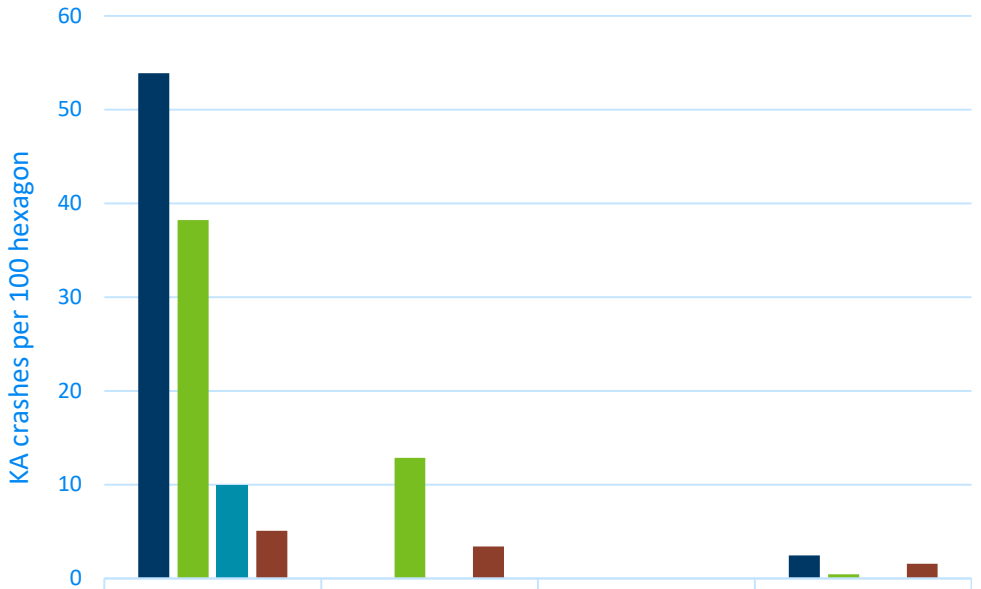
of fatal and injury pedestrian crashes occur in areas with mid-range Suitability of Pedestrian and Cycling Environment (SPACE) scores (50-69).



Crashes by SPACE Demographic Inputs: BIPOC Communities + Low Income

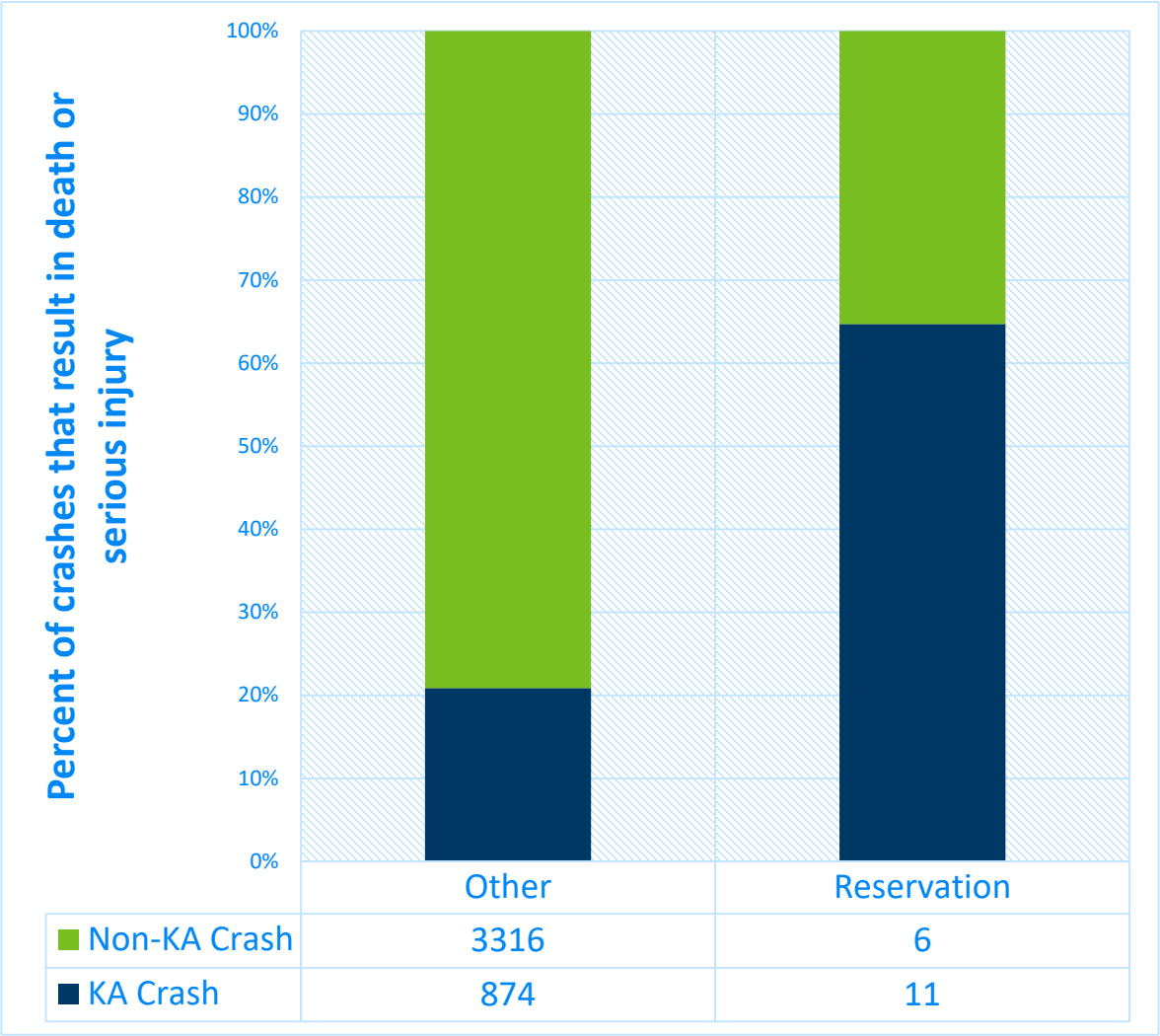
Areas with high poverty rates have **3.9x** as many fatal and injury pedestrian crashes per square mile as high income/low poverty areas.

Areas where a majority of residents are Black, Indigenous, and People of Color have almost **9x** as many fatal and injury pedestrian crashes per square mile as majority white areas.



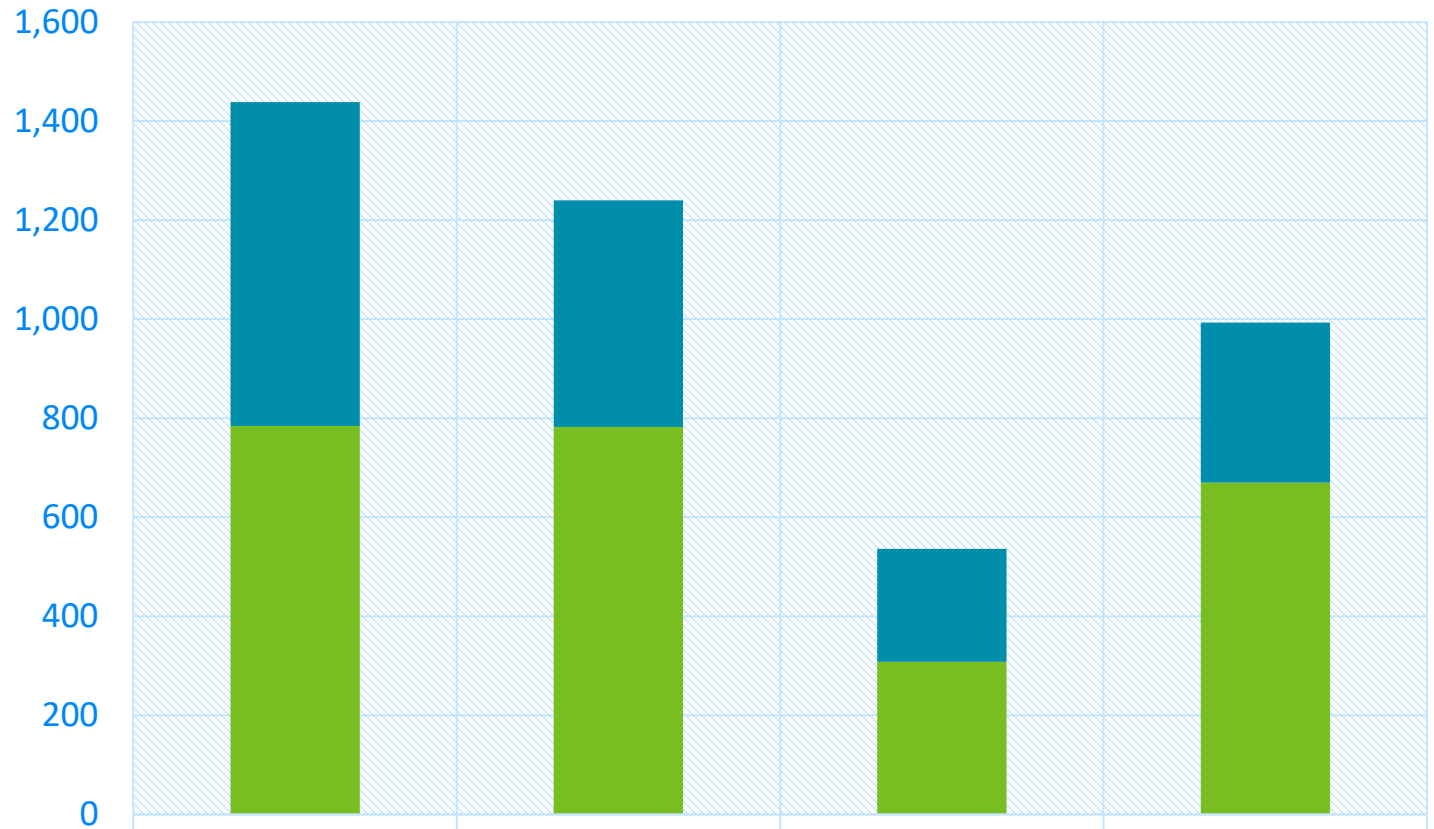
	METRO	METRO - GREATER MN	RURAL	RURAL DOWNTOWN
At least 40% low income - At least 50% POC	53.89		0.02	2.44
At least 40% low income - Less than 50% POC	38.19	12.84	0.01	0.44
Less than 40% low income - At least 50% POC	10.00		0.00	
Less than 40% low income - Less than 50% POC	5.08	3.41	0.02	1.56

Crashes by SPACE Demographic Inputs and Severity: Reservations



Note: Crashes on reservations may be under-reported in DPS/MnDOT's database.

Crashes by Location Type and Severity

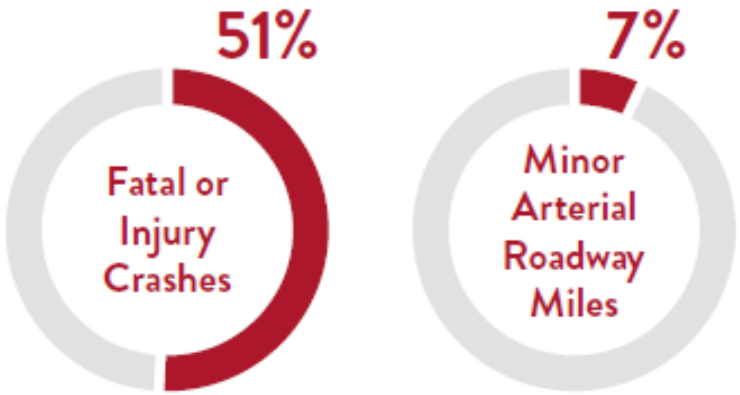


	Intersection with signal	Intersection without signal	Intersection with other/unknown control	Mid-block / segment
Injury C + PDO	654	458	228	323
Fatal + Injury (KAB)	784	782	308	670

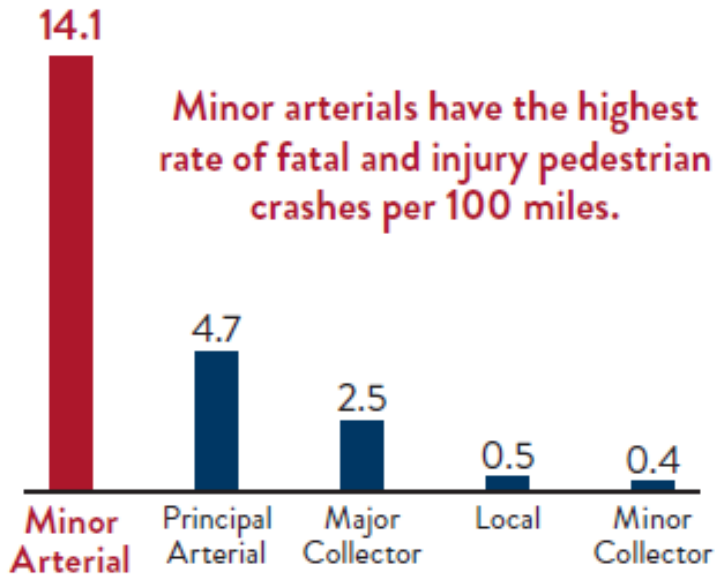
Pedestrian Crashes by Functional Class

Functional classification is the grouping of streets and highways into classes or systems according to the character of service they are intended to provide.

Over half of pedestrian crashes with confirmed injuries, and crashes overall, occurred on Minor Arterials, while only **7%** of Minnesota roads are estimated to be of this type.

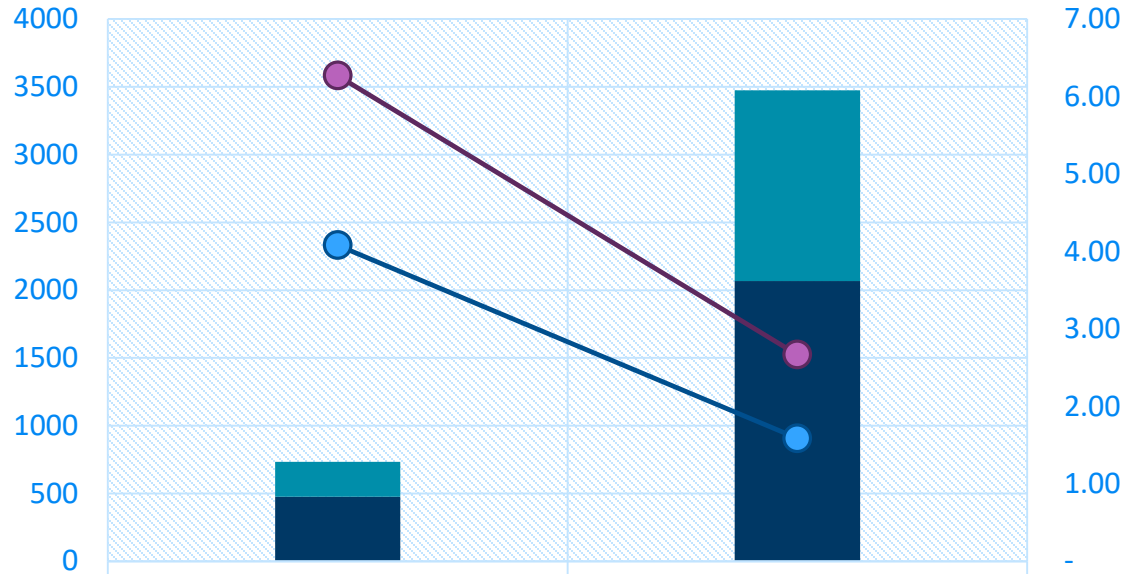


Minor arterials had **over 28x** as many pedestrian injury and fatal crashes per mile as local roads.



Pedestrian Crashes on and off MnDOT Trunk Highways

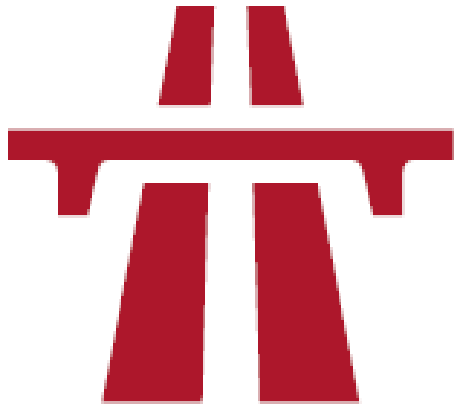
Pedestrian Crashes by Severity and Road Ownership: Frequency and Rate per 100 Miles



	Trunk Highways	Non-Trunk Roadways
Injury C + PDO	256	1407
Fatal + Injury (KAB)	477	2067
KAB/100 Mi	4.08	1.59
All Crashes/100 Mi	6.27	2.67

Trunk highways are MnDOT's network of highways and roads owned and managed by the state.

They range from major freeways to small town main streets where a state highway passes through to busy urban arterials like Central Entrance or Snelling Avenue.



Trunk Highways

Trunk highways had

over 2x

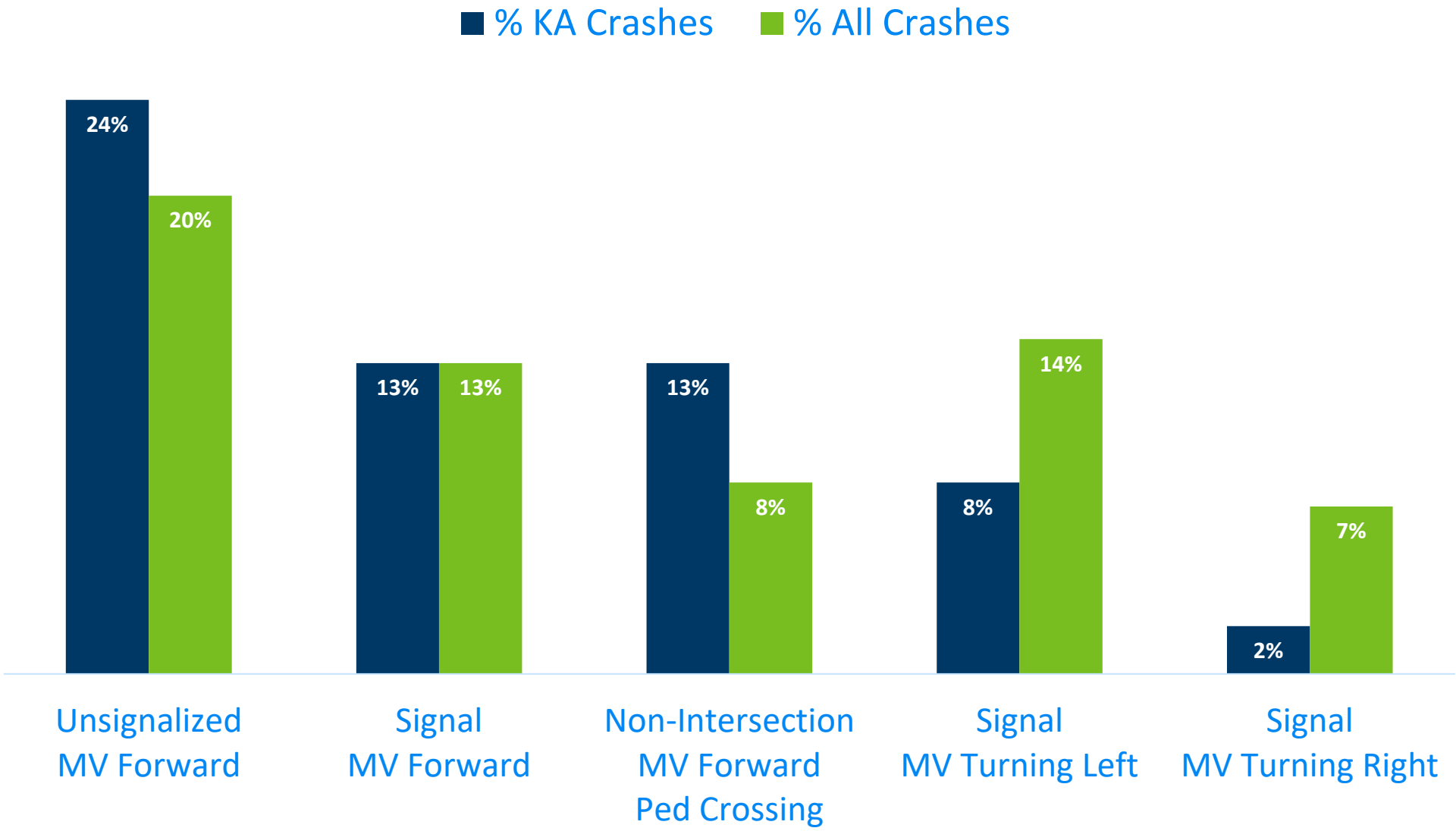
as many pedestrian fatal and injury crashes per mile as non-trunk highways.

Crash Typology

Pedestrian Crash Typology

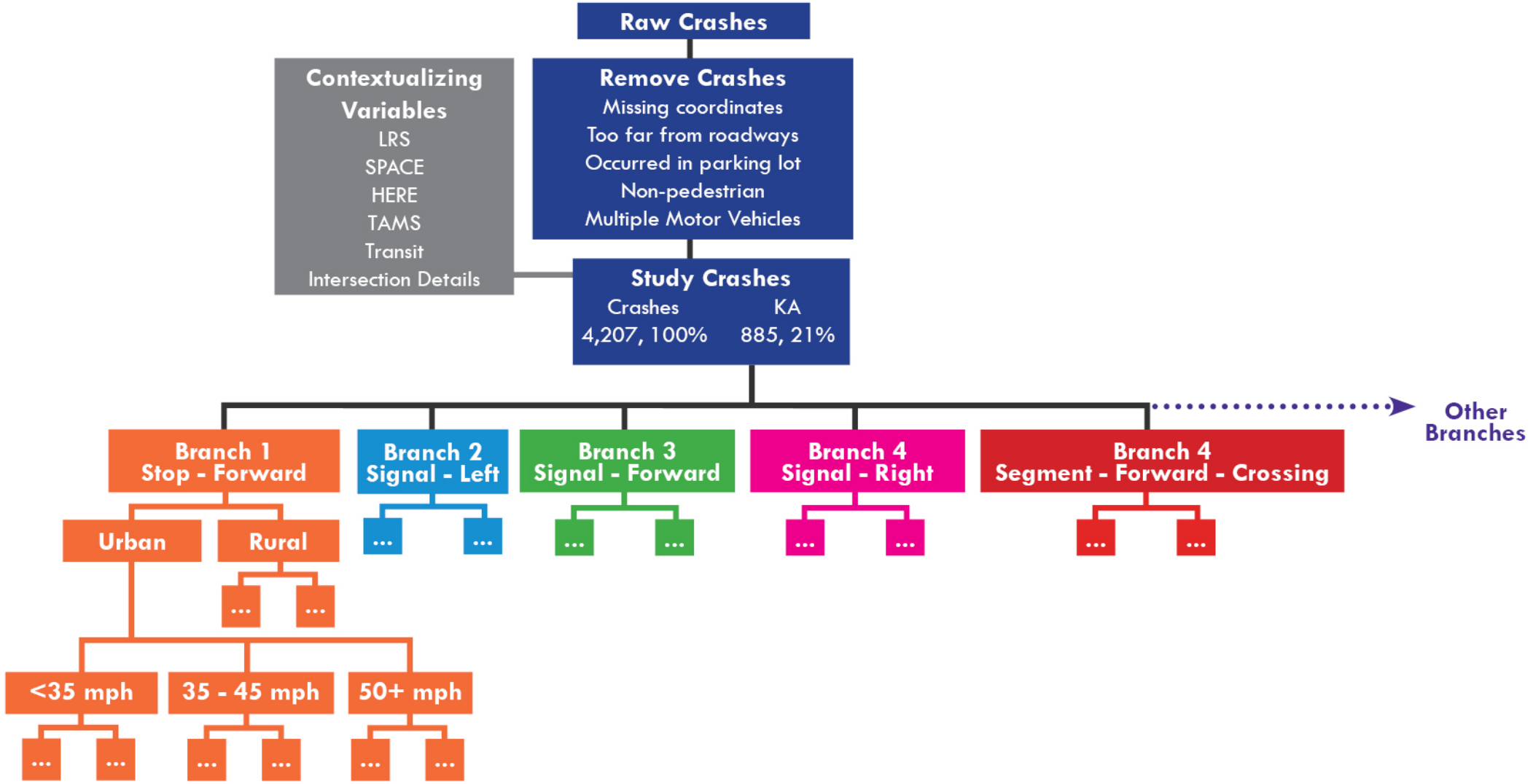
Crash typology adapted from Schneider and Stefanich 2016 *Application of the Location–Movement Classification Method for Pedestrian and Bicycle Crash Typing* https://doi.org/10.3141/2601-09

Crash Types

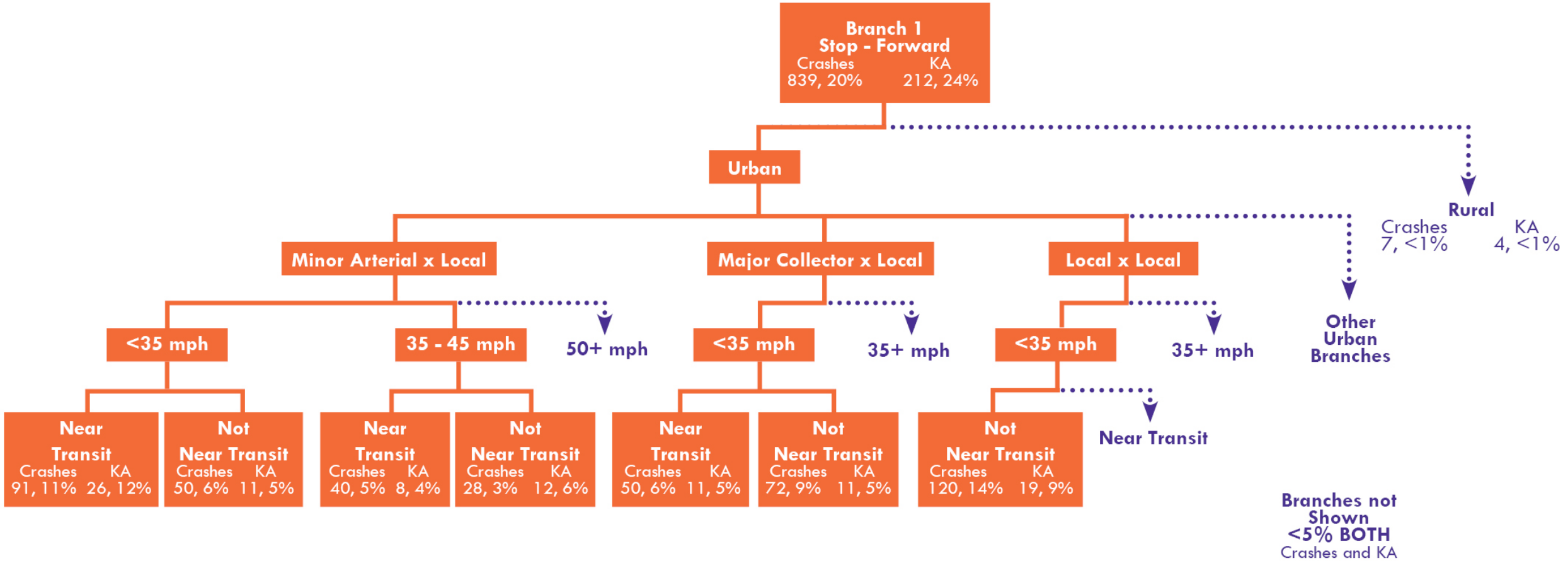


Unable to analyze non-intersection crashes where the pedestrian is walking along the side of the road due to limitations in crash report data

Crash Tree Analysis to identify Common Crash Circumstances



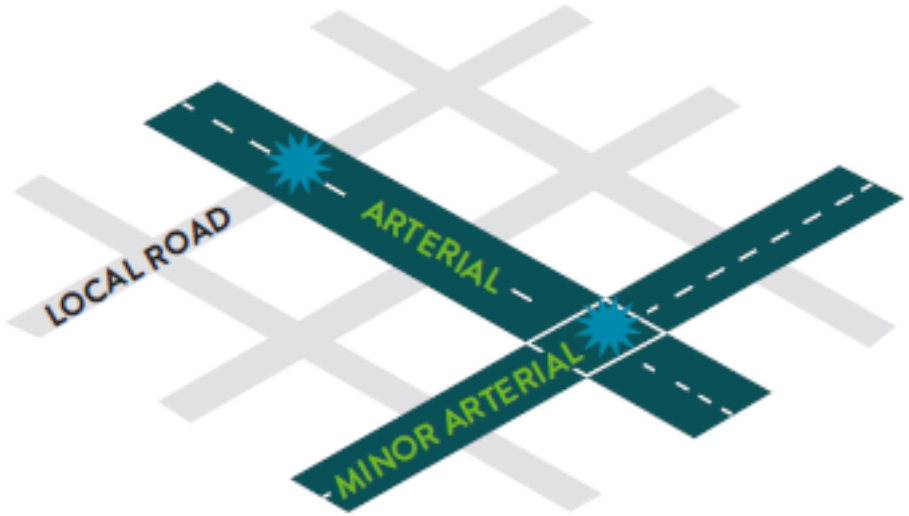
Unsignalized Intersection – Forward – Analysis Process



Unsignalized Intersection – MV Forward – Analysis Results

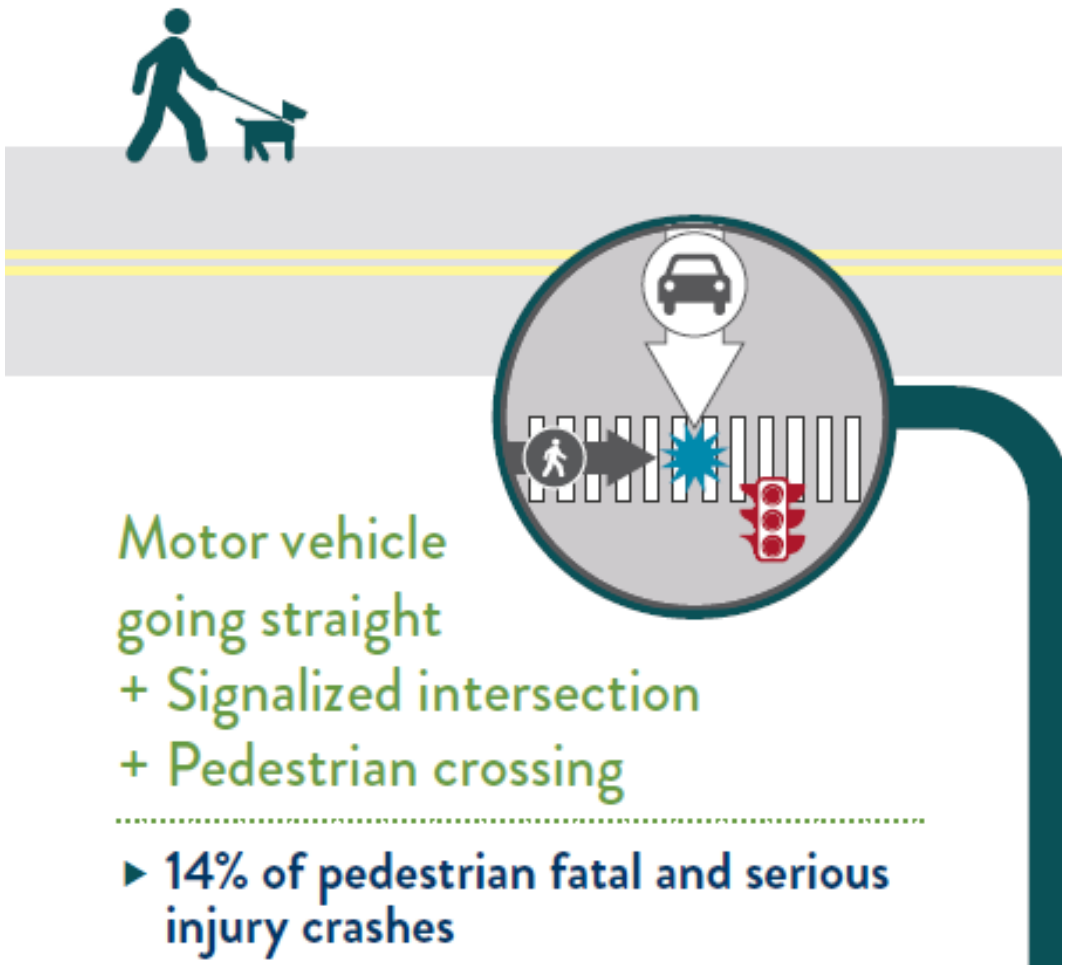
Motor vehicle going straight
+ Unsignalized intersection
+ Pedestrian crossing

- **24% of all pedestrian fatal and serious injury crashes**
- Severe outcomes linked to different functional classes coming together at an intersection, oftentimes with partial stop control. For example, a pedestrian attempting to cross an uncontrolled minor arterial at an intersection with a stop-controlled local road.



- **These crashes occur in almost all land use contexts**, with and without transit, shopping, restaurants, and entertainment.

Signalized Intersection – MV Forward

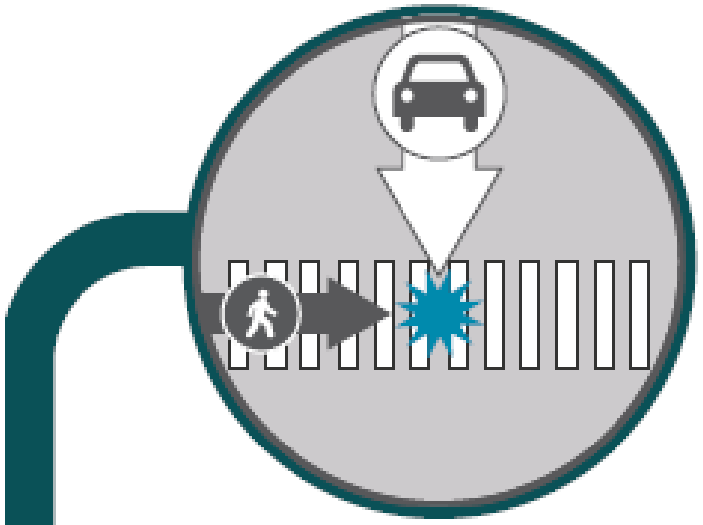


Motor vehicle
going straight
+ Signalized intersection
+ Pedestrian crossing

- **14%** of pedestrian fatal and serious injury crashes

- **96%** of crashes in this branch occur in **urban areas**
- **Over 2/3** of these crashes occurred at an intersection where:
  - Intersections with a posted speed limit of **35 mph or below**
  - **Minor arterial on intersection approach**
  - **Near transit stops**
  - **Near food, entertainment, or commercial establishments**

Not at Intersection – MV Forward – Ped Crossing



Motor vehicle going straight
+ Not at intersection
+ Pedestrian crossing

- **13% of all pedestrian fatal or serious injury crashes**

- **1/4** of fatal or serious injury pedestrian crashes in this branch occur in **rural areas**.
- These crashes most often occur in **urban areas** with a **30-35 mph** speed limit on **2 lane** streets **not near** transit, shopping, entertainment, or restaurants.

Signalized Intersection – MV Turning Left

Motor vehicle turning left
+ Signalized intersection
+ Pedestrian crossing

- **9% of all pedestrian fatal and serious injury crashes**

- **Over 2/3** of fatal or serious injury pedestrian crashes occurred at an intersection where:
  - **Minor arterial on intersection approach**
  - Intersections with a posted speed limit of **35 mph or below**
  - **Near transit stops**
  - **Near food, entertainment, or commercial establishments**

Signalized Intersection – MV Turning Right

Motor vehicle turning right
+ Signalized intersection
+ Pedestrian crossing

- **2% of all pedestrian fatal or serious injury crashes**

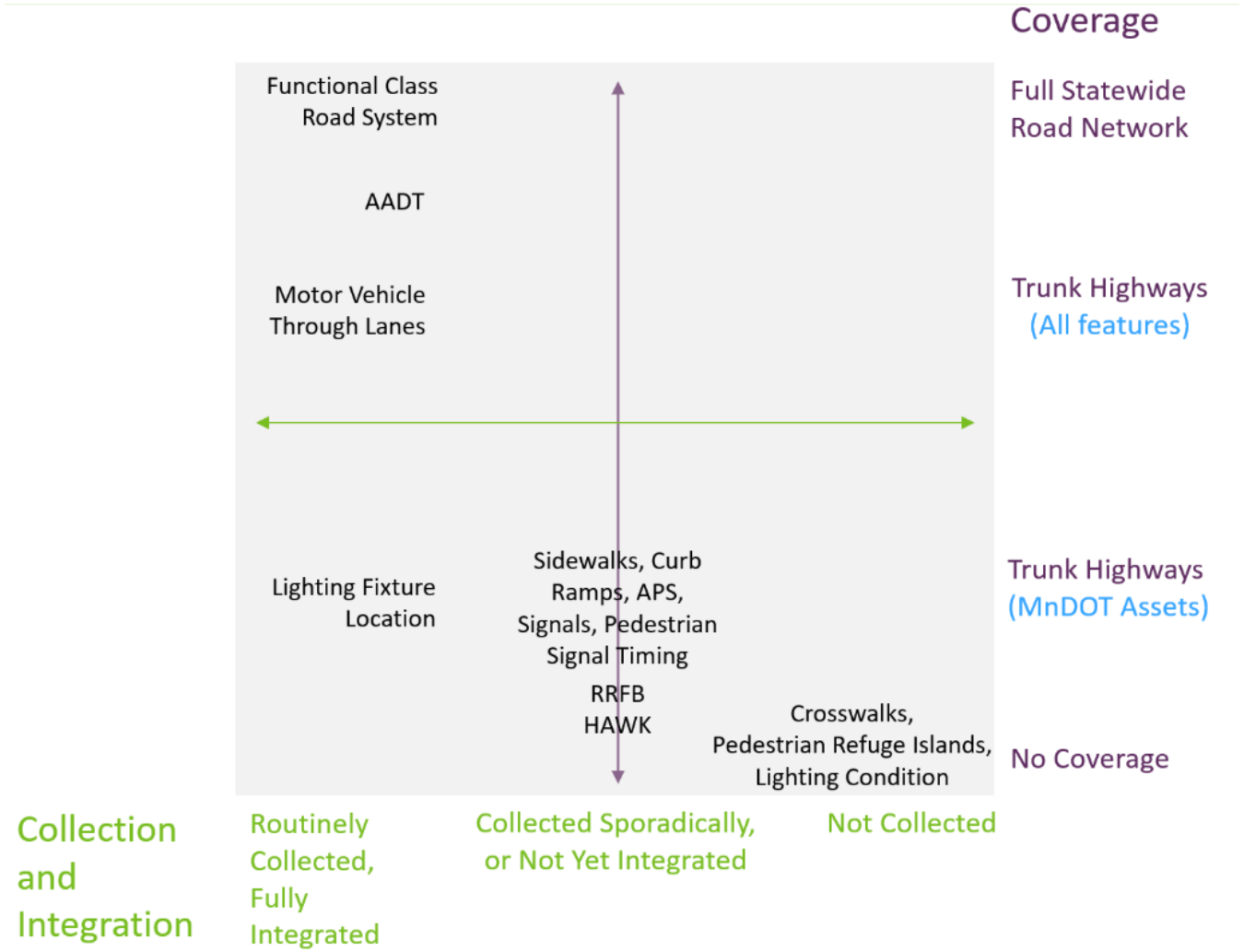
- These crashes most often occur in **urban areas** with a **30-35 mph** speed limit at intersections with a **minor arterial** road near **shopping, entertainment**, or **restaurants**.

Key Project Takeaways

- SPACE Tool useful for understanding safety
- Systemic risk factors from consolidated data and engineering judgment can help fill in other data gaps
- Don’t wait for crashes to happen!
  - Identify proactive safety improvement opportunities that address these types of crashes
  - Low-cost, systemic pedestrian safety projects
  - Reach out to Sonja/MnDOT OTE for help or implementation guidance

Photo source: Toole Design Group

Pedestrian Data Gap Analysis



Additional data would be beneficial to:

- Better understand pedestrian crashes
- Identify countermeasures, and
- Prioritize locations for safety treatments

Recommend better data collection and coverage for:

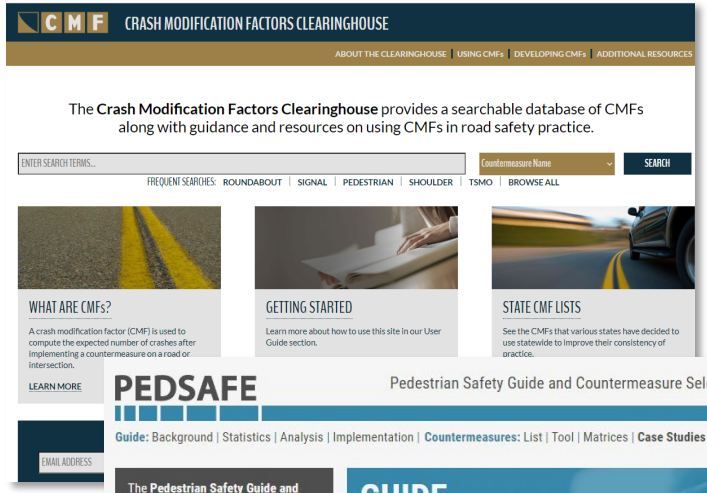
- Operating speeds
- Sidewalks and ADA curb ramps
- Signals, PHBs, and RRFBs
- Crosswalk markings
- Pedestrian crossing islands / pedestrian refuges
- Turn lanes

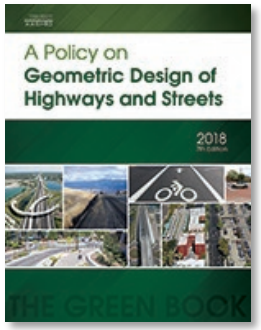
Conclusion

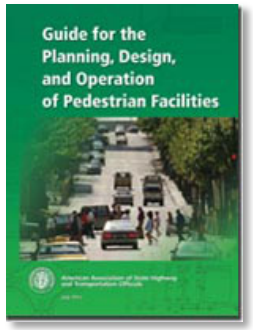
- Ensuring pedestrian safety on Minnesota's roadways can be challenging, but we can use common attributes to identify areas where safety improvements may be needed:
  - Motor vehicle volume
  - Motor vehicle speed
  - Pedestrian-oriented land use characteristics
- Tools and resources are available to improve pedestrian safety
- Now is the time the deploy these measures in a systemic way, to reduce and eventually eliminate pedestrian fatalities and serious injuries

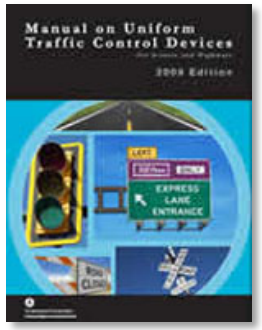
Photo source: Toole Design Group

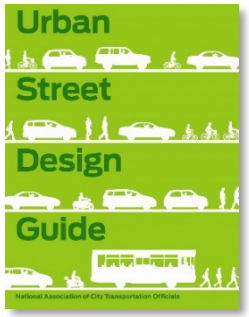
National Pedestrian Safety Resources for Countermeasures

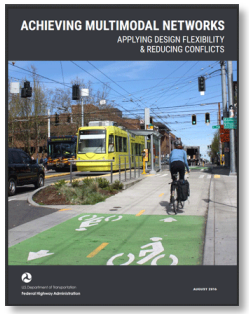


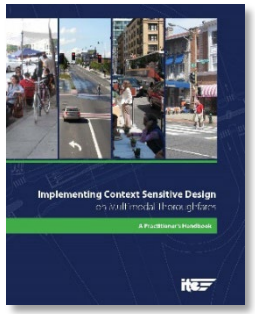


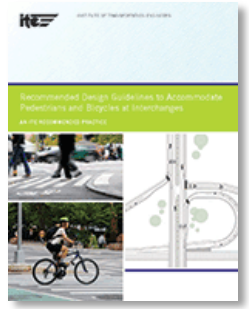


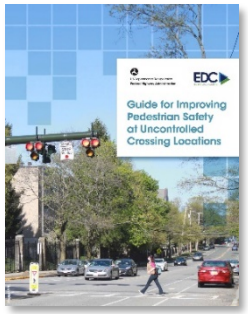


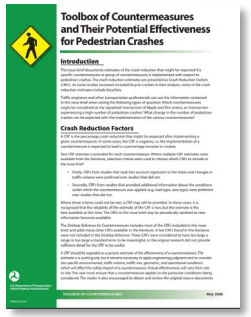












MnDOT Resources

- MnDOT Office of Safety
- Pedestrian and Bicyclist Safety Handbook
- Bicycle Facility Design Manual
- Traffic Engineering Manual
- MnDOT Website: https://www.dot.state.mn.us/peds/design-engineering.html

Photo source: Toole Design Group

Thank you

Sonja Piper, PE
Active Transportation
Safety Engineer
MnDOT
Sonja.piper@state.mn.us

Jessica Schoner, PhD
Data Science Practice Lead
Toole Design
jschoner@tooledesign.com

Photo source: Toole Design Group