Predictive Safety Analysis

Montgomery Planning

Predictive Safety Analysis

A proactive approach to identifying safety challenges and solutions

- Estimate the expected number of crashes at intersections and segments for key crash types
- Identify safety priorities and effective mitigations
- Working with UNC Highway Safety Research Center

Predictive Safety Analysis

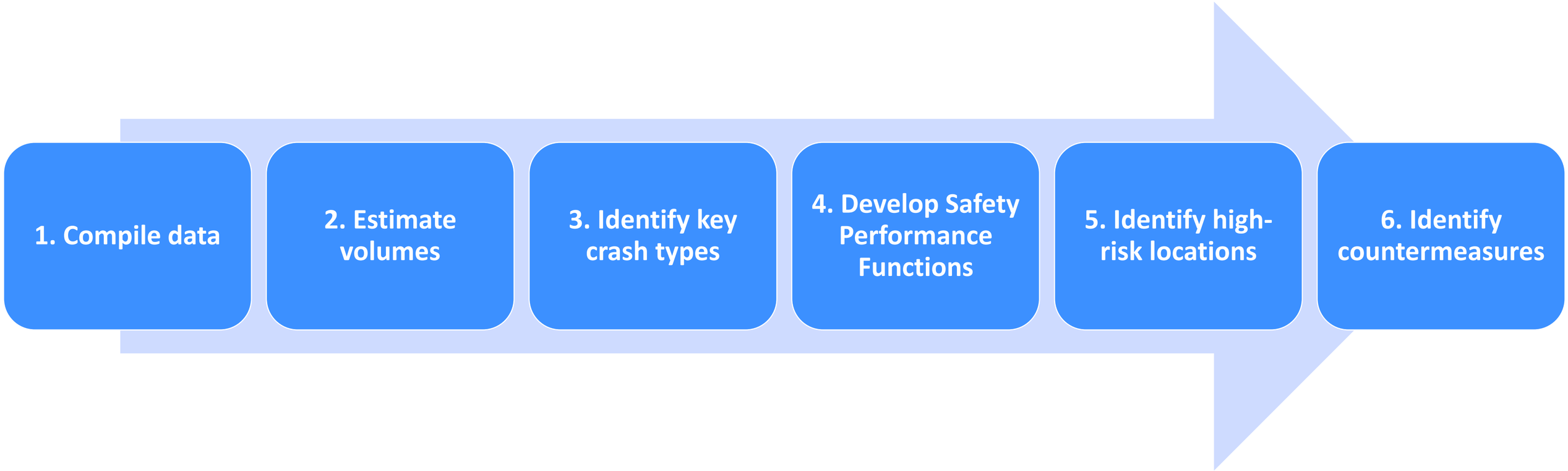
A proactive approach to identifying safety challenges and solutions

The Predictive Safety Analysis uses **crash risk** to understand existing safety challenges, rather relying on crash history.

Crash history is the basis of most crash analysis, but **it is biased by the random nature of crashes**. Even though one intersection has no crashes, and another has one or two, the underlying crash risk at both may be the same.

Reliance on crash history is a particular problem for bicycle crashes, which are **relatively rare** compared to other crash types.

Key Steps


1. Compile data
2. Estimate volumes
3. Identify key crash types
4. Develop Safety Performance Functions
5. Identify high-risk locations
6. Identify countermeasures

1. Compile Data

Transportation Characteristics

- Speed limit
- Number of lanes
- Roadway slope
- Presence and type of crosswalk
- Presence and type of bicycle facility
- Roadway classification
- Intersection control
- Lighting
- Transit service

Land Use Characteristics

- Parks
- Hospitals
- Gas stations
- Parking lots
- Schools
- Government facilities
- Shopping centers
- Alcohol-serving locations
- Population density
- Employment density

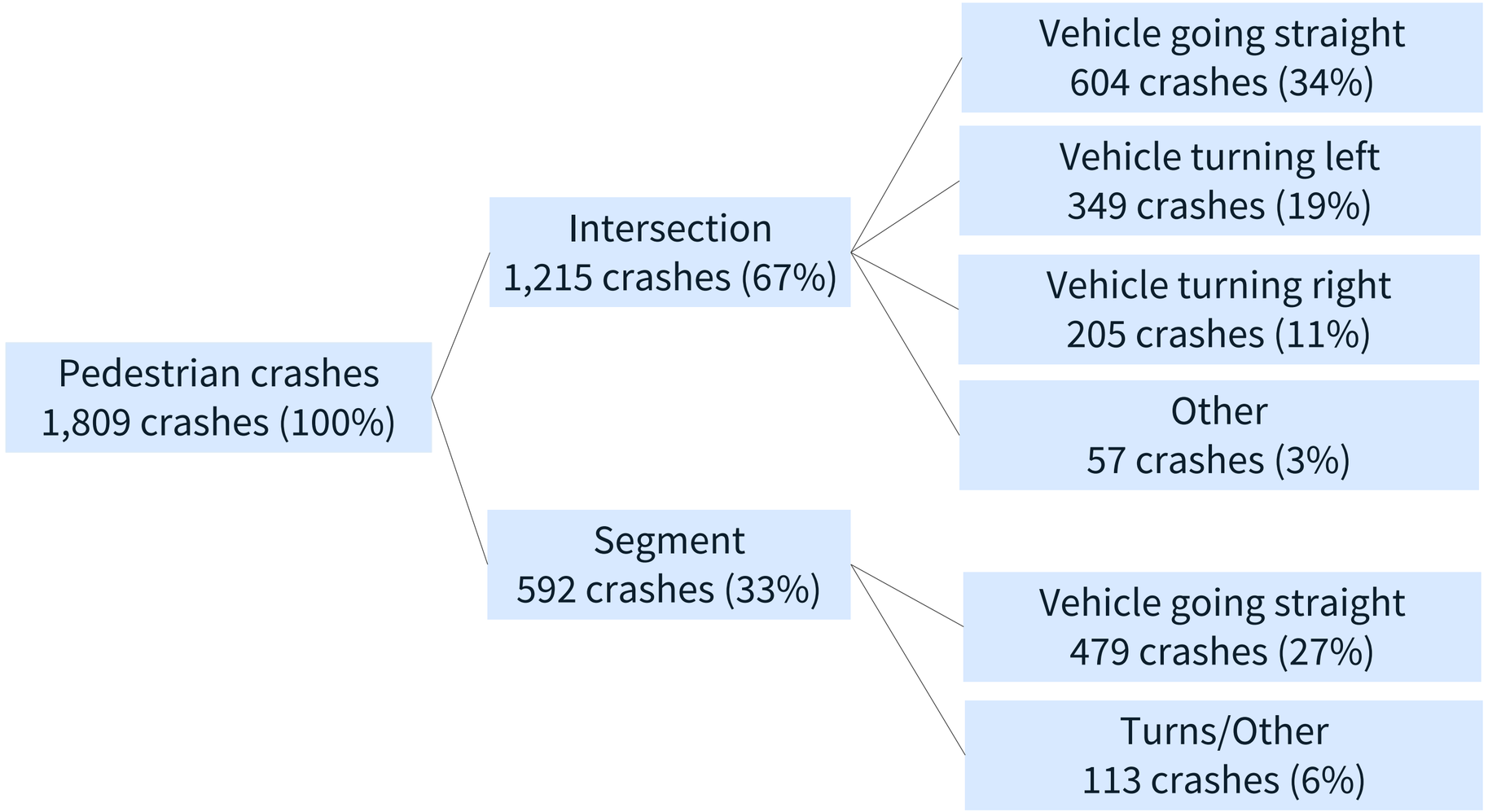
Demographic Characteristics

- Equity Emphasis Areas
- Income distribution
- Race/ethnicity distribution

2. Estimate Volumes

- Pedestrian, bicycle, and driver activity is referred to as exposure
- Exposure is a common variable in estimating crashes
- Compiled counts from development projects, MCDOT, and SHA
- Standardize counts based on time of day, day of week, season
- Estimate counts at all intersections and segments based on transportation, land use, and demographic attributes

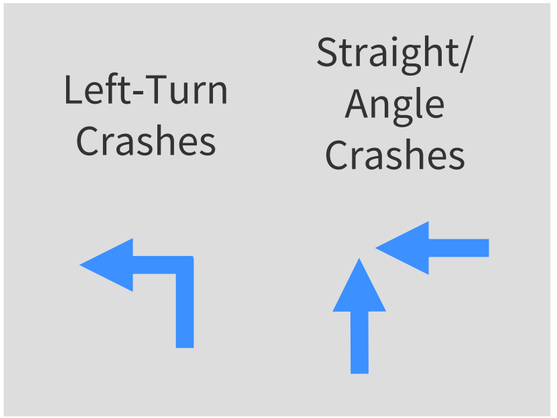
3. Identify Key Crash Types



Balance capturing most crashes with crash types linked to countermeasures

3. Identify Key Crash Types

- Pedestrian crashes after dark at intersections
- Pedestrian crashes along segments with vehicles going straight
- Bicycle crashes at intersections
- Left-turn crashes at intersections (all modes)
- Motor vehicle straight/angle crashes at intersections
- Single vehicle crashes along segments



3. Identify Key Crash Types

Crash types address crashes of all severities to provide a large same size of locations. These crash types were selected given their high injury rates, and overall, they capture a large percentage of severe injuries and fatalities.

Crash Types Summary (2015-2019)

Crash Type	% Severe Injuries & Fatalities
Pedestrian Crashes	73%
Bicycle Crashes	65%
Motor Vehicle Crashes	41%
All Crash Types	**49%**

4. Develop Safety Performance Functions

Annual Pedestrian Crashes at an Intersection =

A*Number of Daily Pedestrians +

B*Number of Daily Vehicles +

C*Speed Limit of Major Road +

D*Speed Limit of Minor Road +

E*Number of Intersection Approaches +

F* Number of High-Visibility Crosswalks

This is an illustrative example and not based on real data!

4. Develop Safety Performance Functions

Pedestrian segment crashes with vehicles going straight

Statistically significant variables		Relationship to crashes
Exposure	Pedestrian traffic	+
	Motor vehicle traffic	+
Transportation	Segment length	+
	Dead end	-
	Street class (state road, major road)	+
	Parking lots	+
	Number of marked crosswalks	+
	Bus routes	+
Land Use	Alcohol establishments	+
	Recreational points of interest	-
	Business points of interest	-
Demographics	Population density	+
	Income	-

4. Develop Safety Performance Functions

- **Observed Crashes** are the historical crashes. These are the basis of most crash analysis but are biased by the random nature of crashes.
- **Predicted Crashes** are the outcome of the SPFs and account for the characteristics in the SFP equation. They are useful for identifying sites which may not have many observed crashes but have the potential to be high-crash sites based on their characteristics.
- **Empirical-Bayes (EB) Crashes (“Crash Risk”)** weighs both observed and predicted crashes based on 1) how well the SPF predicts crashes and 2) the number of predicted crashes at the specific location. EB crashes are the most reliable estimate of the underlying crash frequency at a given location based on all available information.

5. Identify High-Risk Locations

- **Total Annual Crash Risk** the sum of the crash risk for each crash type. This assessment determines which areas have the greatest overall crash risk.
- **Hot Spot Analysis** looks at the top 200 locations with the highest crash risk. This analysis determines the specific locations with the greatest safety challenges and can inform stand-alone capital projects.
- **Average Annual Crash Risk** applies a broader lens to understanding crash risk by dividing the number of crashes by the number of locations for each crash type. This analysis determines type of locations with the greatest safety challenges and can inform systemic improvements.

5. Identify High-Risk Locations

Equity Emphasis Areas vs. Non-Equity Emphasis Areas

EEA	# Ints.	Intersection Crashes				# Segs.	Segment Crashes	
		Ped Dark	Bike	Left Turn	Angle		Ped Seg	Single Veh
Total Crash Risk (# Annual Crashes)								
EEA	3,087	49	25	253	280	5,049	32	125
Non-EEA	13,606	58	62	482	595	26,033	51	663
Hot Spot Analysis (# Locations within the Top 200)								
EEA	3,087	107	67	80	75	5,049	133	26
Non-EEA	13,606	93	133	120	125	26,033	67	174
Average Crash Risk (# Annual Crashes)								
EEA	3,087	0.02	0.01	0.08	0.36	5,049	.007	.025
Non-EEA	13,606	0.00	0.00	0.04	0.20	26,033	.002	.026

Highlighted cells have the highest value for any column.

5. Identify High-Risk Locations

Equity Emphasis Areas vs. Non-Equity Emphasis Areas

EEA	# Ints.	Intersection Crashes				# Segs.	Segment Crashes	
		Ped Dark	Bike	Left Turn	Angle		Ped Seg	Single Veh
Total Crash Risk (# Annual Crashes)								
EEA	3,087	49	25	253	280	5,049	32	125
Non-EEA	13,606	58	62	482	595	26,033	51	663
Hot Spot Analysis (# Locations within the Top 200)								
EEA	3,087	107	67	80	75	5,049	133	26
Non-EEA	13,606	93	133	120	125	26,033	67	174
Average Crash Risk (# Annual Crashes)								
EEA	3,087	0.02	0.01	0.08	0.36	5,049	.007	.025
Non-EEA	13,606	0.00	0.00	0.04	0.20	26,033	.002	.026

Highlighted cells have the highest value for any column.

+270% **+75%** **+130%** **+82%** **+226%** **-4%**

5. Identify High-Risk Locations

Complete Streets Design Guide Area Type (Annual Crashes)

CSDG Area Type	# Ints.	Intersection Crashs				# Segs.	Segment Crashes	
		Ped Dark	Bike	Left Turn	Angle		Ped Seg	Single Veh
Total Crash Risk (# Annual Crashes)								
Downtown	372	32	12	87	87	786	13	42
Town Center	810	20	11	132	132	1,722	17	83
Suburban	12,187	37	49	340	474	22,602	39	430
Country	1,027	0	2	22	20	1,898	3	155
Hot Spot Analysis (# Locations within the Top 200)								
Downtown	372	88	47	22	27	786	53	3
Town Center	810	45	36	42	43	1,722	75	20
Suburban	12,187	40	87	87	97	22,602	34	95
Country	1,027	0	0	1	4	1,898	1	67
Average Crash Risk (# Annual Crashes)								
Downtown	372	0.09	0.03	0.24	0.73	786	0.02	0.06
Town Center	810	0.03	0.01	0.18	0.75	1,722	0.01	0.05
Suburban	12,187	0.00	0.00	0.03	0.17	22,602	0.00	0.02
Country	1,027	0.00	0.00	0.02	0.16	1,898	0.00	0.08

Highlighted cells have the highest value for any column.

5. Identify High-Risk Locations

Complete Streets Design Guide Street Type:
Total Crash Risk (# Annual Crashes)

CSDG Street Type	# Ints.	Intersection Crash Types				# Segs.	Segment Crash Types	
		Ped Dark	Bike	Left Turn	Angle		Ped Seg	Single Veh
Major Highway	18	1	1	11	13	12	0	13
Boulevard	1,191	29	33	334	359	1,145	15	145
Downtown Blvd	134	20	6	57	58	161	7	14
Town Center Blvd	225	13	6	70	89	272	9	26
Downtown Street	210	13	4	26	26	339	5	10
Town Center Street	138	1	1	11	12	186	2	8
Neighborhood Conn	2,825	8	14	64	132	2,956	9	100
Country Conn	280	0	1	14	13	213	1	47
Country Road	90	0	0	1	1	60	0	4
Industrial Street	50	0	0	5	1	58	0	2
Neighborhood Street	9,132	9	6	21	55	21,357	23	311
Rustic Road*	183	0	0	2	4	317	1	36

Highlighted cells have the highest value for any column.

5. Identify High-Risk Locations

Complete Streets Design Guide Street Type:
Hot Spot Analysis (# Locations within the Top 200)

CSDG Street Type	# Ints.	Intersection Crash Types				# Segs.	Segment Crash Types	
		Ped Dark	Bike	Left Turn	Angle		Ped Seg	Single Veh
Major Highway	18	1	0	2	5	12	2	7
Boulevard	1,191	50	109	109	104	1,145	35	37
Downtown Blvd	134	48	29	18	16	161	32	0
Town Center Blvd	225	35	21	22	25	272	51	3
Downtown Street	210	40	8	3	5	339	18	0
Town Center Street	138	0	0	2	3	186	5	1
Neighborhood Conn	2,825	2	7	5	17	2,956	5	3
Country Conn	280	0	0	2	2	213	0	23
Country Road	90	0	0	0	0	60	0	0
Industrial Street	50	0	0	2	0	58	0	0
Neighborhood Street	9,132	1	6	1	1	21,357	16	101
Rustic Road*	183	0	0	2	0	317	0	10

Highlighted cells have the highest value for any column.

5. Identify High-Risk Locations

Complete Streets Design Guide Street Type:
Average Crash Risk (# Annual Crashes)

CSDG Street Type	# Ints.	Intersection Crash Types				# Segs.	Segment Crash Types	
		Ped Dark	Bike	Left Turn	Angle		Ped Seg	Single Veh
Major Highway	18	0.05	0.03	0.60	1.08	12	0.02	1.06
Boulevard	1,191	0.02	0.03	0.28	0.81	1,145	0.01	0.13
Downtown Blvd	134	0.16	0.05	0.43	1.09	161	0.04	0.09
Town Center Blvd	225	0.06	0.03	0.31	1.33	272	0.03	0.10
Downtown Street	210	0.06	0.02	0.12	0.33	339	0.01	0.03
Town Center Street	138	0.01	0.01	0.08	0.32	186	0.01	0.05
Neighborhood Conn	2,825	0.00	0.00	0.02	0.15	2,956	0.00	0.03
Country Conn	280	0.00	0.00	0.05	0.22	213	0.00	0.22
Country Road	90	0.00	0.00	0.01	0.12	60	0.00	0.06
Industrial Street	50	0.01	0.01	0.10	0.28	58	0.01	0.04
Neighborhood Street	9,132	0.00	0.00	0.00	0.03	21,656	0.00	0.02
Rustic Road*	183	0.00	0.00	0.01	0.26	317	0.00	0.12

Highlighted cells have the highest value for any column.

5. Identify High-Risk Locations

Portion of Total Annual Crash Risk included in Top 200 Locations

Crash Type	% Crash Risk in Top 200
Motor vehicle straight/angle crashes at four-legged intersections	48%
Pedestrian crashes after dark at intersections	47%
Left-turn crashes at intersections (all modes)	46%
Single vehicle crashes along segments	27%
Bicycle crashes at intersections	25%
Pedestrian crashes along segments with vehicles going straight	23%

5. Identify High-Risk Locations

Portion of Total Annual Crash Risk included in Top 200 Locations

Crash Type	% Crash Risk in Top 200
Motor vehicle straight/angle crashes at four-legged intersections	48%
Pedestrian crashes after dark at intersections	47%
Left-turn crashes at intersections (all modes)	46%
Single vehicle crashes along segments	27%
Bicycle crashes at intersections	25%
Pedestrian crashes along segments with vehicles going straight	23%

5. Identify High-Risk Locations

Portion of Total Annual Crash Risk included in Top 200 Locations

Crash Type	% Crash Risk in Top 200
Motor vehicle straight/angle crashes at four-legged intersections	48%
Pedestrian crashes after dark at intersections	47%
Left-turn crashes at intersections (all modes)	46%
Single vehicle crashes along segments	27%
Bicycle crashes at intersections	25%
Pedestrian crashes along segments with vehicles going straight	23%

5. Identify High-Risk Locations

Key Takeaways

- Investments need to balance location types with high total crash risk, hot spots, and location types with high average crash risk.
- Prioritization needs to look beyond crash history, as only 55% of fatalities and 46% of severe injuries occurred in top 200 intersections and roadway segments.
- Safety improvements in Equity Emphasis Areas should be prioritized.
- While much of the county is suburban, downtown and town center area types (and their associated street types) have high average crash risk.

6. Identify Countermeasures

Speed Management
- Automated Enforcement – Speed Cameras
- Lower Speed Limit by 5 MPH
- Speed Humps

Pedestrian Crossings
- High-Visibility Crosswalks
- Raised Pedestrian Crosswalk
- Pedestrian Hybrid Beacon

Intersection Control
- Convert Side-Street Stop to All-Way Stop
- Install Traffic Signal
- Convert Median to a “Left-In-Only” Median

Signal Timing
- Increase All-Red Clearance Interval
- Implement Protected/Permissive Left Turn
- Implement Fully Protected Left Turn
- Leading Pedestrian Interval

Other Countermeasures
- Centerline Rumble Strips
- Lighting

6. Identify Countermeasures

Dynamic tools to evaluate different countermeasure scenarios through the following metrics:

- Potential Crash Reduction
- Potential Crash Reduction per Location
- Cost per Crash Reduced
- Percent of Locations in Equity Emphasis Area

Print a list of top-ranked location for each scenario.

6. Identify Countermeasures

Example 1: Determining which Countermeasures to Implement

Example Scenarios for Reducing Angle Crashes with $350,000 (10-Year Impact)

Scenarios	Increase All Red Clearance*	All-Way Stop	Traffic Signal
Number of Locations	116	70	1
Total Estimated Cost	$348,000	$350,000	$350,000
Predicted Crash Reduction	2,557	311	47
Crash Reduction per Location	22.0	4.4	47.4
Cost per Crashes Reduced	$140	$1,130	$7,380
% of Locations in Equity Emphasis Areas	47%	21%	0%

* on Boulevards, Downtown Boulevards, Town Center Boulevards, Major Highways

6. Identify Countermeasures

Example 2: Assessing How Many Locations to Improve

Example Scenarios for Improving Lighting at Signalized Intersections (10-Year Impact)

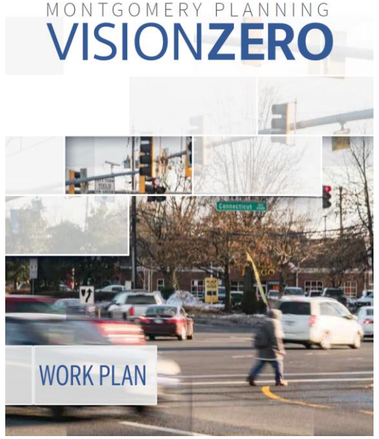
Scenarios	20 Locations	40 Locations	60 Locations
Total Estimated Cost	$100,000	$200,000	$300,000
Predicted Crash Reduction	48	87	109
Crash Reduction per Location	2.4	2.2	1.8
Cost per Crashes Reduced	$2,100	$2,300	$2,700
% of Locations in Equity Emphasis Areas	55%	48%	38%

Applications

The Predictive Safety Analysis is the **first step** towards implementing a proactive approach to safety. Can be used to apply a **data-driven** approach to **recommendations, mitigation, and prioritization,** and can be incorporated into:

- CIP Project Funding
- Systemic Projects Prioritization
- Master Planning
- Regulatory Review
- Grant Applications

Link to Vision Zero Work Program



Building Knowledge and Partnerships
- **Develop a Vision Zero Toolkit**
- Engaging Hard-to-Reach Communities
- **Educate Community, Agency Staff, & Decisionmakers**
- Vision Zero E-Newsletter

Problem Verification
- Develop a Severe and Fatal Crash Dataset
- **Develop a Multimodal Volumes Data Collection Plan**
- **Collect Multimodal Counts and Traffic Speed Data**
- **Estimate Volumes Countywide**
- Create a Dataset to Store Counts and Speed Data
- **GIS Layers of Variables Associated with Crashes**
- **Develop Safety Performance Functions**
- Create a Pedestrian Level of Comfort Map

Develop Solutions
- Identify Best Practices for VZ in the Suburbs
- Develop Policies for Street Types
- Develop Complete Streets Design Guide

Incorporate Solutions into Work Program
- **Educate Staff on Vision Zero**
- Continuing Education
- Incorporate Corridor Master Plans into Work Program
- **Changes to State and Local Policies & Regulations**
- Develop Pedestrian Master Plan
- **Incorporate Vision Zero into Master Plans**
- **Incorporate Vision Zero into Development Review**
- **Incorporate Vision Zero into the GIP**
- **Capital Project Review**

Addressed through Predictive Safety Analysis

Can be addressed/updated with PSA findings

Link to Vision Zero Work Program

Building Knowledge and Partnerships
- Develop a Vision Zero Toolkit
- Engaging Hard-to-Reach Communities
- Educate Community, Agency Staff, & Decisionmakers
- Vision Zero E-Newsletter

Problem Verification
- Develop a Severe and Fatal Crash Dataset
- Develop a Multimodal Volumes Data Collection Plan
- Collect Multimodal Counts and Traffic Speed Data
- Estimate Volumes Countywide
- Create a Dataset to Store Counts and Speed Data
- GIS Layers of Variables Associated with Crashes
- Develop Safety Performance Functions
- Create a Pedestrian Level of Comfort Map

Develop Solutions
- Identify Best Practices for VZ in the Suburbs
- Develop Policies for Street Types
- Develop Complete Streets Design Guide

Incorporate Solutions into Work Program
- Educate Staff on Vision Zero
- Continuing Education
- Incorporate Corridor Master Plans into Work Program
- Changes to State and Local Policies & Regulations
- Develop Pedestrian Master Plan
- Incorporate Vision Zero into Master Plans
- Incorporate Vision Zero into Development Review
- Incorporate Vision Zero into the GIP
- Capital Project Review

Addressed through Predictive Safety Analysis

Can be addressed/updated with PSA findings

Complete or Ongoing

Upcoming Priorities

Questions?

Jesse Cohn McGowan

jesse.mcgowan@montgomeryplanning.org