Scalable Risk Assessment Methods for Pedestrians and Bicyclists

U.S. Department of Transportation
Federal Highway Administration

Safe Roads for a Safer Future
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Introduction

- **Project Objective**
  - Develop approach to estimate pedestrian & bicyclist risk (includes exposure) at several geographic scales

- **Project Motivation**
  - Monitor safety performance measures
  - Identify high-priority areas and facilities
  - Evaluate countermeasures and sites before and after improvements
  - Need exposure in safety and risk analyses

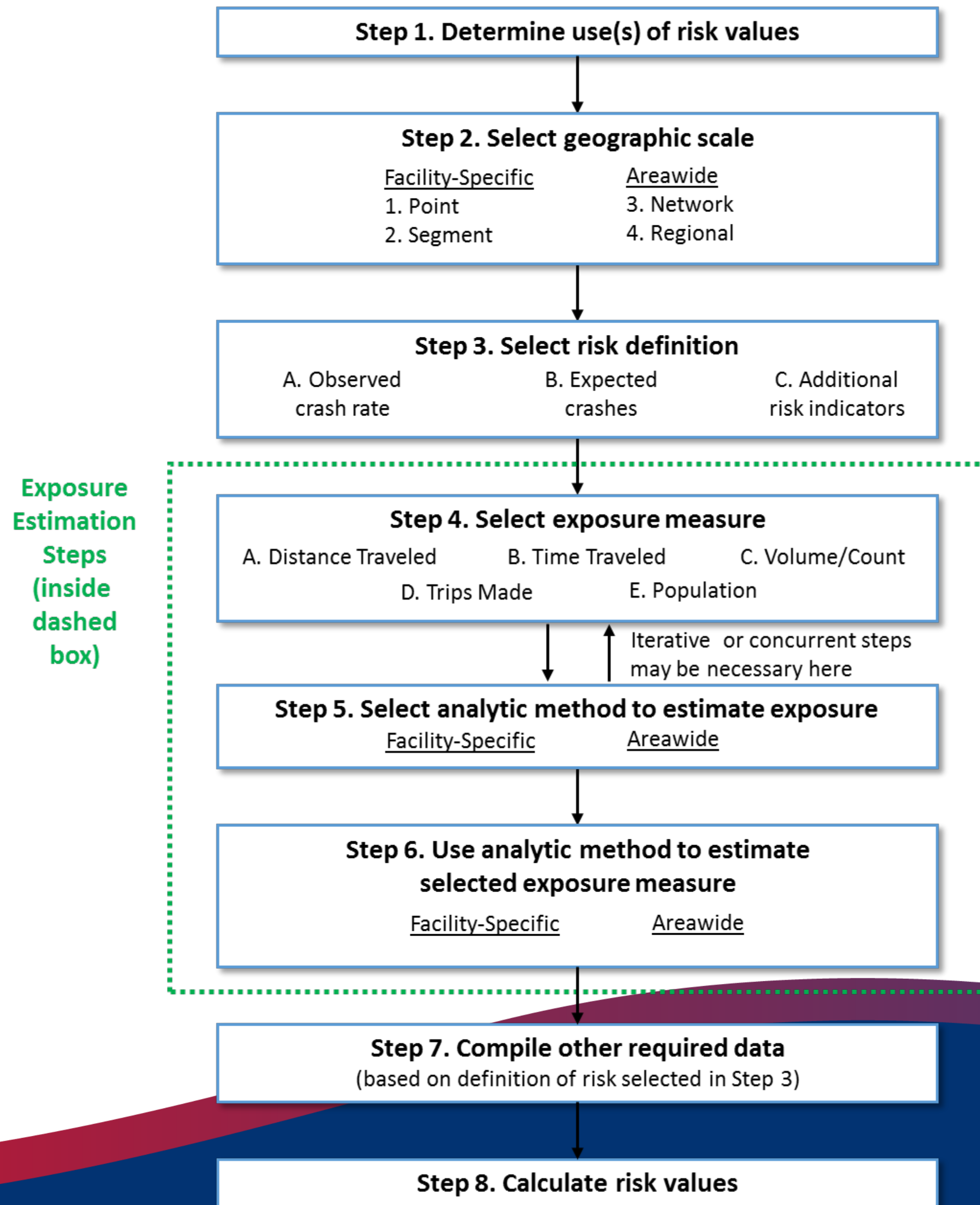
Overview of Training

Topic	Presenter
Overview of Scalable Risk Assessment Methods	Shawn Turner, TTI
Exposure from Counts	Shawn Turner, TTI
Exposure from Demand Estimation Models	Ipek Sener, TTI
Exposure from Travel Surveys, Spreadsheet Tool	Shawn Turner, TTI
Participant Exercise	Stewart Robertson, Kimley-Horn Ravi Wijesundera, Kimley-Horn

Overview of Scalable Risk Assessment Methods

8 Steps

- Framework with flexibility
- Scale matters -- a lot!
- Exposure is key ingredient, focus in project



Step 1. Determine Use(s) of Risk Values

A. Safety performance measures
B. Network screening, area-based
C. Network screening, facility-based
D. Project prioritization
E. Countermeasure evaluation
F. Site evaluation

Step 1. Determine Use(s) of Risk Values

A. Safety performance measures

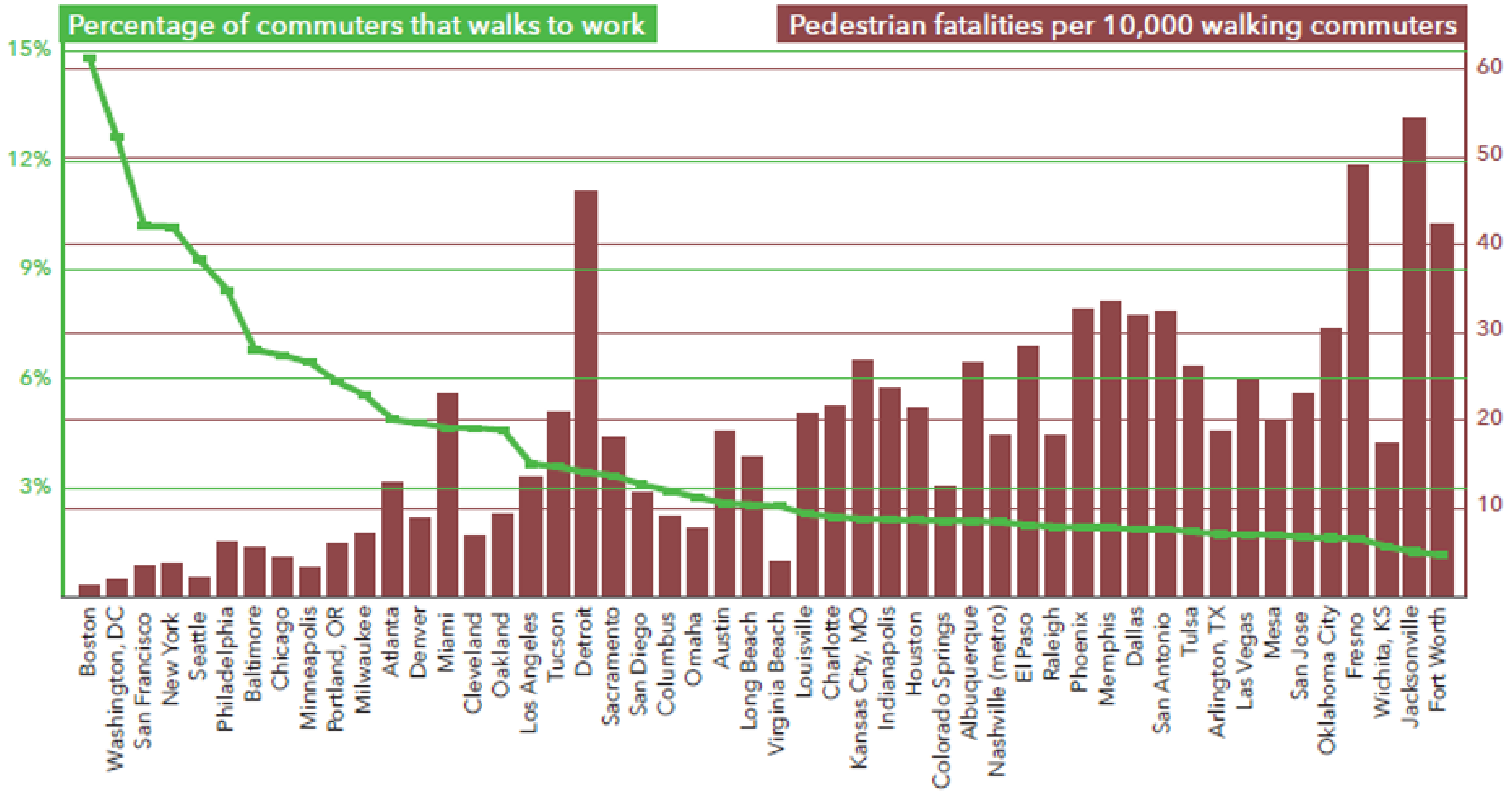
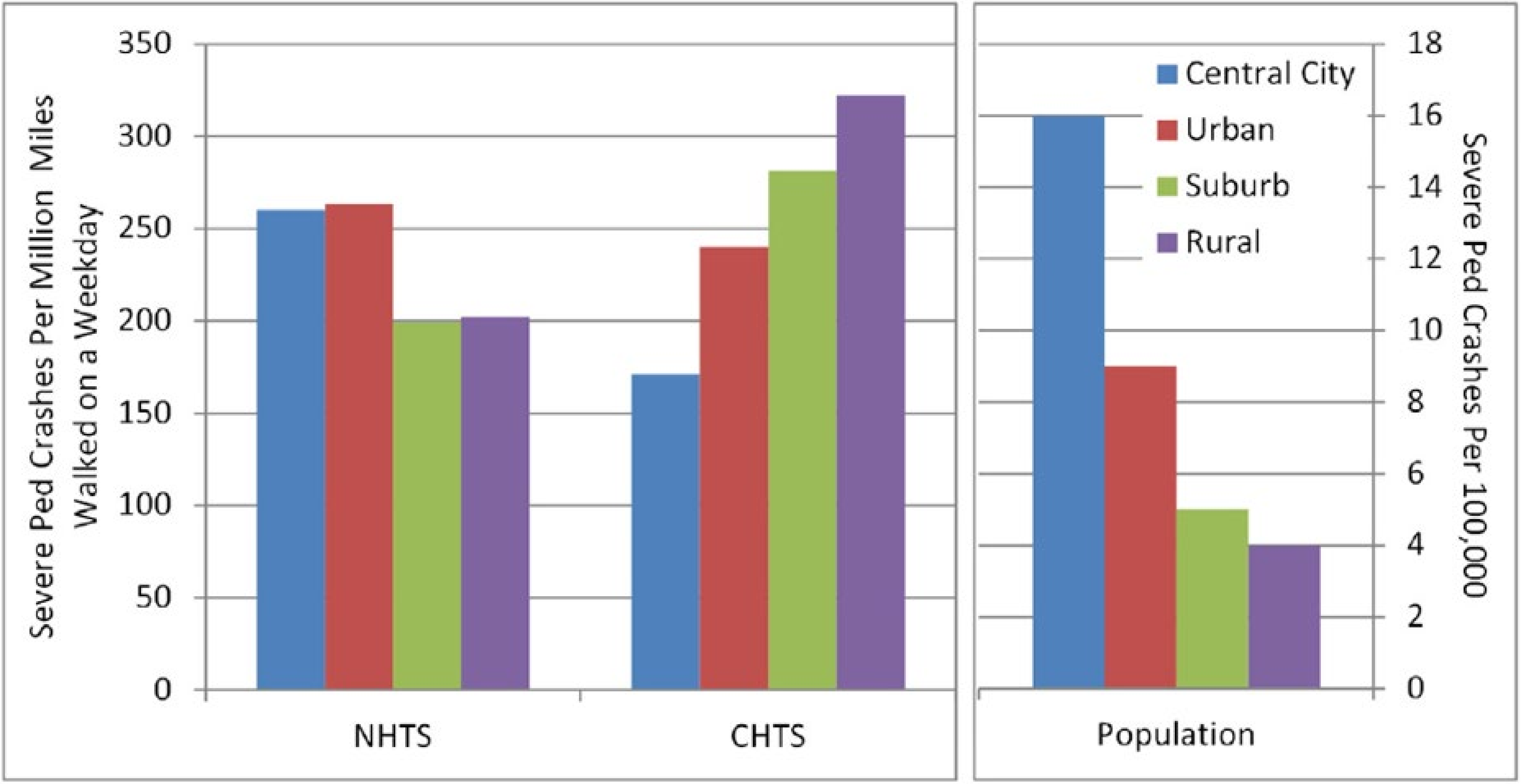


Figure 2. Example of Pedestrian Fatality Risk in 50 Cities
Source: 2016 Benchmarking Report, Alliance for Biking & Walking.

Step 1. Determine Use(s) of Risk Values

B. Network screening, area-based



Step 1. Determine Use(s) of Risk Values

C. Network screening, facility-based

#	Intersection ID	Route System	Route No.	Description	Speed Limit	Cross Product[a]	Traffic Control	Major Corridor Speed	Skew	On/Near Curve	Primary Land Use	Severe Ped/Bike Crash Density	Total Stars	Crash Cost
34	3.210.025	MN	210	4TH ST NWCSAH20 MSAS103/BRNRD	35	★	★	★		★	★		★★★★★	$1,050,200
35	3.024.009	MN	24	CSAH 75/CLEARWATER	40	★	★	★	★		★		★★★★★	$747,600
36	3.023.028	MN	23	19 1/2 AV/ST CLD	35	★		★	★	★	★		★★★★★	$574,800
37	3.023.050	MN	23	TH 25/FOLEY	45	★	★	★	★		★		★★★★★	$558,000
38	3.027.015	MN	27	4TH ST MSAS 106/LITTLE FALLS	30	★	★		★	★	★		★★★★★	$366,400
39	3.023.011	MN	23	RED RVR AVCSAH 2/COLD SPRING	35	★	★	★		★	★		★★★★★	$292,800
40	3.023.020	MN	23	6TH AV S MSAS107 M95/WAITPK	40	★	★	★		★	★		★★★★★	$0
41	3.210.021	MN	210	ELDER DR SM140/BAXTER	55	★		★	★		★		★★★★	$10,558,200
42	3.012.003	US	12	JOHNSON AVE M-54 LT/COKATO	35	★		★			★	★	★★★★	$10,418,000
43	3.015.011	MN	15	N JCT TH 23 DIV ST/ST CLOUD	45	★	★	★			★		★★★★	$5,838,400
44	3.015.012	MN	15	3RD ST N CSAH81 MSAS 114/STC	45	★	★	★			★		★★★★	$4,310,200
45	3.169.004	US	169	197TH AV MSAS116 M118/ELKRV	55	★	★	★			★		★★★★	$1,696,200
46	3.015.019	MN	15	CSAH 29/SAUK RAPIDS	60	★	★	★			★		★★★★	$1,671,800
47	3.010.011	US	10	E JCT TH 210 LT/MOTLEY	30	★	★			★	★		★★★★	$1,612,200
48	3.210.026	MN	210	4TH ST N MSAS114/BRAINERD	35	★	★	★			★		★★★★	$1,241,800
49	3.210.027	MN	210	TH 371B RTM 60 LT/BRAINERD	35	★	★	★			★		★★★★	$1,186,600
50	3.023.022	MN	23	WAITE AVEMSAS101/WAITEPARK	40	★	★	★			★		★★★★	$1,146,000
53	3.025.030	MN	25	RIVER ST MSAS112/MONTICELLO	30	★	★			★	★		★★★★	$891,400
54	3.012.020	US	12	BUFFALO AVCSAH 12TH 25/MONTR	35	★	★	★			★		★★★★	$641,000
55	3.023.088	MN	23	N JCT TH 65 CSAH 6/MORA	30	★	★		★		★		★★★★	$622,200
56	3.025.029	MN	25	BROADWAY CSAH75/MONTICELLO	30	★	★			★	★		★★★★	$619,600

Source: Report FHWA-SA-17-002, Systemic Safety Project Selection Tool Supplemental Case Studies, December 2016.

Step 1. Determine Use(s) of Risk Values

D. Project prioritization

	A	B	C	D	I	J	M	N	U
1		**Step 10A: Calculate Priority Score**							
3									
4									
5	ID	GAP LOCATION	Stakeholder Input SCORE	Stakeholder Input WEIGHTED SCORE	Safety SCORE	Safety WEIGHTED SCORE	Demand SCORE	Demand WEIGHTED SCORE	Prioritization Score
7	1	CENTRAL AVE	6.3	62.5	0.0	0.0	8.1	32.5	95.0
8	2	WASHINGTON/JEFFERSON CORRIDOR	4.2	41.7	7.1	57.1	8.4	33.6	132.4
9	3	3RD ST	9.6	95.8	4.3	34.3	3.8	15.0	145.2
10	4	12TH ST	0.8	8.3	1.4	11.4	2.5	10.0	29.8
11	5	15TH AVE	0.4	4.2	4.3	34.3	3.6	14.6	53.0
12	6	ENCANTO BLVD	6.3	62.5	4.3	34.3	7.7	30.9	127.7
13	7	OSBORN RD	8.8	87.5	2.9	22.9	5.2	20.6	131.0
14	8	OAK ST	3.8	37.5	2.9	22.9	4.0	16.0	76.4
15	9	20TH ST	2.1	20.8	0.0	0.0	3.1	12.6	33.4
16	10	3RD/5TH	1.3	12.5	10.0	80.0	3.1	12.5	105.0
17	11	DEER VALLEY DR	3.3	33.3	0.0	0.0	5.4	21.5	54.8
18	12	UNION HILLS DR	5.0	50.0	7.1	57.1	9.9	39.8	146.9
19	13	19TH AVE	5.8	58.3	7.1	57.1	3.5	14.0	129.5
20	14	32ND ST	8.8	87.5	10.0	80.0	6.8	27.3	194.8
21	15	40TH ST	3.3	33.3	5.7	45.7	3.1	12.6	91.6

Source: NCHRP Report 803, Pedestrian and Bicycle Transportation Along Existing Roads—ActiveTrans Priority Tool Guidebook, 2015.

Step 1. Determine Use(s) of Risk Values

E. Countermeasure evaluation

Treatment Group	Measure	All Crashes with Intersecting Street Name			Crashes coded as Intersection-Related Crashes		
		Before	After	Percent Change	Before	After	Percent Change
HAWK sites (21)	Frequency	11.0	9.2	-17	5.0	3.3	-34
	Total crashes/MEV&P	0.748	0.618	-17	0.341	0.223	-35
	Severe crashes/MEV&P	0.265	0.210	-21	0.138	0.094	-32
	Pedestrian crashes/MEV&P	0.029	0.005	-83	0.017	0.002	-86
	Pedestrian crashes/MEP	3.081	0.511	-83	1.826	0.255	-86
Reference group 1: signalized intersections (36)	Frequency	44.9	41.9	-7	19.6	16.8	-14
	Total crashes/MEV&P	1.953	1.788	-8	0.854	0.716	-16
	Severe crashes/MEV&P	0.549	0.503	-8	0.294	0.241	-18
	Pedestrian crashes/MEV&P	0.020	0.016	-23	0.010	0.008	-16
	Pedestrian crashes/MEP	2.051	1.546	-25	1.025	0.839	-18
Reference group 1: unsignalized intersections (35)	Frequency	4.2	4.3	3	1.6	1.3	-17
	Total crashes/MEV&P	0.285	0.292	2	0.108	0.090	-17
	Severe crashes/MEV&P	0.098	0.088	-10	0.043	0.038	-10
	Pedestrian crashes/MEV&P	0.006	0.009	52	0.003	0.004	42
	Pedestrian crashes/MEP	1.383	2.078	50	0.615	0.866	41
Reference group 2: unsignalized intersections (102)	Frequency	5.9	6.1	3	2.4	2.1	-9
	Total crashes/MEV&P	0.418	0.430	3	0.166	0.150	-9
	Severe crashes/MEV&P	0.140	0.141	0	0.060	0.056	-6
	Pedestrian crashes/MEV&P	0.006	0.011	93	0.001	0.003	143
	Pedestrian crashes/MEP	1.233	2.297	86	0.257	0.602	134

Crashes/MEV&P = Type of given crash (total, severe, or pedestrian crashes) per million entering vehicles and pedestrians.
Pedestrian crashes/MEP = Pedestrian crashes per million entering pedestrians.
Note: Frequency is expressed as the average annual number of total crashes for a site with the given intersection control and study period.

Step 1. Determine Use(s) of Risk Values

F. Site evaluation

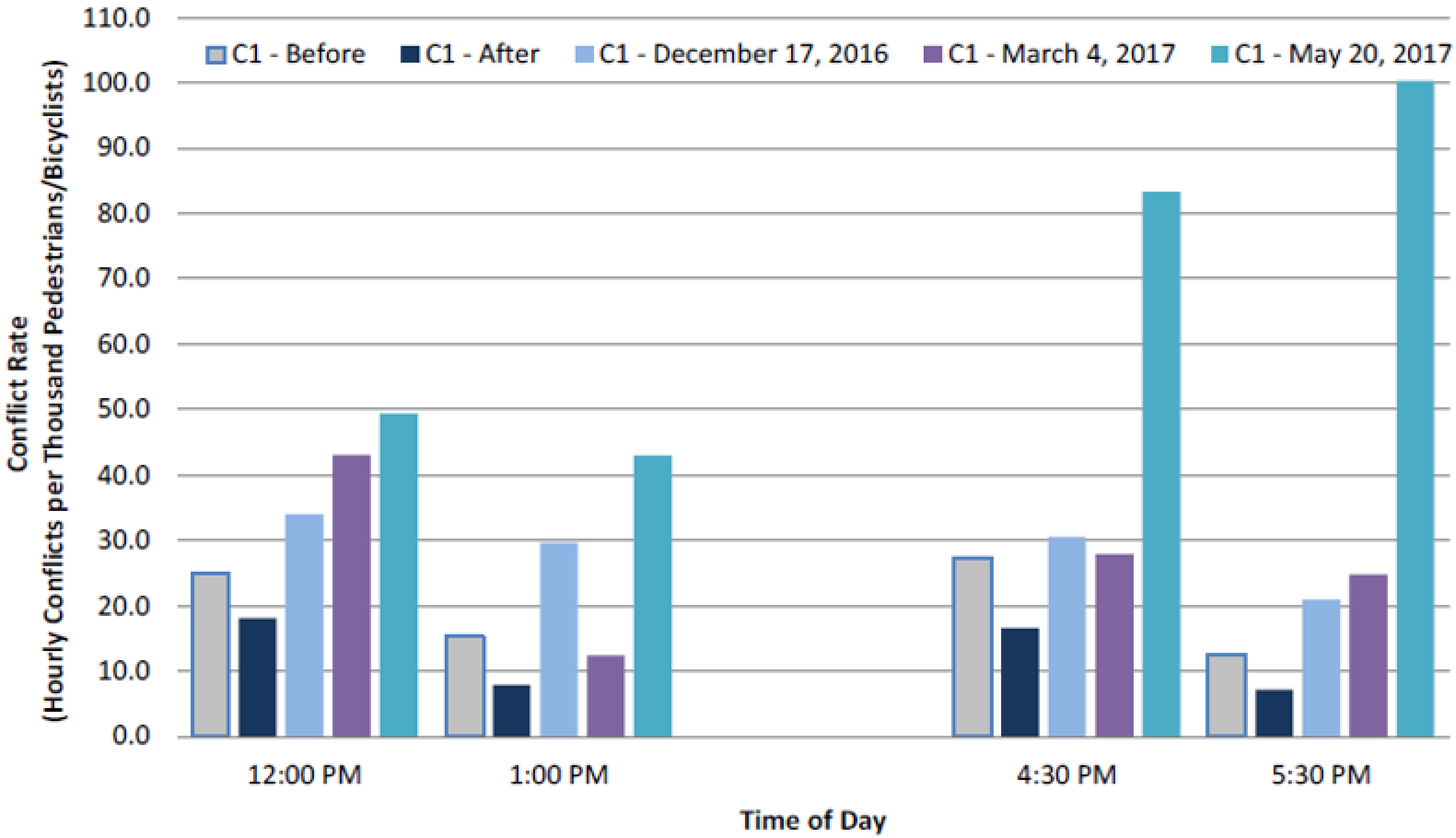
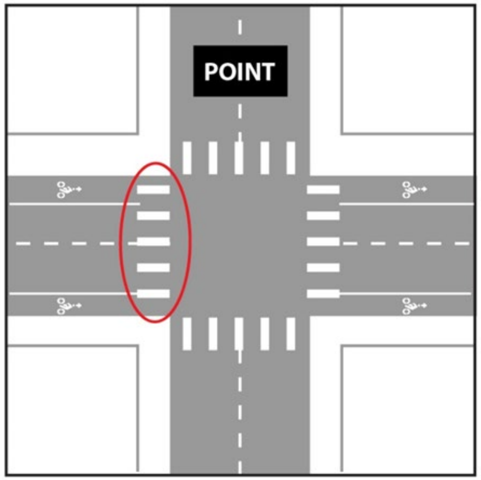
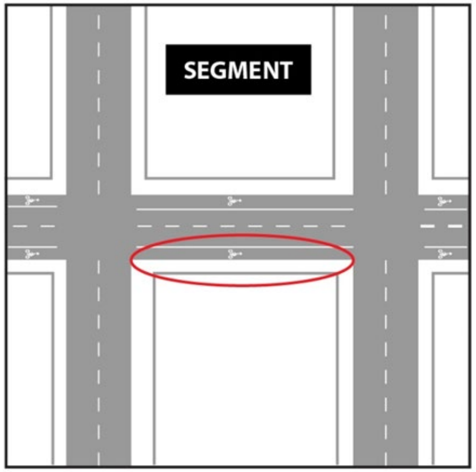


Figure 4. Example of Site Evaluation: Exclusive Pedestrian Phase at Single Intersection

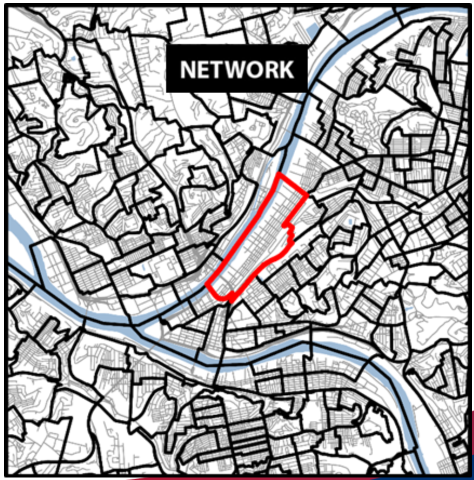
Step 2. Select Geographic Scale

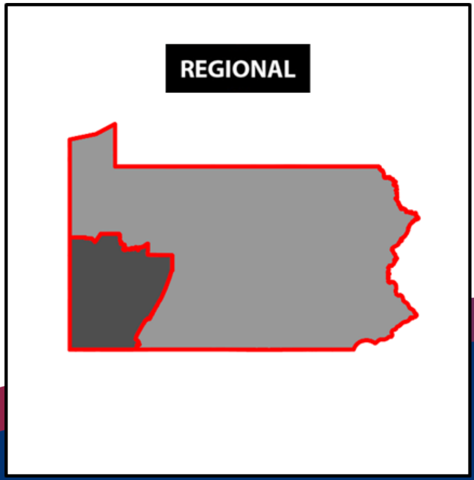
Facility-Specific





Areawide





Step 2. Select Geographic Scale

- In many cases, your defined use(s) from Step 1 will also determine the scale to use
  A. Safety performance measures (typically AREAWIDE)
  B. Network screening, area-based (AREAWIDE)
  C. Network screening, facility-based
  D. Project prioritization
  E. Countermeasure evaluation
  F. Site evaluation

  (C–F: FACILITY-SPECIFIC)

Step 3. Select Risk Definition

1. Observed crash rate

2. Expected crashes

3. Additional risk indicators

Step 3. Select Risk Definition

1. **Observed crash rate**
   - Traditional approach
   - Use with other crash analysis tools
   - Observed crashes on specific facilities may not accurately represent true crash probability
   - Preferred for areawide scales

$$\text{Risk} = \frac{\text{Observed crashes}}{\text{Exposure}}$$

Step 3. Select Risk Definition

2. **Expected crashes**
   - Highway Safety Manual and other statistical models
     - Function of **pedestrian and bicyclist exposure**, other road and traffic variables
   - Overcomes issues with observed crashes on specific facilities
   - Preferred for specific facilities, but requires advanced statistical methods to estimate expected crashes

Step 3. Select Risk Definition

3. **<u>Additional risk indicators</u>**
   - Systemic safety: risk score based on combining pedestrian and bicyclist exposure with other road and traffic variables (i.e., risk factors)
   - Compatible with FHWA's Systemic Safety approach
   - Risk is numeric score or rating, does not estimate crashes
   - Preferred for specific facilities if expected crashes not feasible

Step 4. Select Exposure Measure

- Volume/count
  - E.g., crossing pedestrians, peds x motor vehicles
- Distance traveled
  - E.g., Pedestrian-miles of travel
- Time traveled
  - E.g., Pedestrian-hours of travel
- Trips made
- Population
  - E.g., % of population that walks on regular basis

Step 4. Select Exposure Measure

Exposure Measure	Point	Segment	Network	Region
Volume/count	●			
Distance traveled		●	●	●
Time traveled	○	○	●	●
Trips made			●	●
Population			●	●

Steps 5 & 6. Select and Use Analytic Methods to Estimate Exposure

- Site counts
- Demand estimation models

(FACILITY-SPECIFIC)

- Travel surveys (AREAWIDE)

Steps 5 & 6. Select and Use Analytic Methods to Estimate Exposure

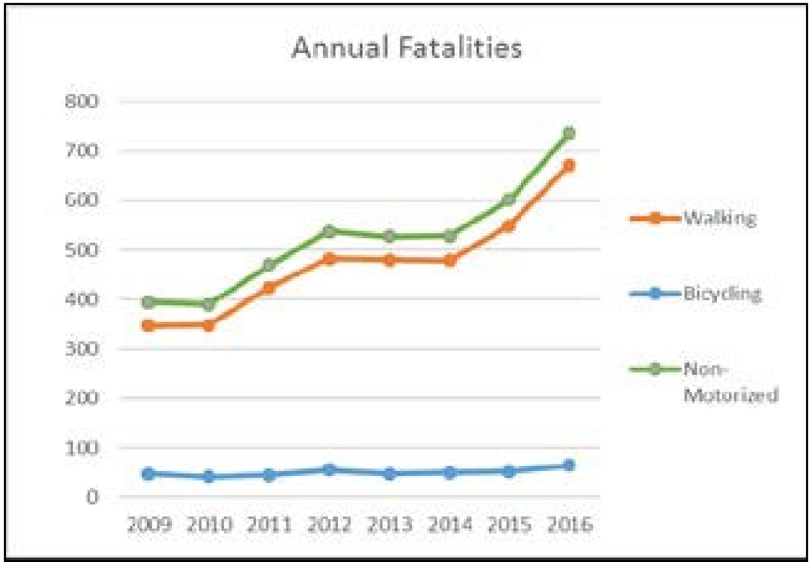
- Limited number of facilities
  - Site counts
- All facilities in city/region
  - Site counts at sample locations used to develop and calibrate demand estimation model for all facilities

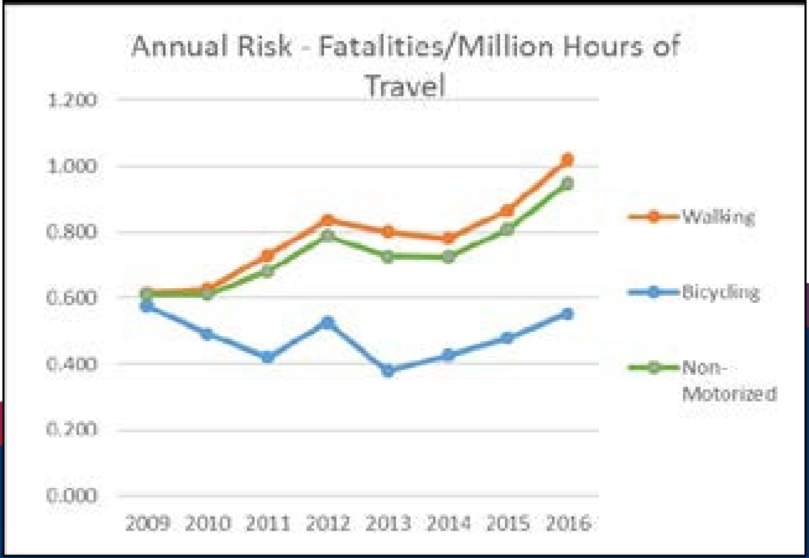
Steps 5 & 6. Select and Use Analytic Methods to Estimate Exposure

- Direct demand models (most common)
- Model variables:
  - Population density
  - Total employment
  - Land use mix
  - Presence of transit stops
  - Presence of walking/biking facilities

Steps 5 & 6. Select and Use Analytic Methods to Estimate Exposure

- Travel surveys
  - National Household Travel Survey (NHTS)
  - American Community Survey (ACS)
  - Regional travel survey
- AREAWIDE uses only
- Spreadsheet tool for state and MPO area exposure estimates





Steps 7 & 8: Compile Other Data, Calculate Risk Values

- Step 7: Compile other required data (based on risk definition from Step 3)

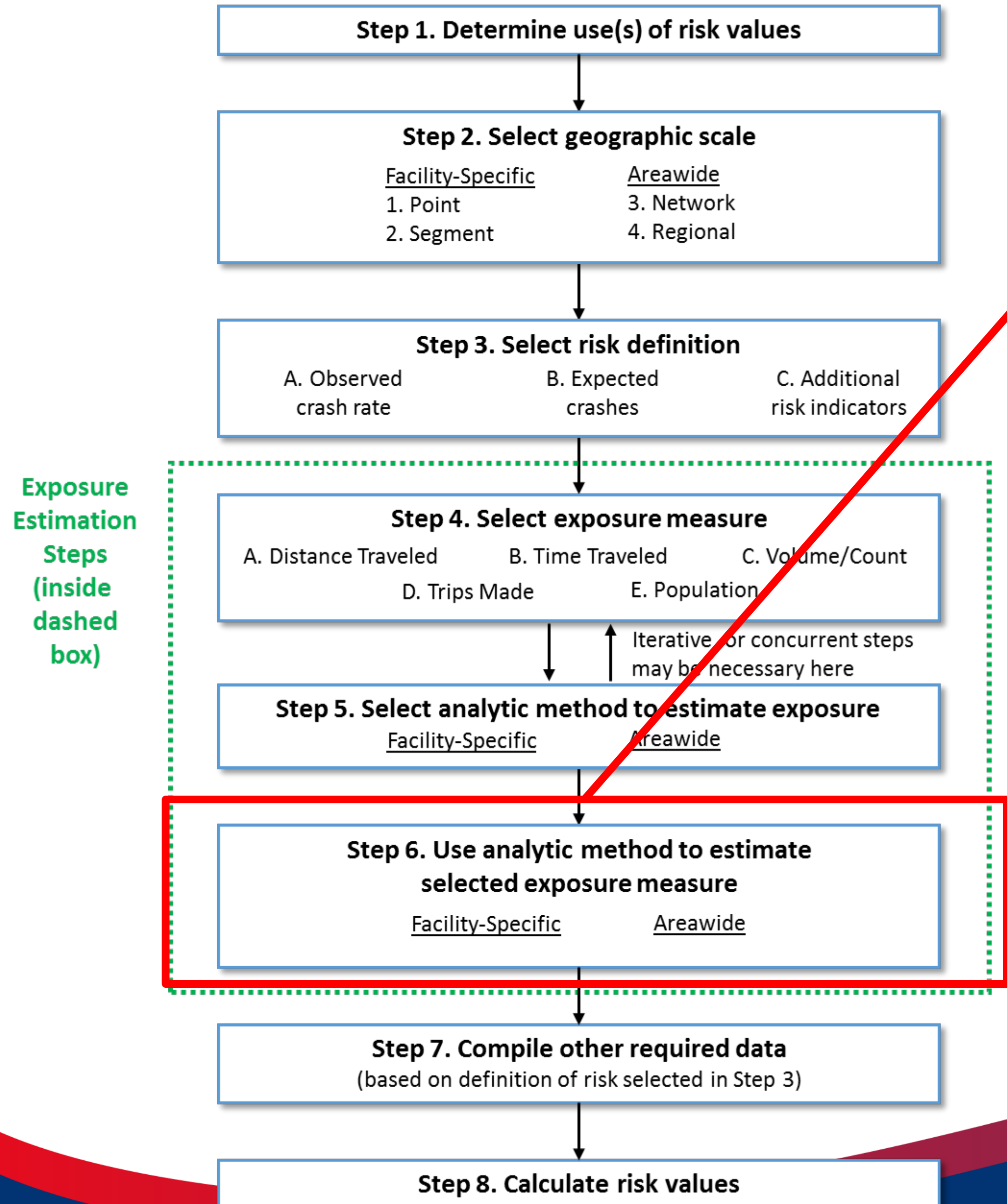
- Step 8: Calculate Risk Values

Resources

- Guide: Scalable Risk Assessment (FHWA-SA-18-032)
  - https://safety.fhwa.dot.gov/ped_bike/tools_solve/fhwasa18032/
  - Spreadsheet tool for statewide and MPO area exposure estimates
- Phase 1: Synthesis of Methods (FHWA-SA-17-041)
  - https://safety.fhwa.dot.gov/ped_bike/tools_solve/fhwasa17041/index.cfm

Exposure from Site Counts

Exposure



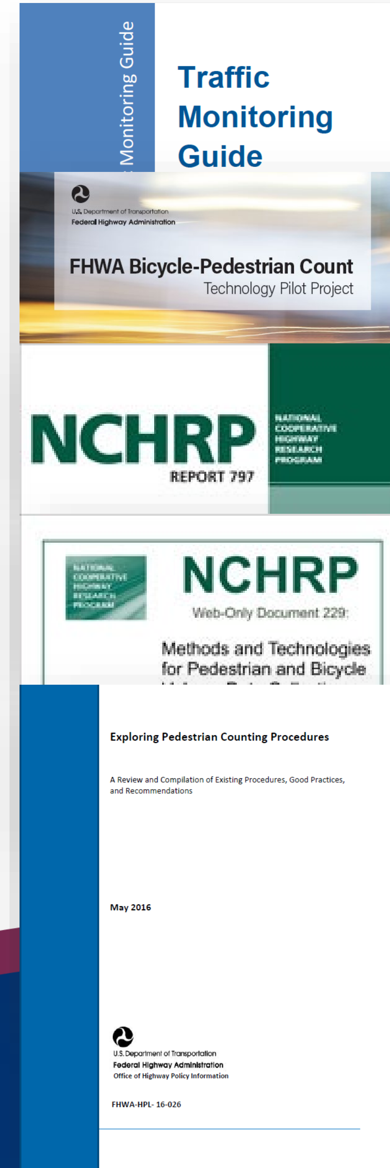
- Analytic methods to estimate exposure
- Facility-Specific:
  - Counts
  - Demand models
- Areawide
  - Travel surveys

Exposure from Site Counts

- Limited number of facilities
- Counts for model development
- Use of automated equipment
  - Annualizing short duration counts
- Balance number of count locations and duration
- Crowdsourced data on horizon

Counting Guides & Resources

- FHWA 2016 Traffic Monitoring Guide
- FHWA-HEP-17-012, Count Tech Pilot
- NCHRP Report 797, Guidebook on Data Collection
- NCHRP Web-only Doc 229, Methods and Tech
- FHWA-HPL-16-026, Ped Counting Practices



Structure of Monitoring Program

- A few permanent continuous count sites
  - Year-round traffic patterns to adjust short-duration counts
  - Typically several perm counters per factor group, several factor groups
    - Commuting
    - Recreational
    - Mixed
- Larger number of short duration sites
  - More geographic coverage
  - Ideally 7 days, but some exceptions

Counter Technology

1. What Are You Counting?

2. How Long? Permanent ↔ Temporary/ Short Term

How Long?	Technology	Bicyclists Only	Pedestrians Only	Pedestrians & Bicyclist Combined	Pedestrians & Bicyclist Separately	Cost
Permanent	Inductance Loops[1]	●			◐	$$
	Magnetometer[2]	○				$-$$
	Pressure Sensor[2]	○	○	○	○	$$
	Radar Sensor	○	○	○		$-$$
	Seismic Sensor	○	○	○		$$
	Video Imaging: Automated	○	○	○	○	$-$$
	Infrared Sensor (Active or Passive)	○[3]	●	●	◐	$-$$
	Pneumatic Tubes	●			◐	$-$$
	Video Imaging: Manual	○	○	○	●	$-$$$
Temporary/ Short Term	Manual Observers	●	●	●	●	$$-$$$

○ Indicates what is technologically possible.
● Indicates a common practice.
◐ Indicates a common practice, but must be combined with another technology to classify pedestrians and bicyclists separately.
$, $$, $$$: Indicates relative cost per data point.
[1] Typically requires a unique loop configuration separate from motor vehicle loops, especially in a traffic lane shared by bicyclists and motor vehicles.
[2] Permanent installation is typical for asphalt or concrete pavements; temporary installation is possible for unpaved, natural surface trails.
[3] Requires specific mounting configuration to avoid counting cars in main traffic lanes or counting pedestrians on the sidewalk.

Counter Technology

Table 3-3. Comparison of common pedestrian and bicycle counting methods: resources.

Characteristic	Passive Infrared	Active Infrared	Pneumatic Tubes	Inductive Loops	Piezoelectric Sensor	Passive IR + Inductive Loops	Radio Beam (One Frequency)	Radio Beam (High/Low Frequency)	Automated Video[1]	Manual Counts[2]
Equipment cost[3]	$$	$$$	$$	$$	$$	$$$	$$$	$$$	$$	$
Preparation cost[4]	$$	$$	$$	$$$	$$$	$$$	$$	$$	$$	$
Installation time[5]	⏲	⏲⏲	⏲	⏲⏲⏲	⏲⏲⏲	⏲⏲⏲	⏲⏲	⏲⏲	⏲	N/A
Hourly cost[6]	$	$	$$	$	$	$	$	$	$$$	$$$$
Data collector training time[7]	⏲	⏲	⏲	⏲	⏲	⏲	⏲	⏲	⏲	⏲⏲⏲
Mobility[8]	+++	++	+++	-	-	-	++	++	+++	+++
Pavement cuts	No	No	No	Yes	Yes	Yes	No	No	No	No

Notes: N/A: not applicable

This table presents generalized information specific to particular counting *technologies*. Other aspects of counting *products*, such as battery life and communication interfaces, are also important to consider but are highly vendor-specific. See the text following this exhibit for more details. See Chapter 5 for specific details (e.g., typical costs) related to each technology.

(1) Existing "automated video" systems may not use a completely automated counting process; they may also incorporate manual data checks of automated video processing.

(2) Includes manual counts from video images.

(3) $: equipment (not including permitting and installation) typically cost less than $1,000 as of 2013, $$: typically costs between $1,000 and $3,000, $$$: typically costs more than $3,000. The cost of most counting technologies is subject to economies of scale, so the per site cost can be reduced by purchasing more counters.

(4) Fewer dollar signs ($) indicate that it takes less time (and therefore fewer financial resources) to find an appropriate site and to obtain any required permits to install the counting product. Preparation can range from less than one day for manual counts to several months for technologies with more restrictive installation requirements.

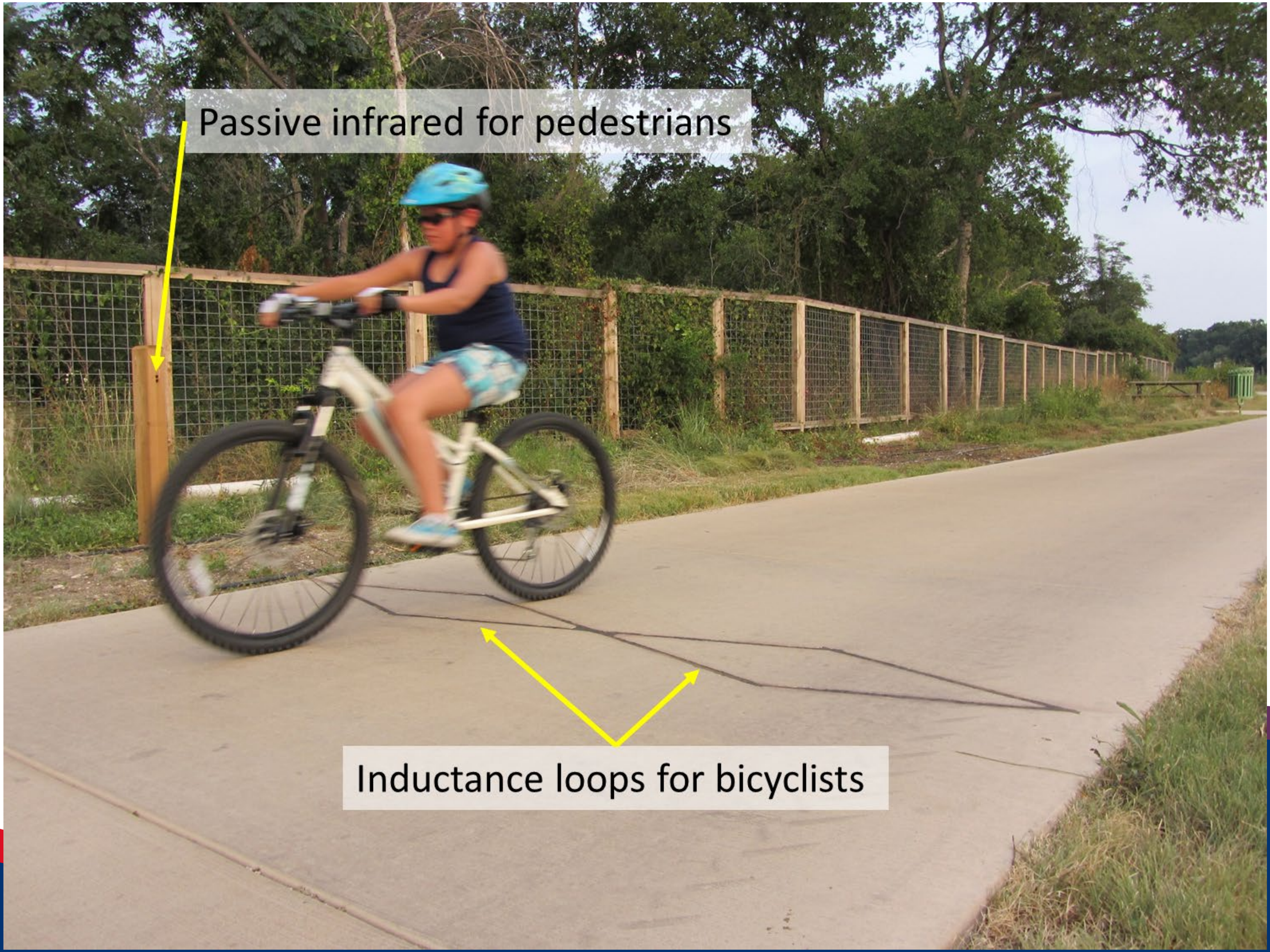
(5) More clocks (⏲) are given to methods that require more installation time (e.g., cut pavement, secure the data logger, test and adjust the equipment). Installation can range from no time for manual counts and less than 30 minutes for passive infrared to more than half a day for inductive loops.

(6) More dollar signs ($) indicate that the method is more costly for an average hour of counts, given the typical count duration for a particular method. These costs can range from a few cents per hour for automated technologies (the full equipment, preparation, and installation cost is spread across months of counts) to more than $50 per hour for manual counts (including training preparation time, management, and on-site labor costs).

(7) More clocks (⏲) indicate that more time is needed to prepare field data collectors to implement the counting method. A single data collector can be trained how to install or download data from a particular automated technology in less than 30 minutes, but it often takes more than one hour to thoroughly train data collectors to collect accurate manual counts.

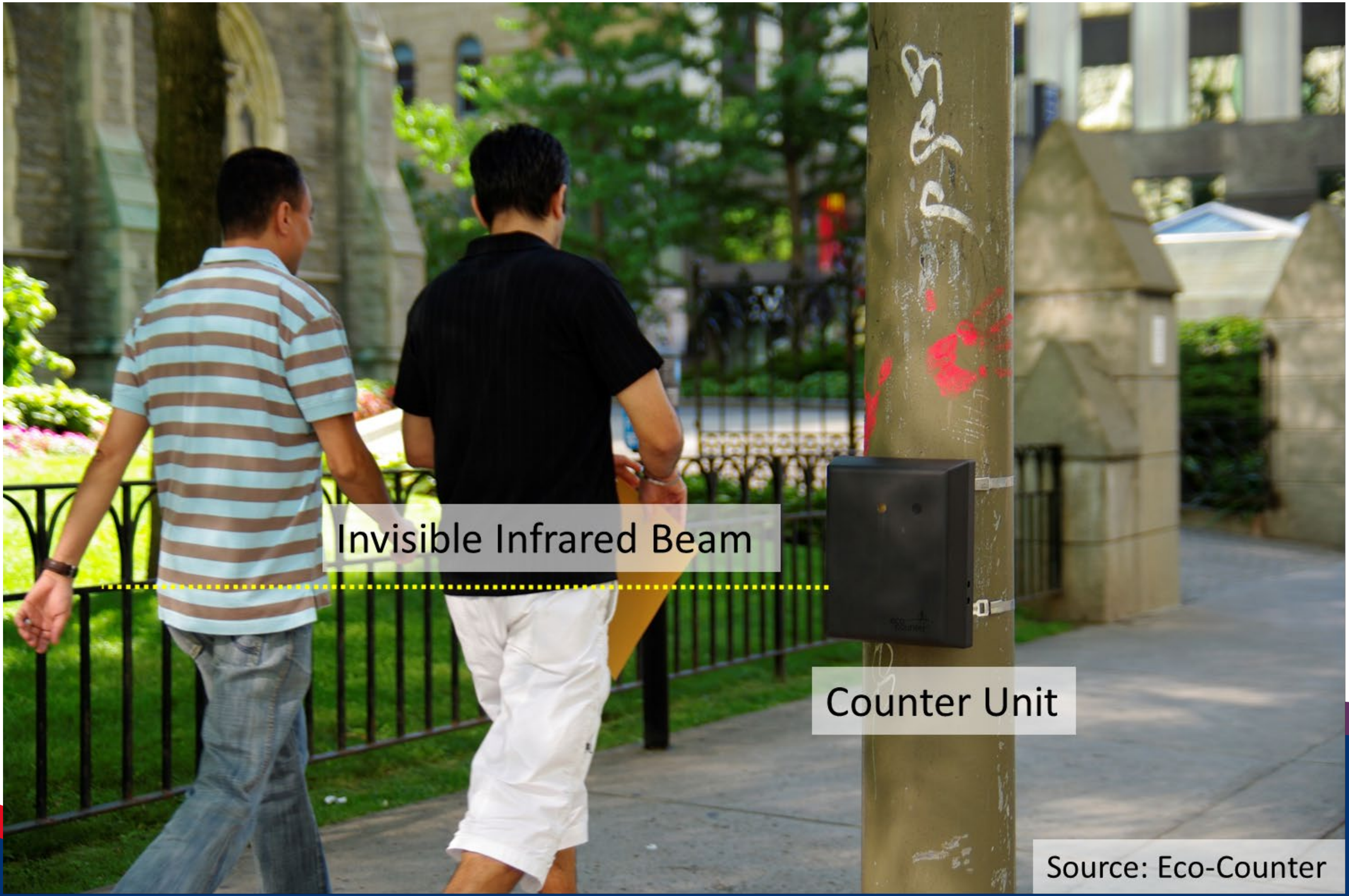
(8) More pluses (++) indicate that a counting technology is easier to move after it has been installed. A minus sign (−) indicates that the technology is generally not intended to be used in more than one location based on the installation being permanent.

Counter Technology

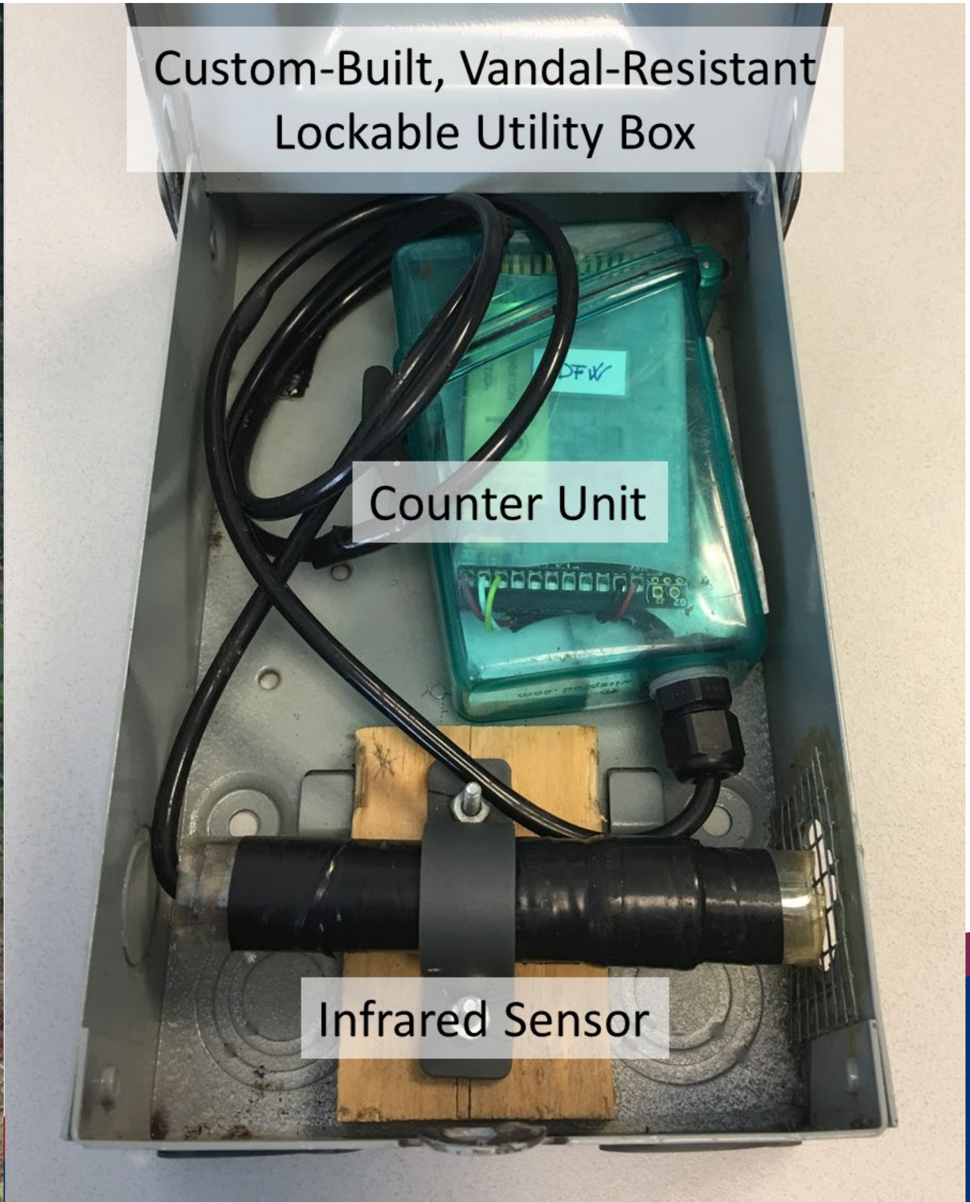


Counter Technology

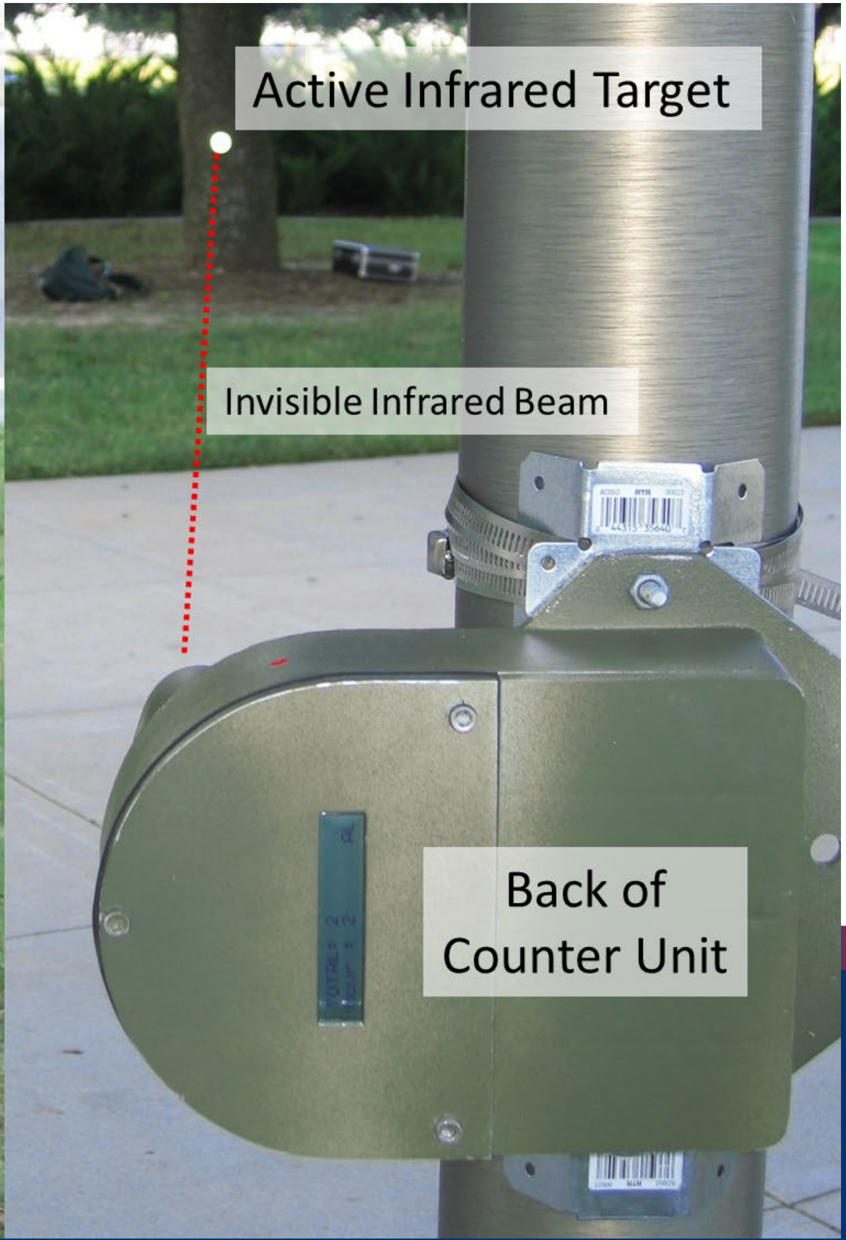
Counter Technology



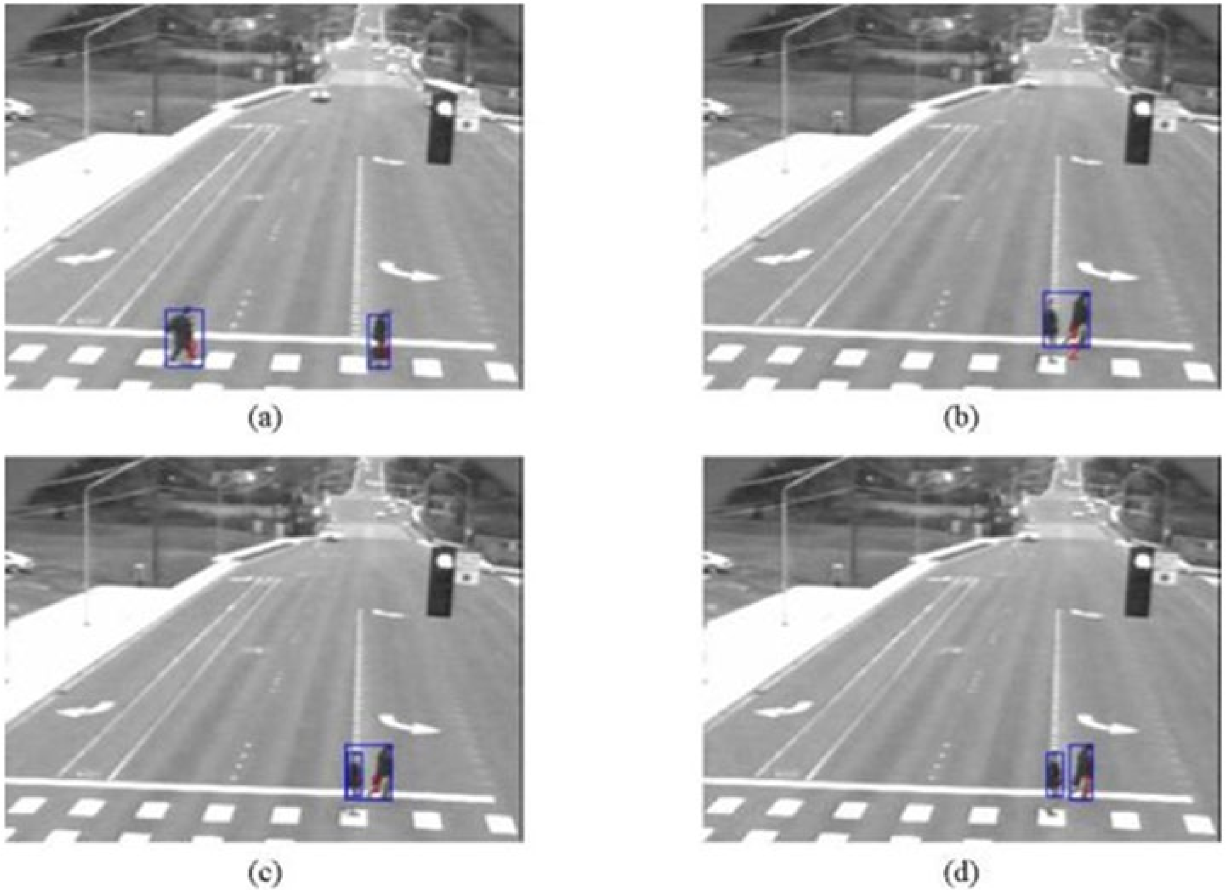
Counter Technology



Counter Technology



Counter Technology



Video: automated and manual reduction

Site Selection

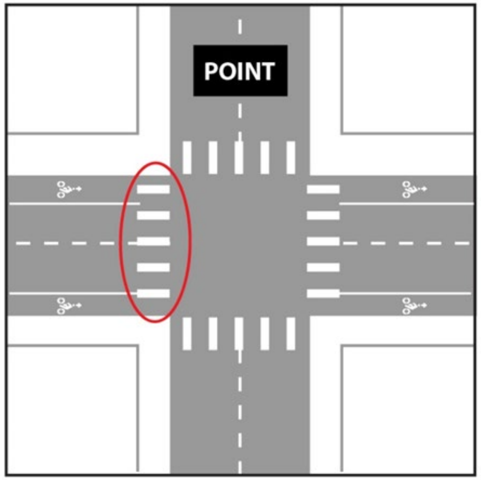
- What is purpose of counts?
- How will you use counts
  - Exposure at safety hot spots? (high crashes)
  - Before-after at future improvements? (maybe both)
  - Document effectiveness? (high activity levels)

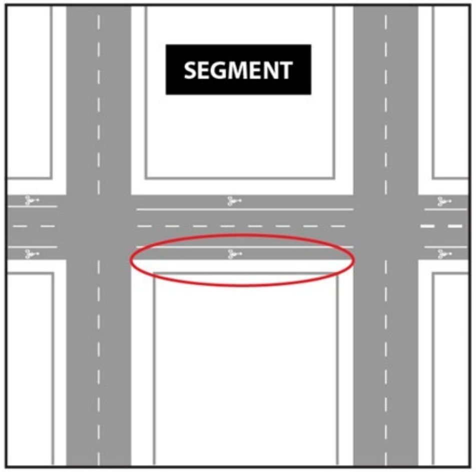
- Collecting counts for multiple purposes may require balancing multiple criteria

Site Selection

- Intersections vs. mid-block locations

Facility-Specific





- Where are the safety problems?
- Where are the improvements?

Site Selection Criteria

- High-activity locations
- High-crash locations (Safety Action Plan)
- Planned improvements
- Representative facilities
  - On-street facilities – different functional classes
  - Shared use paths
  - Sidewalks and crossings
- Designated bicyclist routes
- Local input

Site Selection: Mid-block Locations

- Most pedestrian traffic is local – short trips
- But can't afford to collect everywhere
- Land use and trip generators
  - Dense activity centers
  - Schools, parks, recreational areas
  - Multi-family housing
  - Transit stops
- Intercept points
- Practical consideration of equipment mounting

Short Duration Counts: How Long?

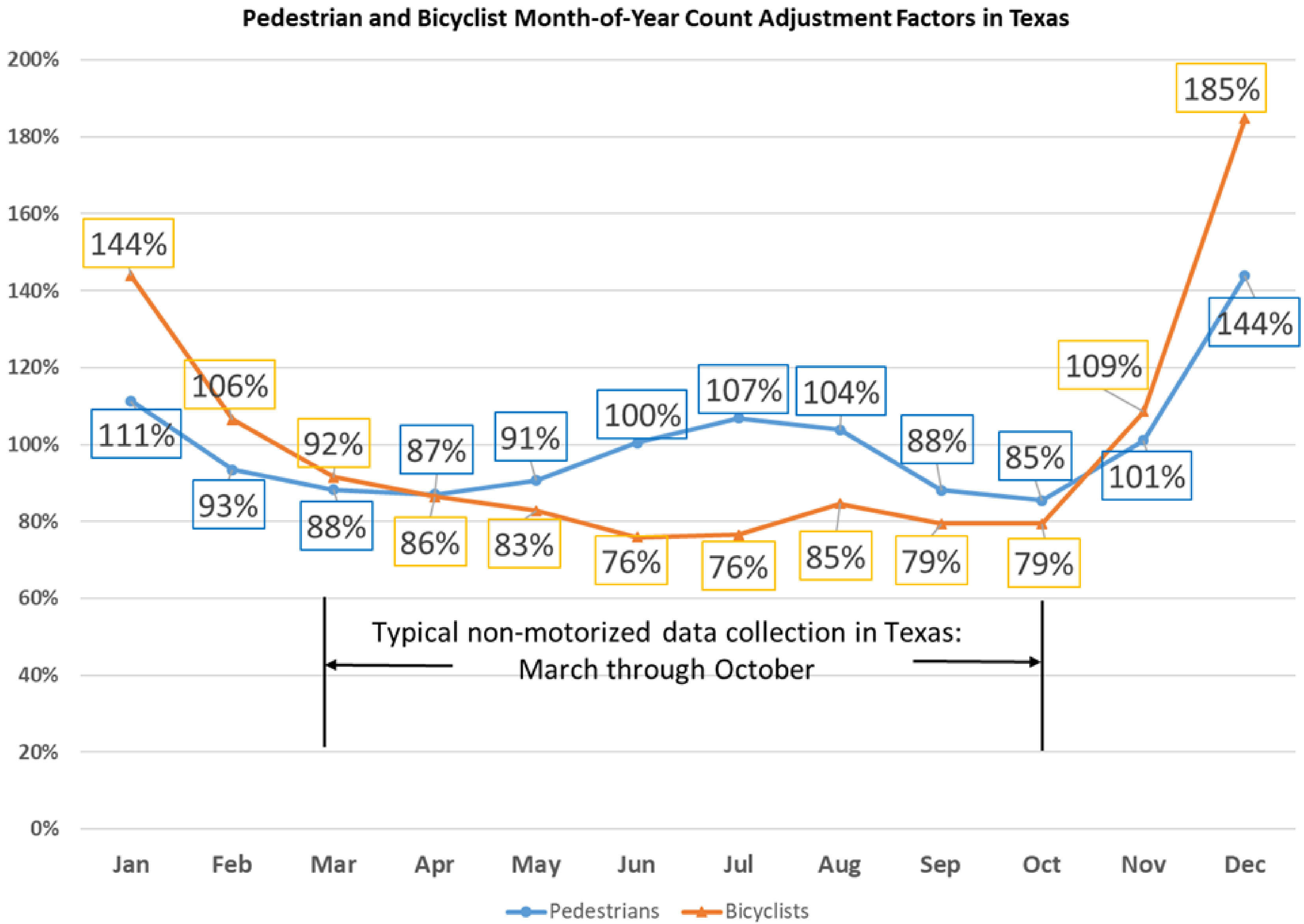
- Counts highly variable
  - Discretionary trips
  - Effects of weather
- Automated collection:
  - 14 days preferred, 7 days minimum
- Manual collection:
  - 12 hours preferred, 4-6 hours minimum
- Must consider tradeoffs – number of sites versus duration at each site

Adjustments to Raw Count Data

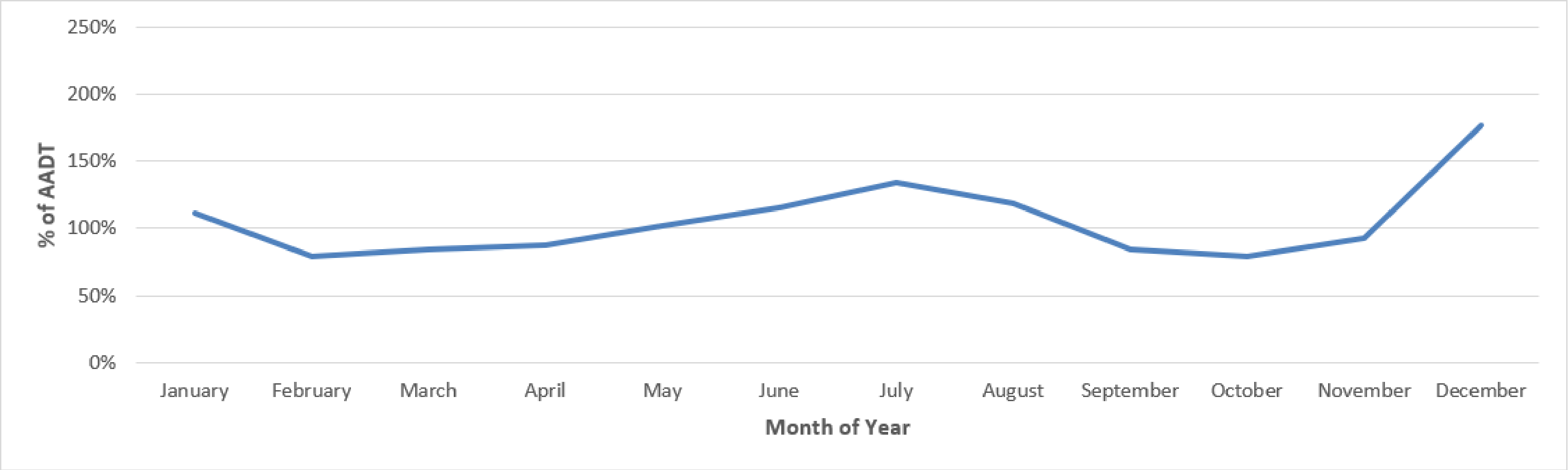
- Time-of-day: if less than 24 hours
- Day-of-week: if less than 7 days (5 weekday, 2 weekend)
- Month-of-year (annualizing)

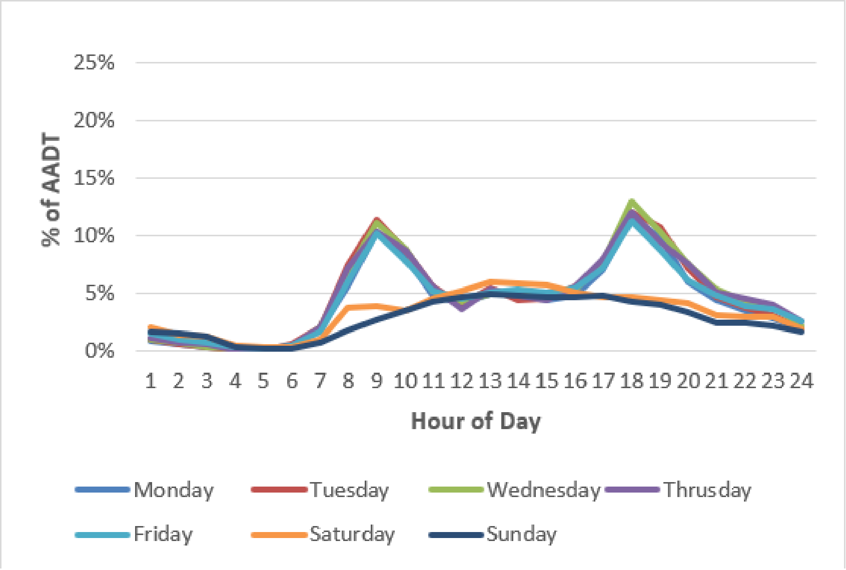
- Occlusion adjustment
  - Address known equipment deficiency in high volumes

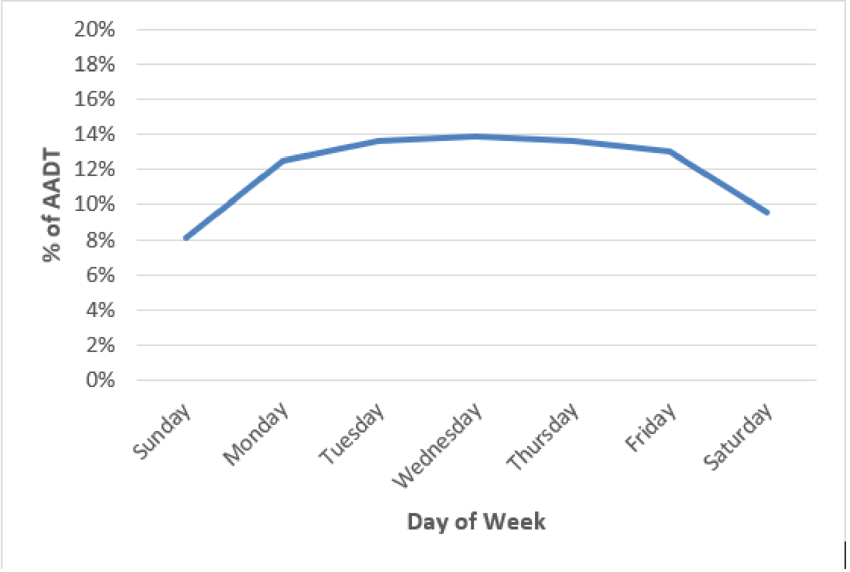
Example: Month-of-Year Adjustment



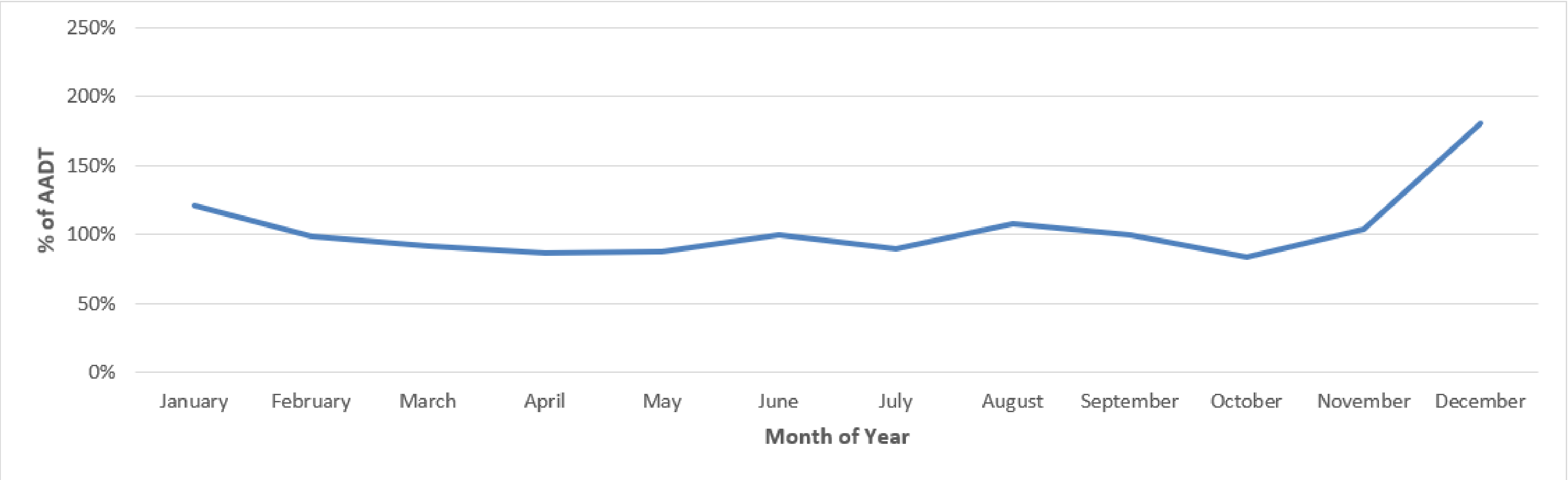
Permanent counter - Commuters

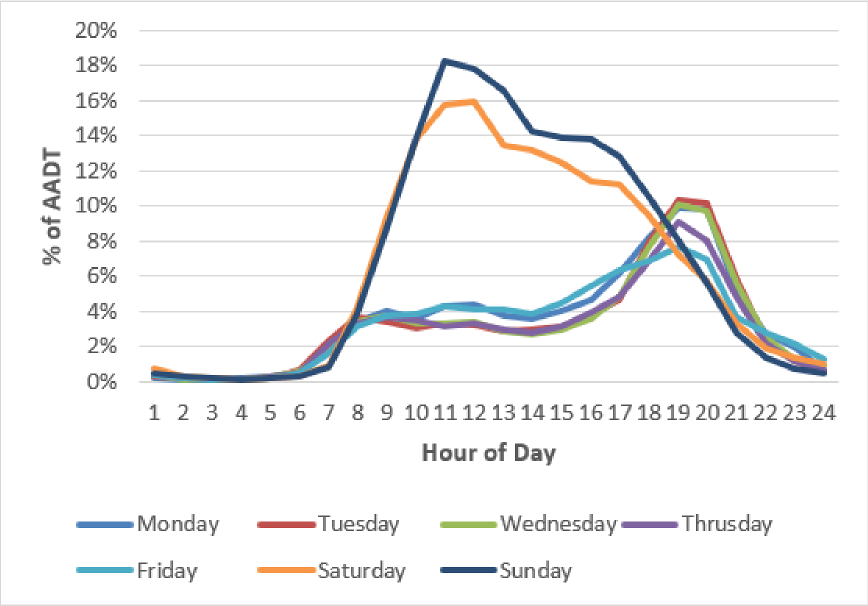


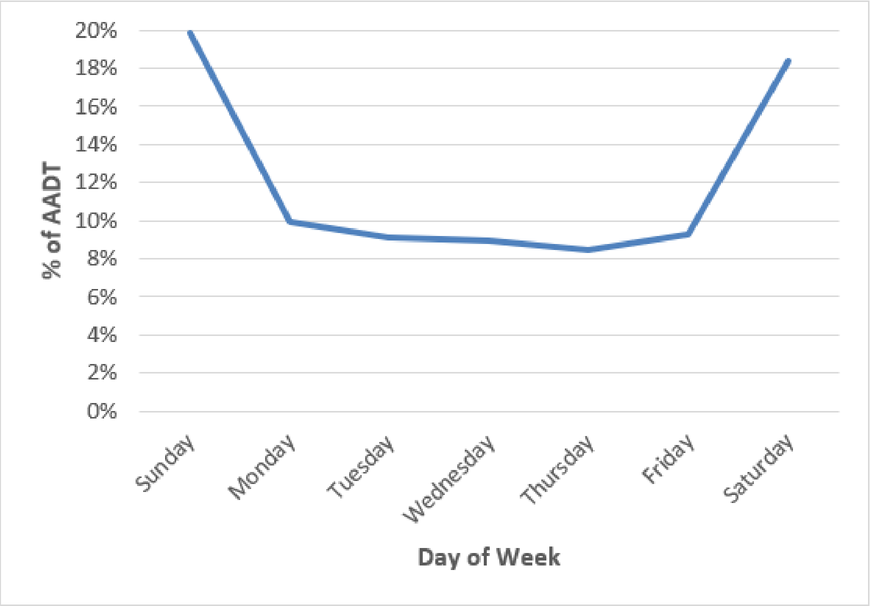




Permanent counter - Recreation







Break!

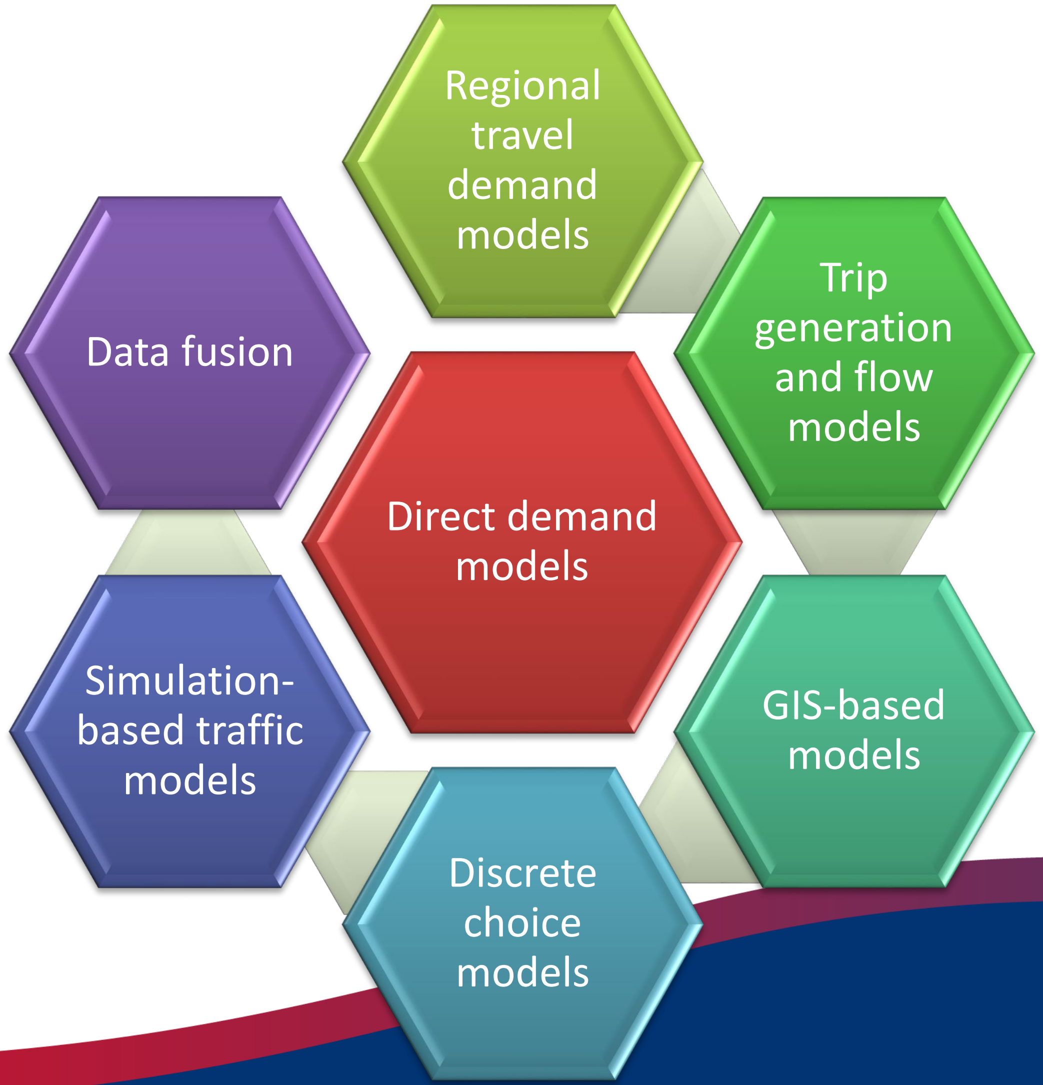
Exposure from Demand Estimation Models

Demand Estimation Models

- Numerous models to estimate pedestrian and bicyclist demand.
- Some have been more commonly used.
- Several rely on pedestrian and bicyclist count data.
- Some provide the volume estimate directly, some must be integrated with other methods.

Demand Estimation Models

Have a potential role as non-motorized planning tools that can be used in exposure estimation.



Demand Estimation Models

Method Selection Matrix

Analytic Method		Input Data Requirements	Technical Complexity	Popularity in Practice	Direct Usability	Accuracy
Site counts		○	○	●	●	○/◐/●
Demand Estimation Models	Direct demand models	◐	○/◐	●	◐	○/◐
	Regional TDM	◐/●	◐/●	○	○/◐/●	○/◐/●
	Trip generation and flow models	◐/●	◐/●	◐	●	◐/●
	GIS-based models	◐	◐	◐	●	◐/●
	Discrete choice models	◐/●	◐/●	◐	○	◐/●
	Simulation-based traffic models	●	●	○	●	●
	Data fusion	●	◐/●	○	●	◐/●
Travel surveys		○	○	●	●	○/◐/●

Legend: ○ = low suitability; ◐ = moderate suitability; ● = high suitability.

Key Considerations

- Review the project goals and resources available.

Key Considerations

- Review the project goals and resources available.
- A model is as good as its input data.

Key Considerations

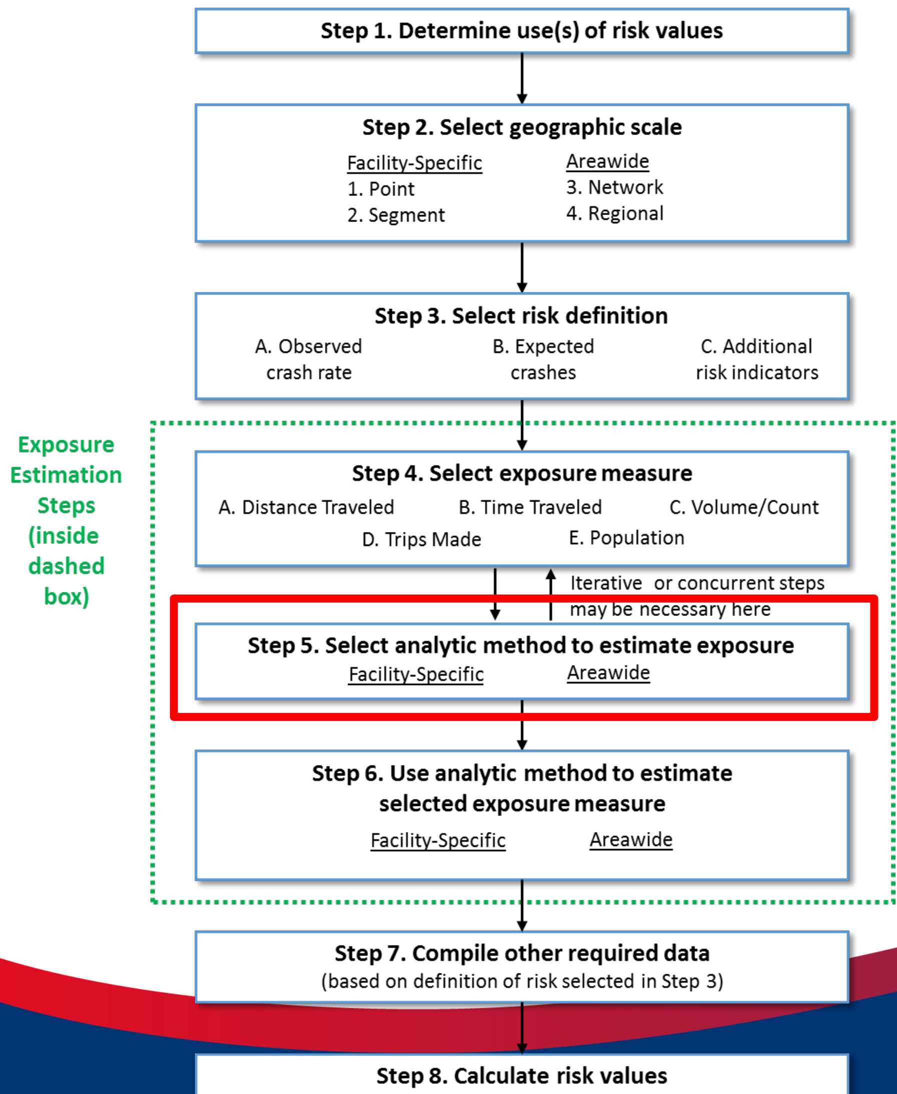
- Review the project goals and resources available.
- A model is as good as its input data.
- Learn and understand what is available in the region.

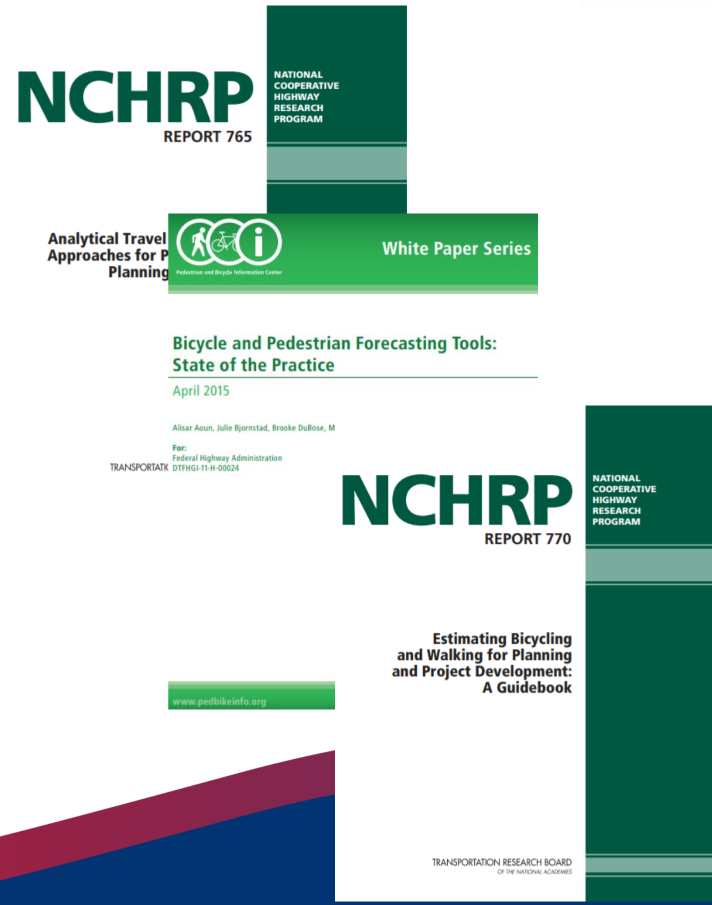
Key Considerations

- Review the project goals and resources available.
- A model is as good as its input data.
- Learn and understand what is available in the region.
- May not be directly transferable.
  - re-design, re-implement, and calibrate with respect to local conditions

Step 5: Select

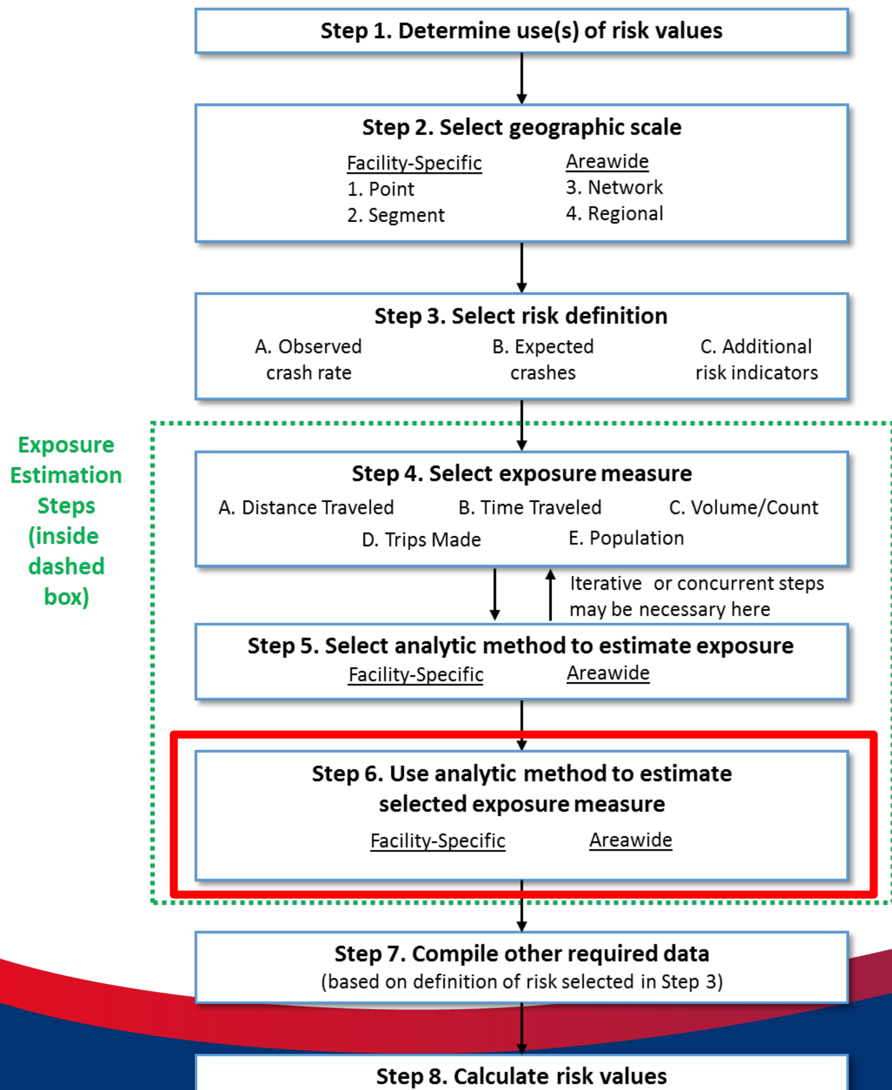
Overview, Considerations, Checklist & Resources





Step 6: Use

Detailed Overview, Development, Examples



Direct Demand Models

Direct Demand Models

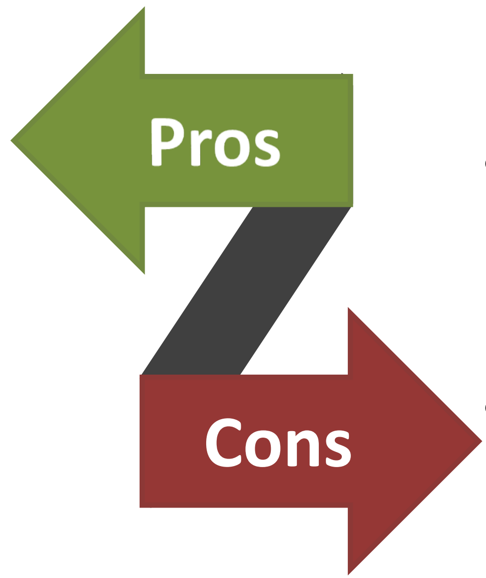
- Statistical models
  - often based on regression analysis
  - developed using different data sources

- Primarily used to develop facility-specific demand estimations
  - facility use or needs
  - estimates of non-motorized activity
  - connection between the built environment and non-motorized demand

Direct Demand Models

- Simple, practical and generally based on available data

- Particularly useful for screening and preliminary analyses when resources are limited



- Usually not transferable

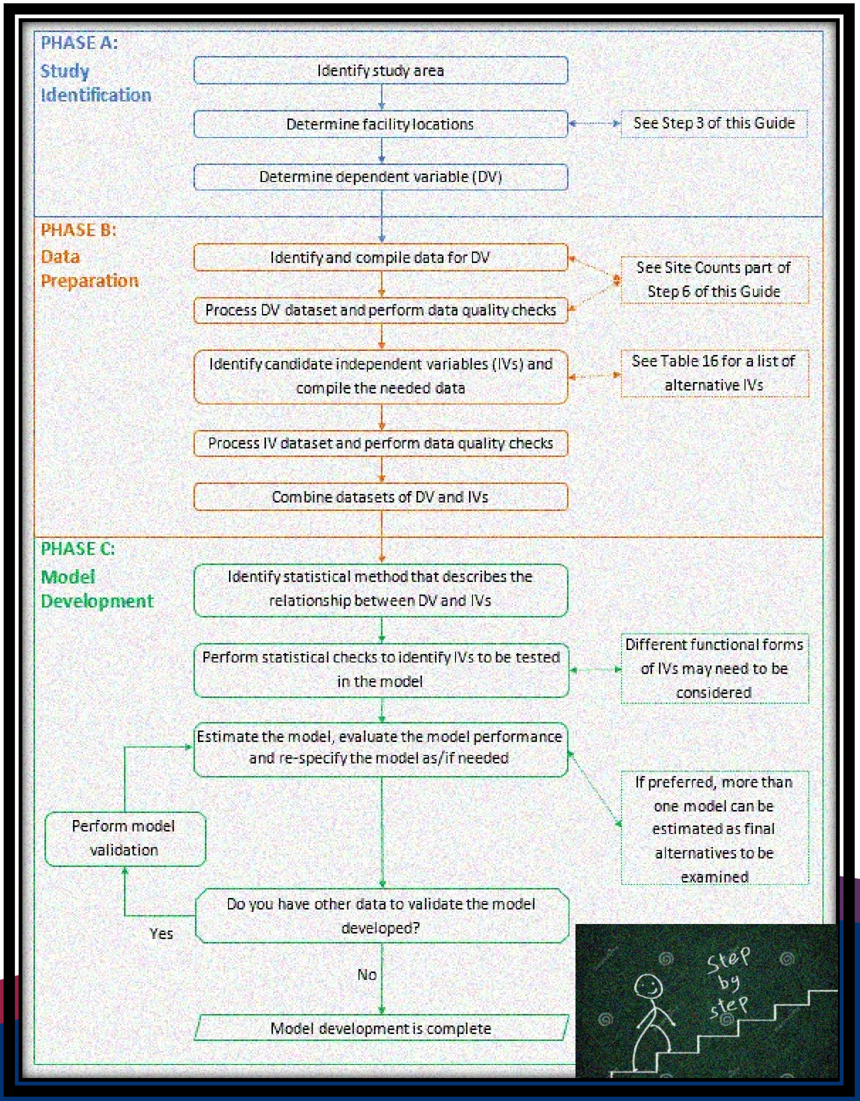
- Limited in terms of capturing the underlying behaviors and travel patterns

Development of a Direct Demand Model

Phase A: Study Identification

Phase B: Data Preparation

Phase C: Model Development



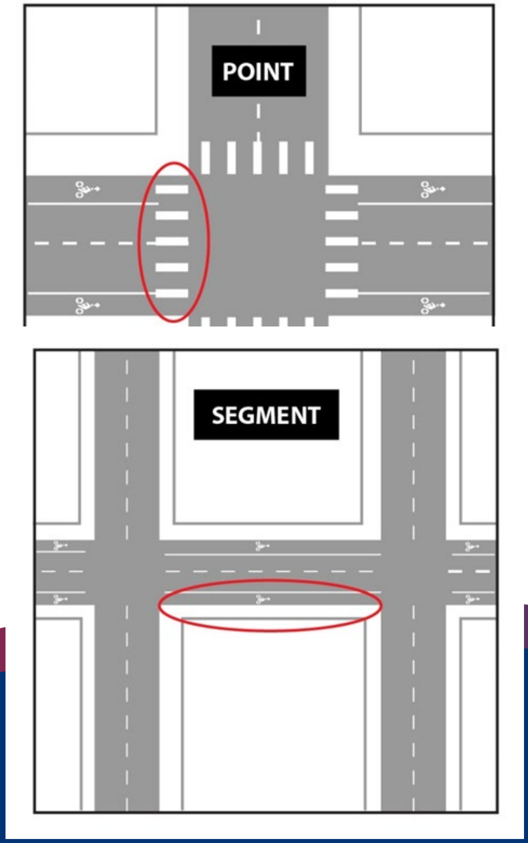
Development Process

Identify the FOCUS

- Avoid any unnecessary process, optimize the resources and limit the bias.

- Location-specific details?
  - geographic scale, facility locations

- Main outcome?
  - e.g. annual pedestrian crossing intersection volume, peak hour bicycle volume



Development Process

Prepare the DATA

Dependent variable

- Site counts are the main ingredients
- Not feasible to collect site counts at all facility locations
  - need a sampling strategy
    - depend on the study focus
  - need representative sample of site counts
    - not just the worst crash locations or busiest sites

Development Process

Prepare the DATA

Explanatory variables

- Various different variables
  - demographic profile (e.g. population density)
  - bike/walk infrastructure (e.g. presence of bike facilities)
  - interaction with vehicle traffic (e.g. speed limit)
  - transit facilities (e.g. presence of transit stops)
  - major generators (e.g. proximity to a university campus)
  - land use (e.g. land use mix)
  - …

Development Process

Prepare the DATA

Explanatory variables

- Differences based on the mode
  - neighborhood forms might be more influential on pedestrian models; infrastructure and system characteristics more on bicycle models
- Consideration of buffer widths
  - some variables have the greatest influence on a large spatial area, and some variables on a smaller spatial area
- Different forms of variables
  - e.g. categorical or binary forms

Development Process

Prepare the DATA

Explanatory variables

- Have an initial (desired) set of variables?
- Need guidance?
- Final model variables
  - intuitive, logical and
    relevant to the action items
    in the decision making process

Category	Variable				
	Proximity to a un				
	Number of schoo				
Weather and environmental	Precipitation				
	Temperature				
	Very warm tempe >32°C)				
Land use	Residential land u				
	Land-use mix (are commercial space				
	Retail area				
	Office space area				
	Industrial area				
	Cultural and ente				
	Job accessibility				
	Dwell count				
	Commercial spac				
	Maximum/mean				
	Traffic signal-con				
	Patch richness de				
	Single-family resi				
	Average visibility				
	Tourist and down				
	Job accessibility				
	Centrality				
	Low-density resid				
	Institutional spac				
	Presence of three approaches			○	-
	Presence of parking entrance			○	-

Legend: ○ = to a small extent(1,2); ◐ = to a moderate extent (3,4); ● = to a great extent (>=5)

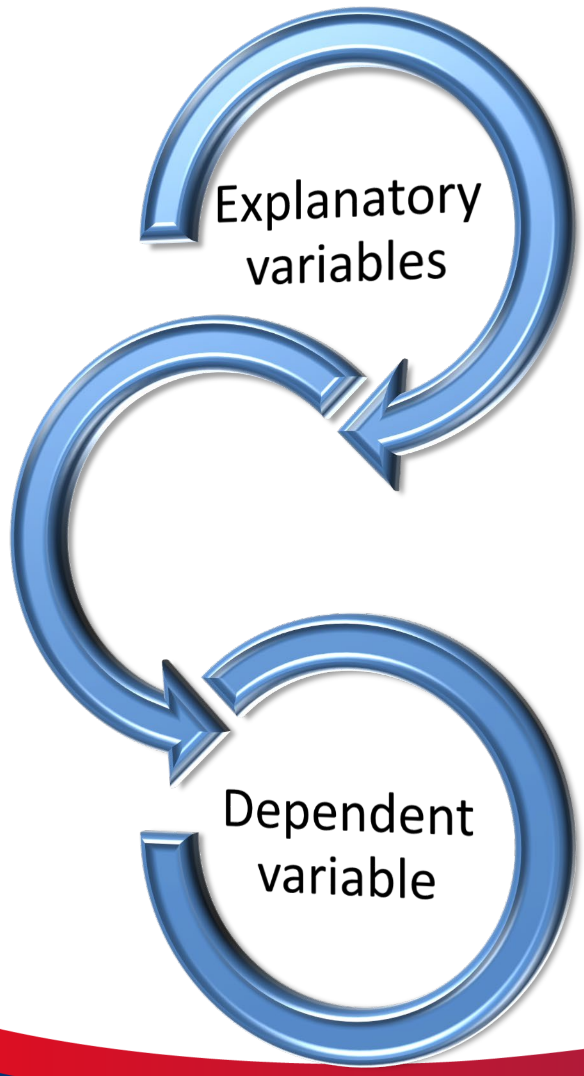
Source: Based on the literature review of 22 studies conducted by Munira and Sener 2017.

Table 18. Key Explanatory Variables of Pedestrian and Bicyclist Direct Demand Models

Category	Variable	Pedestrian		Bicycle	
		Frequency	Impact	Frequency	Impact
Demographic	Population density	◐	+	○	+
	Total population	○	+	○	+
	% of non-white residents	○	+	○	+
	% of black residents	○	-	○	-
	% residents with a college education	◐	+	◐	+
	% residents younger than 5 and older than 65 years			○	+
Socioeconomic	Household income	○	-	●	+/-
	Total employment	○	+	◐	+
	Employment density	○	+/-	○	+
Network/ interaction with vehicle traffic	Number of lanes	○	+	○	+/-
	Speed limit			○	-
	Arterial street (of count location)	◐	+	○	+
	% major arterials	○	-		
	Collector street (of count location)	◐	+		
	Presence of four-way intersection	○	+		
Bicycle- or pedestrian-specific infrastructure	Presence of bike lane	○	+	○	+
	Presence of sidewalk	○	+		
	Footway pavement width	○	+		
	On-street bicycle facility length			●	+
	Presence of a cycle track			○	+
	Bicycle-trail access			○	+
	Bike lane or curb lane width			○	+
	Separated path			○	+
	Presence of bicycle markings on any approach			○	+
Transit facilities	Number of bus/transit stops	●	+	◐	+
	Presence of subway station	○	+	○	+
	Bus frequency	○	+		
	Accessibility to an underground station	○	+		
Major generators	Distance from the central business district/downtown	◐	-	○	-

Development Process

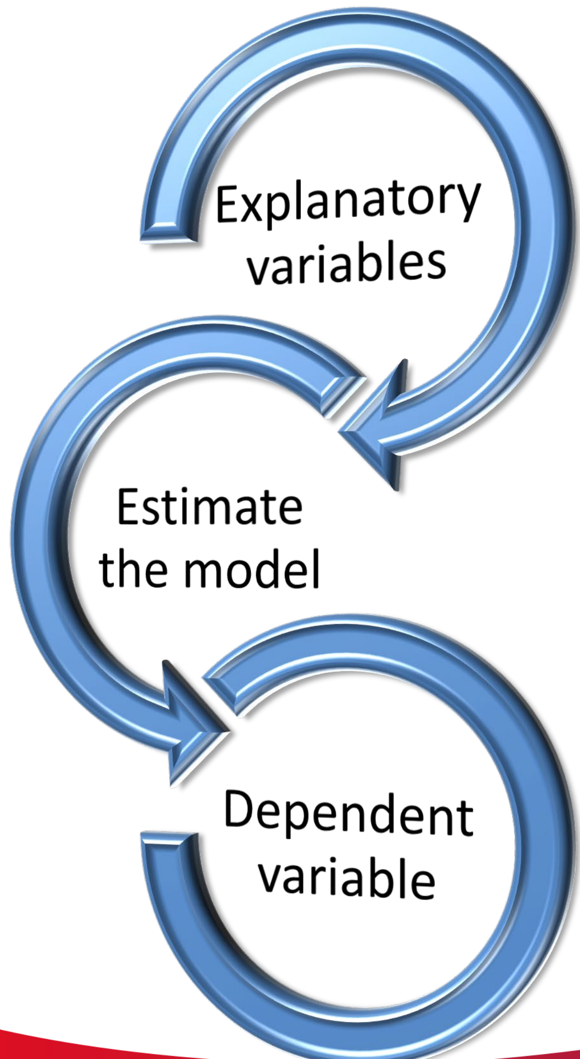
Develop the MODEL



- Examine the data
  - identify the statistical method
  - screen variables and their relationships
    - (e.g. nature of the data, correlations)

Development Process

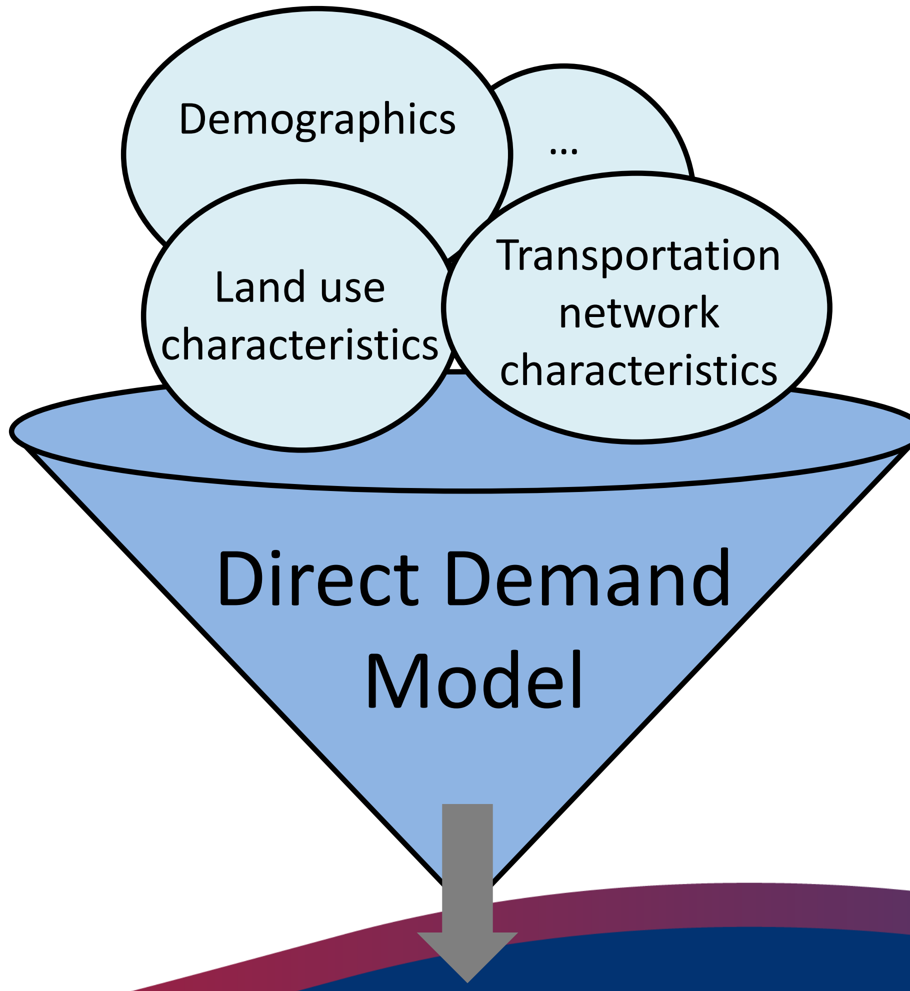
Develop the MODEL



- Estimate
  - evaluate & re-specify as/if needed
  - have data for model validation?
- Final model
  - consider both statistical robustness and intuitiveness

Direct Demand Model – Build

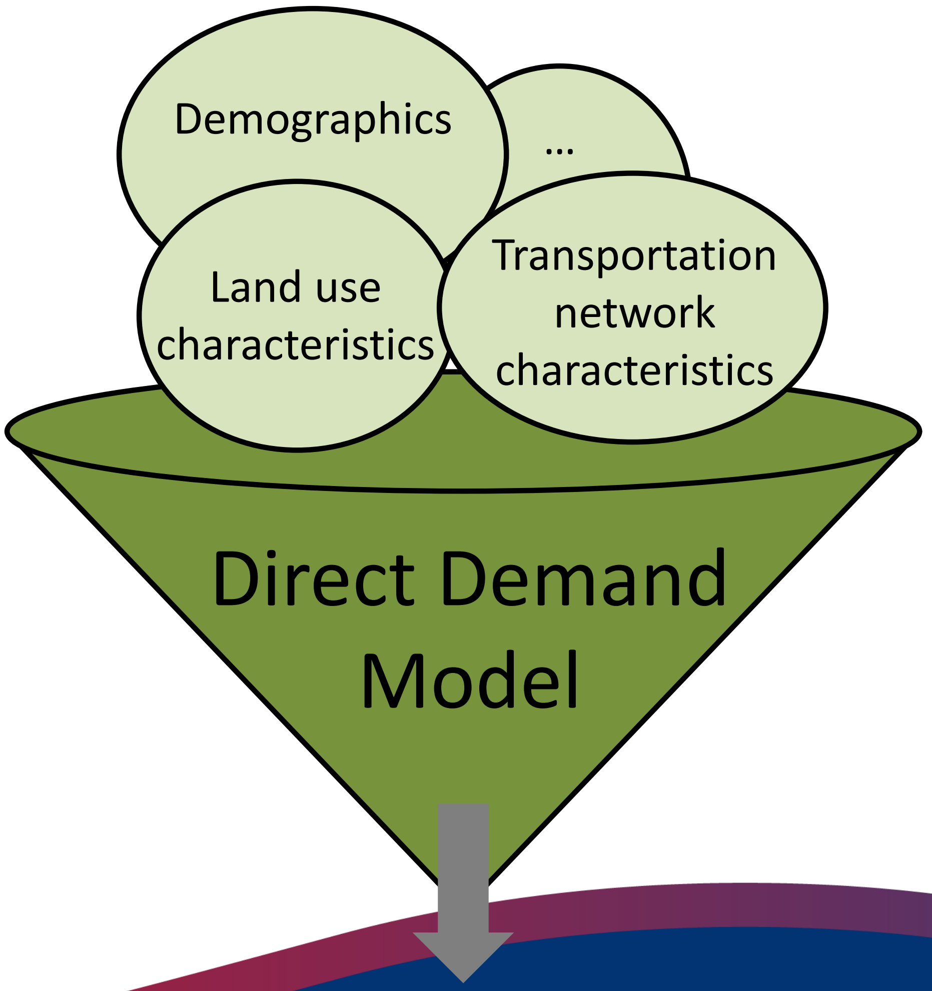
Build a model that predicts walk or bike facility use and volumes based on **observed counts**



Estimate at locations where the count data are collected

Direct Demand Model – Apply

Apply the same model to predict volumes at locations where the **count data are not available** across the study area



Estimate at locations where the count data not available

Exposure from Travel Surveys, Spreadsheet Tool

Travel Surveys

- American Community Survey (ACS)
- National Household Travel Survey (NHTS)
- Regional Household Travel Survey

http://crdtravelsurvey.ca/

American Community Survey (ACS)

- National ongoing survey of U.S. households
- Conducted by the U.S. Census Bureau
- Limited to commute trip information
- Data Availability
  - 3- and 5-year estimates best for small areas
  - 1-year estimates best for larger population areas

AMERICAN COMMUNITY SURVEY
U.S. CENSUS BUREAU

National Household Travel Survey (NHTS)

- National ongoing survey of U.S. households
- Conducted by U.S. DOT / FHWA
- Information
  - All trips
  - Household & person demographics
  - Vehicles
- Data Availability
  - Conducted every 5 to 7 years
  - Add-on samples can be purchased

Regional Household Travel Survey

- Conducted by an MPO/regional planning agency
- Stratified sample to represent local population
- Data Availability
  - Conducted every 8 to 10 years
  - GPS data may be collected

http://crdtravelsurvey.ca/

Travel Surveys

Survey Type	Frequency	Areas Covered	Trip Types	Other Limitations
ACS	Yearly	Census Geographies	Home-to-Work Commute Only	Does not capture trips by children/adults.
NHTS	Periodic (5 – 7 years)	State & CBSA	All	Sample sizes become sparse at small geographic areas.
Regional Household Travel Survey	Periodic (8 – 10 years)	Local	Customizable	High cost to conduct. Expertise required to process and analyze survey data.

Areawide Non-Motorized Exposure Tool

- Purpose
  - Estimate non-motorized exposure to risk at different geographic scales
- Annual exposure for walking & bicycling
  - Trips
  - Miles of travel
  - Hours of travel

Geographic Scales

- **Statewide**
  - 2009 NHTS travel characteristics
  - ACS 1-year estimates to fill gap
- **Metropolitan Planning Organization (MPO)**
  - 2009 NHTS travel characteristics
  - NHTS samples in CBSAs used as proxies for MPOs
  - ACS 5-year estimates interpolated up to MPOs

Statewide Non-Motorized Exposure

- Estimates walking and biking exposure at the state-level for years 2009 – 2016

- 2009 NHTS trips adjusted to represent the analysis year
  - Changes in population
  - Changes in relationship between commute trips and total trips

Statewide Exposure Estimates

State: New York

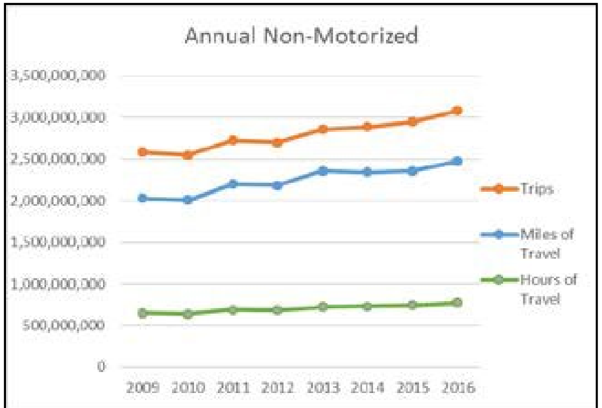
1 Select **State** of interest

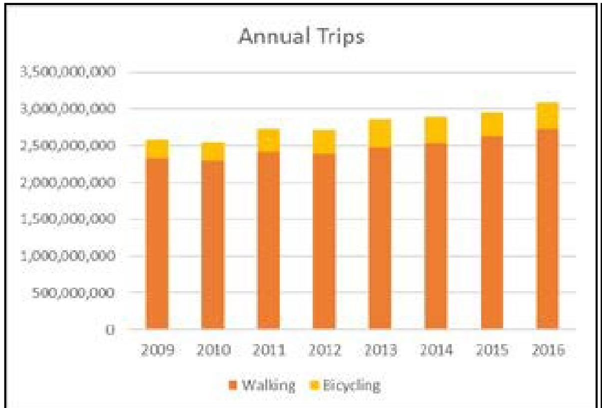
2 Select the source (Default or User Input) of the required inputs. For the User Input option, values are required in the cell below.

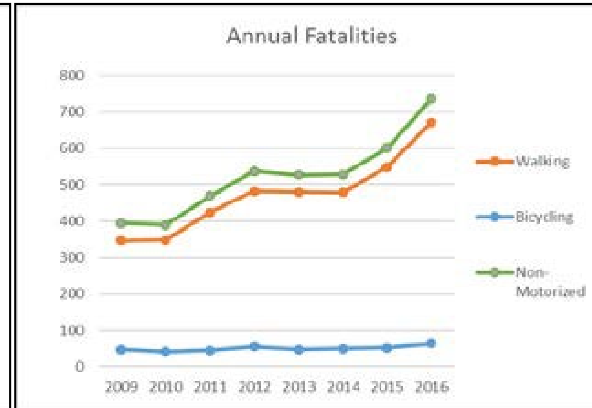
		Walking								
		2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	
Daily Persons Commuting		574,322	542,579	575,553	568,540	574,861	576,752	583,151	577,983	
Commute-to-Total Trips Adjustment Factor		25.49	25.49	25.49	25.49	25.49	25.49	25.49	25.49	
Population Adjustment Factor		1.00	0.99	1.00	1.00	1.01	1.01	1.01	1.01	
Estimated Annual Pedestrian Trips		5,343,405,740	4,997,592,893	5,354,858,779	5,289,610,879	5,401,904,720	5,419,674,236	5,479,804,926	5,431,241,806	
Average Trip Length (Miles)	Source:	Default	Default	Default	Default	Default	Default	Default	Default	2
	Default Value:	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	
	User Input Value:				1					
Estimated Annual Pedestrian Miles of Travel		4,060,988,362	3,798,170,599	4,069,692,672	4,020,104,268	4,105,447,587	4,118,952,419	4,164,651,744	4,127,743,772	
Average Trip Duration (Minutes)	Source:	Default	Default	Default	Default	Default	Default	Default	Default	2
	Default Value:	14.82	14.82	14.82	14.82	14.82	14.82	14.82	14.82	
	User Input Value:									
Estimated Annual Pedestrian Hours of Travel		1,319,821,218	1,234,405,445	1,322,650,118	1,306,533,887	1,334,270,466	1,338,659,536	1,353,511,817	1,341,516,726	
Fatalities		290	288	273	287	293	262	295	300	
Fatalities/Million Hours of Travel		0.220	0.233	0.206	0.220	0.220	0.196	0.218	0.224	

		Bicycling								
		2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	
Daily Persons Commuting		39,185	41,232	44,418	53,119	62,021	58,198	61,618	66,595	
Commute-to-Total Trips Adjustment Factor		11.54	11.54	11.54	11.54	11.54	11.54	11.54	11.54	
Population Adjustment Factor		1.00	0.99	1.00	1.00	1.01	1.01	1.01	1.01	
Estimated Annual Bicyclist Trips		165,051,139	171,936,574	187,093,058	223,742,540	263,851,041	247,587,154	262,136,590	283,309,847	
Average Trip Length (Miles)	Source:	Default	Default	Default	Default	Default	Default	Default	Default	2
	Default Value:	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93	
	User Input Value:									
Estimated Annual Bicyclist Miles of Travel		318,548,697	331,837,588	361,089,602	431,823,102	509,232,508	477,843,207	505,923,618	546,788,006	
Average Trip Duration (Minutes)	Source:	Default	Default	Default	Default	Default	Default	Default	Default	2
	Default Value:	20.81	20.81	20.81	20.81	20.81	20.81	20.81	20.81	
	User Input Value:									
Estimated Annual Bicyclist Hours of Travel		57,245,237	59,633,335	64,890,109	77,601,371	91,512,336	85,871,478	90,917,707	98,261,299	
Fatalities		28	36	57	42	36	46	36	36	
Fatalities/Million Hours of Travel		0.489	0.604	0.878	0.541	0.393	0.536	0.396	0.366	

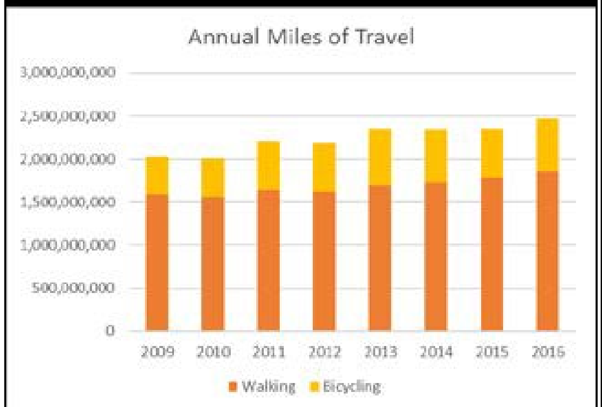
	Non-Motorized							
	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Estimated Annual Non-Motorized Trips	5,508,456,878	5,169,529,467	5,541,951,837	5,513,353,419	5,665,755,761	5,667,261,390	5,741,941,515	5,714,551,653
Estimated Annual Non-Motorized Miles of Travel	4,379,537,059.48	4,130,008,186.64	4,430,782,273.63	4,451,927,370.05	4,614,680,095.64	4,596,795,626.23	4,670,575,361.39	4,674,531,778.15
Estimated Annual Non-Motorized Hours of Travel	1,377,066,454.24	1,294,038,779.66	1,387,540,227.31	1,384,135,258.03	1,425,782,801.77	1,424,531,014.16	1,444,429,523.79	1,439,778,024.83
Non-Motorized Fatalities	318	324	330	329	329	308	331	336
Non-Motorized Fatalities/Million Hours of Travel	0.231	0.250	0.238	0.238	0.231	0.216	0.229	0.233

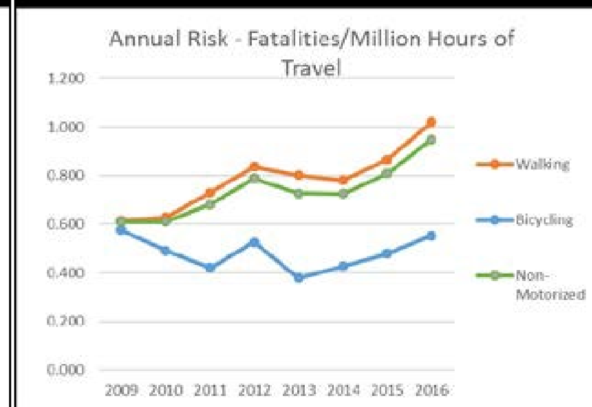

Annual Non-Motorized
3,500,000,000
3,000,000,000
2,500,000,000
2,000,000,000
1,500,000,000
1,000,000,000
500,000,000
0
2009 2010 2011 2012 2013 2014 2015 2016
Trips
Miles of Travel
Hours of Travel

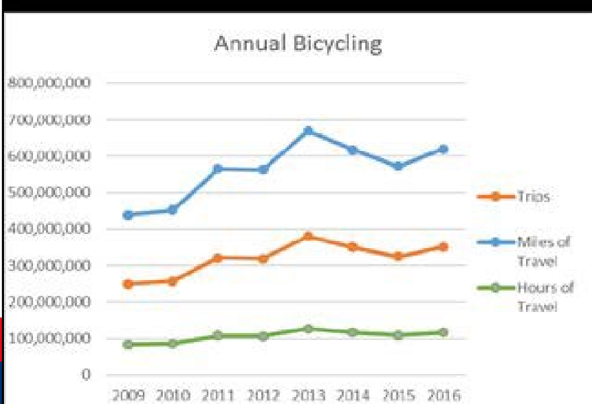

Annual Trips
3,500,000,000
3,000,000,000
2,500,000,000
2,000,000,000
1,500,000,000
1,000,000,000
500,000,000
0
2009 2010 2011 2012 2013 2014 2015 2016
Walking
Bicycling


Annual Fatalities
800
700
600
500
400
300
200
100
0
2009 2010 2011 2012 2013 2014 2015 2016
Walking
Bicycling
Non-Motorized


Annual Walking
3,000,000,000
2,500,000,000
2,000,000,000
1,500,000,000
1,000,000,000
500,000,000
0
2009 2010 2011 2012 2013 2014 2015 2016
Trips
Miles of Travel
Hours of Travel


Annual Miles of Travel
3,000,000,000
2,500,000,000
2,000,000,000
1,500,000,000
1,000,000,000
500,000,000
0
2009 2010 2011 2012 2013 2014 2015 2016
Walking
Bicycling


Annual Risk - Fatalities/Million Hours of Travel
1.200
1.000
0.800
0.600
0.400
0.200
0.000
2009 2010 2011 2012 2013 2014 2015 2016
Walking
Bicycling
Non-Motorized


Annual Bicycling
800,000,000
700,000,000
600,000,000
500,000,000
400,000,000
300,000,000
200,000,000
100,000,000
0
2009 2010 2011 2012 2013 2014 2015 2016
Trips
Miles of Travel
Hours of Travel


Annual Hours of Travel
900,000,000
800,000,000
700,000,000
600,000,000
500,000,000
400,000,000
300,000,000
200,000,000
100,000,000
0
2009 2010 2011 2012 2013 2014 2015 2016
Walking
Bicycling

MPO Non-Motorized Exposure

- Estimates walking and biking exposure at the MPO-level for years 2009 – 2016
- 2009 NHTS trips adjusted to represent analysis year
  - Changes in commute trip making between 2009 and analysis year

MPO Exposure Tool (BETA)

State: Oregon

MPO: Portland Area Comprehensive Transportation System (OR)

1. Select **State** of interest
2. Select **MPO** of interest
3. Select the source (Default or User Input) of the required inputs. For the User Input option, values are required in the cell below.

		Walking								
		2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	
Person Trip Rate	Source:	Default	Default	Default	Default	Default	Default	Default	Default	3
	Default Value:	0.63156	0.63156	0.63156	0.63156	0.63156	0.63156	0.63156	0.63156	
	User Input Value:									
MPO Population Estimate	Source:	Default	Default	Default	Default	Default	Default	Default	Default	3
	Default Value:	1,382,368	1,397,685	1,418,280	1,438,803	1,459,111	1,477,113	1,499,485	1,519,651	
	User Input Value:									
Population Adjustment Factor	Source:	Default	Default	Default	Default	Default	Default	Default	Default	3
	Default Value:	1.00000	1.04175	1.03828	1.12315	1.13918	1.13549	1.16579	1.19087	
	User Input Value:									
Estimated Annual Pedestrian Trips		318,661,769	335,643,597	339,455,956	372,516,428	383,167,403	386,637,020	402,965,257	417,169,821	
Average Trip Length (Miles)	Source:	Default	Default	Default	Default	Default	Default	Default	Default	3
	Default Value:	0.67978	0.67978	0.67978	0.67978	0.67978	0.67978	0.67978	0.67978	
	User Input Value:									
Estimated Annual Pedestrian Miles of Travel		216,619,443	228,163,326	230,754,886	253,228,687	260,468,992	262,827,562	273,927,149	283,583,107	
Average Trip Duration (Minutes)	Source:	Default	Default	Default	Default	Default	Default	Default	Default	3
	Default Value:	14.49607	14.49607	14.49607	14.49607	14.49607	14.49607	14.49607	14.49607	
	User Input Value:									
Estimated Annual Pedestrian Hours of Travel		76,989,059	81,091,888	82,012,959	90,000,408	92,573,696	93,411,959	97,356,881	100,788,720	
Fatalities		12	21	14	25	20	21	24	32	
Fatalities/Million Hours of Travel		0.156	0.259	0.171	0.278	0.216	0.225	0.247	0.317	

		Bicycling								
		2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	
Person Trip Rate	Source:	Default	Default	Default	Default	Default	Default	Default	Default	3
	Default Value:	0.05439	0.05439	0.05439	0.05439	0.05439	0.05439	0.05439	0.05439	
	User Input Value:									
MPO Population Estimate	Source:	Default	Default	Default	Default	Default	Default	Default	Default	3
	Default Value:	1,382,368	1,397,685	1,418,280	1,438,803	1,459,111	1,477,113	1,499,485	1,519,651	
	User Input Value:									
Population Adjustment Factor	Source:	Default	Default	Default	Default	Default	Default	Default	Default	3
	Default Value:	1.00000	1.11245	1.18615	1.25574	1.27402	1.34042	1.39129	1.45871	
	User Input Value:									
Estimated Annual Bicyclist Trips		27,445,001	30,869,364	33,399,511	35,870,766	36,906,645	39,309,202	41,418,949	44,010,206	
Average Trip Length (Miles)	Source:	Default	Default	Default	Default	Default	Default	Default	Default	3
	Default Value:	3.07657	3.07657	3.07657	3.07657	3.07657	3.07657	3.07657	3.07657	
	User Input Value:									
Estimated Annual Bicyclist Miles of Travel		84,436,561	94,971,865	102,756,049	110,359,046	113,546,004	120,937,645	127,428,439	135,400,630	
Average Trip Duration (Minutes)	Source:	Default	Default	Default	Default	Default	Default	Default	Default	3
	Default Value:	22.69772	22.69772	22.69772	22.69772	22.69772	22.69772	22.69772	22.69772	
	User Input Value:									
Estimated Annual Bicyclist Hours of Travel		10,382,317	11,677,738	12,634,881	13,569,745	13,961,613	14,870,489	15,668,597	16,648,857	
Fatalities		4	1	4	3	1	1	2	7	
Fatalities/Million Hours of Travel		0.385	0.086	0.317	0.221	0.072	0.067	0.128	0.420	

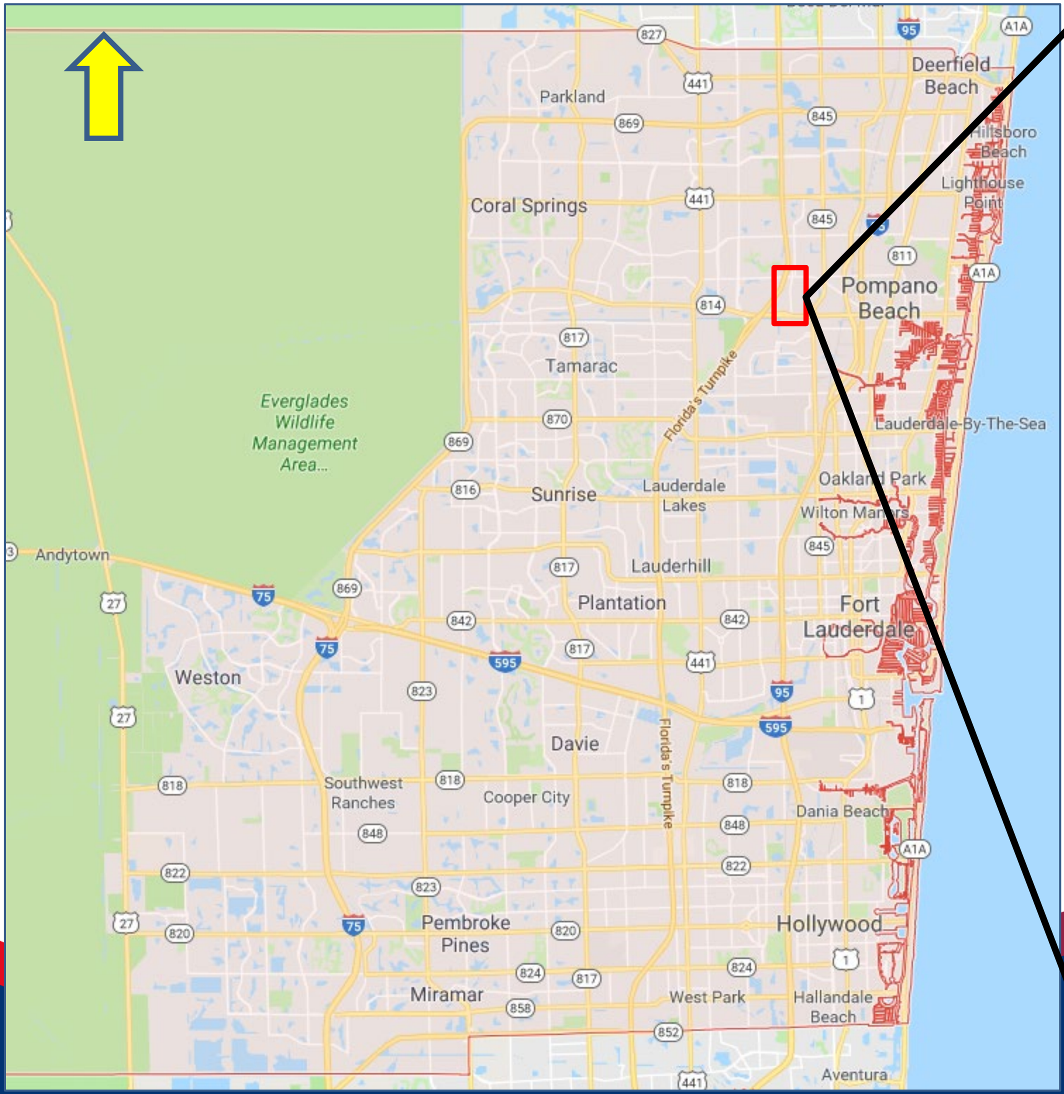
	Non-Motorized							
	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Estimated Annual Non-Motorized Trips	346,106,770	366,512,961	372,855,467	408,387,194	420,074,048	425,946,221	444,384,207	461,180,027
Estimated Annual Non-Motorized Miles of Travel	301,056,004.07	323,135,191.75	333,510,935.19	363,587,732.43	374,014,995.15	383,765,207.22	401,355,587.76	418,983,736.98
Estimated Annual Non-Motorized Hours of Travel	87,371,375.61	92,769,626.10	94,647,839.42	103,570,152.69	106,535,309.07	108,282,448.44	113,025,477.79	117,437,577.47
Non-Motorized Fatalities	16	22	18	28	21	22	26	39
Non-Motorized Fatalities/Million Hours of Travel	0.183	0.237	0.190	0.270	0.197	0.203	0.230	0.332

Participant Exercise

Objectives

- Apply the 8-step process for a location in Broward County
- Discuss considerations of each step
  - Data sources
  - Assumptions
- Applications of results

Location: NW 31 Avenue between MLK Boulevard and Atlantic Boulevard, Pompano Beach



The Context for Location Selection

- NW 31 Avenue is within a Census Block Group identified as a pedestrian crash hotspot in the County
- A study is being done to define the scope of improvements to address pedestrian safety
- The “risk assessment” is one of the analysis tools used in the study

Pedestrian Safety Hot Spots

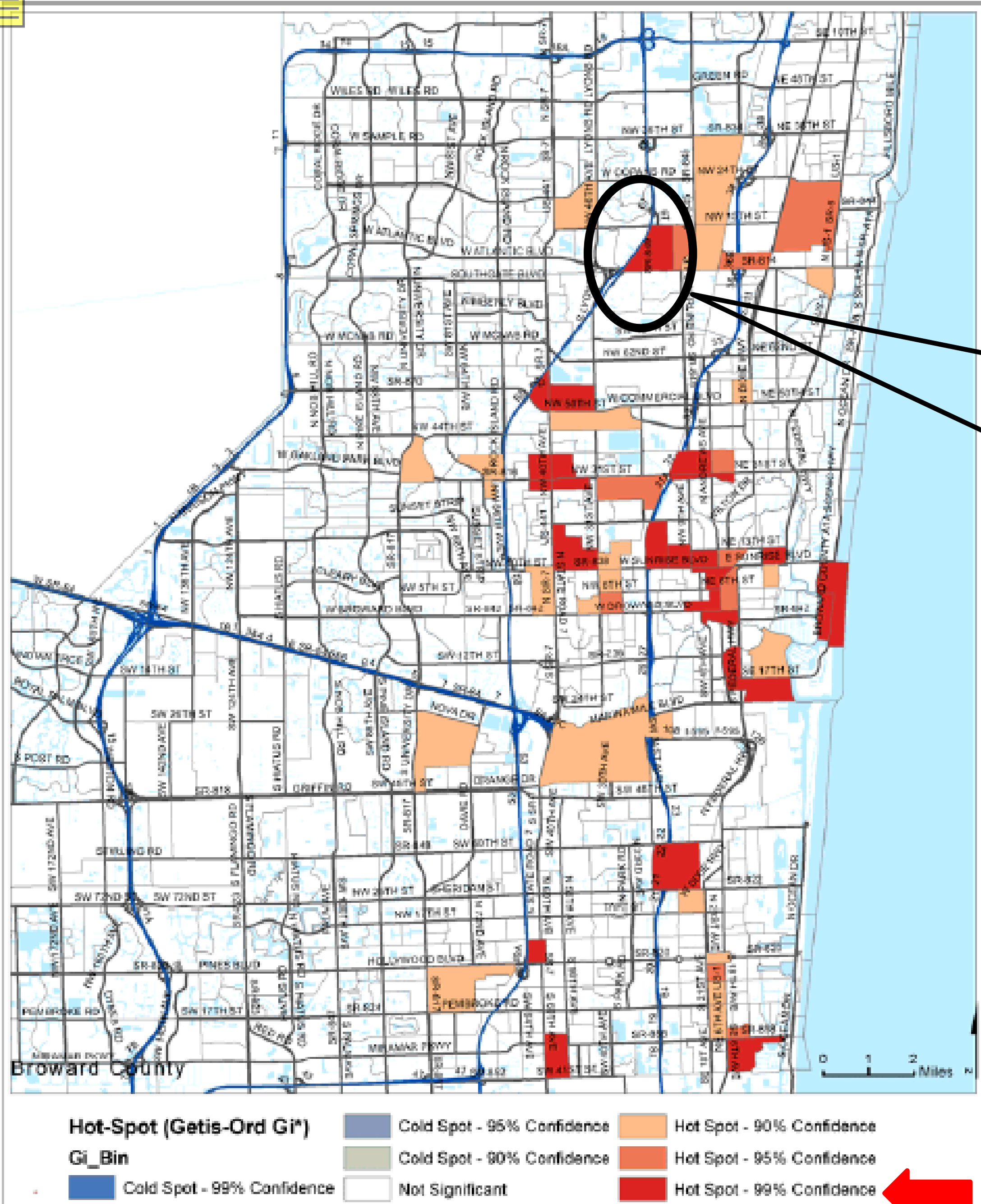
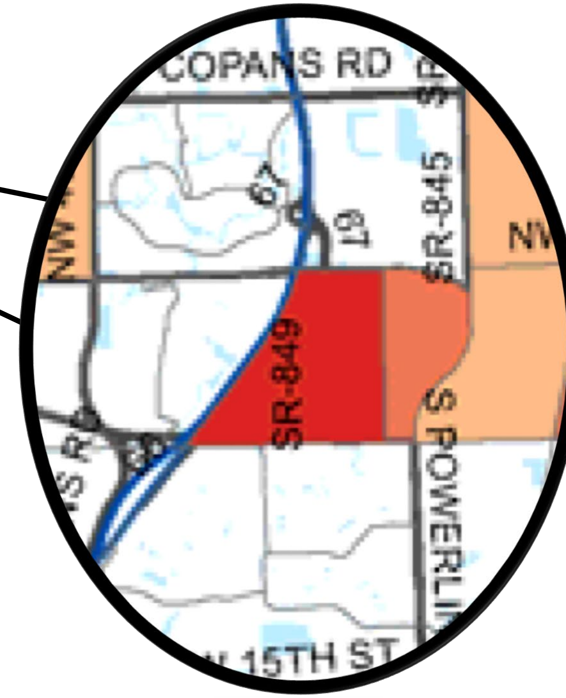


Figure 42. Locations of hot spots in Broward County



Source: Application of Demographic Analysis to Pedestrian Safety, CUTR/FDOT Study, 2017

Step 1: Determine Uses of Risk Values

- Use risk values (in addition to crash data) to prioritize intersections/segments within the study corridor for countermeasures
- Estimate risk for “Before” conditions for a future Before-After evaluation
  - To quantify effectiveness of countermeasures

Exercise: List Location Characteristics

Use Google Streetview

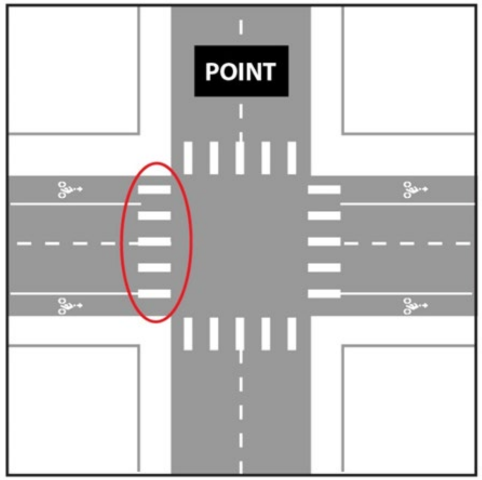
- Type of road
- Posted speed limit
- Major intersections
- Intersection control methods
- Existing pedestrian and bicycle facilities
- Street lighting
- Transit?
- Key land uses/pedestrian trip generators
- Risk factors for pedestrians/bicyclists

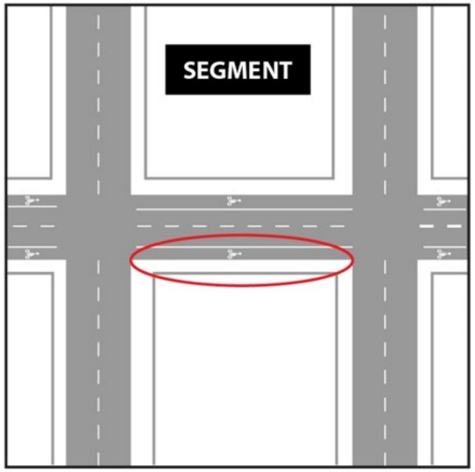
Location Characteristics

- Length: 0.85 miles
- 4-lane road with TWLTL
- Posted speed: 40 mph
- Two signalized intersections
- Bike lanes and sidewalks
- Street lighting on the west side
- Land Uses: School, single family residential, mobile homes, truck stop, motels, fast food restaurant, adult entertainment
- No crosswalks other than at signalized intersections

Step 2: Select Geographic Scale(s)

Facility-Specific

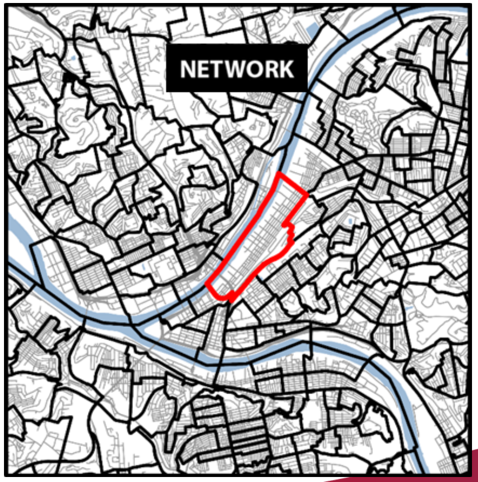


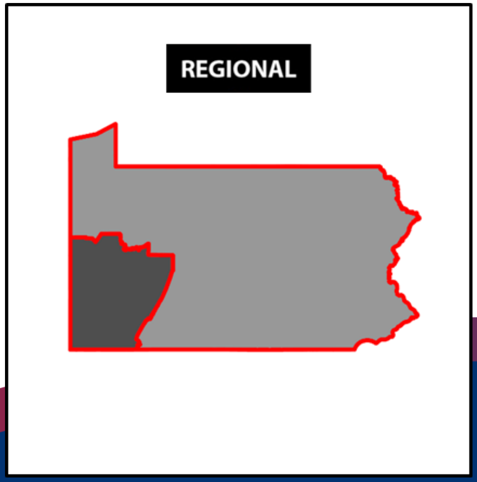


A

B

Areawide





C

D

Exercise: Divide Study Location into Points and Segments

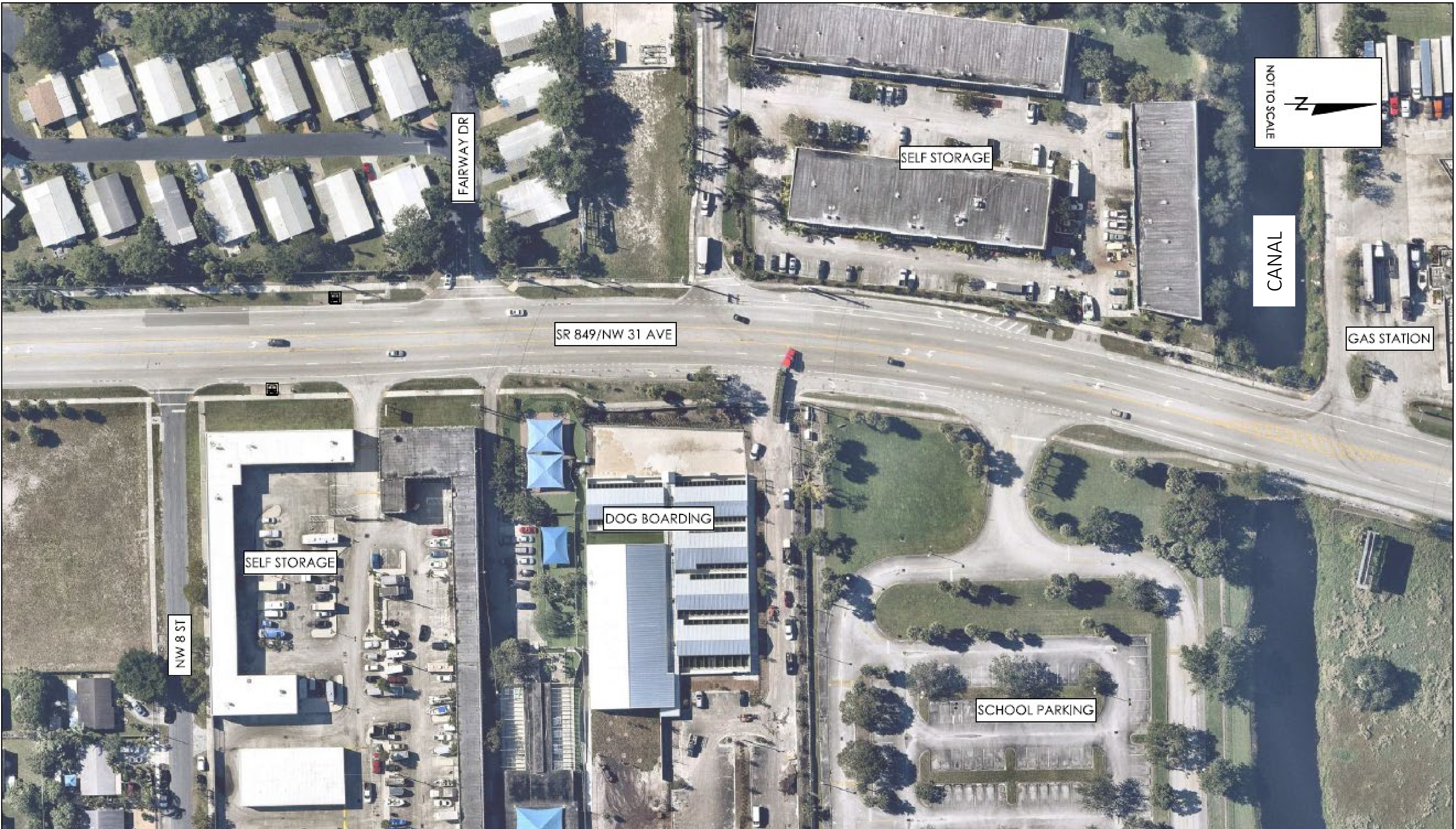
- How many points? Explain the rationale

- How many segments? Explain the rationale

Use Google Streetview

Study Corridor (from North to South)

Study Corridor (from North to South)

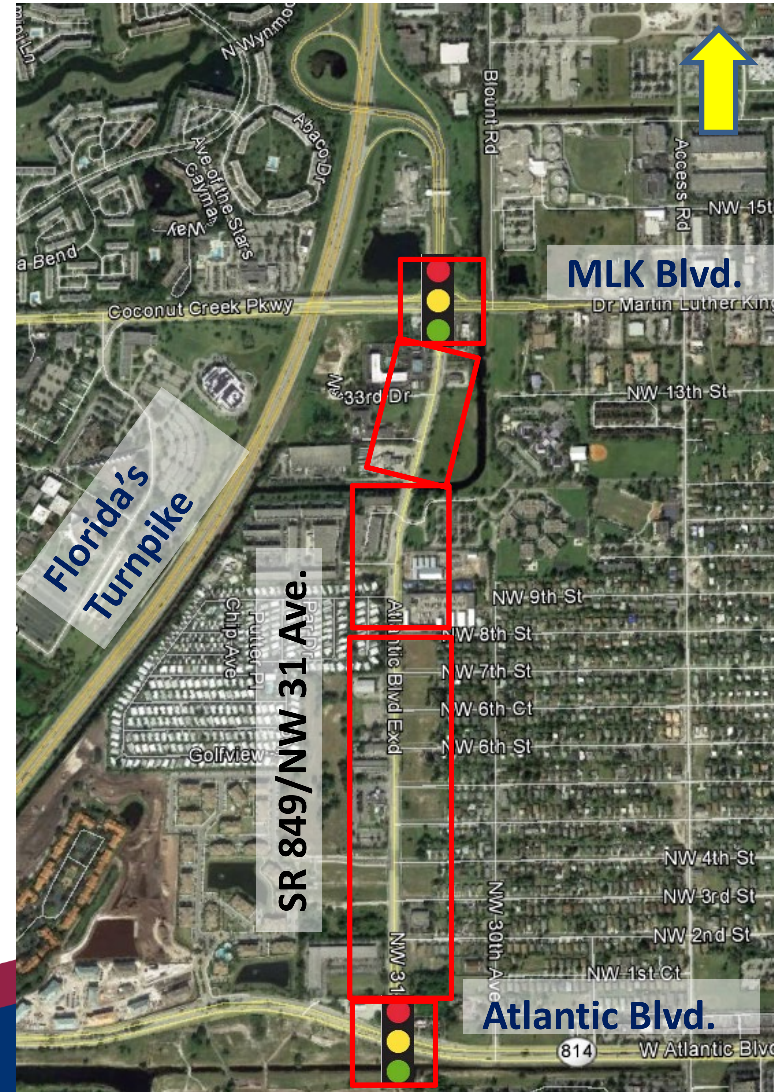


Study Corridor (from North to South)

Study Corridor (from North to South)

Step 2: Divide Study Location into Points and Segments

Point/ Segment	Location/ Limits	Notes
Point 1	MLK Blvd	Signalized intersection, expressway entry/exit
Segment 1	MLK Blvd – Canal	Motels, overnight truck parking, fast-food restaurant
Segment 2	Canal – NW 8 St	School, mobile homes, storage facilities
Segment 3	NW 8 St – Atlantic Blvd	Residential, retail, adult entertainment
Point 2	Atlantic Blvd	Signalized intersection; two State roads



If this were a county-wide network screening, what would be your approach?

Step 3: Select Risk Definition

- Observed crash rate

$$\text{Risk} = \frac{\text{Observed Crashes}}{\text{Exposure}}$$

- Expected crashes

Highway Safety Manual's Predictive Method

- Additional risk indicators

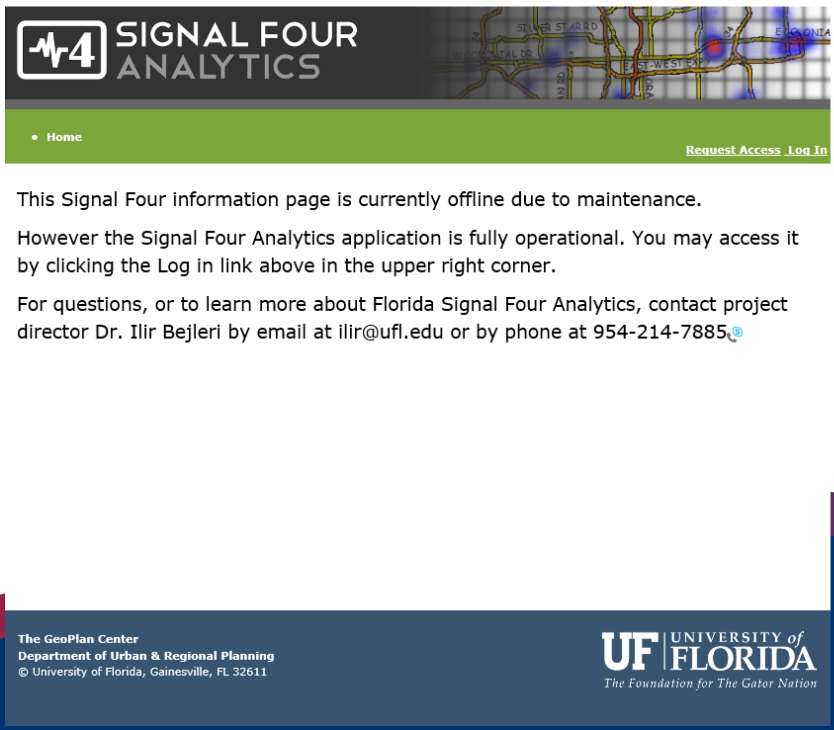
Risk score based on road and traffic variables

Step 3: Possible Crash Data Sources

- What are the possible crash data sources?

CAR Online

Signal Four Analytics



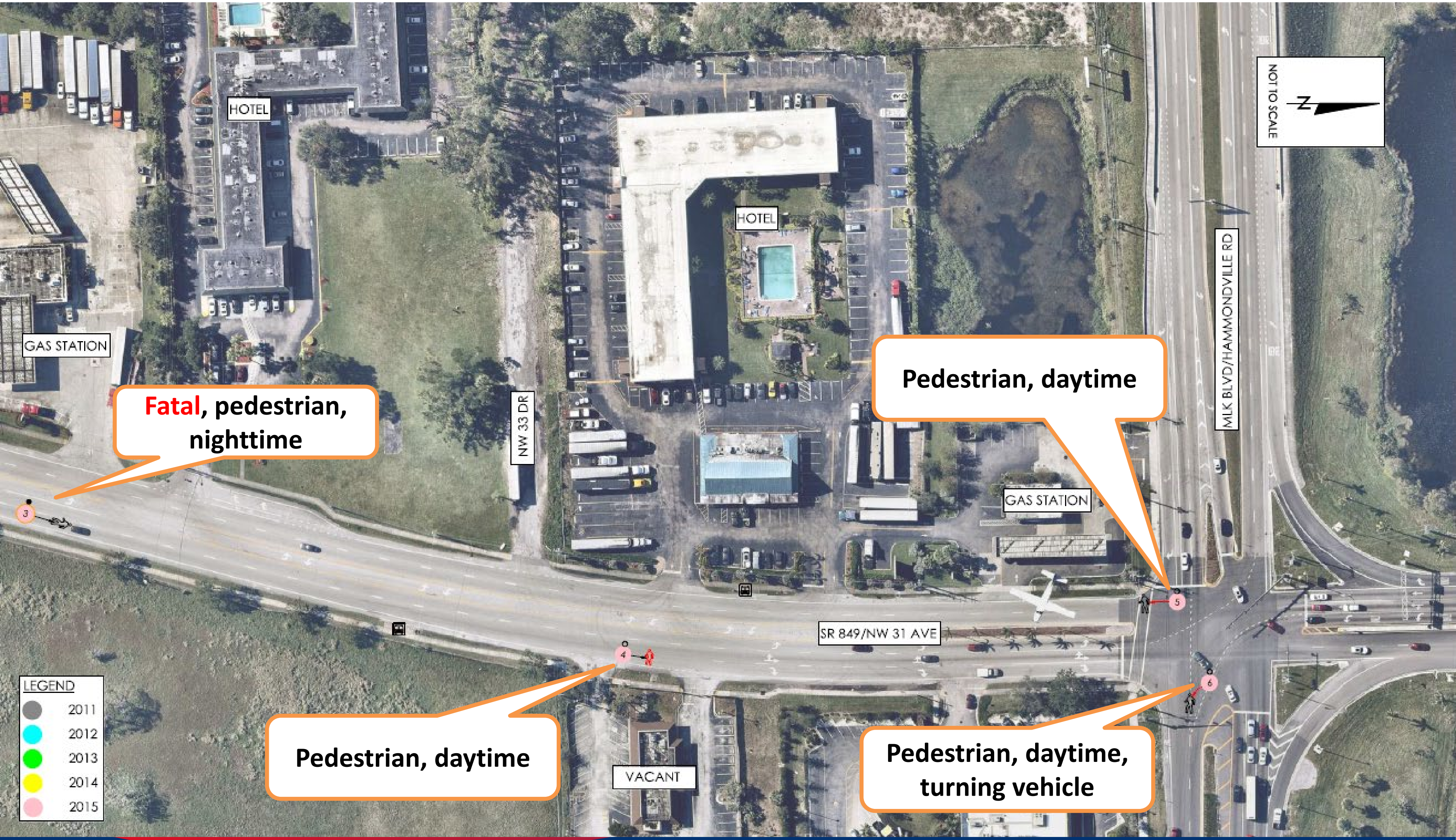
Step 3: Crash Data Sources

Data Source	Notes
Crash Analysis Reporting (CAR) Online • FDOT	• Needs a User ID and password (or request the data from FDOT) • Both State and local road data • Can be downloaded to Excel • Lag in entering data (currently 2015 is the most recent complete data)
Signal Four Analytics • University of Florida • https://s4.geoplan.ufl.edu/	• Needs a User ID and password • Both State and local road data • Typically crash data are uploaded quickly • Crash data and police reports available • Graphic User Interface • Excel and GIS compatible
Local (law enforcement) agencies	• Data formats, completeness, and duration varies by agency • Limited to the jurisdiction of the agency • For small geographic areas, more recent and complete data may be available • May take more time and effort to obtain the data

Exercise: Pedestrian/Bicycle Crash Data

- How many years of crash data should be used?
  - Two years
  - Three years
  - Five years
- Summarize the crash data (see diagrams)
  - By point/segment

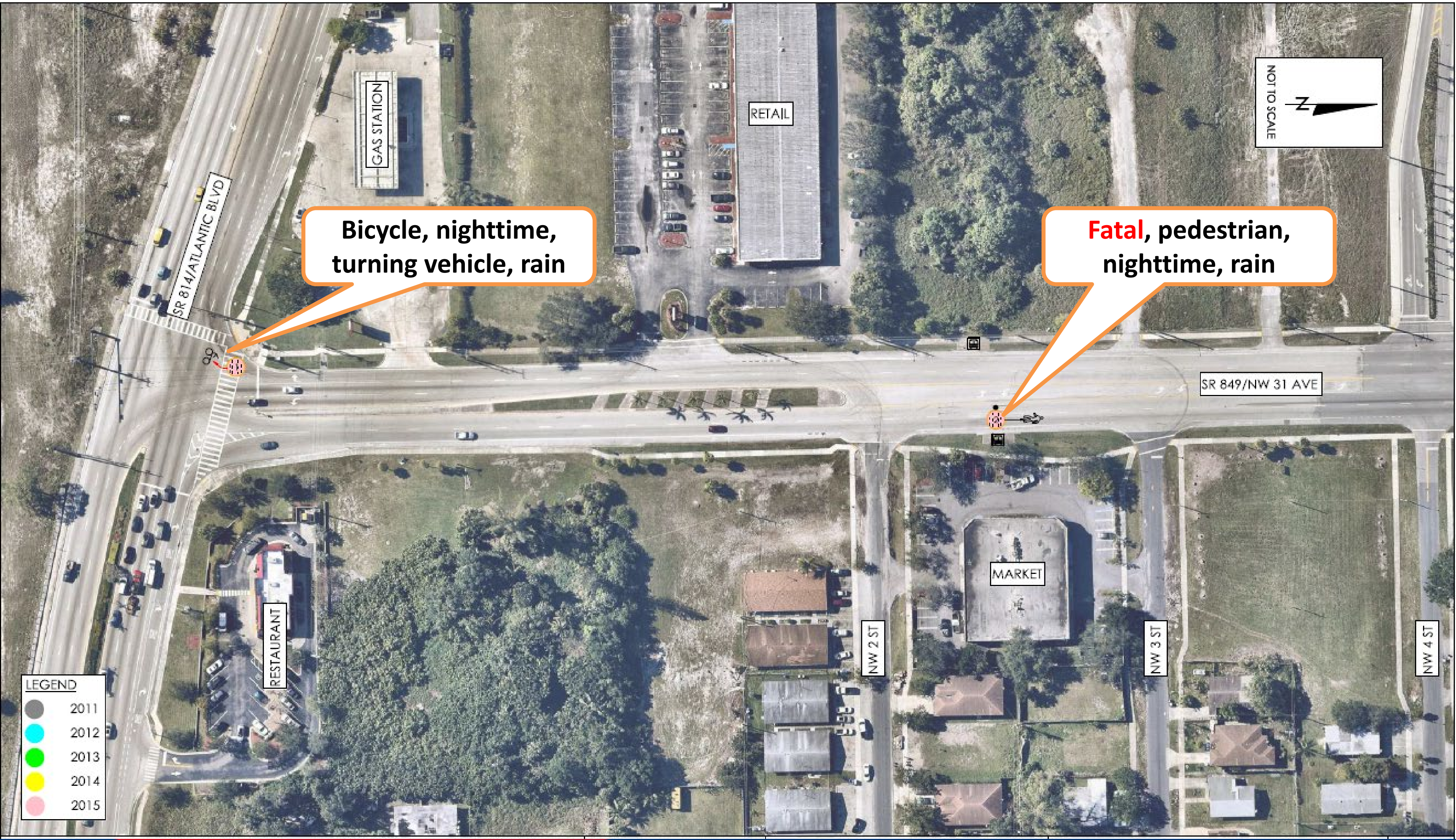
Step 3: Crash Data (Corridor from N to S)



Step 3: Crash Data (Corridor from N to S)

Step 3: Crash Data (Corridor from N to S)

Step 3: Crash Data (Corridor from N to S)



Exercise: Summarize Pedestrian/Bicycle Crash Data by Year

Segment/Point	2011	2012	2013	2014	2015	Total
Point 1 (MLK Blvd)						
Segment 1 (MLK Blvd – Canal)						
Segment 2 (Canal – NW 8 St)						
Segment 3 (NW 8 St – Atlantic Blvd)						
Point 2 (Atlantic Blvd)						
Total						

Step 3: Pedestrian/Bicycle Crash Data by Year

Segment/Point	2011	2012	2013	2014	2015	Total	Average
Point 1 (MLK Blvd)	0	0	0	0	2	**2**	**0.4**
Segment 1 (MLK Blvd – Canal)	0	0	0	0	2	**2**	**0.4**
Segment 2 (Canal – NW 8 St)	0	1	1	2	0	**4**	**0.8**
Segment 3 (NW 8 St – Atlantic Blvd)	0	0	0	0	1	**1**	**0.2**
Point 2 (Atlantic Blvd)	0	0	0	0	1	**1**	**0.2**
Total	**0**	**1**	**1**	**2**	**6**	**10**	**2.0**

Step 3: Pedestrian/Bicycle Crash Data

Crashes by Severity

Segment/Point	Fatal	Injury	Non-Injury
Point 1 (MLK Blvd)	0	2	0
Segment 1 (MLK Blvd – Canal)	1	1	0
Segment 2 (Canal – NW 8 St)	1	2	1
Segment 3 (NW 8 St – Atlantic Blvd)	1	0	0
Point 2 (Atlantic Blvd)	0	0	1
Total	**3**	**5**	**2**

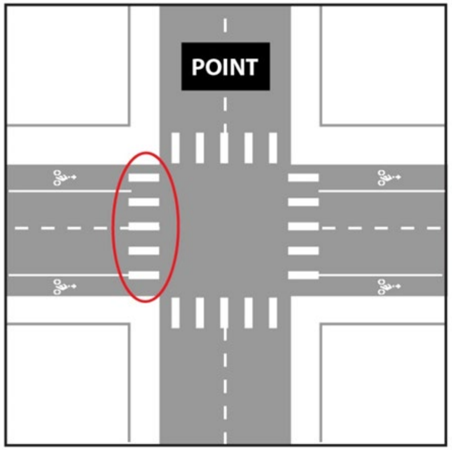
Crashes by Lighting Condition

Segment/Point	Dark	Daylight	Total
Point 1 (MLK Blvd)	2	0	2
Segment 1 (MLK Blvd – Canal)	1	1	2
Segment 2 (Canal – NW 8 St)	4	0	4
Segment 3 (NW 8 St – Atlantic Blvd)	1	0	1
Point 2 (Atlantic Blvd)	1	0	1
Total	**8**	**2**	**10**

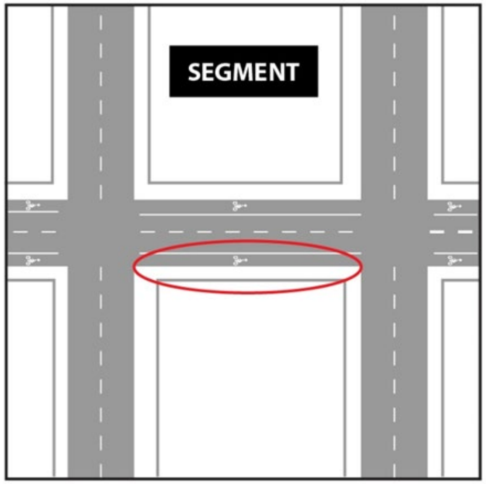
Step 4: Select Exposure Measure

- **Point**: volume/count
  - Number of peds/bikes crossing

  OR
  - Number of peds/bikes crossing x motor vehicles



- **Segment**:
  - Number of peds/bikes (crossing) x motor vehicles x segment length
  - Depends on the study purpose
    - Pedestrians: crossing vs. using sidewalk
    - Bicyclists: crossing vs. riding with traffic vs. riding on sidewalk



Exercise: Pedestrian/Bicycle Counts

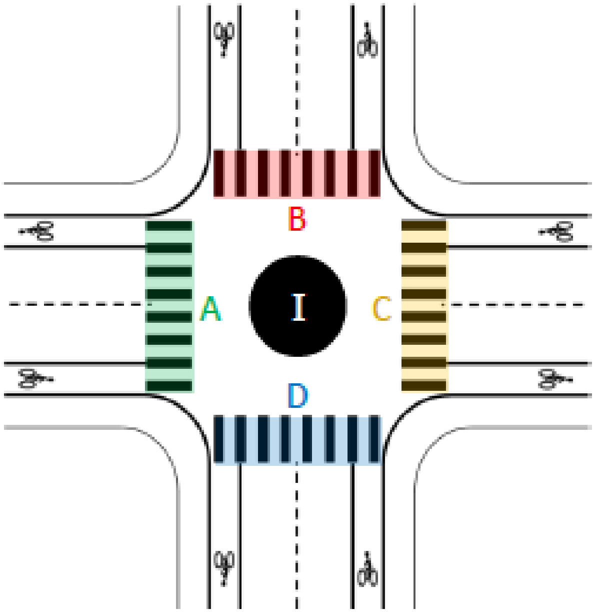
Segment/Point	Pedestrian Count?	Bicycle Count?	Motor Vehicle Count?
Point 1 (MLK Blvd)			
Segment 1 (MLK Blvd – Canal)			
Segment 2 (Canal – NW 8 St)			
Segment 3 (NW 8 St – Atlantic Blvd)			
Point 2 (Atlantic Blvd)			

- What are the factors considered when selecting count locations?
- How many hours per day?
- How many days?
- Count technology?
- What would be different if the data is collected as part of a network screening effort?

Steps 5 & 6: Estimate Exposure

- A hypothetical example for an intersection

Point



Average Daily Volume

Crosswalk	Pedestrians	Bicyclists	Motor Vehicles*
A	120	15	7,000
B	40	25	3,000
C	80	10	6,800
D	30	20	2,600

* Motor vehicles entering the intersection

Steps 5 & 6: Estimate Exposure

- Pedestrian and Bicycle Exposure = (Annual ped/bike volume x annual traffic volume)/100,000,000
  - Crosswalk A = (((120+15) X 364) X (7,000 X 364))/100,000,000 = 1,252
  - Crosswalk B = (((40+25) X 364) X (3,000 X 364))/100,000,000 = 258
  - Crosswalk C = (((80+10) 364) X (6,800 X 364))/100,000,000 = 810
  - Crosswalk D = (((30+20) X 364) X (2,600 X 364))/100,000,000 = 172
  - **Cumulative Exposure for the Intersection = 2,492**

Steps 7 & 8: Calculate Risk

- Pedestrian/Bicycle Crashes in 5 years = 10
  - Average crashes per year = 10/5 = 2.0

$$\text{Risk} = \frac{\text{Observed Crashes}}{\text{Exposure}}$$

Risk = 2.0/2,492

= 8 X 10^{-4}

- How can you account for the severity of crashes?

Hypothetical Risk Estimates for Study Corridor

Segment/Point	Average Crashes per Year	Exposure	Risk = Crashes/Exposure
Points (Intersections)			
Point 1 (MLK Blvd)	0.4	500	**8×10^{-4}**
Point 2 (Atlantic Blvd)	0.2	400	**5×10^{-4}**
Segments			
Segment 1 (MLK Blvd – Canal)	0.4	2,000	**2×10^{-4}**
Segment 2 (Canal – NW 8 St)	0.8	1,600	**5×10^{-4}**
Segment 3 (NW 8 St – Atlantic Blvd)	0.2	800	**2.5×10^{-4}**

- Which points/segments would you prioritize for improvements?
- What countermeasures do you consider?

Applications of Results

- How do you use the results in a Before-After study? Consider the hypothetical results below.

"After" Conditions

Segment/Point	Average Crashes per Year	Exposure	Risk = Crashes/Exposure
Points (Intersections)			
Point 1 (MLK Blvd)	0.4	800	**5×10^{-4}**
Point 2 (Atlantic Blvd)	0.2	500	**4×10^{-4}**
Segments			
Segment 1 (MLK Blvd – Canal)	0.5	2,500	**2×10^{-4}**
Segment 2 (Canal – NW 8 St)	0.5	2000	**2.5×10^{-4}**
Segment 3 (NW 8 St – Atlantic Blvd)	0.2	1000	**2×10^{-4}**

Discussion

- Follow up with us:
  - Shawn Turner S-Turner@tti.tamu.edu