Scalable Risk Assessment Methods for Pedestrians and Bicyclists

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Wednesday, October 10, 2018

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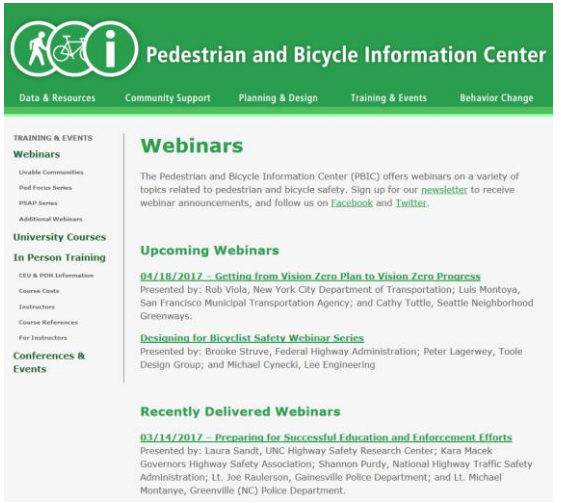

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Introduction

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

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

Webinar Learning Objectives

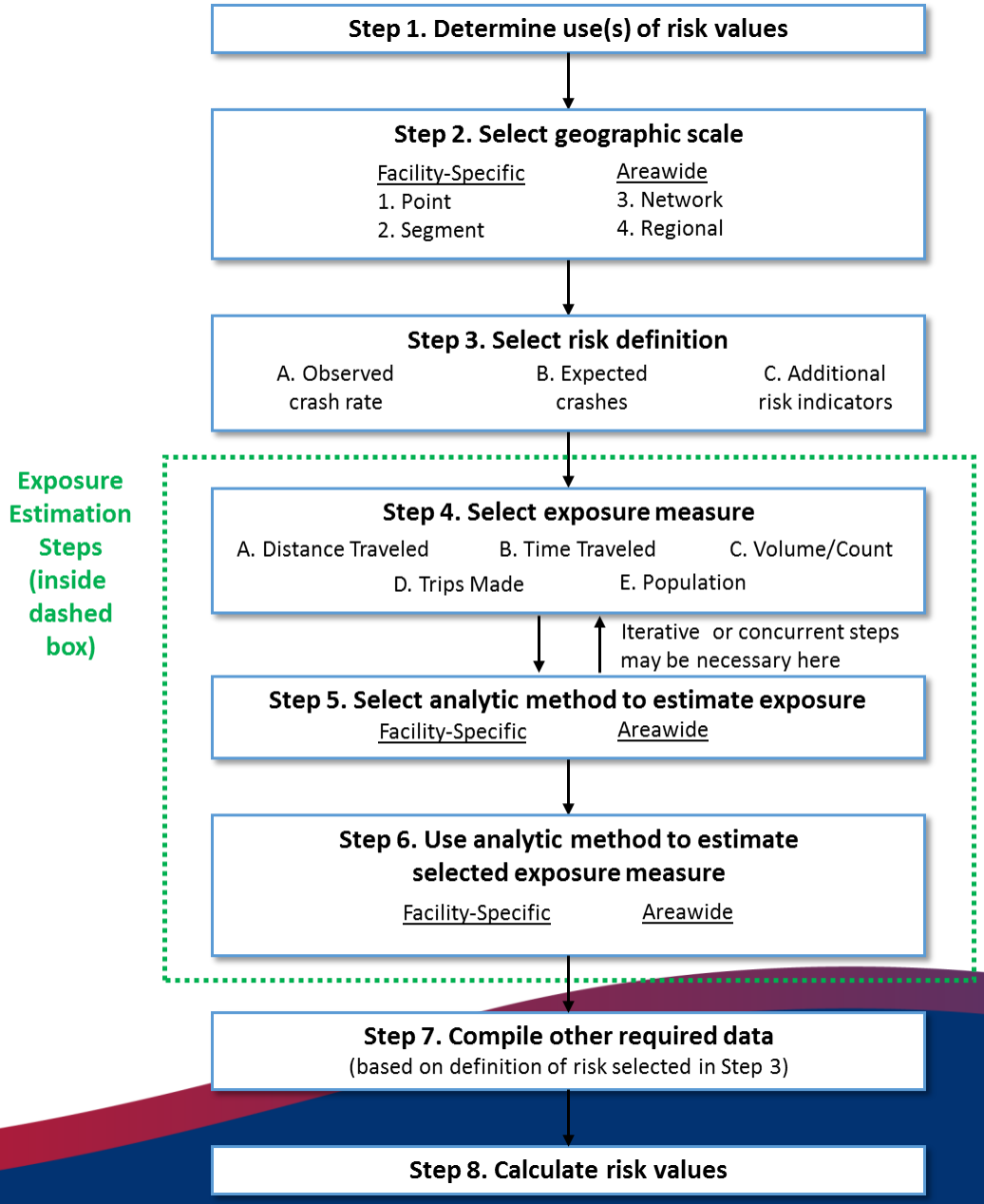
- After the webinar, participants will be able to:
  - Outline the 8 steps in Scalable Risk Assessment for Pedestrians and Bicyclists
  - Describe how exposure is included in the 3 ways to quantify risk
  - Describe the 4 geographic scales and how scale influences the selection of exposure estimation methods and exposure measures

Webinar Overview

Topic	Presenter
Overview of Scalable Risk Methods	Shawn Turner, TTI
Exposure from Counts and Demand Estimation Models	Shawn Turner and Ipek Sener, TTI
Exposure from Travel Surveys	Michael Martin, TTI
Case Study Example in Michigan	Robert Hampshire, UMTRI

8 Steps

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

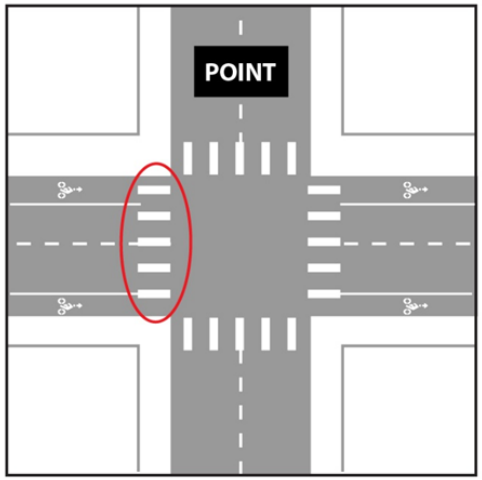


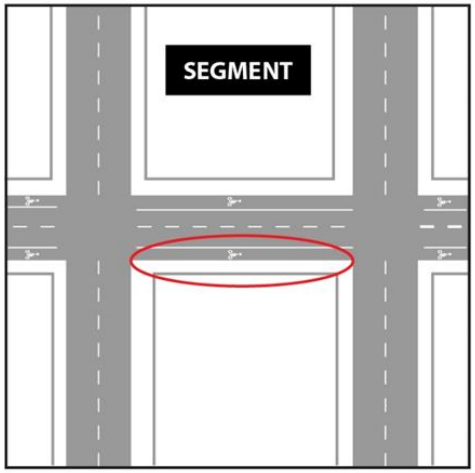
Step 1. Determine Use(s) of Risk Values

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

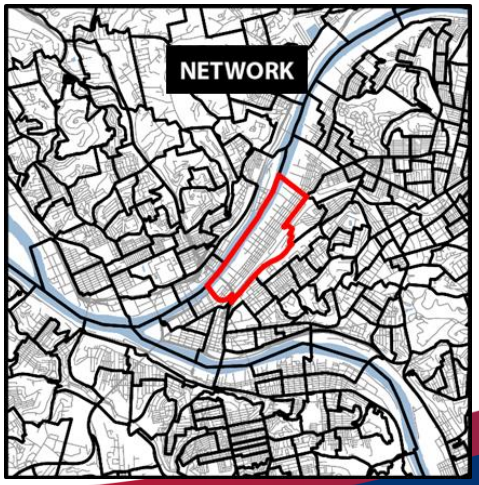
Step 2. Select Geographic Scale

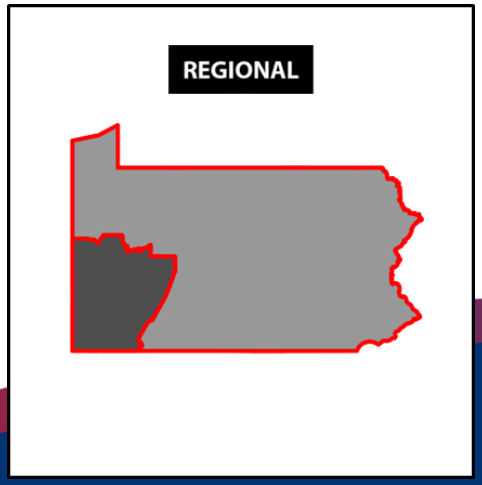
Facility-Specific





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

(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. **Additional risk indicators**
   - 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

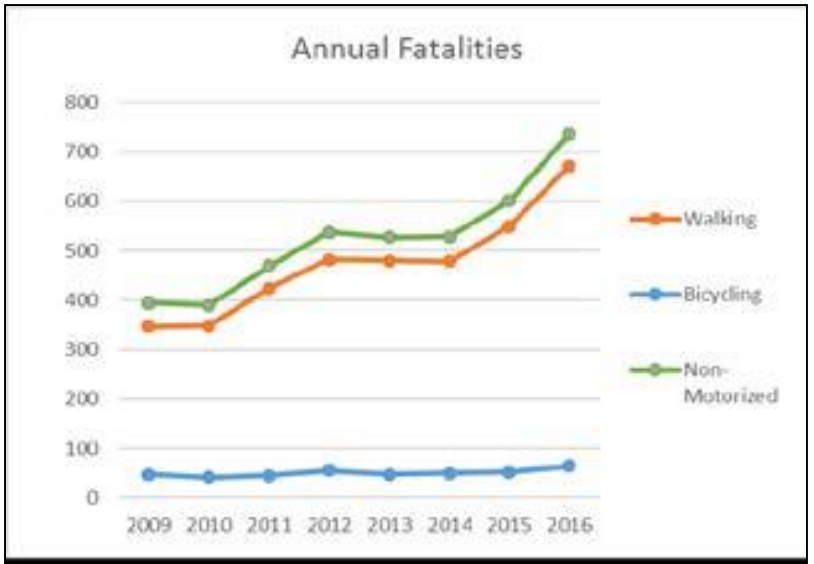
- All facilities in city/region
  - Site counts at sample locations used to develop and calibrate demand estimation model for all facilities

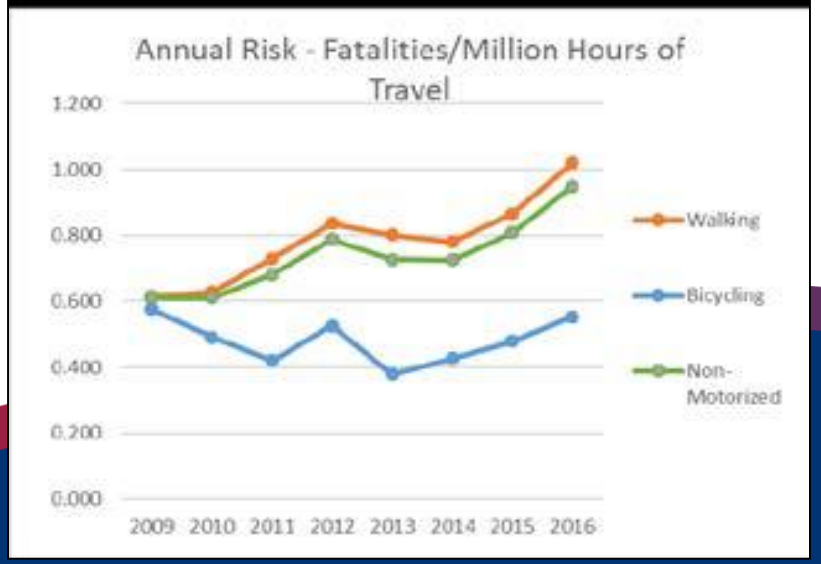
Steps 5 & 6. Select and Use Analytic Methods to Estimate Exposure

- 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

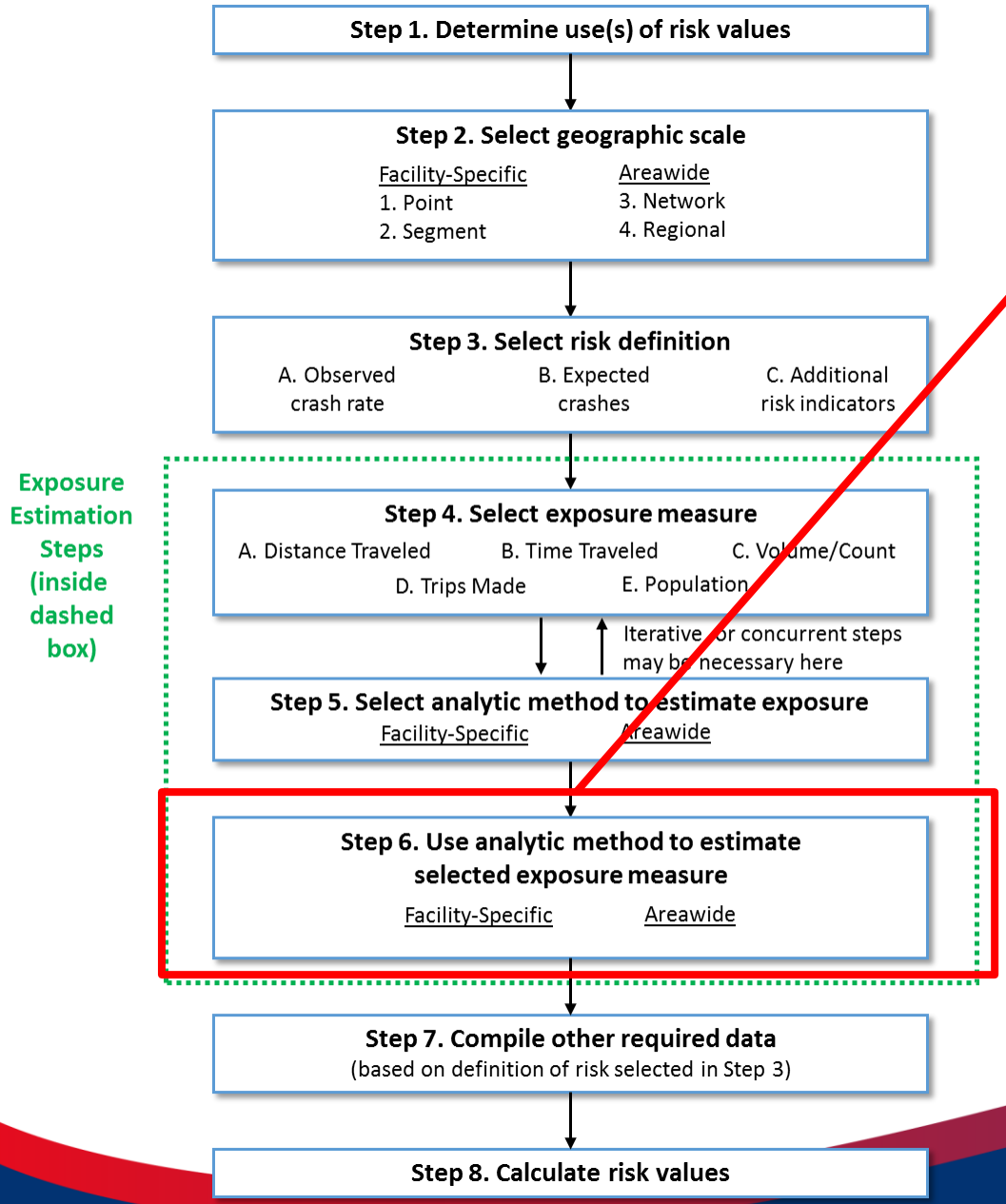
Resources

- 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

Resources

- Technical assistance available through May 2020
- 3 in-person training sessions available late 2018 or early 2019
- Contact s-turner@tti.tamu.edu

Exposure



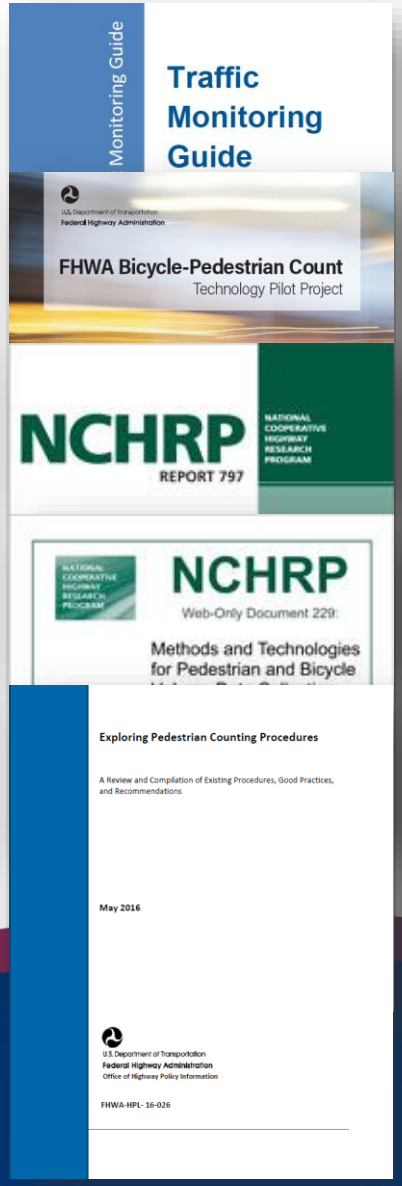
- Analytic methods to estimate exposure
- Facility-Specific:
  - Counts
  - Demand models
- Areawide
  - Travel surveys

Exposure from Site Counts

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

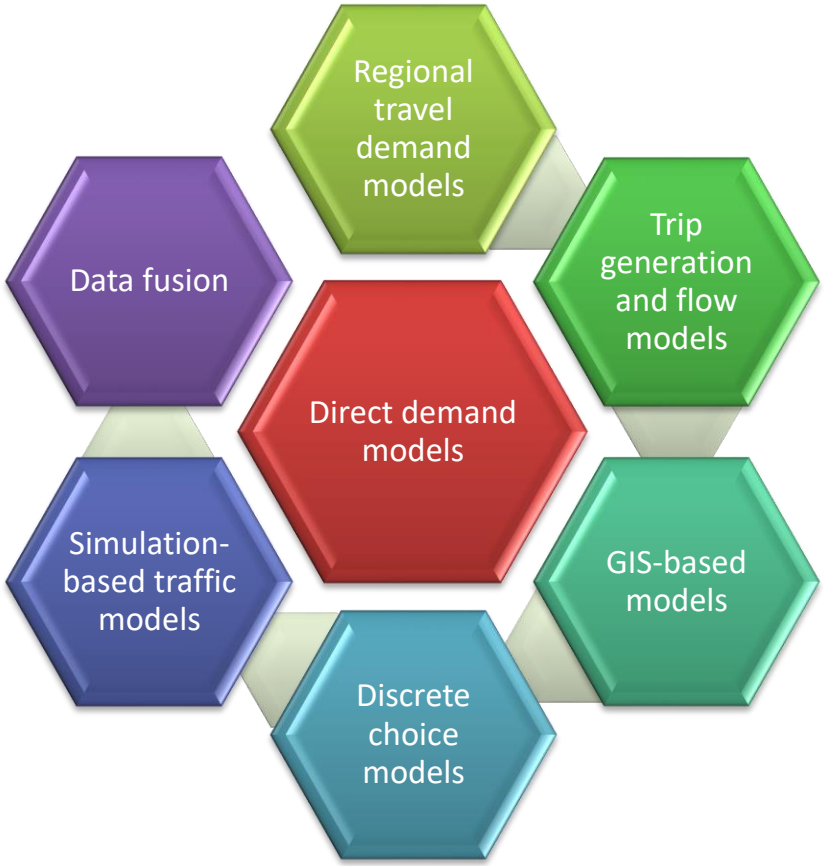
Counting Guides & Resources

- 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



Demand Estimation Models

- Numerous models to estimate pedestrian and bicyclist demand.
- The models range in complexity and input requirements.
- Some have been more commonly used than others.



Step 5: Select

Step 5: Select

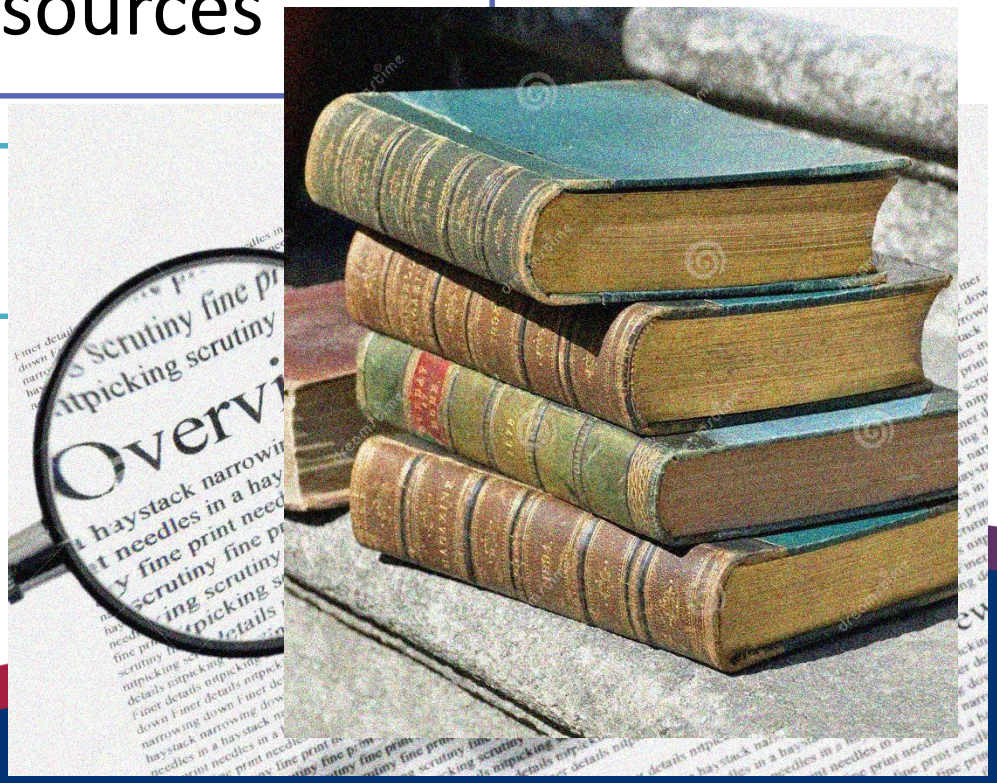
1. • Selection matrix

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.

Step 5: Select

1. • Selection matrix
2. • Overview & resources

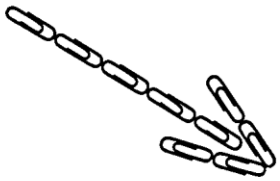


Step 5: Select

1. • Selection matrix
2. • Overview & resources
3. • Key considerations

Step 6: Use

Direct Demand Models



FOCUS

Step 6: Use

1. • Detailed overview

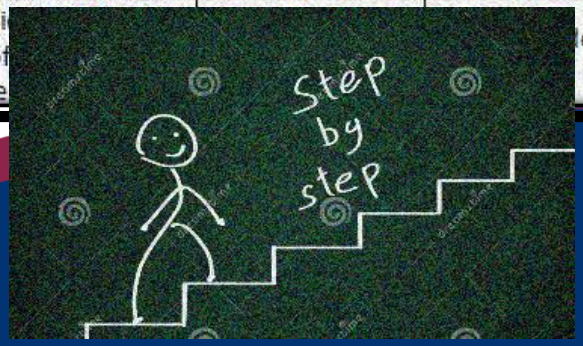
Step 6: Use

1. • Detailed overview
2. • Development – step by step

Step 6: Use

1. • Detailed overview
2. • Development
3. • Examples

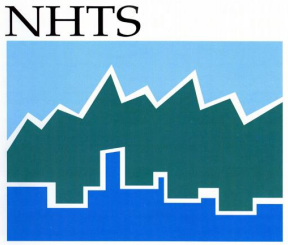
Author (Date)	Coverage	Data Collection Scale	Analysis Methods	Significant Explanatory Variables (Buffer Size)		Model Performance and Validation
				Pedestrian	Bicyclist	
		Pedestrian and bicyclist counts at	Stepwise	Si of le		el:



Travel Surveys

- American Community Survey (ACS)

- National Household Travel Survey (NHTS)



- Regional Household Travel Survey

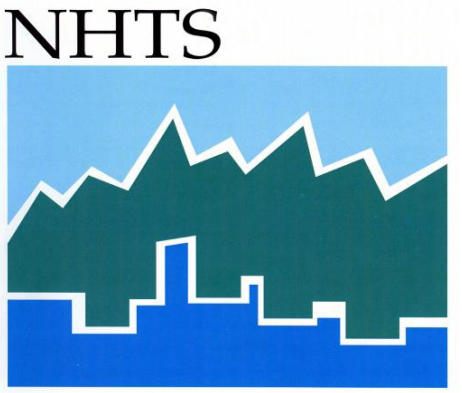
http://crdtravelsurvey.ca/

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

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

Statewide Exposure Estimates

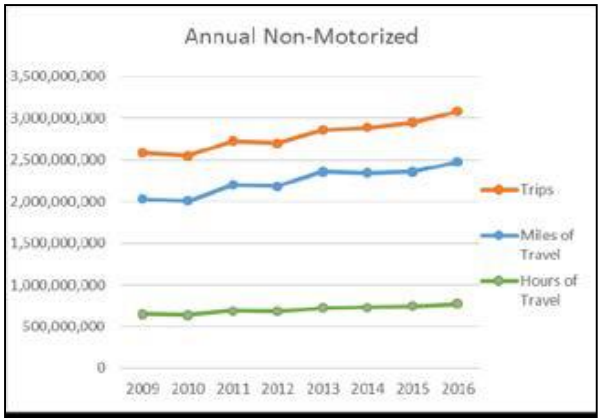
State: New York (1) Select **State** of interest

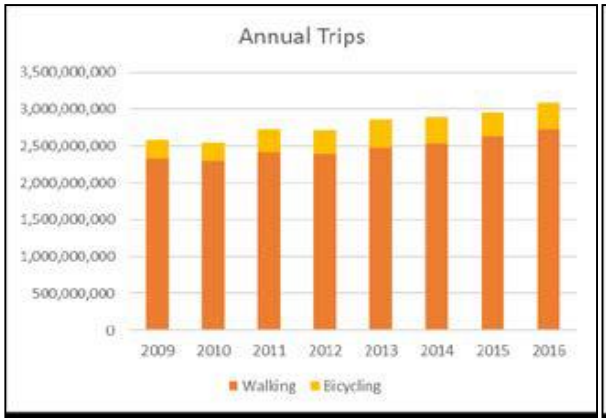
(2) Select the source (Default or User Input) of the required inputs. For the User Input option, values are required in the cell below.

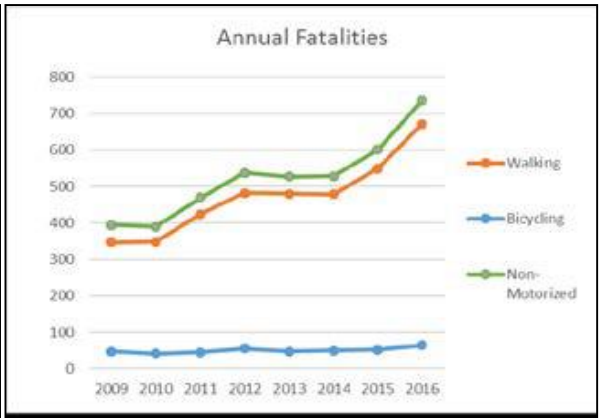
		Walking							
		2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Daily Persons Commuting		574,322	542,579	575,553	568,540	574,861	576,752	583,151	577,983
Commute-to-Total Trips Adjustment Factor		25.49	25.49	25.49	25.49	25.49	25.49	25.49	25.49
Population Adjustment Factor		1.00	0.99	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
	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
	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

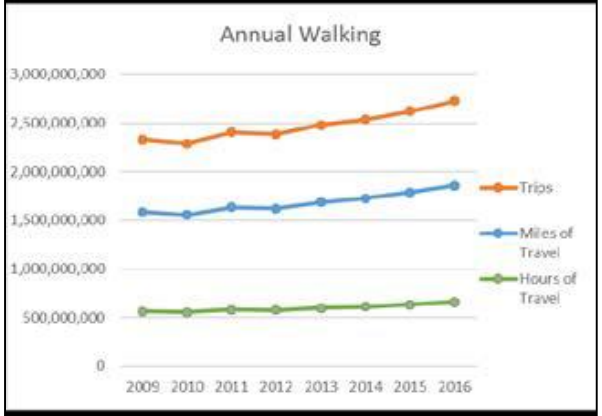
		Bicycling							
		2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Daily Persons Commuting		39,185	41,232	44,418	53,119	62,021	58,198	61,618	66,595
Commute-to-Total Trips Adjustment Factor		11.54	11.54	11.54	11.54	11.54	11.54	11.54	11.54
Population Adjustment Factor		1.00	0.99	1.00	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
	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
	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

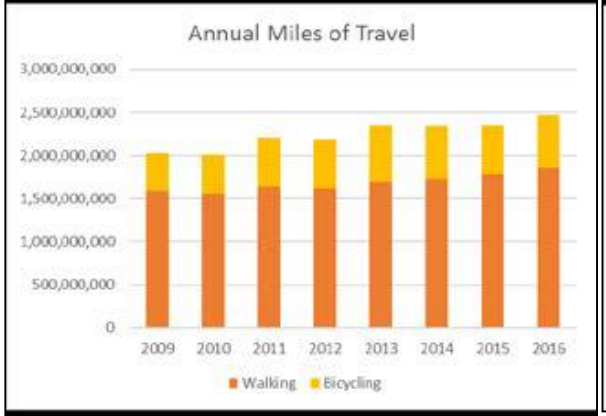
	Non-Motorized							
	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Estimated Annual Non-Motorized Trips	5,508,456,878	5,169,529,467	5,541,951,837	5,513,353,419	5,665,755,761	5,667,261,390	5,741,941,515	5,714,551,653
Estimated Annual Non-Motorized Miles of Travel	4,379,537,059.48	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

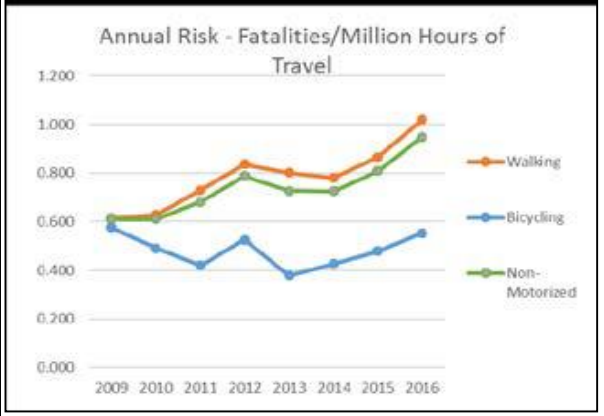

Annual Non-Motorized
3,500,000,000
3,000,000,000
2,500,000,000
2,000,000,000
1,500,000,000
1,000,000,000
500,000,000
0
2009 2010 2011 2012 2013 2014 2015 2016
Trips
Miles of Travel
Hours of Travel


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

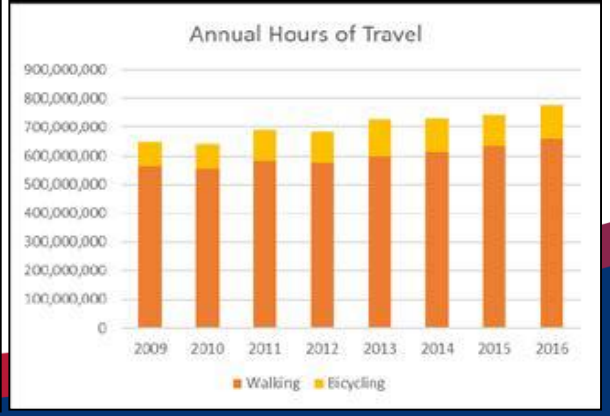

Annual Fatalities
800
700
600
500
400
300
200
100
0
2009 2010 2011 2012 2013 2014 2015 2016
Walking
Bicycling
Non-Motorized


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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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

Case Study: Pedestrian Risk Assessment in Michigan

- Michigan DOT and University of Michigan Transportation Research Institute
- Statewide risk assessment tool for pedestrian crashes
- Goal: create a risk score, based on mapping crashes and the risk characteristics
- Fictional case example based on this project

http://pedbikerisk.umtri.umich.edu

Case Study: Corridor Risk Analysis

- Goal: identify corridors in Detroit Michigan in need of pedestrian enhancement and countermeasures.
- improve the facilities in an entire corridor, not just one location.
- For example, along busy roads, land use features like business districts or the lack of lighting are often consistent over space.

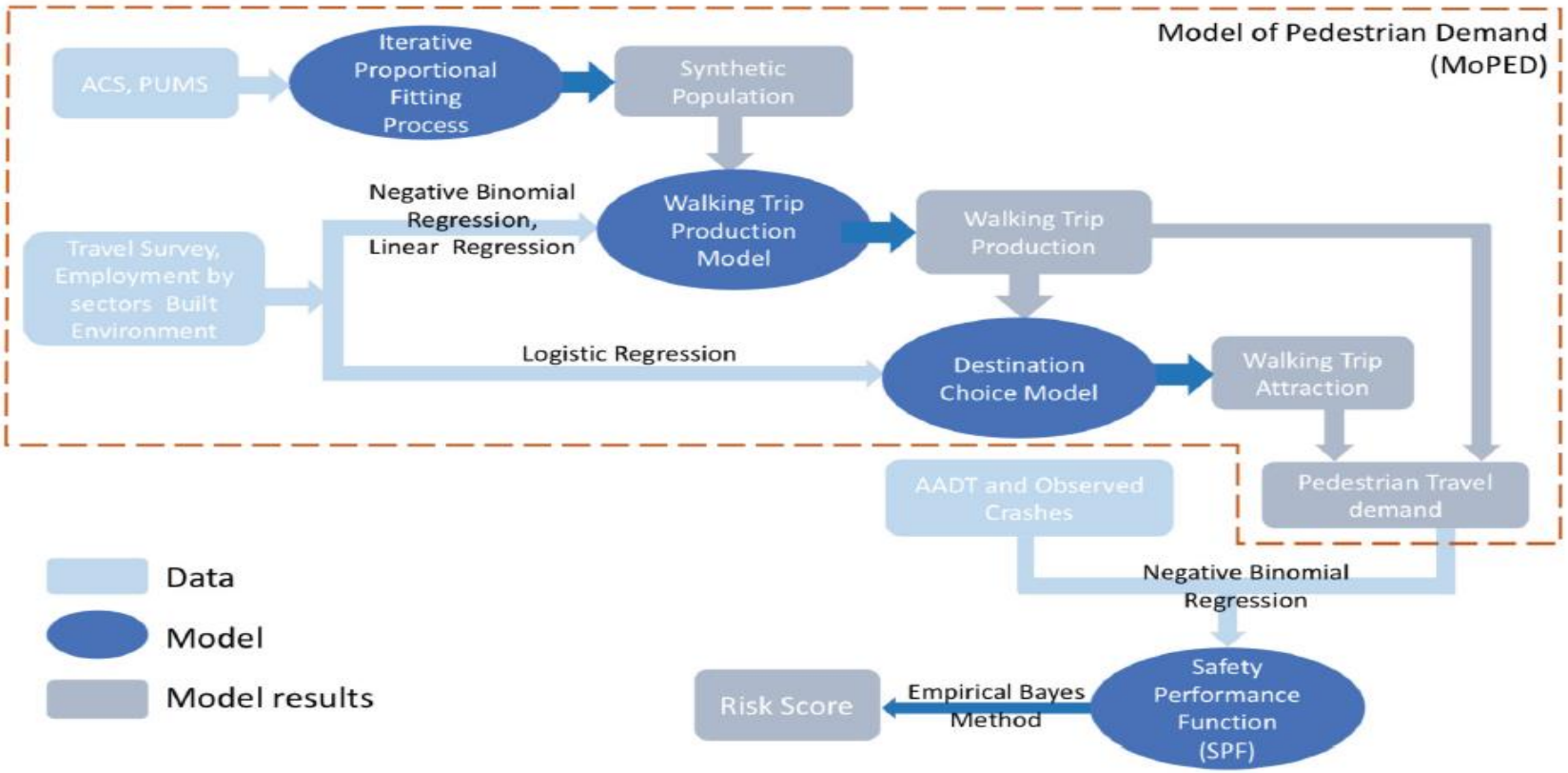
Case Study: Steps 1-4

- Step 1 Determine Use(s) of Risk Values
  - Network screening -> Area based
- Step 2: Select Geographic Scale
  - Areawide -> Network -> Corridor
- Step 3: Select Risk Definition
  - Expected Crashes
- Step 4: Select Exposure Measure
  - Trips made

Case Study: Steps 5-7

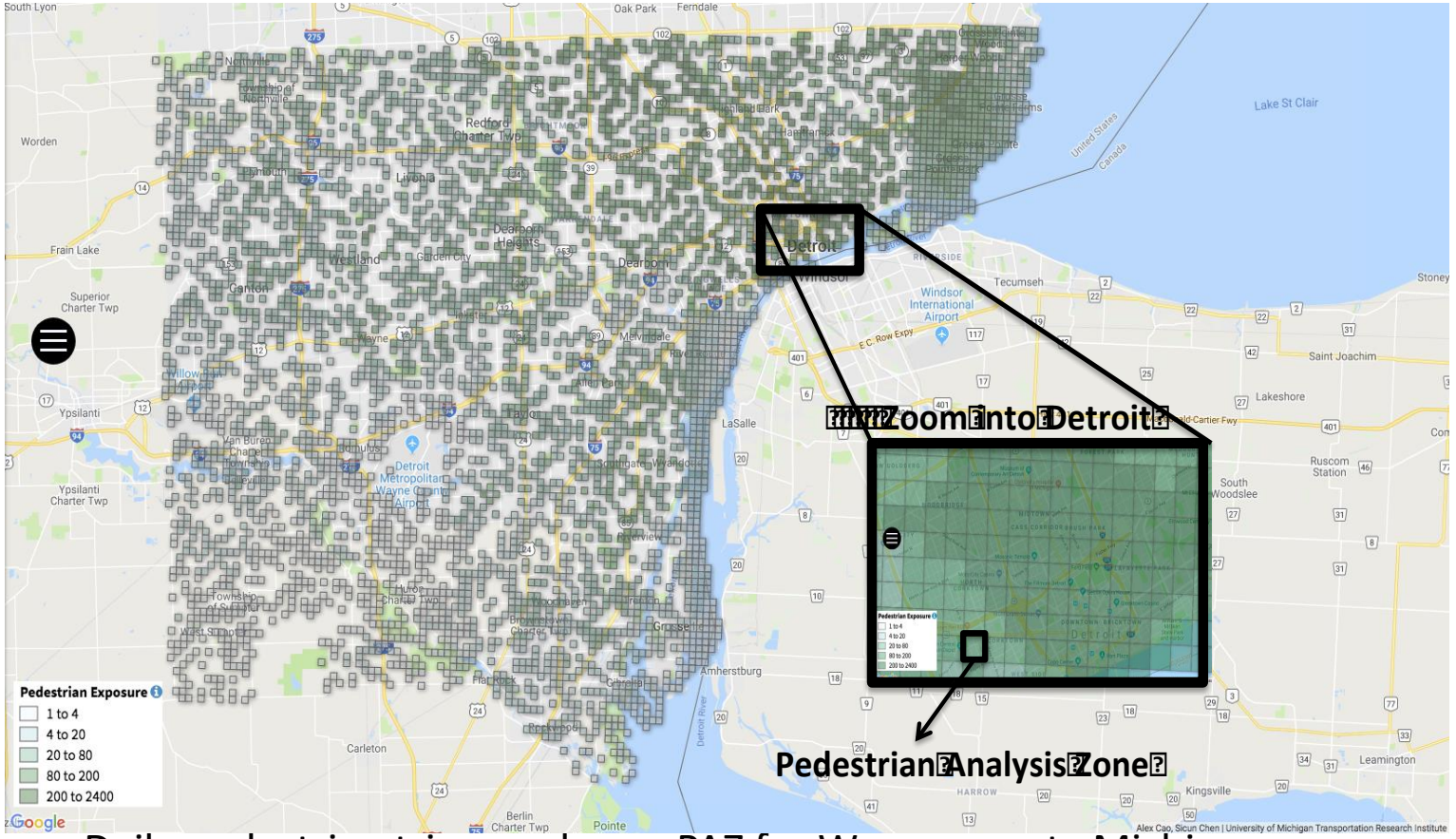
- Step 5: Select analytic method to estimate exposure
  - Demand Estimation Model -> Trip generation and flow model
- Step 6: Use analytic method to estimate Exposure
  - Estimate binomial and logistic regressions
- Step 7: Compile Other Required Data
  - Crash data, roadway characteristics
- Step 8: Calculate Risk Value
  - Empirical Bayes -> pedestrian safety performance functions (SPF)

Steps 5: Select analytic method to estimate exposure



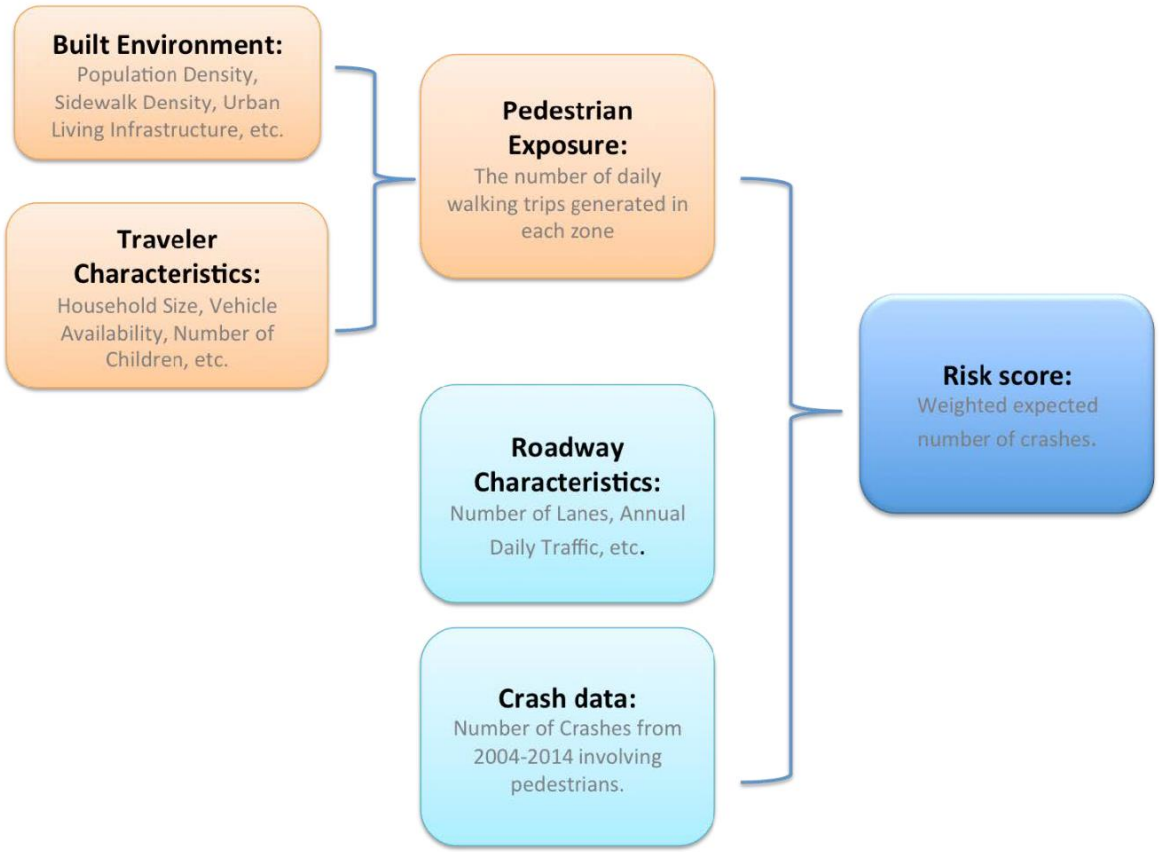
Clifton, K. J., Singleton, P. A., Muhs, C. D., and Schneider, R. J. Representing pedestrian activity in travel demand models: Framework and application. *Journal of transport geography*, Vol. *52*, 2016, pp.111-122.

Step 6: Use analytic method to estimate Exposure

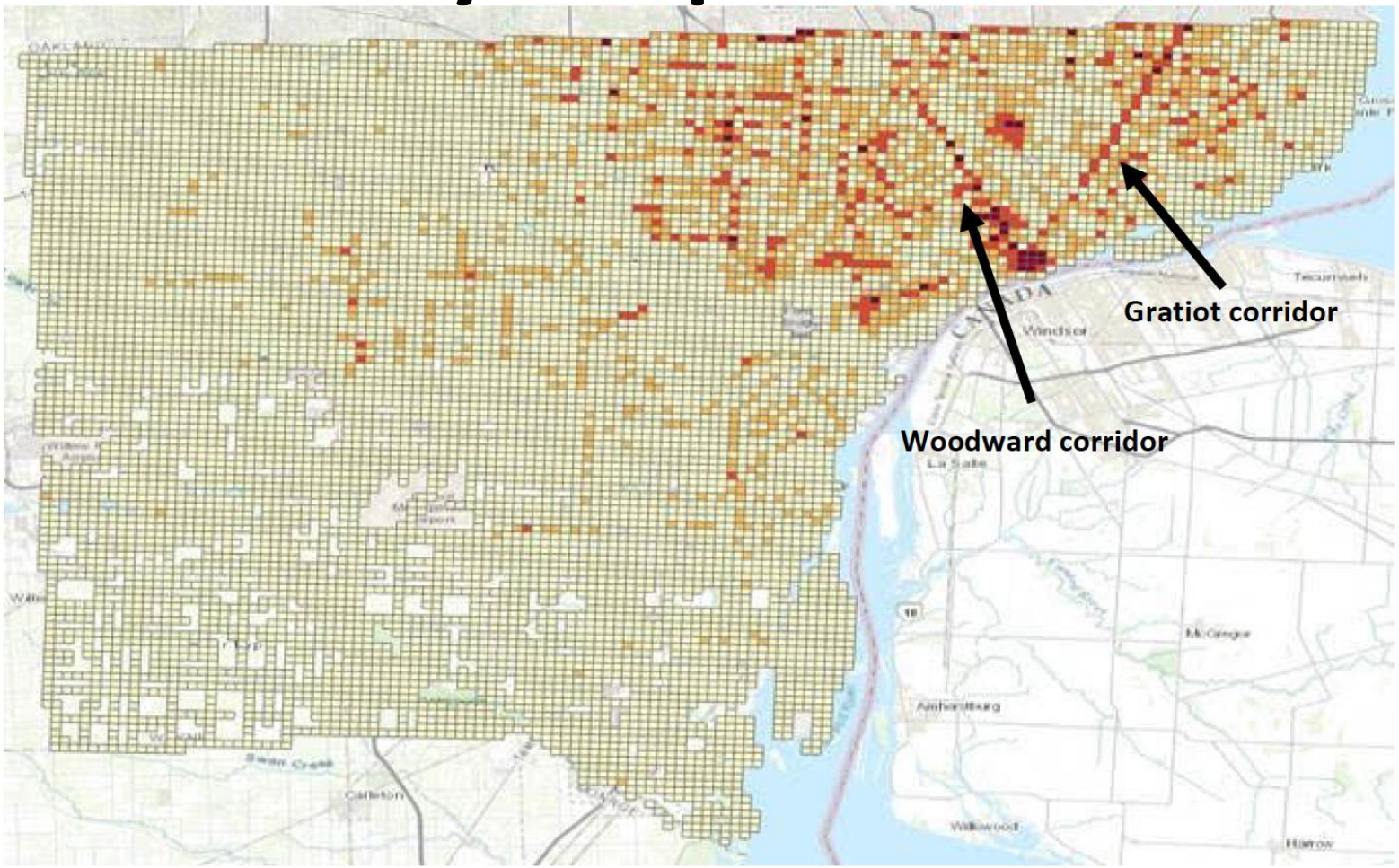


Daily pedestrian trips made per PAZ for Wayne county Michigan

Step 7: Compile other data



Case Study: Step 8 -> Risk



Woodward Corridor Risk = 91 expected crashes
Gratiot Corridor Risk = 50 expected crashes

Case Study: Lessons Learned

- Pedestrian generation and flow models require significant technical capabilities.
- Highway Safety Manual and non-motorized assessment
- Need to validate the exposure and risk models
- How to integrate them into MDOT's processes?

Discussion

- Send us your questions 
- Follow up with us:
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  - Ipek Sener I-Sener@tti.tamu.edu
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  - General Inquiries pbic@pedbikeinfo.org
- Archive at www.pedbikeinfo.org/webinars