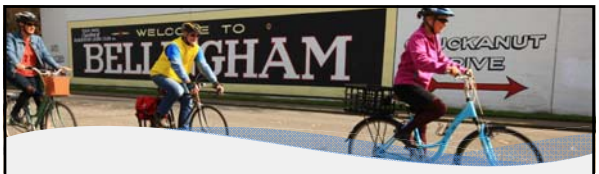


Planning & Implementing a Citywide Bicycle Network in Bellingham, WA

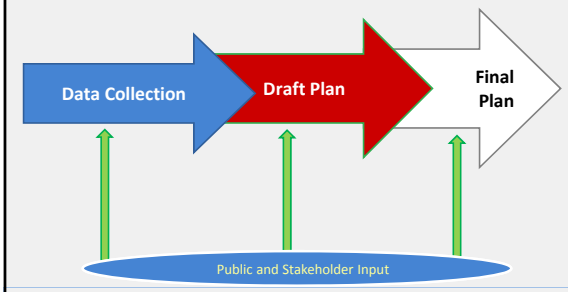
American Planning Association
Washington Chapter
Making Great Communities Happen

Legacy & Prophecy
October 16-17, 2014
Davenport Hotel | Spokane, Washington

Presentation Outline

- Plan Development Process
- Bicycle Network Development
- Prioritization Process
- Implementation – Funding
- Design Guidance
- Performance Measures

Plan Development Process



Target Audience for Increasing Bicycle Mode Share

Public Involvement Process

- Steering Committee Representatives
- Community Focus Groups
- Open House #1 (April 2013)
  - 120 Attended; 418 comments
- Online Survey - 832 Participants
- Online Interactive Map – 634 Comments
- Open House #2 (February 2014)
  - 98 Attendees; 61 Comments
- Transportation Commission (April 2014)
- 2015-2020 TIP Adoption (June 2014)
- City Council (July, August, Sept, Oct 2014)

Interactive On-line Bicycle Mapping

- Identified routes used and locations needing improvements
- 634 comments received
- Comments informed draft study network

Plan Vision

Vision:

Bicyclists of all ages and abilities have access to a safe, well-connected network linking all areas of Bellingham.

Plan Goals

- Safety
- Connectivity
- Equity
- Livability
- Public and Environmental Health
- Mode Choice
- Education
- Mode Shift
- Economy

Network Development & Prioritization Process

Develop Study Network

Network Analysis

Recommended Network

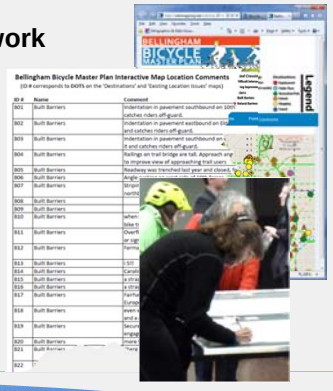
Project Prioritization

Prioritized Project List

BMP Study Network

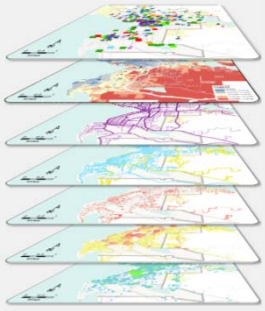
Facilities recommended by the public:

- Previous City Transportation Plans
- Open House Maps
- Online Interactive Map
- Steering Committee



Network Analysis

- Destinations
  Including schools, parks, trails, services, etc.
- Connectivity
  Including route directness index, level of stress, I-5 barriers, etc.
- Traffic volume
- Vehicle speeds
- Terrain (hills)
- Housing
- Employment



Developing Facility Recommendations

- Evaluated results of baseline connectivity model
- Conducted field work
- Adjustments based on local knowledge and expertise
- Recommended facilities for a final network

Various Bicycle Facility Types


Bike Lane


Buffered Bike Lane


Climbing Lane

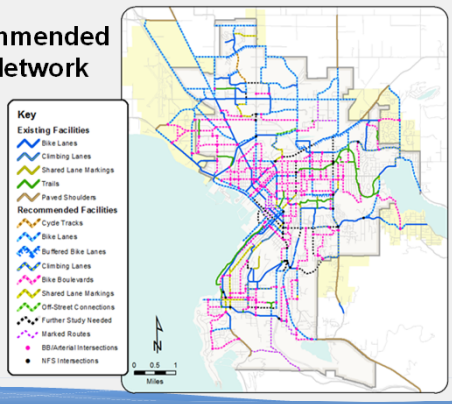

Shared Lane


Cycle Track

but most of all …..

Bike Boulevards

Recommended Bike Network



Percent of City Arterial Network with Bicycle Facility Recommendations

Red = Bicycle Facilities Recommended

Blue = No Bicycle Facilities Recommended

- Narrow + On-Street Parking
- Steep slope/Topography
- Very high traffic volumes
- Other nearby facility
- Not yet constructed (dashed)

Recommended BMP Network Summary

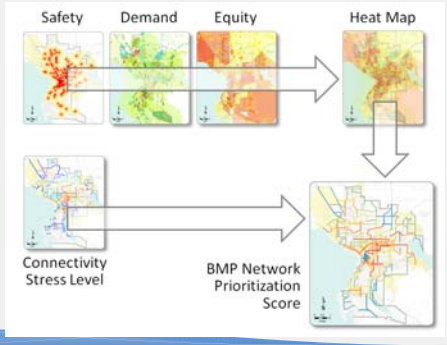
Facility Type	Existing Network Miles	Percent	Complete Network (Existing + Recommended)	Percent
Bike Lanes	31.9	82%	73.7	44%
Buffered Bike Lanes	0.0	0%	4.0	2%
Shared Lane Markings	0.4	1%	7.3	4%
Climbing Lane	0.7	2%	8.6	5%
Bicycle Boulevard	0.0	0%	52.1	31%
Paved Shoulder	5.7	15%	5.7	3%
Cycle Track	0.0	0%	0.8	<1%
Further Study	0.0	0%	9.4	6%
Marked Route	0.0	0%	7.8	5%
TOTAL	38.7	100%	169.4	100%

Project Prioritization Criteria

Table 3.14: Project Prioritization Methodology

Variables		Metric
Safety	15%	• Bike Crashes 2006-2010
Connectivity	45%	• Route Level of Stress and Directness • I-5 Barriers
Demand	25%	• Density of Employment • Density of Population • Locations Near Schools • Bike Count Volumes • Locations Near Trail Access Points • Locations Near Parks
Equity	15%	• High Concentration of Population Under 18 • High Concentration of Low Income Population

Project Prioritization Methodology

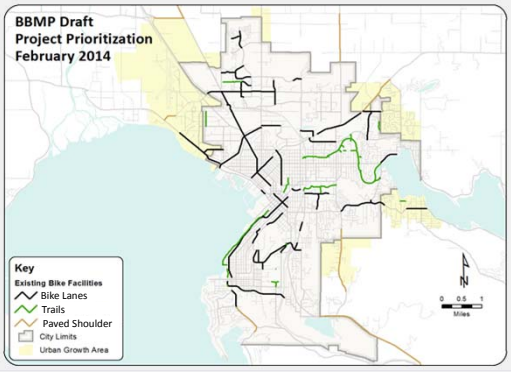


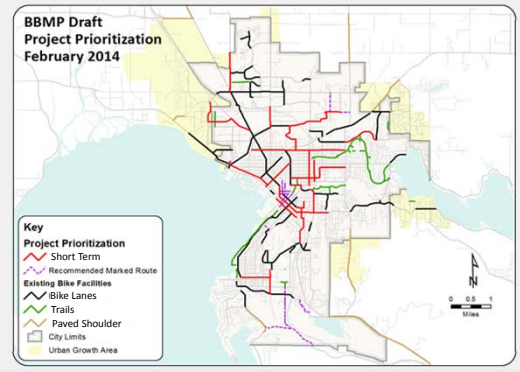
Final Prioritized Bike Network

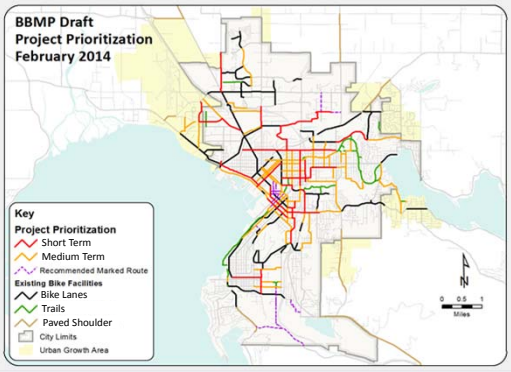
- From 38 to 170 miles
- Various Facility Types

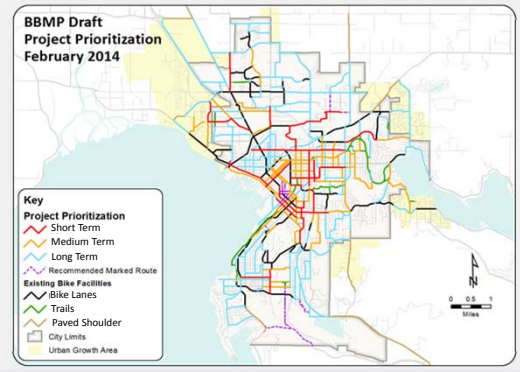
186 Projects
19 Short-term (20 mi)
53 Medium-term (33 mi)
114 Long-term (82 mi)

Prioritized based on RDI value and connectivity benefit
RELATIVE to other projects









Plan Implementation Strategies

- Maintain existing bike facilities
- Continue to install bike facilities with resurfacing projects
- Retrofit intersections with bike markings and signal detection
- Seek grant funding for priority bicycle facilities
- Fund "Further Study Needed" Bike Network links
- Develop way-finding system

Funding for Bicycle Improvements

- Leverage state & federal grants with Transportation Benefit District (TBD) local matching funds

Transportation Improvement Projects 2015-2020 (Fund Page 1)

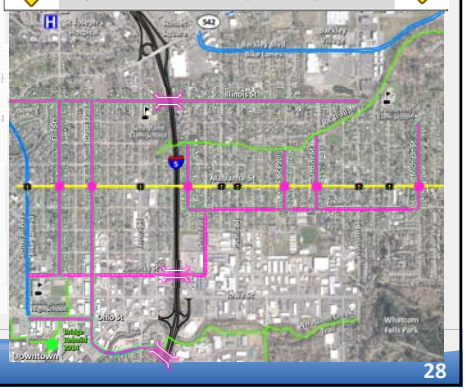
No.	PROJECT DESCRIPTION	FUNDING SOURCE	Cost Estimates (000's) 2014 Dollars: Previous Budget	FUNDED 2015	FUNDED 2016	FUNDED 2017	UNFUNDED 2018	UNFUNDED 2019	UNFUNDED 2020	PROJECT TOTALS
1	Annual Arterial Street Pavement Resurfacing[1]	Street	1,390	790	980	2,300	2,370	2,440	2,515	
		TBD Resurface	1,540	1,607	843	1,667	1,700	1,733	1,767	
	1) Increase annual sales tax 1.5 - 2.0%	Subtotal	2,930	2,397	1,823	3,967	4,070	4,173	4,282	23,642
2	Whatcom Transportation Authority Contract Supplemental Transit Service in Bellingham (Expires 3/14/16)	TBD Contract	1,540	1,000	1,000	0	0	0	0	
		Transit Reserve		607	633	1,667	1,700	1,733	1,767	
		Subtotal	1,540	1,607	1,633	1,667	1,700	1,733	1,767	11,647
3	Non-Motorized Transportation[1] Various Pedestrian and Bicycle Infrastructure Improvements	TBD Non-Motor	1,540	1,447	1,473	1,502	1,530	1,563	1,592	
		10% Reserve	0	160	160	165	170	170	175	
		Subtotal	1,540	1,607	1,633	1,667	1,700	1,733	1,767	11,647

Table 1. Pedestrian & Bicycle Projects Scheduled for 2014-2016

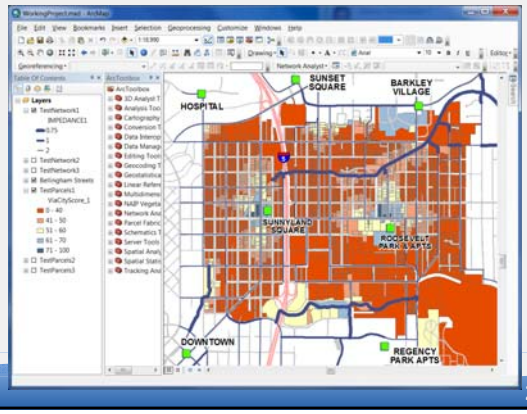
Improvement	Project	Tier 1	Tier 2	Tier 3	X Alabama	X I-5	Est. Cost	Date
Sidewalk + Bike Lanes	25th Street	P					$1,825,768	2014
Sidewalk + Bike Lanes	Eliza Avenue	P					$246,250	2014[3]
Bike Lanes	Ohio Street	B					$0	2014[3]
Crosswalk	Ellis/Ohio	P, B					$150,000	2014[4]
Shared Lanes	14th Street			B			$0	2014[4]
Shared Lanes	Hawthorne			B			$0	2014[4]
	2014 Subtotal for TBD Non-motorized Funds						$2,222,018	
Bicycle Blvd	Texas-Nevada-Kentucky	B				X	$130,000	2015
Sidewalks + Bicycle Blvd	Undine Street	P	B		X		$525,000	2015[5]
Sidewalks + Bicycle Blvd	St. Paul Street	P	B		X		$525,000	2015[5]
Bicycle Blvd	Illinois Street	B				X	$225,000	2015
Bicycle Blvd	Grant Street		B		X		$10,000	2015[5]
Bicycle Blvd	Michigan Street		B		X		$12,000	2015[5]
10% Reserve	Local match funds for grants						$160,000	2015
Bike Study	Further Study Needed (Holly)	B					$0	2015[5]
Bike Study	Further Study Needed (Lakeway)	B				X	$0	2015[5]
	2015 Subtotal for TBD Non-motorized Funds						$1,587,000	
Crosswalk + Bicycle Blvd	Ellis	P	B		X		$25,000	2016[6]
Bicycle Blvd	Moore-Texas			B	X		$12,000	2016[6]
Sidewalk + Bicycle Blvd	Alderwood	P		B			$350,000	2016
Bike Lanes	Lincoln/Meador/Grant/Ohio	B				X	$183,120	2016
10% Reserve	Local match funds for grants						$160,000	2016
Bike Study	Further Study Needed (James)	B					$0	2016[6]
Construction	Lakeway (Ellis to Queen)	B				X	Unknown[8]	?
	2016 Subtotal for TBD Non-motorized Funds						$710,120	

2015-2020 Transportation Improvement Program
Project #3: Non-MotorizedTransportation Improvements

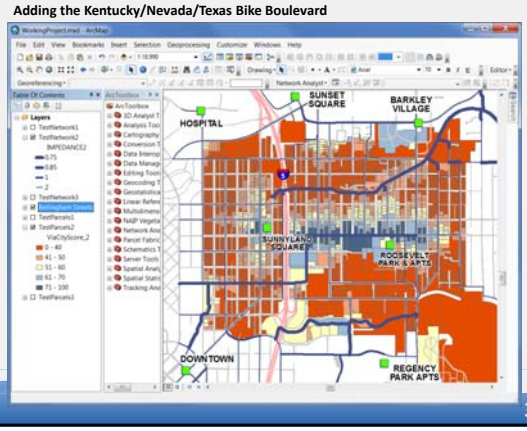
3.a. Kentucky/Nevada/Texas Bike Boulevard: Michigan to Cornwall
3.b. Undine St Sidewalks (Alabama to Texas) & Bike Boulevard (RR Trail to Texas)
3.c. St Paul St Sidewalks (Alabama to Texas) & Bike Boulevard (RR Trail to Texas)
3.d. Illinois St Bike Boulevard: Woburn to Cornwall
3.e. Grant St Bike Boulevard: Illinois to Ohio
3.f. Michigan St Bike Boulevard: Maryland to Texas
3.h. Lincoln/Meador/Grant/ Ohio Climbing Lane & Shared Lanes
3.i. Ellis St Bike Boulevard: Illinois to Kentucky
3.j. Moore/Texas Bike Boulevard: RR Trail to Nevada



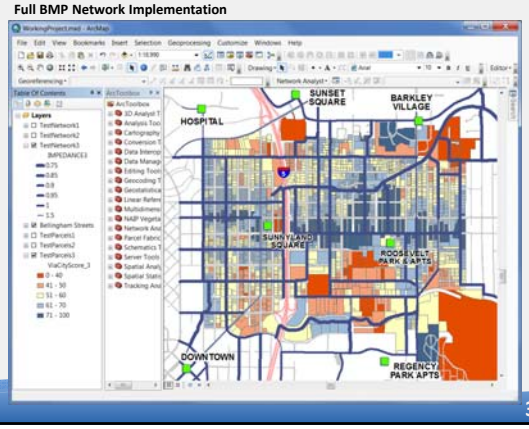
Existing Conditions



Adding the Kentucky/Nevada/Texas Bike Boulevard



Full BMP Network Implementation



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Bicycle-Pedestrian Funding & Costs

- **TBD** (sales tax) non-motorized revenue varies annually
  - ~ $1,450,000 to $1,590,000 per year
- **Sidewalks** = new off-street construction with mitigation for storm water and environmental impacts (especially in north Bellingham)
  - ~$500,000 per block - both sides
- **Bike Boulevard** = existing streets with markings and minor improvements
  - ~$35,000 per mile base cost, plus possible arterial crossing improvements ($75,000 to $100,000 per intersection)
- **Bike Lane** = existing streets with parking (range of $60,000 to $117,000)
  - ~$89,000 per mile (Includes climbing & buffered lanes)
- **Cycle Track** = Bike facility separated from vehicle traffic
  - ~$1,650,000 per mile (Includes intersection treatments)

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Design Guidance


AASHTO


NACTO


MUTCD

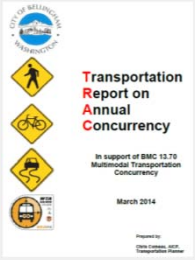
- Bicycle Boulevards
- Buffered Bike Lanes
- Climbing Lanes
- Shared Lane Markings
- Cycle Tracks
- Bike Lanes at Intersections
  - Green Bike Lanes
  - Green Bike Box
- Rectangular Rapid Flashing Beacons
- HAWK Signal
- Bicycle Activated Signal Push Button
- Bicycle Parking
- Travel Lanes

Program Recommendation Strategies

- Education
- Enforcement
- Engineering
- Encouragement

Annual Performance Measures

- Measure annual progress on Bicycle Master Plan implementation (TRAC → TRAM)
- Benchmark for achievement of vision "Bicyclists of all ages and abilities have access to a safe, well-connected network linking all areas of Bellingham"
- Use standard data available or collectable with existing resources
- Expand on existing performance data reported annually: safety, mode shift, etc.



Moving Forward on Two Wheels

- Ambitious, long-term, comprehensive plan
- Part of the City's overall GMA and multimodal transportation planning
- Fulfills City Legacy Goals
  - Mobility & Connectivity
  - Mode Shift
- On-going, living document
- GMA update - 10 years
- Bellingham = A most excellent place to bike!

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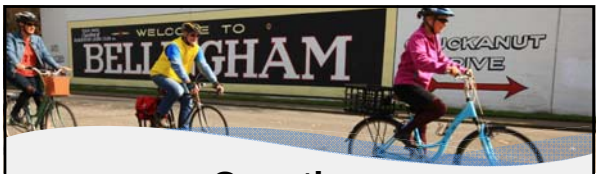


Questions

Chris Comeau, AICP CTP
Transportation Planner
(360) 778-7946 or ccomeau@cob.org

City of Bellingham Public Works

Quantifying Bicycle Exposure

Seth Cool
University of Idaho

Project Goal:

Create a sketch level process to quantify bicycle exposure for scenario analysis.

- BACKGROUND
- METHOD
- RESULTS
- CONCLUSIONS

BACKGROUND

The Challenge of Bicycle Accident Analysis

1. Lack of Bicycle Volume Data (Liu et al., 2012)
   - Data collection in the field is rare
   - Forecast models have poor accuracy
2. Lack of Bicycle Accident Data (Schimek, 2014)
   - Relatively few accidents occur
   - Many accidents not reported (89%)
   - Police reports not descriptive

Citizen Volunteer Counts

National Bicycle and Pedestrian Documentation Project
Conducting Counts

Alta Planning + Design
National Bicycle and Pedestrian Documentation Project

Citizen Volunteer Counts

Washington State Bicycle and Pedestrian Documentation Project

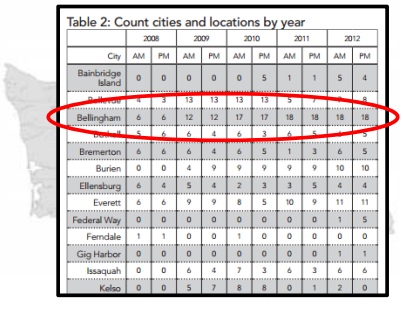
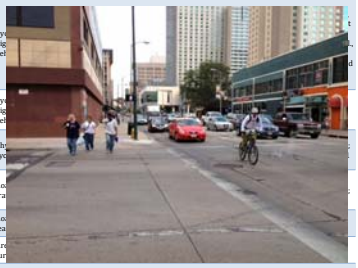


Table 2: Count cities and locations by year

	2008		2009		2010		2011		2012	
City	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
Bainbridge Island	0	0	0	0	0	5	1	1	5	4
[illegible]	4	3	13	13	13	13	5	7	7	8
Bellingham	6	6	12	12	17	17	18	18	18	18
[illegible]	5	6	6	4	6	3	6	5	5	5
Bremerton	6	6	6	4	6	5	1	3	6	5
Burien	0	0	4	9	9	9	9	9	10	10
Ellensburg	6	4	5	4	2	3	3	5	4	4
Everett	6	6	9	9	8	5	10	9	11	11
Federal Way	0	0	0	0	0	0	0	0	1	5
Ferndale	1	1	0	0	1	0	0	0	0	0
Gig Harbor	0	0	0	0	0	0	0	0	1	1
Issaquah	0	0	6	4	7	3	6	3	6	6
Kelso	0	0	5	7	8	8	0	1	2	0

Dangerous Situations
(Situational Antecedents to accidents)

Dangerous Situation	Description	References
Mixed cycling in harsh traffic	Cyc... hig... vel...	
Dedicated ROW in harsh traffic	Cyc... hig... vel...	
Separated cycling	Phy... cyc...	
Cramped Space	Ro... tra...	
Excessive space	Ro... lea...	
Dooring and vehicle parking	Are... tur...	
Frequent access points	High frequency of driveways	Allen-Munley et al, 2004; Emery and Crump, 2003



Dangerous Situations
(Situational Antecedents to accidents)

Dangerous Situation	Description	References
Mixed cycling in harsh traffic	Cycling in the vehicle travel lane on a road with high vehicle volume, speed, and/or percent heavy	Mapes, 2009; Teschke, 2012; Harkey and Stewart, 1997; Elvik et al., 2009; Moritz 1997; Tinsworth et al., 1994; Allen-Munley et al., 2004; Klop and Khattak, 1999; Vandenbulcke 2013; Schepers et al.,
Dedicated ROW in harsh traffic	Cy... hig... ve...	
Separated cycling	Ph... cy...	
Cramped Space	Ro... tra...	
Excessive space	Ro... lea...	
Dooring and vehicle parking	Ar... turnover	
Frequent access points	High frequency of driveways	Allen-Munley et al, 2004; Emery and Crump, 2003

Dangerous Situations
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Dedicated ROW in harsh traffic	C... h... d...	
Separated cycling	P... S...	
Cramped Space	R... t...	
Excessive space	R... l...	
Dooring and vehicle parking	A... t...	
Frequent access points	H...	

Dangerous Situations

Dangerous Situation	Description	References
Crossing harsh traffic		
Complicated intersections		
Right hook		
Left sneak		
Thru clip		
Gaps in bicycle network		
Wrong-way riding	Cycling the wrong-way on a one-way street.	Wachtel and Lewiston, 1994; Räsänen and Summala, 1998; Schimek, 2014; Summala et al., 1996; Hunter et al., 1999;
Sidewalk riding	Cyclist utilizing sidewalks	Schimek, 2014; Wachtel and Lewiston 1994;
Infrequent cyclers	Low cyclist volume	Elvik et al., 2009; Jacobsen, 2003; Nordback et al., 2014; Brüde and Larsson, 1993; CROW 2007

Dangerous Situations

Dangerous Situation	Description	References
Crossing harsh traffic	Crossing a road with high vehicle volume, speed, and/or percentage heavy vehicle	Summala et al., 1996; CROW, 2007; Schepers et al., 2011
Complicated intersections		
Right hook		
Left sneak		
Thru clip		
Gaps in bicycle network		
Wrong-way riding		
Sidewalk riding	Cyclist utilizing sidewalks	Schimek, 2014; Wachtel and Lewiston 1994;
Infrequent cyclers	Low cyclist volume	Elvik et al., 2009; Jacobsen, 2003; Nordback et al., 2014; Brüde and Larsson, 1993; CROW 2007

Dangerous Situations

Dangerous Situation	Descrip...
Crossing harsh traffic	Crossing... and/or ...
Complicated intersections	Navigati... roundab...
Right hook	Right-tu...
Left sneak	Cyclist s... left turn...
Thru clip	Left turn...
Gaps in bicycle network	Disconti...
Wrong-way riding	Cycling ...
Sidewalk riding	Cyclist u...
Infrequent cyclers	Low cyc...

METHOD

Method

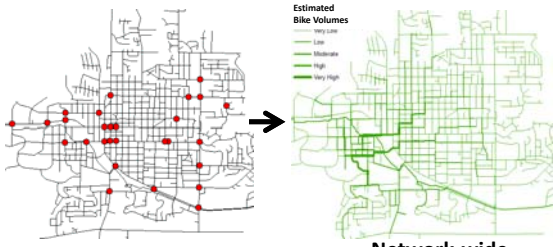
Step 1. Spatially Extrapolate Across Network

Step 2. Temporally Extrapolate 2 Hour to AADB

Step 3. Define Exposure Metrics

Step 4. Calculate Exposure

Step 1. Spatially Extrapolate Across Network

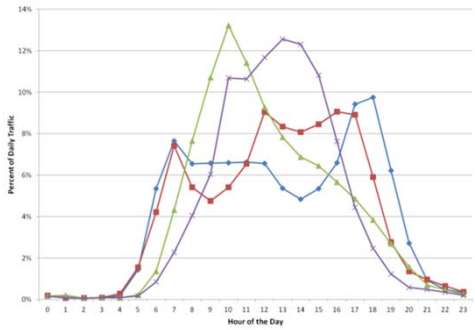


Observed Count Points

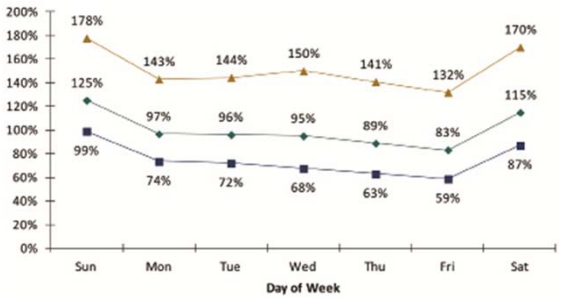
Network-wide
2 Hour Volume

McDaniel, S. and Lowry, M., and Dixon, M. (2014). "Using Origin-Destination Centrality to Estimate Directional Bicycle Volumes." *Transportation Research Record*.

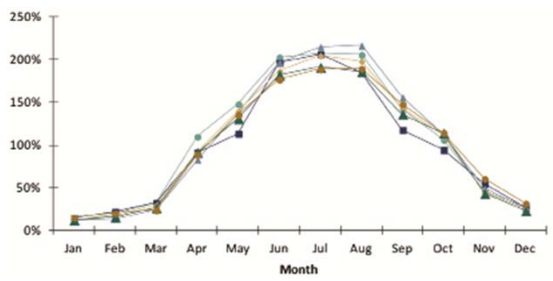
Temporal Variation



Temporal Variation



Temporal Variation



ADJUSTMENT FACTORS

Factor	Path	Street
AM Two Hour	0.11	0.12
PM Two Hour	0.18	0.17
Monday	0.15	0.11
Tuesday	0.16	0.10
Wednesday	0.16	0.11
Thursday	0.15	0.10
Friday	0.14	0.11
Saturday	0.11	0.21
Sunday	0.10	0.21
January	1.43	1.67
February	1.43	1.67
March	1.33	1.54
April	1.11	1.25
May	0.91	1.00
June	0.77	0.77
July	0.67	0.57
August	0.67	0.57
September	0.77	0.71
October	1.00	1.11
November	1.54	1.67
December	1.54	1.67

AADB Adjustment Factors based on:

Nordback, Marshall, and Janson. (2013) *Development of estimation Methodology for Bicycle and Pedestrian Volumes based on Existing Counts.*

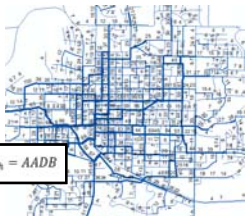
Lindsey, G., Chen, J., and Hankey, S. (2013). "Adjustment Factors for Estimating Miles Traveled by Nonmotorized Traffic."

National Bicycle and Pedestrian Documentation Project (NBPDP), Institute of Transportations Engineers and Alta Planning, http://bikepeddocumentation.org/

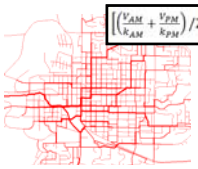
Step 2. Temporally Extrapolate 2 Hour to AADB

AM 2 Hour Volume

$$\left[\left(\frac{V_{AM}}{k_{AM}} + \frac{V_{PM}}{k_{PM}}\right)/2\right] * F_{day} * F_{month} = AADB$$



AADB



PM 2 Hour Volume

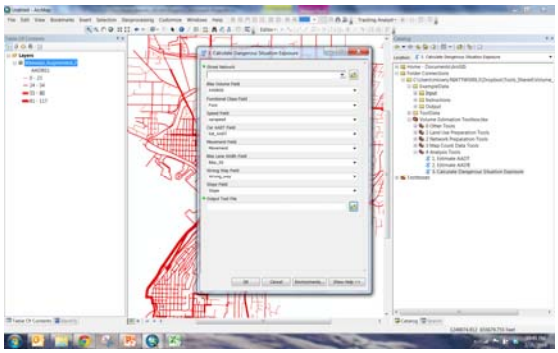
Step 3. Define Exposure Metrics

<u>Community</u>-specific metrics should be based on:

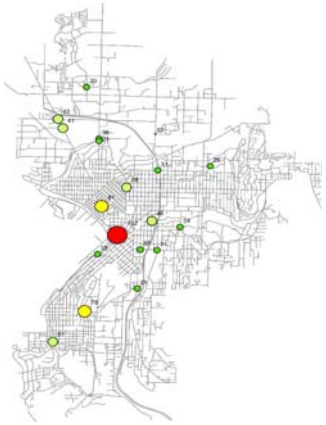
- **Public involvement**
- **Local experience**
- **Latest research**

Dangerous Situation	Metric
Separated cycling in harsh traffic	Bike lane Vehicle volume > 8,000 AADT
Mixed cycling in harsh traffic	No bike lane Vehicle volume > 3,000 AADT
Cramped space	Vehicle lane width < 12 ft Vehicle volume > 1,000 AADT Vehicle speed limit > 20 mph
Parking maneuvers and dooring	Parking turnover > 4 maneuvers per hr
Frequent acces points	Access points > 30 per mile
Steep grade	Grade > 4%
Wrong-way riding	Wrong-way riding occurrence
Unexpected cyclers	Cyclist volume < 50 AADB

Step 4. Calculate Exposure



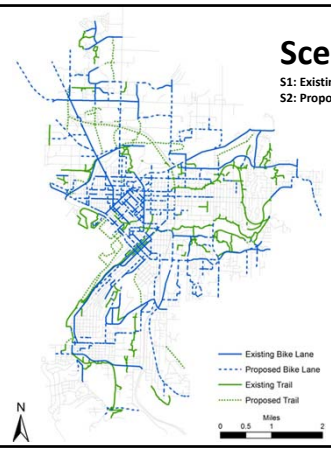
RESULTS



Bellingham Count Locations

Scenarios

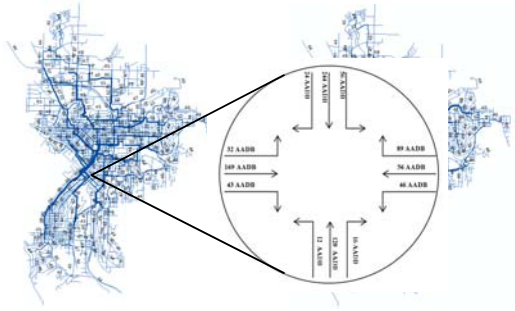
S1: Existing Conditions
S2: Proposed Improvements



AADB

Scenario 1 (Existing)

Scenario 2 (Proposed)



Bicycle Miles Travelled by Facility

Facility	Scenario 1: Existing Conditions	Scenario 2: w/Proposed Improvements	Change
Trail	15%	20%	6
Local			
standard	46%	33%	-14
bike boulevard	0%	12%	11
Collector			
no bike lane	8%	6%	-3
bike lane	2%	4%	2
Minor Arterial			
no bike lane	12%	5%	-7
bike lane	5%	12%	7
Arterial			
no bike lane	9%	4%	-5
bike lane	2%	4%	2
Total	100%	100%	

Exposure Along Street Segments

Dangerous Situation	Metric Conditions	Scenario 1: Existing Conditions (Annual BMT)	Scenario 2: w/Proposed Improvements (Annual BMT)	Change (Annual BMT)	Percent Change
Mixed cycling in harsh traffic	No bike lane Vehicle volume > 3,000 AADT	666,000	272,000	-394,000	-59%
Dedicated ROW in harsh traffic	Bike lane Vehicle volume > 8,000 AADT	97,000	250,000	153,000	158%
Cramped space	Veh. lane width < 12 ft Vehicle volume > 1,000 AADT Vehicle speed limit > 20 mph	307,000	180,000	-127,000	-41%
Dooring and vehicle parking	Vehicle parking turnover > 4 per hr	2,646,000	2,746,000	100,000	4%
Frequent access points	Access points > 30 per mile	3,923,000	3,847,000	-76,000	-2%
Steep grade	Grade > 4%	197,000	197,000	0	0%
Wrong-way riding	Wrong-way riding occurrence	134,000	145,000	11,000	8%
Infrequent cyclers	Cyclist volume < 15 AADB	1,151,000	1,096,000	-55,000	-5%

Exposure at Intersections

Dangerous Situation	Metric Conditions	Scenario 1: Existing Conditions (Annual Bicyclists)	Scenario 2: w/Proposed Improvements (Annual Bicyclists)	Change (Annual Bicyclists)	Percent Change
Crossing harsh intersections	Cross street vehicle volume > 2,000 AADT	7,114,000	6,647,000	-467,000	-7%
Right hook	Vehicle right turns > 1,000 AADT	605,000	577,000	-28,000	-5%
Left sneak	Oncoming thru vehicle volume > 2,000 AADT	7,516,000	7,523,000	7,000	0%
Thru clip	Oncoming left-turn vehicle volume > 1,000 AADT	615,000	613,000	-2,000	0%

Hot Spot Analysis

Right Hook Exposure

Conclusions

The GIS tools are operational, easy to use, and require commonly available data.

Interesting dynamics in dangerous turn movements

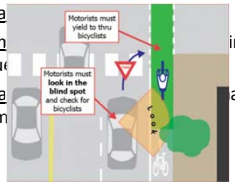
- 5% decrease in right hook exposure
- 7% reduction in harsh intersection crossings

Next Steps

1. Submit academic paper for publication
   - Accident Analysis and Prevention
   - Transportation Research Record
2. Present at the APA Washington Conference
   - October, in Spokane
   - w/ WSDOT & City of Bellingham

Future Work

1. Improved Data
2. Safety Perform … imate expected accident freque…
3. Crash Modifica… reduction from … ate expected



Condition: Collector and Arterial Intersection

SPF: expected right hook accidents = $\beta_0 + \beta_1$(right hook exposure)

CMF: green painted conflict zone = 12% reduction

Bicycle Demand Estimation and Dangerous Situation Analysis

Washington APA,
Spokane, Washingotn, October 16-17, 2014
Mike Lowry and Seth Cool, University of Idaho

Outline

Tool 1: Estimate Bicycle Volumes

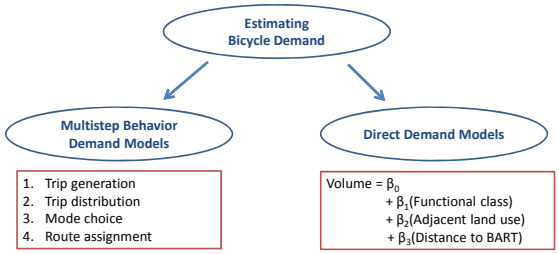
Tool 2: Assess Dangerous Situation Exposure

APA Washington Annual Planning Conference
Legacy & Prophecy
EXPLORE the past ASPIRE for the future EVOLVE in the present
APA WA

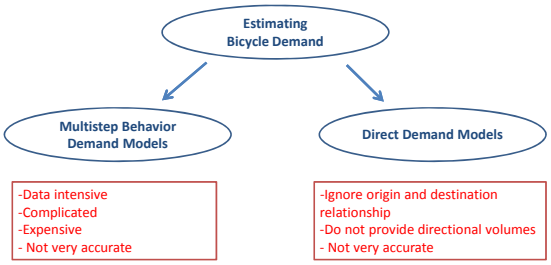
Tool 1

ESTIMATE BICYCLE VOLUMES

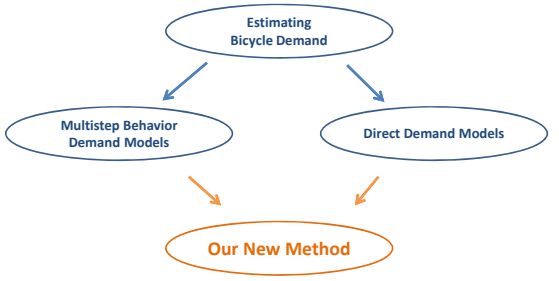
Background



Background



Background



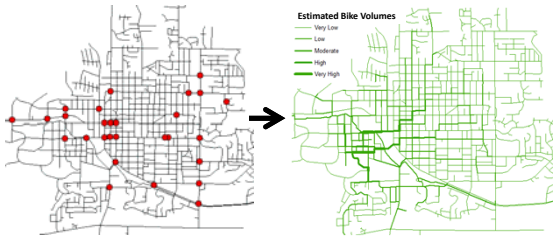
Snap shot of volumes

Origins:
Residential Parcels

Destinations:
Non-residential Parcels

Network Flow

Network Flow
-Minimize distance
-Favor bike lanes
-Avoid slope (grade)
-Avoid car traffic
-Avoid turns

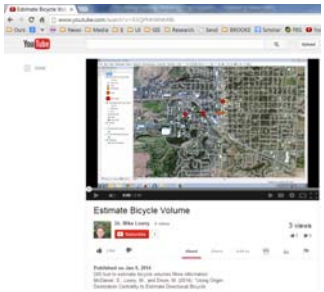


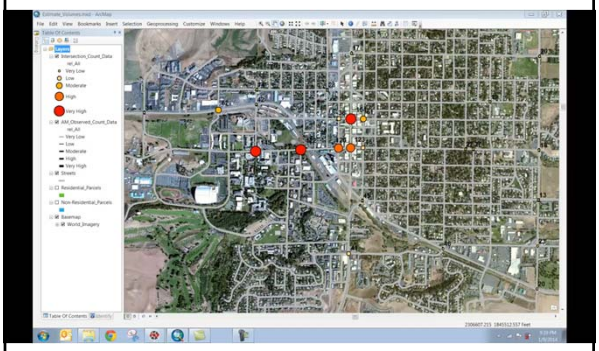
Observed Count Points

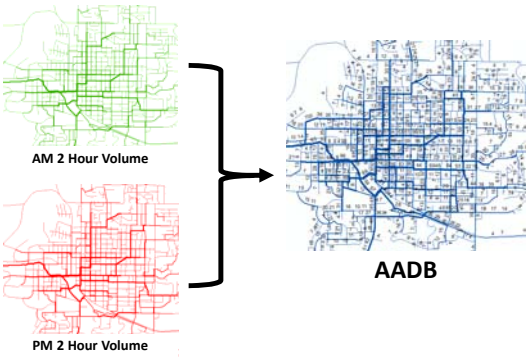
Network-wide 2 Hour Volume

[Volume Estimation Demonstration video]

http://www.youtube.com/watch?v=dMp2XIQaykw







Scenario Planning

Scenario Planning

Third Street Bicycle Volumes Existing and Forecasted

Intersection Cross Street	Existing Conditions (AADB)	Proposed Scenario (AADB)
Van Buren Street	24	226
Harrison Street	28	230
Tyler Street	32	230
Polk Street	44	253
Taylor Street	89	239
Fillmore Street	127	255
Pierce Street	146	255

Increase of about 200 bicyclists per day.

Increase of about 150 bicyclists per day.

Tool 2

ASSESS DANGEROUS SITUATION EXPOSURE

Background

Challenge of Accident Analysis

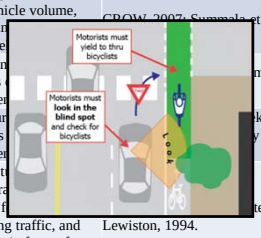
1. Lack of Volume Data
2. Lack of Accident Data

Dangerous Situations
(Situational Antecedents to accidents)

	Dangerous Situation	Description	References
1	Hazardous mixed cycling	Cyclin… with h… speed, … vehicle…	…ROW 2007; Kim …ley et al., 2004; …
2	Hazardous separated cycling	Cyclin… vehicle… and/or… vehicle…	…0; Reynolds et …11; Van Houten
3	Cramped space	Narrow… lane or should…	…rkey and
4	Excessive space	Wide travel la… bike lane.	…04; Hunter et al.,
5	Dooring	Street segmen… street parking… parking turnover…	

	Dangerous Situation	Description	References
6	Driveways	Street segments with frequent or unexpected access points.	Räsänen and Summala, 1998.
7	Railroad tracks	Crossing or riding alongside railroad tracks.	Teschke et al. 2012.
8	Poor pavement	Pot holes and abrupt uneven surfaces.	-
9	Winding road	Frequent and/or sudden sharp curves.	Kim et al., 2007.
10	Steep hills	Hilly terrain and/or steep grades.	Teschke et al., 2012, Klop and Khattak, 1999.

	Dangerous Situation	Description	References
11	Hazardous crossing	Crossing a road with high vehicle volume, speed, ar… heavy ve…	CROW, 2007; Summala et al., 1996.
12	Oncoming left cross	Oncomin… vehicles … movemen…	…mala et al.,
13	Right hook	Right-tur… conflicts … movemen…	…k, 2014; …y and Gilbert,
14	Left sneak	For left t… across tra… waiting f… oncoming traffic, and sneaking in front of oncoming.	…tel and Lewiston, 1994.
15	Complicated Intersection	Navigating for example, five point intersections or roundabouts.	Daniels et al., 2009.



	Dangerous Situation	Description	References
16	Bikeway gap	Discontinuity in bicycle network.	Mekuria et al., 2012; Krizek and Roland, 2005.
17	Wrong-way riding	Cycling the wrong-way.	Hunter et al., 1999; Summala et al., 1996.
18	Sidewalk riding	Cycling on sidewalks.	Schimek, 2014.
19	Safety in numbers	Low cyclist volume.	Nordback et al., 2014, Jacobsen, 2003.
20	Crowded path	High volume shared use paths.	Teschke et al., 2012; CROW 2007.

	Dangerous Situation	Description	References
21	Reckless riding	Riding behavior that is unsafe.	Minikel 2012; Kim et al., 2007.
22	Bad weather	Inclement weather that decreases visibility and/or cyclist control.	Kim et al., 2007.
23	Darkness	Insufficient lighting.	Schimek, 2014; Reynolds et al., 2009.

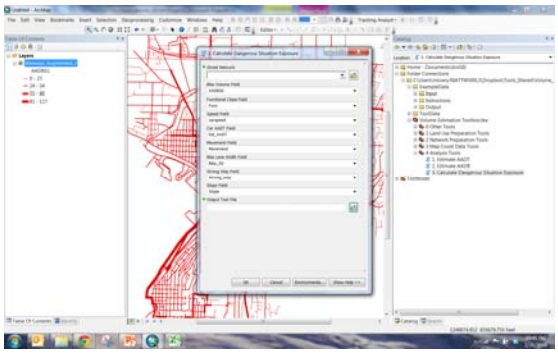
Step 1. Define Exposure Metrics

Dangerous Situation	Conditions and Thresholds
Hazardous mixed cycling	>3,000 AADT, >30 mph, >5% heavy vehicle
Hazardous separated cycling	>8,000 AADT, >50 mph, >10% heavy vehicle
Cramped space	lane width < 12 ft, >1,000 AADT, >20 mph,
Dooring	on street parking, turnover > 4 per hour
Driveways	access points > 30 per mile
Steep hills	grade > 4%

Community-specific metrics should be based on:

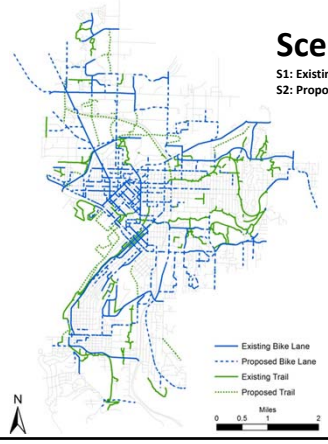
- **Public involvement**
- **Local experience**
- **Latest research**

Step 2. Calculate Exposure



Scenarios

S1: Existing Conditions
S2: Proposed Improvements



AADB

Scenario 1 (Existing)

Scenario 2 (Proposed)

Exposure Along Street Segments

Dangerous Situation	Conditions and Thresholds	Existing Conditions (BMT)	Proposed Plan (BMT)	Change (BMT)	Percent Change (%)
Hazardous mixed cycling	>3,000 AADT, >30 mph, >5% heavy vehicle	11,437	5,138	-6,299	-55%
Hazardous separated cycling	>8,000 AADT, >50 mph, >10% heavy vehicle	4,860	5,977	+1,117	+23%
Cramped space	mixed cycling, lane and shoulder width < 12 ft, >1,000 AADT, >20 mph,	1,349	1,059	-290	-21%
Excessive space	mixed cycling, lane width > 15 ft	8,684	3,232	-5,452	-63%
Dooring	on street parking, turnover > 4 per hour	13,545	13,186	-359	-3%
Driveways	access points > 30 per mile	16,592	17,324	+732	+4%
Steep hills	grade > 4%	9,680	9,832	+152	+2%
Safety in numbers	< 200 AADB	40,503	41,003	+500	+1%
Wrong-way riding	wrong-way riding occurrence	252	236	-16	-6%

Exposure at Intersections

Dangerous Situation	Conditions and Thresholds	Scenario 1: Existing Conditions (AADB)	Scenario 2: w/Proposed Improvements (AADB)	Change (AADB)	Percent Change (%)
Hazardous crossing	bicyclist traveling straight, cross street: > 8,000 AADT, > 50 mph, > 10% heavy vehicle	31,595	33,297	+1,702	+5%
Oncoming cross	bicyclist traveling straight, oncoming left-turning AADT > 2,000	45,577	42,516	-3,061	-7%
Right hook	bicyclist traveling straight, right turning vehicles > 2,000 AADT	51,603	47,737	-3,866	-7%
Left sneak	bicyclist turning left, adjacent vehicles > 8,000 AADT oncoming vehicles > 8,000 AADT	9,015	8,798	-217	-2%

Hot Spot Analysis

Right Hook Exposure

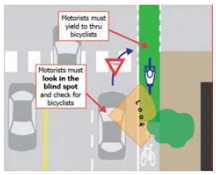
Future Work

1. Create Safety Performance Functions (SPFs) based on exposure.

Expected Number of Right Hook Accidents = $\beta_0 + \beta_1$(right hook exposure)

2. Create Crash Modification Factors (CMFs) to for improvements.

green paint => 12% reduction



Conclusions

New tools are…

- **Inexpensive and easy to use,**
- **Require commonly available GIS data, and**
- **Can produce very good results.**

Tool 1: Estimate Bicycle Volumes

McDaniel, S., Lowry, M., and Dixon, M. (2014). "Using Origin-Destination Centrality to Estimate Directional Bicycle Volumes." *Transportation Research Record: Journal of the Transportation Research Board*.

Tool 2: Assess Dangerous Situation Exposure

Cool, S. and Lowry, M. (Forthcoming). "Quantifying dangerous situation exposure for bicyclists" Scheduled Submission January, 2014.