Planning & Implementing a Citywide Bicycle Network in Bellingham, WA

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

Plan Development Process
- Data Collection
- Draft Plan
- Final Plan
- Public and Stakeholder Input

Target Audience for Increasing Bicycle Mode Share
- Interested
- But Concerned - 60%
- No Way/No How - 33%
- Strong & Enthusiastic - 6%
- Feared & Confident - 1%
- Source: Portland, OR DOT

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

<table>
<thead>
<tr>
<th>Facility Type</th>
<th>Existing Network Miles</th>
<th>Percent</th>
<th>Complete Network (Existing + Recommended)</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bike Lanes</td>
<td>31.9</td>
<td>82%</td>
<td>73.7</td>
<td>44%</td>
</tr>
<tr>
<td>Buffered Bike Lanes</td>
<td>0.0</td>
<td>0%</td>
<td>4.0</td>
<td>2%</td>
</tr>
<tr>
<td>Shared Lane Markings</td>
<td>0.4</td>
<td>1%</td>
<td>7.3</td>
<td>4%</td>
</tr>
<tr>
<td>Climbing Lane</td>
<td>0.7</td>
<td>2%</td>
<td>6.6</td>
<td>5%</td>
</tr>
<tr>
<td>Bicycle Boulevard</td>
<td>0.0</td>
<td>0%</td>
<td>52.1</td>
<td>31%</td>
</tr>
<tr>
<td>Paved Shoulder</td>
<td>5.7</td>
<td>15%</td>
<td>5.7</td>
<td>3%</td>
</tr>
<tr>
<td>Cycle Track</td>
<td>0.0</td>
<td>0%</td>
<td>0.8</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Further Study</td>
<td>0.0</td>
<td>0%</td>
<td>9.4</td>
<td>6%</td>
</tr>
<tr>
<td>Marked Route</td>
<td>0.0</td>
<td>0%</td>
<td>7.8</td>
<td>5%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>38.7</td>
<td>100%</td>
<td>169.4</td>
<td>100%</td>
</tr>
</tbody>
</table>

Project Prioritization Criteria

Table 3.14: Project Prioritization Methodology
**Project Prioritization Methodology**

Safety  Demand  Equity  Heat Map

Connectivity Stress Level  BMP Network Prioritization Score

**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

---

**Bellingham Bicycle Master Plan**

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

Existing Conditions

Adding the Kentucky/Nevada/Texas Bike Boulevard
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)

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!
Questions
Chris Comeau, AICP CTP
Transportation Planner
(360) 778-7946 or ccomeau@cob.org
Project Goal:
Create a sketch level process to quantify bicycle exposure for scenario analysis.

- BACKGROUND
- METHOD
- RESULTS
- CONCLUSIONS

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
Method

Step 1. Spatially Extrapolate Across Network

Step 2. Temporally Extrapolate 2 Hour to AADB

Step 3. Define Exposure Metrics

Step 4. Calculate Exposure

ADJUSTMENT FACTORS


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

**AADB Adjustment Factors based on:**

<table>
<thead>
<tr>
<th>Time</th>
<th>AM Two Hour</th>
<th>PM Two Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nordback,</td>
<td>0.15</td>
<td>0.10</td>
</tr>
<tr>
<td>Marshall,</td>
<td>0.15</td>
<td>0.10</td>
</tr>
<tr>
<td>Janson.</td>
<td>0.16</td>
<td>0.19</td>
</tr>
<tr>
<td>Monday</td>
<td>0.15</td>
<td>0.10</td>
</tr>
<tr>
<td>Tuesday</td>
<td>0.16</td>
<td>0.19</td>
</tr>
<tr>
<td>Wednesday</td>
<td>0.16</td>
<td>0.19</td>
</tr>
<tr>
<td>Thursday</td>
<td>0.15</td>
<td>0.10</td>
</tr>
<tr>
<td>Friday</td>
<td>0.14</td>
<td>0.11</td>
</tr>
<tr>
<td>Saturday</td>
<td>0.11</td>
<td>0.21</td>
</tr>
<tr>
<td>Sunday</td>
<td>0.10</td>
<td>0.21</td>
</tr>
<tr>
<td>January</td>
<td>1.43</td>
<td>1.97</td>
</tr>
<tr>
<td>February</td>
<td>1.38</td>
<td>1.94</td>
</tr>
<tr>
<td>March</td>
<td>1.13</td>
<td>1.25</td>
</tr>
<tr>
<td>April</td>
<td>0.91</td>
<td>1.00</td>
</tr>
<tr>
<td>May</td>
<td>0.99</td>
<td>1.00</td>
</tr>
<tr>
<td>June</td>
<td>0.99</td>
<td>1.00</td>
</tr>
<tr>
<td>July</td>
<td>0.67</td>
<td>0.77</td>
</tr>
<tr>
<td>August</td>
<td>0.67</td>
<td>0.77</td>
</tr>
<tr>
<td>September</td>
<td>0.77</td>
<td>0.71</td>
</tr>
<tr>
<td>October</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>November</td>
<td>1.54</td>
<td>1.47</td>
</tr>
<tr>
<td>December</td>
<td>1.54</td>
<td>1.47</td>
</tr>
</tbody>
</table>

**Step 2. Temporally Extrapolate 2 Hour to AADB**

\[
\text{AADB} = \left( \frac{V_{\text{AM}} - V_{\text{PM}}}{V_{\text{AM}} + V_{\text{PM}}} \right) \times \frac{2}{2} \times \frac{2}{2} = \text{AADB}
\]

**Step 3. Define Exposure Metrics**

*Community-specific metrics should be based on:*

- Public involvement
- Local experience
- Latest research

<table>
<thead>
<tr>
<th>Dangerous Situations</th>
<th>Metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Separated cycling</td>
<td>Bike lane volume &gt; 8,000 AADT</td>
</tr>
<tr>
<td>Bike lane</td>
<td>Vehicle volume &gt; 8,000 AADT</td>
</tr>
<tr>
<td>No bike lane</td>
<td>Vehicle volume &gt; 3,000 AADT</td>
</tr>
<tr>
<td>Cramped space</td>
<td>Vehicle lane width &lt; 12 ft</td>
</tr>
<tr>
<td>Parking maneuvers</td>
<td>Parking turnover &gt; 4 maneuvers per hr</td>
</tr>
<tr>
<td>Parking blockings</td>
<td>Access points &gt; 30 per mile</td>
</tr>
<tr>
<td>Cramped space</td>
<td>Vehicle speed limit &gt; 20 mph</td>
</tr>
<tr>
<td>Traffic density</td>
<td>Vehicle volume &gt; 1,000 AADT</td>
</tr>
<tr>
<td>Traffic density</td>
<td>Vehicle volume &gt; 1,000 AADT</td>
</tr>
</tbody>
</table>

**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

<table>
<thead>
<tr>
<th>Facility</th>
<th>Scenario 1: Existing Conditions</th>
<th>Scenario 2: w/Proposed Improvements</th>
<th>Change</th>
<th>Percent Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trail</td>
<td>51%</td>
<td>37%</td>
<td>-6</td>
<td></td>
</tr>
<tr>
<td>Local</td>
<td>standard</td>
<td>40%</td>
<td>-14</td>
<td></td>
</tr>
<tr>
<td>Local</td>
<td>bike boulevard</td>
<td>19%</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Collector</td>
<td>no bike lane</td>
<td>9%</td>
<td>-3</td>
<td></td>
</tr>
<tr>
<td>Collector</td>
<td>bike lane</td>
<td>6%</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td>Minor</td>
<td>no bike lane</td>
<td>19%</td>
<td>7%</td>
<td></td>
</tr>
<tr>
<td>Minor</td>
<td>bike lane</td>
<td>6%</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>100%</td>
<td>0%</td>
<td></td>
</tr>
</tbody>
</table>

Exposure Along Street Segments

<table>
<thead>
<tr>
<th>Dangerous Situation</th>
<th>Metric Conditions</th>
<th>Scenario 1: Existing Conditions</th>
<th>Scenario 2: Proposed Improvements</th>
<th>Change</th>
<th>Percent Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed cycling in harsh traffic</td>
<td>666,000</td>
<td>272,000</td>
<td>-394,000</td>
<td>-59%</td>
<td></td>
</tr>
<tr>
<td>Dedicated ROW in harsh traffic</td>
<td>97,000</td>
<td>290,000</td>
<td>-13,000</td>
<td>-15%</td>
<td></td>
</tr>
<tr>
<td>Cramped space</td>
<td>187,000</td>
<td>180,000</td>
<td>-7,000</td>
<td>-4%</td>
<td></td>
</tr>
<tr>
<td>Parking and vehicle packing</td>
<td>2,406,000</td>
<td>2,706,000</td>
<td>296,000</td>
<td>12%</td>
<td></td>
</tr>
<tr>
<td>Planned access points</td>
<td>6,020,000</td>
<td>6,447,000</td>
<td>427,000</td>
<td>7%</td>
<td></td>
</tr>
<tr>
<td>Parking area &lt; 10 par cycle</td>
<td>181,000</td>
<td>145,000</td>
<td>-36,000</td>
<td>-20%</td>
<td></td>
</tr>
<tr>
<td>Parking area &gt; 10 par cycle</td>
<td>781,000</td>
<td>780,000</td>
<td>0</td>
<td>0%</td>
<td></td>
</tr>
</tbody>
</table>

Exposure at Intersections

<table>
<thead>
<tr>
<th>Dangerous Situation</th>
<th>Metric Conditions</th>
<th>Scenario 1: Existing Conditions</th>
<th>Scenario 2: Proposed Improvements</th>
<th>Change (Annual Bicyclists)</th>
<th>Percent Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crossing harsh intersections</td>
<td>7,114,000</td>
<td>6,647,000</td>
<td>-467,000</td>
<td>-7%</td>
<td></td>
</tr>
<tr>
<td>Right hook</td>
<td>Vehicle right turns &gt; 1,000 AADT</td>
<td>665,000</td>
<td>377,000</td>
<td>-28,000</td>
<td>-5%</td>
</tr>
<tr>
<td>Left hook</td>
<td>Oncoming left-turn vehicle volume &gt; 1,000 AADT</td>
<td>7,516,000</td>
<td>7,523,000</td>
<td>7,000</td>
<td>0%</td>
</tr>
<tr>
<td>Turn-up</td>
<td>Oncoming left-turn vehicle volume &gt; 1,000 AADT</td>
<td>615,000</td>
<td>613,000</td>
<td>-2,000</td>
<td>-0%</td>
</tr>
</tbody>
</table>
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 Performance Functions (SPFs) to estimate expected accident frequency
3. Crash Modification Factors (CMFs) to estimate expected reduction from proposed improvements

Condition: Collector and Arterial Intersection
SPF: expected right hook accidents = β₀ + β₁(right hook exposure)
CMF: green painted conflict zone = 12% reduction

Thank you... ...Questions?
Tool 1: Estimate Bicycle Volumes

Bicycle Demand Estimation and Dangerous Situation Analysis

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

Outline

Tool 1: Estimate Bicycle Volumes

Tool 2: Assess Dangerous Situation Exposure

ESTIMATE BICYCLE VOLUMES

Background

- Data intensive
- Complicated
- Expensive
- Not very accurate

Our New Method

Volume = β_0 + β_1(FUNCTIONAL CLASS) + β_2(ADJACENT LAND USE) + β_3(DISTANCE TO BART)

- Take origin and destination relationship into account
- Provide directional volumes
- More accurate
Snap shot of volumes

Origins: Residential Parcels
Destinations: Non-residential Parcels

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=dMpZxIqaykw
Scenario Planning

<table>
<thead>
<tr>
<th>Intersection Cross Street</th>
<th>Existing Conditions (AADB)</th>
<th>Proposed Scenario (AADB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Van Buren Street</td>
<td>24</td>
<td>230</td>
</tr>
<tr>
<td>Harrison Street</td>
<td>28</td>
<td>230</td>
</tr>
<tr>
<td>Tyler Street</td>
<td>32</td>
<td>230</td>
</tr>
<tr>
<td>Polk Street</td>
<td>44</td>
<td>253</td>
</tr>
<tr>
<td>Taylor Street</td>
<td>89</td>
<td>239</td>
</tr>
<tr>
<td>Fillmore Street</td>
<td>127</td>
<td>255</td>
</tr>
<tr>
<td>Pierce Street</td>
<td>146</td>
<td>255</td>
</tr>
</tbody>
</table>

Increase of about 200 bicyclists per day.
Increase of about 150 bicyclists per day.

Background

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

Tool 2
ASSESS DANGEROUS SITUATION EXPOSURE
**Dangerous Situations (Situational Antecedents to accidents)**

<table>
<thead>
<tr>
<th>Dangerous Situation</th>
<th>Description</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazardous oncoming cycling</td>
<td>Cramped space or vehicle conflict.</td>
<td>Kim et al., 2007; Reynolds et al., 2009.</td>
</tr>
<tr>
<td>Hazardous separated cycling</td>
<td>Oncoming left-turning vehicle.</td>
<td>Kim et al., 2007; Reynolds et al., 2009.</td>
</tr>
<tr>
<td>Cramped space</td>
<td>Narrow lane or shoulder.</td>
<td>Kim et al., 2007; Reynolds et al., 2009.</td>
</tr>
<tr>
<td>Driveways</td>
<td>Inefficient driving behavior.</td>
<td>Kim et al., 2007; Reynolds et al., 2009.</td>
</tr>
<tr>
<td>Steep hills</td>
<td>Steep terrain or steep grades.</td>
<td>Kim et al., 2007; Reynolds et al., 2009.</td>
</tr>
</tbody>
</table>

**Dangerous Situations (Situation Conditions)**

<table>
<thead>
<tr>
<th>Dangerous Situation</th>
<th>Description</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>11 Hazardous crossing</td>
<td>Cross with high vehicle volume.</td>
<td>CROW, 2007; Summala et al., 1996.</td>
</tr>
<tr>
<td>12 Oncoming left-turning vehicle</td>
<td>Right hook conflicts.</td>
<td>Hunter et al., 1999; Summala et al., 1996.</td>
</tr>
<tr>
<td>13 Right hook</td>
<td>For left-turning cyclist.</td>
<td>Hunter et al., 1999; Summala et al., 1996.</td>
</tr>
<tr>
<td>14 Left sneak</td>
<td>Complicated intersection.</td>
<td>Hunter et al., 1999; Summala et al., 1996.</td>
</tr>
</tbody>
</table>

**Step 1. Define Exposure Metrics**

**Community-specific metrics should be based on:**
- Public involvement
- Local experience
- Latest research

---

**Antecedents**

- Hazardous oncoming cycling
- Hazardous separated cycling
- Cramped space
- Driveways
- Steep hills

**Situation Conditions**

- Hazardous crossing
- Oncoming left-turning vehicle
- Right hook
- Left sneak
- Complicated intersection

**Situation References**

- Kim et al., 2007
- Reynolds et al., 2009
- Hunter et al., 1999
- Summala et al., 1996

---

**Steep hills**

- Hill terrain and/or steep grades.

---

**Step 1. Define Exposure Metrics**

**Community-specific metrics should be based on:**
- Public involvement
- Local experience
- Latest research
Step 2. Calculate Exposure

Exposure Along Street Segments

<table>
<thead>
<tr>
<th>Dangerous Situation</th>
<th>Conditions and Thresholds</th>
<th>Existing Conditions (AADB)</th>
<th>Proposed Plan (AADB)</th>
<th>Change (AADB)</th>
<th>Percent Change (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazardous mixed cycling</td>
<td>&gt; 10,000 AADT, &gt; 30 mph, &gt; 10% heavy vehicle</td>
<td>11,437</td>
<td>5,138</td>
<td>-6,299</td>
<td>-55%</td>
</tr>
<tr>
<td>Hazardous separated cycling</td>
<td>&gt; 20 mph, &gt; 10% heavy vehicle</td>
<td>4,860</td>
<td>5,477</td>
<td>+617</td>
<td>+22%</td>
</tr>
<tr>
<td>Crushed space</td>
<td>mixed cycling, lane and shoulder width &lt; 12 ft, &gt; 1,000 AADT, &gt; 20 mph</td>
<td>1,349</td>
<td>1,059</td>
<td>-290</td>
<td>-21%</td>
</tr>
<tr>
<td>Exposure space</td>
<td>mixed cycling, lane width &gt; 15 ft</td>
<td>8,684</td>
<td>7,222</td>
<td>-1,462</td>
<td>-17%</td>
</tr>
<tr>
<td>Crossing</td>
<td>at street parking; turnover &gt; 4 per hour</td>
<td>13,045</td>
<td>13,186</td>
<td>+141</td>
<td>+1%</td>
</tr>
<tr>
<td>Roundabouts</td>
<td>access points &gt; 10 per mile</td>
<td>16,092</td>
<td>17,124</td>
<td>+1,032</td>
<td>6%</td>
</tr>
<tr>
<td>Lane widths</td>
<td>grade &gt; 4%</td>
<td>9,680</td>
<td>9,680</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Safety in numbers</td>
<td>&lt; 200 AADB</td>
<td>40,303</td>
<td>41,303</td>
<td>+100</td>
<td>+1%</td>
</tr>
<tr>
<td>Wrong-way riding</td>
<td>wrong-way riding occurrence</td>
<td>252</td>
<td>236</td>
<td>-16</td>
<td>-6%</td>
</tr>
</tbody>
</table>

Exposure at Intersections

<table>
<thead>
<tr>
<th>Dangerous Situation</th>
<th>Conditions and Thresholds</th>
<th>Scenario 1: Existing Conditions (AADB)</th>
<th>Scenario 2: w/Proposed Improvements (AADB)</th>
<th>Change (AADB)</th>
<th>Percent Change (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazardous crossing</td>
<td>bicyclist traveling straight, cross street: &gt; 8,000 AADT, &gt; 50 mph, &gt; 10% heavy vehicle</td>
<td>31,506</td>
<td>33,287</td>
<td>+1,781</td>
<td>+5%</td>
</tr>
<tr>
<td>Obtuse crossing</td>
<td>bicyclist traveling straight, encountering left turning AADT &gt; 1,000</td>
<td>45,577</td>
<td>43,514</td>
<td>-2,063</td>
<td>-7%</td>
</tr>
<tr>
<td>Right bow</td>
<td>bicyclist traveling straight, right turning vehicles &gt; 2,000 AADT</td>
<td>51,603</td>
<td>47,737</td>
<td>-3,866</td>
<td>-7%</td>
</tr>
<tr>
<td>Left cross</td>
<td>bicyclist turning left, adjacent vehicles &gt; 8,000 AADT</td>
<td>9,015</td>
<td>8,786</td>
<td>-229</td>
<td>-2%</td>
</tr>
</tbody>
</table>
Conclusions
New tools are...
- Inexpensive and easy to use,
- Require commonly available GIS data, and
- Can produce very good results.

Future Work
1. Create Safety Performance Functions (SPFs) based on exposure.
   \[
   \text{Expected Number of Right Hook Accidents} = \beta_0 + \beta_1(\text{right hook exposure})
   \]
2. Create Crash Modification Factors (CMFs) to for improvements.
   Green paint => 12% reduction

Thank you...
...Questions??

Tool 1: Estimate Bicycle Volumes

Tool 2: Assess Dangerous Situation Exposure