Applying the Highway Safety Manual to the Alternative Selection Process: A Case Study in Missoula, Montana

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Presentation Overview

- Highway Safety Manual overview
- Crash frequency prediction process
- Application to a multimodal corridor
- Results
Missoula, Montana

- Population 68,000 (2009)
  - 2nd largest city in Montana
- Located in the Rocky Mountains
- Active population
  - Outdoor activities
  - Politics
- Home of the University of Montana
Highway Safety Manual

- Published in 2010 by AASHTO
  - American Association of State Highway and Transportation Officials
- Definitive, science-based manual
- Provides quantitative methods for conducting safety evaluations
HSM Contents

- Part A – Introduction and Fundamentals
  1: Introduction
  2: Human Factors
  3: Fundamentals
- Part B – Roadway Safety Management
  4: Network Screening
  5: Diagnosis
  6: Select Countermeasures
  7: Economic Evaluation
  8: Prioritization
  9: Safety Effectiveness Evaluation
- Part C – Predictive Method
  10: Two-Lane Rural Highways
  11: Multilane Rural Highways
  12: Urban and Suburban Arterials
- Part D – Crash Modification Factors
  13: Roadway Segments
  14: Intersections
  15: Interchanges
  16: Special Facilities
  17: Networks
- Glossary
Part B – Roadway Safety Management Process

- Part B provides tools to implement and maintain a quantitative, systematic, process for studying roadway safety.
**Part D – Crash Modification Factors**

- CMFs are ratios showing the expected change in the number of crashes attributed to particular countermeasures.

\[
CMF = \frac{\text{Expected crash frequency with countermeasure}}{\text{Expected crash frequency without countermeasure}}
\]

- Part D presents CMFs for:
  - Roadway segments
  - Intersections
  - Interchanges
  - Special facilities and geometric situations
  - Road networks
Predicting Crash Frequency

- Process to predict average number of crashes per year
- Addresses the issue of regression to the mean
Applying the Predictive Method

Your Site's Predicted Crashes = \left( \frac{\text{Default Prediction for Generic Sites}}{\text{Safety Performance Function}} \right) \times \left( \frac{\text{Adjustment Factors for Local Conditions}}{\text{Crash Modification Factors}} \right) \times \left( \text{Calibration Factor} \right)

N_p = \left( \frac{\text{Safety Performance Function}}{\text{Crash Modification Factors}} \right) \times \left( \text{Calibration Factor} \right)

N_p = \left( N_{spf} \right) \times \left( \text{CMF}_1 \times \text{CMF}_2 \ldots \text{CMF}_n \right) \times C
Russell Street Corridor, Missoula, Montana

- 2.5 km study area
- Contains one of five bridge crossings in the city
- 2–3 lane cross-section
- Average daily traffic volumes range from 25,000 (north end) to 20,000 (south end)
- Important route for bicycle commuters
- Funding secured for project implementation
Russell Street/3rd Street EIS Evaluation

- 2000 – Environmental Impact Statement (EIS) initiated
  - Design year volumes for 2025
- 2005 – First traffic analysis completed
  - Updated in 2007
- 2008 – Draft EIS completed
- 2009 – Traffic analysis update
  - Design year volumes for 2035
- Late 2010 – Record of Decision anticipated
Why Update the Analysis?

- Update travel demand model to current design year
- Public opposition to the Draft EIS
  - *One advocacy group formed specifically to fight*
  - *Bike/pedestrian groups uneasy*
  - *Opinion that safety was not sufficiently quantified*
- City Council responsibility to represent public
Analysis Update Components

- Detailed vehicular operations
  - Synchro
  - VISSIM

- Multimodal performance measures
  - NCHRP Report 616
    (measures to be included in Highway Capacity Manual 2010)

- Safety performance measures
  - Highway Safety Manual, Chapter 12
Existing Crash Conditions

PROPERTY DAMAGE ONLY CRASHES (7/04-6/08)

INJURY CRASHES (7/04-6/08)
## Alternatives

<table>
<thead>
<tr>
<th>Segment/Intersection</th>
<th>DEIS Alternatives</th>
<th>Option 6</th>
<th>Option 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>W. Broadway</td>
<td><img src="image1" alt="Alt 1" /></td>
<td><img src="image2" alt="Alt 2" /></td>
<td><img src="image3" alt="Alt 3" /></td>
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<tr>
<td>W. Broadway to Wyoming</td>
<td><img src="image2" alt="Alt 2" /></td>
<td><img src="image3" alt="Alt 3" /></td>
<td><img src="image4" alt="Alt 4" /></td>
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<tr>
<td>Wyoming</td>
<td><img src="image8" alt="Traffic" /></td>
<td><img src="image9" alt="Traffic" /></td>
<td><img src="image10" alt="Traffic" /></td>
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<tr>
<td>Wyoming to S. 3rd</td>
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<tr>
<td>S. 3rd</td>
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<td><img src="image9" alt="Traffic" /></td>
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<tr>
<td>S. 3rd to S. 5th</td>
<td><img src="image8" alt="Traffic" /></td>
<td><img src="image9" alt="Traffic" /></td>
<td><img src="image10" alt="Traffic" /></td>
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<tr>
<td>S. 5th</td>
<td><img src="image8" alt="Traffic" /></td>
<td><img src="image9" alt="Traffic" /></td>
<td><img src="image10" alt="Traffic" /></td>
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<tr>
<td>S. 5th to S. 6th</td>
<td><img src="image8" alt="Traffic" /></td>
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<tr>
<td>S. 6th to S. 8th</td>
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<td><img src="image9" alt="Traffic" /></td>
<td><img src="image10" alt="Traffic" /></td>
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<tr>
<td>S. 8th to S. 11th-Knowles</td>
<td><img src="image8" alt="Traffic" /></td>
<td><img src="image9" alt="Traffic" /></td>
<td><img src="image10" alt="Traffic" /></td>
</tr>
<tr>
<td>S. 11th-Knowles</td>
<td><img src="image8" alt="Traffic" /></td>
<td><img src="image9" alt="Traffic" /></td>
<td><img src="image10" alt="Traffic" /></td>
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<tr>
<td>S. 11th-Knowles to S. 14th-Mount</td>
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<tr>
<td>S. 14th-Mount</td>
<td><img src="image8" alt="Traffic" /></td>
<td><img src="image9" alt="Traffic" /></td>
<td><img src="image10" alt="Traffic" /></td>
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</tbody>
</table>

**Traffic control alt.**

**Cross-section alt.**
Predicted Average Crash Frequency

- Calculations done in Excel spreadsheets

<table>
<thead>
<tr>
<th>Segment</th>
<th>From</th>
<th>To</th>
<th>Segment Type</th>
<th>N_{base}</th>
<th>N_{base}</th>
<th>N_{predicted(n=100)}</th>
<th>N_{predicted(n=1000)}</th>
<th>N_{predicted(n=10000)}</th>
<th>N_{predicted(n=100000)}</th>
<th>N_{predicted(n=1000000)}</th>
<th>N_{predicted(n=10000000)}</th>
<th>N_{predicted(n=100000000)}</th>
<th>N_{predicted(n=1000000000)}</th>
<th>N_{predicted(n=10000000000)}</th>
<th>N_{predicted(n=100000000000)}</th>
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<tbody>
<tr>
<td>1</td>
<td>Broadway St</td>
<td>N of Bridge</td>
<td>2J</td>
<td>0.09</td>
<td>0.05</td>
<td>2.76</td>
<td>0.91</td>
<td>1.84</td>
<td>1.24</td>
<td>0.35</td>
<td>0.68</td>
<td>0.16</td>
<td>0.02</td>
<td>0.13</td>
<td>1.22</td>
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<tr>
<td>2</td>
<td>N of Bridge</td>
<td>S of Bridge</td>
<td>2J</td>
<td>0.10</td>
<td>0.05</td>
<td>2.87</td>
<td>0.88</td>
<td>1.90</td>
<td>2.42</td>
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<td>1.73</td>
<td>0.30</td>
<td>0.04</td>
<td>0.26</td>
<td>0.00</td>
</tr>
<tr>
<td>3</td>
<td>S of Bridge</td>
<td>River St</td>
<td>2J</td>
<td>0.08</td>
<td>0.03</td>
<td>1.83</td>
<td>0.57</td>
<td>1.26</td>
<td>1.40</td>
<td>0.42</td>
<td>1.06</td>
<td>0.18</td>
<td>0.03</td>
<td>0.16</td>
<td>0.07</td>
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<tr>
<td>4</td>
<td>River St</td>
<td>Main St</td>
<td>3T</td>
<td>0.06</td>
<td>0.04</td>
<td>1.55</td>
<td>0.51</td>
<td>1.04</td>
<td>0.83</td>
<td>0.21</td>
<td>0.48</td>
<td>0.05</td>
<td>0.01</td>
<td>0.04</td>
<td>0.77</td>
</tr>
<tr>
<td>5</td>
<td>Idaho St</td>
<td>Montana St</td>
<td>3T</td>
<td>0.06</td>
<td>0.04</td>
<td>1.42</td>
<td>0.49</td>
<td>0.93</td>
<td>0.82</td>
<td>0.27</td>
<td>0.55</td>
<td>0.07</td>
<td>0.02</td>
<td>0.05</td>
<td>0.44</td>
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<tr>
<td>6</td>
<td>Montana St</td>
<td>Wyoming St</td>
<td>3T</td>
<td>0.06</td>
<td>0.03</td>
<td>1.32</td>
<td>0.45</td>
<td>0.87</td>
<td>0.80</td>
<td>0.23</td>
<td>0.54</td>
<td>0.07</td>
<td>0.02</td>
<td>0.05</td>
<td>0.37</td>
</tr>
</tbody>
</table>
Results of the Crash Analysis

Alternatives 2, 3, and 5-R were rated as “good”
Alternative 4 and Options 6 and 7 were rated as “fair”
Alternative 1 (no-build) was rated as “poor”
  - Roundabouts, medians, and left turns account for the biggest differences
  - The predicted proportion of fatality/injury crashes is lower in alternatives with roundabouts

<table>
<thead>
<tr>
<th>Percentage of Crashes Compared to No-Build Scenario (Alternative 1)</th>
<th>3-Lane Volume Scenario</th>
<th>5-Lane Volume Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alt 1</td>
<td>Alt 2</td>
<td>Alt 3</td>
</tr>
<tr>
<td>100%</td>
<td>67%</td>
<td>65%</td>
</tr>
</tbody>
</table>
Results of the Overall Corridor Analysis

<table>
<thead>
<tr>
<th>Performance Measure</th>
<th>DEIS Alternatives</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Alt 1</td>
<td>Alt 2</td>
</tr>
<tr>
<td>Safety</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Automobile</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pedestrian</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bicycle</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Good**: Black circle
- **Fair**: Half-black circle
- **Poor**: White circle

Kittelton & Associates, Inc.
Transportation Engineering/Planning
Challenges

- Local calibration data not available
  - Resolution: Calculate predicted average crash frequencies for each scenario and compare on a relative basis to the respective no-build scenario (3-lane or 5-lane)

- Unable to predict pedestrian/bike crashes at roundabouts
  - Resolution: Did not include pedestrian/bicyclist crashes in results (used multimodal level of service instead)

- No multimodal level of service method for roundabouts
  - Resolution: Applied concepts from signalized and unsignalized intersection methodologies in a hybrid methodology
Conclusions

- The HSM provided a quantitative method for comparing intersection control options and roadway segment cross-sections

- The analysis provided an effective means for evaluating trade-offs between design features

- The results assisted the engineers in effectively communicating with the public and with elected officials
Questions?

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