Applying HSM Crash Prediction to Manage Transportation Networks

ITE Western District Annual Meeting
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Presentation overview

• HSM background
• Case Study #1: Network Analysis
• Case Study #2: Corridor Analysis
Background: The AASHTO HSM

- Qualitative analysis → quantitative prediction
- Statistically rigorous methods reduce bias
HSM Content

Part A – Introduction and Fundamentals
- 1: Introduction
- 2: Human Factors
- 3: Fundamentals

Part B – Roadway Safety Management Process
- 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
What Investment is Required?

- **Data collection and management**
  - 3 to 5 years of crash data
  - Average Daily Traffic volume (ADT)
  - Roadway geometry and traffic control
- **Training**
  - Staff education
- **Calibration factors**
- **Resources**
  - Highway Safety Manual
  - Spreadsheet tools
  - Optional software (HiSafe)
Case Study #1: Network Analysis

- City of Bend, Oregon
- Population 80,000
- Study goal: establish a safety management program
  - Understand crash patterns
  - Prioritize safety projects
  - Improve collaboration with other agencies
City of Bend Safety Program: Background and Need

Current Limitations
- Perceived Safety
- Reactive
- One-time
- Uncoordinated

Opportunities
- Objective Safety
- Proactive
- Repeatable
- Coordinated

Objective vs. Perceived Safety

Proactive vs. Reactive Measures

Repeatable vs. One-time Actions

Coordinated vs. Uncoordinated Strategies

MOVING FORWARD THINKING
Performance-based Framework

- Benchmarking
  - Network Screening
    - Safety Effectiveness Evaluation
    - Prioritize Projects
    - Economic Appraisal
  - Diagnosis
    - Select Countermeasures
City of Bend Safety Program: Framework

**Benchmarking**
- Establish focus areas
- Identify measurable goals

**Network Screening**
- Identify sites within each focus area

**Diagnosis**
- Identify contributing factors and potential countermeasures

**Project Ranking**
- Apply crash prediction method to prioritize implementation
## Network Screening: Select Performance Measures

<table>
<thead>
<tr>
<th>Statistical Bias/Data Requirement Continuum*</th>
<th>City of Bend Implementation Category</th>
<th>Network Screening Performance Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short-term – Data is available</td>
<td>Crash Frequency</td>
<td></td>
</tr>
<tr>
<td>Medium-term – Requires volume data</td>
<td>Equivalent Property Damage Only Crash Frequency</td>
<td></td>
</tr>
<tr>
<td>Excess Proportion of Specific Crash Types</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long-term – Requires calibrated safety performance functions and detailed geometric information</td>
<td>Relative Severity Index</td>
<td></td>
</tr>
<tr>
<td>Crash Type Performance Threshold</td>
<td></td>
<td></td>
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<tr>
<td>Excess Predicted Crashes Using SPFs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level of Service of Safety</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expected Crash Frequency with EB Adjustment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EPDO Crash Frequency with EB Adjustment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excess Expected Crash Frequency with EB Adjustment</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Network Screening: Results

<table>
<thead>
<tr>
<th>Site Rank</th>
<th>High Ranking Intersections by Performance Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Site Rank</strong></td>
<td><strong>RSI</strong></td>
</tr>
<tr>
<td>1</td>
<td>HIGHWAY 20/ NE 8TH ST</td>
</tr>
<tr>
<td>2</td>
<td>HIGHWAY 20/ NE GREENWOOD AVE</td>
</tr>
<tr>
<td>3</td>
<td>HIGHWAY 97/ POWERS RD</td>
</tr>
<tr>
<td>4</td>
<td>REED MARKET RD/ SE 3RD ST</td>
</tr>
<tr>
<td>5</td>
<td>BROSTERHOUS RD/ SE 3RD ST</td>
</tr>
<tr>
<td>6</td>
<td>NE NEFF RD/ NE PURCELL BLVD</td>
</tr>
<tr>
<td>7</td>
<td>POWERS RD/ SE 3RD ST</td>
</tr>
<tr>
<td>8</td>
<td>NE 3RD ST/ NE FRANKLIN AVE</td>
</tr>
<tr>
<td>9</td>
<td>NW OLNEY AVE/ NW WALL ST</td>
</tr>
<tr>
<td>10</td>
<td>NW FRANKLIN AVE/ NW WALL ST</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### FIELD REVIEW OBSERVATIONS AND FINDINGS

<table>
<thead>
<tr>
<th>Contributing Factors</th>
<th>Potential Countermeasures</th>
<th>Crash Modification Factor (CMF)</th>
</tr>
</thead>
</table>
| 1) Multi-lane pedestrian crossing (north-south) | • Road diet (reduce cross-section to three lanes with center left-turn lane and bike lanes)  
• Provide striped crossing and advanced warning signage  
• Provide intersection illumination               | • 0.71                                   |
| 2) On-street parking reduces pedestrian sight distance | • Extend on-street parking restriction 10-15 feet upstream of crosswalks  
• Provide bulb-outs to improve pedestrian sight distance at intersection | • N/A                                     |
| 3) No major-street left-turn lanes          | Road diet (reduce cross-section to three lanes with center left-turn lane and bike lanes) | 0.71                                     |
Project Ranking

1. **Quantify benefits of countermeasures**
   1. No-build crash cost – CMF * No-build crash cost = cost savings (benefit)
   2. Monetary cost of crashes from FHWA's Technical Advisory "Motor Vehicle Accident Costs"

2. **Estimate cost of countermeasures**
3. **Calculate cost-benefit ratios of projects**
4. **Rank by B-C Ratio**
## Project Results

<table>
<thead>
<tr>
<th>Location</th>
<th>Countermeasures</th>
<th>Benefit/Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Division Street/Revere Ave</td>
<td>• Signal Timing and Left-turn Phasing&lt;br&gt;• Road Diet</td>
<td>9.8</td>
</tr>
<tr>
<td>Neff Road/Purcell Boulevard</td>
<td>• Eliminate Right-turn-on-red&lt;br&gt;• Convert to protected-only left-turn</td>
<td>8.0</td>
</tr>
<tr>
<td>Awbrey Road/Portland Avenue</td>
<td>• Mini Roundabout</td>
<td>2.8</td>
</tr>
<tr>
<td>Mt. Washington/Archie Briggs Road</td>
<td>• Curve warning signs, guard rail</td>
<td>1.8</td>
</tr>
<tr>
<td>Franklin Ave/Wall St</td>
<td>• Eliminate right-turn lane</td>
<td>1.2</td>
</tr>
<tr>
<td>Greenwood Ave/Hill Street</td>
<td>• Curb extension&lt;br&gt;• Illumination</td>
<td>0.4</td>
</tr>
</tbody>
</table>
City of Bend Safety Program: Background and Need

Current Limitations
- Perceived safety
- Reactive
- One-time
- Uncoordinated

Opportunities
- Objective safety
- Proactive
- Repeatable
- Coordinated

Outcomes
- Effective use of safety funds
- Justifies spending on safety projects
- Comprehensive plan incorporating 5 E’s

Effective use of safety funds
Justifies spending on safety projects
Comprehensive plan incorporating 5 E’s

MOVING FORWARD THINKING
Case Study #2: SR 46 Corridor Safety Study

- Facility: 7.4 miles of two-lane rural highway in Seminole County, Florida
- Goal: Evaluate crash history and identify countermeasures to reduce crash frequency and severity
  - Identify project cost-benefit ratios to justify funding and objectively prioritize projects
• Corridor crash trends
  - 30% rear-end
  - 24% run-off-road
  - 45% at night

• Contributing Factors
  - Careless Driving
  - Failure to Yield ROW
  - Excessive Speeds
Richmond Avenue to St Johns River Bridge
25 crashes (44% injury, 4% fatality)
Prevailing crash types: run-off road (32%), rear-end (28%)
Corridor Crash Map

Mullet Lake Park Road to Avenue C
28 crashes (21% injury, 4% fatality)
Prevailing crash types: run-off road (25%), sideswipe (18%)
SR 46 & CR 426
25 crashes (28% injury)
Prevailing crash types: rear-end (44%), turning (36%)
Case Study #2: Potential Safety Countermeasures

- **Countermeasures include:**
  - Roadway Improvements
    - Centerline / shoulder rumble strips
  - Roadside Improvements
    - Widen paved shoulder
    - Increase distance to roadside features (i.e. extend clear zone)
  - Signage Improvements
    - Intersection warning signage with street name plaque
    - Increased retroreflectivity
  - Intersection Improvements
    - Provide left and/or right-turn lane(s)
    - Pave existing gravel or dirt approaches
    - Intersection lighting
  - Access Management
    - Driveway consolidation
Case Study #2: Existing Scenario Crash Prediction

- 5-Year Historical Period (2007-2011)
  - 20.8 reported crashes per year
- Expected Number of Crashes from HSM Crash Prediction Models
  - 26.8 crashes per year
- SR 46 Traffic Volumes in 2011
  - 10,000 AADT
Case Study #2: Future “No Build” Scenario Crash Prediction

- Projected traffic volume growth through 2020
  - 18,000 AADT
- Roadway segments and intersections do not change
- Expected number of crashes from HSM crash prediction models
  - 44.9 crashes in 2020
- Average annual cost of crashes through 2020
  - $4,080,000 per year
### Case Study #2: Countermeasure Evaluation

**Benefit**
- Identify CMFs for countermeasures
- Calculate crash reduction

**Cost**
- Estimate construction cost of countermeasures

**Prioritize**
- Rank countermeasures by cost per crash reduced
- Organize projects into tiers for prioritizing implementation (greatest benefit per dollar spent)

#### Example

<table>
<thead>
<tr>
<th>Location</th>
<th>Expected Annual Crashes</th>
<th>Countermeasure</th>
<th>CMF</th>
<th>Crash Reduction</th>
<th>Construction Cost</th>
<th>Cost per Crash Reduced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mullet Lake Park Rd to Avenue C</td>
<td>10.5</td>
<td>Install centerline rumble strips</td>
<td>86%</td>
<td>1.47</td>
<td>$29,400</td>
<td>$20,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Install shoulder rumble strips</td>
<td>86%</td>
<td>1.47</td>
<td>$35,100</td>
<td>$23,878</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Widen paved shoulder from 4 to 5 ft</td>
<td>96%</td>
<td>0.42</td>
<td>$144,200</td>
<td>$343,333</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Increase distance to roadside features</td>
<td>87%</td>
<td>1.37</td>
<td>$676,200</td>
<td>$495,385</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Install a passing lane</td>
<td>87%</td>
<td>1.37</td>
<td>$764,900</td>
<td>$560,366</td>
</tr>
</tbody>
</table>
### Case Study #2: “Build” Scenario – Tier I Benefit / Cost Analysis

#### Example Locations

<table>
<thead>
<tr>
<th>Location</th>
<th>Project Countermeasures</th>
<th>Project CMF</th>
<th>Construction Cost</th>
<th>No-Build Crash Costs</th>
<th>Build Crash Costs</th>
<th>Project Benefit</th>
</tr>
</thead>
</table>
| Mullet Lake Park Rd to Avenue C | · Install centerline rumble strips  
· Install shoulder rumble strips  
· Install intersection warning signage  
· Pave gravel approach at Torren Pt | 74%         | $87,000          | $8,813,000          | $6,518,000        | $2,295,000      |
| SR 46 & Avenue C | · Install intersection warning signage  
· Provide a N/WB left-turn lane on SR 46 at Woodbridge | 72%         | $1,000           | $2,377,000          | $1,711,000        | $666,000        |
| Avenue C to CR 426 | · Install centerline rumble strips  
· Install shoulder rumble strips  
· Install Intersection warning signage  
· Install retroreflective tape on signal Ahead sign pole | 74%         | $22,000          | $2,842,000          | $2,102,000        | $740,000        |
| SR 46 & CR 426 | · Install street name plaque at Signal Ahead sign  
· Relocate stop bars to improve sight distance for RTOR  
· Upgrade intersection signage, internally illuminated signs | 77%         | $9,000           | $2,993,000          | $2,305,000        | $688,000        |
## Case Study #2: Project Benefits

- **Tier I Projects**
  - Centerline/shoulder rumble strips, turn lanes, signage improvements

- **Tier II Projects**
  - Widen paved shoulders, turn lanes, intersection lighting, pave minor intersection approaches

- **Tier III Projects**
  - Widen paved shoulders, increase roadside clear zone, install a passing lane, access management

<table>
<thead>
<tr>
<th>Project Tier</th>
<th>Total Project Cost</th>
<th>Project Cost Thru 2020</th>
<th>Project Benefit Thru 2020</th>
<th>Average B/C Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>$472,000</td>
<td>$258,000</td>
<td>$7,495,000</td>
<td>29.1</td>
</tr>
<tr>
<td>II</td>
<td>$1,164,000</td>
<td>$636,000</td>
<td>$1,452,000</td>
<td>2.3</td>
</tr>
<tr>
<td>III</td>
<td>$2,870,000</td>
<td>$1,570,000</td>
<td>$1,769,000</td>
<td>1.1</td>
</tr>
</tbody>
</table>
Conclusions

• Process is adaptable to networks or corridors
• Objective
  – Supports federal funding requirements (MAP 21)
  – Justifies spending
  – Supports decisions
Questions?

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