Applying the Highway Safety Manual at the Regional and Local Level

- **Presenters**
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Agenda

- Traffic Safety Background
- Highway Safety Manual (HSM) Overview
- HSM Tools
- Questions
Traffic Safety Background

- Far too many people are dying from traffic crashes
- Traffic safety is an epidemic
- Decade of Action for Road Safety launched by United Nations 5/12/11
- FHWA has established Toward Zero Deaths
- Some states have set a goal of Zero Fatalities
  - Is that possible?
  - What is a good goal for your family?
How many people are killed on America's roads?
Highway Safety Manual (HSM) Overview

- Proven and science-based approach
- Characterizes the safety effects (i.e., crash frequency and severity) of decisions and actions
- Highway Safety Manual V1 released 2010 by AASHTO
- Based on Highway Capacity Manual
- Not mandated by FHWA
HSM = Substantive Safety

Nominal Safety → Substantive Safety

Standards Compliance

Expected or Actual Crash Frequency and Severity
HSM Primary Benefits

• Better safety analysis tools to support decision making

• Cost-effective investments in safety

• More lives saved and serious injuries avoided
Where Does HSM Fit in Project Cycle

- All transportation projects, although limitations on data
- Applies to:
  - Planning
  - Pre-design and Scoping
  - Design
  - Construction
  - Operations
Applying the HSM in Planning

- Incorporate HSM into Long-Range Plans
  - Access Management Policy
  - Roundabout First Policy
- Incorporate HSM into Corridor Planning
  - Frequency of intersections
  - Frequency of driveways
  - Parking
  - Median types
Applying the HSM in Pre-design and Scoping

- Project scoping
  - Safety of project design alternatives
  - Component of project prioritization
- Environmental Analysis
  - Evaluate alternatives
Applying the HSM in Design & Construction

- Design Alternatives
  - Geometric parameters such as lane or shoulder width, rumble strips
  - Design exceptions
  - Design criteria
  - Time duration of work zones
Applying the HSM in Operations

- Performance measures
  - Safety performance evaluation

- Operations
  - Before/after studies
  - Operational strategies such as signal timing, signal phasing, or roundabouts versus signals
Crash Modification Factor (CMF)

\[
CMF = \frac{\text{EXPECTED CRASHES WITH TREATMENT}}{\text{EXPECTED CRASHES WITHOUT TREATMENT}}
\]

<table>
<thead>
<tr>
<th>CMF</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMF = 1.0</td>
<td>Expected to have no impact on safety</td>
</tr>
<tr>
<td>CMF &lt; 1.0</td>
<td>Expected to reduce crashes</td>
</tr>
<tr>
<td>CMF &gt; 1.0</td>
<td>Expected to increase crashes</td>
</tr>
</tbody>
</table>

\[
\text{CRF} = (1 - \text{CMF}) \times 100
\]

10.1 crashes / year x 0.91 (CMF) x 1.04 (CMF) = 9.6 crashes / year:
- a reduction of 0.5 total crashes per year and a CRF of 5%
CMF Application

- CMFs from HSM Part D, FHWA CMF Clearinghouse (4 stars or above)
- CMF selected must match project
  - Situational – area type, time of day
  - Geometrics – number of lanes, driveway density
  - Operational – ADT, crash history
- Applying multiple CMFs must be used cautiously
Why Not Use Just Historical Crash Data?

- Variation in short term crash data

![Graph showing variation in short-term observed crash frequency over years. The graph includes short-term average crash frequency and expected average crash frequency.](image)
Why Not Use Just Historical Crash Data?

- Regression-to-the-mean

![Figure 3-5. Regression-to-the-Mean (RTM) and RTM Bias](image)
Predictive Method

SAFETY PERFORMANCE FUNCTION (SPF)
Predictive Method

**SPF CRASH MODIFICATION FACTOR**

The crash predictions are calculated based on the particular roadway conditions for a homogenous site/segments specified by a SPF. These SPFs have particular CMFs associated with their development and are included in the HSM for that particular roadway type. All of the CMFs associated with a SPF in the HSM may be applied to the crash reduction calculations, unlike the CMF method, which is limited to three.

<table>
<thead>
<tr>
<th>CMF</th>
<th>Expected crashes with treatment</th>
<th>Expected crashes without treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Expected to have no impact on safety</td>
<td></td>
</tr>
<tr>
<td>&lt; 1.0</td>
<td>Expected to reduce crashes</td>
<td></td>
</tr>
<tr>
<td>&gt; 1.0</td>
<td>Expected to increase crashes</td>
<td></td>
</tr>
</tbody>
</table>
A calibration factor ($C$) is applied to adjust the estimated crashes from national data to local conditions by comparing observed crashes for 30 to 50 local sites and the crashes predicted from the national data. Available calibration factors that are to be used will be listed on NDOT’s PSP website and do not need to be calculated on a project basis. If a calibration factor is not available for specific SPF on the NDOT PSP website, a calibration factor of 1 should be used.

\[
C = \frac{\sum \text{Observed Crashes (all sites)}}{\sum \text{Predicted Crashes (all sites)}}
\]
Predictive Method

The estimated crashes are further refined through a weighting process using the Empirical Bayes (EB) method.

- Observed # at a location
- Corrected expected # at this location by EB method
- Potential for Safety Improvement (PSI)
- Predicted # from SPF

Graph showing the relationship between crash # and AADT with an SPF curve.
Predictive Method

- Sample results table

<table>
<thead>
<tr>
<th>Predictive Method results table:</th>
<th>Annual Crashes</th>
<th>Annual Crash Reduction</th>
<th>CRF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing Condition</td>
<td>100</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Project Alternative A</td>
<td>95</td>
<td>5</td>
<td>5%</td>
</tr>
<tr>
<td>Project Alternative B</td>
<td>90</td>
<td>10</td>
<td>10%</td>
</tr>
</tbody>
</table>
### Benefit-Cost Ratio

**BCR** = \( \frac{PV \text{ BENEFITS}}{PV \text{ COSTS}} \)

- **PV BENEFITS** = Present value of project benefits
- **PV COSTS** = Present value of project costs

<table>
<thead>
<tr>
<th>Category</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatal</td>
<td>$5,339,711</td>
</tr>
<tr>
<td>Injury A</td>
<td>$285,349</td>
</tr>
<tr>
<td>Injury B</td>
<td>$104,302</td>
</tr>
<tr>
<td>Injury C</td>
<td>$59,037</td>
</tr>
<tr>
<td>PDO</td>
<td>$9,638</td>
</tr>
</tbody>
</table>
# Benefit-Cost Ratio Sample Table

<table>
<thead>
<tr>
<th></th>
<th>Alt. 1</th>
<th>Alt. 2</th>
<th>Alt. 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CL Rumble Strip</td>
<td>RSA Curve at MP 9</td>
<td>Superelevation Improvements</td>
</tr>
<tr>
<td>Total Alternative Cost</td>
<td>$65,693</td>
<td>$1,474,704</td>
<td>$945,031</td>
</tr>
<tr>
<td>Total Annual Benefit Including 2% Growth Per Year</td>
<td>$270,273</td>
<td>$228,808</td>
<td>$52,956</td>
</tr>
<tr>
<td>Total Annualized Cost</td>
<td>$9,518</td>
<td>$106,429</td>
<td>$69,998</td>
</tr>
<tr>
<td>Benefit-Cost Ratio</td>
<td>28.40</td>
<td>2.15</td>
<td>0.76</td>
</tr>
<tr>
<td>Average Annual Net Return</td>
<td>$260,755</td>
<td>$122,380</td>
<td>($17,043)</td>
</tr>
</tbody>
</table>
### HSM Tools

<table>
<thead>
<tr>
<th>HSM Part</th>
<th>Supporting Tool</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><a href="http://www.safetyanalyst.org">www.safetyanalyst.org</a></td>
</tr>
<tr>
<td>Part C: Predictive Method</td>
<td>IHSDM</td>
</tr>
<tr>
<td></td>
<td><a href="http://www.ihsdm.org">www.ihsdm.org</a></td>
</tr>
<tr>
<td>Part D: Crash Modification Factors</td>
<td>FHWA CMF Clearinghouse</td>
</tr>
<tr>
<td></td>
<td><a href="http://www.cmfclearinghouse.com">www.cmfclearinghouse.com</a></td>
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- NCHRP 1738 Spreadsheets
  - Publicly available spreadsheets for Part C
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- Questions?

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