Transportation Safety: Integrating quantified safety evaluations in project planning

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Presentation Outline

- Overview
- Quantitative Safety Analysis
- Performance-based Analysis
Overview—We hope to share how….

- Performance-based analysis is a means to support project planning and design decisions
- We can make more informed project decisions based on quantitative safety performance
- We are considering factors beyond capacity-based mobility to guide project decisions
Overview

- **The past....**
  - Focusing on maximizing motor vehicle capacity as the measure of project success.
  - Using dimensional values as the primary determinant of design acceptability.
  - Considering design standards as a surrogate for safety.

- **The present....**
  - Considering and integrating pedestrians and bicyclists in design configurations.
  - Using performance-based analyses to support project decision making.
  - Integrating quantitative safety performance in planning, design, and management.

*The future: Incrementally integrating technology into infrastructure and vehicles for maximum safety and mobility performance...*
Safety is a continuum not an absolute

Is a 499 foot radius curve substantially less safe than a 500 foot radius curve?

Source: NCHRP Report 480
Presentation Outline

- Overview
- Quantitative Safety Analysis
- Performance-based Analysis
Quantitative Safety Analysis

Perpetually Chasing Black Spots or Hot Spots

Meaningful and Sustained Crash Reduction

HOT SPOTS  HIGH INJURY CORRIDORS  SYSTEMIC SAFETY  CRASH PREDICTION  SAFETY SYSTEMS

REACTIVE SAFETY  PROACTIVE SAFETY

Traditional Approach
Often Basis for Vision Zero Action Plans

Direction of AASHTO’S Highway Safety Manual
Basis for Performance Based Planning and Design
Quantitative Safety Analysis Benefits

- Measure safety performance objectively (i.e., quantitatively)
  - Differentiate “safety” from “security”

- New tools enhance our current practice
  - Improve reliability
  - Provide new capabilities (e.g., predicting crashes)
  - Quantify safety and compare with other project advantages and disadvantages

- Incorporate new tools and methods in the near-term and plan for further integrating them in the long-term
  - No need to do everything at once
Quantitative Safety Performance begins early, too!

- Safety integration throughout project development process
  - Quantify safety performance
  - Comprehensively address safety issues
  - Cost-effectively reduce crashes
Quantitative Safety Analysis

- Apply tools that quantify safety performance (frequency and severity)
- Conduct objective safety analyses
- Focus on mitigations that best address contributing factors
- Spend your money wisely...be prepared for non-engineering solutions

...We can not “design” our way to target safety performance...
Quantitative Safety Analysis Resources

  - 2nd Edition under development
- FHWA CMF Clearinghouse
  - Crash Modification Factors
  - Weighted and ranked
- Agency-specific SPFs
  - Safety Performance Functions
- Publically accessible spreadsheets
Quantitative Safety Analysis: Network Screening

- Understand available data
  - Crash characteristics
  - Roadway attributes
  - Activity (volume)
  - Context and land use
  - Constraints

- Determine best available safety performance measures
  - What is the focus of the study?
  - What are our analysis constraints?
  - How will the results be used?
Quantitative Safety Analysis: Network Screening

- Three ways of thinking about crashes:
  - Frequency, Severity, Type

- Easy-to-implement *Highway Safety Manual* performance measures:
  - Crash Rate
  - Equivalent Property Damage Only Score
  - Excess Proportion of Crash Types

- Improving statistical confidence
  - Better data
  - Better methods
Network Screening Spectrum

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PROACTIVE SAFETY
Success Story: Pasadena Safer Streets Projects

- Integrated HSM performance measures into their crash database and site selection process
- Developed long-term safety evaluation process
- Identified top projects and develop concept designs
- Successful HSIP Cycle 8 grant for 3 intersections
- Additional grants totaling $1.5 million for the City

Screen Network → Develop Projects → Findings → Get Funded!
Presentation Outline

- Overview
- Quantitative Safety Analysis
- Performance-based Analysis
Performance-based Analyses

- Adapting to each project context
  - Identifying intended project outcomes
  - Establishing whom we are trying to serve
  - Selecting performance measures based on what we are trying to achieve

- Intersection control evaluations
  - Consider safety performance, multi-modal needs, service life, and other metrics beyond traffic operations
  - Alternative intersections and interchanges

- Quantified Safety Performance
  - Highway Safety Manual (AASHTO 2010)

- Multimodal Quality of Service

...Focusing on the “value” of our investments...
Applications of the Predictive Method

- **Safety Management**
  - Network screening to identify high priority sites

- **Corridor and System Planning**
  - Assess and compare safety performance
  - Identify hot spots
  - Identify potential safety improvements and mitigation measures
  - Prioritization criteria

- **Project Scoping and Pre-design**
  - Compare the safety performance of alternatives
  - Evaluate effect of proposed improvements and crash countermeasures
  - Assess the effect of design options (e.g. cross section, horizontal curvature, lighting, etc)
  - Evaluate design exceptions
## HSM Predictive Models

<table>
<thead>
<tr>
<th>Facility</th>
<th>Segment</th>
<th>3-leg Unsig</th>
<th>3-leg Sig</th>
<th>4-leg Unsig</th>
<th>4-leg Sig</th>
<th>5-leg Sig</th>
<th>All-way Stop</th>
<th>Roundabout</th>
<th>SPUI Sig</th>
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<td>4-lane divided</td>
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<td>3-lane (TWLTL)</td>
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<td>4-lane undivided</td>
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<td>Freeways &amp; Interchanges</td>
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</table>
**Existing Conditions:**
- **AADT:** 1,500 (2011); 1,700 (2030)
- 5-Year Crash Data
  - Fatal: 1   Injury: 5   PDO: 14
- Level Terrain
- 12-foot lanes
- 2 foot paved shoulders

**Projects Under Consideration:**
- 8-foot shoulders
- Reconstructing Flying-Y intersection,
- Adding Two Way Left Turn Lane

US 191: MP 38.0 to MP 45.9
### HSM Predictive Method Analysis Results

<table>
<thead>
<tr>
<th></th>
<th>Expected Crash Frequency (crashes per year)</th>
<th>Estimated 20-year Total Crashes</th>
<th>Estimated 20-year Total Crash Reduction</th>
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<tbody>
<tr>
<td></td>
<td>FI</td>
<td>PDO</td>
<td>Total</td>
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<tr>
<td><strong>Existing Roadway</strong></td>
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<tr>
<td>2010</td>
<td>1.6</td>
<td>3.2</td>
<td>4.8</td>
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<tr>
<td>2030</td>
<td>1.9</td>
<td>3.9</td>
<td>5.8</td>
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<tr>
<td><strong>Remove Flying-Y intersection at Pearce Rd</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2010</td>
<td>1.6</td>
<td>3.2</td>
<td>4.8</td>
</tr>
<tr>
<td>2030</td>
<td>1.9</td>
<td>3.8</td>
<td>5.7</td>
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<tr>
<td><strong>Add TWLTL north of SR 181</strong></td>
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<td></td>
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<tr>
<td>2010</td>
<td>1.6</td>
<td>3.2</td>
<td>4.8</td>
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<tr>
<td>2030</td>
<td>1.9</td>
<td>3.8</td>
<td>5.7</td>
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<tr>
<td><strong>Widen shoulders to 8 feet with rumble strips</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>1.3</td>
<td>2.6</td>
<td>3.9</td>
</tr>
<tr>
<td>2030</td>
<td>1.4</td>
<td>3.2</td>
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</table>
## Expected Safety Benefit

<table>
<thead>
<tr>
<th>Crash Costs (ADOT)</th>
<th>Fatal</th>
<th>Injury A</th>
<th>Injury B</th>
<th>Injury C</th>
<th>PDO</th>
<th>Total</th>
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<tbody>
<tr>
<td></td>
<td>$5,800,000</td>
<td>$400,000</td>
<td>$80,000</td>
<td>$42,000</td>
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<td>$4,000</td>
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</table>

**Project: Widen Shoulders to 8 feet with rumble strips**

<table>
<thead>
<tr>
<th>Expected Crash Reduction (average over 20 Years)</th>
<th>0.9</th>
<th>0.9</th>
<th>0.9</th>
<th>3.5</th>
<th>12.4</th>
<th>18.6</th>
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<tr>
<td>Benefit over service life (20 years)</td>
<td>$5,137,143</td>
<td>$354,286</td>
<td>$70,857</td>
<td>$148,800</td>
<td>$49,600</td>
<td>$5,760,686</td>
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Intersection Control Evaluation
### Project Performance Measures

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<tr>
<th>Performance Measure</th>
<th>Traffic Signal</th>
<th>Roundabout</th>
<th>All-Way Stop Control</th>
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<tbody>
<tr>
<td>Weekday Vehicle Delay (hours/year)</td>
<td>52,850</td>
<td>55,150</td>
<td>250,000</td>
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<td>Predicted Crash Frequency</td>
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<tr>
<td>Fatal &amp; Injury</td>
<td>23.2</td>
<td>10.5</td>
<td>10.5</td>
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<tr>
<td>Total</td>
<td>68.5</td>
<td>50.7</td>
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</table>
## Calculate Net Present Value of Costs

<table>
<thead>
<tr>
<th>Cost Categories</th>
<th>Net Present Value of Costs</th>
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<tbody>
<tr>
<td></td>
<td>Traffic Signal</td>
</tr>
<tr>
<td>Planning &amp; Construction Costs</td>
<td>$956,142</td>
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<tr>
<td>Annual Operations and Maintenance Costs</td>
<td>$138,349</td>
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<tr>
<td>Auto Passenger Delay</td>
<td>$13,744,297</td>
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<tr>
<td>Truck Delay</td>
<td>$556,454</td>
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<tr>
<td>Safety</td>
<td>$25,265,135</td>
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<tr>
<td>Greenhouse Gases</td>
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<tr>
<td>Criteria Pollutants</td>
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<tr>
<td><strong>Total cost</strong></td>
<td>$40,660,377</td>
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## Benefit-Cost Analysis

<table>
<thead>
<tr>
<th>Benefit Categories</th>
<th>Net Present Value of Benefits Relative to Base Case</th>
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<tbody>
<tr>
<td></td>
<td>Traffic Signal</td>
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<tr>
<td>Auto Passenger Delay</td>
<td>$51,411,607</td>
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<td>Truck Delay</td>
<td>$2,081,458</td>
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<td>Safety</td>
<td>$(6,625,129)</td>
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<td>Greenhouse Gases</td>
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<td>Criteria Pollutants</td>
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<td><strong>Net Present Value of Benefits</strong></td>
<td><strong>$46,867,936</strong></td>
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<tr>
<td><strong>Net Present Value of Costs</strong></td>
<td><strong>$1,050,022</strong></td>
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<tr>
<td><strong>Present Value of Net Benefits</strong></td>
<td><strong>$45,817,915</strong></td>
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<tr>
<td><strong>Benefit-Cost Ratio</strong></td>
<td><strong>44.64</strong></td>
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</table>
Thank You!