A Context Sensitive Solutions (CSS) Webinar
Flexible & Performance-Based Design Overview

Scott Bradley (MnDOT) - March 13, 2013 - 9:30 am to 11:30 am - U of MN CECC
Webinar Presenters / Panelists

- Scott Bradley - FASLA, Director of CSS, MnDOT
- Jim Rosenow - P.E., Design Flexibility Engineer, MnDOT
- William Stein - P.E., Safety Engineer, FHWA MN Division

Thanks to the University of Minnesota Center for Transportation Studies and their Continuing Education Conference Center for supporting this MnDOT Webinar
Growing out of ISTEA 1991 and NHSDA 1995, this 1997 FHWA Guide explored and illustrated flexibilities and opportunities that already exist to balance community, environmental, safety, and mobility objectives in our transportation projects.

Sufficient flexibility permitted to encourage independent designs tailored to particular situations (Consistent with AASHTO Green Book)

Provoked Birth of CSS
MnDOT Was Positioned for Leadership in CSS

Initial MnDOT “Pilot State” Effort (1999 & 2000)

As a “pilot state”, MnDOT partnered with FHWA’s MN Division & U of MN Center for Transportation Studies in advancing our CSD / CSS approach.

Assembled steering team & advisory group that guided a Principle-Based Approach, Training Development and Deployment, Development of Policy (Tech Memo) and Marketing with an emphasis on (6) Core Principles that were deemed critically important … many deemed Flexibility in Design as the most important principle.

www.dot.state.mn.us (Search A to Z for Context Sensitive Solutions)
Why Flexibility in Design is So Important

It’s Very Difficult To Address & Balance Competing Needs & Objectives Within Constrained Resources & Overly Conservative Design Approaches & Standards
Why Flexibility in Design is So Important

Born Out of Necessity:

- Revenue Limitations
- Increasing Needs
- Increasing Costs
- Deteriorating Infrastructure
- Diminishing Resources
- Complete Streets
- Socio-Economic Concerns
- Environmental Concerns
- Quality of Life Concerns...
CSS & MnDOT’s Strategic Vision & Plan

CSS Elevated as a “Flagship Initiative” in December 2009

- To integrate CSS as a business model
- To build customer relationships & trust
- To improve processes & decision-making
- To balance competing objectives
- To seek collaborative & right-sized solutions
- To improve return on investments
- To achieve 20+ CSS-correlated benefits
MnDOT’s Flexibility in Design Forum
Learning From Ourselves and Others - February, 2009
(Maryland, Massachusetts, Pennsylvania, Kentucky, Missouri, Washington, FHWA)

www.dot.state.mn.us (Search A to Z for Context Sensitive Solutions)
Key Themes - Reallocating Cross-Section Space
How Much Space Do You Really Need and For What?
Nominal Guidelines & Design Standards are often seen and used as general Absolutes without adequately evaluating applicability to unique attributes.

Actual Needs and Substantive Safety and Performance fall on a continuum based upon unique roadway, setting, and user attributes.
Right-Sizing design elements to the point of diminishing returns for Higher Benefit to Cost Ratios and the capability to achieve greater public benefits without greater cost.
MN TH 38 Reconstruction Case Study
2005 AASHTO Best Project Award - National Best Practices in CSS Competition

Flexibility in Design:

• Reduced design speed (50 mph) provided greater geometric flexibility to address constraints and balance the competing objectives

• Upgraded to 10-ton road but maintaining much of the existing horizontal & vertical alignments ... balanced with strategic spot and intersection improvements where accident frequency was documented

• 12’ lanes, 4’ paved shoulders with 2’ of added reinforced soft shoulder, rumble stripes, steeper back slopes and variable ditch cross-sections to minimize adverse environmental impacts and costs
MN TH 38 Reconstruction Case Study

Some Lessons Learned:

• Reconstruction was advanced 10 years ahead of schedule

• Reduced adverse impacts dramatically and costs by more than 40%

• Non-conformance with nominal standards and geometric design guidelines, does not mean a highway will be “substantively” unsafe ... it all depends on the unique combinations of circumstances / attributes

• Total accidents were reduced 55% + in the 5-year analysis after completion of the first reconstruction segment ... even more so in the second reconstruction segment
MN TH 100 Retrofit - St. Louis Park Case Study

Narrowed Lanes & Shoulders to Add 3\textsuperscript{rd} Lane Each Direction

Reduced Congestion & Crashes (13:1 Benefit To Cost Ratio)
MN TH 61 North Shore Hwy Reconstruction Case Studies

Influencing Driver Behavior Through Schroeder, MN

Vehicle Simulator Evaluation of Potential Traffic Calming Options

Contrasting Pavement Colors had the Most Pronounced Influence

More than a 70% Decrease in the Annual Average of Post-Reconstruction Crashes
MN CSAH 3 Excelsior Blvd Case Study
Flexibility in Design - St. Louis Park, MN

Case Study in ITE’s 2006 Proposed Recommended Practice Publication
Reduced design speed and flexibility in design (narrowed lanes, shortened turn lanes, etc.) reallocated space to balance stakeholder needs and objectives while also calming traffic and improving safety for all modes and users.

Other improvements include on street and off street parking in shared mid-block structures, pedestrian safety and comfort amenities, off route bicycle accommodation, near and far side transit stops, public seating and green spaces to create integrated & mutually supportive transportation and land use.

Crashes were reduced over 60% in the first segment of reconstruction.
MnDOT Advanced Flexibility in Design Workshops
Piloted in 2009 and Typically Offered Twice a Year

2.5 Day “Roll Up Your Sleeves” Workshop Focus Includes:

- Rationale for Using Design Flexibility
- Introduction to a Performance Based Approach & Tools
- Using Traffic Data
- Serving All Modes / Users of Transportation
- Risk Management & Safety
- Selecting Design Speed
- Allocating Space in Confined Cross-Sections & Intersections
- Designing Horizontal & Vertical Alignments
- Designing Freeway Interchanges
- Minimizing Construction Impacts
- Classroom Exercises & ADA Field Walk

www.dot.state.mn.us (Search A to Z for Context Sensitive Solutions)
CSS & Performance-Based Design

CSS & Performance-Based Design are both systematic approaches for striving to find “best fit” solutions that consider all the relevant factors of context from planning & project inception thru operations & maintenance.
Some Performance-Based Design Attributes

• Focusing on system context in addition to project context

• Analyzing project alternatives as investments with an understanding of the returns that should be realized … plus the diminishing points of return

• Seeking lower cost & impact approaches targeting acceptable levels of project improvements or measures of effectiveness

• Achieving substantive (as opposed to nominal) safety

• Achieving more safety, mobility and public benefits (rather than less) within the same level of resource constraints and available funding

• Seeking collaborative and right-sized solutions to achieve the best balance points specific to competing project and system-level needs and objectives
What is Performance-Based Design?!?!?!
National Research Scene

Strategic research needs workshop – 2004

<table>
<thead>
<tr>
<th>Topic</th>
<th>AASHTO Votes</th>
<th>TRB Votes</th>
<th>Total Votes</th>
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<td>1.0 Median Type and Design (Crossover Crash)</td>
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<td>Performance-Based Geometric Design Analysis (1.1)</td>
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<td>Multimodal Highway Design for &quot;Complete Streets&quot; (1.2)</td>
<td>6</td>
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<td>Determine the primary and secondary users for various functional</td>
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<td>classes (2.3)</td>
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<td>Investigation of Alternative Geometric Highway Design Processes (</td>
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<td>Design Decision Support) (1.1)</td>
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<td>Horizontal Curve Design Philosophy (Should it be for driver</td>
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<td>comfort?) (1.1)</td>
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<td>Right-turn intersections and channelized right turns/Four-Right</td>
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<td>Turn lane Design and Impacts/Continue the work of NCHRP 3-72 (</td>
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<td>1.7)</td>
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<td>Ramp and Interchange Spacing (2.2)</td>
<td>9</td>
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<td>Transition Zones - Design from High-speed to Low-speed Rural Sections (3.1)</td>
<td>5</td>
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<td>Ramp Design as a System (2.2)</td>
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<td>Freeway - Lane and Shoulder Width (Safety and Operational Trades)</td>
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<td>Safety, operations and usability trade-offs between user groups,</td>
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<td>2.3: Safety and Operational Tradeoffs Roadway Users of Urban</td>
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<td>Cross Section Decisions (2.4)</td>
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<td>Operational and Safety Impacts of Four Lane versus Six Lane with</td>
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<td>4</td>
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<td>Raised Median versus TW/LSTL (coordinated pedestrian accessibility) (2.6)</td>
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<td>Super-elevation Criteria for Sharp Cutoff on Sharp Horizontal</td>
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<td>Curves (1.1)</td>
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<td>Geometric design guidelines for major intersections alternatives to</td>
<td>4</td>
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<td>accommodate multimodal users (pre-interchanges, CFIs,</td>
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<td>interchanges, quadrant roadways, etc.) (2.2)</td>
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<td>Design, safety and operations of pedestrian geometric intersection</td>
<td>3</td>
<td>7</td>
<td>10</td>
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<td>installations (2.3)</td>
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<td>One-lane and Two-lane Loop Ramp Design (2.2)</td>
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<td>Effectiveness of Various Mid-block Crossing Treatments (2.4)</td>
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<td>Intersections to accommodate pedestrian crosswalk cross-</td>
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<td>(Vehicle dynamics and design) (1.2)</td>
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<td>Guidelines for provision of side-walks (1.2)</td>
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<td>3</td>
<td>7</td>
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<td>Safety Effects of Intersection Show Angle (1.2)</td>
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<td>3</td>
<td>7</td>
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<td>Accommodating Bicycles on Rural Highways (2.2)</td>
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<td>Operational and Safety Impacts of Angle versus parallel versus</td>
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<td>backup-in parking (2.4)</td>
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# National Research Scene

## Strategic research needs workshop – 2004

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<td>14</td>
<td>18</td>
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</table>
Substantive Safety

Prediction of the Expected Safety Performance of Rural Two-Lane Highways – 2000
Predictive Modeling

Interactive Highway Safety Design Model – 2003
Predictive Modeling

AASHTO Highway Safety Manual – 2010
Performance-Based Analysis of Geometric Design of Highways and Streets

- NCHRP Project 15-34 (2006-2010)
- NCHRP Project 15-34A (2012-2013)

“The objective of this project is to develop a guide for performance-based analysis of geometric design throughout the development of a project. The guide should identify existing tools for estimating performance and illustrate their use. Further, the guide should describe additional tools or enhancements to existing tools needed for estimating performance and a plan for developing them.”
National Research Scene

TRB: Geometric Design Strategic Research – 2007
# National Research Scene

## TABLE 4 Proposed Research Program Sequence

(Corresponding Numbers for Problem Statements in Part III Shown in Parenthesis)

<table>
<thead>
<tr>
<th>Research Categories</th>
<th>Research Sequence</th>
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<tr>
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<td>Methodology</td>
<td>Performance-based Geometric Design Analysis (2)</td>
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<td>Criteria</td>
<td>Superelevation Criteria for Steep Grades on Horizontal Curves (13)</td>
</tr>
<tr>
<td>Highways</td>
<td>Median Design and Barrier Considerations in Urban and Rural Environments (1)</td>
</tr>
</tbody>
</table>

TRB: *Geometric Design Strategic Research – 2007*
What were we talking about again?
Performance-Based Design?
Definition

Performance-based design
is

designing for performance
Definition

Another way to put it:

an OUTCOME based
rather than
OUTPUT based
methodology
Traditional “Code-Based” Design

...intended to be geared toward performance, but...
### Table 6-1.04A
Distance Between Successive Ramp Terminals (ft)*

<table>
<thead>
<tr>
<th></th>
<th>Entrance – Entrance OR Exit - Exit</th>
<th>Exit – Entrance</th>
<th>Turning Roadways</th>
<th>Entrance - Exit (Weaving)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full Freeway</td>
<td>C-D Road</td>
<td>Full Freeway</td>
<td>C-D Road</td>
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<tr>
<td>Desirable</td>
<td>1500</td>
<td>1200</td>
<td>750</td>
<td>600</td>
</tr>
<tr>
<td>Adequate</td>
<td>1200</td>
<td>1000</td>
<td>600</td>
<td>500</td>
</tr>
<tr>
<td>Absolute Minimum</td>
<td>1000</td>
<td>800</td>
<td>500</td>
<td>400</td>
</tr>
</tbody>
</table>

*Road Design Manual: Ramp Terminal Spacing*
Traditional “Code-Based” Design

It doesn’t account for...

- Respective ramp volumes
- Mainline traffic density
- Speeds
- Geometry
- Signing considerations
- Cost or feasibility of attaining the standard
- Design context
Performance-Based Methodology

“...balance system efficiency and safety with the need to provide access...

“The selection criteria include geometric design needs, operational performance, signing needs, and safety performance.”
Performance Characteristics

- Safety  (Highway Safety Manual)
- Mobility  (Highway Capacity Manual, etc.)
  - Travel time
    - Peak hour
    - Consistency / predictability
  - Throughput
  - Modal accommodation
Performance Characteristics

• Speed
• Surface condition
• Usability
  – Drivability, walkability, bike-ability, ______ability
  – Way finding
  – Traversability (i.e. cross-ability)
  – Other uses…
Performance Characteristics

- Visual quality
- Context sensitivity
- ???

Engineering Judgement

Balancing Design Issues
Code-based vs. Performance-based
Code-based vs. Performance-based
Code-based vs. Performance-based

Joint AASHTO / TRB meeting – Summer 2013

- Applications of HSM in project development
- HSM applications for use in developing geometric design policy & criteria
- Future vision for the Green Book in light of performance based tools and methods
Overall Goal

Tailoring solutions to the unique needs of each project context

Flexible ranges

Criteria

Tools
Questions?
What is the HSM?

Contains Best Science & Research

- Synthesis of previous research
- New research commissioned by AASHTO and FHWA
A primary benefit

Safety and the relative safety of design choices can be better analyzed:

• Quantitatively.
• Objectively.
• Less reliance on judgment or opinion.
Example: Lane Width

This factor applies to single-vehicle run-off-road, multiple-vehicle same direction sideswipe accidents, and multiple-vehicle opposite-direction accidents.

- 1.50 for 9-ft lanes
- 1.30 for 10-ft lanes
- 1.05 for 11-ft lanes
- 1.00 for 12-ft lanes

Average Daily Traffic Volume (veh/day)
Other benefits

• Communicating tradeoffs with the public and local officials.
Other benefits

- Fund projects or improvements that will have the greatest impact.

National Highway Performance Program ($21.8)

Surface Transportation Program ($10.0)

HSIP ($2.2)

CMAQ ($2.2)

Transportation Alternatives ($0.8)

Metro Planning ($0.3)

Railway-Highway Crossing ($0.2)
Other benefits

• Wiser investment of transportation funds.
We ought to understand the expected safety performance of a $250 million investment.

Would you expect these three alternatives to experience the same number and severity of crashes over a 30 year project life? If not, would it be helpful to understand the potential differences when selecting a preferred design alternative?
Useful at various stages of project development.

- Alternatives Development and Analysis
Alternative 1: No Build

- Urban arterial.
- Commercial land use; multiple direct access points.
- Five lanes and 14-ft center two-way left-turn lane.
- On-street parallel parking.
- Sidewalk exists, 3 feet minimum in some locations.
- Overrepresentation of fatal and serious injury crashes involving parked vehicles and vehicles turning left into driveways.
Alternative 2

- Partial, four lanes with raised 14-foot median.
- Partial, five lanes with center two-way left-turn lane.
- Remove on-street parallel parking.
- Provide bus pullouts at selected locations.
- Modify to 12-foot sidewalk with 4-foot landscaped buffer.
Alternative 3

- More comprehensive consolidation of driveways.
- Two lanes in each direction with dedicated HOV lane.
- Additional right-of-way for raised median and left-turn pockets at specific locations.
- Remove on-street parallel parking.
- Provide bus pullouts at selected locations.
- Four-foot landscaped buffer with 5-foot pedestrian path.
## Safety Comparison of Alternatives

<table>
<thead>
<tr>
<th></th>
<th>Fatal and Injury Crashes per year (design year = 2025)</th>
<th>Difference from No Build</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Build – Alt 1</td>
<td>110</td>
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<tr>
<td>Alternative 2</td>
<td>65</td>
<td>45 fewer/year</td>
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<tr>
<td>Alternative 3</td>
<td>45</td>
<td>65 fewer/year</td>
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</table>
A Balance

Safety can now be considered quantitatively along with other goals, impacts, constraints.
Very briefly: A few definitions

For rural two-lane, two-way undivided roadway segments the predictive model is shown in Equation 10-2:

\[
N_{\text{predicted } rs} = N_{spf rs} \times C_r \times (CMF_{lr} \times CMF_{2r} \times ... \times CMF_{12r})
\]  

(10-2)

Where:

- \(N_{\text{predicted } rs}\) = predicted average crash frequency
- \(N_{spf rs}\) = predicted average crash frequency
- \(C_r\) = calibration factor for roadway or geographical area; and
- \(CMF_{lr} \ldots CMF_{12r}\) = crash modification factors

This model estimates the predicted average crashes that would occur regardless of the presence of an intervention.
Very briefly: A few definitions

For rural two-lane, two-way undivided roadway segments the predictive model is shown in Equation 10-2:

\[ N_{\text{predicted } rs} = N_{spf rs} \times C_r \times (CMF_{1r} \times CMF_{2r} \times \ldots \times CMF_{12r}) \]

(10-2)

Where:

- \( N_{\text{predicted } rs} \) = predicted average crash frequency for an individual roadway segment for a specific year;
- \( N_{spf rs} \) = predicted average crash frequency for base conditions for an individual roadway segment;
- \( C_r \) = calibration factor for roadway segments of a specific type developed for a particular jurisdiction or geographical area; and
- \( CMF_{1r} \ldots CMF_{12r} \) = crash modification factors for rural two-lane, two-way roadway segments.

This model estimates the predicted average crash frequency of non-intersection related crashes (i.e., crashes that would occur regardless of the presence of an intersection).
Safety Performance Function (SPF)

- Equation used to estimate or predict the expected average crash frequency per year at a location as a function of traffic volume and roadway or intersection characteristics (e.g., number of lanes, traffic control, type of median, etc.)
  - All crashes
  - Fatal and injury crashes
  - Specific crash types

\[
N_{spfrs} = AADT \times L \times 365 \times 10^{-6} \times e^{(-0.312)}
\]

Where:
- \(N_{spfrs}\) = predicted total crash frequency for roadway segment base conditions;
- \(AADT\) = average annual daily traffic volume (vehicles per day); and
- \(L\) = length of roadway segment (miles).
Safety Performance Function (SPF)

Base Conditions
- Lane width = 12 feet
- Shoulder width = 6 feet
- Shoulder type = paved
- Roadside hazard rating = 3
- Driveway density = 5 driveways per mile
- Horizontal curvature = none
- Vertical curvature = none
- Shoulder/Centerline rumble strips = none
- Passing Lanes = none
- Two-way left turn lanes = none
- Lighting = none
- Automated speed enforcement = none
- Grade = 0%
Crash Modification Factor (CMF)

• Quantifies the change in expected average crash frequency as a result of geometric or operational modifications to a site that differs from set base conditions.
Very briefly: A few definitions

For rural two-lane, two-way undivided roadway segments the predictive model is shown in Equation 10-2:

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\[ N_{\text{predicted } rs} = N_{spf,rs} \times C_r \times \left( \text{CMF}_{1r} \times \text{CMF}_{2r} \times \ldots \times \text{CMF}_{12r} \right) \]  

(10-2)

Where:

\( N_{\text{predicted } rs} \) = predicted average crash frequency for an individual roadway segment for a specific year;

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\( \text{CMF}_{1r} \ldots \text{CMF}_{12r} \) = crash modification factors for rural two-lane, two-way roadway segments.

This model estimates the predicted average crash frequency of non-intersection related crashes (i.e., crashes that would occur regardless of the presence of an intersection).
Calibration factor

- A factor to adjust crash frequency estimates produced from a safety prediction procedure to approximate local conditions. The factor is computed by comparing existing crash data at the state, regional, or local level to estimates obtained from predictive models.
  - Crash reporting thresholds.
  - Crash reporting procedures.
  - Variations in conditions (mountainous parts of a State with snow/ice vs. other areas with only wet winter driving conditions).
US 52 – CR 9
(2003 – 2011)
US 52 – CR 9
(2003 – 2011)
Reduced Conflict Intersection
RCI Safety

- Study looked at 9 sites in Maryland.

<table>
<thead>
<tr>
<th>Crash Reductions by Severity (MD RCI sites)¹</th>
<th>PDO</th>
<th>Injury</th>
<th>Fatal</th>
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<tr>
<td>21%</td>
<td>42%</td>
<td>70%</td>
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</table>
CMF Clearinghouse

A crash modification factor (CMF) is a multiplicative factor used to compute the expected number of crashes after implementing a given countermeasure at a specific site. The Crash Modification Factors Clearinghouse houses a Web-based database of CMFs along with supporting documentation to help transportation engineers identify the most appropriate countermeasure for their safety needs. Using this site, you can search to find CMFs or submit your own CMFs to be included in the clearinghouse.

**Recently Added CMFs**

- Improve pavement friction (increase skid resistance)
  - CMF: 0.866
  - ORF: 13.4
- Crash type: Rear end
- Crash severity: All

- Replace TW TL with raised median
  - CMF: 0.81
  - ORF: 19
  - Crash type: Rear end
  - Crash severity: All

- Convert two-way to all-way stop control
  - CMF: 0.319
  - ORF: 68.1
  - Crash type: All
  - Crash severity: All

This site is funded by the U.S. Department of Transportation Federal Highway Administration and maintained by the University of North Carolina Highway Safety Research Center.
Intersections

• Operations: Highway Capacity Manual and other modeling tools.
• Safety can now be analyzed.
• Intersection Control Evaluation (ICE process).
• HSM methods can assist with considering and analyzing a wider array of intersection types and geometry.
Welcome to the Highway Safety Manual website. Here you can find news, resources supporting implementation of the HSM, and a user discussion forum.

**NEWS:**
- Implementation Guide for Managers from FHWA
- Check out the new Frequently Asked Questions
- New materials from FHWA

**LINKS TO HIGHWAY SAFETY MANUAL PARTNERS:**
- FHWA Highway Safety Manual Website
- TRB Safety Performance Committee Website

**QUICK LINKS:**
- User Discussion Forum
- Spreadsheets for Part C calculations:
  - Download information
  - Direct link to spreadsheets
- FHWA’s “A Guide for Developing Quality Crash Modification Factors”
- Errata for the first edition
- FHWA Resource Center Webinar Recordings
- Overview information
Software tools

• Spreadsheets on the HSM website.
  http://www.highwaysafetymanual.org

• ISATe: Interchange Safety Analysis Tool enhanced.
  http://www.highwaysafetymanual.org/Pages/support.aspx

• Interactive Highway Safety Design Model.
  http://www.ihsdm.org

• Safety Analyst.
  http://www.safetyanalyst.org
There are gaps. 1st Edition.

Table 1 Facility Types with Safety Performance Functions

<table>
<thead>
<tr>
<th>HSM Chapter</th>
<th>Undivided Roadway Segments</th>
<th>Divided Roadway Segments</th>
<th>Intersections</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Stop Control on Minor Leg(s)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3-Leg</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3-Leg</td>
</tr>
<tr>
<td>10 Rural Two-Lane, Two-Way Roads</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>11 Rural Multilane Highways</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>12 Urban and Suburban Arterials</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

- Freeways and interchanges: not in HSM, but models and software are available.
- Shoulder width on bridges.
- Effect of lane width on pedestrian safety (urban arterials).
Predicting pedestrian safety

• NCHRP 17-56: Development of Crash Modification Factors for Uncontrolled Pedestrian Crossing Treatments.
• Develop CMFs by crash type and severity for:
  ➢ Unsignalized pedestrian crosswalk signs and pavement markings, including advance yield markings.
  ➢ Pedestrian hybrid beacon (HAWK signal).
  ➢ Rectangular rapid flashing beacons.
  ➢ Pedestrian refuge areas.
  ➢ Curb extensions.
  ➢ In-pavement warning lights.
  ➢ High-visibility crosswalk marking patterns.
• 10/31/2014 completion date.
• $500,000 budget.
Suggestions

• Start using it on real projects.

• Follow a good process:
  ➢ Clearly understand and identify the problem(s) (purpose & need).
  ➢ Don’t jump to a solution. Examine a range of alternatives, intersection types, etc.
  ➢ Quantify/compare the expected safety performance.
Suggestions

• Work with others.
• Good places to start:
  ➢ Comparing design alternatives.
  ➢ Environmental process.
  ➢ Intersection Control Evaluation.
Highway Safety Manual:
A tool to help us make better decisions and wiser investments.

110 fatal/injury crashes per year

65 fatal/injury crashes per year

45 fatal/injury crashes per year
Contact information

Will Stein
Safety Engineer
FHWA, Minnesota Division
william.stein@dot.gov
651-291-6122
Questions?
Kentucky’s Performance-Based Concept

Practical Solutions

&

Targeted Measures

of “Effectiveness”

Objective and Goal

- Use available funds more efficiently
  - Address more needs faster
  - Complete more projects
  - Opportunities for balancing priorities system-wide

- Deliver an improved system with limited resources

Scott Bradley (MnDOT) - March 13, 2013 - U of MN CECC
Kentucky’s Practical Solutions Concept

KY Practical Solutions Principles-1

- Target the goals/objectives of the Purpose and Need Statement
Kentucky’s Practical Solutions Concept

KY Practical Solutions Principles-2

- Meet anticipated capacity needs

Typical (4 Lane; LOS B)  
Practical (2 Lane; LOS D)

15,000 Vehicles per day

Time of Day
Kentucky’s Practical Solutions Concept

KY Practical Solutions Principles-3

- Evaluate safety compared to the existing conditions

Alternative A
Alternative B
Existing

UK
Kentucky’s Practical Solutions Concept

KY Practical Solutions Principles-4

- Develop and evaluate design options and alternatives
Kentucky’s Practical Solutions Concept

KY Practical Solutions Principles-5

- Maximize design to the point of diminishing return
Kentucky’s Practical Solutions Concept

Typical 2-Lane Rural Kentucky Roadway With 15,000+ ADT

Existing Cross Section
2 Lane, 10 ft L, 2 ft S

Crashes per Year
5.4

Travel Speed (mph)
41.4
Kentucky’s Practical Solutions Concept

Analyzing Safety & Operational Performance of Various Cross Section Alternatives Based Upon Highway Capacity & Safety Manual Procedures
Kentucky’s Practical Solutions Concept

Analyzing Safety & Operational Performance of Various Cross Section Alternatives Based Upon Highway Capacity & Safety Manual Procedures
Kentucky’s Practical Solutions Concept

Considering Mobility Only and Average Speed as the Metric, the Point of Diminishing Returns on Investment for this 15,000 ADT Roadway is at the Width of 52’ (4 Lane Undivided with 12’ Lanes and 2’ Shoulders)
Kentucky’s Practical Solutions Concept

Considering Safety Only and Annual Crash Reductions as the Metric, the Point of Diminishing Returns on Investment for this 15,000 ADT Roadway occurs at a Width of 40’ (2 Lane Highway with 12’ Lanes and 8’ Shoulders)
Kentucky’s Practical Solutions Concept

The Improved 2 Lane Cross Section has Higher Return on Investment as compared to the 4 Lane Cross Section.

At a System Level you get a 200% increase in miles you improve, a 150% increase in total crash reductions and a 9% increase in total travel time reductions ... therefore, a more Practical Solution with a $500 million budget.

Road Improvement Example

<table>
<thead>
<tr>
<th>Cross Section</th>
<th>Crashes per Year</th>
<th>Cost (millions)</th>
<th>Speed (mph)</th>
<th>Total Reductions</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Lane, 10 ft/2 ft</td>
<td>5.4</td>
<td>--</td>
<td>41.4</td>
<td>--</td>
</tr>
<tr>
<td>2 Lane, 12 ft/8 ft</td>
<td>2.9</td>
<td>$7.2</td>
<td>46.7</td>
<td>69.4</td>
</tr>
<tr>
<td>4 Lane, 12 ft/8 ft</td>
<td>2.4</td>
<td>$21.5</td>
<td>55.9</td>
<td>23.3</td>
</tr>
</tbody>
</table>

More miles, fewer crashes and fewer delays for same budget!
Kentucky’s Practical Solutions Concept

Replace 1.8 Miles of 2-Lane Bridge Over Lake Barkley & Kentucky Lake
Kentucky’s Practical Solutions Concept

Meeting their targeted measures (effectiveness) with a 25%+ reduction in the bridge cross-section which makes $80 million available for additional system improvements.
Summary

- More projects with same funds
  - Decreased traffic delays
  - Improved safety
- Potential for setting system-wide approach and priorities
- Appropriate and contextual design
Final Thoughts

- Purpose and need
  - Establish targets
  - Do not exceed them
- Identify true problems
- Think beyond the standards
- Documentation
Key Theme - Optimizing Return on Investments

Smart Transportation Means Flexibility

Right-Sizing design elements to the point of diminishing returns for Higher Benefit to Cost Ratios and the capability to achieve greater public benefits without greater cost.
Implementation

Common performance factors:

• Safety
• Mobility
• Speed
• Surface condition
• Usability
• Visual quality
• Context sensitivity
• Etc…
Implementation

Common performance factors:

• Safety – subject to calibration, local conditions; gaps
• Mobility
• Speed
• Surface condition
• Usability
• Visual quality
• Context sensitivity
• Etc…
Implementation

Common performance factors:
- **Safety** – subject to calibration and local conditions
- **Mobility**
- **Speed** – easy to measure; difficult to predict
- **Surface condition**
- **Usability**
- **Visual quality**
- **Context sensitivity**
- **Etc…**
Implementation

Common performance factors:

- Safety – subject to calibration and local conditions
- Mobility
- Speed – easy to measure; difficult to predict
- Surface condition
- Usability
- Visual quality
- Context sensitivity
- Etc…

 difficult to measure
Implementation

Common performance factors:

- Safety – subject to calibration and local conditions
- Mobility
- Speed – easy to measure; difficult to predict
- Surface condition
- Usability
- Visual quality
- Context sensitivity
- Etc...
Implementation

Measurements of success:

• Functional – improved safety, mobility, etc.
• Community satisfaction and support
• Environmental – compliance and quality
• Social and Economic Progress – enhanced quality of life indicators
• Financial – return on investment, larger-picture sustainability
The Larger Picture

Getting out of the mud
The Larger Picture

Getting out of the mud
The Larger Picture

Getting out of the mud
The Larger Picture

Early geometric design
The Larger Picture

Incremental improvement
The Larger Picture

The "Big Cut"

"BIG CUT" ON SANTA FE TRAIL BETWEEN SANTA FE AND ALBUQUERQUE, NEW MEXICO
The Larger Picture

The ultimate solution
The Larger Picture

The ultimate solution
Wow, was there another way?
In this case, yes

The nuclear option (Project Carryall)
The Soapbox Slide

We need economical solutions that solve problems
not

- $40 million solutions to $400,000 problems
- Solving imaginary or perceived problems
- Sizable expenditure for little or no benefit
  - Overdesign
Overdesign

Figure 4. Conceptual Relationship Between Available Sight Distance and Safety at Crest Vertical Curves

Points of diminishing or zero return
Application

Can we achieve and balance these things...:

- Safety
- Mobility
- Speed
- Surface condition
- Usability
- Visual quality
- Context sensitivity
- Etc...
Application

...within the framework of these things?:

- **Functional** – improved safety, mobility, etc.
- **Community satisfaction and support**
- **Environmental** – compliance and quality
- **Social and Economic Progress** – enhanced quality of life indicators
- **Financial** – return on investment, larger-picture sustainability
Performance-Based Design

MnDOT’s recent one-page briefing:

“...an approach to preserving and building transportation facilities...

...by more skillfully applying investments to address needs and solve problems.”
Performance-Based Design

MnDOT’s recent one-page briefing:

“Building upon traditional policy-based design...
Performance-Based Design

MnDOT’s recent one-page briefing:

“...uses sophisticated analytical tools, flexible design criteria and a value-conscious approach...”
Performance-Based Design

MnDOT’s recent one-page briefing:

“...to balance competing considerations, optimize return on investment and increase local and system-level performance.”
Objectives

50,000-foot View

Not so much to optimize each project as to seek an increased optimization of the entire system.
Objectives

15,000-foot View

Achievement of project goals
• Solving the problems
• Addressing the needs
• Satisfying the stakeholders
Objectives

Ground Level

Applying design elements skillfully, consistent with project objectives and overall principles

• Using design criteria for structure, guidance and consistency

• Using analytical tools to compare alternatives, assess benefits and help weigh considerations
Objectives

Ground Level

Making sound judgments...
Ground Level Judgments

Design Tradeoffs
You can’t have one without the other...

Balance  →  Performance

Judgment

Flexibility

Context

Sensitivity

Judgment
Discussion / Questions