Exploring Performance-Based Solutions & Design Flexibility

Scott Bradley & Greg Ous - MN Dept of Transportation - April 21, 2011
An Initiative Closely Aligned With CSS

Performance-Based Solutions

Performance-Based Solutions are born of necessity to address public needs and economic constraints.

CSS and Performance-Based Solutions are both systematic approaches for striving to find “best fit” solutions considering all relevant factors of context from inception thru operations and maintenance.

Performance-Based Solutions rely on application of CSS principles but add an additional principle: Address system-level context avoiding over-optimization of projects (beyond diminishing returns) at the expense of not being able to achieve more system-level benefits.
An Initiative Closely Aligned With CSS
Performance-Based Solutions “Draft Definition”

A broadly informed and structured decision making process that explores and evaluates design options and trade-offs ... what might be gained and what might be lost ... to determine the best solutions and risk management approaches for balancing competing objectives and for optimizing the ratio of benefits to costs consistent with system level needs and goals and the clearly defined purpose, need, objectives, and scope for a project as agreed to by a full range of affected stakeholders.
An Initiative Closely Aligned With CSS

Attributes of Performance-Based Solutions

• Focusing on system context in addition to project context

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

• Seeking lower cost / lower impact approaches to achieving acceptable levels of project improvements but not beyond diminishing returns for investments

• Applying design flexibility to achieve substantive, rather than nominal, safety

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

• Seeking right-sized and best-fit solutions that achieve the best balance points specific to competing project and system-level objectives
FHWA Promotion of Context Sensitivity
Provocation & Guidance To Think & Act Differently

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.
Design Flexibility vs. Standards

AASHTO “Green Book”

A series of “guidelines” and geometric design concepts and criteria ... with ranges of flexibility used to help establish physical features of a roadway ... not intended as design “standards”...
Why Flexibility in Design is Important

Trends & Public Concerns

- Revenue Limitations
- Increasing Needs
- Increasing Costs
- Deteriorating Infrastructure
- Diminishing Resources
- Complete Streets
- Socio-Economic Concerns
- Environmental Concerns
- Quality of Life Concerns
Flexibility in Design

It’s Difficult To Balance Competing Objectives Within Overly Conservative Design Approaches & Standards
North Shore Hwy Case Studies

- Explored Higher Design Speed Alignments
- Limited Use Safety Rest Area
- Shoreline & Creek Erosion
- State Park Land
- Historic Overlook & Vistas
- Cliff & Falling Rock Area
- Commercial Development
- Residential Development

Selected Lower Design Speed (55mph)
Reduced Design Speed Maximized Geometric Flexibility to Balance Competing Objectives and Reduce Costs & Annual Crashes (56%)
TH 100 3rd Lane NB & SB C-D Retrofit

Reduced Congestion & Crashes (13:1 Benefit To Cost Ratio)
Minnesota TH 38 Case Study

Flexibility in Design:

• Reduced 50 mph design speed to provide greater geometric flexibility in balancing competing objectives

• Upgrading to a 10-ton road ... maintaining much of the existing horizontal / vertical alignments ... balanced with strategic spot and intersection improvements where accident frequency occurred

• 12’ lanes, 4’ paved shoulders with 2’ of added reinforced soft shoulder, rumble stripes, steeper back slopes and variable ditch cross-sections to minimize the environmental impacts
TH38 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 circumstances

• Total accidents were reduced 55% + in the 5-year analysis after completion of the first reconstruction segment
CSAH 3 Excelsior Blvd Case Study

Case Study in ITE’s 2006 Proposed Recommended Practice Publication

Context Sensitive Solutions in Designing Major Urban Thoroughfares for Walkable Communities
CSAH 3 Excelsior Blvd Case Study

- Reduced design speed and flexibility in design 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 that all combine to create a desired sense of place

- Accidents were down over 60% in the (2) years following completion of the first reconstruction segment
TH 212 Typical Cross-Section
Performance-Based Flexibility in Re-Design

- Efficiencies added
- Values added
- Impacts reduced
- Earthwork reduced
- Schedule reduced
- Costs reduced by nearly $100 million

Courtesy of HNTB
Flexible Design Philosophy

- Recognize that flexibility is a necessary and desired aspect of the design process
- Use a risk assessment and risk management approach for all aspects of the design
- Apply performance criteria in evaluating flexible design decisions, as well as condition criteria
- Applying flexibility involves understanding the risks and consequences for design decisions – this typically requires more information and higher level analysis than simply applying criteria “by the book”
Learning From Others - MODOT

• Ensuring projects are good solutions for the surroundings - “Right Sizing”
• Improvements are considered based on their contribution to the system instead of their individual perfection
• Each District was challenged to cut the budget of their STIP by 10% and still deliver the Program
• Engineers were told to put their design manuals on the shelf and to follow 3 rules: 1) Every project must get safer, 2) Collaboration is needed in developing every practical solution, and 3) Practical solutions must function properly without leaving a legacy of maintenance challenges
Learning From Others - MODOT

- The challenge resulted in savings of $400 Million across a 5-year STIP
- Missouri demonstrated the largest drop in traffic fatalities in 2006 and the downward trend continued
- 5-year STIP delivered under budget
- Pavement condition went from 3rd worst to 9th best
- 83% of Missouri’s major roads are now in good condition (up 47%)
- Customer satisfaction with MODOT rose to 78% in 2008 and 90% of the newspaper editorials were positive
- 95% of MODOT’s customers believe their projects are the right solutions
Learning From Others - MODOT

The Way Things Were
Wasting Money and Effort Perfecting Spots Consistent with Standards but Inconsistent with Adjoining Systems
Learning From Others - MODOT

**Practical Design**
6 Foot Paved Shoulder with Rumble Stripe
(Less Costly and Safer)

**The Way Things Were**
10 ft Paved Shoulder
(More Costly and Less Safe)
Learning From Others - KY Practical Solutions

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
Options for improving mobility and safety on their existing system of two-lane highways
Looking for the Point of Diminishing Return for an Investment
**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>
<th>Miles</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>
<td>--</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>
<td>173.5</td>
<td>367.8</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>
<td>69.9</td>
<td>337.9</td>
</tr>
</tbody>
</table>

More miles, fewer crashes and fewer delays for same budget!
Learning From Others - PennDOT
Smart Transportation Guidebook

Smart Transportation Themes

- Money counts
- Choose projects with high value/price ratio
- Enhance the Local Network
- Look beyond level-of-service
- Safety first and maybe safety only
- Accommodate all modes
- Leverage and preserve existing investments
- Build towns not sprawl
- Develop local governments as strong land use partners
- Understand the context; plan and design within the context
Learning From Others - PennDOT

Optimizing Return on Investment

Right-Sizing design elements to the point of diminishing returns for High Benefit to Cost Ratios and the capability to achieve greater public benefit at the system level.
Learning From Others - PennDOT

Ranges of Values for 7 Area Types & 5 Roadway Types
## Regional Arterial

<table>
<thead>
<tr>
<th>Roadway</th>
<th>Regional Arterial</th>
<th>Rural</th>
<th>Suburban Neighborhood</th>
<th>Suburban Corridor</th>
<th>Suburban Center</th>
<th>Town/Village Neighborhood</th>
<th>Town/Village Center</th>
<th>Urban Core</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lane Width¹</td>
<td>11 to 12’ (14 to 15 outside lane if no shoulder or bike lane)</td>
<td>11 to 12’ (14 to 15 outside lane if no shoulder or bike lane)</td>
<td>11 to 12’ (14 outside lane if no shoulder or bike lane)</td>
<td>11 to 12’ (14 outside lane if no shoulder or bike lane)</td>
<td>10 to 12 (14 outside lane if no shoulder or bike lane)</td>
<td>10 to 12 (14 outside lane if no shoulder or bike lane)</td>
<td>10 to 12 (14 outside lane if no shoulder or bike lane)</td>
<td>10 to 12</td>
</tr>
<tr>
<td>Shoulder Width²</td>
<td>8 to 10’</td>
<td>8 to 10’</td>
<td>8 to 12’</td>
<td>4 to 6’ (if no parking or bike lane)</td>
<td>4 to 6’ (if no parking or bike lane)</td>
<td>4 to 6’ (if no parking or bike lane)</td>
<td>4 to 6’ (if no parking or bike lane)</td>
<td>4 to 6’ (if no parking or bike lane)</td>
</tr>
<tr>
<td>Parking Lane³</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>8 parallel</td>
<td>8 parallel; see 7.2 for angled</td>
<td>8 parallel; see 7.2 for angled</td>
<td>8 parallel; see 7.2 for angled</td>
<td>8 parallel</td>
</tr>
<tr>
<td>Bike Lane</td>
<td>NA</td>
<td>5’ to 6’</td>
<td>5’ to 6’</td>
<td>5’ to 6’</td>
<td>5’ to 6’</td>
<td>5’ to 6’</td>
<td>5’ to 6’</td>
<td>5’ to 6’</td>
</tr>
<tr>
<td>Median</td>
<td>4’ to 6’</td>
<td>16’ to 18’ for LT; 6’ to 8’ for pedestriansonly</td>
<td>16’ to 18’ for LT; 6’ to 8’ for pedestriansonly</td>
<td>16’ to 18’ for LT; 6’ to 8’ for pedestriansonly</td>
<td>16’ to 18’ for LT; 6’ to 8’ for pedestriansonly</td>
<td>16’ to 18’ for LT; 6’ to 8’ for pedestriansonly</td>
<td>16’ to 18’ for LT; 6’ to 8’ for pedestriansonly</td>
<td>16’ to 18’ for LT; 6’ to 8’ for pedestriansonly</td>
</tr>
<tr>
<td>Curb Return</td>
<td>30 to 50’</td>
<td>25 to 35’</td>
<td>30 to 50’</td>
<td>25 to 50’</td>
<td>15 to 40</td>
<td>15 to 40</td>
<td>15 to 40</td>
<td>15 to 40</td>
</tr>
<tr>
<td>Travel Lanes</td>
<td>2 to 6</td>
<td>2 to 6</td>
<td>2 to 6</td>
<td>4 to 6</td>
<td>4 to 6</td>
<td>4 to 6</td>
<td>4 to 6</td>
<td>4 to 6</td>
</tr>
<tr>
<td>Clear Sidewalk Width</td>
<td>NA</td>
<td>5’</td>
<td>5’ to 6’</td>
<td>5’ to 6’</td>
<td>6’ to 8’</td>
<td>6’ to 8’</td>
<td>6’ to 8’</td>
<td>6’ to 10’</td>
</tr>
<tr>
<td>Buffer</td>
<td>NA</td>
<td>0’</td>
<td>5’ to 6’</td>
<td>5’ to 6’</td>
<td>4’ to 6’</td>
<td>4’ to 6’</td>
<td>4’ to 6’</td>
<td>4’ to 9’</td>
</tr>
<tr>
<td>Side Distance</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>0’</td>
<td>2’</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Sidewalk Width</td>
<td>NA</td>
<td>6’</td>
<td>6’ to 8’</td>
<td>6’ to 14’</td>
<td>10’ to 18’</td>
<td>12’ to 18’</td>
<td>12’ to 20’</td>
<td>12’ to 20’</td>
</tr>
<tr>
<td>Speed</td>
<td>45-55</td>
<td>35-40</td>
<td>35-45</td>
<td>30-35</td>
<td>30-35</td>
<td>30-35</td>
<td>30-35</td>
<td>30-35</td>
</tr>
</tbody>
</table>

¹ Lane width preferred for regular transit routes and heavy truck volumes > 5%, particularly for speeds > 35 mph or greater.

² Shoulders should only be installed in urban contexts as a retrofit of wide travel lanes to accommodate bicyclists.

³ Buffer is assumed to be planted area (grass, shrubs and/or trees) for suburban neighborhood and corridor contexts; street furniture or curbs for other land use contexts. Min. of 4’ for transit access.

⁴ Curb return radius should be as small as possible. Number of lanes, on-street parking, bike lanes, and shoulders should be utilized to determine effective radius.
Design Using the Principles

- Understand the context
- Consider the role of the roadway within the network
- Know the roadway type
- Set the desired operating speed
- Refer to the Matrix for the starting design values

Requisite for process: understand the flexibility provided by the AASHTO Green Book
### Design Speeds

<table>
<thead>
<tr>
<th>Area Type</th>
<th>Freeway</th>
<th>Major*</th>
<th>Minor</th>
<th>Major</th>
<th>Minor</th>
<th>Local Roads</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural Natural</td>
<td>50 to 75</td>
<td>40 to 80*</td>
<td>35 to 60</td>
<td>30 to 60</td>
<td>30 to 55</td>
<td>20 to 45</td>
</tr>
<tr>
<td>Rural Developed</td>
<td>50 to 75</td>
<td>40 to 80*</td>
<td>35 to 60</td>
<td>30 to 60</td>
<td>30 to 55</td>
<td>20 to 45</td>
</tr>
<tr>
<td>Rural Village</td>
<td>N/A</td>
<td>30 to 45</td>
<td>30 to 40</td>
<td>25 to 40</td>
<td>25 to 35</td>
<td>20 to 35</td>
</tr>
<tr>
<td>Suburban Low Intensity Development</td>
<td>50 to 75</td>
<td>35 to 80*</td>
<td>30 to 55</td>
<td>30 to 55</td>
<td>30 to 55</td>
<td>20 to 45</td>
</tr>
<tr>
<td>Suburban High Intensity Development</td>
<td>50 to 75</td>
<td>35 to 80*</td>
<td>30 to 55</td>
<td>30 to 55</td>
<td>30 to 55</td>
<td>20 to 45</td>
</tr>
<tr>
<td>Suburban Town Center</td>
<td>N/A</td>
<td>25 to 40</td>
<td>25 to 40</td>
<td>25 to 40</td>
<td>25 to 35</td>
<td>20 to 35</td>
</tr>
<tr>
<td>Urban</td>
<td>50 to 75</td>
<td>25 to 50</td>
<td>25 to 40</td>
<td>25 to 40</td>
<td>25 to 35</td>
<td>20 to 35</td>
</tr>
</tbody>
</table>

* N/A: Not Applicable

* A higher design speed may be appropriate for arterials with full access control.

Source: Adapted from: A Policy on Geometric Design of Highways and Streets, AASHTO, 2004 – Chapter 3 Elements of Design

Ranges of Values for 9 Area Types & 6 Roadway Types
### Intersections

#### Multimodal LOS Balance

<table>
<thead>
<tr>
<th>Exhibit 6-11</th>
<th>Level-of-Service Targets</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Target Level-of-Service Ranges</strong></td>
<td><strong>Pedestrian</strong></td>
</tr>
<tr>
<td>Urban Center</td>
<td>A-C</td>
</tr>
<tr>
<td>Urban Residential</td>
<td>A-C</td>
</tr>
<tr>
<td>Suburban Commercial</td>
<td>C-E</td>
</tr>
<tr>
<td>Suburban Residential</td>
<td>B-B</td>
</tr>
<tr>
<td>Small Town, Village Center</td>
<td>A-C</td>
</tr>
<tr>
<td>Small Town, Village Residential</td>
<td>A-C</td>
</tr>
<tr>
<td>Rural Settlement (Crossroads, Residential)</td>
<td>A-B</td>
</tr>
<tr>
<td>Rural Open Space</td>
<td>A-B</td>
</tr>
</tbody>
</table>

NA: Level-of-service criteria may not apply in dense urban or suburban commercial centers.

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Seamless Multimodal Integrations
Common Threads and Challenges

“Cooler Rules & Solutions”
Shortcomings of the AASHTO Green Book

Many Aspects of Design Are Not Addressed

- Only defines 3 Functional Classes (Arterial, Collector & Local) and 2 Settings (Urban & Rural) … this does not adequately address the range of functions and settings encountered.

- Does not directly address: problem or project definition, determination of functional class and requirements, project concept development, design appropriate to context, etc.
Multimodal Planning Challenges

Not All Modes on All Roads but a Need to Integrate All Modes via System Planning Inclusive of Each Mode
Transportation & Land Use Challenges
Leveraging Development and Redevelopment so Land Use and Transportation Become Mutually Supportive in Design and Functions

Re-examining Multi-functional Roadways and Context Zones
Functional Classification Challenges

Not An Exact Science

Road Functions Change as Land Uses Change and Need Ongoing Evaluation
The allowable range of flexibility available in roadway design is directly related to and limited by the functional classification that is established. Traditionally, functional class determinations are made on a system-wide basis as a part of long-range transportation planning and well before a project may be programmed and moved into a design phase.
Once the Function and Context of the roadway have been fully considered, the choice of the appropriate Design Speed follows which then influences all the subsequent design parameters.
Influencing Driver Behaviors

Schroeder and Tofte
Area Traffic Calming Directions Informed By Vehicle Simulator Studies (at U of MN)

70% + Annual Crash Reduction After Reconstruction
Speed Really Matters In Many Ways

Today’s Paradigm

*Design Speed*

*Operating Speed*

*Posted Speed*
Speed Really Matters In Many Ways

Tomorrow’s Paradigm?

Target Operating Speed

Actual Operating Speed

Rational Posted Speed
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.
Allocation Of Space Challenges

How Much Space Do You Need and For What?

Exploring Flexibility in Design to Balance Competing Objectives and Optimize the Return Upon Investment
Accessibility & Safety Challenges
Operations & Maintenance Challenges

Complete Street in Summer

How About in Winter?

Multimodal Operations & Maintenance Issues Year-Round
What’s The Cost Of Past Approaches?
Benefit To Cost Ratios Could Have Been Higher

Meeting Level of Service C / D for peak hour volumes might give you this return on investment most of the day every day
Learning From Forum Breakout Groups

Brainstormed Challenges With Highest Vote-Getting Frequency

- Culture, Silos, Authority & Discretion within Mn/DOT
- Planning Processes & Project vs. System Perspectives
- Conservative Design Standards & Criteria
- Buy-in, Perceptions & Misperceptions
- Performance Measurement
- Lack of Knowledge, Data & Analysis
- Multimodal Priorities & Perspectives
- Purpose & Need Issues
- Design Speed & Speed Management Issues
- Liability & Design Exception Process Concerns
Learning From Forum Advisory Group

Brainstormed Next Steps With Highest Vote-Getting Frequency

- Emphasize Purpose & Need & Scoping Processes
- Expand Training & Resources
- Review & Update Design Standards & Criteria for Flexibility ... start with AASHTO’s 13 critical design elements
- Develop & Define the Vision
- Involve the Right People & Perspectives
- Develop Policy & Guidelines
- Research, Document & Disseminate Case Studies
- State-Aid Rules & Standards should be addressed
Questions & Discussion

The Road Best Traveled

Your Destination...Our Priority