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

Your Destination...Our Priority

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

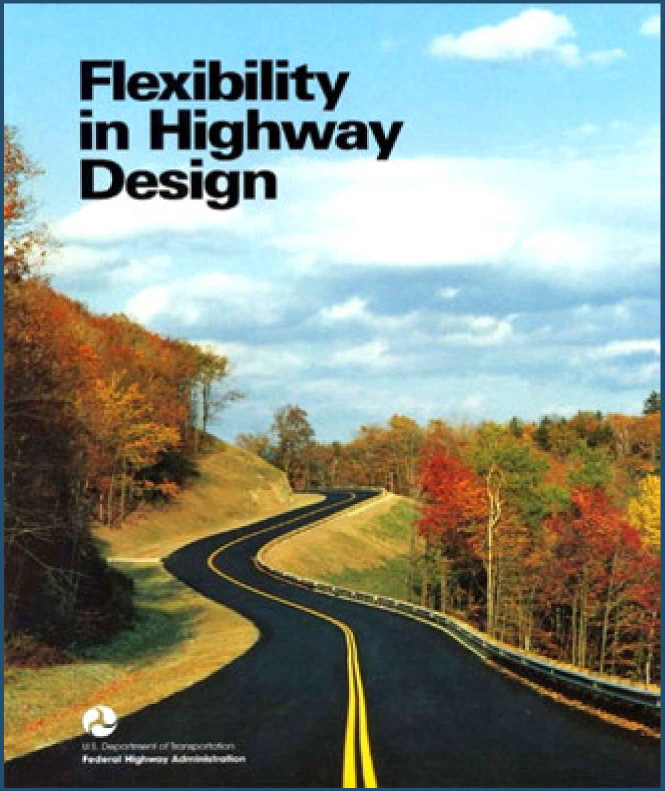
FHWA Advocacy and Guidance in 1997

Provocation to Think and 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.

Sufficient flexibility permitted to encourage independent designs tailored to particular situations

(Consistent with AASHTO Green Book)



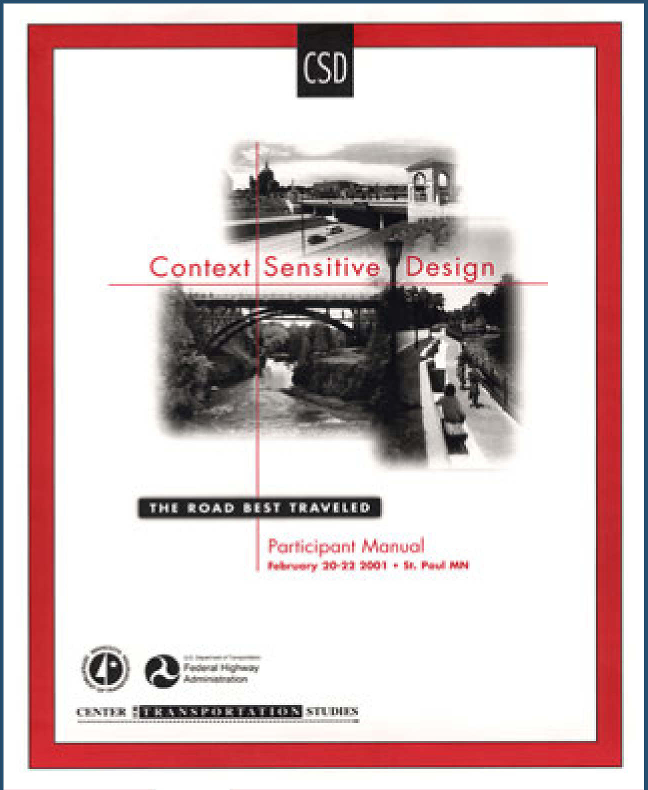
Provoked Birth of CSS

MnDOT Was Positioned for Leadership in CSS

Initial MnDOT "Pilot State" Effort (1999 & 2000)

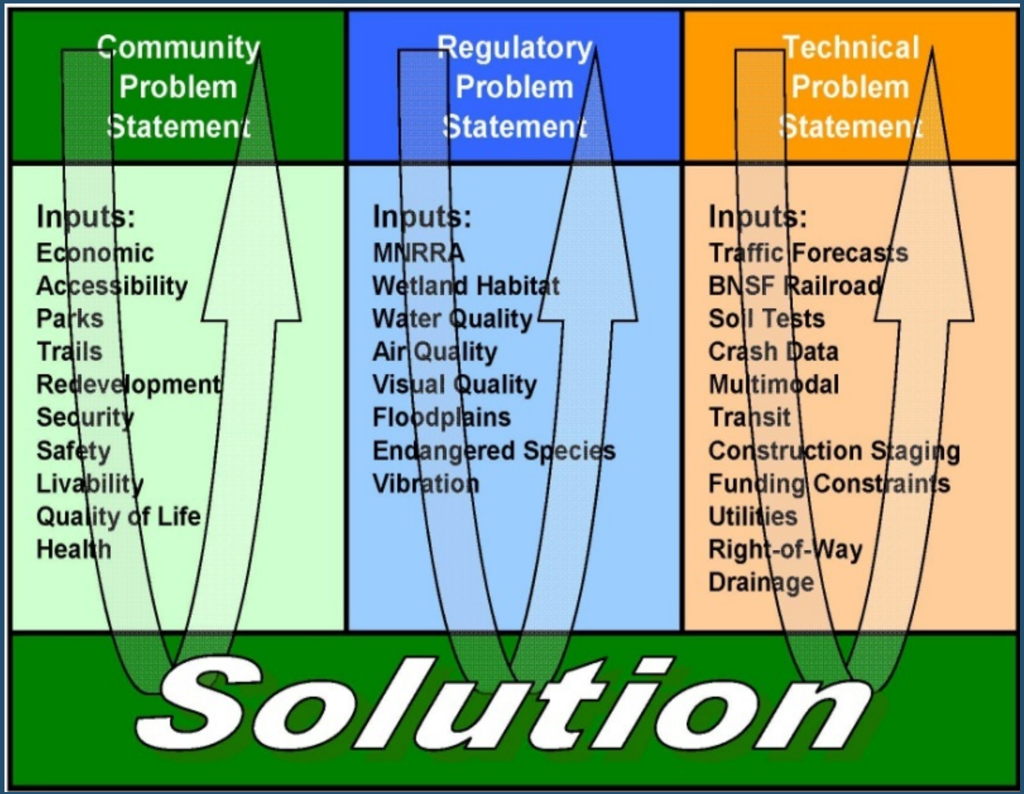
As a "pilot state", MnDOT partnered with FHWA's MN Division & U of MN Center for Transportation Studies in advancing our CSD / CSS approach.

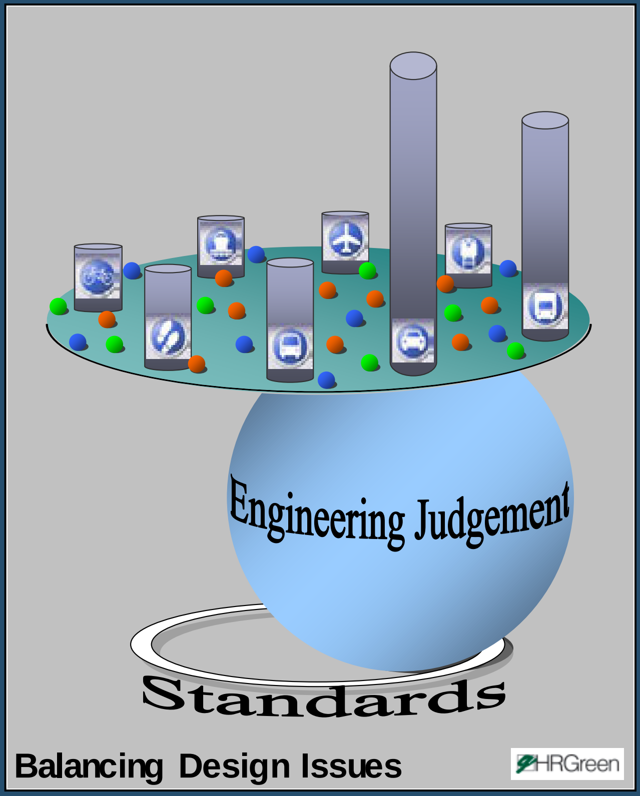
Assembled steering team & advisory group that guided a Principle-Based Approach, Training Development and Deployment, Development of Policy (Tech Memo) and Marketing with an emphasis on (6) Core Principles that were deemed critically important … **many deemed Flexibility in Design as the most important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



www.dot.state.mn.us (Search A to Z for Context Sensitive Solutions)

Why Flexibility in Design is So Important



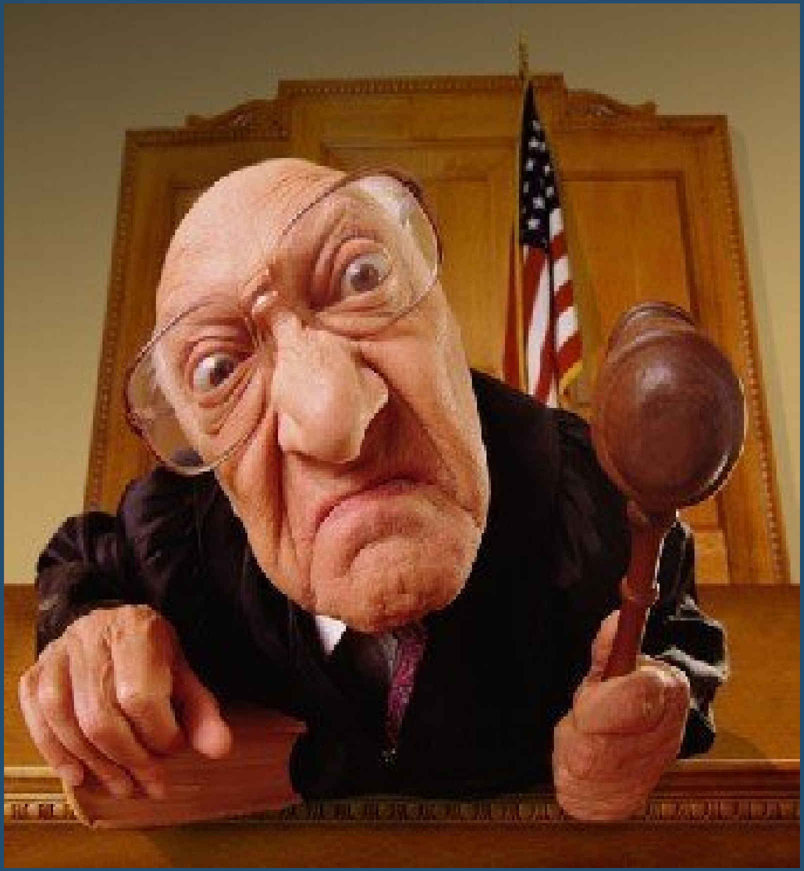


It's Very Difficult To Address & Balance Competing Needs & Objectives Within Constrained Resources & Overly Conservative Design Approaches & Standards

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

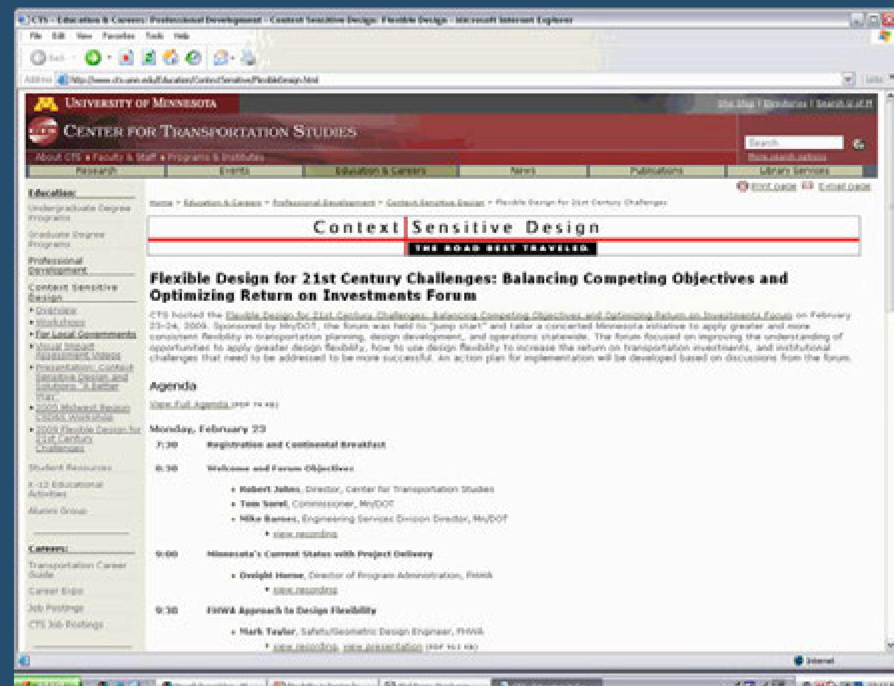
CSS Elevated as a "Flagship Initiative" in December 2009

- 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)



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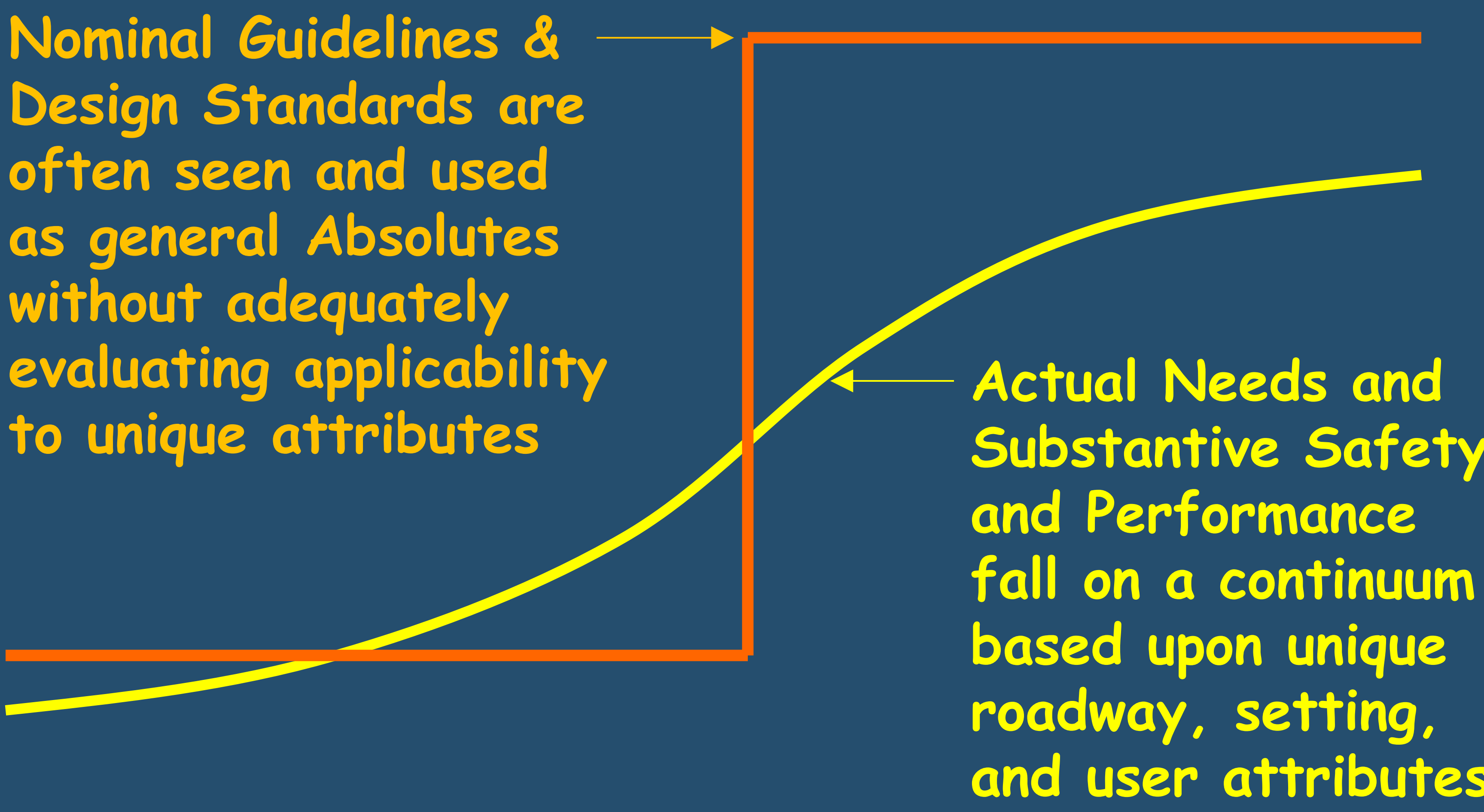
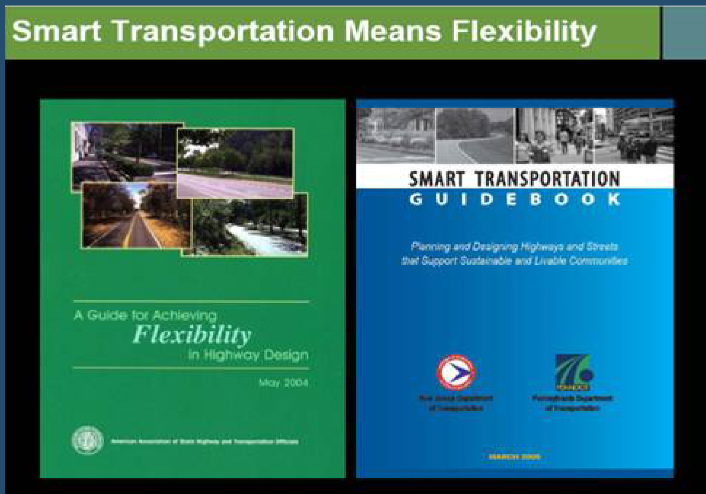
Key Themes - Reallocating Cross-Section Space

How Much Space Do You Really Need and For What ?

Key Themes - Substantive vs. Nominal Safety

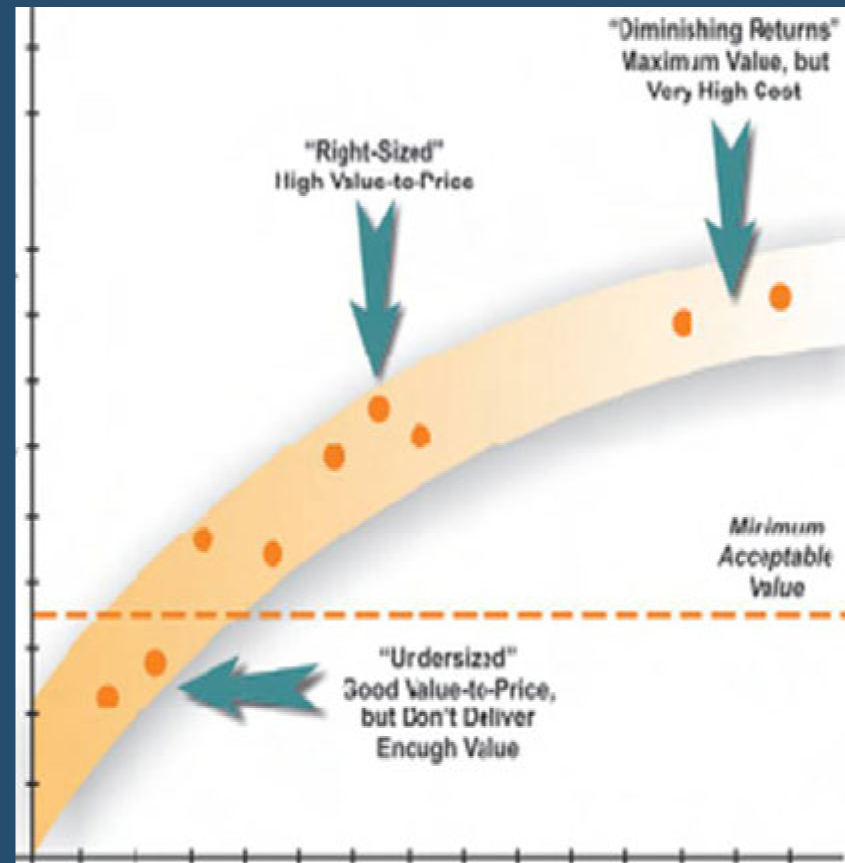


Key Themes - Optimizing Return on Investments



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

VALUE (all benefits)



PRICE (cost + impacts)

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 3rd 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

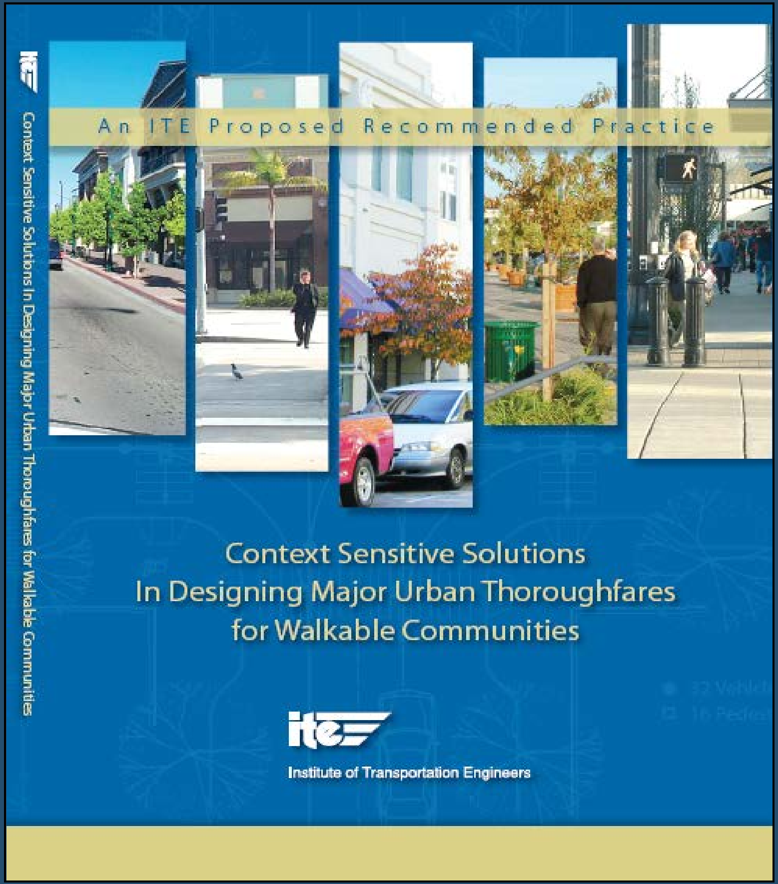
Vehicle Simulator Evaluation of Potential Traffic Calming Options

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

MN CSAH 3 Excelsior Blvd Case Study

- 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

Topic (SORTED BY TOTAL VOTES)	AASHTO Votes (22)	TRB Votes (34)	Total Votes
Median Design and Barrier Issues in Urban and Rural Environments (1.1)/Median: Types and Design (Crossover Crashes) (2.1)	13	15	28
Performance-based Geometric Design Analysis (1.3)	7	17	24
Multimodal Highway Design for "Complete Streets" (1.2)/ Determine the primary and secondary users for various functional classes. (2.3)	6	17	23
Investigation of Alternative Geometric Highway Design Processes (Design Decision Support) (1.3)	8	12	20
Horizontal Curve Design Philosophy (Should it be for driver comfort?) (1.1)/Revision of Horizontal Curve Design Friction Factors (1.1)	4	14	18
Right-turn interactions and channelized right turns/Free-Right Turn lane Design and Impacts/Continue the work of NCHRP 3-72. (1.2)	5	11	16
Ramp and Interchange Spacing (2.2)	9	7	16
Transition Zones – Design from High-Speed to Low-Speed Rural Sections (2.1)	5	9	14
Ramp Design as a System (2.2)	3	11	14
Freeway: Lane and Shoulder Widths (Safety and Operational Tradeoffs) (2.2)	4	9	13
Safety, operations and usability trade-offs between user groups. (2.3)/Safety and Operational Tradeoffs Roadway Users of Urban Cross Section Decisions (2.4)	2	11	13
Operational and Safety Impacts of Four Lane versus Six Lane with Raised Median versus TWLTL (consideration pedestrian accessibility) (2.4)	8	4	12
Superelevation Criteria for Steep Grades on Sharp Horizontal Curves (1.1)	7	4	11
Geometric design guidelines for major intersection alternatives to accommodate multimodal users (pre-interchanges: CFI, superstreet, quadrant roadway, etc.) (2.3)	4	7	11
Design, safety and operations of pedestrian geometric intersection treatments. (2.3)	3	7	10
One-lane and Two-Lane Loop Ramp Design (2.2)	5	4	9
Effectiveness of Various Mid-block Crossing Treatments (2.4)	0	7	7
Intersection design to accommodate pedestrian crosswalk cross slope [Vehicle dynamics and drainage] (1.2)	4	2	6
Guidelines for provision of sidewalks (1.2)	4	1	5
Safety Effects of Intersection Skew Angle (1.2)	4	1	5
Accommodating Bicycles on Rural Highways (2.1)	3	0	3
Operational and Safety Impacts of Angle versus parallel versus back-in parking (2.4)	2	0	2

Strategic research needs workshop – 2004

National Research Scene

Topic (SORTED BY TOTAL VOTES)	AASHTO Votes (22)	TRB Votes (34)	Total Votes
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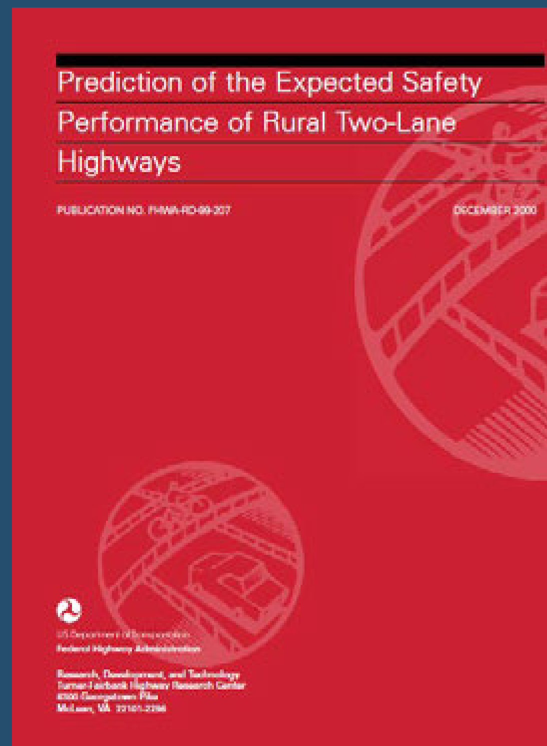
Horizontal Curve Design Philosophy (Should it be for driver			

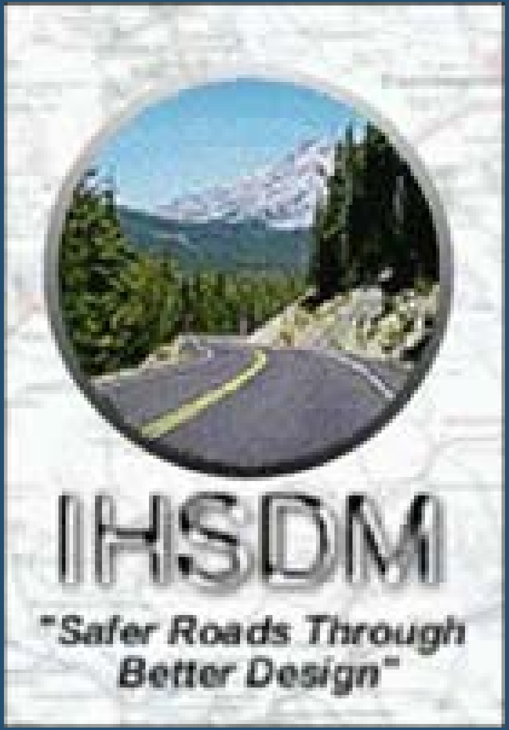
Strategic research needs workshop – 2004

Substantive Safety



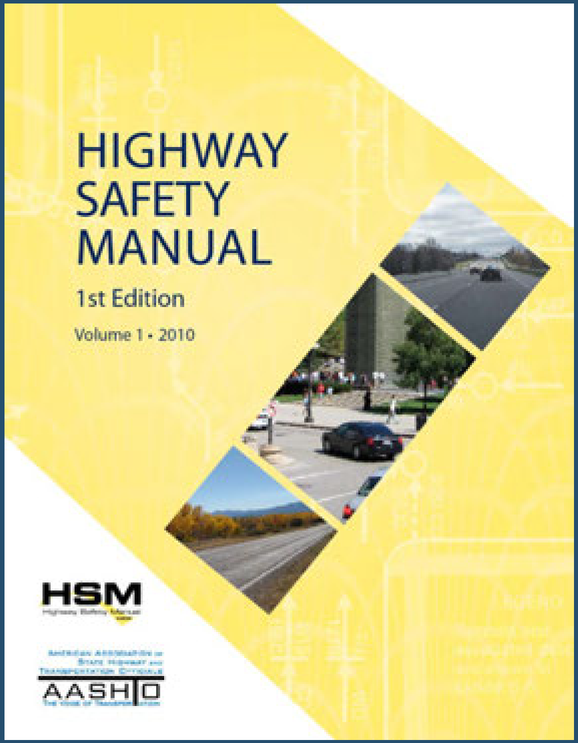
Prediction of the Expected Safety Performance of Rural Two-Lane Highways – 2000

Predictive Modeling



Interactive Highway Safety Design Model – 2003

Predictive Modeling



AASHTO Highway Safety Manual – 2010

National Research Scene

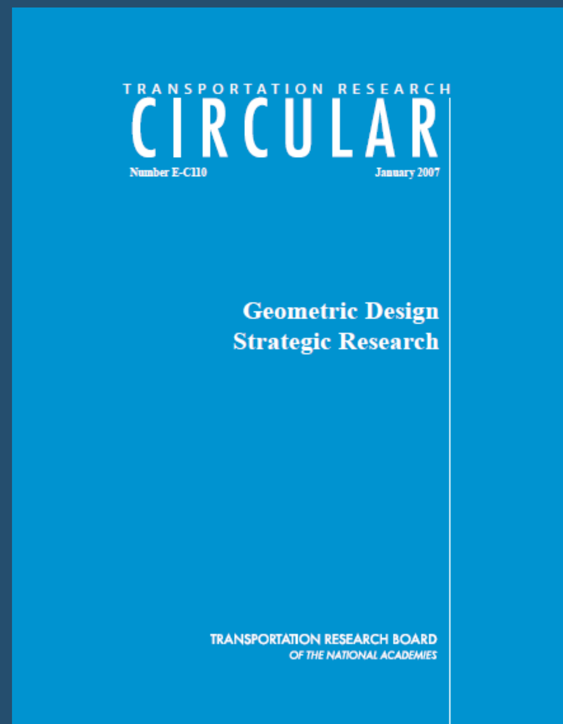
TRB TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

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

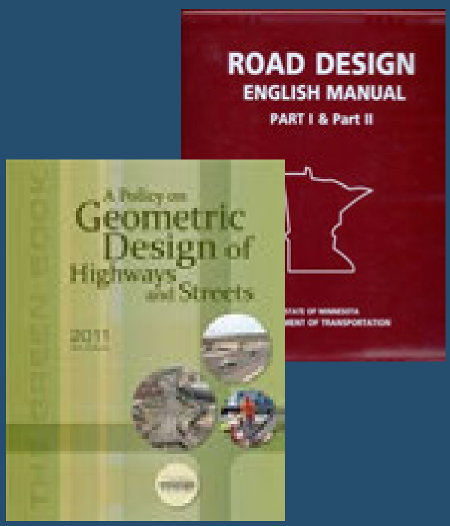
TABLE 4 Proposed Research Program Sequence
(Corresponding Numbers for Problem Statements in Part III Shown in Parenthesis)

Research Categories	Research Sequence			
	A	B	C	D
Methodology	Performance-based Geometric Design Analysis (2)	Investigation of Alternative Geometric Highway Design Processes (4)	Continued	Continued
Criteria	Superelevation Criteria for Steep Grades on Horizontal Curves (13)	Horizontal Curve Design Philosophy (5)		
Highways	Median Design and Barrier Considerations in Urban and Rural Environments (1)	Transition Zone Design (8)	Accommodating Bicyclists on Rural Highways (21)	

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:

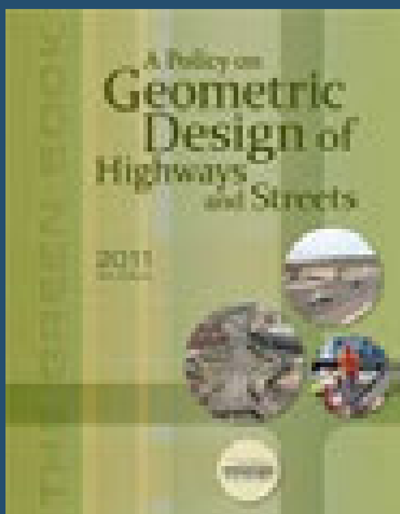
an OUTCOME based

rather than

OUTPUT based

methodology

Traditional "Code-Based" Design



...intended to be geared toward performance, but...

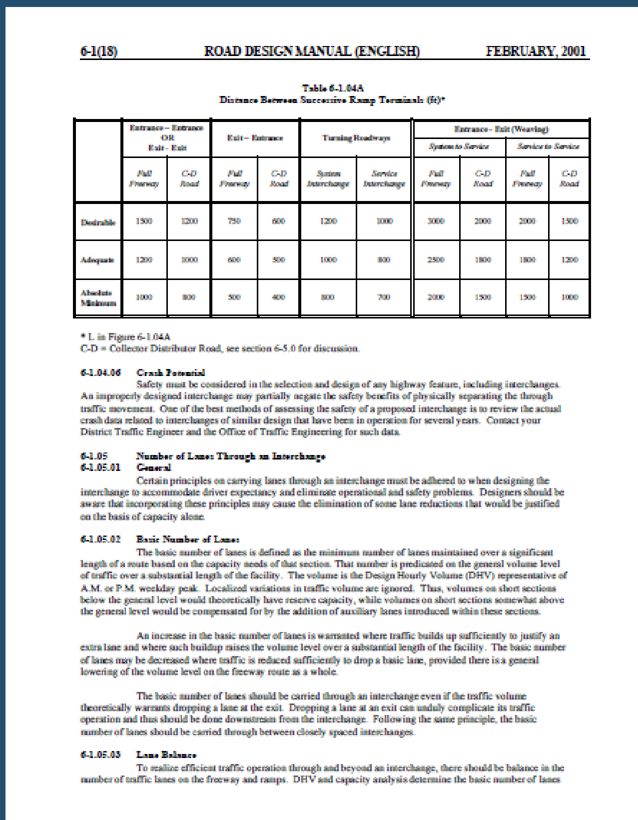
Traditional "Code-Based" Design

Table 6-1.04A
Distance Between Successive Ramp Terminals (ft)*

	Entrance – Entrance OR Exit - Exit		Exit – Entrance		Turning Roadways		Entrance - Exit (Weaving)			
							System to Service		*Service to Service*	
	Full Freeway	*C-D Road*	*Full Freeway*	*C-D Road*	*System Interchange*	*Service Interchange*	*Full Freeway*	*C-D Road*	*Full Freeway*	*C-D Road*
Desirable	1500	1200	750	600	1200	1000	3000	2000	2000	1500
Adequate	1200	1000	600	500	1000	800	2500	1800	1800	1200
Absolute Minimum	1000	800	500	400	800	700	2000	1500	1500	1000

Road Design Manual: Ramp Terminal Spacing

Traditional “Code-Based” Design



6-1(18) ROAD DESIGN MANUAL (ENGLISH) FEBRUARY, 2001

Table 6-1.04A
Distance Between Successive Ramp Terminals (ft)*

	Entrance – Entrance OR Exit - Exit		Exit – Entrance		Turning Roadways		Entrance - Exit (Weaving)			
							System to Service		*Service to Service*	
	Full Freeway	*C-D Road*	*Full Freeway*	*C-D Road*	*System Interchange*	*Service Interchange*	*Full Freeway*	*C-D Road*	*Full Freeway*	*C-D Road*
Desirable	1500	1200	750	600	1200	1000	3000	2000	2000	1500
Adequate	1200	1000	600	500	1000	800	2500	1800	1800	1200
Absolute Minimum	1000	800	500	400	800	700	2000	1500	1500	1000

* L in Figure 6-1.04A
C-D = Collector Distributor Road, see section 6-5.0 for discussion.

6-1.04.06 Crash Potential

Safety must be considered in the selection and design of any highway feature, including interchanges. An improperly designed interchange may partially negate the safety benefits of physically separating the through traffic movement. One of the best methods of assessing the safety of a proposed interchange is to review the actual crash data related to interchanges of similar design that have been in operation for several years. Contact your District Traffic Engineer and the Office of Traffic Engineering for such data.

6-1.05 Number of Lanes Through an Interchange
6-1.05.01 General

Certain principles on carrying lanes through an interchange must be adhered to when designing the interchange to accommodate driver expectancy and eliminate operational and safety problems. Designers should be aware that incorporating these principles may cause the elimination of some lane reductions that would be justified on the basis of capacity alone.

6-1.05.02 Basic Number of Lanes

The basic number of lanes is defined as the minimum number of lanes maintained over a significant length of a route based on the capacity needs of that section. That number is predicated on the general volume level of traffic over a substantial length of the facility. The volume is the Design Hourly Volume (DHV) representative of A.M. or P.M. weekday peak. Localized variations in traffic volume are ignored. Thus, volumes on short sections below the general level would theoretically have reserve capacity, while volumes on short sections somewhat above the general level would be compensated for by the addition of auxiliary lanes introduced within these sections.

An increase in the basic number of lanes is warranted where traffic builds up sufficiently to justify an extra lane and where such buildup raises the volume level over a substantial length of the facility. The basic number of lanes may be decreased where traffic is reduced sufficiently to drop a basic lane, provided there is a general lowering of the volume level on the freeway route as a whole.

The basic number of lanes should be carried through an interchange even if the traffic volume theoretically warrants dropping a lane at the exit. Dropping a lane at an exit can unduly complicate its traffic operation and thus should be done downstream from the interchange. Following the same principle, the basic number of lanes should be carried through between closely spaced interchanges.

6-1.05.03 Lane Balance

To realize efficient traffic operation through and beyond an interchange, there should be balance in the number of traffic lanes on the freeway and ramps. DHV and capacity analysis determine the basic number of lanes

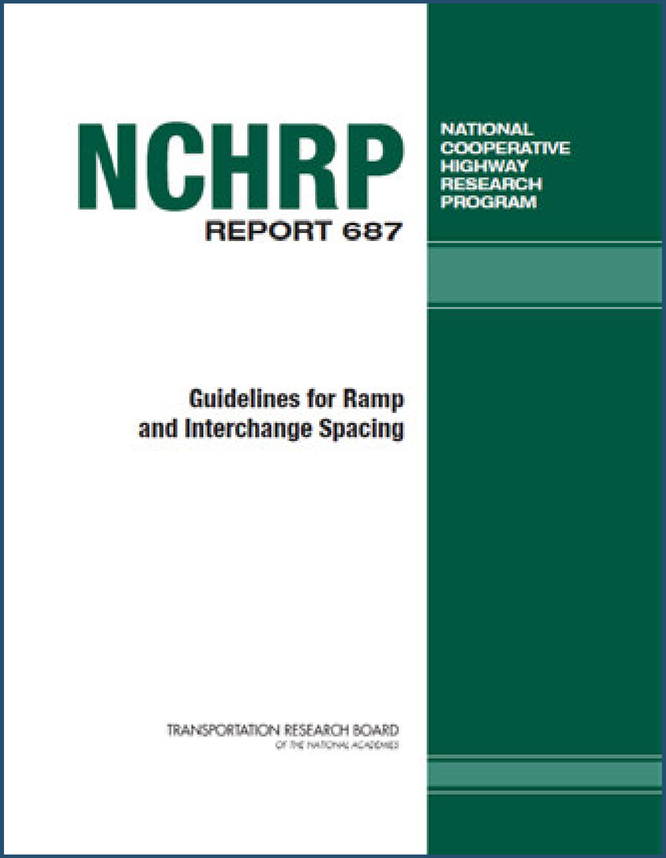
It doesn’t account for…

- 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

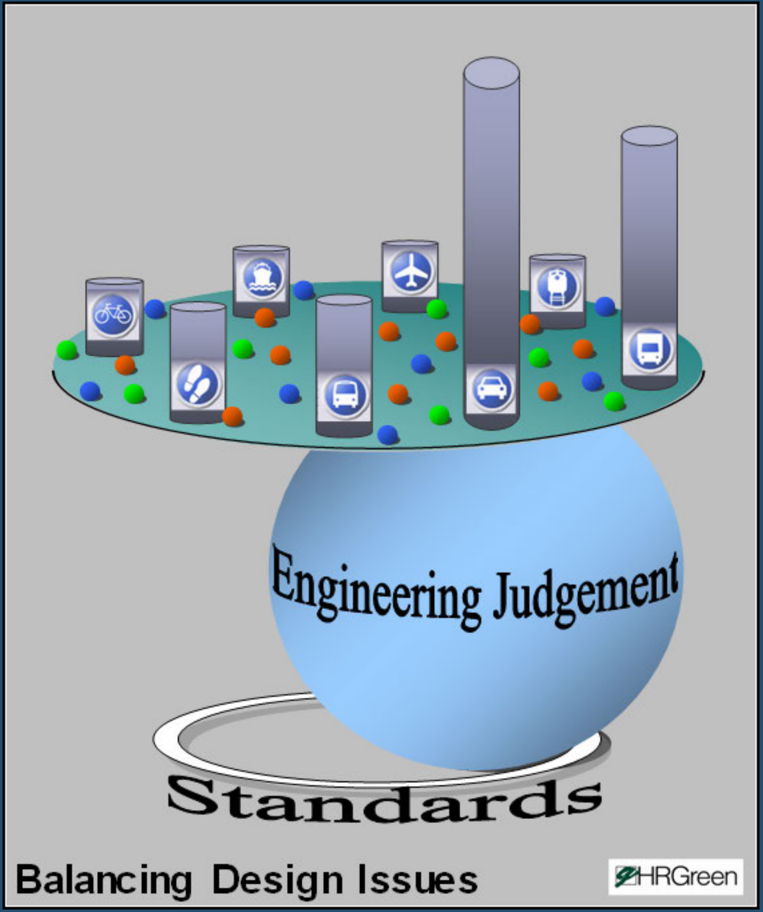
- Safety (Highway Safety Manual)
- Mobility (Highway Capacity Manual, etc.)
  - Travel time
    - Peak hour
    - Consistency / predictability
  - Throughput
  - Modal accommodation

Performance Characteristics

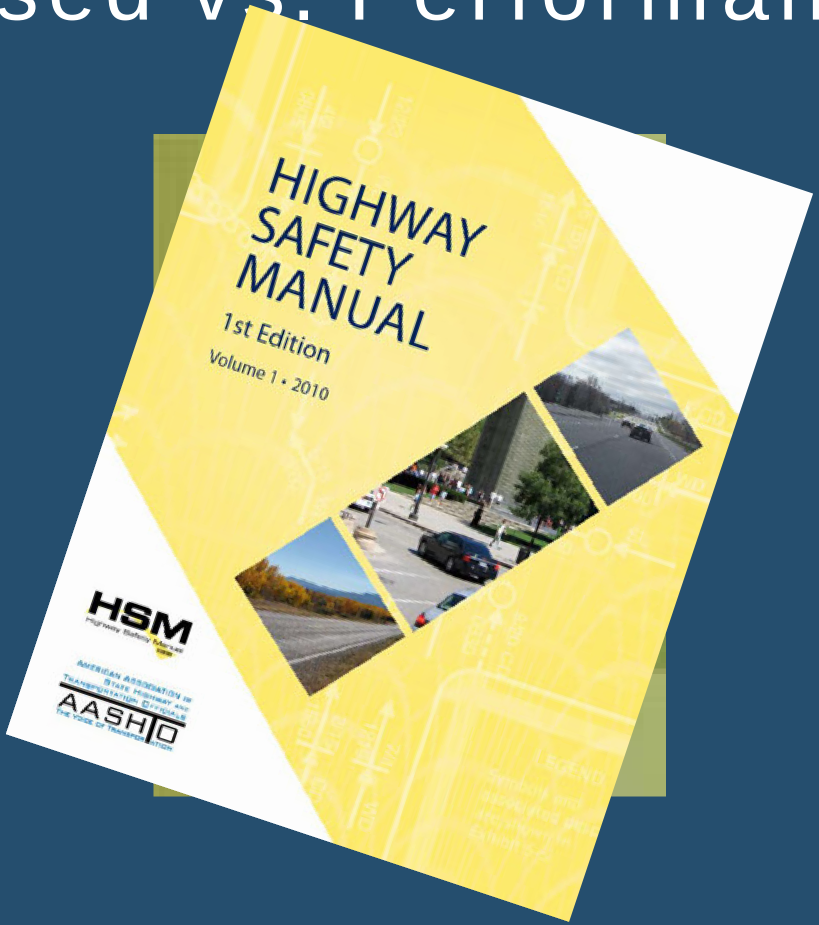
- Speed
- Surface condition
- Usability
  - Drivability, walkability, bike-ability, ______ability
  - Way finding
  - Traversability (i.e. cross-ability)
  - Other uses…

Performance Characteristics

- Visual quality
- Context sensitivity
- ???

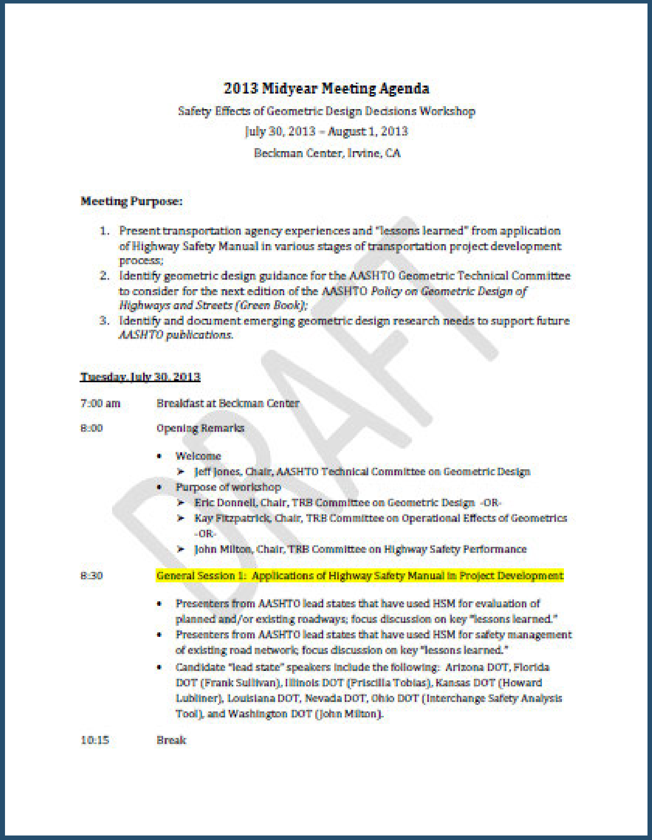


Code-based vs. Performance-based



Code-based vs. Performance-based

Code-based vs. Performance-based



2013 Midyear Meeting Agenda

Safety Effects of Geometric Design Decisions Workshop

July 30, 2013 – August 1, 2013

Beckman Center, Irvine, CA

Meeting Purpose:

1. Present transportation agency experiences and "lessons learned" from application of Highway Safety Manual in various stages of transportation project development process;
2. Identify geometric design guidance for the AASHTO Geometric Technical Committee to consider for the next edition of the AASHTO *Policy on Geometric Design of Highways and Streets (Green Book);*
3. Identify and document emerging geometric design research needs to support future *AASHTO publications.*

Tuesday, July 30, 2013

7:00 am Breakfast at Beckman Center

8:00 Opening Remarks

- Welcome
  - Jeff Jones, Chair, AASHTO Technical Committee on Geometric Design
- Purpose of workshop
  - Eric Donnell, Chair, TRB Committee on Geometric Design -OR-
  - Kay Fitzpatrick, Chair, TRB Committee on Operational Effects of Geometrics -OR-
  - John Milton, Chair, TRB Committee on Highway Safety Performance

8:30 General Session 1: Applications of Highway Safety Manual in Project Development

- Presenters from AASHTO lead states that have used HSM for evaluation of planned and/or existing roadways; focus discussion on key "lessons learned."
- Presenters from AASHTO lead states that have used HSM for safety management of existing road network; focus discussion on key "lessons learned."
- Candidate "lead state" speakers include the following: Arizona DOT, Florida DOT (Frank Sullivan), Illinois DOT (Priscilla Tobias), Kansas DOT (Howard Lubliner), Louisiana DOT, Nevada DOT, Ohio DOT (Interchange Safety Analysis Tool), and Washington DOT (John Milton).

10:15 Break

DRAFT

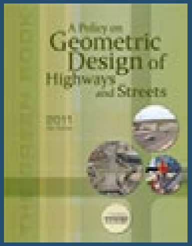
Joint AASHTO / TRB meeting – Summer 2013

- 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

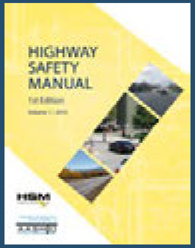
Overall Goal

Tailoring solutions to the unique needs of each project context

Flexible ranges



Criteria



Tools

Questions?

Your Destination...Our Priority

Context Sensitive Solutions Webinar
March 13, 2013

Highway Safety Manual Overview

Will Stein

FHWA

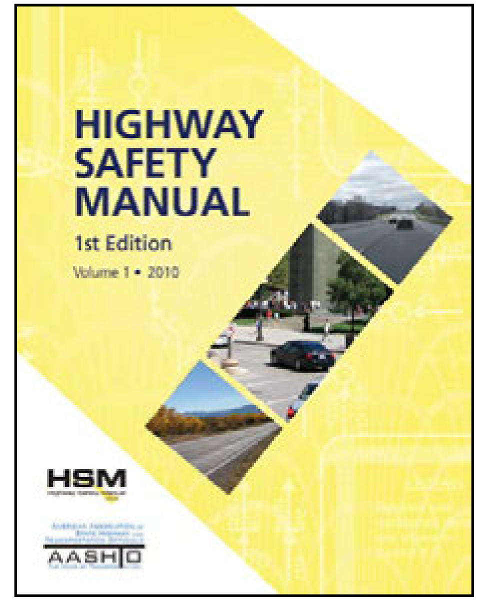
Minnesota Division

U.S. Department of Transportation
Federal Highway Administration

Safe Roads for a Safer Future
Investment in roadway safety saves lives
http://safety.fhwa.dot.gov

What is the HSM?

Contains Best Science & Research



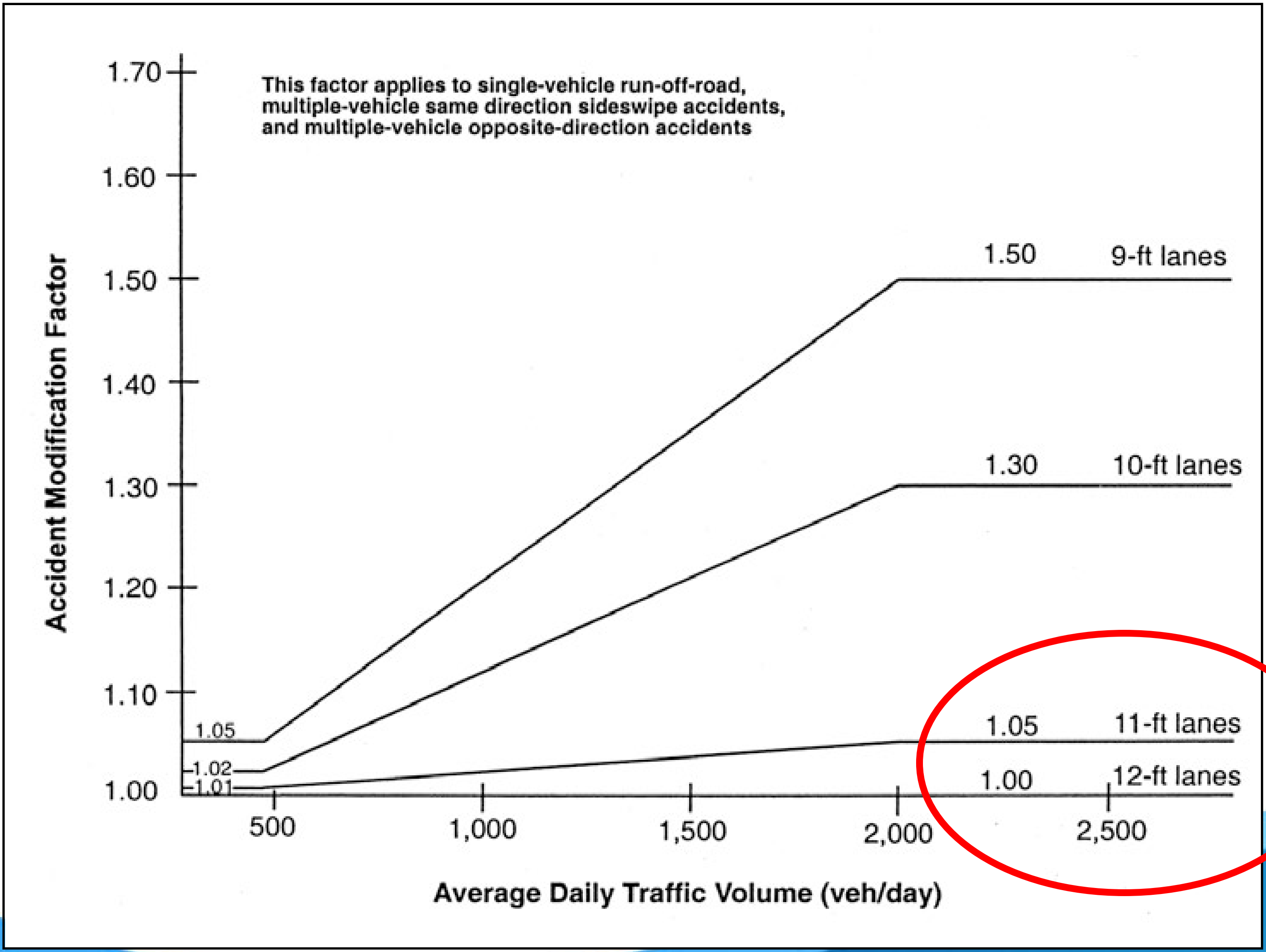
- Synthesis of previous research
- New research commissioned by AASHTO and FHWA

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



Safe Roads for a Safer Future
Investment in roadway safety saves lives

http://safety.fhwa.dot.gov

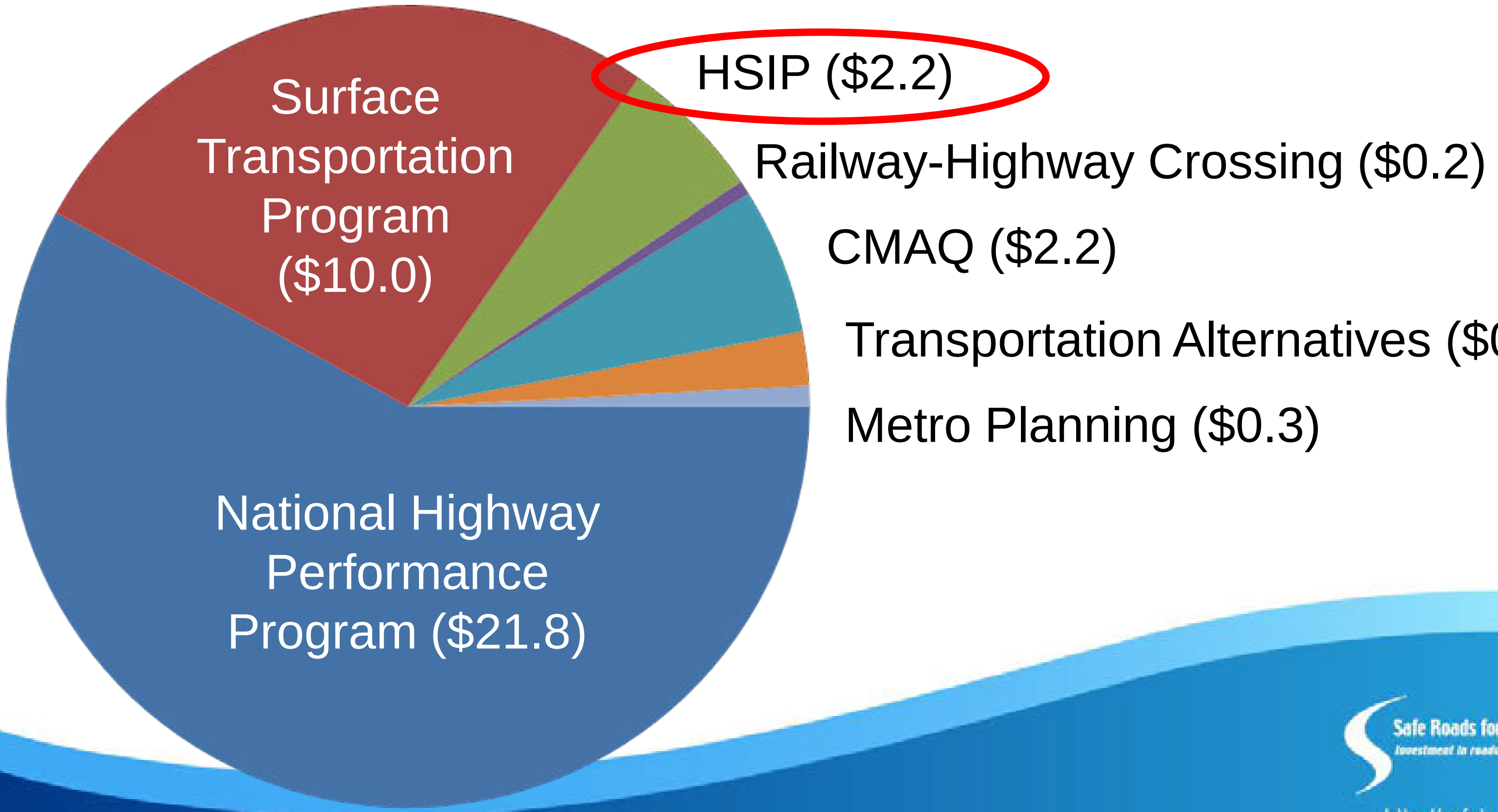

STOP
AHEAD

Other benefits

- Communicating tradeoffs with the public and local officials.

Other benefits

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



Safe Roads for a Safer Future
Investment in roadway safety saves lives
http://safety.fhwa.dot.gov

Other benefits

- Wiser investment of transportation funds.

Safe Roads for a Safer Future
Investment in roadway safety saves lives

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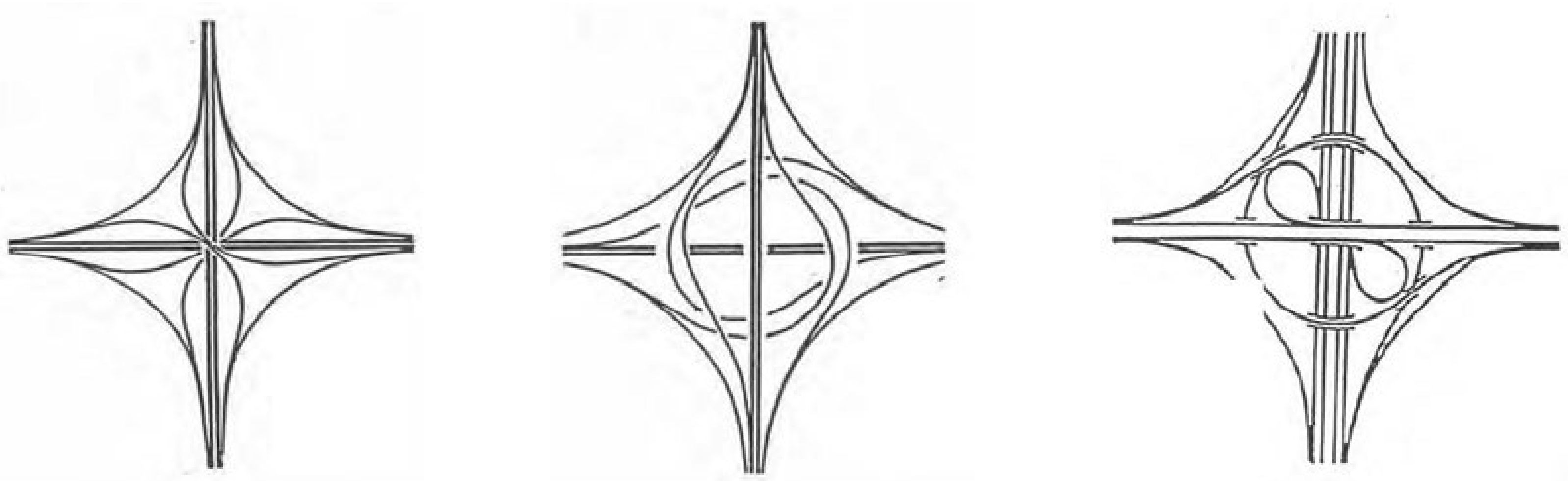
We ought to understand the expected safety performance of a $250 million investment



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?

Safe Roads for a Safer Future
Investment in roadway safety saves lives

http://safety.fhwa.dot.gov

Slide courtesy: Tim Neuman, CH2M Hill

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

	Fatal and Injury Crashes per year (design year = 2025)	Difference from No Build
No Build – Alt 1	110	--
Alternative 2	65	45 fewer/year
Alternative 3	45	65 fewer/year

A Balance

Safety can now be considered <u>quantitatively</u> 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:

$$N_{predicted\ rs} = N_{spf\ rs} \times C_r \times (CMF_{1r} \times CMF_{2r} \times \ldots \times CMF_{12r}) \qquad (10\text{-}2)$$

Where:

$N_{predicted\ rs}$ = predicted average crash f

$N_{spf\ rs}$ = predicted average crash f

C_r = calibration factor for road
or geographical area; and

$CMF_{1r} \ldots CMF_{12r}$ = crash modification factor

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$N_{spf\ rs}$ = 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

$$N_{spf\,rs} = AADT \times L \times 365 \times 10^{-6} \times e^{(-0.312)} \qquad (10\text{-}6)$$

Where:

$N_{spf\,rs}$ = 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).

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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

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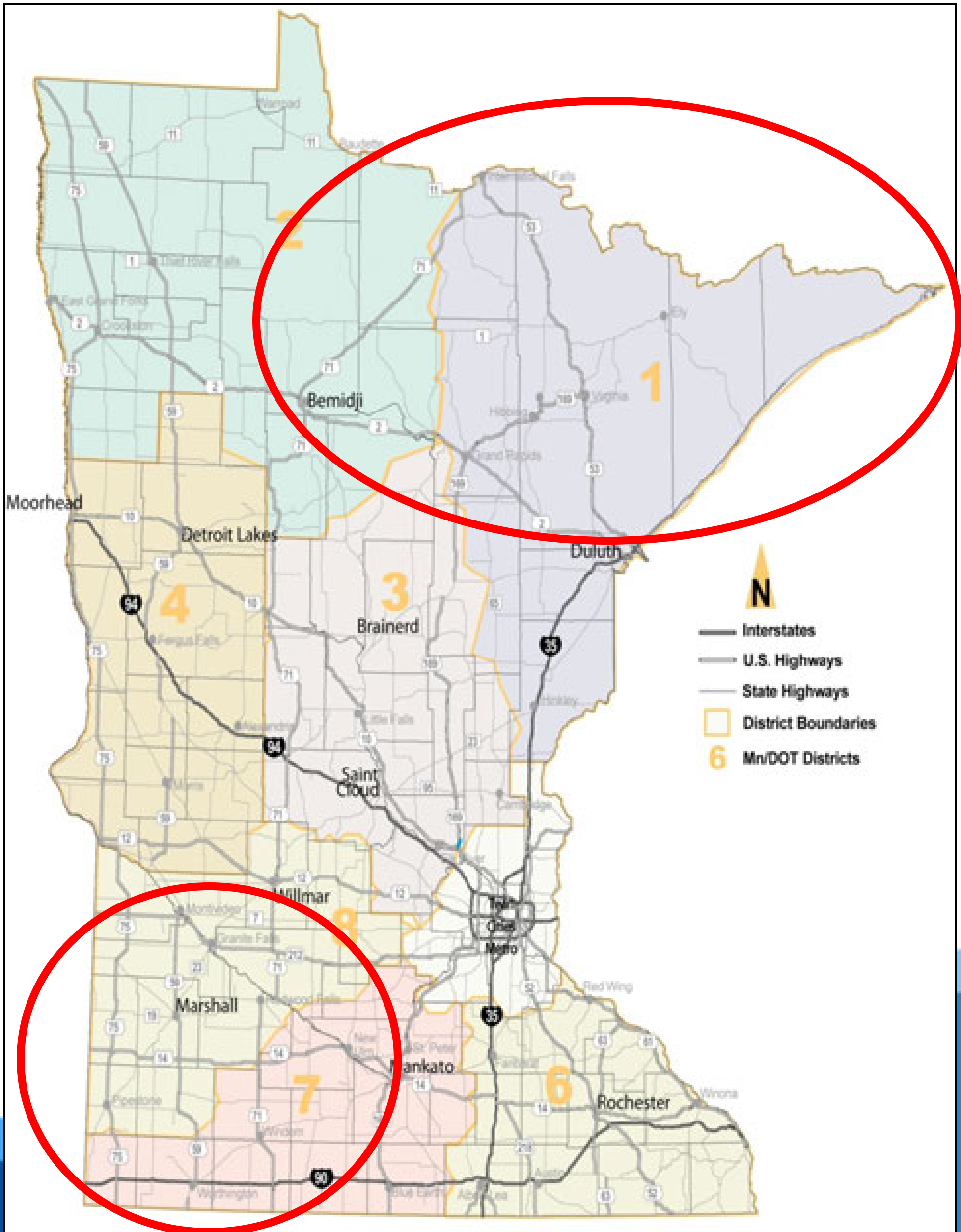
This model estimates the predicted average crash frequency of non-intersection related crashes (i.e., crashes that would occur regardless of the presence of an intersection).

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).

Calibration factor



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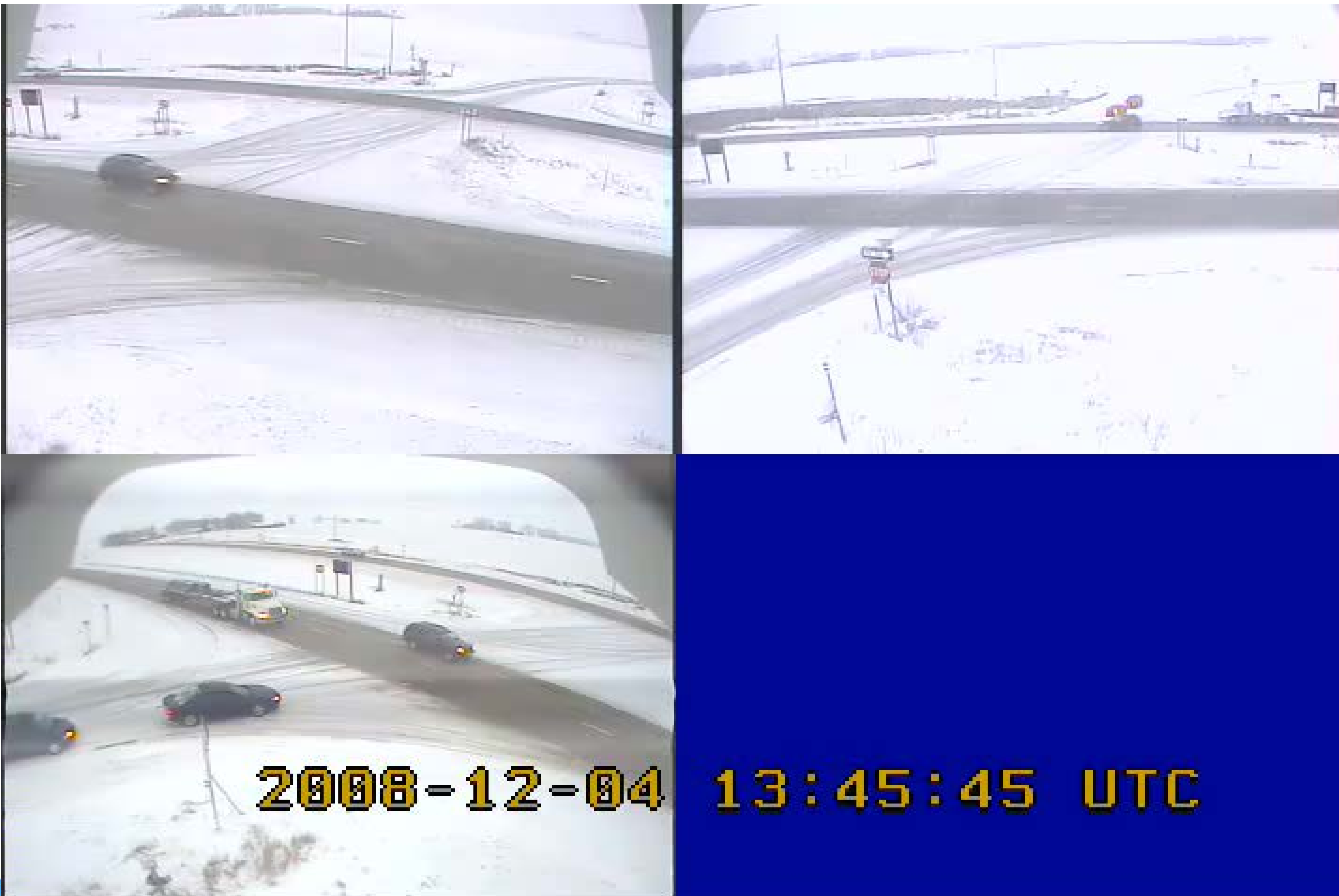
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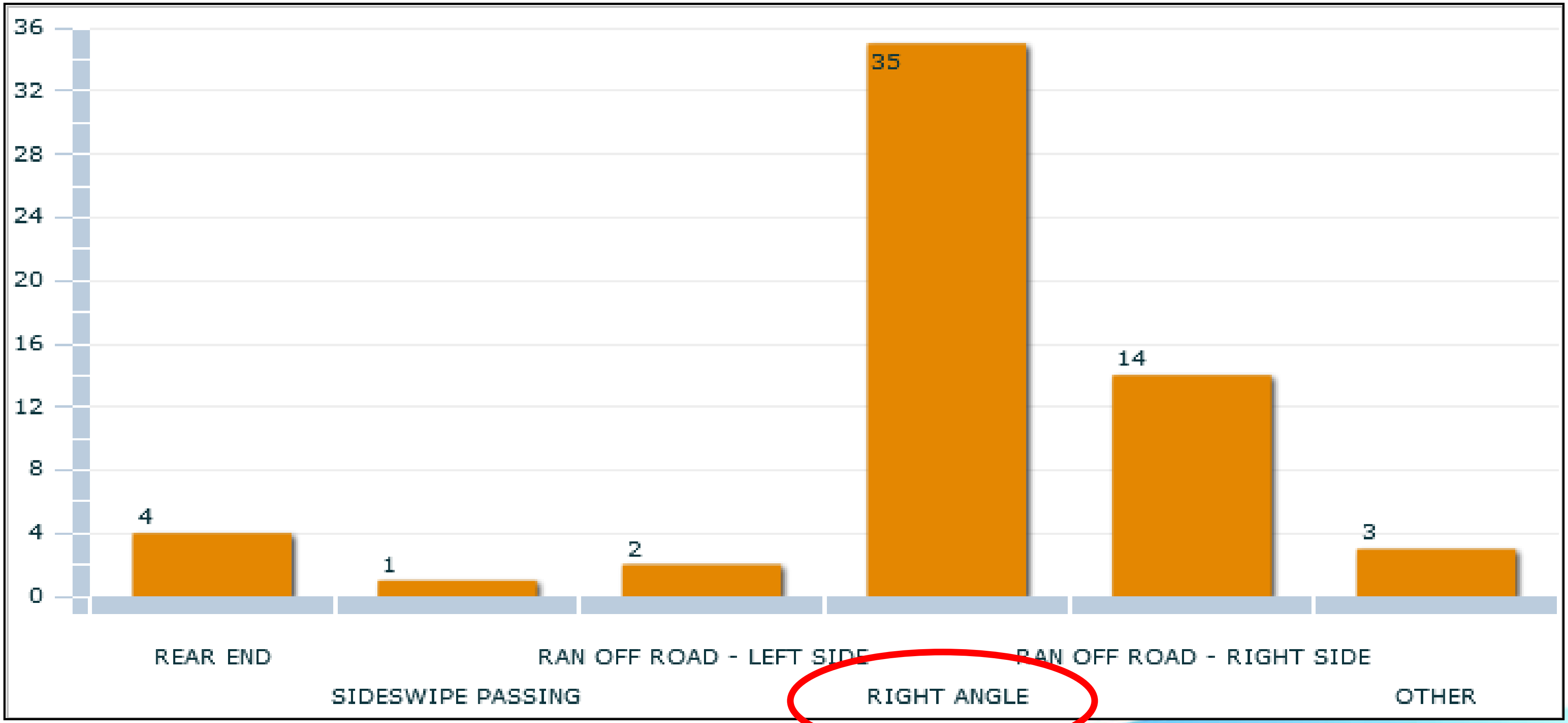
US 52 – CR 9 (2003 – 2011)

US 52 – CR 9 (2003 – 2011)



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Reduced Conflict Intersection

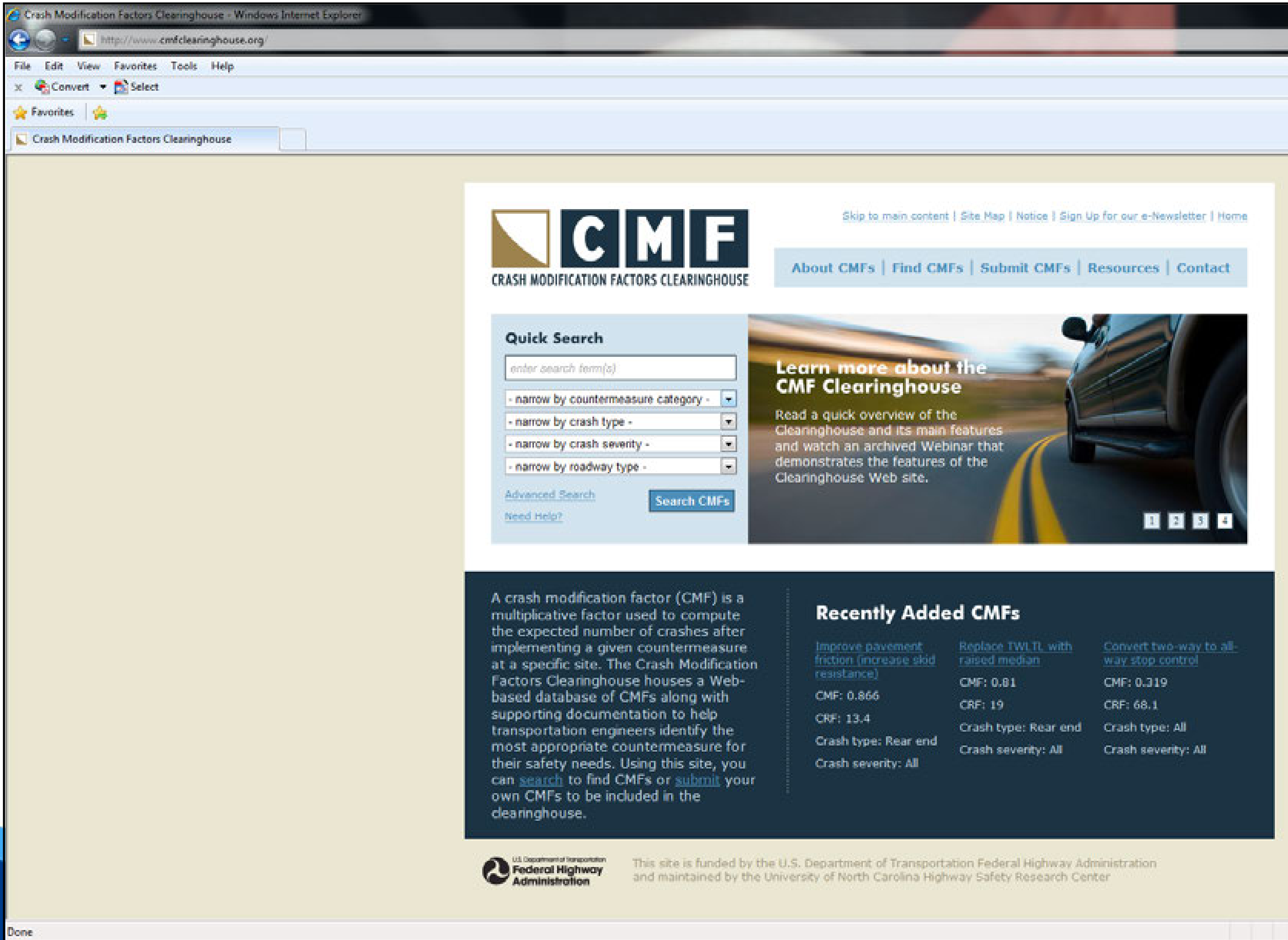
RCI Safety

- Study looked at 9 sites in Maryland.

Crash Reductions by Severity (MD RCI sites)[1]		
PDO	Injury	Fatal
21%	**42%**	**70%**

1. *Field Evaluation of a Restricted Crossing U-Turn Intersection (FHWA-HRT-11-067)*

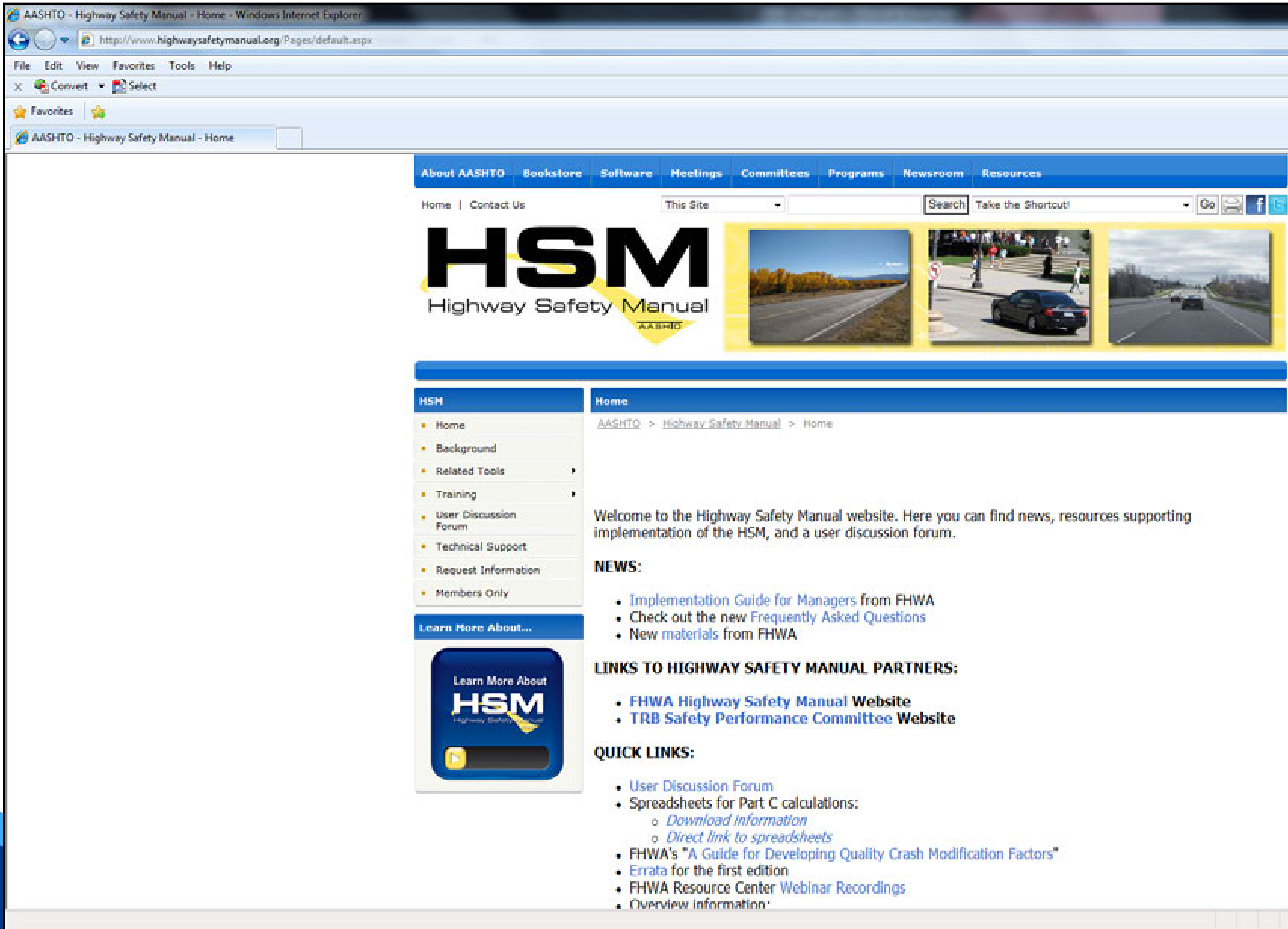
CMF Clearinghouse



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.

HSM website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Learn More About
HSM
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AASHTO > Highway Safety Manual > Home
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

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

HSM Chapter	Undivided Roadway Segments	Divided Roadway Segments	Intersections			
			Stop Control on Minor Leg(s)		Signalized	
			3-Leg	4-Leg	3-Leg	4-Leg
10 Rural Two-Lane, Two-Way Roads	✓		✓	✓		✓
11 Rural Multilane Highways	✓	✓	✓	✓		✓
12 Urban and Suburban Arterials	✓	✓	✓	✓	✓	✓

- 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

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651-291-6122

Questions?

Kentucky's Performance-Based Concept

Practical Solutions

&

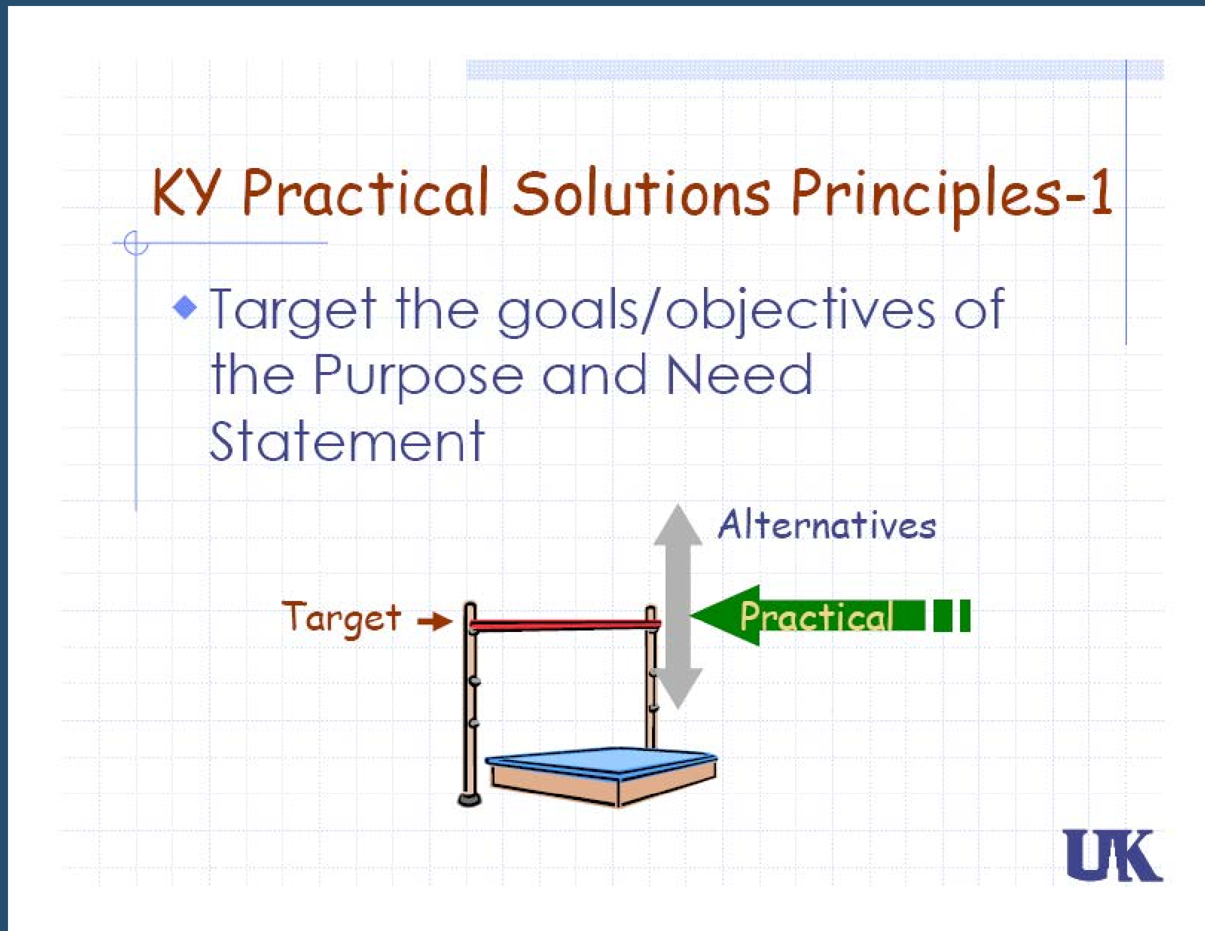
Targeted Measures of "Effectiveness"

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

UK

Kentucky’s Practical Solutions Concept



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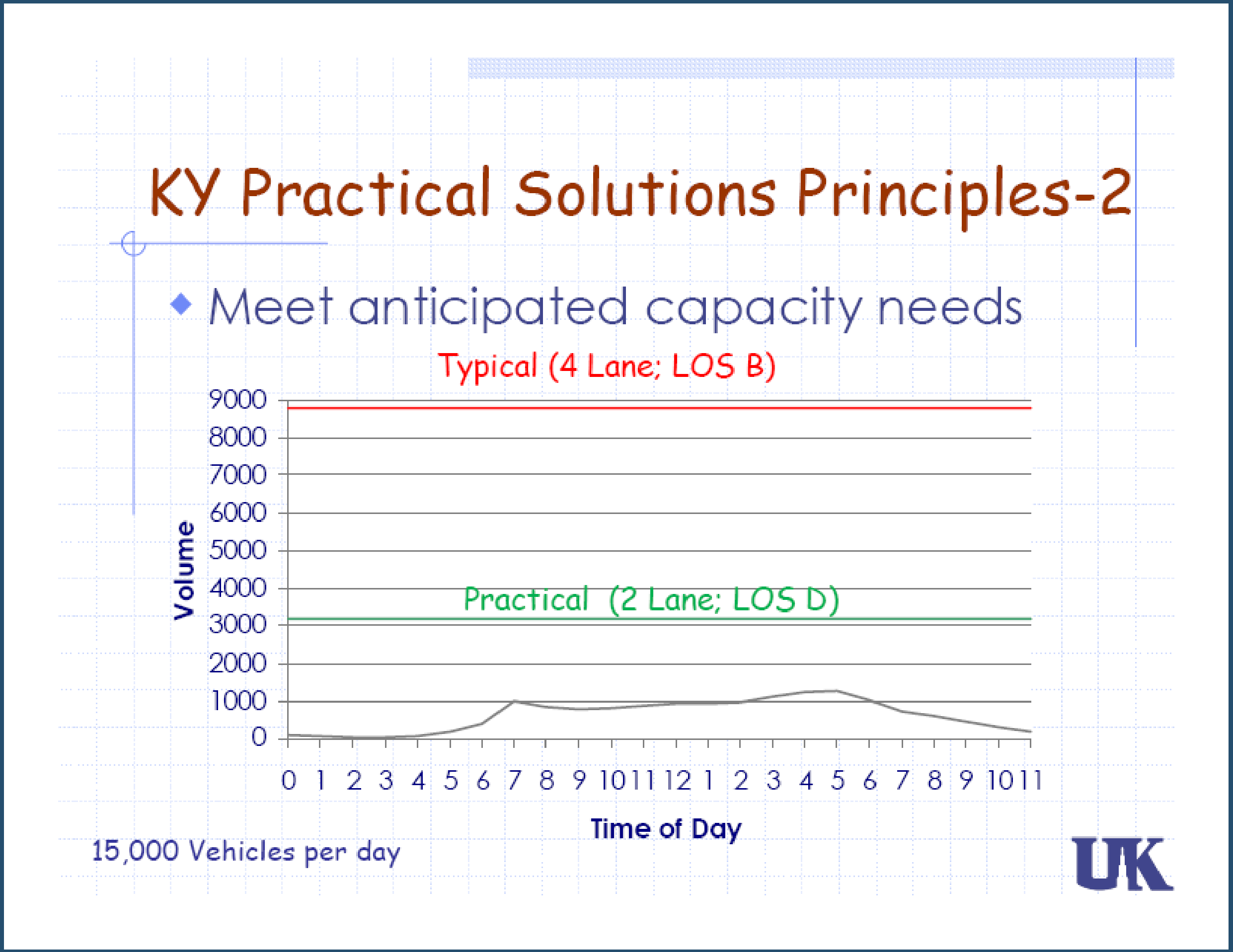
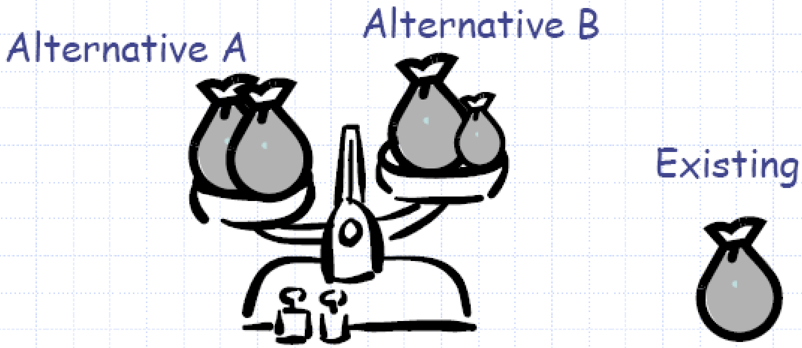


Kentucky’s Practical Solutions Concept

KY Practical Solutions Principles-3

- Evaluate safety compared to the existing conditions



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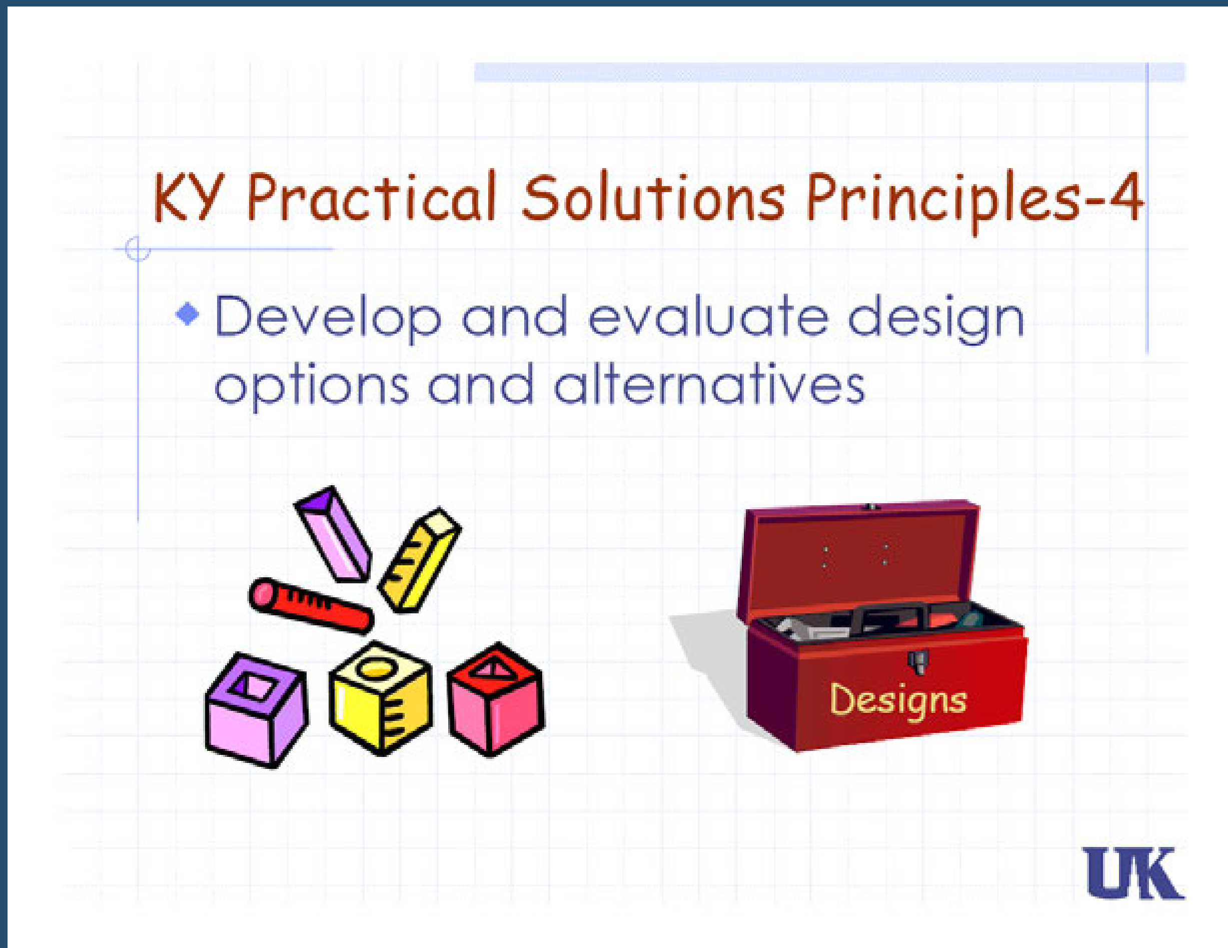

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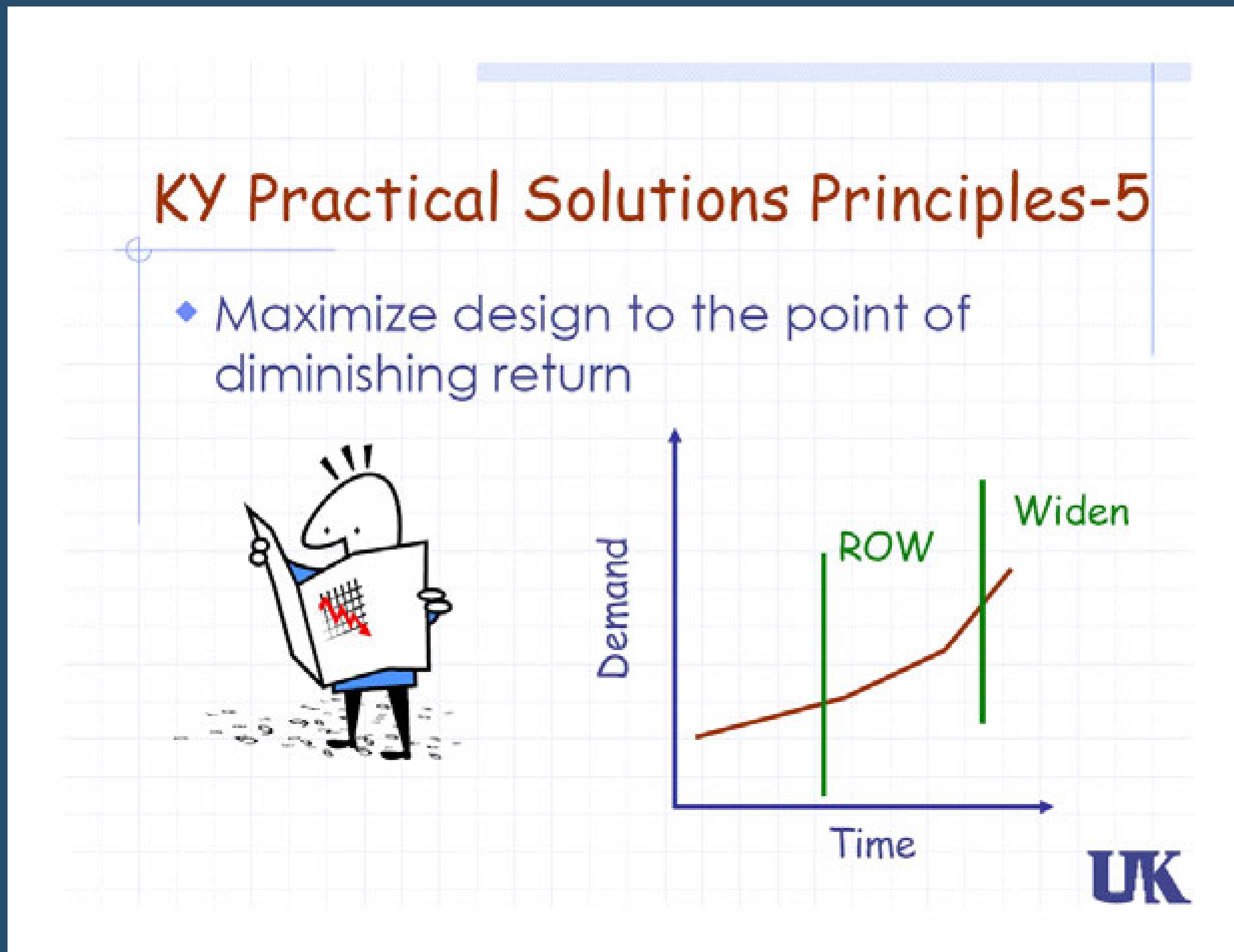


Kentucky's Practical Solutions Concept

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

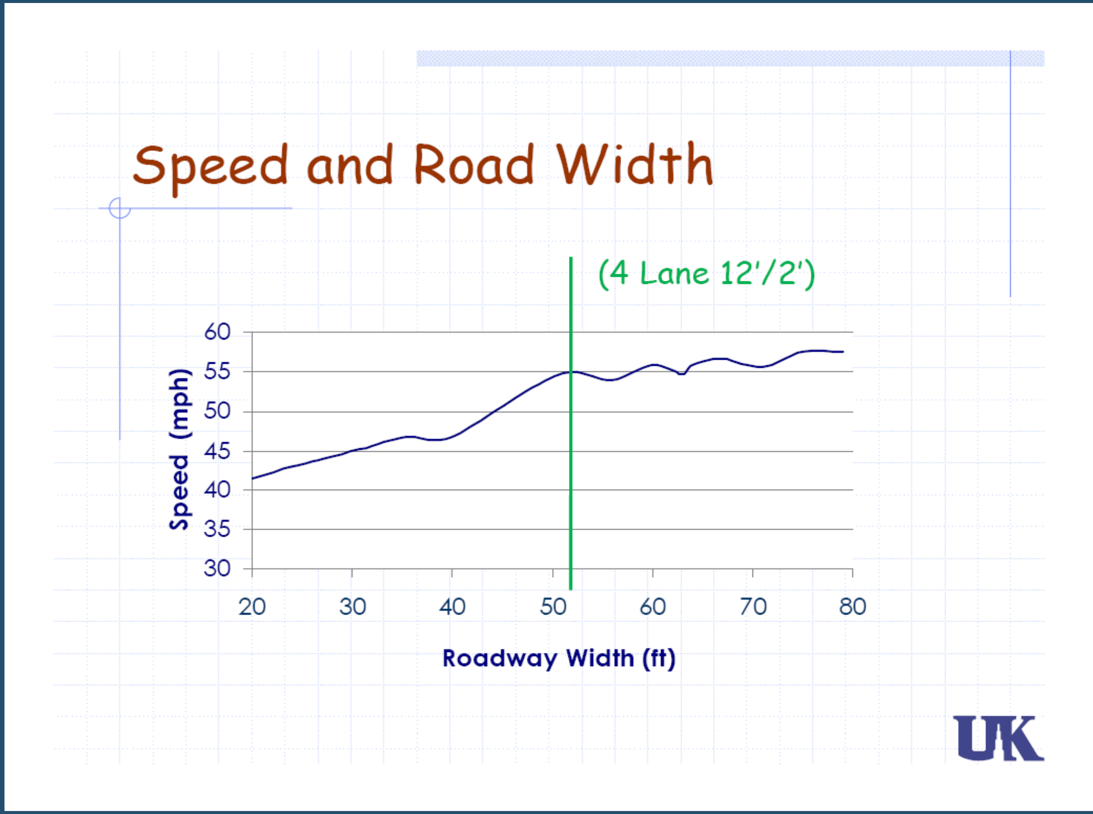
Kentucky's Practical Solutions Concept

Analyzing Safety & Operational Performance of Various Cross Section Alternatives Based Upon Highway Capacity & Safety Manual Procedures

Kentucky’s Practical Solutions Concept

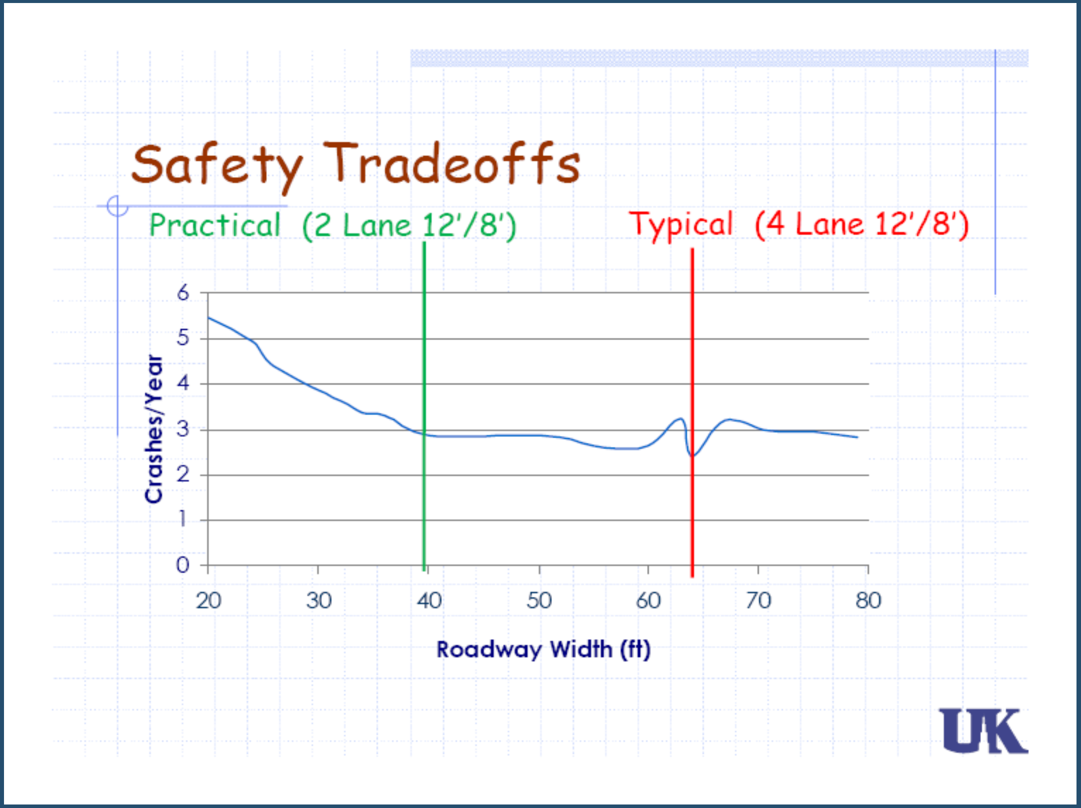
Analyzing Safety & Operational Performance of Various Cross Section Alternatives Based Upon Highway Capacity & Safety Manual Procedures

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 … therefor, a more Practical Solution with a $500 million budget

Road Improvement Example

Available budget $500 m to improve 2 lane roads

Cross Section	Crashes per Year	Cost (millions)	Speed (mph)	Miles	Total Reductions: Crashes	Total Reductions: Travel
2 Lane, 10 ft/2 ft	5.4	--	41.4	--	--	--
2 Lane, 12 ft/8 ft	2.9	$7.2	46.7	69.4	173.5	367.8
4 Lane, 12 ft/8 ft	2.4	$21.5	55.9	23.3	69.9	337.9

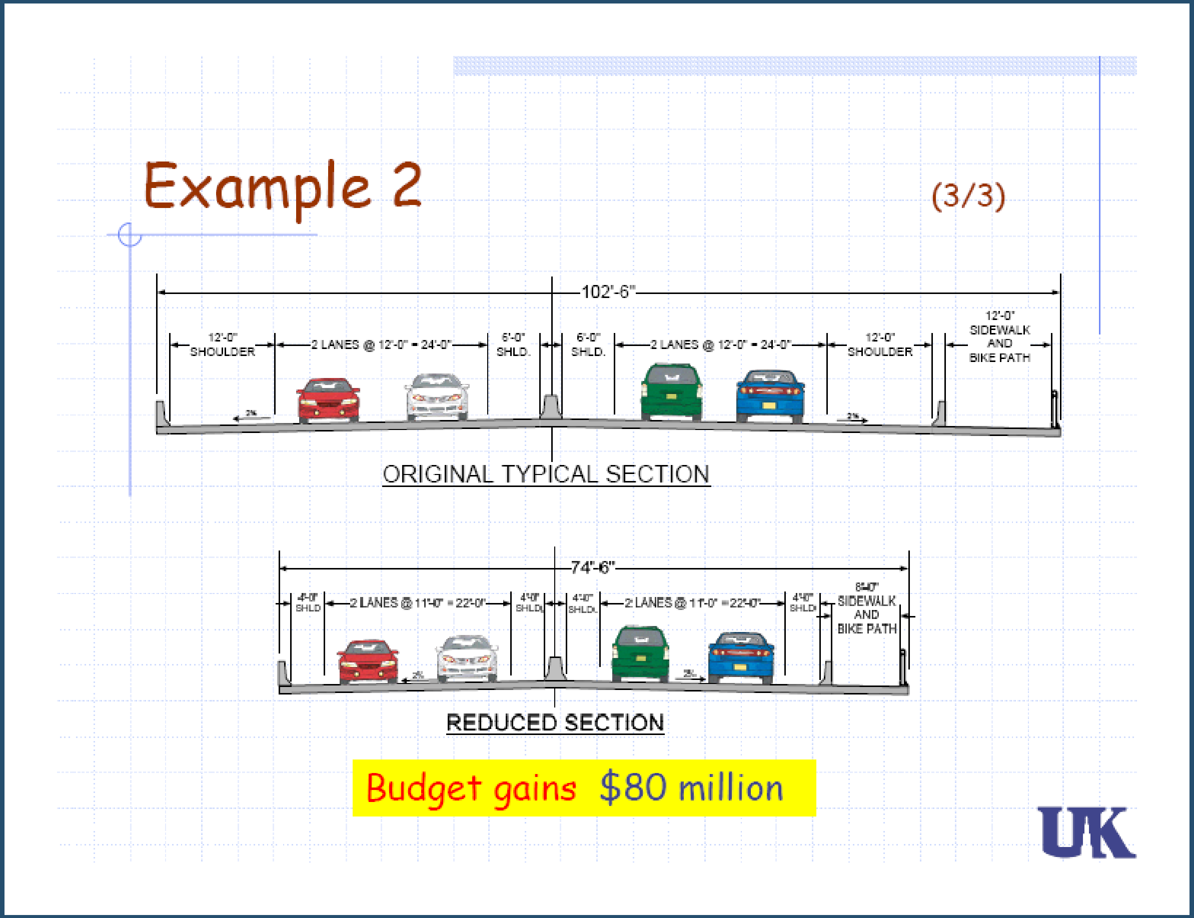
More miles, fewer crashes and fewer delays for same budget!

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



Kentucky's Practical Solutions Concept

Summary

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

UK

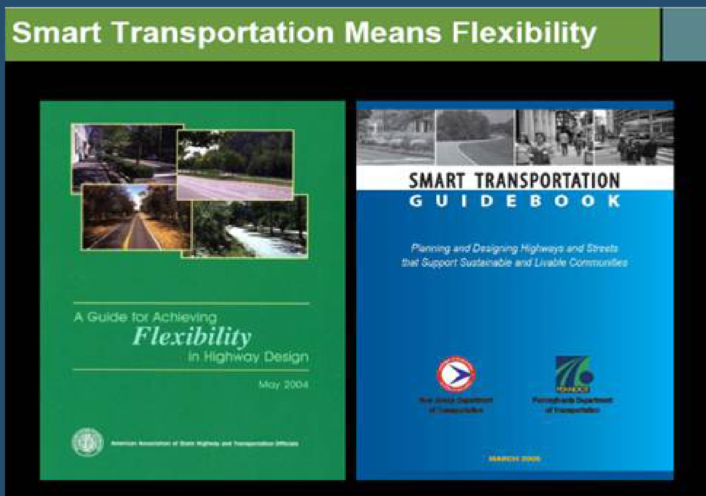
Kentucky’s Practical Solutions Concept

Final Thoughts

- Purpose and need
  - Establish targets
  - Do not exceed them
- Identify true problems
- Think beyond the standards
- Documentation

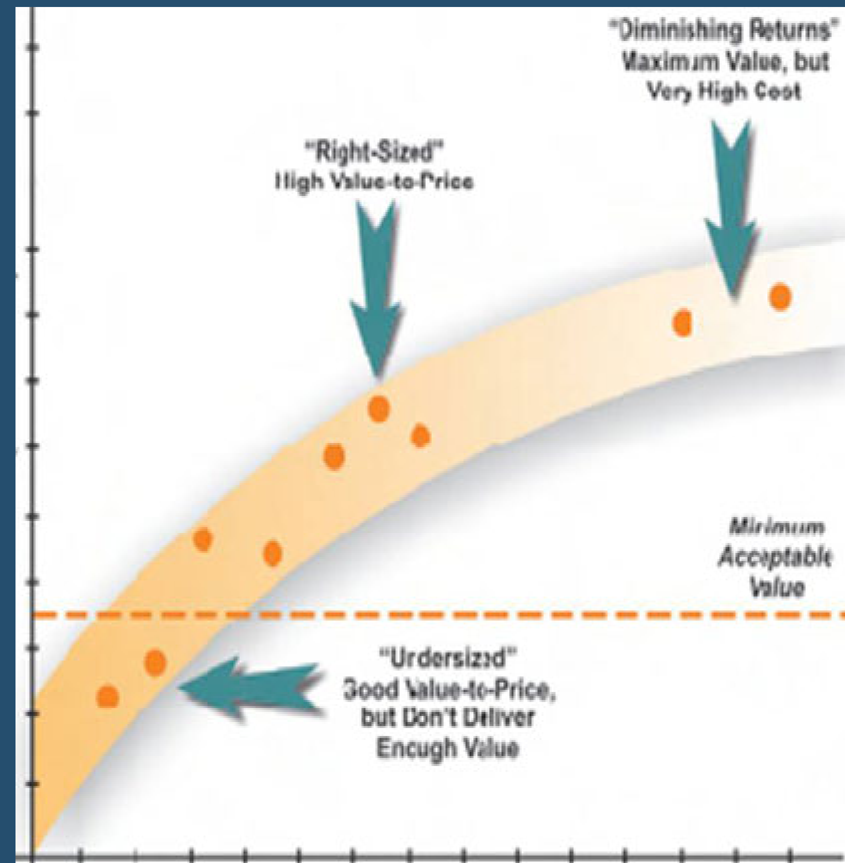
UK

Key Theme - Optimizing Return on Investments



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

VALUE (all benefits)

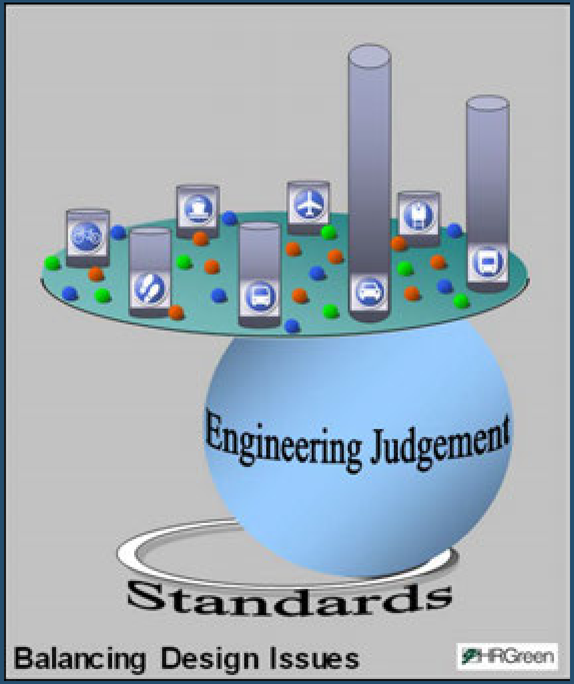


PRICE (cost + impacts)

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…

(Usability, Visual quality, Context sensitivity) } 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…

(Usability, Visual quality, Context sensitivity) } difficult to measure

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

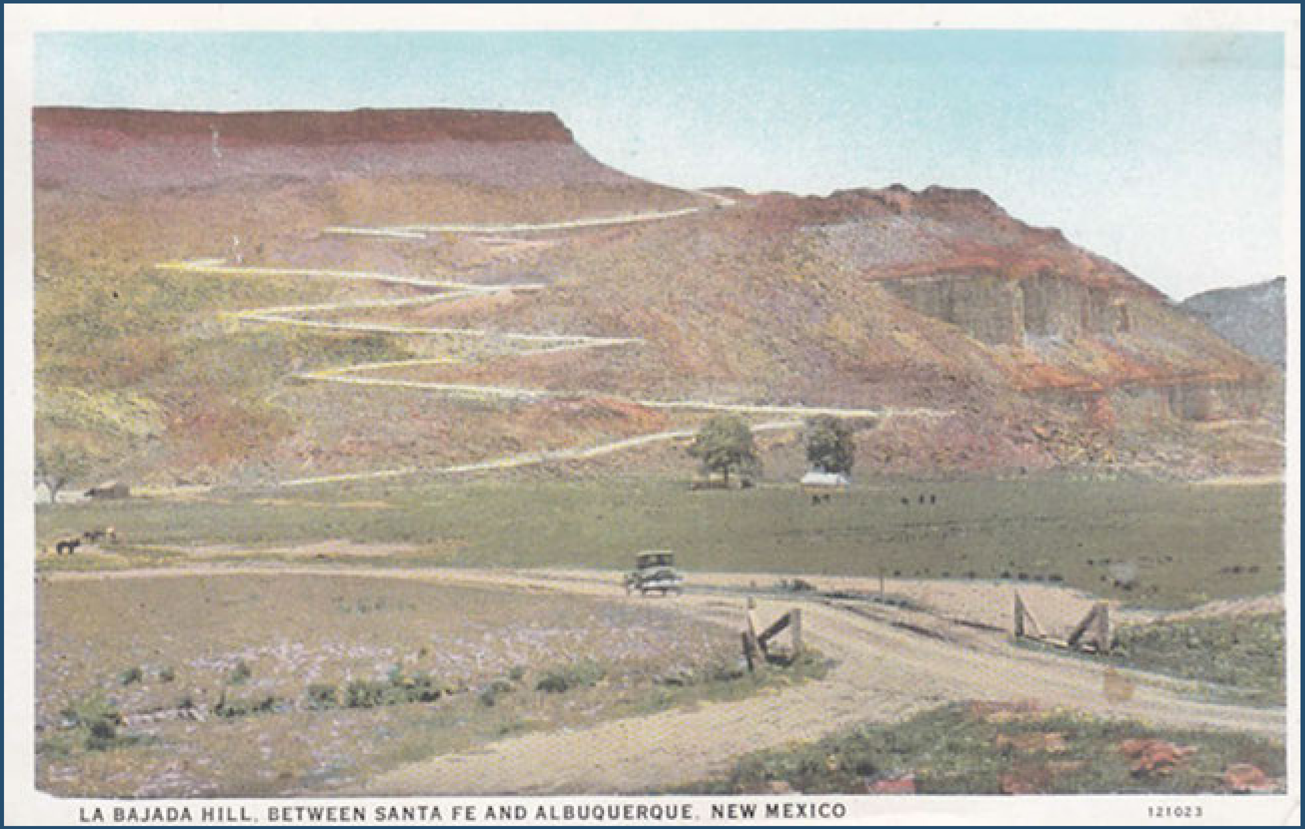
The Larger Picture

Getting out of the mud

The Larger Picture

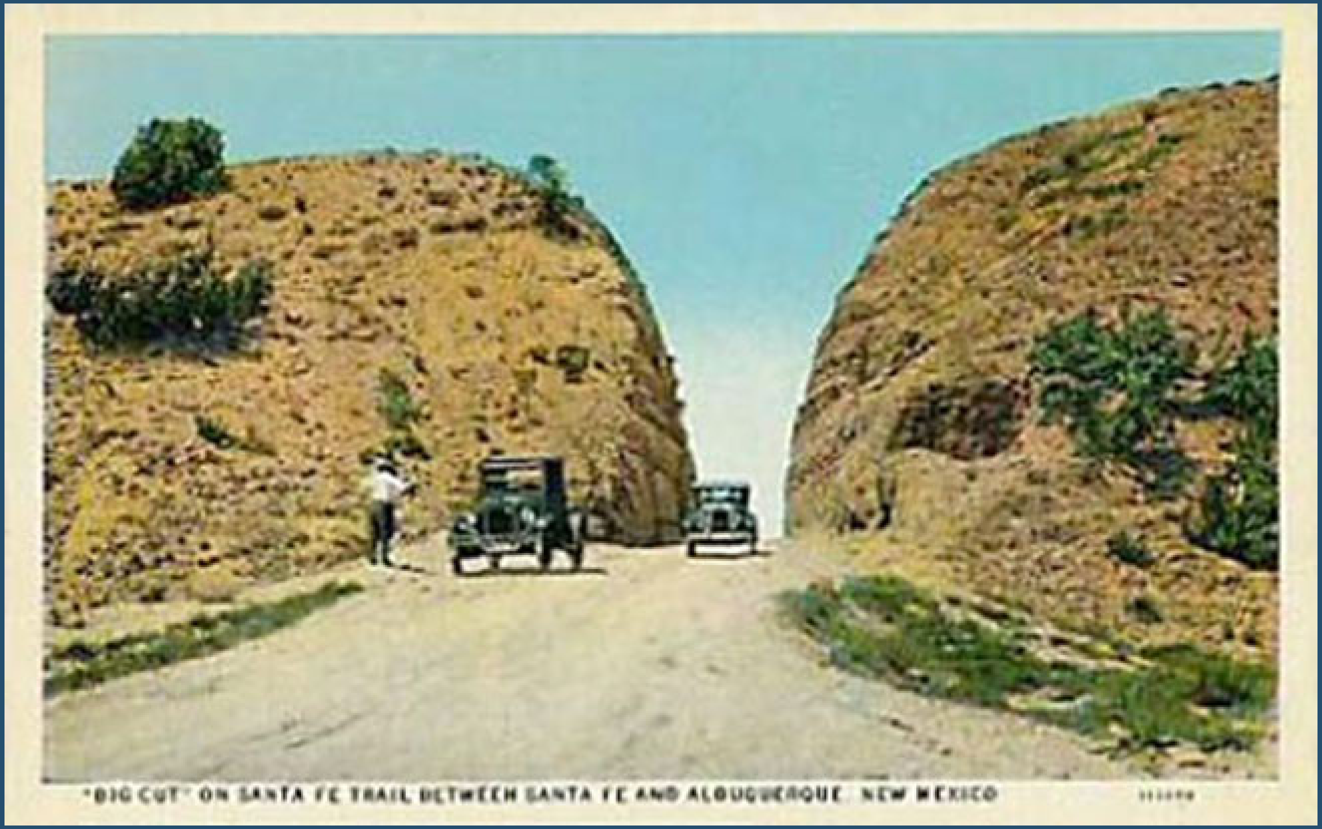
Early geometric design

The Larger Picture



Incremental improvement

The Larger Picture



The "Big Cut"

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

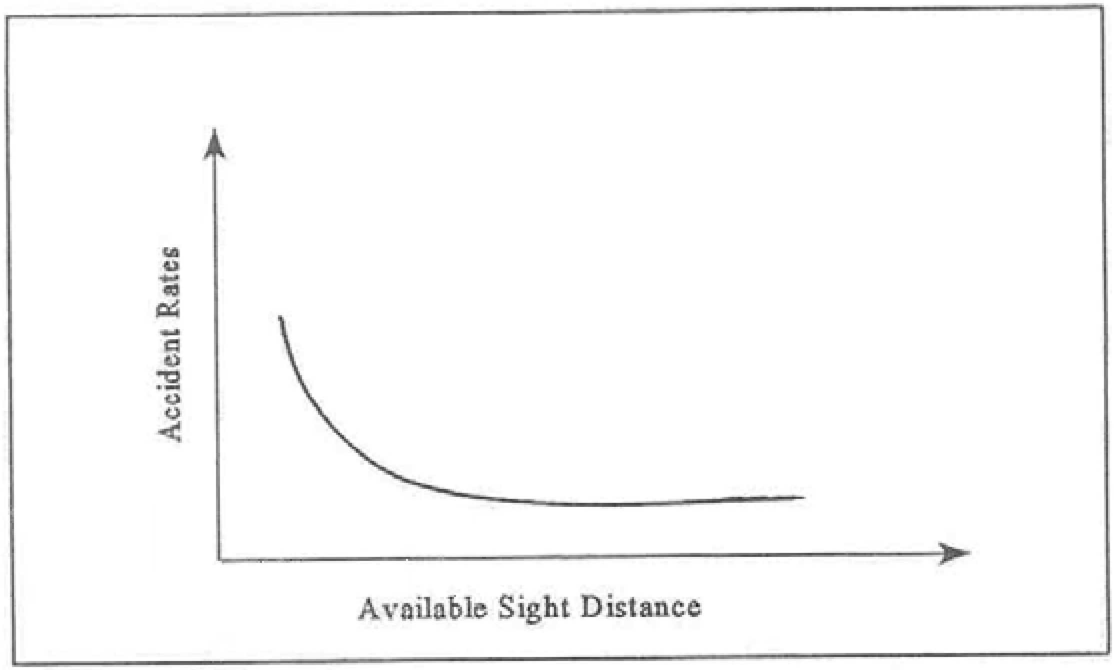


Figure 4. Conceptual Relationship Between Available Sight Distance and Safety at Crest Vertical Curves

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

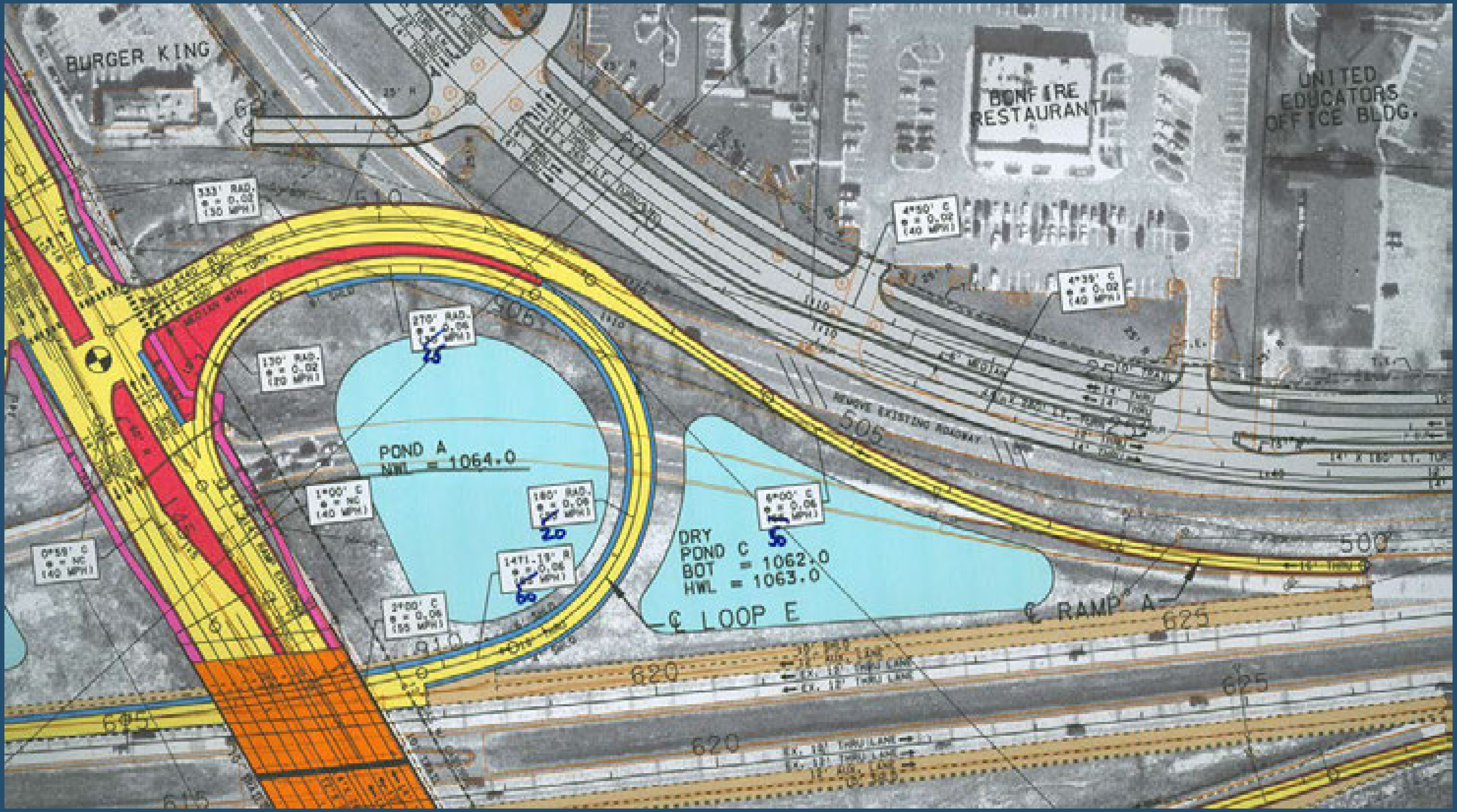
- Using design criteria for structure, guidance and consistency
- Using analytical tools to compare alternatives, assess benefits and help weigh considerations

Objectives

<u>Ground Level</u>

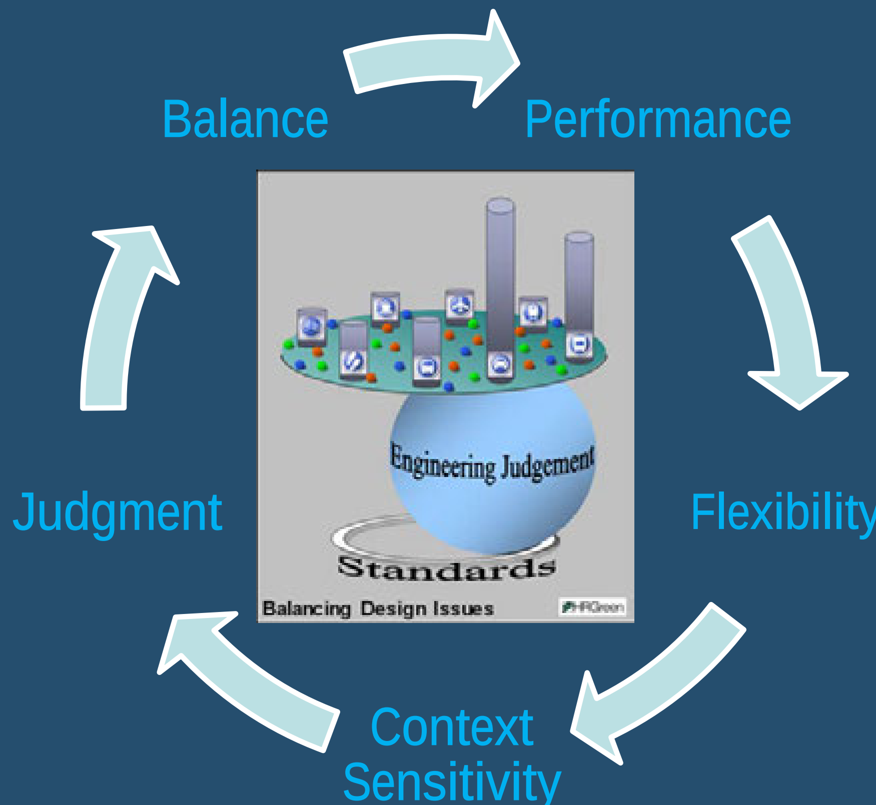
Making sound judgments…

Ground Level Judgments



Design Tradeoffs

You can't have one without the other…



Discussion / Questions