Data-Driven Safety Analysis – Nominal vs. Substantive Safety.

Analysis

Integrating Safety Performance into ALL Highway Investment Decisions

Efficiency through technology and collaboration

Every Day Counts
innovation ingenuity invention imagination

U.S. Department of Transportation
Federal Highway Administration

"Safety"

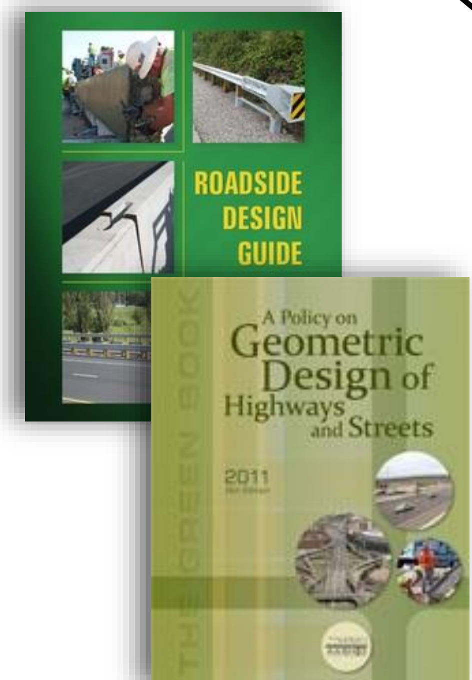
- A core value for all transportation agencies
- Our customers have been assured that maintaining and improving safety is a top priority
- Much of an agency's investments are intended to produce a "safe" highway or system
- "Safety" has traditionally been incorporated in highway programs and projects within a standards-based framework

Approaches for Considering Safety

Nominal Safety

Substantive Safety

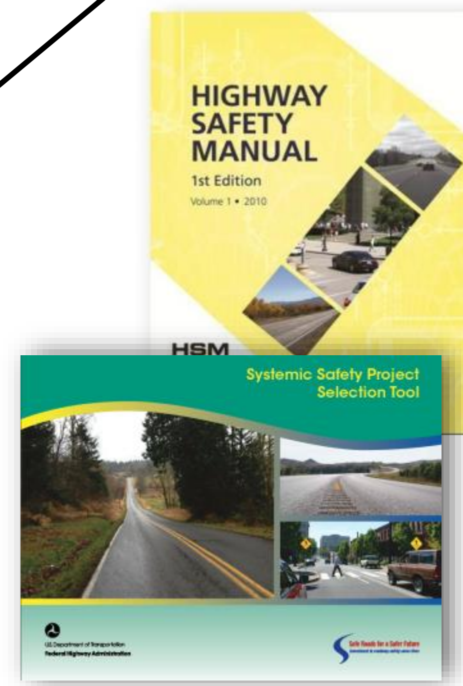
Source: AASHTO



Examined in reference to compliance with standards, warrants, guidelines and sanctioned design procedures

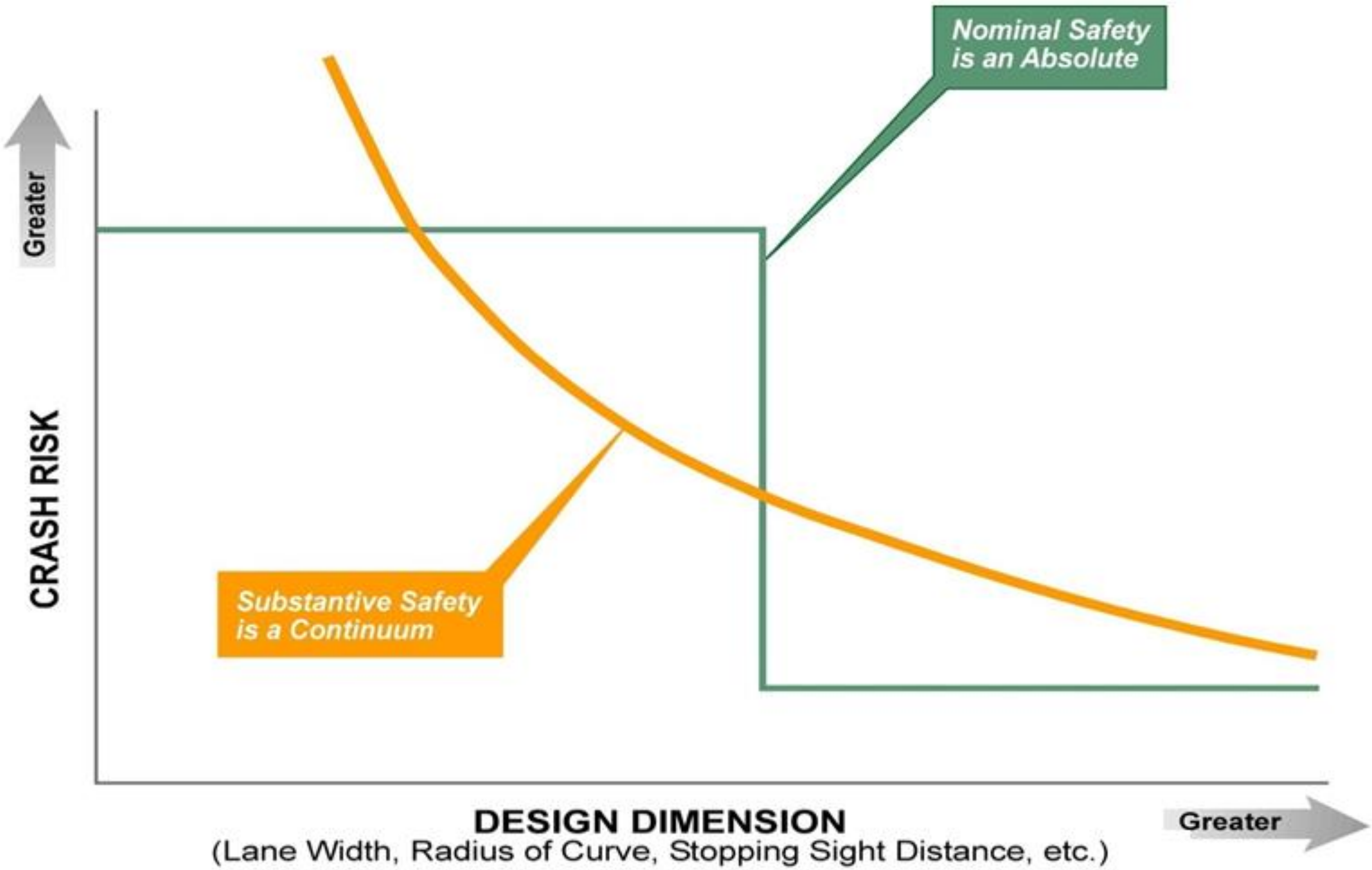
The actual or expected performance in terms of crash frequency and severity

Source: AASHTO



**Adapted from Ezra Hauer, ITE Traffic Safety Toolbox Introduction, 1999*

Nominal vs Substantive Safety



Hwy Design Standards in the U.S.

Initially, AASHO's Committee on Standards confined itself to disseminating information on design to its members, but in 1928 it proposed that the Association adopt "standards of practice" to guide the member States in technical matters in which some uniformity from State to State was urgently needed. As a result, on March 1, 1928, AASHO approved its first four standards which read as follows:

- That wherever practicable shoulders along the edges of pavements shall have a standard width of not less than 8 feet.
- That on pavements 10 feet shall be considered as the standard width for each traffic lane.
- That the crown of a two-lane concrete pavement shall be 1 inch.
- That no part of a concrete pavement shall have a thickness of less than 6 inches, and that all unsupported edges shall be strengthened. *(6)*

Hwy Design Standards in the U.S.

TABLE 1-1
Evolution of AASHTO (AASHO) Design Policies in the United States[1]

A Policy on Highway Classification, September 16, 1938
A Policy on Highway Types (Geometric), February 13, 1940
A Policy on Sight Distance for Highways, February 17, 1940
A Policy on Criteria for Marking and Signing No-Passing Zones for Two and Three-Lane Roads, February 17, 1940
A Policy on Intersections at Grade, October 7, 1940
A Policy on Rotary Intersections, September 26, 1941
A Policy on Grade Separations for Intersecting Highways, June 19, 1944
A Policy on Design Standards-Interstate, Primary and Secondary Systems, 1945
Policies on Geometric Highway Design, 1950
A Policy on Geometric Design of Rural Highways, 1954
A Policy on Arterial Highways in Urban Areas, 1957
A Policy on Geometric Design of Rural Highways, 1965
A Policy on Design of Urban Highways and Arterial Streets, 1973
A Policy on Geometric Design of Highways and Streets, 1984
A Policy on Geometric Design of Highways and Streets, 1990
A Policy on Geometric Design of Highways and Streets, 1994
A Policy on Geometric Design of Highways and Streets, 2001

Hwy Design Standards in the U.S.

TITLE 23 - HIGHWAYS
CHAPTER 1 - FEDERAL-AID HIGHWAYS

§ 109. Standards

(a) **In General.**— The Secretary shall ensure that the plans and specifications for each proposed highway project under this chapter provide for a facility that will—

(1) adequately serve the existing and planned future traffic of the highway in a manner that is conducive to safety, durability, and economy of maintenance; and

(2) be designed and constructed in accordance with criteria best suited to accomplish the objectives described in paragraph (1) and to conform to the particular needs of each locality.

Federal Highway Administration, DOT

in the geometric and structural design of highways.

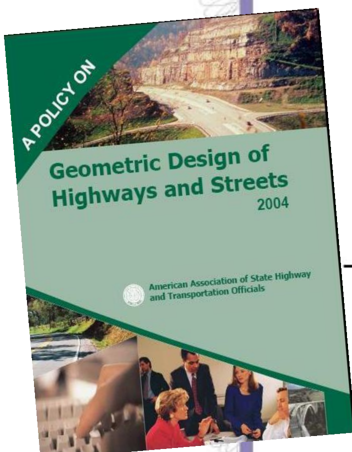
§ 625.2 Policy.

(a) Plans and specifications for proposed National Highway System (NHS) projects shall provide for a facility that will—

(1) Adequately serve the existing and planned future traffic of the highway in a manner that is conducive to safety, durability, and economy of maintenance; and

(2) Be designed and constructed in accordance with criteria best suited to accomplish the objectives described in paragraph (a)(1) of this section and to conform to the particular needs of each locality.

FHWA Adopts AASHTO for NHS



Certificate of Adoption

AASHTO Policies on Geometric Design

Was adopted on ______________________________

By ____

§ 625.4 Standards, policies, and standard specifications.

The documents listed in this section are incorporated by reference with the approval of the Director of the Federal Register in accordance with 5 U.S.C. 552(a) and 1 CFR part 51 and are on file at the Office of the Federal Register in Washington, DC. They are available as noted in paragraph (d) of this section. The other CFR references listed in this section are included for cross-reference purposes only.

(a) *Roadway and appurtenances.* (1) A Policy on Geometric Design of Highways and Streets, AASHTO 2001. [See § 625.4(d)(1)]

(2) A Policy on Design Standards Interstate System, AASHTO, January 2005. [See § 625.4(d)(1)]

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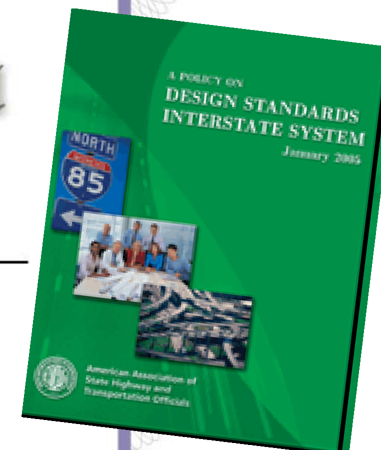
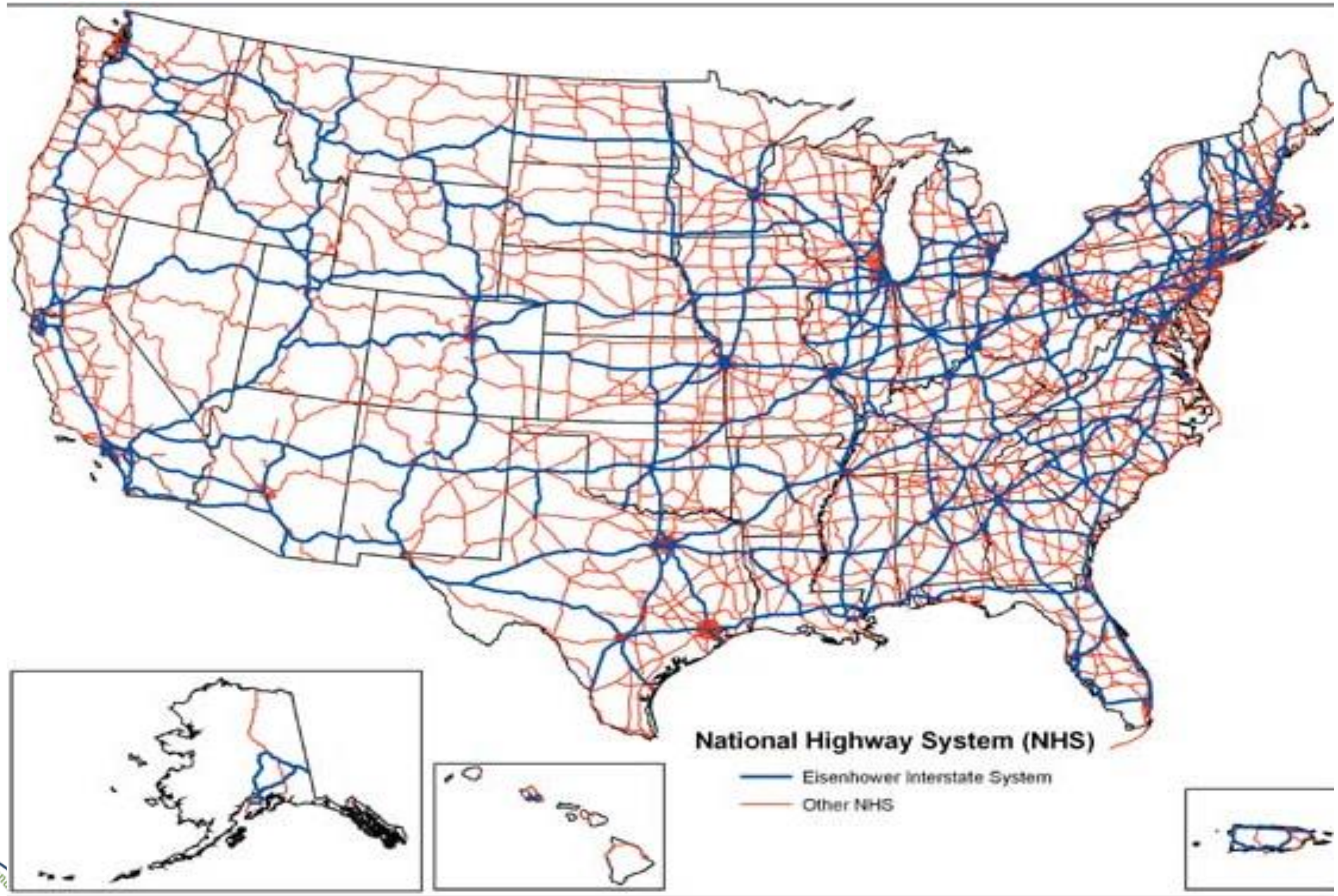


FHWA Standards Only for NHS

(o) Compliance With State Laws for Non-NHS Projects.— Projects (other than highway projects on the National Highway System) shall be designed, constructed, operated, and maintained in accordance with State laws, regulations, directives, safety standards, design standards, and construction standards.

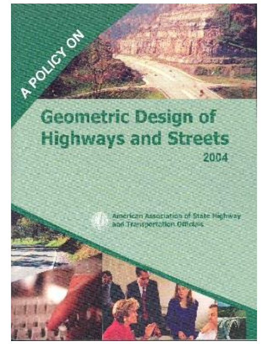


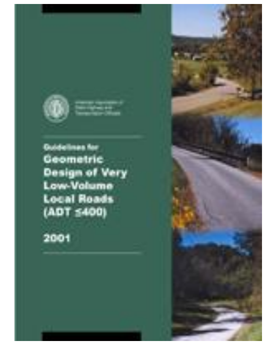
States Designate Standards Off NHS

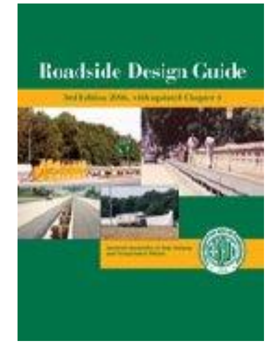
State Roadway Design Manuals

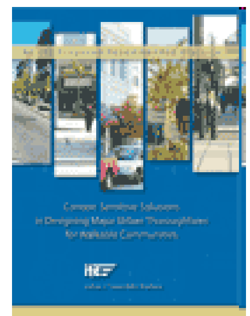
The table below indicates the online location of State highway agency roadway design manuals, when available. If the design manual is not available online the URL listed is the State web site with other design information. If you are just looking for State Standard Drawings, see http://www.fhwa.dot.gov /programadmin/statestandards.cfm

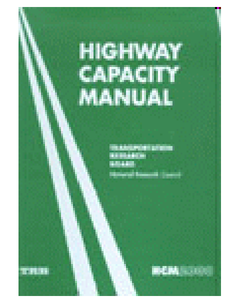
State	URL
AL	Design Bureau's Engineering Support Section
AK	Standard Specs
AZ	Engineering Records Publications
AR	Arkansas State Highway & Transporation Department Info
CA	Highway Design Manual
CO	CDOT Design Guide 2005
CT	Division of State Design
DE	Road Design Manual
DC	Design and Engineering Manual
FL	Designer Manuals
GA	GDOT Construction Standards & Details
HI	Highways - Design Branch
ID	Design Manual
IL	Bureau of Design & Environment Manual - 2002 Edition
IN	Design Manual
IA	Office of Design - Design Manual (.pdf)
KS	Standard Specifications for State Road and Bridge Construction
KY	Highway Design Manual
LA	Road Design Manual
ME	Contractor Information
MD	Business Standards and Specifications











A Predictive Illustration…

All three of these meet design standards…

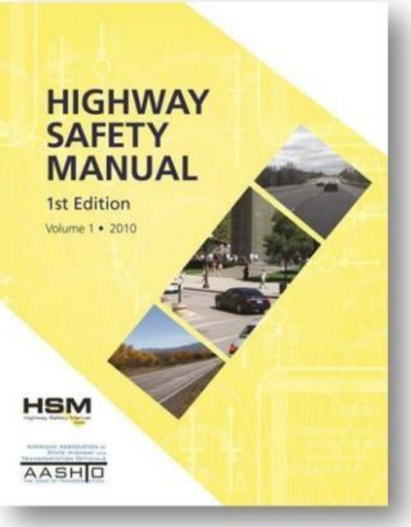
Source: CH2MHILL

but predictive analysis tells us they would perform very differently from a safety perspective.

The EDC Data-Driven Safety Analysis Initiative…

- Goal: Integrate **safety performance** into **ALL** highway investment decisions

What is the HSM?

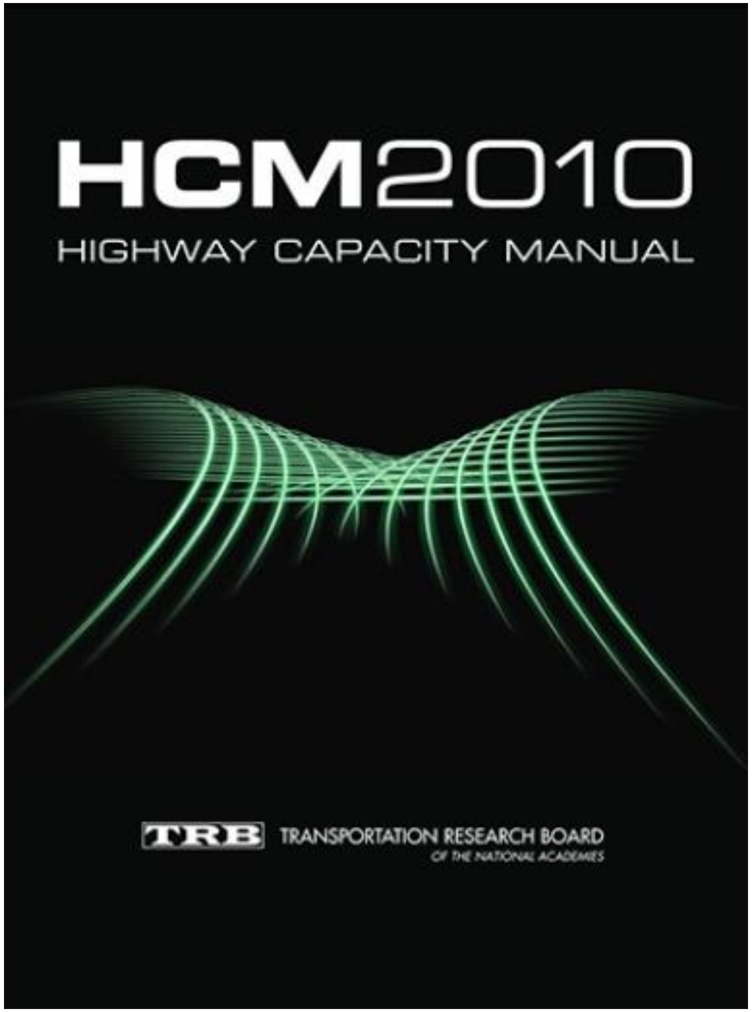


- A tool that applies an **evidence-based** technical approach to safety
- Provides reliable **estimates** of an existing or proposed roadway's **expected safety performance**.
- Helps agencies **quantify** the **safety impacts** of transportation decisions, similar to the way agencies quantify:
  - traffic growth
  - environmental impacts
  - traffic operations
  - pavement life
  - construction costs

The Vision for the HSM

A Document Akin To the HCM…

1. Definitive; represents quantitative ‘state-of-the-art’ information
2. Widely accepted within professional practice of transportation engineering
3. Science-based; updated regularly to reflect research



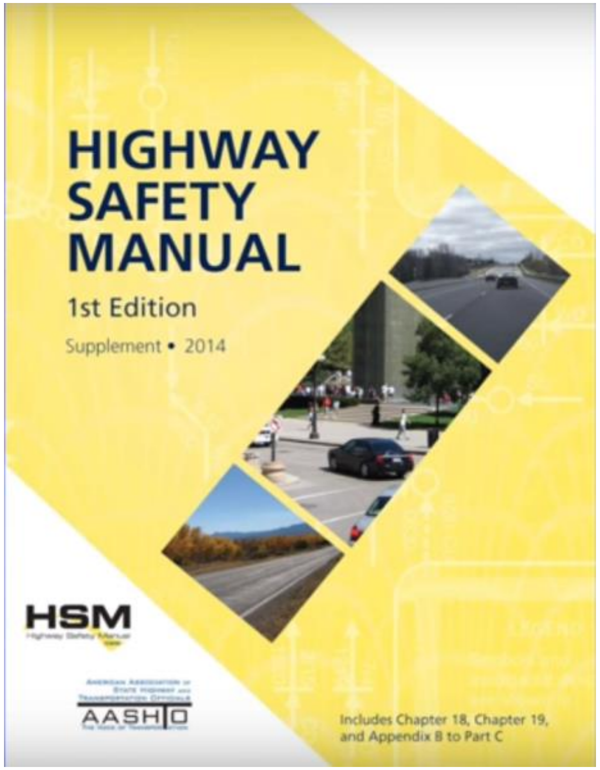
AASHTO Highway Safety Manual, First Edition

2010 Release:

- Rural Two-Lane Roads
- Multilane Rural Highways
- Urban/Suburban Arterials

2014 Supplement:

- Freeway Segments
- Ramps
- Ramp Terminals



Highway Safety Manual Organization

Part A	Introduction, Human Factors & Fundamentals
Part B	Safety Management Process
Part C	Predictive Methods
Part D	Crash Modification Factors

HSM Companion Software

HSM Part	Supporting Tool
PART B: Roadway Safety Management Process	AASHTOWare SafetyAnalyst Agile Assets Safety Analyst CARE Numetric usRAP Vision Zero Suite Other commercial… State-Developed
PART C: Predictive Methods	HSM & ISATe Spreadsheets IHSDM
PART D: CMFs	FHWA CMF Clearinghouse

Design Practice Involves Risk

- Two fundamental types of risk:
  - Risk of tort lawsuits arising from crashes alleged to be associated with a design ("Tort Risk")
  - Risk of the solution not performing as expected in terms of safety and operations ("Engineering Risk")

Tort Risk

- Adherence to criteria does not automatically prove *reasonable care*
- Deviation from criteria does not automatically prove *negligence*

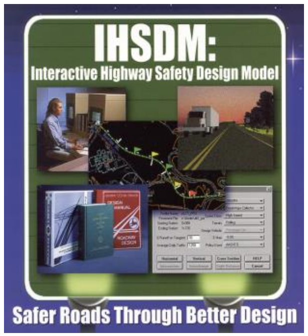
Tort Risk

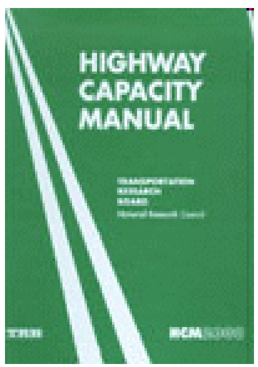
- In most jurisdictions, the Court does not have authority to rule that the design decision was the "correct" choice
- The Court can only render judgment on whether the process was complete and whether the outcome was reasonable given the process

Meeting Design Criteria Important

- "Transportation agencies limit greatly the risk of a successful tort suit by focusing on design solutions that are proven, i.e., that are within current design guidelines and criteria".
- "Providing a nominally safe design is the first and major step toward minimizing tort risk".

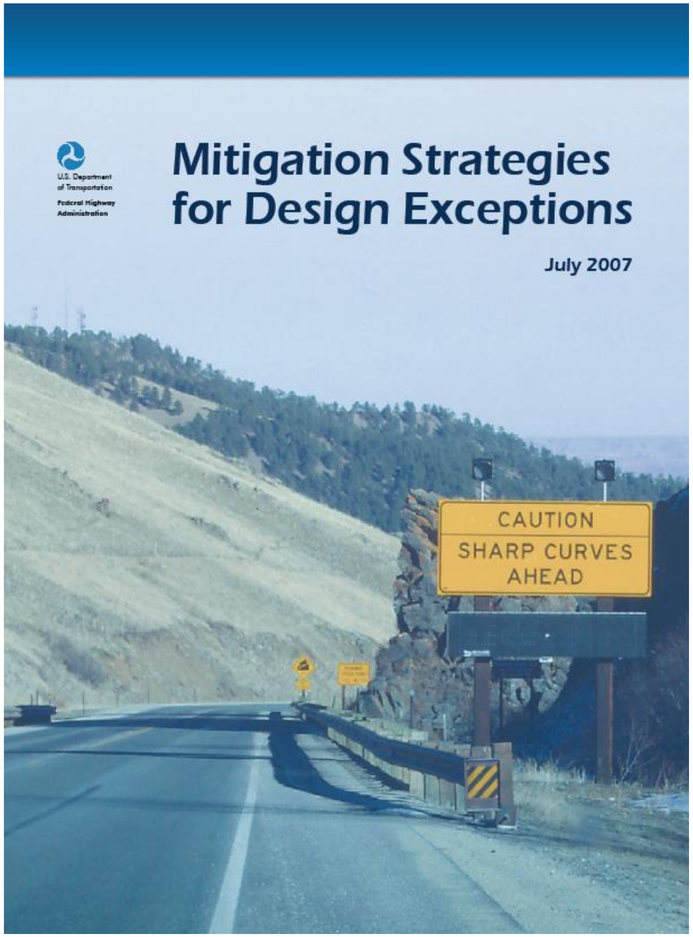
Engineering Risk





- How good (or poor) is the existing substantive safety performance?
- What should the long term safety performance of the roadway be?
- What is the difference in expected substantive safety if the exception is implemented?

Engineering Risk



- What is the degree to which a standard is being reduced?
- Will the exception affect other geometric elements?
- What additional features will be introduced, (e.g., signing or delineation) that would mitigate the potential adverse effects of the exception?

CSS Approach Helps Minimize Risk

- It is an unavoidable fact that DOTs face public and legal scrutiny for virtually all their actions.
- However, if a design team works closely with stakeholders, is creative within the bounds of good engineering practice, and fully documents all decisions, they will have gone a long way toward minimizing the risk associated with a future tort action should that occur

Case Study – Arizona DOT

Parameters for Existing & Proposed Conditions:

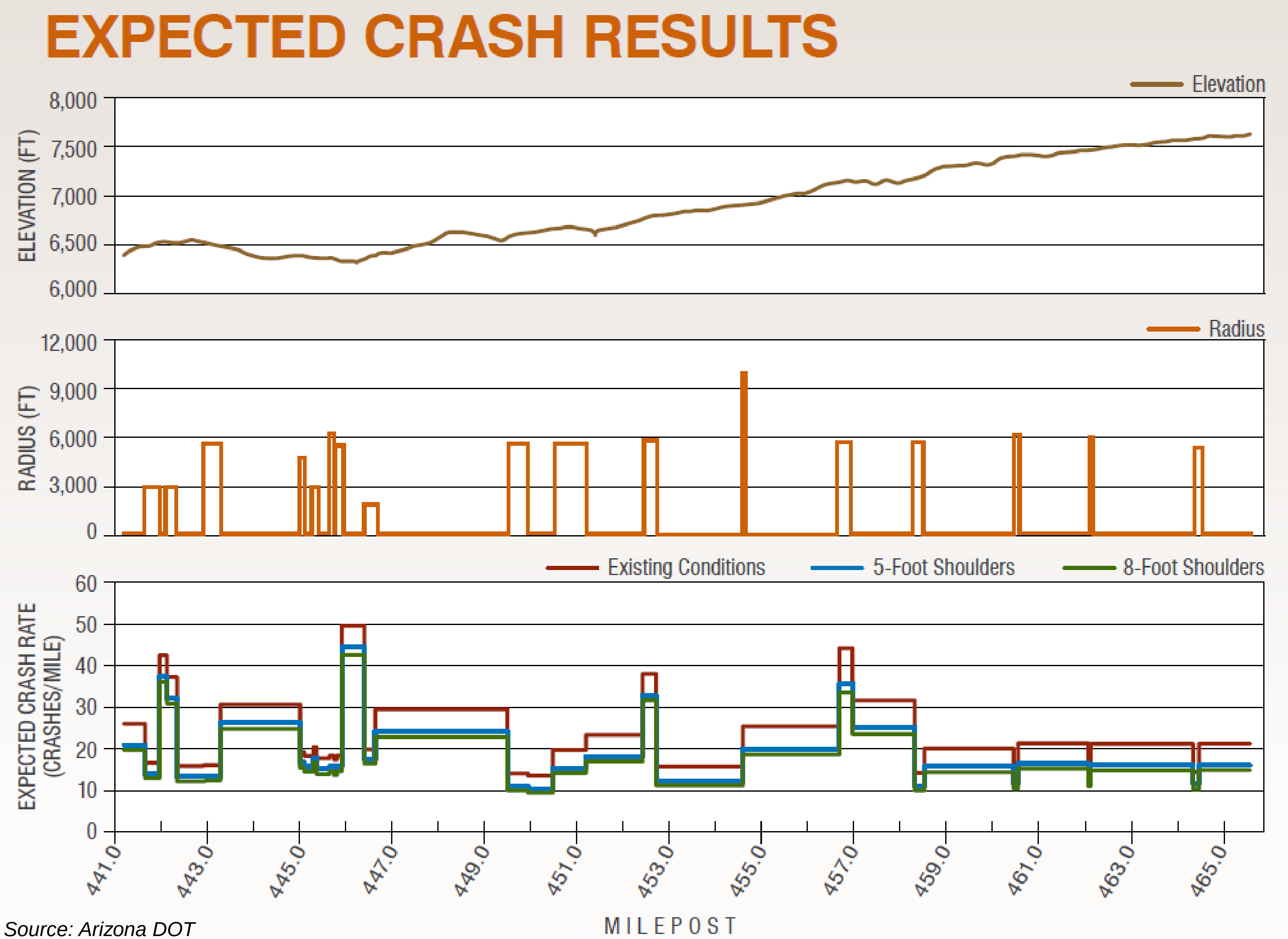
- Used IHSDM to perform safety analysis

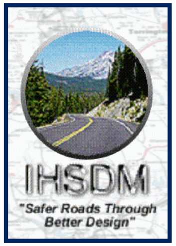
ROADWAY ELEMENT	HSM Base Condition	Existing SR 264 (1-Foot Shoulders)	Alternative A (5-Foot Shoulders)	Alternative B (8-Foot Shoulders)
Lane width	12-Foot	12-Foot	12-Foot	12-Foot
Shoulder width	6-Foot	1-Foot	5-Foot	8-Foot
Shoulder type	Paved	Paved	Paved	Paved
Roadside hazard rating	3	Varies (6 or 7 most frequent)	Varies (1 or 2 most frequent)	Varies (1 or 2 most frequent)
Driveway density	≤ 5 per mile	Per survey & Holbrook District turnout database	Per survey & Holbrook District turnout database	Per survey & Holbrook District turnout database
Horizontal curves: length, radius, and presence or absence of spiral transitions	None	Per best fit alignment	Per best fit alignment (match existing)	Per best fit alignment (match existing)
Horizontal curves: Superelevation	None	Per as-builts & survey	Per as-builts & survey (match existing)	Per as-builts & survey (match existing)
Grades	≤ 3%	Per as-builts & survey	Per as-builts & survey (match existing)	Per as-builts & survey (match existing)
Centerline rumble strips	None	None	Present	Present
Passing lanes	None	Per survey	Per survey (match existing)	Per survey (match existing)
Two-way left-turn lanes	None	Per survey	Per survey (match existing)	Per survey (match existing)
Lighting	None	Present @ US 191 Intersection	Present @ US 191 Intersection (match existing)	Present @ US 191 Intersection (match existing)
Automated speed enforcement	None	None	None	None

Source: Arizona DOT

Case Study – Arizona DOT

Plot of Geometric Features and Expected Crashes





Source: Arizona DOT

Case Study – Arizona DOT

Crash Prediction Results

Expected Crash Frequency by Severity: 2016–2036

Source: Arizona Department of Transportation, Traffic Safety Evaluation Report

Alternative	Total Crashes	Fatal and Injury Crashes	Property Damage Only Crashes	Reduction in Total Crashes over Existing Conditions	Percent Reduction
No Build	636.4	283.4	353.0	—	—
Alternative A	531.6	230.5	301.1	104.8	16.5
Alternative B	504.2	216.8	287.4	132.2	20.8
Only Superelevation Improvements	635.3	282.7	352.6	1.1	0.2

- **IHSDM Safety Analysis:**
  - Model was un-calibrated as used (not necessary for comparative alternatives analysis)
  - **Alternative B** (8-ft shoulders) **would reduce crashes by 4 percent more** than Alternative A (5-ft shoulders)

Case Study – Arizona DOT

Benefit to Cost Ratio: Design Alternatives

Alternative	Annual Benefit	Annual Cost	Benefit/Cost Ratio
Alternative A	$3,873,681	$1,680,561	2.30
Alternative B	$5,084,207	$2,678,713	1.90
Superelevation Improvements	$41,807	$135,464	0.31

Source: Arizona Department of Transportation, Traffic Safety Evaluation Report

- **Economic analysis:**
  - Although Alternative B (8-ft shoulders) could provide the greater benefit in reduction in fatal and injury crashes, **Alternative A** (5-ft shoulders) would provide the **greater return on investment** and was selected as the preferred alternative.

Questions & Answers

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