

Trade-Off Considerations in Highway Geometric Design

Presented to:

OTEC 2011

Presented by:

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Introduction

- NCHRP Synthesis 422 – Trade-Off Considerations in Highway Geometric Design published 17 October 2011
- Goal
 - Identify and compile existing practices for assessing trade-offs in design and the process for selecting and approving a specific design.

Agenda

- Background
- Survey Results
- Future Needs

Background

- Conventional approach to highway design
 - *A Policy on Highway Classification* (1938)
 - *AASHTO A Policy on Geometric Design of Highways and Streets* (2004)
- Design is based on a large body of research relating driver and vehicle performance to geometric elements

Background

- With completion of Interstate, design focus shifting
 - Few new alignment
 - Improvement and reconstruction of existing
- 1990's
 - Focus on flexibility in highway design

Background

- ISTEA (1991)
 - “If a proposed project...involves a historic facility or is located in an area of historic or scenic value, the Secretary may approve such project...if such project is designed to standards that allow for the preservation of such historic or scenic value and such project is designed with mitigation measures to allow preservation of such value and ensure safe use of the facility.”

Background

- Challenge
 - Balance competing objectives
 - Trade-off analysis necessary
- Design criteria form the basis from which to understand trade-offs

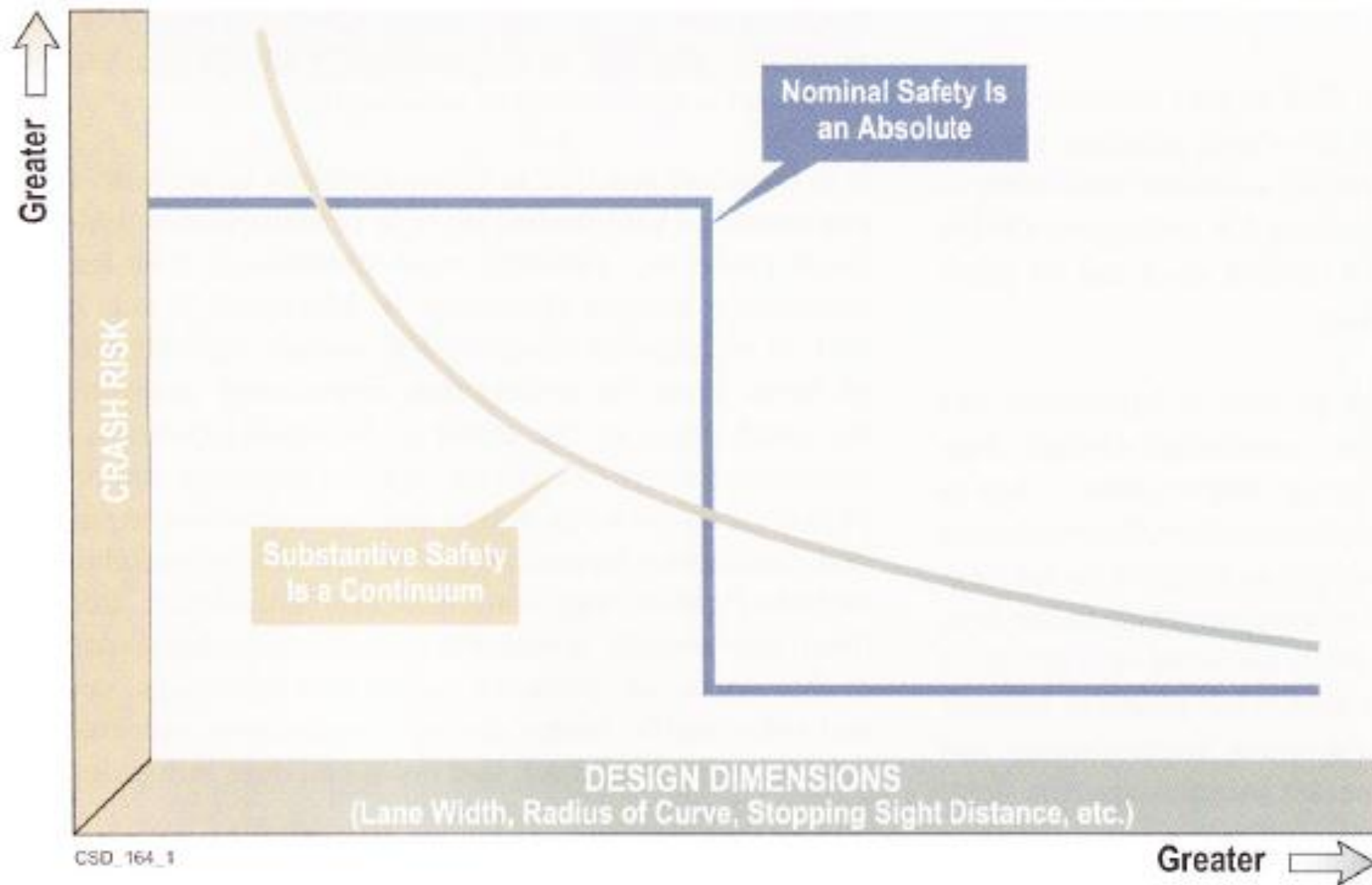
Basic Controls/Criteria

- Highway functional classification
- Design speed
- Acceptable operational level of service of the facility
- Physical characteristics of the design vehicle
- Performance of the design vehicle
- Capabilities of the typical driver
- Existing and design traffic demand.

Tools

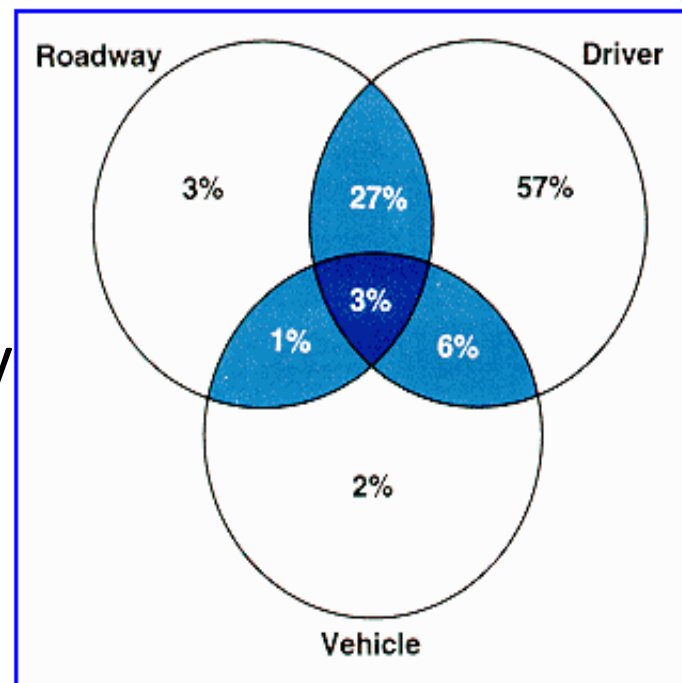
- *Older Driver Highway Design Handbook (FHWA 1995)*
- *Highway Capacity Manual (TRB 2010)*
- *Guide for the Development of Bicycle Facilities (AASHTO 1999)*
- *Traffic Safety Toolbox: A Primer on Traffic Safety (ITE 1999)*
- *Access Management Manual (TRB 2003)*
- *Access Management Guidelines for Activity Centers (TRB 1992)*
- *Impacts of Access Management Techniques (TRB 1999)*
- *Driveway and Street Intersection Spacing (TRB 1996)*
- *HOV Systems Manual (TRB 1998)*
- *Design and Safety of Pedestrian Facilities (ITE 1998)*
- *Building a True Community (U.S. Access Board 2001)*
- *Interactive Highway Safety Design Model (FHWA 2010)*
- *Highway Safety Manual (AASHTO 2010)*
- *Guide for Achieving Flexibility in Highway Design (AASHTO 2004)*
- *Flexibility in Highway Design (FHWA 1997)*
- *Designing Walkable Urban Thoroughfares (ITE 2010)*

Nominal and Substantive Safety



Crash Experience

- View that standards equals safety
- Rumar study of crashes in US/UK
 - 3 % of crashes are caused by roadway environment alone
 - 57% only related to drivers
 - 2% only related to vehicles
 - 34% associated with road-related elements
 - 94% associated with driver-related elements



Design Exceptions

13 Controlling Criteria

- Design speed
- Lane width
- Shoulder width
- Bridge width
- Structural capacity
- Horizontal alignment
- Vertical alignment
- Grade
- Stopping sight distance
- Cross slope
- Superelevation
- Vertical clearance
- Horizontal clearance

Literature Review

- Conventional Design Approach
- Context Sensitive Solutions/Context Sensitive Design
- Practical Solutions/Design
- Performance Based Planning
- Value Engineering
- Choosing by Advantages (CBA)
- Project Risk Analysis
- Risk and Reliability Analysis
- Risk Management
- Psychology of Risk Perception
- Organizational Accidents
- Safety-Conscious Planning
- Road Safety Audits
- Interactive Highway Safety Design Model (IHSDM)
- Highway Safety Manual (HSM)
- Safety Analyst

Survey

- Sent to 50 STAs, District of Columbia, Puerto Rico
- Responded to by 41 STAs, District of Columbia, Puerto Rico

Survey Results

- Few State Transportation Agencies have codified procedures for evaluating trade-offs in highway geometric design.
- Majority of STA's rely on "engineering judgment."
- MoDOT – *Practical Design: Meeting Our Customers' Needs*
- CDOT – *Context Sensitive Solutions (CSS) Vision for CDOT*
- PennDOT – *Community Context Audit*

Survey Results

- Where are trade-offs handled?
- Concern expressed when identified late as most flexibility is gone
- Concern that sufficient design resources may not be available in early process

7	0% -- Project Initiation
34	20% -- Preliminary Engineering
20	40 to 60% -- Environmental Clearance
12	80% -- Final Design
4	100% -- Plans, Specifications and Estimates

Survey Results

- Trade-off analysis typically completed by a consultant
- Approval authority is typically centralized
- Same division typically approves both a trade-off analysis and design exception documentation

Survey Results

	As a P&N Goal			Measurement		
	Always	Sometimes	Never	Quantitative	Qualitative	Both
Access Management	6	31	4	8	11	20
Cost	21	18	2	25	2	13
Environmental Issue	21	17	3	2	10	27
Historic Impact	16	22	3	4	14	22
Human Factors/Driver Expectancy	14	21	6	2	19	16
Operational Efficiency	20	21	0	13	5	23
Right-of-Way Availability	16	21	4	14	3	21
Safety	32	7	2	1	5	35
Schedule	12	24	5	20	4	12
Social Concerns	13	26	1	1	25	14
Tort Liability Exposure	9	19	12	2	10	19

Survey Results

- Trade-off most used as justification for design exception

All Responses

Access Management	2
Cost	29
Environmental Issue	24
Historic Impact	5
Human Factor/Driver Expectancy	4
Operational Efficiency	12
Right-of-Way Availability	10
Safety	28
Schedule	6
Social Concerns	2
Tort Liability Exposure	4

Survey Results

- Likelihood of a trade-off being accepted as a justification for design exception

Access Management	5.8
Cost	7.8
Environmental Issue	8.1
Historic Impact	7.7
Human Factors/Driver Expectancy	6.5
Operational Efficiency	7.3
Right-of-Way Availability	6.8
Safety	8.1
Schedule	5.7
Social Concerns	5.9
Tort Liability Exposure	5.3

Survey Results

- Half STAs identified gaps, problems or missing components in procedures for trade-off analysis
- About three-quarters of STAs did not have procedures for conducting risk analysis
- About half have some tool to assist in decision making (HSM, IHSDM, VE, crash history, life cycle cost, etc...)

Survey Results

- Only 5 have developed specific performance goals regarding the evaluation of trade-offs
 - Crash reduction/right-sizing cost savings goals
 - Rehabilitation work must provide a certain life at an acceptable condition rating
 - Safer, longer lasting, operations and quality of life
 - Reducing operating expenses/increasing infrastructure investment.
 - Target Zero, a strategic highway safety plan

Figure 3.1 Annual Number of Design Exceptions Submitted

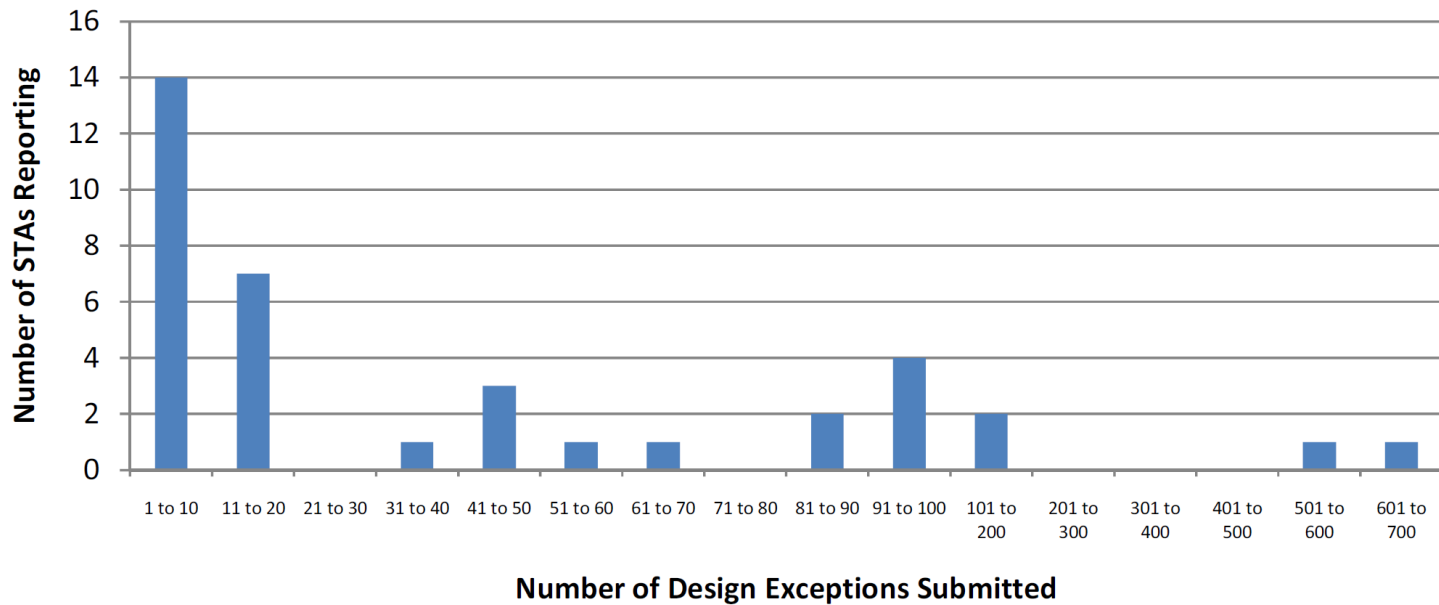
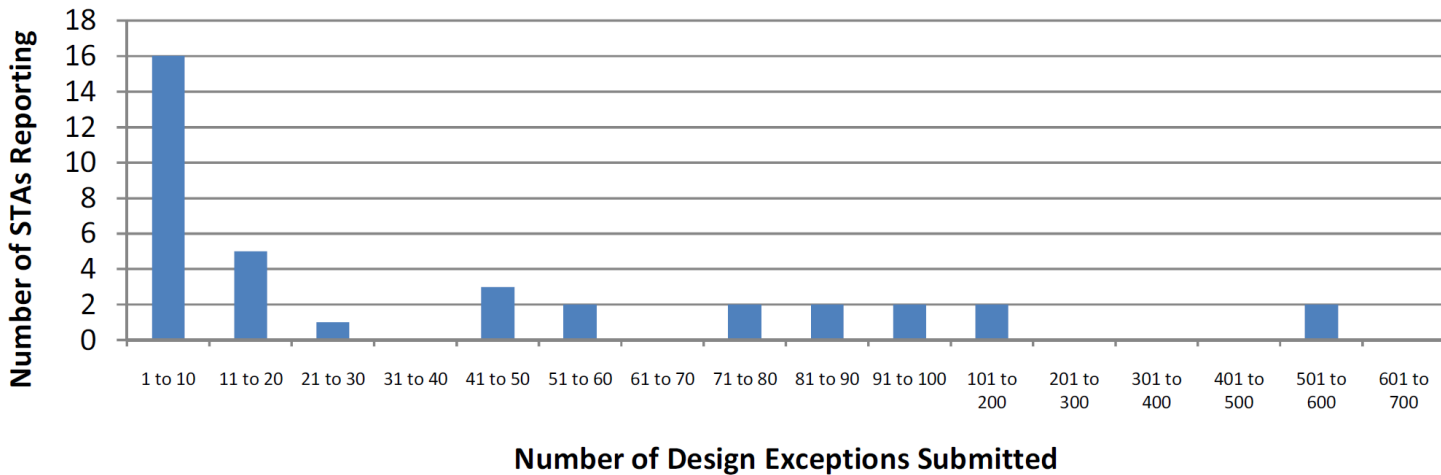
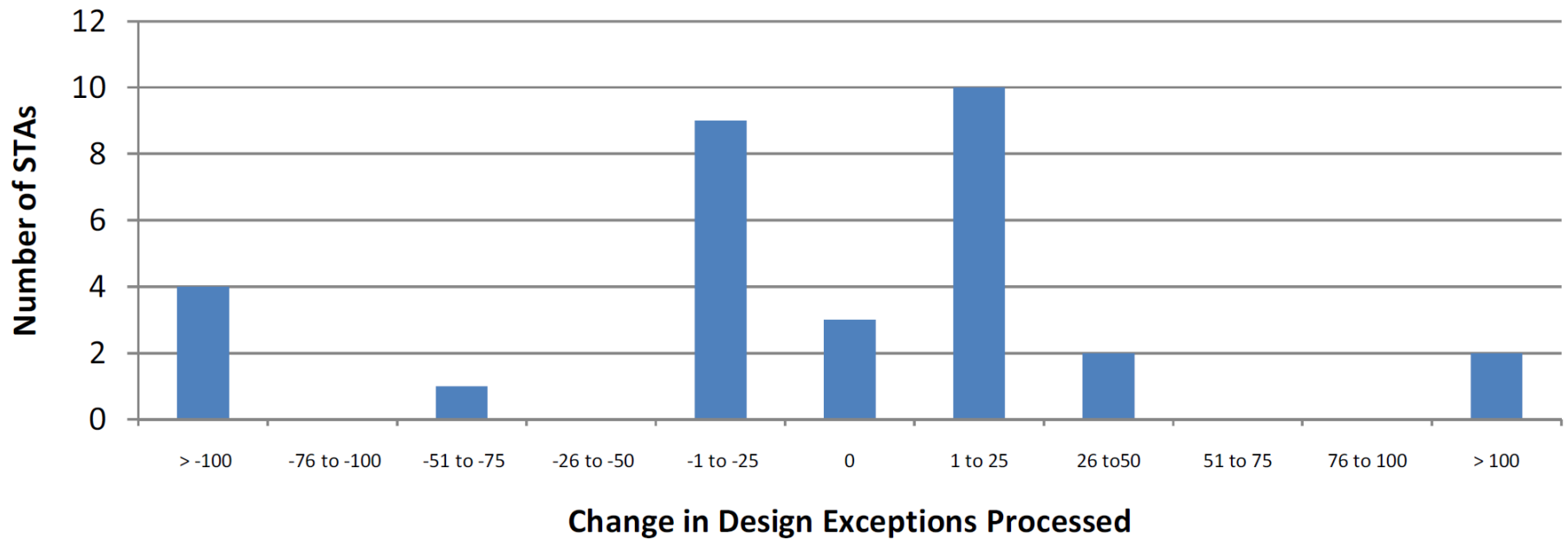


Figure 3.2 Annual Number of Design Exceptions Accepted



Survey Results

Figure 3.3 Change in Design Exceptions Processed (2002 vs 2010)



Survey Results

- Willingness to consider a design exception

Design Speed	3.9
Lane Width	6.2
Shoulder Width	7.7
Bridge Width	5.5
Structural Capacity	2.0
Horizontal Alignment	5.7
Vertical Alignment	6.4
Grade	6.1
Stopping Sight Distance	4.5
Cross Slope	5.4
Superelevation	5.5
Vertical Clearance	4.5
Horizontal Clearance	5.2

Survey Results

- Future
 - Three-quarters of STAs have no plans to change how they handle trade-offs in the next 6-12 months

Future Needs

- Formal process for evaluating trade-offs
- Risk prediction tools
- Tools for evaluating trade-offs
- Online resources for the Green Book
- Impact of design consistency
- Highway Safety Manual
- Integration of project and system level trade-offs
- Self enforcing design

Questions?

[http://www.trb.org/Publications/
PubsNCHRPSynthesisReports.aspx](http://www.trb.org/Publications/PubsNCHRPSynthesisReports.aspx)