

Advanced Design Flexibility Workshop

Session 3

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Risk Management and Safety



Risk Management

Are You a “Risk-Taker”?

Risk *n.* 1. The possibility of suffering harm or loss; danger.

2. A factor, element, or course involving uncertain danger; hazard.

3. The danger or probability of loss to an insurer.

v 1. To expose to a chance of loss or damage.



A-2



International
Organization for
Standardization

What is Risk Management?

The International Standards Organization (ISO) characterizes Risk Management as:

- Explicitly addresses uncertainty
- Based on the best available information
- Part of the decision making process
- Systematic, structured, and an integral part of organizational processes
- Dynamic, iterative, responsive to change, and capable of continual improvement and enhancement
- Accounts for human factors
- Transparent and inclusive

Source: [ISO/IEC Guide 73:2002 \(2002\). Risk management – Vocabulary – Guidelines for use in standards.](#)

Applicability to Transportation

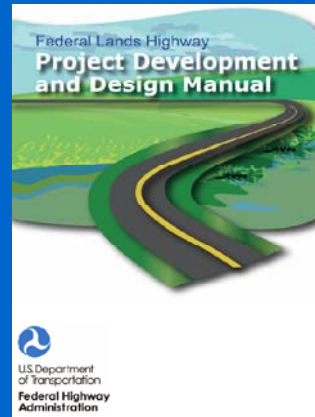
Risk comes in many forms and is inherent in the delivery and operation of transportation projects. Examples of where risk is incurred:

- Project cost (cost escalation, changes to project scope)
- Level of engineering analysis (greater investigation generally means fewer unknowns)
- Serviceability (when projects fail to satisfy performance demands)
- Legal claims and tort liability
- Safety (geometric design, structure design, geotechnical design)

Adapted from: FHWA Federal Lands Highway Division *Project Development and Design Manual*, March 2008

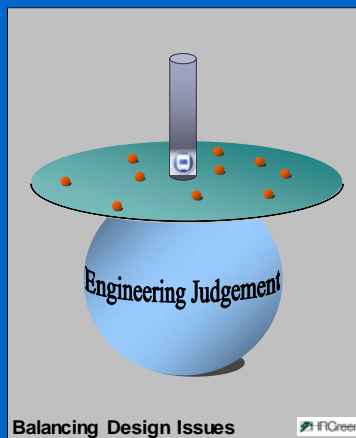
Highway-related Principles

- “It is *not feasible or intended for highway projects to be entirely risk-free*, as there are potential rewards to the project when risk is taken.”
- “To understand the risks associated with decisions involving the selection and application of design standards and criteria, it is essential to *have knowledge of the basis and assumptions underlying the standards, as well as knowing the conditions (physical, traffic and safety) for the project.*”



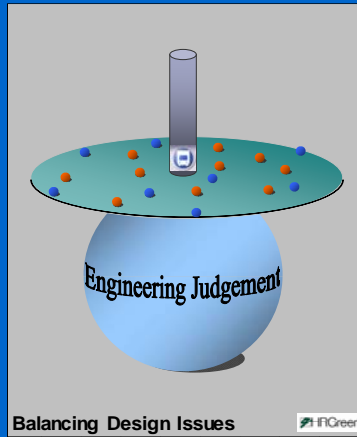
Historical Perspective

Balancing technical “marbles” and vehicles.



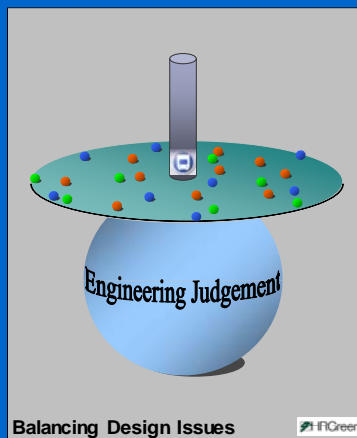
Historical Perspective

Balancing technical and environmental "marbles" and vehicles.



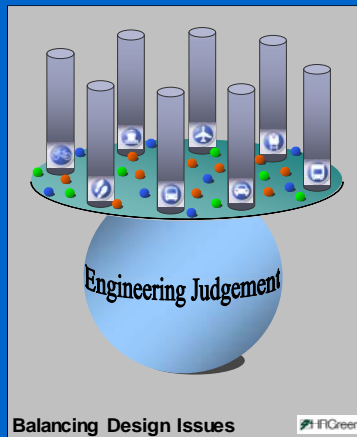
Historical Perspective

Balancing technical and environmental and social "marbles" and vehicles.



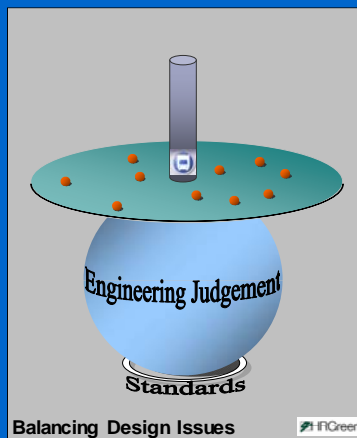
Historical Perspective

Balancing technical and environmental and social “marbles” and vehicle, *transit, pedestrian, cycling, freight rail, shipping, aviation modes!*



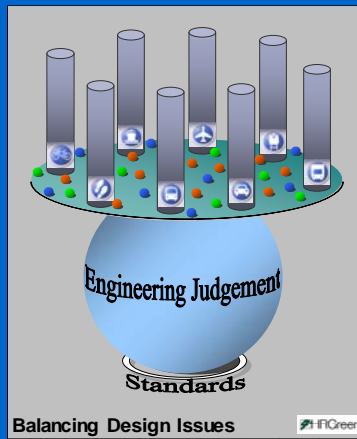
Historical Perspective

Most Standards were developed “back then”.



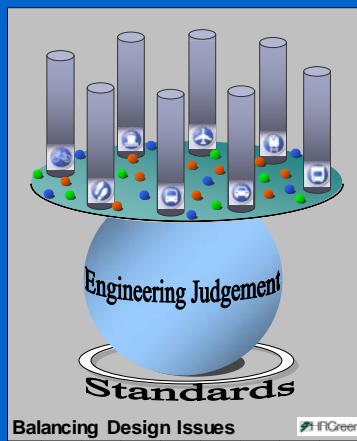
Historical Perspective

Today's need to balance is limited by current standards



Future Standards?

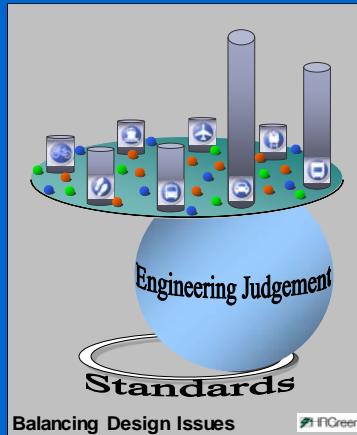
New standards are being considered to allow greater flexibility...



Real Project Scenario

New standards are being considered to allow greater flexibility...

To address real world situations.



Risk Basis for Improving Design



- “In many cases, **the risks associated with decisions can be mitigated with inclusion or enhancement of other features**, which may offset the risk.”
- “**The evaluation of risk is an interdisciplinary process** requiring involvement of project team members and stakeholders based on the specific issues and an evaluation of risk tolerability.”

Assessing the Risks

- Risk assessment is the process of **assessing the probability and severity** of adverse consequences associated with activities, recommendations or designs.
- For most transportation projects the risk assessment is not a complicated quantitative assessment, but rather **a practical assessment based on experience, engineering judgment and historical standard of practice.**
- **To the extent possible, risks should be quantified**, both on the basis of their potential probability and for their potential consequences.

Risk and Geometric Design

Risk management in geometric design involves:

- Applying engineering knowledge and judgment
- Incorporating performance prediction tools
- Using latest best practices and new technologies
- Balancing competing objectives, including but not limited to, cost, operational efficiency, environmental issues, social concerns, and safety performance

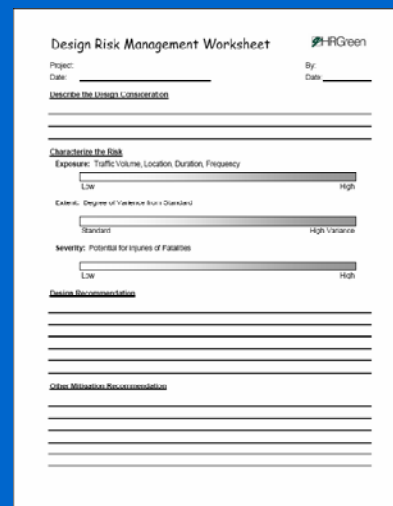
Risk Management = Trade-Off Considerations

Trade-Offs and Project P&N

- The Purpose and Need statement of a project should define the project's performance goals and their relative importance.
- Evaluating design trade-offs is often about assessing competing objectives such as:
 - cost
 - operational efficiency
 - safety
 - environmental issues
 - social concerns

Design Risk Management Worksheet

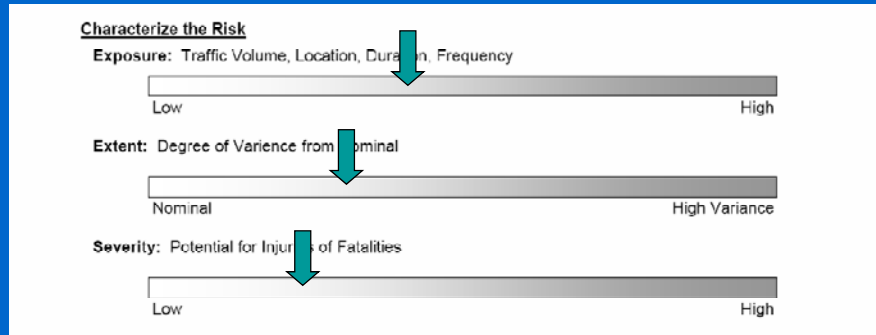
- Describe the condition
- Characterize the risk
 - Probability
 - Exposure
 - Extent
 - Severity
- Recommendation
- Mitigation



The image shows a 'Design Risk Management Worksheet' form. It includes fields for 'Project' and 'Date' on the left, and 'By' and 'Date' on the right. Below these are sections for 'Describe the Design Consideration', 'Characterize the Risk' (with sub-sections for Exposure, Extent, and Severity, each with a scale from Low to High), 'Design Recommendation', and 'Other Mitigation Recommendation'. The form is titled 'Design Risk Management Worksheet' and has a logo for 'iGreen' in the top right corner.

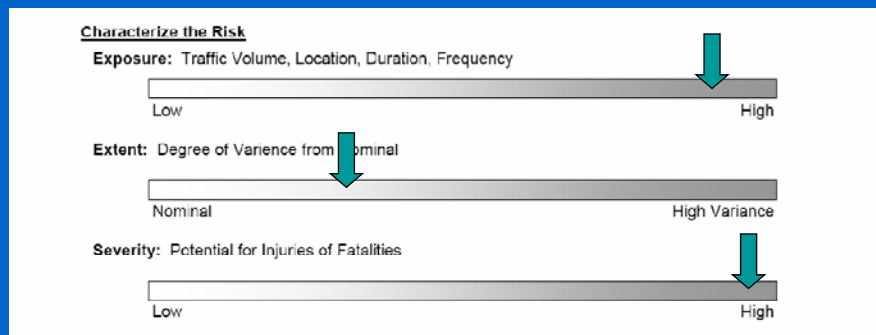
Characterize the Risk

- Portland Ave in Richfield: 3-Lane Section, 35 mph with 15,000 ADT
 - Garbage collection on 6' vs. 8' shoulder



Characterize the Risk

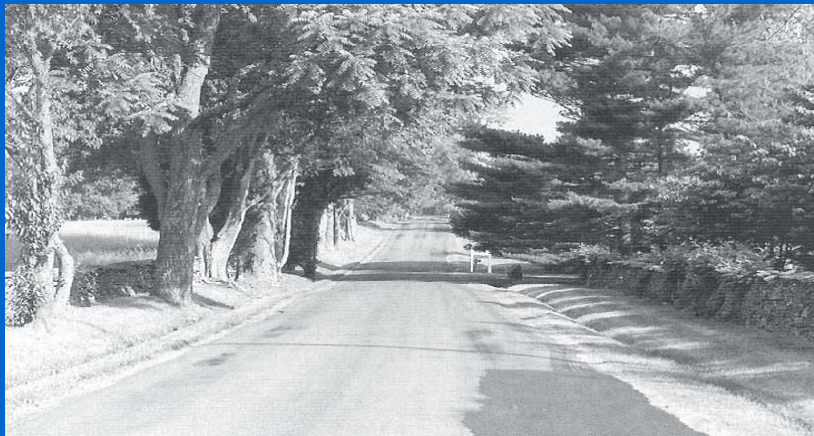
- Snelling and University:
 - Eliminate Free-Right



Risk Management Exercise

- (Exercise might require some quantifiable effort, or identify the need to quantify.)

Question: “Safe” or “Unsafe”?



Safety Performance Viewpoints

- **Nominal Safety** refers to compliance with standards, warrants, guidelines and sanctioned design procedures
- **Substantive Safety** is the expected crash frequency and severity for a highway or roadway
- **Subjective Safety** refers to the users perception of how safe a facility feels
- **Objective Safety** refers to the number of crashes and severity of crashes occurring on a particular facility in a particular time period

Is This “Safe”?

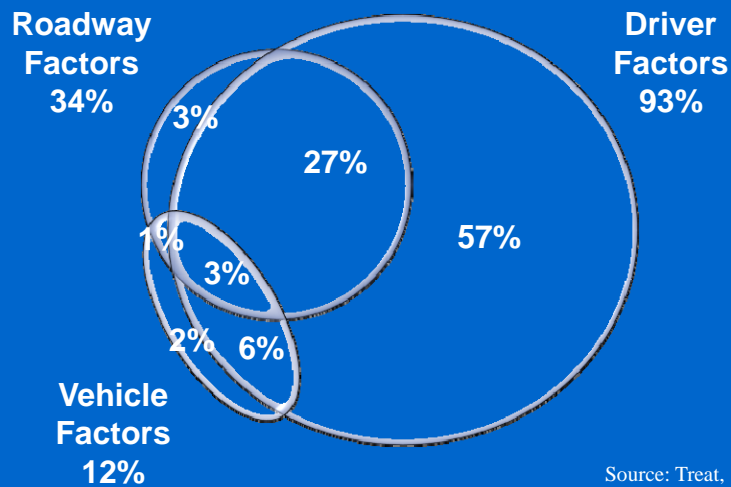


On this crest vertical curve with restricted sight distance, what roadway features other than the vertical alignment geometry may influence the safety risk of this location?

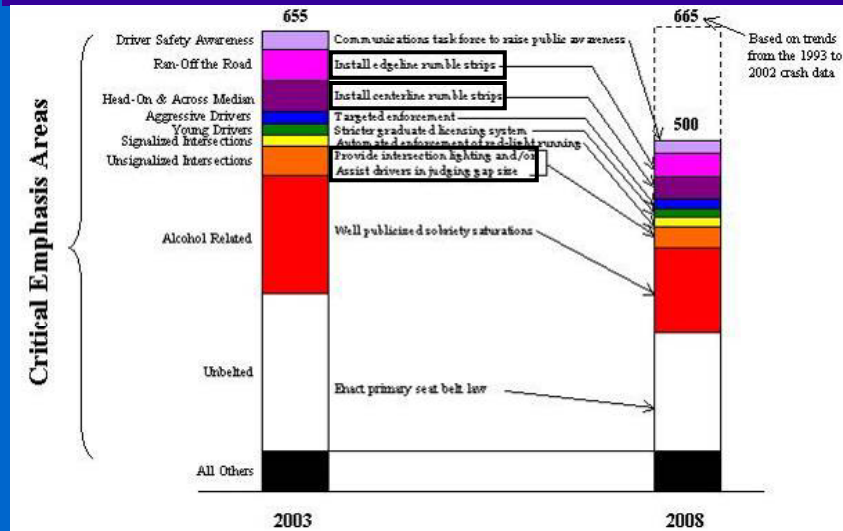
Comprehensive Safety

- Roadway Design
- Vehicle Design
 - Preventing Crashes
 - Reducing Injuries
- Human Behavior
 - Young Drivers
 - Elderly Drivers
 - Cell Phones
 - DUI, etc

Contributing Factors to MV Crashes



Notion: "Better roads" can cure highway fatalities



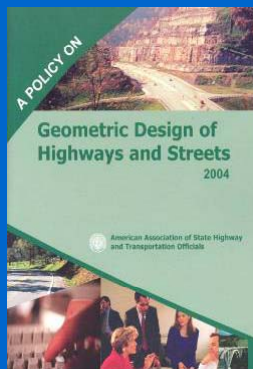
- ### Vehicle Design
- 1973 Energy-absorbing steering column
 - 1974 Energy-absorbing bumpers
 - 1974 Gas tank relocated for enhanced safety
 - 1978 Child booster cushion for children
 - 1982 Under-run protection
 - 1982 Door mirrors of wide-angle type
 - 1984 ABS, anti-locking brakes
 - 1986 Brake lights at eye level
 - 1986 Three-point seat belt in the middle of the rear seat
 - 1987 Seat belt pre-tensioner
 - 1987 Driver's airbag
 - 1990 Integrated booster cushion for children
 - 1991 SIPS, side impact collision protection
 - 1991 Automatic height adjustment of front seat belts
 - 1993 Three-point inertia-reel seat belt in all the seats
 - 1994 SIPS, side-impact airbags
 - 1997 ROPS, Roll-Over Protection System convertible (C70)
 - 1998 WHIPS, protection against whiplash injuries
 - 1998 IC, inflatable curtain,
 - 1998 DSTC, Dynamic Stability and Traction Control
 - 2000 Volvo Cars Safety Centre inaugurated in Göteborg
 - 2000 ISOFIX attachments for child seats
 - 2000 Two-stage airbag
 - 2000 Volvo On Call safety system
 - 2000 Volvo Cars Safety Centre new crash laboratory inaugurated,

Comprehensive Safety

- Towards Zero Death Initiative's 4E's
 - Engineering
 - Education
 - Enforcement
 - Emergency Medical Services



Nominal Safety



The concept of nominal safety is considering whether a design element meets minimum criteria

- It is a simple "Yes/No" assessment

Safety Considerations in Design

“The direct application of established design criteria or standards (i.e., nominal safety) is no assurance that a certain quality of design (i.e., substantive safety) will be achieved--indicating that such criteria are not sufficient in themselves.”

Jack E. Leisch

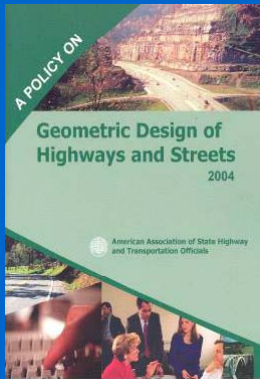
Dynamic Design for Safety

FHWA/ITE 1975

“But Captain, ... it met all the standards”



Considerations in Nominal Safety

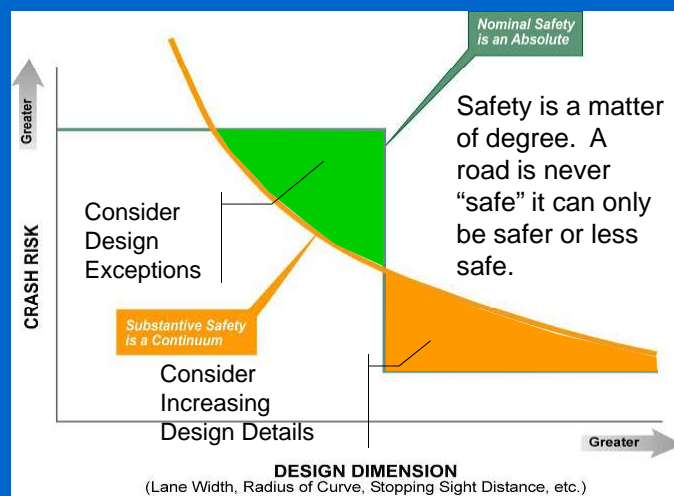


Safety is one of many considerations that influence the derivation of design criteria.

Others include:

- Cost Effectiveness
- Operational Efficiency
- Constructability
- Consistency

Substantive Safety is a Continuum

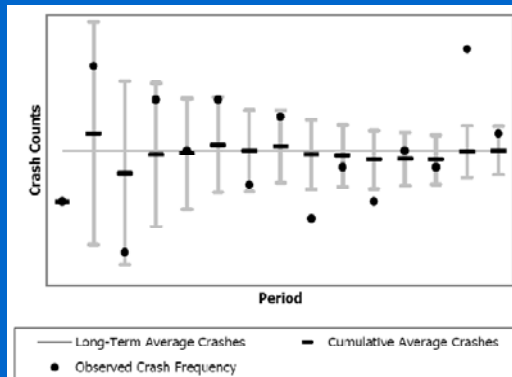


Analyzing Safety on Existing Roads

- Crash Analysis (intersection or segment)
 - Average Crash Rate
 - Compares intersection/segment crash rate with state/county wide averages for similar intersections.
 - Critical Crash Rate
 - Performed if the crash rate is ABOVE average.
 - Tests the crash rate to see if there is statistical significance to the value.
 - Crash Severity
 - Measures how “bad” the crashes are.
 - Crash rate may be low, but crash severity may be high.
 - Crash Type
 - Indicates how the crash occurred.
 - 9 categories.
 - Useful in troubleshooting intersection deficiencies.

Crash Count Limitations

Crash counts alone are not the best estimate of safety because of variations in reporting, the rare and random nature of crashes and the possibility of regression to the mean bias.

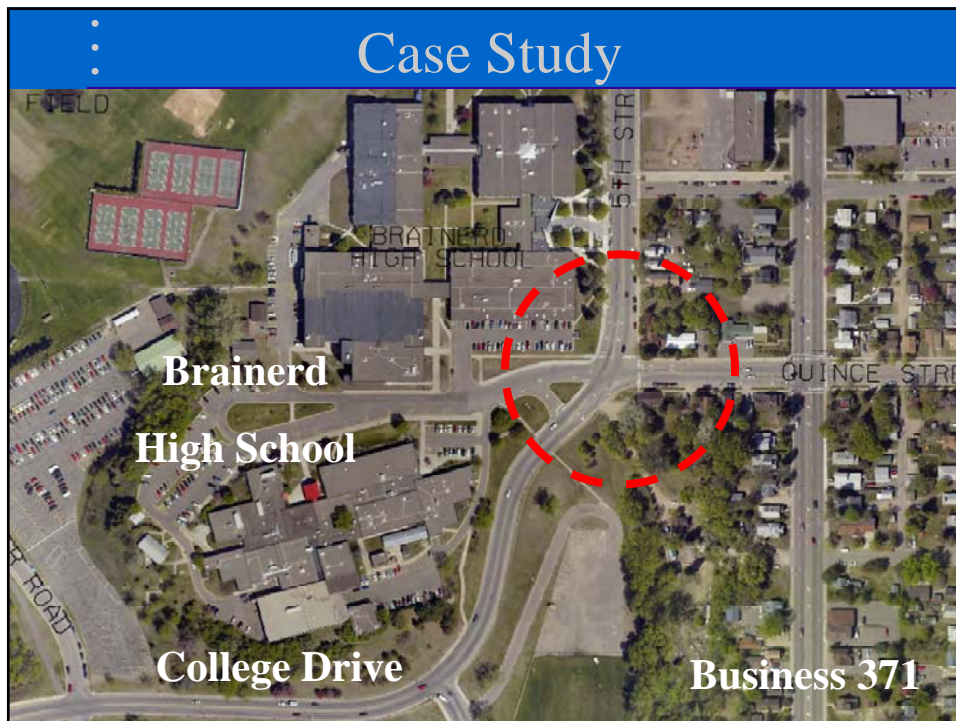


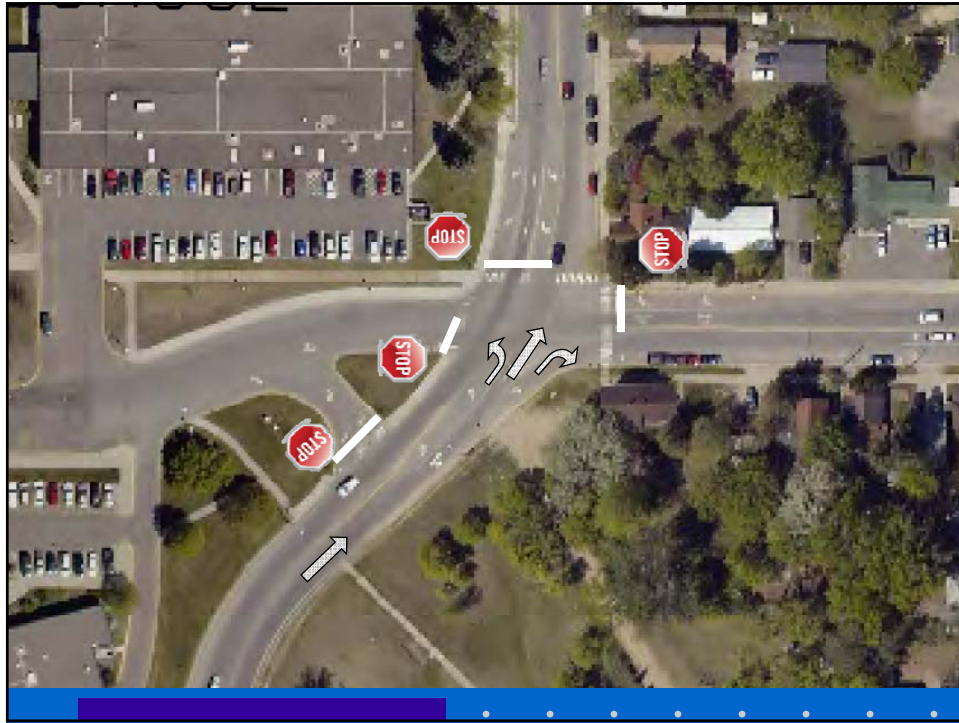
Although the number of crashes at any particular site will fluctuate over time, in the long run the count of crashes will tend to converge to a mean value (an “expected” crash frequency).

Crash Count Limitations

- Does crash data include bicycle-pedestrian crashes?
- Does crash data include solo bicycle crashes?
- What about areas that are “high risk” for travel?

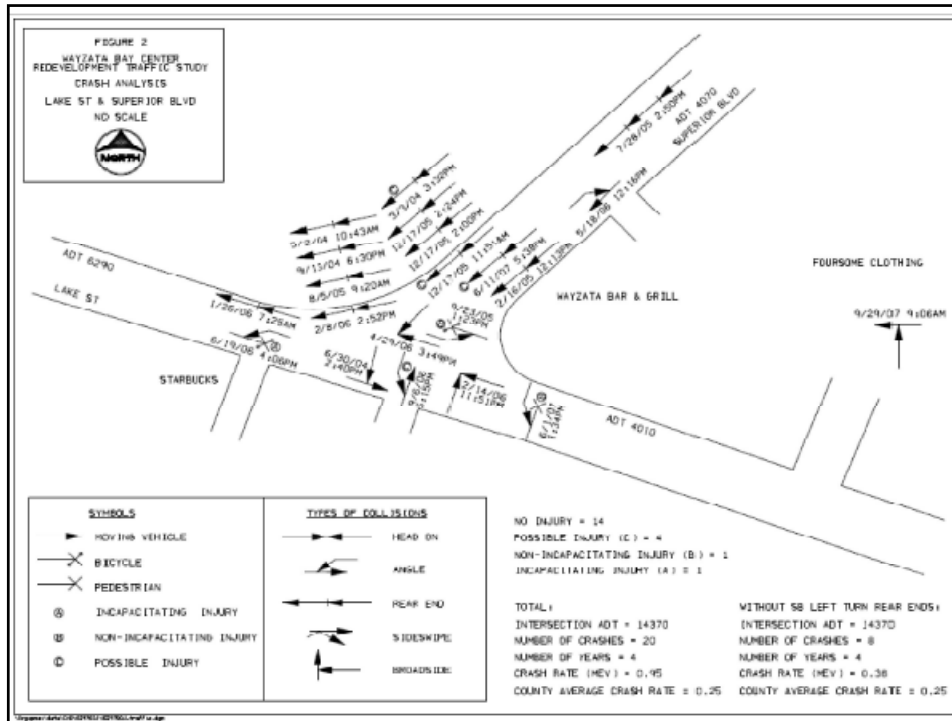
Case Study





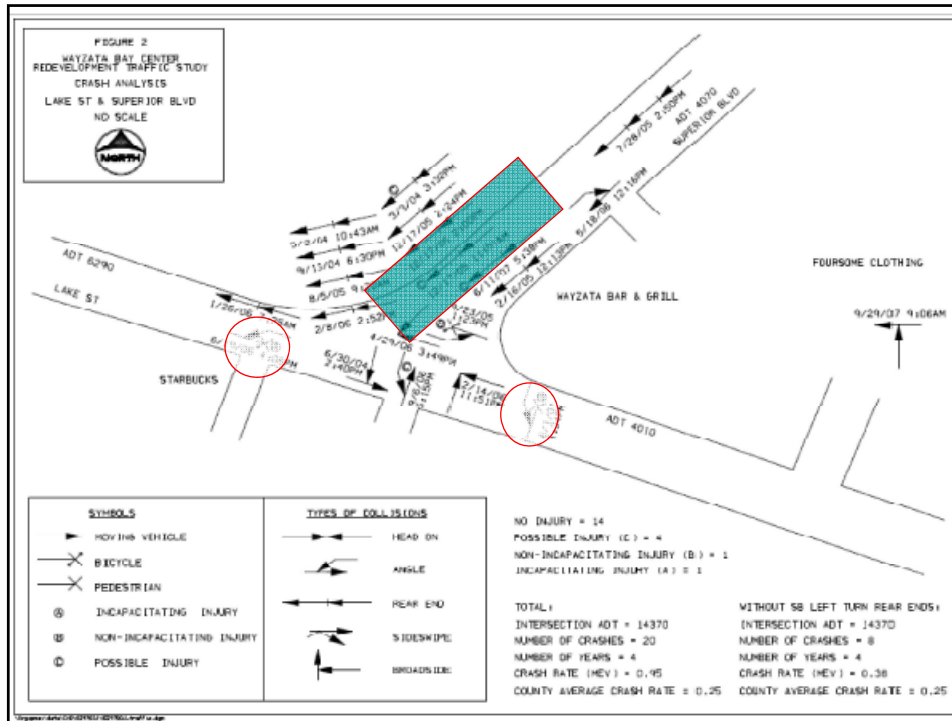
Crash Rate Example





Analyzing Safety on Existing Roads

- Crash Analysis (intersection or segment)
 - Average Crash Rate **Yes**
 - Actual crash rate 0.95 crashes per million vehicles entering.
 - Average = 0.25 crashes per million vehicles entering.
 - Critical Crash Rate
 - 0.45 crashes per million vehicles entering. **Yes**
 - (95% certain)
 - Crash Severity
 - Actual Crash Severity Index = 31% **No**
 - Crash Severity Index for similar intersections = 38% **Yes**
 - Several of the injury crashes included pedestrians and cyclists
 - Actual Ped/bike crash rate 15%, average = 4%
 - Crash Type **Yes**
 - 60% rear ends, average is 28% for similar intersections.



Project Safety Review (PSR)

- Systematic and comprehensive safety review of any proposed construction project impacting a section of roadway usually completed during the scoping process.
- These improvements can be *proactive* (based on the **SHSP** and engineering judgment) or *reactive* (based on existing crash data).
- Should be performed on all projects

Project Safety Review Worksheet

Person completing form: _____ Date: _____
 SP (TH) #: _____ Project Mgr: _____
 Project Limits: _____

TRAFFIC SCOPING WORKSHEET

To "check" in the check boxes, double click and click on "checked" in the Default value box

ITEM	ITEM NEEDED			NOTES (or see below) (Location, Quantity/Cost estimate and other comments)
	Need	Want	Not	
Crash Data	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	
Super Correction	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Horizontal Curve Correct	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Vertical Curve Correct	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Interchange Revision	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Turn Lanes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
ICE	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Local Participation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Striping	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Signing / Overheads	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Lighting	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Traffic Signals	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
RR Crossing Signal	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Preemption	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Preservation Proj. Coord	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Access Changes*	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Traffic Control/Work Zones	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Project Safety Review	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

* these items and any other out-of-the-ordinary major quantity

Comments: _____

The Strategic Highway Safety Plan provides initial guidance on potential low cost systematic improvements for each project. TRB Special Report 214 provides informational background and potential guidance on the subject of low-cost safety improvements for Preservation-type projects

Analyzing Safety on Existing Roads

- Road Safety Audit
 - Assemble interdisciplinary team
 - Analyze performance of existing facilities
 - Speed
 - Safety
 - Traffic control
 - Geometrics – elements, alignments, sight dist., etc.
 - Observe performance in the field
 - Recommend improvements/mitigate issues

Interactive Highway Safety Design Model

“Making Safety a Priority in Highway Design”

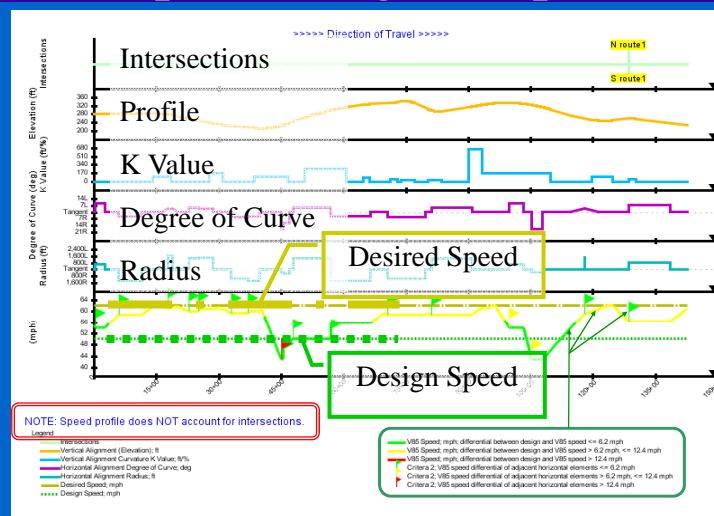
- Performs Nominal Design Criteria check
- Helps diagnose operational/safety concerns at curves and along grades
- Helps to achieve corridor consistency
- Latest version incorporates H-F



Info: <http://www.tfhrc.gov/safety/ihsdm/ihsdm.htm>

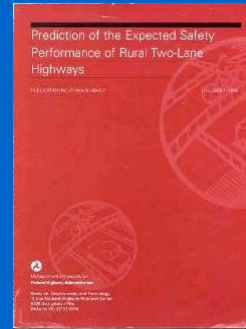
Free Software Download: <http://www.ihsdm.org>

Helpful Design Output



Substantive Safety Models

- Models for predicting the safety effects of design decisions
 - horizontal alignment
 - vertical alignment
 - cross-section
 - intersections
- Highway Safety Manual
 - draft expected in 2009



Safety Performance Functions

- Safety Performance Functions (SPFs) are mathematical equations (models) used to predict the average number of crashes per year at a location as a function of traffic volume and roadway or intersection characteristics (e.g. number of lanes, type of traffic control, median type, etc.)
- SPFs are developed for specific roadway or intersection conditions (i.e. rural unsignalized intersections, urban multilane undivided, etc.) and/or specific crash types or severity
- SPFs are developed through statistical regression modeling using data collected over a number of years at sites with similar traffic characteristics.

Accident Modification Factors

- Accident (Crash) Modification Factors (AMFs) quantify the expected change in crashes at a site after implementing a particular countermeasure, or treatment.
- AMFs are used to compare possible safety outcomes of different alternatives, treatments or countermeasures.

Safety Effects of Increasing Degree of Horizontal Curvature

Treatment	Setting Road type	Traffic Volume	Accident type Severity	AMF	Std. Error
Increase horizontal curvature by one degree	Urban and suburban arterials	Unspecified	Off-the-road Injury	1.06	0.01
			Off-the-road Non-injury	1.04	0.01
			Off-the-road All severities	1.05	0.01

NOTE: Degree of curvature approximately = 5730 / radius in ft or = 1747 / radius in m



Learning Check

What are some possible strategies for assessing the relative value of design trade-offs?



Exercise