Highway Safety Manual Update

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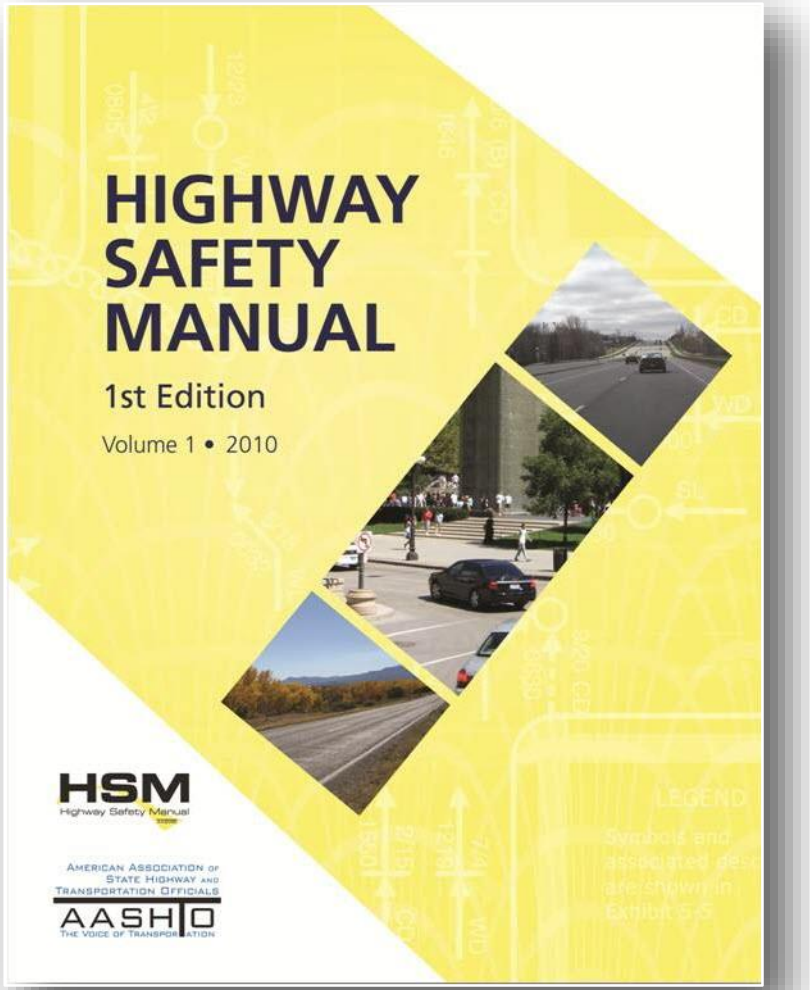
FDOT Highway Safety Manual Update



Overview

- Fundamentals
- Update
- Florida Implementation efforts
- Resources
- Training

Fundamentals

- The HSM uses ***crashes*** as a measure of safety

Fundamentals

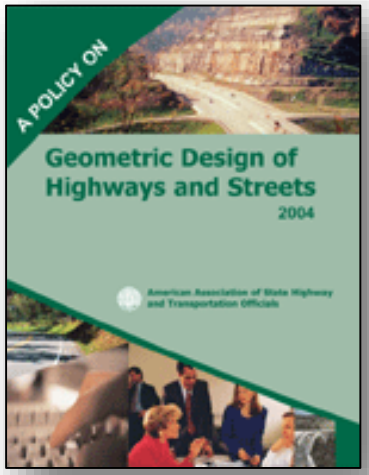
- Crash Frequency is the basis for safety analyses

$$N = \frac{Number\ of\ Crashes}{Period\ in\ Years}$$

- Compare and evaluate alternative designs
- Nominal versus Substantive safety
- Tool for making informed decisions

Nominal versus Substantive Safety

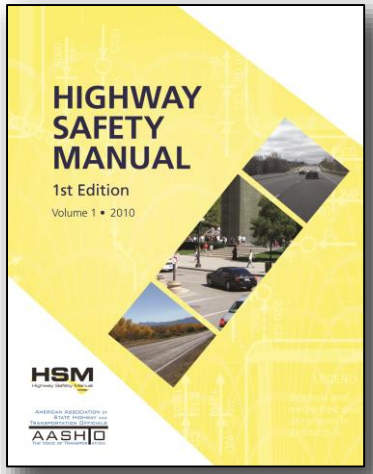
Nominal Safety



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

Substantive Safety

The expected or actual crash frequency and severity for a highway or roadway



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*Ezra Hauer, ITE Traffic Safety Toolbox Introduction, 1999

Nominal and Substantive Safety

Knowledge is imprecise, judgment is essential

- Meeting standards does not necessarily make a highway safe

- Some Important features of highways are not determined by standards

  - Alignment of left turn lanes (offset or in-line)
  - Spiral transitions to Horizontal curves
  - Center Two-Way Left Turn Lanes

Nominal and Substantive Safety

Example: At 20,000 ADT

1st Step

26.3 crashes/year

2nd Step

4.2 crashes/year

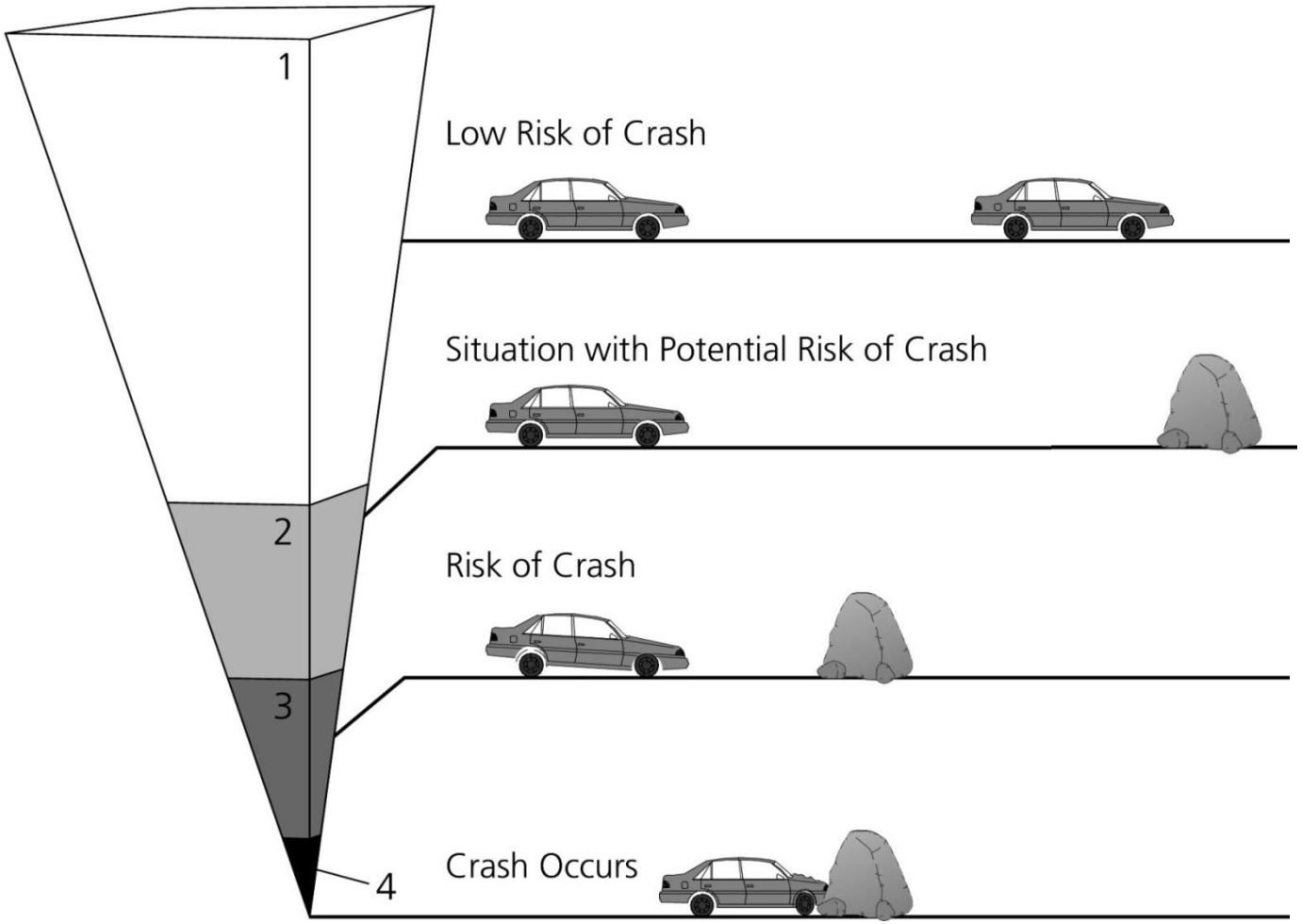
Nominal Safety – Two 12' wide lanes in each direction

+Add median
= Substantive Safety

Other Considerations

- Crashes are rare and random events
- **93%** of all crashes involve human error
- Contributing factors influence crashes and can be mitigated using various strategies
- Changing the roadway/environment can reduce crashes

Crashes are Rare Events

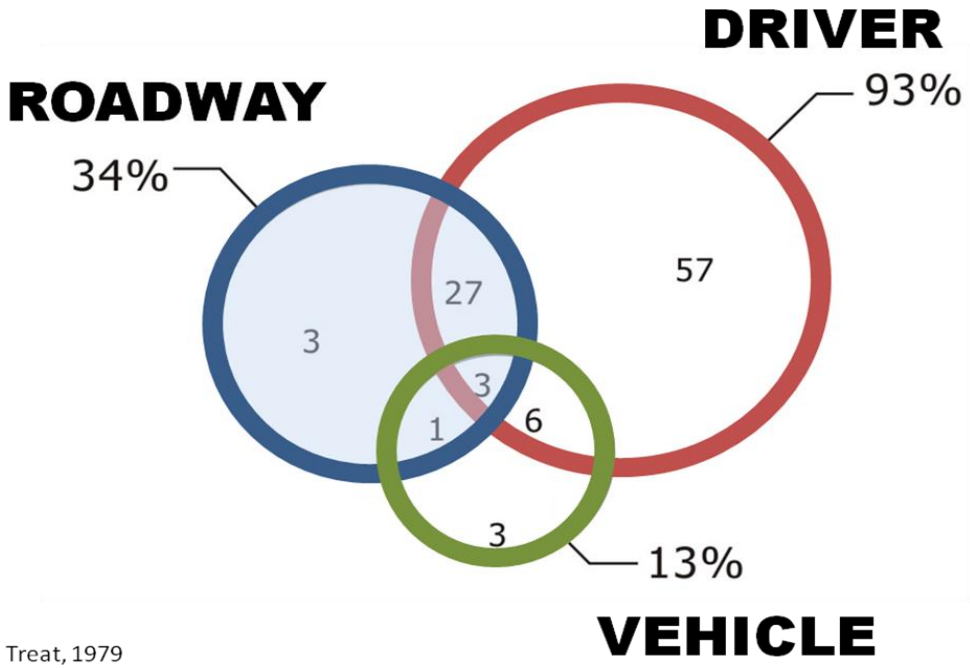


Relative Proportion of Crash Events

Crashes are Random Events

Contributing Crash Factors

- Judgment errors
- Distractions
- Information overload
- Driver expectation violations
- Rules of the road violations



Treat, 1979

Road Message Cues

Road Message Cues

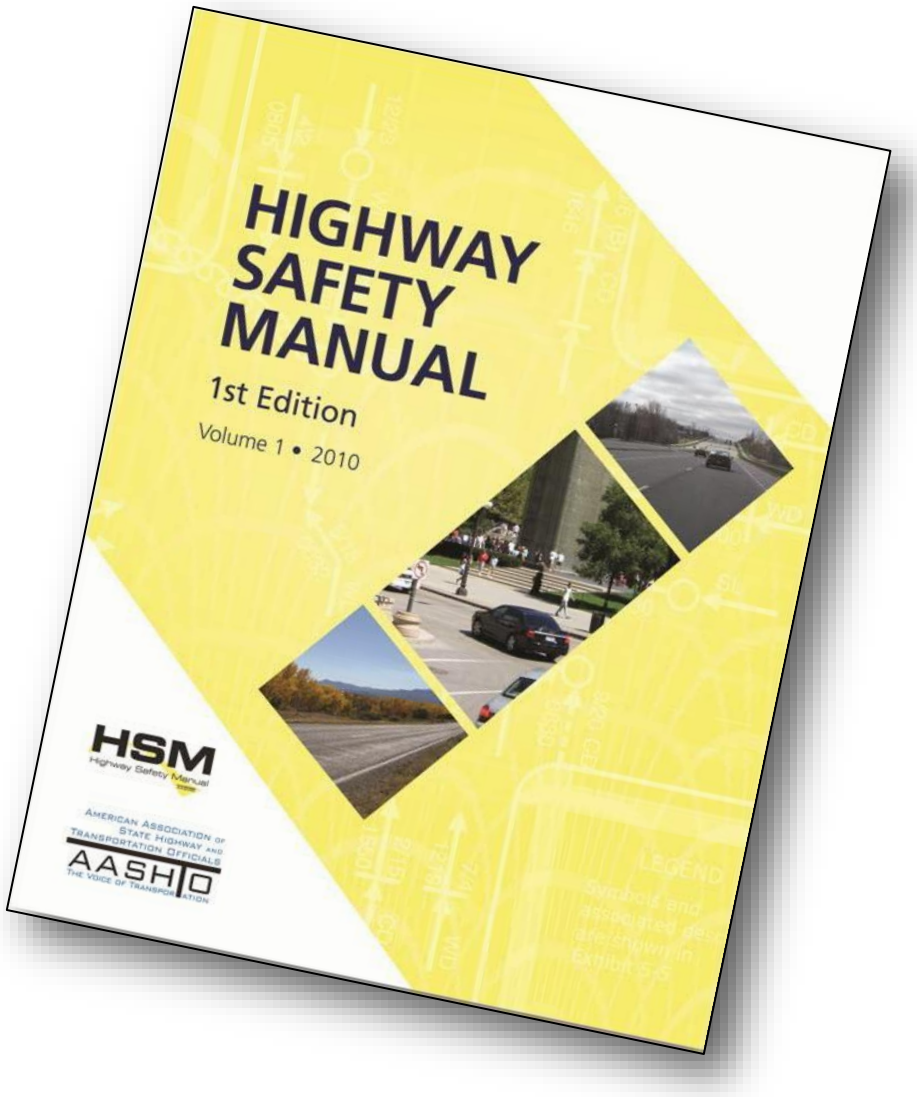
Road Message Cues

Some locations require more than minimum stopping sight distance

Adjusting alignment can improve operations within an existing project without increasing cost or impacts

Data Needs for Crash Estimation

- Crash Data
- Facility Physical Data
- Facility Traffic Data



Data Needs – Physical Facility Features

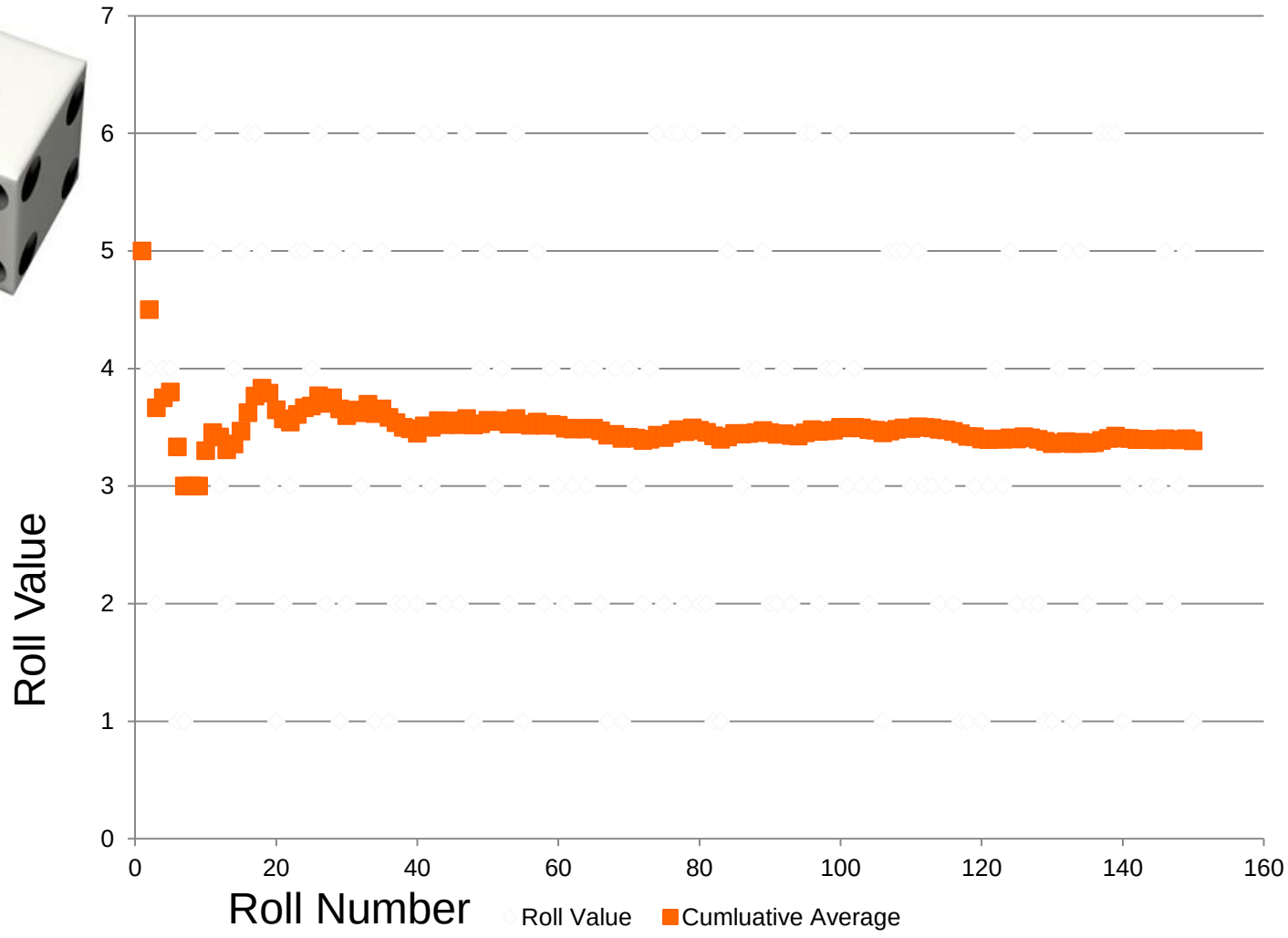
Limitations of Crash Data

- Not all crashes are reported
- Differences in crash reporting thresholds
- Judgment of observer preparing crash report
- Differing standards for crash databases
- Subsequent injury or fatality
- Data entry can introduce typographical errors, imprecise location data, incorrect entries, lack of training, subjectivity

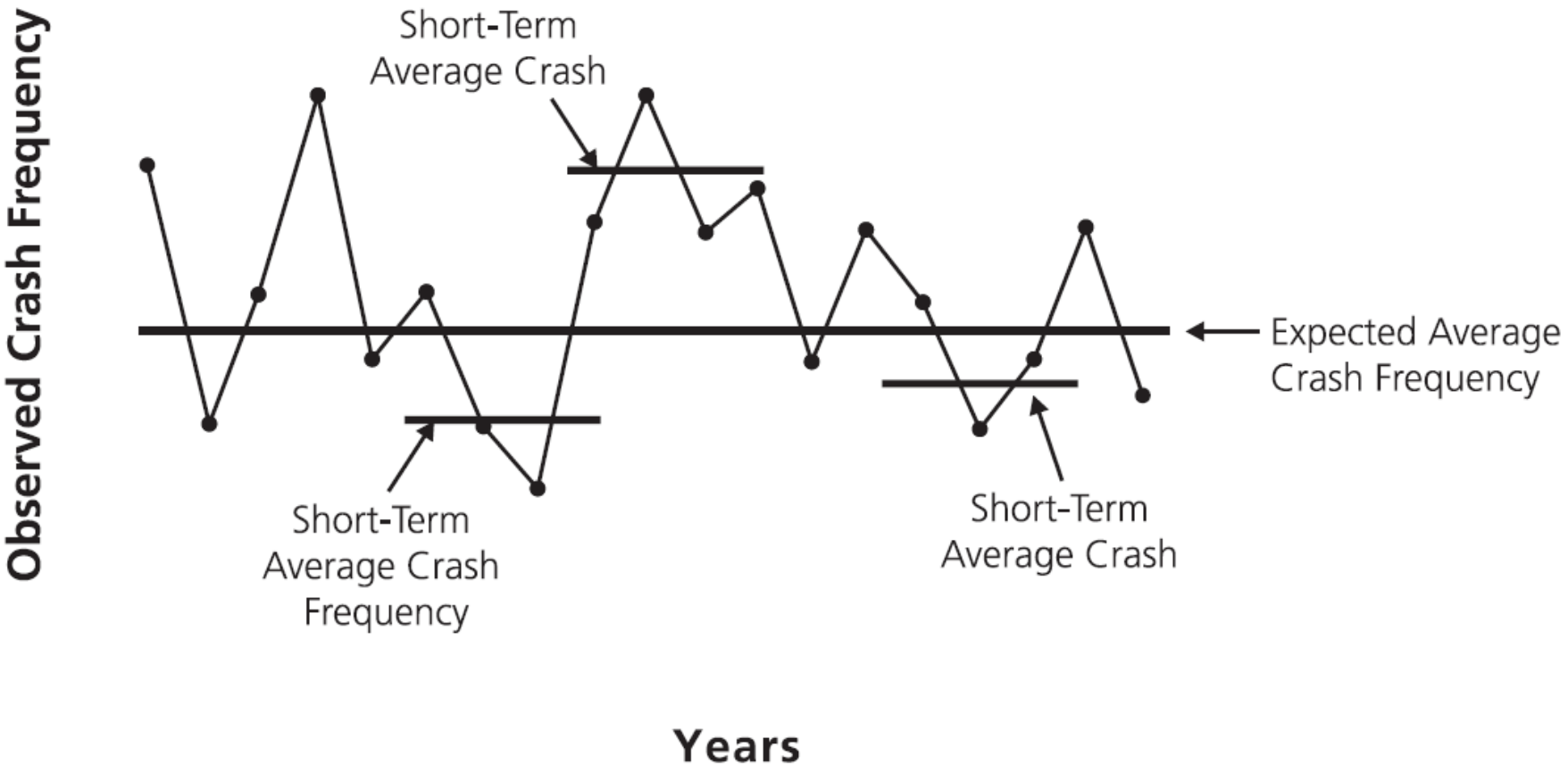
Data Randomness and Change

- Natural variability in crash frequency
- Regression-to-the-mean
- Variations in roadway characteristics
- Conflict between crash frequency variability and changing site conditions

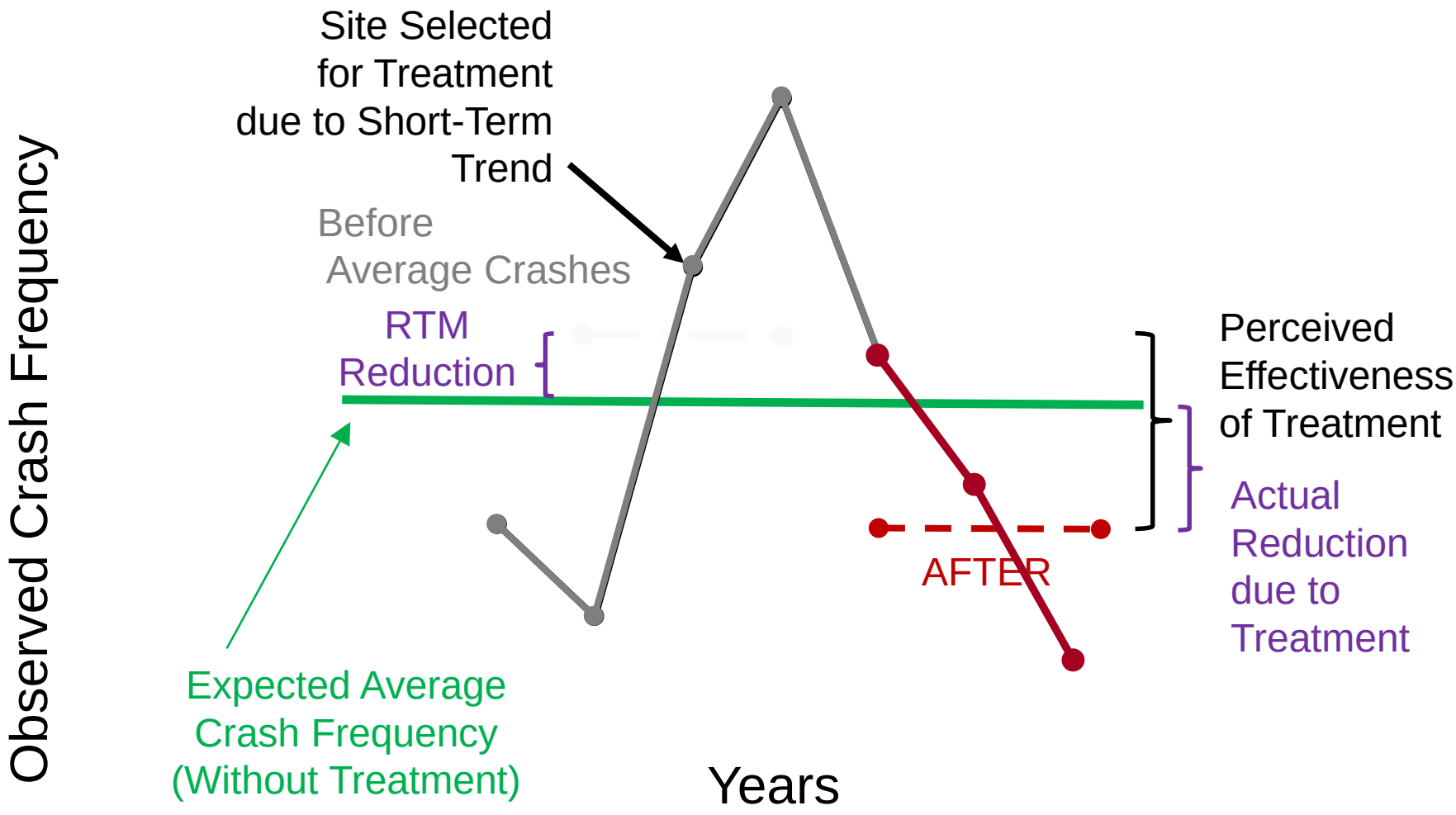
Regression to the Mean (RTM)



Crashes Regress to the Mean as Well



RTM and RTM BIAS



Adapted from Part A, Figure 3-5, Page 3-12

Crash Estimation – Predictive Models

- Safety Performance Functions
- Crash Modification Factors
- Calibration Factors
- Rural Two-Lane Two-Way Roads
- Rural Multilane Highways
- Urban and Suburban Arterials
- Freeways and Ramps (NCHRP 17-45)
  - http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=2512

Safety Performance Functions

$$N_{SPFrs} = (AADT) \times (L) \times 365 \times 10^{-6} \times e^{(-0.4865)}$$

(Example)

- N_{SPFrs} = Predicted crash frequency for base conditions for a rural 2-lane, 2-way roadway segment
- *AADT* = Average Annual Daily Traffic
- *L* = Length of Roadway Segment (Miles)

SPFs in the HSM

Rural two-lane

- 1 segment SPF
- 3 intersection SPFs

Rural multilane

- 2 segment SPFs
- 3 intersection SPFs

Urban and suburban arterials

- 5 segment SPFs
- 4 intersection SPFs

18 SPFs in First Edition HSM

Intersection Safety Performance Functions

	Intersections			
	Stop Control on Minor Leg(s)		Signalized	
	3-Leg	4-Leg	3-Leg	4-Leg
Rural 2-Lane Roads	✓	✓	—	✓
Rural Multi-Lane Highways	✓	✓	—	✓
Urban and Suburban Arterial Highways	✓	✓	✓	✓

Crash Modification Factors

Crash Modification Factors represent the relative change in crash frequency due to a change in one specific condition, when all other conditions and characteristics remain constant

CMFs Modify the Base Condition

$$N_{predicted} = N_{SPF\,x} \times (CMF_{1x} \times CMF_{2x} \times \ldots \times CMF_{yx}) \times C_x$$

Where –

N_{SPFx} = Base condition crash frequency from SPF for site type x

CMF_{yx} = Crash Modification Factors

C_x = Calibration factor for site type x

Crash Modification Factors (CMF)

CMFs are the ratio of the crash frequencies at a site under two different conditions

$$\textbf{CMF} = \frac{\textbf{Crash Frequency with Site Condition 'A'}}{\textbf{Crash Frequency with Site Condition 'B'}}$$

Therefore –

Crashes for Condition 'A' = CMF × Crashes for Condition 'B'

Where –

Condition 'A' is a change from "base" or existing condition
Condition 'B' is the base or existing condition

CMFs may serve as an estimate of the effect of a particular geometric design or traffic control feature or the effectiveness of a particular treatment or condition.

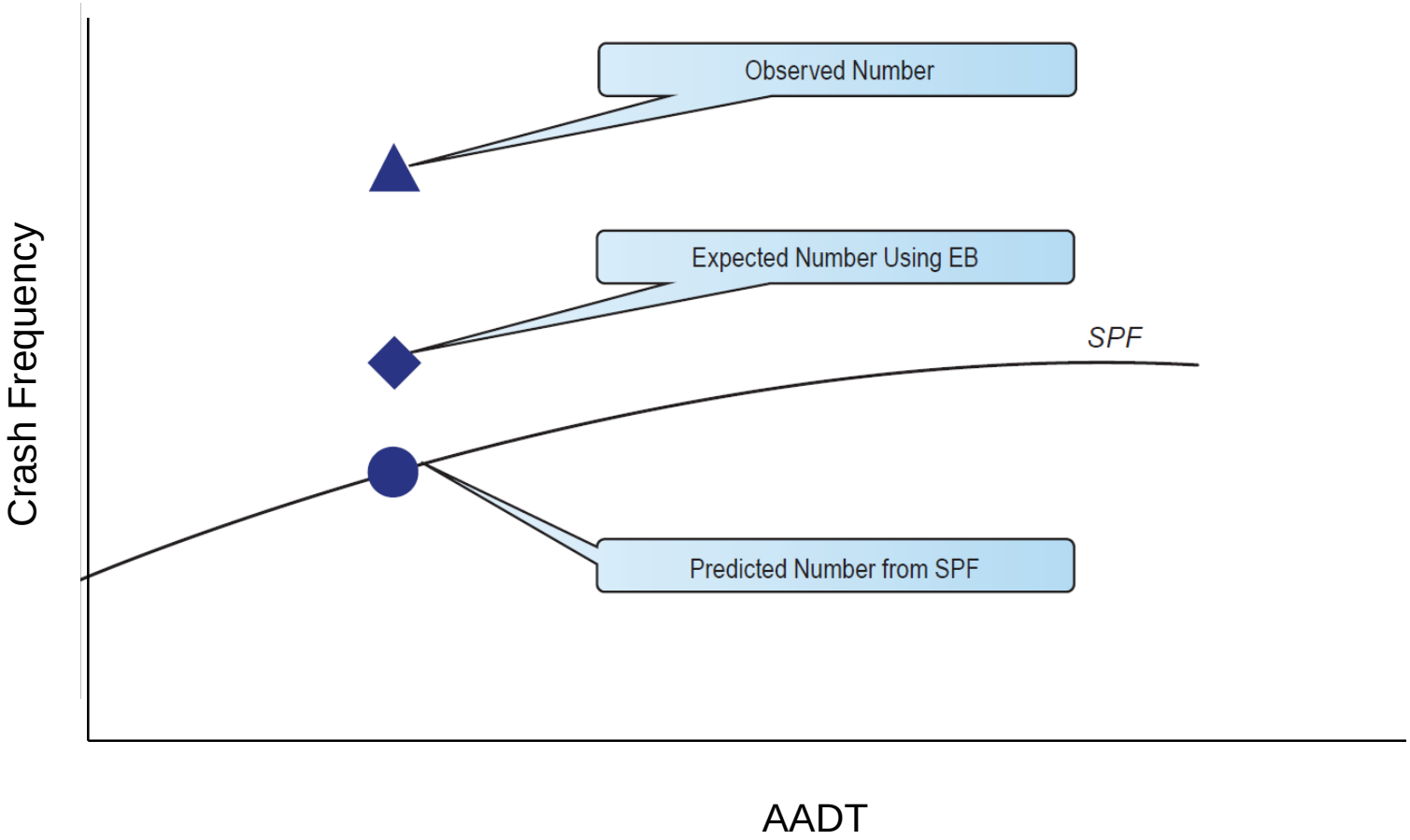
Crash Modification Factors

- If a CMF = 0.90, then the expected change is 100% × (1.0-0.90) = 10% (Reduction)
- If a CMF = 1.20, then the expected change is 100% × (1.0-1.20) = -20% (Increase)
- Crash Reduction Factors
  - ✓ If a CRF = 10%, then the corresponding CMF is
    100%-10% ÷ 100 = 0.90
  - ✓ If a CRF = -20%, then the corresponding CMF is
  - ✓ 100% + 20% ÷ 100 = 1.20

Calibration Factors

- Account For Differences In Geographical Areas
  - ✓ Driver Characteristics
  - ✓ Terrain
  - ✓ Climate
  - ✓ Animal Population
  - ✓ Crash Reporting Threshold
  - ✓ Crash Reporting Practices

Empirical Bayes (EB) Method Concept



EB Method Equations

$$N_{expected} = w \times N_{predicted} + (1 - w) \times N_{observed}$$

Weighted Adjustment

$$w = \frac{1}{1 + k \times \left(\sum_{\substack{\text{all} \\ \text{study} \\ \text{years}}} N_{predicted} \right)}$$

Overdispersion Parameter
(given with SPF)

Evolution of Crash Estimation Methods

- Crash Rates - Probability per million vehicle miles

$$Crash\ Rate = \frac{Average\ Crash\ Frequency\ in\ a\ Period}{Exposure\ in\ Same\ Period}$$

- Historical Crash Method – 3 to 5 years of data
- Highway Safety Manual – Statistical analysis using EB Method

Development & Content of HSM Methods

- Human Factors & Fundamentals
- Roadway Safety Management
- Site Crash Diagnoses
- Performance Measures of Improvements
- Predictive Method
- Selecting Countermeasures
- Performance Monitoring

FDOT HSM Progress

- Calibration of Segments and Intersections
- District Pilot Projects
- Manual Updates
- Advanced Training in all Districts

FDOT HSM Initiatives

- Recalibration of Segments
- Recalibration of Intersections
- Vetting of CMFs (Part D)
- Standards for CMFs
- Design Exception and Design Variation Training
- Freeway and Ramps Training
- Managed Lanes Research

HSM Websites

- AASHTO HSM, http://www.highwaysafetymanual.org/
  - ✓ About, Getting Started, Tools, Training, Resources
- FHWA HSM, http://safety.fhwa.dot.gov/hsm/
  - ✓ Outreach materials, Guidance, Case Studies
- FDOT HSM, http://www.dot.state.fl.us/safety/11A-SafetyEngineering/TransSafEng/HighwaySafetyManual.shtm
  - ✓ Crash Distribution, Calibration Factors, Organizational Chart, Implementation Summary, Implementation Plan Timeline, Presentations
- TRB, NCHRP 17-45, Freeways and Interchanges http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=2512

HSM Training

- National Highway Institute (NHI), https://www.nhi.fhwa.dot.gov/default.aspx
  - ✓ FHWA-NHI-380106, Highway Safety Manual Online Overview
    - Free Web Based Training (WBT) course includes an introduction of terminology, examples of the Roadway Safety Management Process (Part B) and Predictive Methods (Part C), explains the relationship of Crash Modification Factors (CMFs) to decision making and quantitative safety analysis, and human factors
    - Length: 12 Hours

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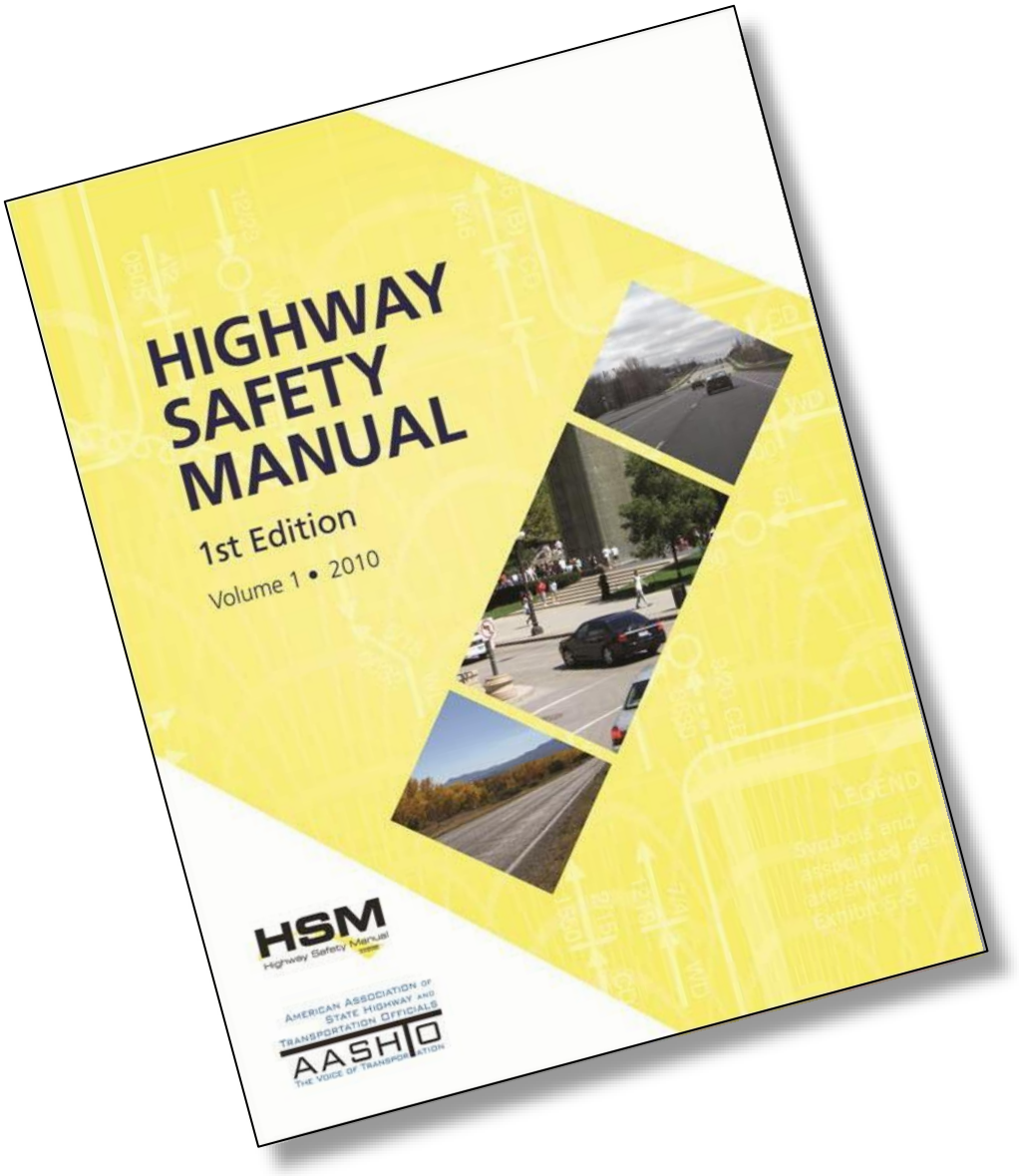
Questions?



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