Today I’ll Cover

• What it is
• What it contains
• How it differs from the way we used to consider infrastructure safety
• Why it’s beneficial to use
What is the HSM?

- AASHTO publication
- 1st Edition, dated 2010
- Periodically updated, 2014 Supplement
- 2nd Edition, targeted for 2019
- Developed with considerable technical input from the safety research community
What is the HSM (like)?

Akin to the HCM, but for safety...

- Definitive; represents quantitative ‘state-of-the-art’ information
- Widely accepted within professional practice of transportation engineering
- Science-based; updated regularly to reflect research
How the HSM describes itself...

• “…a resource that provides safety knowledge and tools in a useful form to facilitate improved decision making based on safety performance.”

• “The focus … is to provide quantitative information for decision making.”

• “…assembles currently available information and methodologies on measuring, estimating, and evaluating roadways in terms of crash frequency … and crash severity ….”
How the HSM describes itself...

• “...presents tools and methodologies for consideration of “safety” across the range of highway activities: planning, programming, project development, construction, operations, and maintenance.”

• “The purpose is to convey present knowledge regarding highway safety information for use by a broad array of transportation professionals.”
What it contains...

Part A Introduction, Human Factors, and Fundamentals

Part B Roadway Safety Management Process

Part C Predictive Methods

Part D Crash Modification Factors
Part B Roadway Safety Management Process

Ch. 4 Network Screening
Ch. 5 Diagnosis
Ch. 6 Countermeasure Selection
Ch. 7 Economic Appraisal
Ch. 8 Prioritization
Ch. 9 Safety Effectiveness
Part D Crash Modification Factors

- Ch. 13: Roadway Segments
- Ch. 14: Intersections
- Ch. 15: Interchanges
- Ch. 16: Special Facilities and Geometric Situations
- Ch. 17: Road Networks
### New Concepts

<table>
<thead>
<tr>
<th>Traditional</th>
<th>HSM</th>
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<tr>
<td>“Nominal” Safety</td>
<td>“Substantive” Safety</td>
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<tr>
<td>Observed Crash History...</td>
<td>Predicted/Expected Crash Frequency</td>
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<td>Random...</td>
<td>Predictable</td>
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<td>Reactive...</td>
<td>Proactive</td>
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Nominal vs Substantive Safety

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

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

*Ezra Hauer, ITE Traffic Safety Toolbox Introduction, 1999
Nominal vs Substantive Safety

Nominal Safety is an Absolute

Substantive Safety is a Continuum

CRASH RISK

DESIGN DIMENSION
(Lane Width, Radius of Curve, Stopping Sight Distance, etc.)
### Ways to Estimate a Roadway’s Safety Performance

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<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>Observed</strong></td>
<td>Historical crash count</td>
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<tr>
<td>Crash Frequency</td>
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<tr>
<td><strong>Predicted</strong></td>
<td>Estimate based upon roadway characteristics using a regression model</td>
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<tr>
<td>Crash Frequency</td>
<td></td>
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<tr>
<td><strong>Expected</strong></td>
<td>Weighted average of observed and predicted crash frequencies</td>
</tr>
<tr>
<td>Crash Frequency</td>
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</tbody>
</table>
Observed Crash Frequency

1983-1985

Number of Crashes

Mile Point
Observed Crash Frequency

1986-1988

Number of Crashes

Mile Point

PA SAFETY SYMPOSIUM toward zero deaths
Observed Crash Frequency

1989-1991

Number of Crashes

Mile Point

Number of Crashes

0 1 2 3 4 5 6 7 8 9 10

1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0 8.5

Mile Point
Observed Crash Frequency

1992-1994

Mile Point

Number of Crashes

0 1 2 3 4 5 6 7 8 9 10
1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0 8.5
Observed Crash Frequency

1998-2000

Number of Crashes vs Mile Point for the years 1998-2000.
Long-term 3-Year Average Crash Frequency

1983-2000

Number of Crashes

Mile Point

0 1 2 3 4 5 6 7 8 9 10

0 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0 8.5

PA SAFETY SYMPOSIUM toward zero deaths
3-Year Average Crash Frequency: 1983-2000

Number of Crashes

Traffic Volumes Increase

Mile Point
Random vs Predictable

• There is (some) randomness in the location of crashes and, therefore, in crash frequency by location.

• But, crash frequency by location:
  – Is not totally random, but rather somewhat predictable
  – Can be explained (and, therefore, predicted) by roadway characteristics with some (not perfect) statistical reliability.
Observed vs Predicted vs Expected

• Short-duration observed crash frequency counts aren’t a totally reliable estimator of either historical or future safety performance.

• Predictive methods use additional relevant information (i.e., data from other similar sites) to improve estimates of future safety performance.

• A weighted average of observed and predicted crash frequencies (i.e., “expected”) uses the most information and provides the most reliable estimate.
Predictive Methods

- **Foundational Elements:**
  - Safety performance functions (SPFs)
  - Crash modification factors (CMFs)
  - Calibration factors (C)

Predicted crash frequency = \( \text{SPF (AADT)}_{\text{base conditions}} \times \text{CMFs} \times C \)
Safety Performance Function (SPF)

Definition:
An (regression) equation to predict long-term average crash frequency on a particular type of roadway based on exposure—typically measured in terms of Average Annual Daily Traffic (AADT, vehicles per day)
SPFs for Two-Lane Rural Roadways

![Graph showing Predicted Total Crashes/mile/year vs AADT (veh/day) with lines for N (HSM), N (PA), N (D8), and N(Lebanon). A Calibration Factor is indicated on the graph.]
Crash Modification Factor (CMF)

Definition:
Relative change in crash frequency due to a change in one specific condition

\[
CMF = \frac{\text{Crash Frequency with Specified Condition}}{\text{Crash Frequency with Base Condition}}
\]
HSM CMFs for Two-Lane Rural Highways

- **Segments**
  - Lane Width
  - Shoulder Width/Type
  - Horizontal Curves
  - Grades
  - Driveway Density
  - Roadside Design
  - Passing Lanes
  - Two-way Left-Turn Lanes

- **Intersections**
  - Skew Angle
  - Left-Turn Lanes
  - Right-Turn Lanes
Predicted Crash Frequency for a Particular Two-Lane Rural Roadway

- Predicted Crash Frequency
- CMFs
- For Base Conditions

Predicted Total Crashes/mile/year vs. AADT (veh/day)
Expected crash frequency =
\[ w \times \text{Predicted crash frequency} + (1-w) \times \text{Observed crash frequency} \]
# Reactive vs Proactive

<table>
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<th>Proactive</th>
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<tr>
<td>Rank high-crash locations based on observed crash frequency</td>
<td>Rank sites with potential for safety improvement based on expected crash frequency</td>
</tr>
<tr>
<td>Treat locations that had high observed crash frequencies in the past</td>
<td>Treat locations based upon the presence of high-risk roadway features</td>
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</table>
FHWA’s Every Day Counts
Data-Driven Safety Analysis Initiative

Goal: Integrate safety performance into all transportation investment decisions
For more information...

- Contact me at Ray.Krammes@dot.gov or 202-366-2175
- Go to:
  - http://www.highwaysafetymanual.org
  - http://www fhwa dot gov/innovation/everyday
counts/edc-3/ddsa.cfm