Traffic Academy Safety Studies & Freeway Safety Study Guidelines

2017
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<th>Traffic Academy Agenda</th>
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<td>I. Introductions (5 min)</td>
<td>9:00 to 9:05</td>
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<td>II. Background and Overview of the HSM (40 min)</td>
<td>9:05 to 9:45</td>
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<tr>
<td>III. Safety Prediction for ODOT (15 min)</td>
<td>9:45 to 10:00</td>
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<tr>
<td>Break</td>
<td>10:00 to 10:15</td>
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<td>IV. ODOT Safety Program Overview (15 min)</td>
<td>10:15 to 10:30</td>
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<td>V. Collect Data and Diagnose Crash Patterns – TIMS/CAMTool Demos (45 min)</td>
<td>10:30 to 11:15</td>
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<td>VI. Confirm or Identify Potential for Safety Improvement (15 min)</td>
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<td>Break</td>
<td>11:30 to 12:30</td>
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<tr>
<td>VII. Perform Relevant Traffic Studies (15 min)</td>
<td>12:30 to 12:45</td>
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<td>VIII. Identify and Evaluate Countermeasures – ECAT Demo (75 min)</td>
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<td>IX. Freeway Safety Studies Overview (30 minutes)</td>
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<td>Break</td>
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<td>X. Develop Plan and Finalize Report (30 min)</td>
<td>2:45 to 3:15</td>
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<td>XI. Interpretation and Documentation of Safety Analysis (30 min)</td>
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<td>XII. Final Questions and Course Closing</td>
<td>3:45 to 4:00</td>
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Appendix A: Supplemental Studies

Appendix B: Reference Materials
I. Course Introduction
Housekeeping

- Cell phones
- Breaks
  - Authorized Areas
  - Restroom Locations
  - Lunch
- Emergency Exits

Agenda

Course Introduction 9:00 - 9:05
Background and Overview of the HSM 9:05 - 9:45
Safety Prediction for ODOT 9:45 - 10:00
Break 10:00 - 10:15
ODOT Safety Program Overview 10:15 - 10:30
Collect Data and Diagnose Crash Patterns 10:30 - 11:15
Confirm or Identify Potential for Safety Improvements 11:15 - 11:30
Lunch 11:30 - 12:30
Perform Relevant Traffic Studies 12:30 - 12:45
Identify and Evaluate Countermeasures 12:45 - 2:00
Freeway Safety Analysis Overview 2:00 - 2:30
Break 2:30 - 2:45
Develop Plan and Finalize Report 2:45 - 3:15
Interpretation and Documentation of Safety Analysis 3:15 - 3:45
Final Questions and Course Summary 3:45 - 4:00
Course Goals & Objectives

- Provide an understanding of what a Safety Study is and when and why a Safety Study needs to be completed.
- Describe what information is required for a Safety Study.
- Describe how/where to obtain the required information.
- Discuss evaluation of obtained information.
- Discuss presentation and format of the information for the Safety Study.
- Important! Describe changes to ODOT safety program and safety study processes as a result of the implementation of the Highway Safety Manual

Introductions

- Instructors
- Class Introductions
Up Next:

II. Background and Overview of the Highway Safety Manual (HSM)
II. Background and Overview of the Highway Safety Manual

Traffic Academy – Safety Studies
ODOT – Division of Planning – Program Management

Background and Overview of the AASHTO Highway Safety Manual

Why introduce a new methodology?
The two dimensions of 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

The two dimensions of safety produce different outlooks
Nominal Safety is an Absolute
Substantive Safety is a Continuum

(Design Dimension: Lane Width, Radius of Curve, Stopping Sight Distance, etc.)
Substantive safety is “context sensitive”

What types and severity of crashes would you expect at each of these locations?

A good decision is an informed decision – and an informed decision requires data

More Quantitative

• Design Standards
• Crash Rates
• TNM Vers. 2.5
• CAL3QHC
• Mobile 5a
• 3-D Visualization
• CITYGREEN
• HCM
• SYNCHRO
• CORSIM
• PASSER
• VISSIM
• GEOPAK Plans
• Cost Models
• Real Estate Appraisals
• DOT Databases

More Importance

Safety Impacts
Environmental Impacts
Traffic Operations
Right-of-Way
Costs

‘Safety’?
Typical Decisions that Impact Safety

- Which projects to do and not do
- Alignment and cross section
- Intersection improvements
  - Turn Lanes, Traffic Control, Roundabouts
- Roadside improvements
- Signalization
  - Permissive/Protected Only Modes, RTOR
- Access management
- Design exceptions

Quantitative tools help us make informed decisions

- Highway Capacity Manual (HCM)
  - statistical models of traffic operations (e.g., delay, density, speeds) of all types of facilities
- ITE Trip Generation Manual
  - statistical models of attractions to land uses and types
- TNM (Traffic Noise Model)
  - statistically-derived model for predicting sound levels associated with traffic

- Highway Safety Manual (HSM)
Highway Safety Manual – 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

The HSM - summarizes the best science and research in quantitative safety

- Synthesis of previous research
- New research commissioned by AASHTO and FHWA (peer reviewed through the National Academies)
- Ohio data was used in a number of HSM research topics
Traditional approaches produce misleading or incorrect results

- Adherence to design criteria tells us nothing about safety performance
- Crash rate as benchmark for decisions is not correct
  - Volume effects are non-linear (crash rate bias favors lower volume roads)
  - Expected crashes vary by number of lanes for the same highway type (e.g., we can not compare 4, 6 and 8-lane freeways)

The HSM and the ‘Science of Safety’

- New concepts and understanding of crashes
  - Focus on crash frequency and on the expected crash frequency
  - Eliminating ‘regression to the mean’ bias in use of best practices
  - Disaggregating crashes by type (SV, MV, Ped)
  - Analyzing crashes by severity
- We can for the first time predict crashes based on our contemplated actions
  - Statistical models for the full range of facility types
  - Proven effects of roadway geometry and dimensions on crash frequency
Crash Frequency

- The basic measure of crashes in the HSM is crash frequency per unit of time (typically one year)

\[ N_c = \text{Number of crashes per year}^* \]

*expressed for a location or site; or per mile depending on the context

Each part of the HSM brings value to the work of transportation professionals

The 1st edition of the Highway Safety Manual has 17 chapters in three volumes
Part A -- Introduction, Human Factors, and Fundamentals

1. Introduction & Overview
2. Human Factors
3. Fundamentals of Safety

Contributing factors to crashes

- Roadway: 34%
- Driver: 93%
- Vehicle: 13%

[Diagram showing the overlap between roadway, driver, and vehicle factors]
Part B – Road Safety Management Process (Ch. 4 – 9)

- Network Screening
- Diagnosis & Countermeasure Selection
- Economic Appraisal & Prioritization
- Safety Effectiveness Evaluation

Safety Priority Locations - ODOT is using Safety Analyst

- Reduced the number of manual safety studies performed from 600 to 300
- Greatly increased the identification of sites with highest potential for safety improvement

SA Implemented in 2010
SA Safety Study Location Effectiveness
SA Implemented in 2010

Number of Fatalities Per Mile Studied
Number of Serious Injuries Per Mile Studied
Number of Total Crashes Per Mile Studied

SA Safety Study Location Effectiveness
SA Implemented in 2010

Number of Expected Crashes Per Mile Studied
Number of Excess Crashes Per Mile Studied
Number of Predicted Crashes Per Mile Studied
Part C – Methods for Predicting Crashes

Predictive Methodology
- ‘Safety Performance Functions’
- ‘Crash Modification Factors’
- ‘Calibration’

Applications
Economic Crash Analysis Tool (ECAT)

Roadway types included in Part C

Ch. 10 Rural Two-lane Roads

Ch. 11 Rural Multi-lane Roads

Ch. 12 Urban & Suburban Arterials
Roadway Types – Freeways and Interchanges

- Published as 2014 HSM Supplement
- Chapter 18 – Freeways
- Chapter 19 - Ramps

Part A
Part B
Part C
Part D

Part C – Methods for Predicting Crashes

Appendix: Common Procedures for all three chapters
- Calibrating predictive methods
- Empirical Bayes --- combining predicted with observed crashes (i.e., crash history)

ECAT includes analysis methods from HSM Chapters 10, 11, and 12

ISATe has analysis methods for freeways and interchanges
The HSM uses statistical methods for obtaining reliable estimates of expected crash frequency

- **Existing locations**
  - How well does the location perform compared to what we would expect (i.e., the expected average crash frequency)?

- **Design projects**
  - How will the project perform assuming it is designed and constructed properly?

**HSM Predictive Methods in Part C**

- Estimate the “expected average crash frequency” ........

which is associated with a particular geometric design, given time period, and specific traffic volume.
**Statistical Methods in the HSM – Part C**

- Mathematical models based on high quality data from multiple states
  - Control for regression to the mean
  - Establish predictive relationships
  - Incorporate relationship of traffic volume to crash frequency

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**HSM Part C – Predictive Methods**

- Safety Performance Functions (SPF)
- Crash Modification Factors (CMF)
- Calibration (C)
- Incorporating Observed Crashes – Weighting with Empirical Bayes’
Safety Performance Functions (SPF)

• Mathematical expression used to estimate the expected average crash frequency for a base condition
• Product of a statistical modeling process

Safety Performance Functions

- Separate models and functions for
  - Different highway types
  - Road segments vs. intersections
  - Types of intersections (signalized, unsignalized)
- Can be for total crashes, certain crash types, or certain crash severities (KABCO)
- Base conditions established in modeling process
HSM Part C Crash Modification Factors (CMF)

Expresses a change in expected crashes when a factor or element is different from the base conditions
- e.g., ‘base condition’ is lane width of 12 ft;
- CMF for 11-ft lanes computes expected crashes when lane width is changed

\[
CMF = \frac{\text{Expected Average Crash Frequency With Condition 'b'}}{\text{Expected Average Crash Frequency With Condition 'a'}}
\]

HSM Equation (3-5)

CMFs and Part C

\[
N_{\text{predicted}} = N_{\text{SPF}} \times (CMF_{1x} \times CMF_{2x} \times \ldots \times CMF_{yx}) \times C_{x}
\]

- \(N_{\text{predicted}}\) = predicted crash frequency for given site conditions (incl. traffic volume)
- \(N_{\text{SPF}}\) = expected crash frequency from the SPF for the base condition
- \(CMF_{ix}\) = crash modification factors (one for each roadway element that is included in the SPF database)
- \(C_{state}\) = calibration factor for the state

HSM Equation (3-3)
Part C CMFs come from the same modeling effort as the SPF

- Derived with reference to the established base conditions
- Can be applied only in the same setting and road type for which they were developed
- Can be applied only within the AADT range included in the underlying model
- Apply for the crash type and severity addressed by the CMF

Calibration – C

- SPFs and CMFs were developed from many states’ databases
- Calibration is required for each state (incl. Ohio)
- Relative comparisons are still possible using uncalibrated models
- ODOT has calibrated the Part C models (including Freeways and Ramps)
What about observed crash history? Don’t we use that in our analysis?

Regression to the mean bias exists when only crash history is used.
Site-Specific Empirical Bayes (EB) Method

- Reduces effects of regression-to-the-mean
- Improves the crash frequency estimate
- *Both SPF and crash data must be available*

Weighting reflects strength and reliability of the model used

Reliability of a model is function of:
- Fit of original data
- Variance
- How well model was calibrated for local data
Part D – Crash Modification Factors (CMF)

Resource on the effectiveness of safety countermeasures or treatments
- Ch. 13 -- Roadway Segments
- Ch. 14 -- Intersections
- Ch. 15 -- Interchanges
- Ch. 16 -- Special Facilities and Geometric Situations

Also included in ECAT

The Highway Safety Manual

- Informs decisions on expected effects of actions on crashes
- Does NOT produce mandates or warrants
- Does NOT make decisions for you
Up Next:

III. Safety Prediction for ODOT
III. Safety Prediction for ODOT

Traffic Academy – Safety Studies
ODOT ~ Division of Planning ~ Program Management

Predictive Method Analysis Process

PREPARATION

1. Determine data needs Homogeneous segments & intersections
2. Calculate predicted number of crashes for base condition
3. Calculate predicted number of crashes for each element (similar sites)

In some cases, we can incorporate crash history using the Empirical Bayes (E.B.) process to get to expected expected number of crashes for each element (actual site)*
Preparation

Determine Data Needs
- Study limits
- Facility type
- Study period
- Site conditions (geometry, traffic control, etc.)
- Traffic volumes (vehicles/day)

Preparation

Divide locations into homogeneous segments or intersections
- Presence (and type) of intersections
- Number of lanes
- Cross section dimensions (LW, SW)
- Alignment change (Horiz, Vertical)
- Change in roadside conditions
- Change in traffic volume
Creating Homogeneous Segments

A new roadway segment begins where:
- Base conditions* change
- Major changes in
  - Traffic volume
  - Geometric alignment*
- Presence of an intersection

* Homogeneous sections will vary based on the facility type (SPF and CMFs)

Example: Homogeneous Segments

A new roadway segment begins at:
- Center of each intersection
- Horizontal curves (PC)
- End of grade (VPI)
- Limits of passing lanes or short 4-lane sections
- Limits of two-way left-turn lane
- Average daily traffic volume change
- Lane or shoulder width or type
- Change in driveway density (per mile)
- Roadside hazard rating change
- Presence of centerline rumble strip, lighting, or automated speed enforcement
1. Calculate the predicted # of crashes for SPF base condition

Identify & apply the appropriate SPF

Chapter 10 for 2-lane Rural Highway SPFs

Chapter 12 for Urban Arterial SPFs

Chapter 11 for Multilane Rural Highway SPFs

2. Calculate the predicted number of crashes

1. Predicted crashes for the base condition

2. Adjust for site conditions that are different from the SPF base condition

3. Apply Calibration Factor

SPF x \((CMF_1 \times \ldots \times CMF_i)\) x C
Apply CMFs to Calculated SPF Values

- Review applicable SPF “base case” or typical features
- Determine how study site differs from “base case”
- Select CMFs for road type and atypical features from Part C
- Multiply SPF value by applicable CMFs

Apply Local Calibration Factor (C)

- “C” adjusts HSM SPF-derived crash estimates to reflect local conditions
  - Reporting levels
  - Weather and other similar factors
- Each SPF requires its unique “C”
- “C” values would be provided to you by the Office of Program Management
Apply Site-Specific Empirical Bayes (EB) Method

- Reduces effects of RTM
- Improves the crash frequency estimate
- Requires SPF & historic crash data
- Steps: HSM Part C Appendix

EB Method Application and Formula

\[ N_{expected} = w \times N_{predicted} + (1.00 - w) \times N_{observed} \]

Weighted Adjustment \((w)\):

\[ w = 1 / \left[ 1 + k \times (\sum N_{predicted}) \right] \]

where

- \(k\) is over-dispersion parameter (unique to each SPF) and
- \(\sum N_{predicted}\) is predictive model estimate for all study yrs

Site is expected to have more crashes per year on average than its peers → Potential for improvement!

Difference = Expected Excess Crashes (Potential for Safety Improvement)

Site is expected to fewer more crashes per year on average than its peers

Expected average crash frequency for the site

Predicted Average Crash Frequency for the site (how are its peers performing on average?)

Expected average crash frequency for the site

What is the benefit of the EB step?

- Incorporate the site crash history to
  - improve our estimate,
  - reduce effects of RTM,
  - understand the unbiased potential for safety improvement.
When is the EB method applicable?

- **No-build option**
  - Sites at which the roadway geometrics and traffic control are not being changed (e.g., the “do-nothing” alternative);

- **# through lanes consistent**
  - Projects in which the roadway cross section is modified but the basic number of through lanes remains the same(e.g., projects for which lanes or shoulders were widened or the roadside was improved, but the roadway remained a rural two-lane highway);

- **Minor alignment changes**
  - Projects in which minor changes in alignment are made, such as flattening individual horizontal curves while leaving most of the alignment intact;

- **Passing lanes**
  - Projects in which a passing lane or a short four-lane section is added to a rural two-lane, two-way road to increase passing opportunities; and

- **Any combination of the above improvements**

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When is the EB method NOT applicable?

- **New alignment and/or cross section**
  - Across substantial proportion of the project length; major change in facility type (e.g., 2 lane to multilane road)

- **Intersections where**
  - Change in # intersection legs
  - Change in traffic control
STEP 1: Calculate weight $w$

$$W = \frac{1}{1 + k \times (\Sigma N_{\text{predicted}})}$$

Eq A-5 (p.A-19)

STEP 2: Combine observed and predicted crash #

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

Eq A-4 (p.A-19)

STEP 3: Adjust estimated value of expected average crash frequency to future time period (if needed)

$$N_f = N_p \times \frac{N_{bl}}{N_{bp}} \times CMF_{1f} \times CMF_{2f} \times \ldots \times CMF_{nf}$$

$$N_{bf} \times CMF_{1b} \times CMF_{2b} \times \ldots \times CMF_{nb}$$

Eq A-15 (p.A-23)

Predictive Methods & Reliability

- Part C Predictive Method & EB adjustment with/ without Part D CMFs
- SPF only & CMFs & C (no EB adjustment) with/ without Part D CMFs
- Part C SPFs & CMFs but no C (relative comparison within facility type) with/ without Part D CMFs
- Observed crash frequency & Part D CMFs
Up Next:

IV. ODOT Safety Program Overview
What is a Safety Study?

- A method to provide an organized approach to the identification, analysis and mitigation of crash patterns and frequency at highway safety priority locations.
- A systematic approach to evaluate contributing factors to crashes and identify strategies for improvement with the greatest potential to benefit safety.
- A method to estimate the effectiveness of our proposed countermeasure(s)
- If applying for safety funds, a means to justify the proposed countermeasures and project.
Procedures

Problem & Goal Identification
- Identified by ODOT District, MPO or local government as a problem area

Study Area Definition

Start Up Meeting with District Safety Review Team (DSRT)
- Start up meeting can also serve as kick-off meeting for in-house ODOT projects and PDP process
- These studies are likely to recommend a Minor PDP project – should have multi-disciplines represented at kickoff meeting and red flag evaluation.

District Safety Review Team (DSRT)
- Multi-disciplinary committee
  - Consultant may interact with DSRT or District Safety Coordinator only
  - Review project scope - Full or Abbreviated Safety Study as directed by ODOT District
  - The higher the complexity and cost to address the problem, the more information will be needed.
- Review study area
- Request Crash Data - agree on most recent and available 3-calendar year time frame (i.e. January 1, 2009-December 31, 2011)
- Two funding rounds each year. Applications can be submitted every April 30th and September 30th.
Procedure
Locally-sponsored safety studies

- Seeking ODOT funds? Contact the District Safety Coordinator to verify the level of effort and schedule for submitting a study and application.

- All studies and applications must be reviewed and approved by the District DSRT committee before they can be submitted to Central Office (April 30th and September 30th).

- At a minimum, studies should be received by the District at least three months prior to the application deadline. This will typically provide enough time for review, changes and approval.

ODOT Safety Study Process

1. Step 1: Collect Data and Diagnose Crash Patterns
2. Step 2: Identify Potential for Site Safety Improvements & Possible Countermeasures
3. Step 3: Perform Relevant Traffic Studies
4. Step 4: Evaluate Countermeasures
5. Step 5: Develop Plan and Finalize Report
Highway Safety Contacts:

- For questions regarding a specific location contact your District Highway Safety Coordinator.
- For general questions about the ODOT Safety Program, contact Michelle May or Julie Walcoff (SRTS).
- For questions regarding crash data and analysis, contact Derek Troyer.

ODOT Highway Safety Program Website

http://www.dot.state.oh.us/Divisions/Planning/ProgramManagement/HighwaySafety/ Pages/default.aspx

For specific safety study questions, please contact the appropriate District Highway Safety Coordinator.
ODOT’s Highway Safety Program

- ODOT has one of the largest Safety Programs in the Country
- In 2012, the Department increased safety funding from $72 million to $102 million for engineering improvements at high-crash or severe-crash locations
  - Funding can be used by Districts or Local Public Agencies to improve safety on any public roadway
  - ODOT uses funding for millions of dollars of systematic improvements annually
  - Portion of funding is used to fund education and enforcement programs that encourage safety driving
- In 2013, Ohio had 990 traffic-related deaths – the lowest number of fatalities since 1936.

Ohio’s Strategic Highway Safety Plan

The SHSP is a comprehensive statewide plan that identifies the greatest causes of serious injuries and deaths on Ohio roads. It establishes common goals, priorities, and strategies using data; identifies and tracks investments across organizations; and helps Ohio leverage and maximize its resources to prevent injuries and save lives. The plan was developed in collaboration with local, state, federal, and private sector organizations from a variety of traffic safety disciplines, including engineering, education, enforcement, and emergency response. These stakeholders developed a comprehensive plan that focuses on existing and emerging crash trends, and safety for all road users, including cars, trucks, buses, motorcycles, pedestrians, and bicyclists.

Based on this collaborative input, Ohio identified four emphasis areas and 15 subareas where multi-agency coordination and collaboration is critical to saving lives. Over the next several years, Ohio organizations are committed to making investments that:

1. Improve the quality, accuracy, timeliness, and availability of crash, roadway and emergency care data;
2. Reduce the occurrence and severity of roadway departure, intersection, rear and sideswipe and highway/roadway crossing crashes;
3. Address high-risk drivers and behaviors such as young and older drivers, impaired driving, low seat belt use, distracted driving and excessive speed; and
4. Address bicycle and pedestrian crashes, pedestrian and commercial vehicles, which are more likely to be involved in serious crashes.

These emphasis areas represent the greatest threat to safety and are the cause of most serious injuries and deaths on Ohio roads.

The Highway Safety Manual

Technical background on the basic ‘science’ of crashes
Safety management methods and approaches
Methodologies for predicting crashes
Understanding the effects of treatments on crashes

Safety is a top priority for ODOT and the HSM will help in making the best possible safety decisions.

Integrating the Highway Safety Manual into ODOT’s Highway Safety Program

ODOT’s HSM Implementation Plan
ODOT Safety Program Priority Locations

ODOT's updated process now focuses on sites that have the most potential to benefit from a safety improvement.

Top 50 locations in each of the following categories will be studied:
- Rural Intersection
- Rural Non-Freeway (non-intersection)
- Rural Freeway (non-intersection)
- Urban Intersection
- Urban Non-Freeway (non-intersection)
- Urban Freeway (non-intersection)

http://www.dot.state.oh.us/Divisions/Planning/ProgramManagement/HighwaySafety/HSIP/Pages/Priority-Lists-Initiatives.aspx
ODOT Highway Safety Maps

Ohio’s safety and priority locations.
Can be mapped by State, District, County, or Township

[http://www.dot.state.oh.us/Divisions/Planning/ProgramManagement/HighwaySafety/HSiP/Pages/MapRoom.aspx](http://www.dot.state.oh.us/Divisions/Planning/ProgramManagement/HighwaySafety/HSiP/Pages/MapRoom.aspx)

Highway Safety Training Opportunities

Available Training Material:
- HSM Overview
- HSM Focused Training
- HSM Freeways
- Safety Studies
- GCAT

[http://www.dot.state.oh.us/Divisions/Planning/ProgramManagement/HighwaySafety/Pages/Training.aspx](http://www.dot.state.oh.us/Divisions/Planning/ProgramManagement/HighwaySafety/Pages/Training.aspx)
HSM Implementation and Training Tools

- SafetyAnalyst
- GIS Crash Analysis Tool
- Transportation Information Mapping System (TIMS)
- Crash Analysis Module (CAM) Tool
- Economic Crash Analysis Tool (ECAT)

We will be demonstrating several of these tools throughout the day.

http://www.dot.state.oh.us/Divisions/Planning/ProgramManagement/HighwaySafety/HSIP/Pages/Crash-Data-Analysis-Tools.aspx

Project Development and the Highway Safety Manual

**ODOT's Project Development Process ~ A Phased Approach**

Planning (PE)
- Project Seed
- Purpose
- Need Identification

Preliminary Engineering (PE)
- Feasibility Study
- HSTF Studies
- Evaluation
- Report
- Value Engineering
- Main Design
- Stakeholder involvement

Environmental Engineering (EE)
- Preferred Alternative
- Stage 1 Design & Approvals
- Value Engineering
- Corridor Evaluation
- NEPA
- Permit Approval
- Stage 2 Design & Approvals
- ROW Plans
- Stakeholder involvement

Final Engineering (FE)
- ROW Utility Acquisition & Relocations
- Stage 3 Design & Approvals
- Final Estimates
- Final Plan Package
- Mitigation
- Stakeholder involvement

Construction (CO)
- Advertisement
- Award Contract
- Monitor Contract
- Stakesholder involvement

Where does the HSM & Safety Analysis apply in the PDP?

http://www.dot.state.oh.us/projects/pdp/Pages/Path-Views.aspx
Step 1: Collect Data and Diagnose Crash Patterns

Step 2: Identify Potential for Site Safety Improvements & Possible Countermeasures

Step 3: Perform Relevant Traffic Studies

Step 4: Evaluate Countermeasures

Step 5: Develop Plan and Finalize Report

Where does the HSM apply in the Safety Study Process?

Up Next:

V. Safety Study Process Step 1: Collect Data and Determine Crash Patterns
V. Collect Data and Diagnose Crash Patterns

Traffic Academy – Safety Studies
ODOT ~ Division of Planning ~ Program Management

ODOT Safety Study Process

Step 1: Collect Data and Diagnose Crash Patterns

Step 2: Identify Potential for Site Safety Improvements & Possible Countermeasures

Step 3: Perform Relevant Traffic Studies

Step 4: Evaluate Countermeasures

Step 5: Develop Plan and Finalize Report
Topics

- Historical Studies/Reports
- Existing Condition Data
- Crash Data
- Summarize Crash Data
- Collision Diagram
- Interpret Crash Data
- Supplemental Data

Background Information

- Research previous studies, pertinent information, or improvements in the study area

- Talk to DSRT Members or local authorities
Existing Conditions

- Determine study limits
- Identify HSM site subtypes so appropriate data can be collected from field visit

Data Needs - Segments

- Length of segment, L (mi)
- AADT (veh/day)
- Lane width (ft)
- Shoulder width (ft)
- Shoulder type
- Median width (ft)
- Side Slopes
- Length of horizontal curve (mi)
- Radius of curvature (ft)
- Spiral transition curve (present/not present)
- Super elevation variance (ft/ft)
- Grades (\%)
- Driveway density (driveways/mile)
- Centerline rumble strips (present/not present)
- Passing lanes (present (1 lane), present (2 lanes), not present)
- Two-way left turn lane (present/not present)
- Roadside hazard rating (1-7 scale)
- Segment lighting (present/not present)
- Auto speed enforcement (present/not present)
- Roadway type (divided / undivided)
- Auto speed enforcement (present, not present)
- Major commercial driveways (number)
- Minor commercial driveways (number)
- Major industrial / institutional driveways (number)
- Minor industrial / institutional driveways (number)
- Major residential driveways (number)
- Minor residential driveways (number)
- Other driveways (number)
- Speed Category
- Roadside fixed object density (fixed objects / mi)
- Offset to roadside fixed objects (ft if greater than 30, Not Present, input 30)

Note: Indicate how existing conditions compare to current design criteria – add reference to ODOT Location & Design Manual, Vol. One
Data Needs - Intersections

- Intersection type (3ST, 4ST, 3SG, 4SG)
- AADT major (veh/day)
- AADT minor (veh/day)
- Intersection shape angle (degrees)
- Intersection lighting (present/not present)
- Number of approaches with left-turn lanes
- Number of approaches with right-turn lanes
- Number of approaches with left-turn signal phasing
- Type of left-turn signal phasing
- Number of approaches with right-turn on red prohibited (for 3SG, use maximum value of 3)
- Intersection red light cameras (present/not present)
- Sum of all pedestrian crossing volumes (PedVol) -- Signalized intersections only
- Maximum number of lanes crossed by a pedestrian (if any)
- Number of bus stops within 300 m (1,000 ft) of the intersection
- Schools within 300 m (1,000 ft) of the intersection (present/not present)
- Number of alcohol sales establishments within 300 m (1,000 ft) of the intersection
- Type of on-street parking (none/parallel/angle)
- Proportion of curb length with on-street parking

Note: Indicate how existing conditions compare to current design criteria – add reference to ODOT Location & Design Manual, Vol. One

Physical Conditions Diagram

Diagram should be to scale linearly, but may be exaggerated horizontally for clarity

Prepare Physical Conditions Diagram that includes:
- Roadway geometrics
  - Alignment
  - Proportional representation
  - Pavement/ Lane width
  - State overhead clearances
- Detours
- Speed limits
- Landscaping (where appropriate)
- Signing
- Signals
- Pavement markings
- Guardrail
- Other pertinent data from Existing Condition Data
- Typical Sections
Existing Conditions

Transportation Information Mapping System (TIMS) Demonstration
Data Needs – Crash Reports

- Year
- Crash type
- Crash severity
- Crash location
- Road conditions
- Lighting conditions
- NLFID/logpoint or Location ID

NLFID System

- ODOT’s system for unique identification
- Applies to all roads – on or off ODOT system

Example: SHAMUS00027**C

- Jurisdiction (State, County, Twp, Muni.)
- County abbreviation
- Route type (IR, US, SR, CR, TR, MR, Ramp, Bike)
- Route number
- Route Number Extension (CR, TR, Muni Roads only)
- Route Type (Alternate, Bypass, Turnpike, Temp)
- Cardinal/Non-Cardinal direction
Crash Data and Analysis

- Crash data in the study area may be obtained from:
  - ODOT
  - Ohio Department of Public Safety (ODPS)
  - Locality (City, County, etc.) or any other relevant source if needed to show trends or if HSP numbers are low

- Crash data can be downloaded for ease in data sorting using ODOT CAM Tool

- Crash forms (OH-1 Reports) with details for each crash can be obtained from ODPS – available online:
  [https://services.dps.ohio.gov/CrashRetrieval/OHCrashRetrieval.aspx](https://services.dps.ohio.gov/CrashRetrieval/OHCrashRetrieval.aspx)

### Crash Data

<table>
<thead>
<tr>
<th>ACCIDENT'S O&amp;M NBR</th>
<th>LOCAL REPORT NBR</th>
<th>STREET1</th>
<th>STREET2</th>
<th>DISTANCE OFFSET</th>
<th>STREET2 REPRESENTATIVE</th>
<th>CRASH PATH</th>
<th>STREET2 REPRESENTATIVE2</th>
<th>CRASH DATE</th>
<th>DAY OF WEEK</th>
<th>HOUR OF OCCUR</th>
<th>LOCATION TYPE</th>
<th>TYPICAL VEHICLES</th>
<th>CRASH TYPE</th>
<th>WEATHER CONDITION</th>
<th>ROAD CONDITION</th>
</tr>
</thead>
</table>
**Summarize Crash Data**

- Summarize crash data in tables/graphs and in report text for:
  - Type of crash
  - Severity
  - Time of day
  - Contributing circumstances
  - Environmental conditions

**CRASH DATA ANALYSIS**

Data Graphs

Data Charts

Histograms
CRASH DATA ANALYSIS

Before Analysis Period: 2001 to 2003
Total Crashes: 1,170

After Analysis Period: 2009 to 2011
Total Crashes: 1,336
- Fatal Crashes increased from 3 to 9
- Serious Injury Crashes increased from 27 to 54
- Minor Injury Crashes decreased from 341 to 239

Project prohibited westbound CR 151 traffic from exit at Monroe Rd. This reduced the number of crashes in the CR 151 segment between CR 181 and Monroe Rd as well as at the Monroe Rd interchange.
Summarize Crash Data
Report Text Summary Example

Crash Data and Countermeasure Discussion
From 2009-2011, 181 crashes occurred within the study area. After reviewing the crash data, the following observations were compiled:

- 35% of all crashes involved fixed object collisions. Based on previous studies of this data and a review of the 2010-2011 OH-1 Crash reports, these crashes were concentrated on the ramps at the SR-562 and Ridge interchanges. As stated in Table 1, a project is currently under construction that is increasing the pavement friction and installing additional warning delineation on these ramps (H4M-71-0.19 PID 89069).

- 45% of all crashes occurred heading northbound compared with 24% heading southbound. Removing the fixed object crashes from the analysis, which mostly occur on the interchange ramps, shows that 59% of the remaining crashes occur on northbound I-71 compared with 29% heading southbound. In addition, 70% of the northbound crashes occurred during the evening peak hours (3pm-7pm). Based on field observations and a review of the OH-1 Crash reports, these crashes are likely related to northbound congestion that occurs during the evening as two lanes drop at the SR-562 and Ridge North interchange. Northbound queues can extend as far as Dana Avenue, which is more than 1.5 miles south of the study area. To address this crash trend, ODOT 08 has applied for safety funds to widen northbound I-71 to provide three continuous through lanes through the SR-562 and Ridge Avenue interchanges. Please refer to Appendix B for an excerpt of this Safety Fund Application.

Please refer to Appendix A for a summary of the crash experience for this segment of I-71.

---

Summarize Crash Data
Report Text Summary Example

Noteworthy crash patterns within the intersection influence area include:

- **Driveway access crashes**: Of the 30 driveway related angle crashes, 8 occurred on the north leg of Reynolds Road (at Melvin Drive and Starbucks access) and 19 occurred on the east leg of Airport Highway (Melvin Drive and Baskin Robbins access). This statistic does not include rear end crashes at these locations.

- **EB/WB rear end crashes on Airport Highway**: Of the 118 total rear end crashes, the predominant direction was eastbound on Airport Highway approaching Reynolds Road with 47 crashes (40 percent). Westbound Airport Highway had the fewest rear end crashes of all the approaches.

- **NB rear end crashes on Reynolds Road**: Of the 118 total rear end crashes, 32 occurred northbound on Reynolds Road (27 percent). Over 40 percent of the NB rear end crashes occurred during the mid-day hours from 10AM to 2PM with 30 percent occurring during the evening peak hours from 3PM to 6PM.

- **Left turn crashes**: There were 16 eastbound left turn crashes on Airport Highway. A majority of these crashes involved vehicles making left turns during the permissive, lagging phase.

- **Red Light Crashes**: A total of 10 crashes were attributed to red light running crashes during the 3-year study period (2008-2010). This is an increase of 2 crashes when compared to 2002-2004 data.
Summarize Crash Data
Alternate Presentations

<table>
<thead>
<tr>
<th>CRASH TYPE</th>
<th>EASTBOUND AIRPORT HWY</th>
<th>WESTBOUND AIRPORT HWY</th>
<th>NORTHBOUND REYNOLDS RD</th>
<th>SOUTHBOUND REYNOLDS RD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rear End</td>
<td>47</td>
<td>17</td>
<td>32</td>
<td>22</td>
</tr>
<tr>
<td>Left Turn Angle</td>
<td>16</td>
<td>4</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Right Angle</td>
<td>4 (@ Airport)</td>
<td>0</td>
<td>1 (@ Melvin)</td>
<td>2 (@ Airport)</td>
</tr>
<tr>
<td>Turning Angle</td>
<td>3 (@ Badkin Rest.</td>
<td>13 (@ Melvin)</td>
<td>5 (@ Reynolds)</td>
<td>2 (@ Airport)</td>
</tr>
<tr>
<td>Sideswipe (Rear)</td>
<td>6</td>
<td>6</td>
<td>4</td>
<td>10</td>
</tr>
</tbody>
</table>

Crash Analysis Module (CAM) Tool Demonstration
Prepare Collision Diagram

- Collision diagrams are schematic and not intended to show exact vehicle location
- Graphical representation of individual crashes
- Extremely useful in providing a pictorial summary of the crashes
- Length of section to scale, may exaggerate horizontal scale to show more detail
- Crashes should be placed in lane in which they occurred if information available on crash report

Prepare Collision Diagram

- Crash reports should be reviewed to verify key data elements (location information, narrative, diagram etc., are critical)
- Collision diagrams must possess basic information:
  - Type of crash
  - When crash occurred (hour and date)
  - Road characteristics/condition
  - Light conditions (i.e. day, night, dusk, dawn)
  - Severity (i.e., fatal, injury, or property damage only (PDO))
  - Schematic of location with approaches labeled & north arrow
  - Legend to denote all symbols
  - Title box with county, route, section, Safety Analyst year and rank (if applicable) & creators initials and date
OH-1 Examples

This crash actually occurred on private property.

U-turn crash
Does it indicate a demand for U-turn movements?

This crash was labeled as "at intersection". However, it may not be related to this intersection.
OH-1 Examples

Emergency vehicle involved – not problem related to “normal” vehicles driving left of center

Diagram shows that queuing may be an issue

Collision Diagram Example
Supplemental Data

Supplement crash data with a field review noting the following:
- Skid marks on pavement
- Tire tracks or excessive wearing of roadway shoulder material
- Damaged guardrail, bushes, etc.
- Broken glass, chrome strips or other vehicle debris
- Collision marks on trees
- Bent or damaged sign post, delineation markers, etc.
- Video logs from ODOT Office of Innovation, Partnerships & Energy upon request

*Document and Photograph*

Up Next:

VI. Safety Study Process Step 2: Identify Potential for Site Safety Improvements
VI. Confirm or Identify Potential for Site Safety Improvement

Traffic Academy – Safety Studies
ODOT – Division of Planning – Program Management

ODOT Safety Study Process

- Step 1: Collect Data and Diagnose Crash Patterns
- Step 2: Identify Potential for Site Safety Improvements & Possible Countermeasures
- Step 3: Perform Relevant Traffic Studies
- Step 4: Evaluate Countermeasures
- Step 5: Develop Plan and Finalize Report
Procedure

- Use collected data to calculate the following:
  - Predicted Crash Frequency
  - Expected Crash Frequency
  - Potential for Safety Improvement

- Use HSM or ECAT to complete calculations

Predictive Method Analysis Process

1. Determine data needs: Homogeneous segments & intersections
2. Calculate predicted number of crashes for base condition
3. Calculate predicted number of crashes for the site condition
4. Calculate expected number of crashes for the site condition*

*We can incorporate crash history using the Empirical Bayes (E.B.) process to get to expected

ECAT will help you complete Steps 1, 2, and 3
A positive difference between expected and predicted = potential for safety/site improvement

Site is expected to have more crashes per year on average than its peers → Potential for improvement!

Difference = Expected Excess Crashes (Potential for Safety Improvement)

Site is expected to have fewer crashes per year on average than its peers

Part D – Crash Modification Factors (CMF): Ch. 13 - 17

Resource on the effectiveness of safety countermeasures or treatments

- Ch. 13 – Roadway Segments
- Ch. 14 – Intersections
- Ch. 15 – Interchanges
- Ch. 16 – Special Facilities and Geometric Situations
- Ch. 17 – Road Networks
Methods for estimating safety effectiveness

- Part C Predictive Method with Part C CMFs and Crash History using EB method & Part D CMFs
- Part C Predictive Method with Part C CMFs only & Part D CMFs
- Part C Predictive Method & Part D CMFs
- SPF only & Part D CMFs
- Observed crash frequency & Part D CMFs

ECAT performs this level of analysis.
A clarification on CMFs in the Highway Safety Manual

Part C CMFs are not the same as Part D CMFs.

- Part C CMFs were developed in conjunction with the statistical models (SPFs) for base conditions and are used to adjust base conditions to site conditions.
- Part D CMFs estimate the effectiveness (expected change in crashes) as a result of implementing countermeasures.
- Part D CMFs include part C CMFs but Part C CMFs do not include Part D CMFs.
- CMFs in Part D should not be used with Part C unless they were originally from Part C.

Identification and Evaluation of Countermeasures using HSM Methodologies

- Requires knowledge of the PREDICTED and/or EXPECTED performance of the site condition.
- Predicted performance reflects how the site is predicted to perform based on knowledge of the performance of similar ‘peer’ sites.
- Expected performance reflects how the site is expected to perform based on the performance of peer sites and considering historical crash performance.
Analyze Results

- Determine locations with potential for safety improvement
- Compare results to existing crash patterns
- Begin thinking about possible safety improvements to reduce crashes

Economic Crash Analysis Tool can be used to determine the potential for safety improvement.

Tool demonstration will be included with Module 6.
### RSI (Relative Severity Index)

<table>
<thead>
<tr>
<th>Code</th>
<th>Type</th>
<th>Freeway</th>
<th>Urban</th>
<th>Rural</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Not Stated</td>
<td>$12,580.65</td>
<td>$35,117.69</td>
<td>$22,390.26</td>
</tr>
<tr>
<td>1</td>
<td>Head On</td>
<td>$329,680.62</td>
<td>$84,538.34</td>
<td>$207,656.34</td>
</tr>
<tr>
<td>2</td>
<td>Rear End</td>
<td>$22,048.06</td>
<td>$18,240.80</td>
<td>$27,569.58</td>
</tr>
<tr>
<td>3</td>
<td>Backing</td>
<td>$15,903.92</td>
<td>$10,652.56</td>
<td>$13,625.45</td>
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<tr>
<td>4</td>
<td>Sideswipe - Meeting</td>
<td>$103,875.36</td>
<td>$73,400.01</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Sideswipe - Passing</td>
<td>$19,418.41</td>
<td>$24,921.10</td>
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</tr>
<tr>
<td>6</td>
<td>Angle</td>
<td>$25,325.51</td>
<td>$24,089.41</td>
<td>$54,763.60</td>
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<td>7</td>
<td>Parked Vehicle</td>
<td>$37,293.60</td>
<td>$13,170.35</td>
<td>$18,641.69</td>
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<tr>
<td>8</td>
<td>Pedestrian</td>
<td>$377,243.58</td>
<td>$121,514.41</td>
<td>$211,676.84</td>
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<tr>
<td>9</td>
<td>Animal</td>
<td>$10,939.99</td>
<td>$10,611.46</td>
<td>$11,261.74</td>
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<tr>
<td>10</td>
<td>Train</td>
<td>$0.00</td>
<td>$32,798.93</td>
<td>$317,130.53</td>
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<tr>
<td>11</td>
<td>Pedalcycles</td>
<td>$102,933.50</td>
<td>$60,989.67</td>
<td>$122,811.17</td>
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<tr>
<td>12</td>
<td>Other Non-Vehicle</td>
<td>$0.00</td>
<td>$8,128.00</td>
<td>$48,926.75</td>
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<tr>
<td>13</td>
<td>Fixed Object</td>
<td>$29,504.92</td>
<td>$43,409.80</td>
<td>$25,212.25</td>
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<tr>
<td>14</td>
<td>Other Object</td>
<td>$11,351.44</td>
<td>$17,975.93</td>
<td>$25,212.25</td>
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<tr>
<td>15</td>
<td>Falling from or in vehicle</td>
<td>$0.00</td>
<td>$0.00</td>
<td>$0.00</td>
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<tr>
<td>16</td>
<td>Overtaking</td>
<td>$81,838.65</td>
<td>$38,776.39</td>
<td>$79,972.46</td>
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<tr>
<td>17</td>
<td>Other Non-Collision</td>
<td>$16,630.86</td>
<td>$17,769.60</td>
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</tr>
<tr>
<td>18</td>
<td>Left Turn</td>
<td>$27,134.61</td>
<td>$29,144.72</td>
<td>$53,537.01</td>
</tr>
</tbody>
</table>

*Costs updated 8/1/2012*

---

### EDPO Value (Equivalent Property Damage Only)

#### Human Capital Costs

<table>
<thead>
<tr>
<th>Crash Severity</th>
<th>2011</th>
<th>Number of Crashes</th>
<th>EDPO Value</th>
<th>EDPO Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatal K</td>
<td>$1,581,912</td>
<td>941</td>
<td>194.63</td>
<td>194.63</td>
</tr>
<tr>
<td>Disabling Injury A</td>
<td>$141,478</td>
<td>7,635</td>
<td>17.41</td>
<td>17.41</td>
</tr>
<tr>
<td>Evident Injury B</td>
<td>$93,213</td>
<td>31,181</td>
<td>6.55</td>
<td>6.55</td>
</tr>
<tr>
<td>Possible Injury C</td>
<td>$36,988</td>
<td>33,427</td>
<td>4.44</td>
<td>4.44</td>
</tr>
<tr>
<td>PDO O</td>
<td>$8,128</td>
<td>218,746</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

#### Comprehensive Societal Costs

<table>
<thead>
<tr>
<th>Crash Severity</th>
<th>2011</th>
<th>Number of Crashes</th>
<th>EDPO Value</th>
<th>EDPO Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatal K</td>
<td>$5,284,734</td>
<td>941</td>
<td>558.17</td>
<td>558.17</td>
</tr>
<tr>
<td>Disabling Injury A</td>
<td>$287,842</td>
<td>7,635</td>
<td>29.74</td>
<td>29.74</td>
</tr>
<tr>
<td>Evident Injury B</td>
<td>$102,927</td>
<td>31,181</td>
<td>10.87</td>
<td>10.87</td>
</tr>
<tr>
<td>Possible Injury C</td>
<td>$58,178</td>
<td>33,427</td>
<td>6.14</td>
<td>6.14</td>
</tr>
<tr>
<td>PDO O</td>
<td>$9,468</td>
<td>218,746</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Equivalent Property Damage Only (EPDO) Average Crash Frequency – Each crash is weighted based on the crash severity and the equivalent property damage only crash cost.
EDPO Rate
(Equivalent Property Damage Only)

\[
EDPO\ Rate = \frac{(F_C \times k_F) + (I_C \times k_I) + (P_C \times k_P) \times 1,000,000}{Y_S \times 365 \times T_E \times S_L}
\]

- \( F_C \) = Number of fatal crashes for the study years
- \( I_C \) = Number of injury crashes for the study years
- \( P_C \) = Number of property damage only crashes for the study years
- \( k_F \) = Fatal Crash EPDO Factor
- \( k_I \) = Injury Crash EPDO Factor
- \( k_P \) = PDO Crash EPDO Factor (Always 1.0)
- \( Y_S \) = Number of years in study
- \( T_E \) = Average Daily Traffic in section (averaged over the number of years in study)
- \( S_L \) = Segment length in miles
  (For intersections or short segments, length = 1.0 miles)

Crash Rate = crash rate per million vehicle-miles

<table>
<thead>
<tr>
<th>Severity</th>
<th>EPDO Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatal Crash</td>
<td>194.63</td>
</tr>
<tr>
<td>Injury Crash</td>
<td>9.47</td>
</tr>
<tr>
<td>PDO Crash</td>
<td>1.00</td>
</tr>
</tbody>
</table>

*Costs updated 8/1/2012

Up Next:

VII. Safety Study Process Step 3:
Perform Relevant Traffic Studies
VII. Perform Relevant Traffic Studies

Ohio Department of Transportation

John R. Kasich, Governor
Jerry Wray, Director

Traffic Academy – Safety Studies
ODOT – Division of Planning – Program Management

ODOT Safety Study Process

Step 1: Collect Data and Diagnose Crash Patterns

Step 2: Identify Potential for Site Safety Improvements & Possible Countermeasures

Step 3: Perform Relevant Traffic Studies

Step 4: Evaluate Countermeasures

Step 5: Develop Plan and Finalize Report
Procedure

- **Determine Appropriate Supplemental Studies**

- **Work with ODOT District Safety Review Team (DSRT) or local highway agency**

Supplemental Studies

- Select supplemental studies and analyses such as volume, signal warrant, capacity analysis, and sight distance based on:
  - **Crash Patterns**
    - Data Summaries
    - Collision Diagrams
  - **Existing Conditions**
    - Existing Conditions Diagram
  - **Locations with the greatest potential for safety improvement**

See Appendix A for a list of possible studies
Determining Appropriate Supplemental Studies

**Important!**
Once relevant supplemental studies are identified, take recommendations to ODOT DSRT or Project Manager for approval before commencing studies.

**KNOW YOUR STUDY AREA!!!**

Supplemental Studies

**Resources available to help perform studies:**
- ITE Traffic Engineering Handbook
- ITE Manual of Traffic Engineering Studies
- Ohio Manual of Uniform Traffic Control Devices (OMUTCD)
- FHWA Highway Safety Engineering Studies, Procedural Guide
- AASHTO Highway Safety Manual (HSM)
Supplemental Studies
Present information in creative ways

Supplemental Studies
Present information in creative ways
Up Next:

VIII. Safety Study Process Step 4: Identify & Evaluate Countermeasures
VIII. Identify and Evaluate Countermeasures
Safety Studies

Procedure

- Modify crash prediction based on Traffic Engineering study results by adjusting Part C CMFs or by adding Part D CMFs

- Use HSM or ECAT to complete calculations

Goal

- Lower the expected number of crashes so it approaches or goes below the predicted crash frequency.

- The amount that crashes can be reduced will be based on the benefit-cost analysis

**Always begin with low cost, short term improvements**
(Examples: Signing, Signal timings, Pavement Friction, vegetation removal)
A positive difference between expected and predicted crashes = potential for safety/site improvement

- Site is expected to have more crashes per year on average than its peers → Potential for improvement!
- Site is expected to have fewer crashes per year on average than its peers

Difference = Expected Excess Crashes (Potential for Safety Improvement)

Expected average crash frequency for the site

Predicted Average Crash Frequency for the site (how are its peers performing on average?)

Expected average crash frequency for the site

A clarification on CMFs in the Highway Safety Manual

Part C CMFs are not the same as Part D CMFs.

- Part C CMFs were developed in conjunction with the statistical models (SPFs) for base conditions and are used to adjust base conditions to site conditions.
- Part D CMFs estimate the effectiveness (expected change in crashes) as a result of implementing countermeasures.
- Part D CMFs include part C CMFs but Part C CMFs do not include Part D CMFs.
- CMFs in Part D should not be used with Part C unless they were originally from Part C
Remember it this way:

- Part C CMFs are used to predict the number of crashes for a site (Existing or Proposed).
- Part D Countermeasures are only applied to PROPOSED conditions.
- Part C countermeasures should be used if available over a Part D countermeasure to estimate the proposed conditions.

Economic Crash Analysis Tool Demonstration
Up Next:

IX. Freeway Safety Studies Overview
IX. Freeway Safety Studies Overview

Interchange and Corridor Planning and Design Issues

- Configuration (service and system)
- Design geometry (e.g., design speed of ramps)
- Interchange spacing
- Weaving vs. CD roads vs. ramp braids
- Design Level of Service (number of lanes and amount of traffic for which design should accommodate)
- Design exceptions
HSM Chapter on Freeways and Interchanges

- NCHRP Project 17-45 – ‘ISATe’ – *Interchange Safety Analysis Tool Enhanced*
  - Texas Transportation Institute (Jim Bonneson, PI)
  - CH2M HILL subcontractor (Tim Neuman)
- Research completed in later 2011 and approved in September 2012 (in publication)
- Specifically funded to support HSM development
- Reviews under way for incorporation into HSM by AASHTO CMTEs; TRB Highway Safety Performance CMTE recommended adoption into the HSM

Potential HSM Freeway Applications

- Predict crashes before and after reconstruction of a corridor
- Evaluate affect of adding new interchange
- Predict interchange configuration alternatives
- Evaluate and refine geometry
Crash Prediction for Freeway Segments and Interchanges

- Statistical modeling process similar to other chapters was used
  - SPF, CMF, C
  - Data from California, Maine and Washington state
- ‘Google earth’ used to obtain horizontal and cross sectional data on hundreds of miles of freeways and interchanges

Freeway Crash Prediction Components

- **Freeway Segments**
- **Ramps**
- **Ramp Terminal Intersections with Crossroad**

[Diagram of a highway layout with intersections, freeways, and ramps]
### Freeway Segments

#### Geometric Data
- Basic Roadway Data – Length, number of lanes, area type
- Alignment – horizontal curve
- Cross Section – lane width, inside/outside shoulder widths, rumble strips, median barrier
- Roadside data – clear zone, roadside barrier
- Ramp Access – presence, side, length of speed-change area

#### Traffic Data
- AADT - Segment, entrance ramp, exit ramp
- Proportion of AADT during high-volume hours

### Ramp Segments

#### Geometric Data
- Basic Roadway Data – Length, number of lanes, Average Speed on Freeway, type of traffic control at ramp terminal, area type
- Alignment – horizontal curve
- Cross Section – lane width, left/right shoulder widths, lane add/drop in segment
- Roadside data – barrier
- Ramp Access – length of speed-change area, length of weaving section

#### Traffic Data
- AADT - segment
Ramp Terminal Intersections

- **Geometric Data**
  - Basic Intersection Data – area type, terminal configuration, presence of non-ramp public street
  - Alignment – skew, distance to nearest public street intersection on outside crossroad leg, distance to adjacent ramp terminal
  - Traffic Control – presence of protected left/right turn control on crossroad
  - Cross Section – crossroad median width, number of lanes crossroad and ramp, right-turn channelization on crossroad, left-turn and right-turn lanes/bays on crossroad
  - Access data – number of drives, public street approaches
  - Ramp Access – presence, side, length of speed-change area

- **Traffic Data**
  - AADT – ramp, crossroad

HSM Freeway Analysis

- **Segmentation**
  - Divide facility (freeway/ramps) into homogenous segments and intersections (ramp terminal)
  - Most time-intensive part of analysis
  - Most important part of analysis
  - The more homogenous a section, the more accurate your results!

- **Both Directions of Freeway Analyzed**
  - May require averaging of values - see comments/notes in tools
  - Situations with significantly different cross section or differing number of lanes by direction requires special analysis approach – ASK ODOT !!!
Limitations

- **Site types not addressed**
  - Facilities with HOV lanes
  - Freeways with managed lanes separated by a buffer
  - Ramp metering
  - Frontage roads
  - Speed change lanes at crossroads

- **Geometric elements not addressed**
  - Vertical geometry
  - > 10-lane freeway segments
  - > 2-lane ramp segments
  - Differing barrier types (i.e. cable barrier vs. jersey barrier)

Special Conditions

- **Freeways with Barrier Separated Managed Lanes**
  - Managed Lanes (Express, HOT, HOV) are considered part of median
  - Analysis is performed for General Purpose lanes with managed lane entry/exit points treated as entrance or exit ramps

- **Toll Facilities**
  - Can be analyzed provided the section is sufficiently distance from toll facility so that the facility does not influence vehicle operations
  - Areas in immediate vicinity of a toll plaza, where widened to accommodate vehicles through a toll plaza, or areas that experience toll-related traffic queues or speed changes cannot be analyzed via HSM
Calibration

- Model derived from multiple state databases
- Reporting thresholds vary state-by-state
- Uses of a calibrated vs. uncalibrated model
  - Calibrated - preferred
    - ODOT has calibration factors for use in Ohio analysis for many conditions – included in ECAT
  - Uncalibrated - still a good analysis tool
    - Compare multiple alternatives against one another
    - K/A reporting is fairly consistent state-by-state
    - Compare predicted crash pattern against observed crash pattern
    - Meaningful for work outside Ohio or where calibration factors don’t exist (for conditions not covered by HSM models there will be no calibration factors - ASK ODOT !!!)

Predictive Methods for Freeway Segments (HSM Ch. 18)

- Safety Performance Functions
  - Rural vs. Urban
  - Number of Lanes
  - Single Vehicle
  - Multiple Vehicle
  - Fatal and Injury
  - Property Damage Only

Table 38-1, Freeway Segment SPF:

<table>
<thead>
<tr>
<th>Site Type (x)</th>
<th>Cross Section (c)</th>
<th>Crash Type (y)</th>
<th>Crash Severity (z)</th>
<th>SPF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Four-lane (4)</td>
<td>Multiple vehicle (mv)</td>
<td>Fatal and injury (k)</td>
<td>Property damage only (p)</td>
<td>N_{k,4,m,p}</td>
</tr>
<tr>
<td>Single vehicle (s)</td>
<td></td>
<td></td>
<td></td>
<td>N_{s,4,m,p}</td>
</tr>
<tr>
<td>Six-lane (6)</td>
<td>Multiple vehicle (mv)</td>
<td>Fatal and injury (k)</td>
<td>Property damage only (p)</td>
<td>N_{k,6,m,p}</td>
</tr>
<tr>
<td>Single vehicle (s)</td>
<td></td>
<td></td>
<td></td>
<td>N_{s,6,m,p}</td>
</tr>
<tr>
<td>Eight-lane (8)</td>
<td>Multiple vehicle (mv)</td>
<td>Fatal and injury (k)</td>
<td>Property damage only (p)</td>
<td>N_{k,8,m,p}</td>
</tr>
<tr>
<td>Single vehicle (s)</td>
<td></td>
<td></td>
<td></td>
<td>N_{s,8,m,p}</td>
</tr>
<tr>
<td>Ten-lane (10)</td>
<td>Multiple vehicle (mv)</td>
<td>Fatal and injury (k)</td>
<td>Property damage only (p)</td>
<td>N_{k,10,m,p}</td>
</tr>
<tr>
<td>Single vehicle (s)</td>
<td></td>
<td></td>
<td></td>
<td>N_{s,10,m,p}</td>
</tr>
</tbody>
</table>
Freeway Segments

Safety Performance Functions
- Rural vs. Urban
- Number of Lanes
- Cross Roadway Cross Section

\[ N_{fs(mvi)} = L_{fs} \times \exp (a + b \times \ln [c \times AADT_{fs}]) \]

Freeway Segment CMFs

Crash Modification Factors
- Developed to work with SPFs
- Most are functions of geometric variables
- May affect single vehicle vs. multiple vehicles

- Horizontal Curve
- Lane Width
- Inside Shoulder Width
- Median Width
- Median Barrier
- High Volume
- Lane Change
- Outside Shoulder Width
- Shoulder Rumble Strip
- Outside Clearance
- Outside Barrier
- Ramp Entrance Ramp Exit
Freeway Segment CMFs

**Median Barrier**
- Data requirements include:
  - length and offset to median and roadside barrier
  - width of continuous median barrier
- Requires consideration of preliminary barrier layout at earlier point in project development

Freeway Segment CMFs

**High Volume**

**Volume Variation During Average Day**
- Proportion of AADT during hours where volume exceeds 1,000 veh/h/ln
  - Hourly volumes continuously high
  - A few high peak hours
- Use nearest traffic count station (ATR) data
Ramp spacing and taper lengths

- Ramp spacing impacts lane change CMF
- Useful metric during design phase: how does this CMF change as ramps are spaced closer and closer to one another?
- What happens if a ramp is removed entirely?

Type B Weaving

- Presence of Type B weave adds a “bonus” CMF to analysis
- Other types of weaving accounted for by generic lane change CMF
- How does this CMF affect predicted number of crashes as the Type B weave gets shorter?
Ramp spacing and taper lengths

- **Ramp in segment**
  - Define type (lane add or speed change lane)
  - Define length of entrance/exit between taper point and 2' separation
  - Define side (left or right)

- **Ramp outside of segment**
  - Entrance: Define distance from begin milepost of the current segment to ramp gore (2' separation point) of previous upstream entrance ramp
  - Exit: Define distance from end milepost of the current segment to ramp gore (2' separation point) of next downstream exit ramp

Predictive Methods for Ramps or C-D Roads (HSM Ch. 19)

- **Ramp Analysis:**
  - Entrance Ramp Segment (one or two lanes)
  - Exit Ramp Segment (one or two lanes)
  - Crossroad Ramp Terminal Intersection

- **Ramp:** Roadway between the freeway speed change lane and either the cross road ramp terminal or crossroad speed-change lane.

- **C-D Road:** is the roadway between the freeway ramp exit speed-change lane and the freeway ramp entrance speed-change lane

- HSM methods cannot evaluate frontage roads unless they can be considered a roadway type covered in Chapters 10, 22, 12!
Freeway Ramp Segments

- **Segment-based evaluation**
  - Works for all ramp configurations up to 2 lanes
  - Similar to freeway segment analysis
  - Can also analyze C-D roads

Safety Performance Functions

- Defined by whether ramp segment is Exit, Entrance, C-D
- Area Type
- Number of Lanes

\[ N_{r/mvfi} = L_{r} \times \exp \left( a + b \times \ln\left[c \times AADT_{r}\right] + \left[d \times AADT_{r}\right] \right) \]
Freeway Ramp Segments

Crash Modification Factors
- Ramp or C-D Road
  - Horizontal Curve
  - Lane Width
  - Shoulder width
    - Right
    - Left
  - Barrier
    - Right
    - Left
- Lane add or drop
- Ramp speed change Lane
- C-D Road
- Weaving section

Ramp Segments - Mileposting
- Used to model the speed of a vehicle along the ramp
- Establishes ramp horizontal curve CMF
- Milepost = distance along ramp to start of curve
- Establish one milepost 0.0 for all segments on ramp
- Establish one milepost 0.0 for all ramps with a common entrance or exit location
Ramp Segments - Mileposting Special Case

- Some ramps have two possible milepost 0.0 locations
- Goal is to estimate average curve entry speed on these segments

Ramp Terminal Analysis

- Most rigid part of ISATe analysis
- Method addresses seven configurations
Ramp Terminal Analysis

- Safety Performance Functions
- Characteristics
  - Traffic Control
  - Cross Section
  - Area Type
  - AADT Volume

Ramp Terminal Analysis

- Crash Modification Factors
  - Exit Ramp Capacity
  - Cross Road Turn Lane
    - Right turn
    - Left turn
  - Access point frequency
  - Segment length
  - Median width
  - Stop
    - Skew angle
  - Signal
    - Protected-only left-turn phase
    - Channelized right-turn phase
      - Crossroad
      - Exit ramp
    - Non-ramp leg
The ISATe Model and Tool

Excel Spreadsheet

- **Input**
  - Individual site
  - Freeway segment
  - Ramp or CD road segment
  - Crossroad ramp terminal
  - Freeway facility
  - **Segmentation is key!**

- **Output**
  - Crashes for entire facility
  - Crashes by component
  - Distribution of crashes

ECAT Input Freeway Segments Tab
ECAT Input Ramp Terminals Tab

### Estimated Crash Statistics

<table>
<thead>
<tr>
<th>Crashes for Entire Facility</th>
<th>Total</th>
<th>K</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>PDO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated number of crashes during Study Period, crashes</td>
<td>776.0</td>
<td>31</td>
<td>84</td>
<td>53.9</td>
<td>152.6</td>
<td>558.0</td>
</tr>
<tr>
<td>Estimated average crash freq., during Study Period, crashes/yr</td>
<td>155.2</td>
<td>0.6</td>
<td>1.7</td>
<td>10.8</td>
<td>30.5</td>
<td>111.6</td>
</tr>
</tbody>
</table>

- Multiple-vehicle (head-on, right-angle, side-swipe, other)
- Single-vehicle (fixed-object, animal, parked vehicle)

### Distribution of Crashes for Entire Facility

<table>
<thead>
<tr>
<th>Crash Type</th>
<th>Number of Expected Crashes During the Study Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>K</td>
</tr>
<tr>
<td>Multiple-vehicle</td>
<td>Head-on crashes</td>
</tr>
<tr>
<td></td>
<td>Right-angle crashes</td>
</tr>
<tr>
<td></td>
<td>Rear-end crashes</td>
</tr>
<tr>
<td></td>
<td>Side-swipe crashes</td>
</tr>
<tr>
<td></td>
<td>Other multiple-vehicle crashes</td>
</tr>
<tr>
<td></td>
<td>Total multiple-vehicle crashes</td>
</tr>
<tr>
<td>Single-vehicle</td>
<td>Crashes with animal</td>
</tr>
<tr>
<td></td>
<td>Crashes with fixed object</td>
</tr>
<tr>
<td></td>
<td>Crashes with other object</td>
</tr>
<tr>
<td></td>
<td>Crashes with parked vehicle</td>
</tr>
<tr>
<td></td>
<td>Other single-vehicle crashes</td>
</tr>
<tr>
<td></td>
<td>Total single-vehicle crashes</td>
</tr>
<tr>
<td>Total crashes</td>
<td>129.1</td>
</tr>
</tbody>
</table>
Reviewing Results

Crashes by Facility Component

<table>
<thead>
<tr>
<th>Crashes by Facility Component</th>
<th>Nbr. Sites</th>
<th>Total</th>
<th>K</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>PDO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freeway segments, crashes</td>
<td>4</td>
<td>33.4</td>
<td>0.2</td>
<td>0.0</td>
<td>3.9</td>
<td>7.0</td>
<td>21.0</td>
</tr>
<tr>
<td>Ramp segments, crashes</td>
<td>8</td>
<td>4.9</td>
<td>0.0</td>
<td>0.1</td>
<td>0.7</td>
<td>1.1</td>
<td>2.0</td>
</tr>
<tr>
<td>Crossroad ramp terminals, crashes</td>
<td>8</td>
<td>0.1</td>
<td>1.2</td>
<td>8.0</td>
<td>34.9</td>
<td>46.0</td>
<td></td>
</tr>
</tbody>
</table>

Freeway Safety Studies

- Each Safety Study will be individually discussed and requirements identified

- Predicted analysis comparison of the alternatives will be required

- Summary Report prepared
Up Next:

X. Safety Study Process Step 5: Develop Plan and Finalize Report
X. Develop Plan and Finalize Report

ODOT Safety Study Process

- Step 1: Collect Data and Diagnose Crash Patterns
- Step 2: Identify Potential for Site Safety Improvements & Possible Countermeasures
- Step 3: Perform Relevant Traffic Studies
- Step 4: Evaluate Countermeasures
- Step 5: Develop Plan and Finalize Report
Recommend a Plan

- Recommendations should be based upon the potential for safety improvement.
- Recommendations should consider engineering, enforcement, driver education and/or other factors.
- Recommendations should be based on knowledge of the effectiveness of the proposed improvement in the context of the traffic and site conditions.

Recommendations

- A combination of improvements may be the best plan for addressing a location.
- All practical improvements, including doing nothing should be identified, considered, and analyzed for safety so that no feasible alternative is overlooked.
Safety Studies

Report Formats

- Full Study
- Abbreviated Study

Report Formats - Full Study

- Title Page
- One Page Project Summary
- Executive Summary
  - Purpose
  - Background
  - Overview of Possible Causes
  - Recommended Countermeasures & Related Costs
- Purpose and Need
  - Develop draft Purpose & Need statement for project
  - Include background information and past crash performance
- Existing Conditions
- Crash Data
  - Collision Diagram(s)
  - Crash summary
  - Crash analysis graphs or tables
- Crash Analyses
Report Formats – Full Study (Cont'd)

- Other Transportation Analyses & Results
  - Summation of relevant traffic studies/analyses

- Proposed Countermeasure Evaluation
  - Countermeasure Descriptions and potential for safety improvement
  - Countermeasure Cost Analysis
  - Benefit-Cost Analysis Results

- Conclusions

- Recommendations & Prioritization

- Appendices (If Completed or Authorized)
  - Traffic Counts
  - Crash data report print outs (Only if Requested)
  - Other Traffic Studies Data & Analyses (if applicable)
  - Cost Estimates
  - HSM Calculation Results
  - Benefit Cost Results
  - Photos (Only if Requested)

Title Page

- District
- County
- Route
- Section
- Safety Analyst number
- Safety Annual Work Program (SAWP) year
- Study Completion Date
- Consultant
- Location Map
One Page Project Summary

- Basic project information and map
- Major crash patterns
- Recommended solutions
  - Directly reflects what is being requested for safety funding
One Page Project Summary Example

Summary Information Examples

Proposed Conditions Diagram
BUT-4 & Halden/Gilmour
City of Fairfield
ODOT District 8
August 2011

One Page Project Summary Example

SAFETY APPLICATION SUMMARY
HAM-71-14.13 (2012-0D09-03)
IR-71 & SR-102
Hamilton County
October 2012

Description
- Signalize the left turn from the southbound IR-71 and ramp to SR-143
- Add a left turn lane from SR-143 to IR-71

Notes
- Incomplete schedule:
  -岱\d\d\d
  -岱\d\d\d\d
  -岱\d\d\d\d
  -岱\d\d\d\d

Schedule
- Construction Project:
  -岱\d\d\d\d
  -岱\d\d\d\d
  -岱\d\d\d\d
  -岱\d\d\d\d

Funding
-岱\d\d\d\d
  -岱\d\d\d\d
  -岱\d\d\d\d
  -岱\d\d\d\d

Traffic Academy
Executive Summary

- **Background**
  - History of problems or crashes
  - Include previous improvements to mitigate crashes
  - Reason for study
- **Purpose**
  - Safety Analyst Priority List & Ranking
  - Analyze crashes
  - Potential for Safety Improvement
- **Overview of Possible Causes**
  - Crash patterns
  - Roadway conditions
  - Existing traffic control
  - Traffic volumes
- **Recommended Countermeasures & Related Costs**
  - Short term countermeasures
  - Medium term countermeasures
  - Long term countermeasures
  - (All that are Applicable)
  - (Identify which is being requested for funding)

Purpose and Need

- **This part of the report is used to identify location studied and give reasons for conducting study.**

- Roadway and crash data is analyzed to develop countermeasures to mitigate crashes specific to a given location.

The Purpose & Need should include:

- Safety Analyst Ranking
- Crash Analysis
- Potential for Safety Improvement
Existing Conditions

Background
- Location
  - County, city, or township
  - Facility designation
  - Log points
- Facility
  - Classification (rural principal arterial, urban minor collector, etc.)
  - Number of lanes and Direction
- Traffic control
- History of problems or crashes
  - Include previous improvements to mitigate crashes
- Reason for study

Condition Diagrams
- Road geometrics
- Traffic control
- Traffic volumes
- Other pertinent existing conditions data

Possible items to highlight:
- Traffic counts (new & existing)
- Truck volumes
- Signing & striping
- Access locations & type
- Intersection locations & traffic control
- Signal coordination
- Speed limit
- Horizontal & vertical curves
- Sight distance
- Clear zone conditions
- Parking
- Adjacent building locations/land use
- Functional Classification
- Lane & shoulder widths
- Roadway lighting
- Visual pavement inspection
- Railroad crossings & protection type
- School or major pedestrian crosswalk location
- Bicycle routes
- Bridge locations
- Roadway classification
- Changes in condition, i.e. land use
- Any other relevant condition data
Existing Conditions

Physical condition write-up

Example 3 (Page 9 of Safety Study Guidelines, January 2002)

The intersection under study is located approximately a third of a mile west of the City of Delaware corporation limits, as shown in Figure --. It is unsignalized with stop signs on the approaches of South Section Line Road. Signs on South Section Line Road also indicates that US 36 cross traffic does not stop (see pictures included in Appendix X). US 36 runs mostly east-west, with a skew to southwest-northeast. South Section Line Road runs north-south and intersects other major traffic carriers; primarily Airport Road, US 42, and US 37. Average daily traffic on US 36 and South Section Line Road is 8610 and 4575 vehicles, respectively. The posted speed limit is 45 mph on south Section Line Road and 55 mph on US 36. There is no street lighting at the intersection. There are no exclusive turn lanes on any of the approaches. There is a slight crest on the east approach of US 36 and a stand of trees on the southwest corner of the intersection.

Crash Data

Collision Diagram(s)
Crash summary
Crash analysis graphs or tables
Crash Analysis

Present characteristics such as:
- Type of crash
- Severity
- Contributing factors
- Environmental conditions
- Time period

Note: The detailed analysis of these characteristics are conducted to identify potential for safety improvements and countermeasures.

Present possible countermeasures in crash analysis discussion.
- Index of Countermeasure Strategies checklist
- Index of Strategies
- FHWA Table 70
- NCHRP Report 500
- HSM
- CMF Clearinghouse

Other Transportation Analyses & Results

Provide brief overview of methodology
- When was data collected?
  - Defined procedure in TEM, OMUTCD, etc.?
- Where was data collected?
- How was data analyzed?

Provide summary of results of analyses
Provide correlation of results to crash patterns and countermeasures
Proposed Countermeasures Evaluation

- Discuss all evaluated countermeasures & identify proposed countermeasures
- Present Cost Estimates
  - Determined for all recommended countermeasures
  - Check R/W plans to see if countermeasure will fit in existing R/W
  - Assessment of existing R/W may be necessary to ensure good recommendations and cost estimates
- Present Benefit Cost analysis results

Conclusions

- Present
  - Why the crashes were occurring?
  - Deficiencies related to the crashes
  - All countermeasures evaluated
  - Were they dismissed?
    - Why?
Recommendations & Prioritization

Present Recommendations
- Present identified areas for potential safety improvement at the location
- Discuss effectiveness of recommended countermeasures and associated analysis/justification for the countermeasures
- Discuss traffic & site conditions
- Discuss priority of improvements
  - Short-Term Countermeasures (Under 1 Year)
  - Medium-Term Countermeasures (1-5 Years)
  - Long-Term Countermeasures (Over 5 Years)

Proposed Conditions Diagrams

Project may include minor upgrades to the two adjacent traffic signals to update software and/or controllers & detectors to provide improved signal system operations and traffic flow on corridor. Specific needs will be determined in Preliminary Engineering stage of the project.
Appendices

- Traffic Counts
- Crash data report print outs (Only if Requested)
- Other Traffic Studies Data & Analyses (if applicable)
  - Queue length study data
  - Traffic lane occupancy data
  - Signal warrant analyses sheets
  - Other relevant study data
- Cost Estimates
- HSM Calculation Results
- Benefit Cost Results
- Photos (Only if Requested)

Report Format-Abbreviated Study*

- Title Page
- Overview
  - Existing Conditions
  - Crash Data
  - Comments & Possible Causes
- Implementation Plans
  - Countermeasures Completed (In place)
  - Short-Term Countermeasures (Under 1 Year)
  - Medium-Term Countermeasures (1-5 Years)
  - Long-Term Countermeasures (Over 5 Years)
- Appendices
  - Traffic Counts
  - Crash data printouts
  - Other Traffic Studies Data & Analyses (if applicable)
Title Page

- District
- County
- Route
- Section
- Safety Analyst Priority List and Rank
- Safety Annual Work Program (SAWP) year
- Study Completion Date
- Consultant
- Location Map

Overview

- Existing Conditions
  - Condition Diagrams
- Crash Data
  - Discussion
  - Tables & charts
- Other traffic analyses
  - Discussion
- Comments & Probable Causes
Implementation Plans

- Countermeasures completed (in place)
- Use Index of Countermeasures to determine:
  - Short-Term Countermeasures (Under 1 year)
  - Medium-Term Countermeasures (1 to 5 years)
  - Long-Term Countermeasures (Over 5 years)

Appendices

- Traffic counts
- Crash data printouts
- Other traffic studies data & analyses results (if applicable)
Up Next:

XI. Interpretation and Documentation of Safety Analysis
XI. Interpretation and Documentation of Safety Analysis

Traffic Academy – Safety Studies
ODOT – Division of Planning ~ Program Management

Learning Objectives

- Gain perspective on the issue of safety, risk and trade-offs
- Stakeholder understanding of the two dimensions of safety
- Communicating safety in report writing and stakeholder discussions
- Legal protections for use of safety data
- Risk management, tort liability and professionals’ responsibilities
Trading off safety sounds “risky”

Won’t we get sued if we use the HSM and select the ‘wrong’ approach?

“Safety always comes first in everything we do. We can’t trade off or compromise safety or we would get sued!”
The two dimensions of 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

*Ezra Hauer, ITE Traffic Safety Toolbox, 1999

Nominal Safety*

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

The three aspects of nominal safety:
- Roadway design must enable road users to behave legally
- Roadway design should enable the vast majority of users to operate without difficulties
- Owning agency requires protection against claims of moral, professional, and legal liability

*Ezra Hauer, ITE Traffic Safety Toolbox, 1999
The AASHTO Policy and L&D Manual are NOT ‘Safety Manuals’

- Traffic Operations
- Costs and cost effectiveness
- Maintainability
- Constructability
- Safety

Nominal and Substantive Safety are Not the Same Thing

<table>
<thead>
<tr>
<th>Nominal Safety</th>
<th>Substantive safety</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ Standards and models not related to safety performance</td>
<td>✓ Varies by context</td>
</tr>
<tr>
<td>✓ Standards and criteria common across highway types and contexts</td>
<td>✓ Directly related to traffic volume</td>
</tr>
<tr>
<td>✓ Standards and models exclude traffic volume</td>
<td>✓ Varies incrementally with incremental changes in conditions</td>
</tr>
</tbody>
</table>
The two dimensions of safety produce different outlooks

We routinely ‘trade-off’ substantive safety in many decisions we make
Successful stakeholder communications

- Understand and communicate the relationship between a design element or function and substantive safety (crashes)
- Never refer to something as ‘safe’ or ‘unsafe’ (absolute terms)
- Communicate reasons or basis for a nominal safety value

Successful Stakeholder Communications

- Avoid use of judgmental and subjective terms
  - ‘poor’ or ‘unacceptable’ (to whom?)
  - ‘hazardous’ or ‘dangerous’
  - ‘high accident site’
- Stick to reporting facts and figures when discussing crash data
  - Referencing benchmarks for comparison is fine
  - Reporting facts such as crashes, predicted crashes, etc is appropriate
- Focus attention on the trade-offs; always have a range of alternatives with varying performance
Keep the conversation and discussion as objective as possible – use performance based terms

The HSM does not

- establish a legal standard of care
- create a public duty
- set requirements or mandates
- establish design/operation best practices
- contain warrants or standards
- supersede other publications
Legal Context of Safety Data

Protected under Federal Law 23 USC 409

Data and reports can not be used against ODOT in tort suits

The Highway Safety Manual

• Informs decisions on expected effects of actions on crashes
• Does NOT produce mandates or warrants
• Does NOT make decisions for you
Best Practices for Risk Management in Safety Analysis

- Include appropriate disclaimers and notices regarding legal protection of data in reports that cite crash data
- Edit reports for unnecessary subjective language – stick to the facts
- Fully document all safety trade-off decisions (e.g., design exceptions)

Tort claim risks from design decisions – an overview

- Torts and negligence
- Functions of government – discretionary and mandatory actions
Torts and Negligence

- A **tort** is defined as a civil wrong or injury.
- A tort action seeks repayment for damages to property and injuries to individuals. Most lawsuits arising out of highway crashes allege “negligence” on the part of one or more parties.
- **Negligence** involves a failure to do what an ordinary, reasonably prudent person would do under similar circumstances; a failure to use reasonable care in dealing with others.
- A finding of negligence in their actions (or lack of action) results in a potential liability for a tort claim and compensation for the plaintiff.

Necessary Elements of a Successful Tort Claim

- Did damages occur?
- Did a potentially dangerous defect exist?
- Was the defect a proximate cause of the damages?
- Did the party being sued have knowledge of the defect?
- Was the party being sued acting in a discretionary or ministerial/mandatory role?
- Did the plaintiff (injured party) contribute to his/her damages through negligent behavior?
Tort Claims in Ohio – Levels of Review

- **Administrative (< $2,500)** – handled by ODOT Counsel
  - ‘Several hundred per year’
  - Typical cases – potholes, windshields, drop-offs, snowplows hitting mailboxes, etc.
  - ‘Rolling docket’ of 300 to 400 such claims
- **Claims > $2,500** handled by Attorney General (defends all state agencies)
- **Total payout in Ohio** ‘on average less than $3 million per year’

Mandatory vs. Discretionary Functions

- **Mandatory** (referred to in some states as ministerial) functions -- clearly defined tasks or responsibilities entailing little personal judgment (e.g., highway maintenance activities such as snowplowing)
- **Discretionary** functions -- involve decisions requiring judgments by professionals (e.g., where or how to place the highway; establishing the design features)

*Ohio law (like most states) holds that discretionary actions or functions of the state are largely immune from lawsuits by private individuals*
Mandatory and Discretionary Actions

- Language in OMUTCD and ODOT Manuals using ‘shall’ imposes a mandatory duty on ODOT
- Language using ‘should’ or ‘may’ means discretion is to be exercised (e.g., AASHTO Policy uses these terms)
- Discretionary decisions or actions should
  - be consistent across the state
  - involve good judgment
  - be well documented

What does this all mean?

- Establishment of policies and making judgments and decisions are discretionary functions of Ohio government agencies, and as such are largely immune from suits
- Implementation of policies in fair and even manner in a reasonable time frame becomes a mandatory duty
- Once a policy is established, Court of Claims may hold ODOT liable if it is not implemented properly
**Typical issues of concern in Ohio**

- Bridge fencing
- Railroad Grade Crossings (policy to eliminate high risk at-grade crossings)
- Shoulder edge drop-off (ODOT policy is a 3-inch or less performance standard)
- Guardrail (proper installation, timely repair)

_All of the above are ministerial duties (maintenance or carrying out of set policies)_

**Design decisions, safety and tort risk**

- Selection of one alternative over another
  - Differing costs and impacts
  - _Differing expected safety performance_
- Design features of the alternative
  - Appropriate use of design standards and criteria
  - Design errors and omissions
  - Design Exceptions or Deviations
If you haven’t been conducting quantitative safety studies, how do you know how ‘safe’ your solution is?

ODOT does not always select the ‘safest’ (substantive) solution

- Shoulders, guardrail vs R/W for clear zone
- Rumble strips vs. bicycle mobility
- Turn lanes and signals
- Alignment shifts to avoid environmental resources
- Raised medians vs. commercial access
The Highway Safety Manual does NOT tell you what to do

- Construction costs
- Right-of-way
- Protected environmental features
- Stakeholder values
- Traffic operations

Professional Responsibilities Remain

- We are held to a standard of care that includes use of the profession’s manuals and guides and our best judgment
- We must document our work so it can be defended if necessary
ODOT can still face liability for design decisions......

- A design with an apparent error (undocumented design exception) for which there is no explanation
  - No design report or record of why the design was implemented
  - Court may find ODOT failed their mandatory duty as professional engineer
- Missing design exception report
- Failure to follow an established policy in completing the design

Risk Management Best Practices

- Establish reasonable design criteria and adhere to them
- When necessary employ design exceptions
  - Use the HSM to test effect on safety
  - Mitigate potential adverse effects
- Use HSM methods to inform a decision
- Document everything
Best Practices for Risk Management for Design Exceptions

- Evaluate the ‘nominal safety’ solution for comparison
- Justify on considerations other than cost alone
- Use the HSM to test effect on safety
- Mitigate potential adverse effects (use the HSM)
- Fully document your engineering work, judgments and trade-offs

Up Next:

XII. Final Questions and Course Closing
Step 1: Collect Data and Diagnose Crash Patterns

Step 2: Identify Potential for Site Safety Improvements & Possible Countermeasures

Step 3: Perform Relevant Traffic Studies

Step 4: Evaluate Countermeasures

Step 5: Develop Plan and Finalize Report
Exams

- Exam should be completed online within 2-3 weeks of class
- Refer to handout or LTAP for more information on exam procedures/policies

Questions and Discussion
Volume Study

**Purpose**
- To determine the number and movement of vehicles and/or pedestrians

**Need**
- Based on need for traffic and/or truck volumes in the study area

**Application**
- Volumes will be used for numerous items in the study
  - Establish ADT
  - Establish peak hour volumes
  - Calculate crash rates

Procedure referenced in:
- Manual of Traffic Engineering Studies
- Highway Safety Engineering Studies Procedural Guide (Procedure 7)
Traffic Control Device Study

**Purpose**
- To review the effective application of
  - stop signs
  - traffic signals
  - yield signs
  - no-turn restrictions
  - right-turn-on-red provisions
  - speed reduction signs
  - sign visibility

**Need**
- Primarily dictated by crash data

**Use**
- To determine countermeasures for location

Procedure referenced in:
- Ohio Manual of Uniform Traffic Control Devices
- Highway Safety Engineering Studies Procedural Guide (Procedure 22)

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Signal Warrant Analysis

**Purpose**
- To indicate if signal control may be appropriate for an intersection.

**Need**
- Indicated by occurrence of crashes involving crossing or merging traffic
- Field review
- Complaints

**Use**
- To identify signal installation as possible countermeasure

Procedure referenced in:
- Ohio Manual of Uniform Traffic Control Devices (Section 4C)
- Traffic Engineering Manual (Part 4)
Safety Studies

Signal Timing/Phasing Analysis

Purpose
- Conducted to determine if the present signal operation meets the existing traffic demands.

Need
- Indicated by the presence of crash pattern that indicates inadequate signal timing such as
  - Right-angle collisions
  - Rear-ends
  - Left-turning/Head-on collisions (absence of left turn phase)

Use
- Helpful to conduct extensive field observation during the period(s) of high crash frequencies to familiarize yourself with operating conditions

Procedure Referenced in:
- Highway Capacity Manual (Chapter 10)

Spot Speed Study

Purpose
- Used to determine the speed distribution of a traffic stream at a spot location.

Application
- Median Speed
- Modal Speed
- 85th Percentile Speed
- Skewness
- Pace

Need
- Crash pattern
- Field review
- Complaints

Use
- Determining and justifying the need for countermeasures
- Posting of advisory speed indicators at curves
- Adjusting signal timing

ODOT DISTRICT MUST APPROVE METHODOLOGY

Procedure Referenced in:
- Manual of Traffic Engineering Studies (Chapter 16)
- Highway Safety Engineering Studies Procedure Guide (Procedure 8)
Crash Patterns Relating a Need for a Spot Speed Study

<table>
<thead>
<tr>
<th>Situation</th>
<th>Pattern</th>
<th>Possible Causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signalized Intersection</td>
<td>Right-angle crashes</td>
<td>Short term amber phase or high travel speed</td>
</tr>
<tr>
<td></td>
<td>Left-turn crashes</td>
<td>Short term amber phase or high travel speed</td>
</tr>
<tr>
<td></td>
<td>Rear-end crashes</td>
<td>Long amber-phase</td>
</tr>
<tr>
<td>Unsignalized Intersection</td>
<td>Right-angle crashes</td>
<td>Insufficient sight distance or high travel speed</td>
</tr>
<tr>
<td>Curve section of roadway</td>
<td>Head-on, run-off-road, or fixed object crash</td>
<td>High travel speed</td>
</tr>
<tr>
<td>Any location</td>
<td>High severity characteristics</td>
<td>High travel speed</td>
</tr>
</tbody>
</table>

Travel Time and Delay Study

**Purpose**
- to obtain data on the amount of time it takes to traverse a specified section of roadway & identify the amount, cause, location, duration and frequency of delays occurring during the trip

**Need**
- Used where crash patterns reveal the occurrence of traffic congestion
- Rear-end
- Right-angle
- Left-turn
- Field review or complaints indicate congestion

**Use**
- Identifying & defining sources of congestion for use in developing countermeasures
- Calculating delay costs used in economic analyses
- Evaluating the effectiveness of various traffic improvements

Procedure referenced in:
Highway Safety Engineering Studies Procedural Guide (Procedure 9)
Manual of Traffic Engineering Studies (Chapter 7)
Roadway & Intersection Capacity Analysis

**Purpose**
- Measure the ability (supply) of an intersection or section to accommodate or service traffic volumes (demand).

**Need**
- Triggered by the occurrence of congestion related crashes
  - Rear-end
  - Right-angle
  - Left-turning

**Use**
- Planning & justifying safety countermeasures
- Selecting a safety project
- Evaluating the successful implementation of safety projects

Procedure referenced in:
Highway Safety Engineering Studies Procedural Guide (Procedure 10)
Highway Capacity Manual

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Gap Analysis

**Purpose**
- To measure the time headway (gap) between vehicles along a highway or at an intersection & to analyze the capability of a major traffic stream to accommodate a minor traffic stream.

**Need**
- Indicated by occurrence of crashes involving crossing or merging traffic

**Use**
- Identifying operational deficiencies in a traffic stream
- Determining the safety of crossing, merging, & weaving situations
- Assessing the need for countermeasures
- Evaluating the effectiveness of a safety improvement

Procedure referenced in:
Highway Safety Engineering Studies Procedural Guide (Procedure 12)
**Traffic Lane Occupancy Study**

**Purpose**
- To provide a measure of the traffic performance of a highway facility by measuring the percent time a point on a roadway is occupied.

**Need**
- Identified by presence of congestion related crashes at a location
  - Rear-end
  - Right-angle
  - Left-turning

**Use**
- Defining the level of operation of a roadway facility
- Identifying location of bottlenecks
- Determining the effects of traffic control changes such as signal timing
- Evaluating safety improvements

Procedure referenced in:
Highway Safety Engineering Studies Procedural Guide (Procedure 13)

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**Queue Length Study**

**Purpose**
- To identify the number of vehicles that are stopped in a traffic lane behind the stop line at an intersection

**Need**
- Determined by crash information identifying congestion along an intersection approach or in an individual traffic lane

**Use**
- Describe the level of operation at a location
- Identify the location of bottlenecks
- Select appropriate countermeasures
- Evaluate safety improvements

Procedure referenced in:
Highway Safety Engineering Studies Procedural Guide (Procedure 14)
### Sight Distance Study

**Purpose**
- Measure the sight distance at intersections or along a roadway section.

**Need**
- Determined by crash pattern-varies per type of sight distance

**Use**
- To determine sight distance restrictions caused by horizontal or vertical alignment, roadside obstructions or vegetation for any of the following:
  - Passing Sight Distance
  - Stopping Sight Distance
  - Intersection Sight Distance (also called Cross-Corner Sight Distance)
- Minimum distance required to respond appropriately to approaching cross traffic.
- Normally performed at unsignalized locations

Procedure referenced in:
- ODOT Location & Design Manual

### Skid Resistance Study

**Purpose**
- To assess the frictional properties of a pavement surface

**Need**
- Based on pattern of “wet weather” or “skidding” crashes

**Use**
- To compare results to pre-established standards based on vehicle travel speeds

ODOT WILL PERFORM THIS STUDY

Procedure referenced in:
**Highway Lighting Study**

**Purpose**
- Used to determine the adequacy of existing lighting systems and the need for new, additional or improved systems.

**Need**
- Determined on observed pattern of nighttime crashes
- Determined on input from local users
- Determined by warrants for safety lighting (lighting installed to resolve a night crash problem) contained in Traffic Engineering Manual

**Use**
- To determine if a safety deficiency exists due to insufficient or inadequate lighting

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**Horizontal Curve Study (Ball Bank)**

**Purpose**
- To determine the safe speed around a curve as indicated by trial speed runs with a ball bank indicator
- Examine existing warning signs and advisory speed signs to determine if corrective action is needed
- Examine physical characteristics of curve to see if corrective action is needed

**Need**
- Crash pattern indicative of unsafe speed
  - Run-off road
  - Head-on collision

**Use**
- To determine countermeasures

ODOT DISTRICT WILL PERFORM THIS STUDY
Turning Path Analysis

**Purpose**
- To evaluate the ability of the vehicle types to perform turning maneuvers

**Need**
- Determined by crash patterns such as:
  - Object struck
  - Rear-end
- Determined by field observations of slow maneuvering or tire marks on sidewalks or barriers
- Determined by complaints

**Use**
- To determine appropriate countermeasures such as:
  - Increasing turning radii

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Parking Study

**Purpose**
- Conducted to document current parking practices or determine the need to establish a parking control zone.

**Application**
- Conduct to observe parking practices which may cause:
  - Lane blockages
  - Sight distance restrictions
  - Encroachment into traveled lane
  - Ignorance of existing parking restrictions
- Conduct during time when problems have been documented to occur

**Use**
- Used to make recommendations on parking

---

Procedure referenced from:
- Traffic Engineering Handbook (Chapter 3)
Bicycle or Pedestrian Study

**Purpose**
- To study safety situations involving the bicycle or pedestrian modes

**Need**
- Determined from a crash patterns such as:
  - Bicycle/vehicle
  - Pedestrian/vehicle

**Use**
- To develop safety related countermeasures based on:
  - Crash characteristics
  - Field conditions
  - Vehicular & pedestrian or bicycle volume counts and conflict data
  - Effectiveness of existing traffic control devices


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Various Studies

**Time Lapse Video Study**
- Method of conducting engineering studies which utilizes video recording with a time lapse feature of a frame recorded every one to six seconds.
- Movements in time lapse video are exaggerated, making unusual maneuvers more noticeable.

**Video Study**
- Method of conducting engineering studies which utilizes real-time video recording. ODOT, Office of Traffic Engineering performs time lapse video for ODOT and local jurisdictions upon request in VHS format.

**Maintenance Records Study**
- Review of maintenance history for the location for the period of interest.
- Request maintenance records for the time period during which the problem occurred from the maintaining group.

Appendix B:
Reference Materials

Traffic Academy – Safety Studies
ODOT ~ Division of Planning ~ Program Management

Highway Safety Manual (HSM)
http://www.highwaysafetymanual.org/Pages/default.aspx
Introduction:
CMF Clearinghouse

http://www.cmfclearinghouse.org/

FHWA Crash Modification Factors

http://safety.fhwa.dot.gov/tools/crf/resources/#pubs
Safety Studies

FHWA Table 70
http://safety.fhwa.dot.gov/tools/crf/resources/fhwasa08011/

NCHRP Report 500 Series
http://safety.transportation.org/guides.aspx
Safety Analyst
http://www.safetyanalyst.org/
http://www.aashtoware.org/Safety/Pages/default.aspx

Safety
Manage highway safety
AASHOWeb Safety Analyst facilitates cost-effective, site-specific highway safety improvements. The software, which serves local as well as state highway agencies, integrates the analytic approaches recommended in the Highway Safety Manual (HSM) into a single package, providing a program to guide the decision-making process, prioritize improvements and help you agency get the greatest possible safety benefit from each dollar it spends.

Traffic Engineering Manual
ODOT Safety Studies Guidelines
http://www.dot.state.oh.us/Divisions/Planning/SPPMSystemsPlanning/Pages/FundingGuidelines.aspx

Supplemental Lists
- Index of Countermeasure Strategies checklist
- Index of Strategies
- FHWA Table 70