Highway Safety Manual Analysis Utilizing Michigan Tools

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The Cliff-Cliff-Cliff Notes Version

Objectives

- Background
- Types of Safety
- Crash Data
- Language of the HSM

- EXAMPLES – EXAMPLES – EXAMPLES

- Systemic Safety

What is the Highway Safety Manual?

A method to quantify safety!!

Why do HSM Analysis?

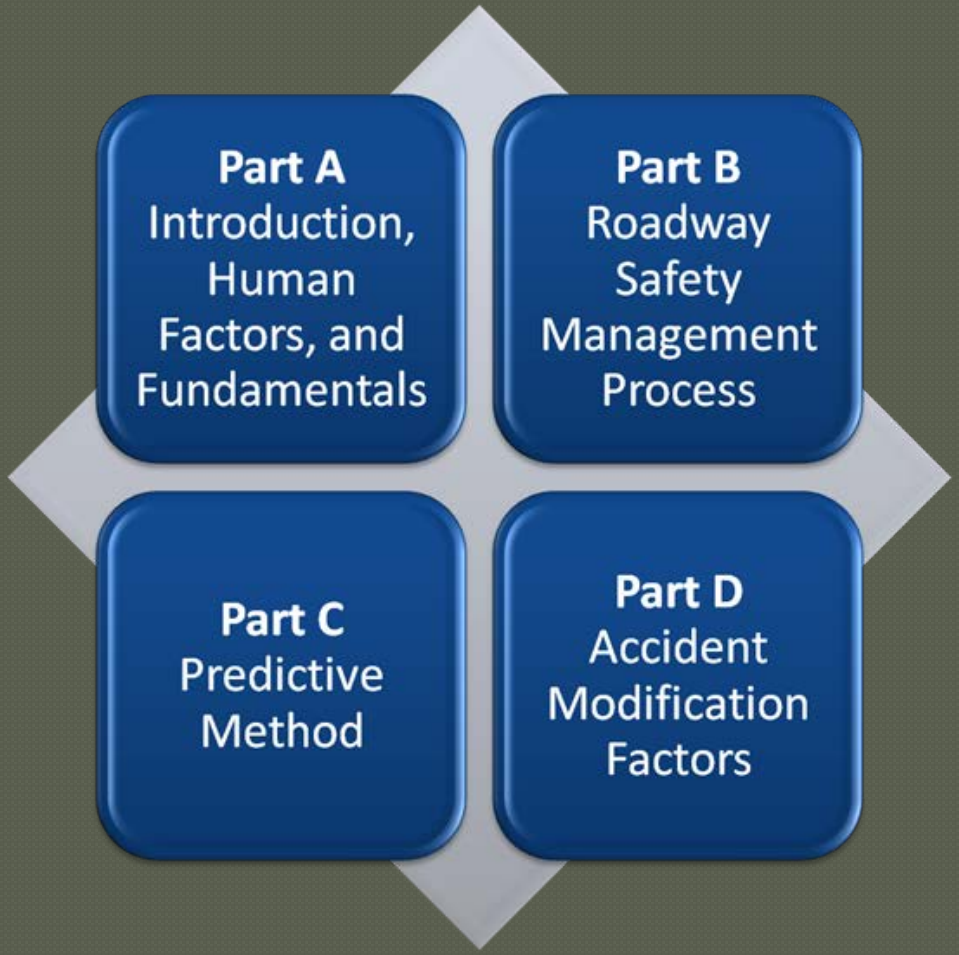
Why do capacity analysis?

HSM Vision

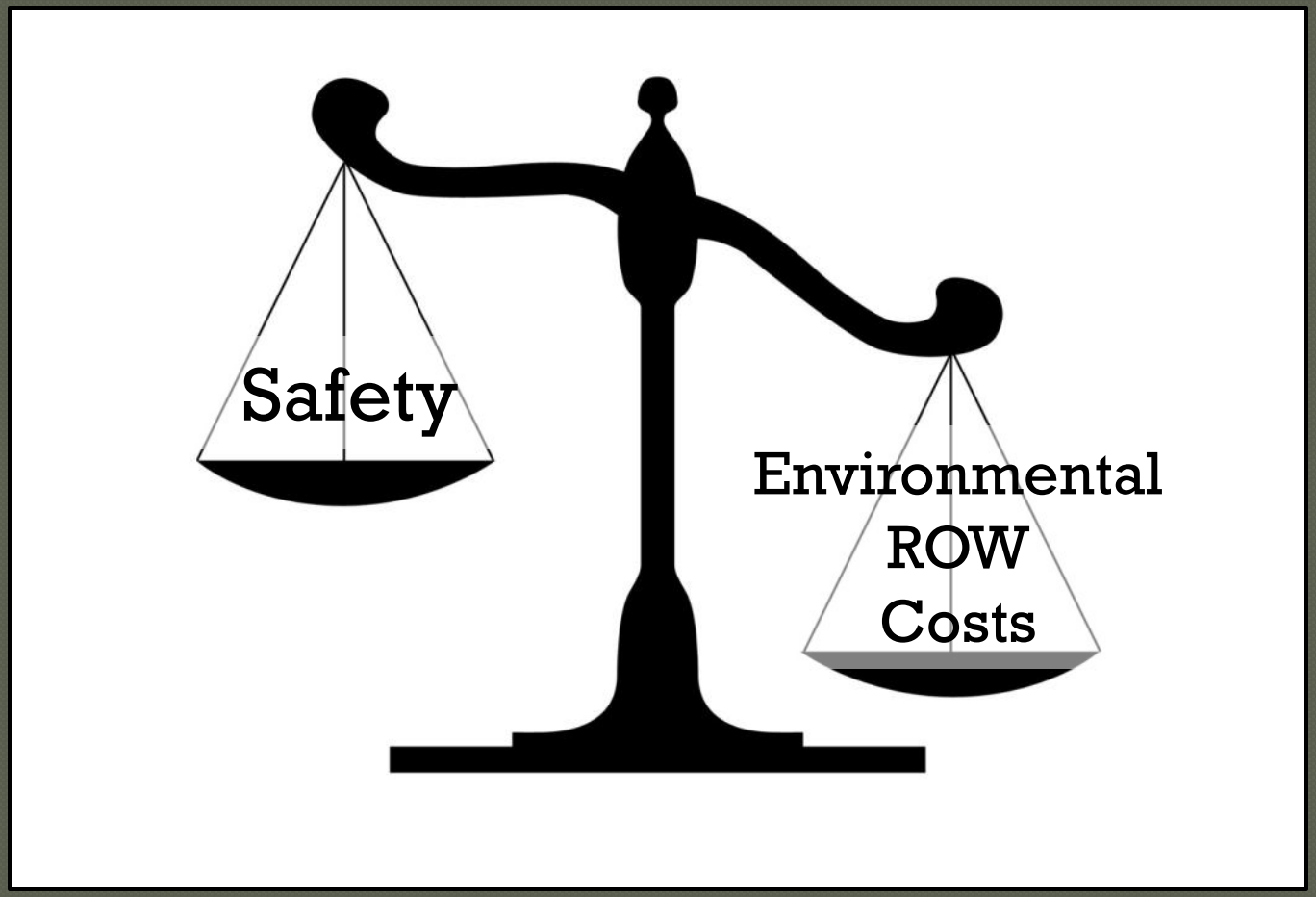
Document akin to Highway Capacity Manual

- State-of-the-art info
- Widely accepted
- Science-based

Outline of the HSM



Balancing Safety

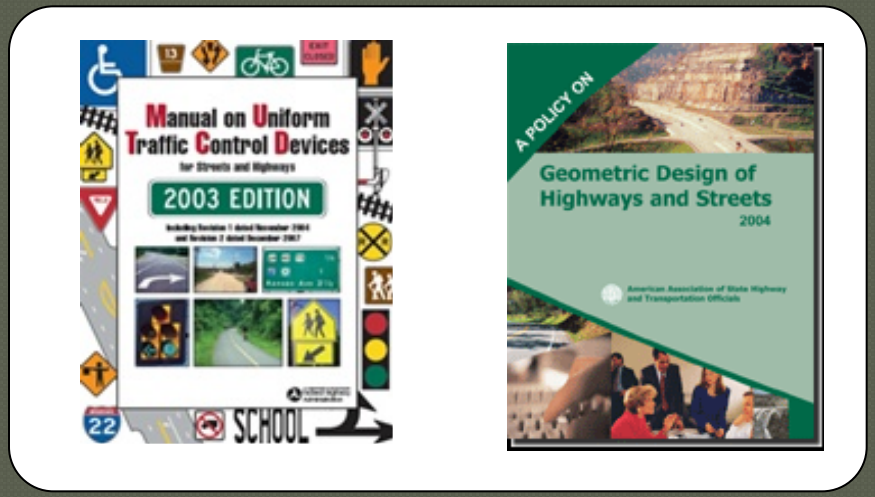


Where can HSM be applied?

- Project Development
  - Planning, Project Scoping, Design, Road Safety Audits, Design Exceptions
- System Management
  - Network Screening, Road Safety Audits, Operations

What the HSM is NOT

- Does NOT set requirements or mandates
- Is NOT a best practice document
- Does NOT contain warrants or standards

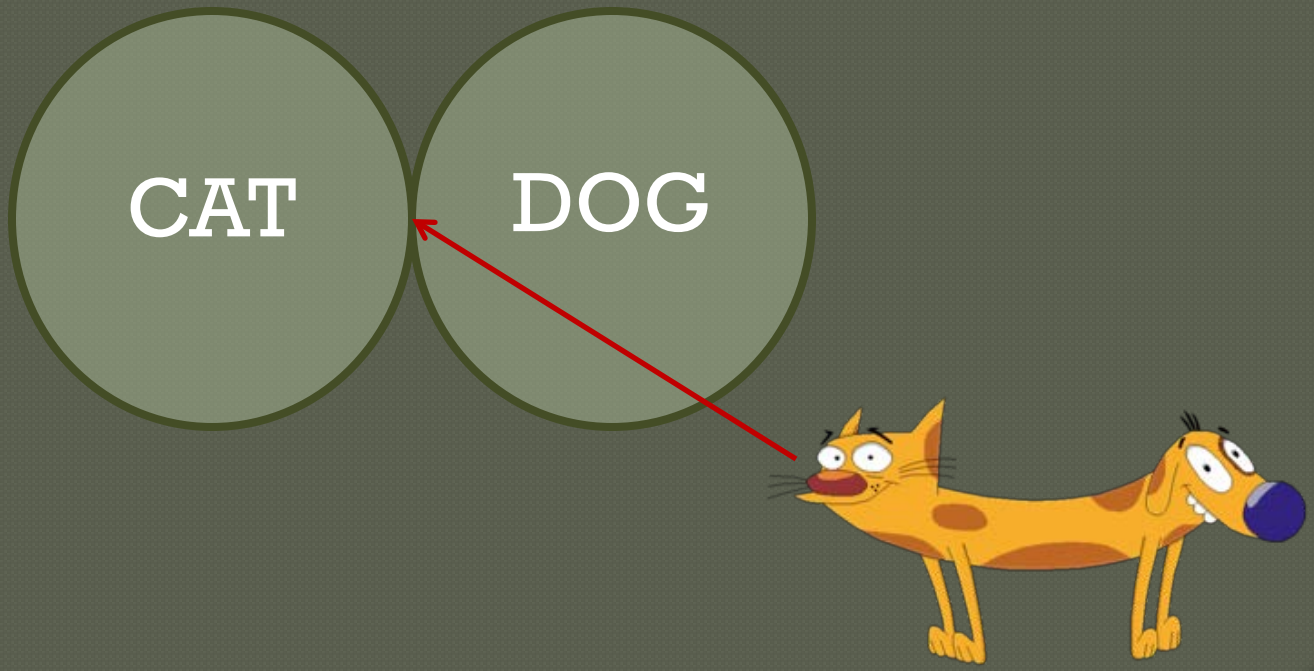


Important!

The HSM does NOT establish a legal standard of care nor does it create a duty to the public.

Nominal Safety

- Nominal safety = Compliance with a design standard or warrant



It met all the design standards…

Substantive Safety

- Going beyond those minimums
- Previous example?
  - Curve warning, chevrons, target arrow, rumble stripEs, horizontal signing
  - Vegetation, lighting

Substantive Safety Can Vary When Nominal Safety Does Not

Existing
23.6 Crsh/Mi

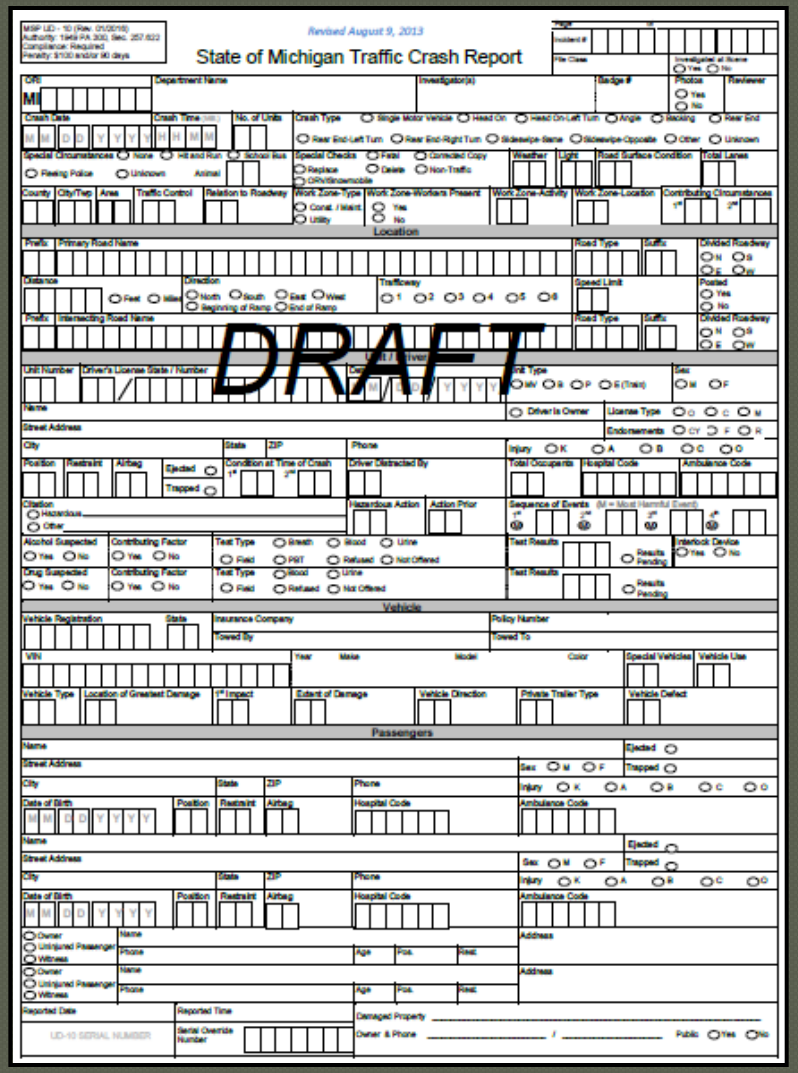
Alternative 1
17.2 Crsh/Mi

Alternative 2
8.6 Crsh/Mi

Alternative 3
4.2 Crsh/Mi

Crash Data

Crash Reporting



- Quality & Accuracy
- Reporting Thresholds
- Jurisdictional Differences
- Randomness & Change

New UD-10 Form
January 1, 2016

Observed Crash Rates

Before

Year	No. Crashes	AADT	Rate
1988	13	2,900	2.11
1989	11	2,900	1.79
1990	13	3,050	2.01
1991	23	3,400	3.19
Average Rate = 2.28			

After

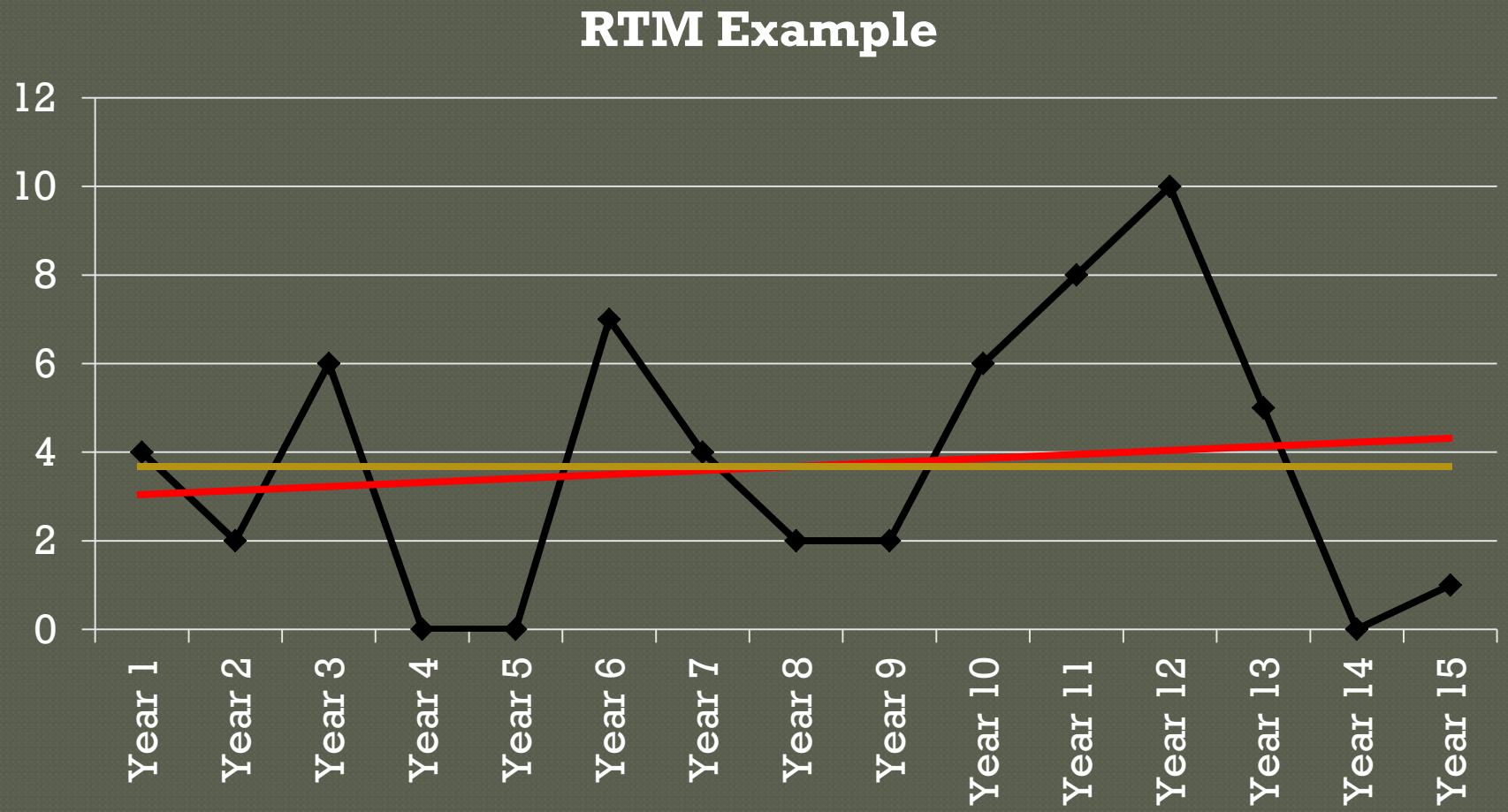
Year	No. Crashes	AADT	Rate
1992	30	10,618	1.33
1993	30	13,200	1.07
1994	36	14,300	1.19
1995	40	13,900	1.36
Average Rate = 1.24			

Gambling Introduced in 1992

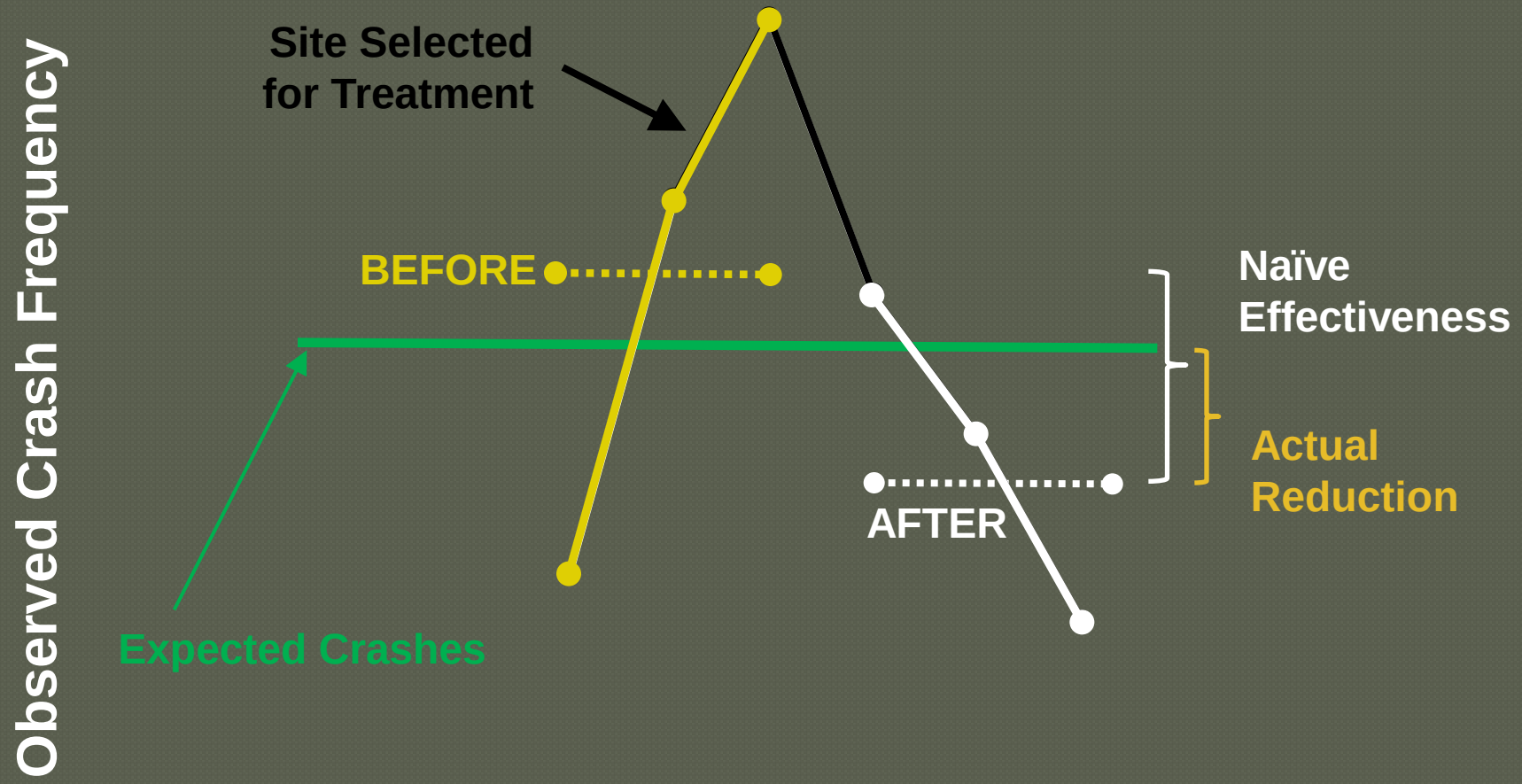
Example Provided by Jake Kononov, Ph.D., P.E., Colorado DOT (retired)

Crash Rate Example

Regression to the Mean



RTM Project Example



The Language of the HSM

HSM Lingo

- Observed Crashes
  - What is happening right now
- Predicted Crashes
  - What a Safety Performance Function (SPF) says will happen
- Expected Crashes
  - What will happen once you apply known info to a SPF

Empirical Bayes

A statistical method of analysis
to combat
Regression to the Mean.

Product of EB = EXPECTED Crashes

Excess Crashes

Excess = Observed – Expected

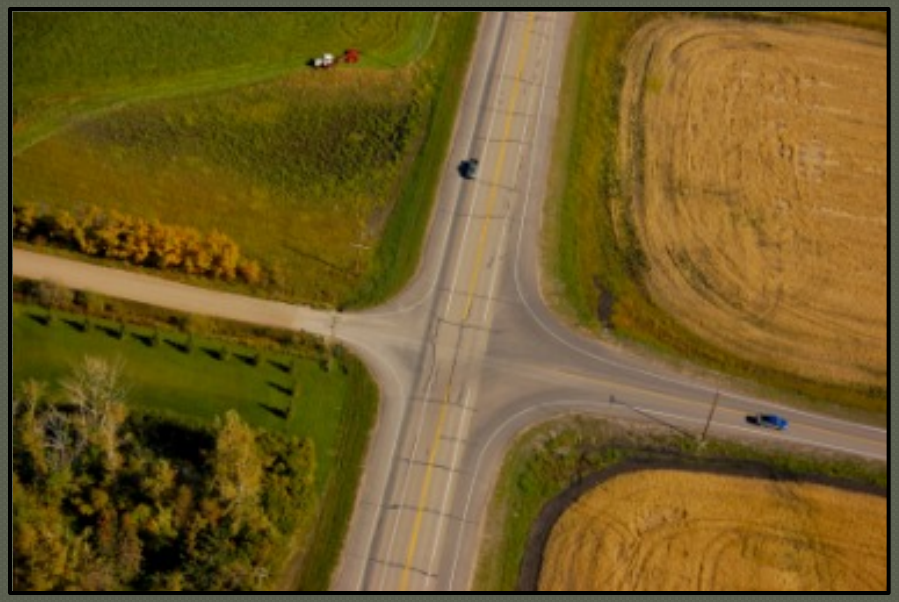
How much opportunity
we have to improve safety!

Elements of Predicting Crashes

- Safety Performance Functions
  - Predict crashes for base conditions
- Crash Modification Factors
  - Alter the SPF to match existing or proposed
- Calibration Factors
  - Account for local conditions
  - Already included in MI spreadsheet tool

Base Conditions

- Conditions a SPF was developed around
  - Site Types



CMFs vs CRFs

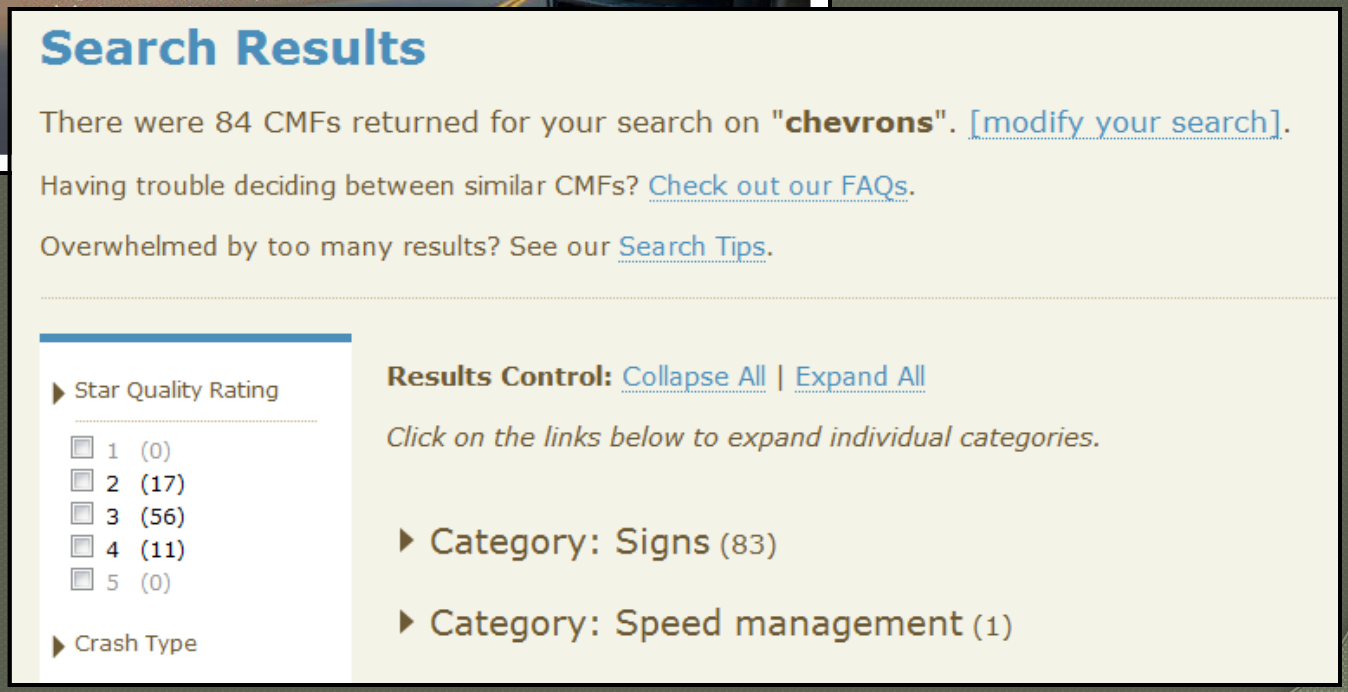
Crash Modification Factors

- CMFs related to base conditions
- CMFs applied during calculations

1 – (CRF/100) = CMF

10% CRF = 0.90 CMF

CMF Clearinghouse



When Selecting CMFs

- Know Background Conditions
- Same Setting and Road Type
- With Volume Range
- Crash Type/Severity

Applying CMFs

- Quality
  - Study Design
  - Sample
  - Standard Error
  - Bias
  - Data Source

- Can be used outside predictive process
  - Countermeasure selection

Safety Performance Functions

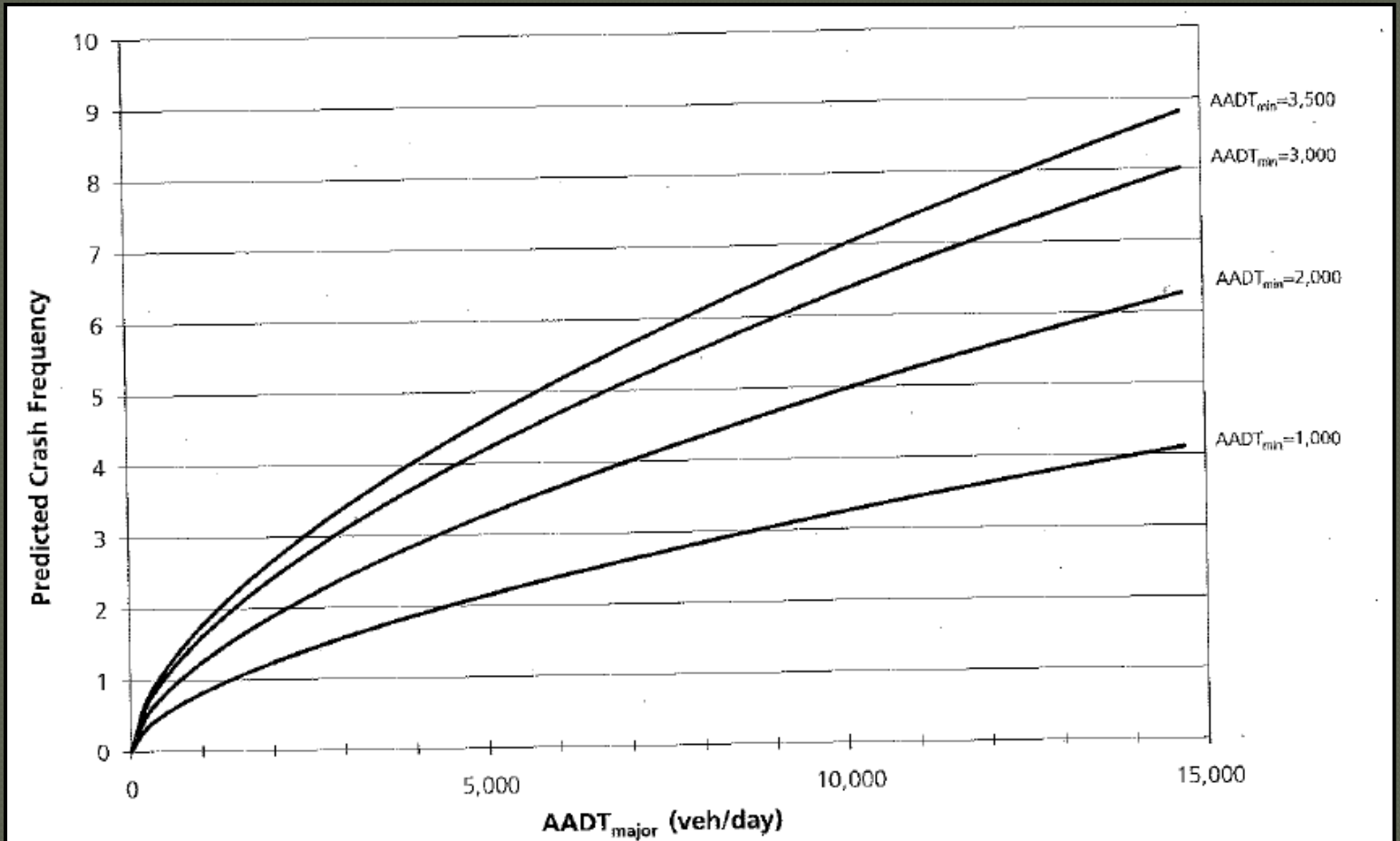


Figure 10-5. Graphical Representation of the SPF for Four-leg, Stop-controlled (4ST) Intersections (Equation 10-9)

Where CAN we Predict?

Two-Lane
Rural Roads

Urban/ Suburban
Arterial Highways

Rural Multilane
Highways

Freeways

Where CAN'T we Predict?

- Gravel Roads
- Ultra Low Volume
- One Way Roads
- Tee Intersections can be tricky

HSM 1st Edition!

Safety Projects on the Local System

LAP Safety Funding Targets

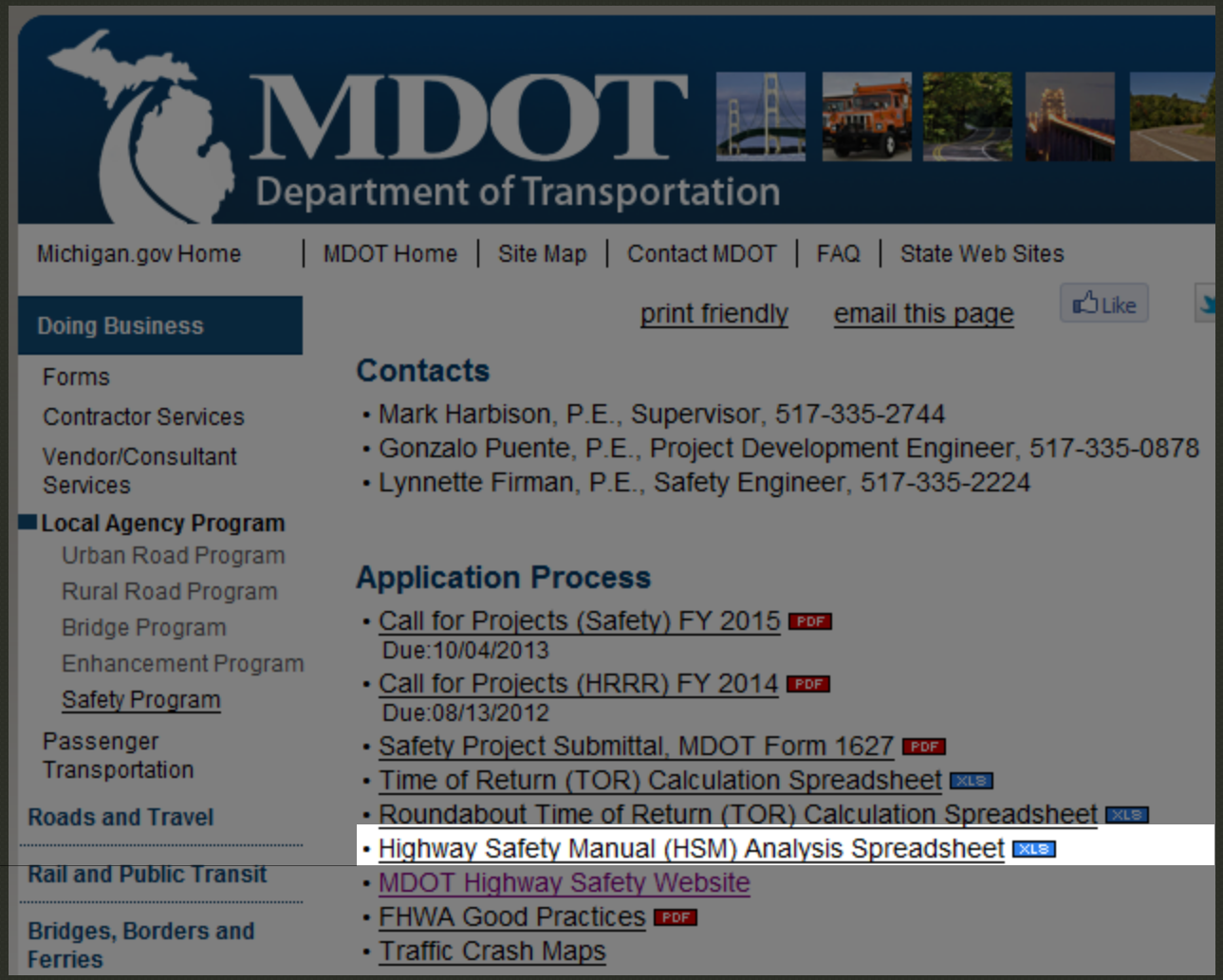
FY 2015 Safety Program Financial Goals:

Project Type	Total Program
Road Safety Audits (RSA)	$50,000
Non-motorized facility/Pedestrian improvements	$100,000
Traffic signal optimization (all red phase)	$150,000
Centerline and Shoulder Rumble Strip	$200,000
Guardrail Upgrades and Clear Zone Improvements	$1,500,000
Projects with scopes that directly correct areas with a concentration of Types "A" and "K" crashes	$9,500,000
Safety Funds per MDOT Region	$350,000

TOR vs HSM Analysis

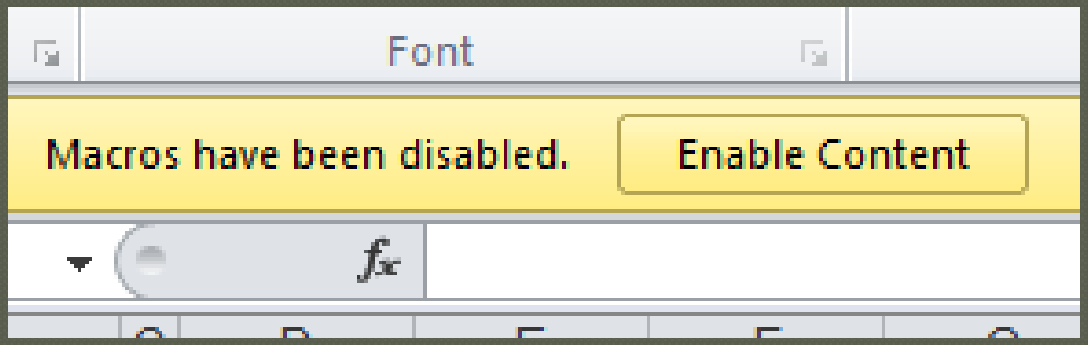
- CRFs may be DIFFERENT
  - Rumble Strips:
  - TOR – 20% reduction (targeted crashes)
  - HSM – 16% reduction (all crashes)
- Years of analysis may be DIFFERENT
  - TOR – 2009-2013
  - HSM – 2006-2010 (can use TOR crash data)

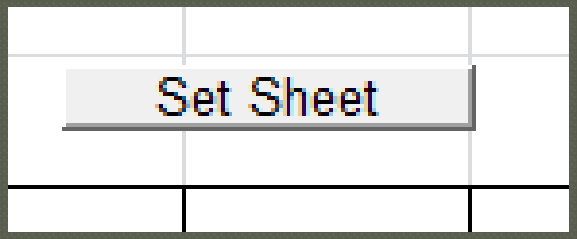
Where is the MI Spreadsheet?

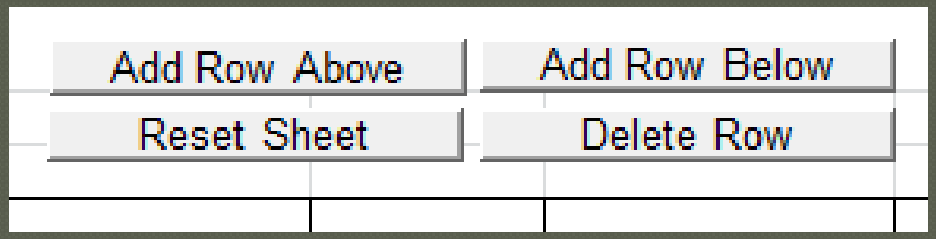


Demo Spreadsheet

- Instructions
- Input
- Models

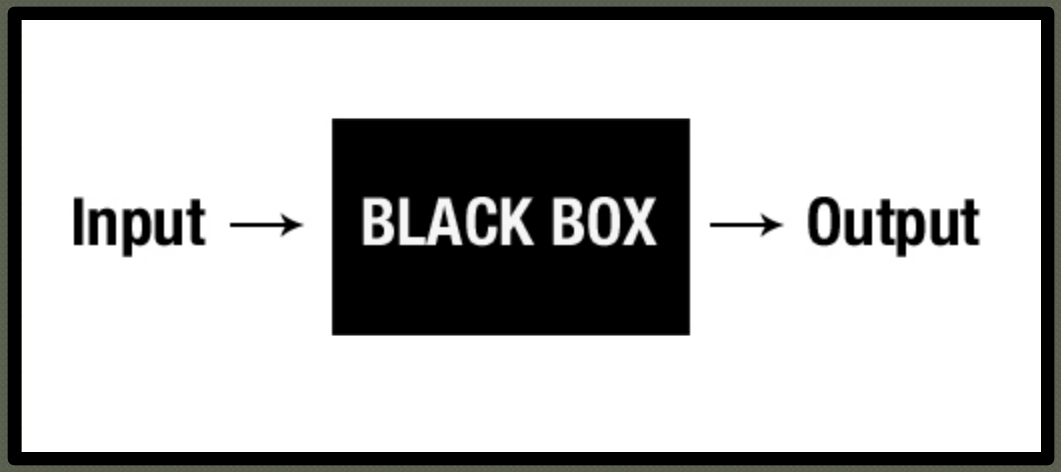






Caution Using MI Spreadsheets

- HSM 1st Edition
- Engineering Judgment



Good Safety Projects

Lane Departure Projects

Shoulder Paving
Rumble Strips
Curve Signing

Shoulder Paving

- Input existing conditions
- Input shoulder paving info

- Existing: Expected Ave Crash Freq = 1.79

- Pave Sh: Exp Ave Crash Freq = 1.77

UNITS: Crashes/Mile/Year

Rumble Strips

- Apply CMF for shoulder rumble strips
- Rumbles: Exp Ave Crash Freq = 1.52
- NOTE: 2 ways to reflect countermeasures
  - Change input information for feature
  - Apply CMF from dropdown or type in

Intersection Projects

Sign/Marking Upgrades
Transverse Rumble Strips
Flashing Beacons/Box Span
Signal Backplates

Sign/Marking Upgrades

- Upgrade signing at stop control
  - Clearinghouse – Targeted Crash Types
  - TOR – Targeted Crash Types
  - ENGINEERING JUDGMENT
    - 5% reduction in total crashes (0.95)
- Existing: Exp Ave Crash Freq = 3.89
- Signing: Exp Ave Crash Freq = 3.78

Signal Backplates

- Add traffic signal backplates

- Existing: Exp Ave Crash Freq = 1.948
- Backplates: Exp Ave Crash Freq = 1.725

Network Screening

Intersections
Segments
Curves
Other?

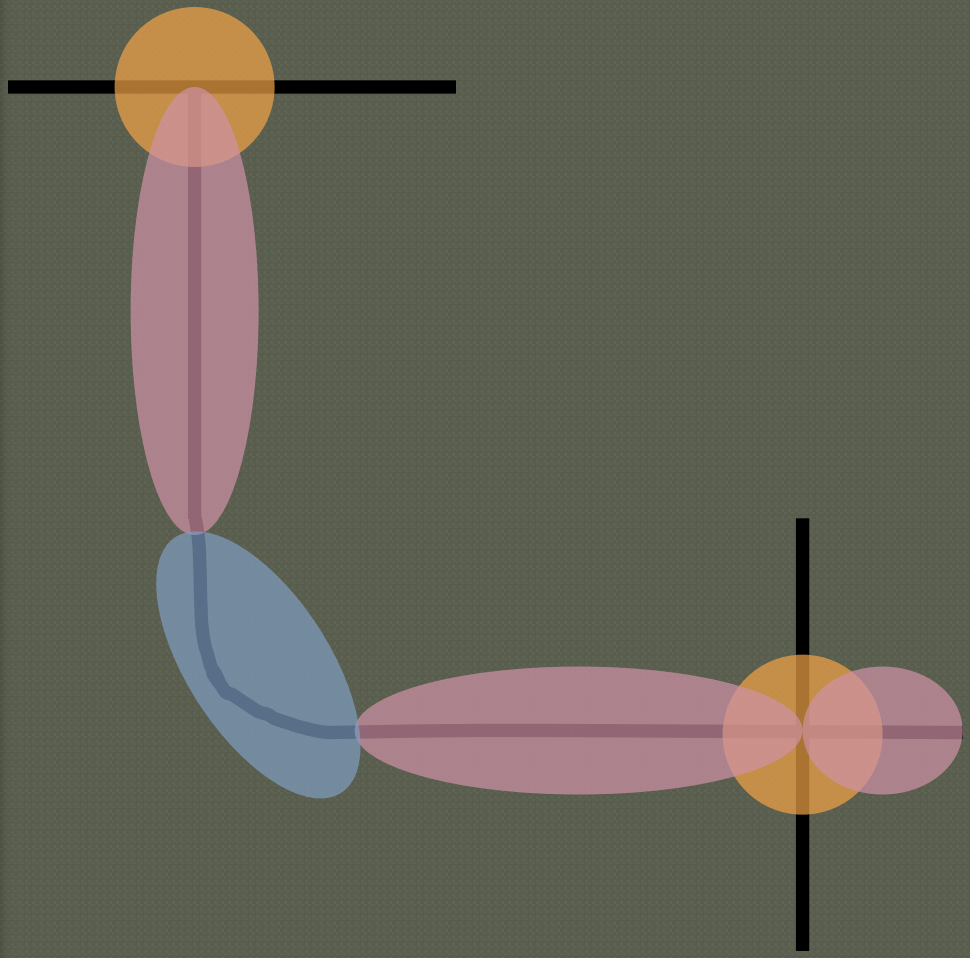
Network Screening Example

Project Level Analysis

Project Analysis Basic Method

- Collect Data
- Divide Project into Segments & Intersections
- Fill out Spreadsheets
- Calculate Predicted Crashes:
  - Without Treatment
  - With Treatment
  - Compare to Observed Crashes

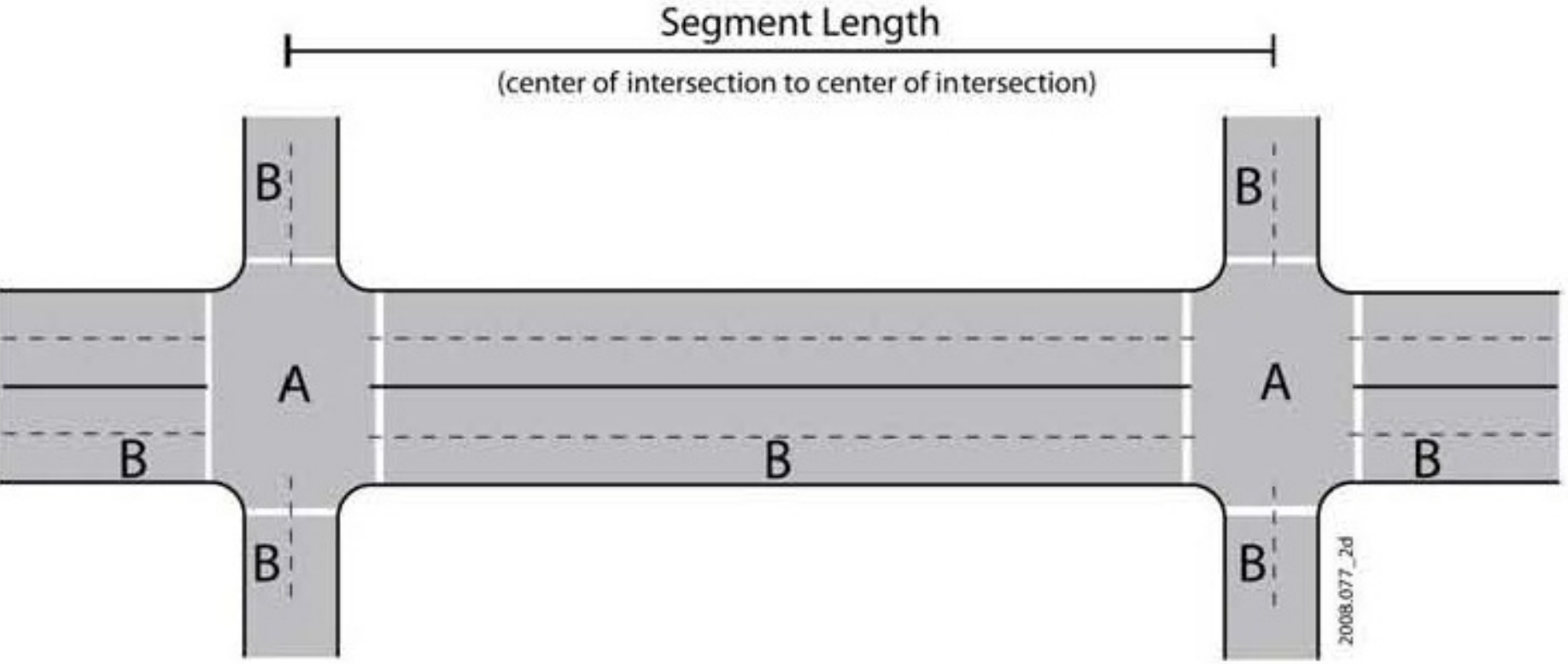
Divide Project



- Intersections
- Tangents
- Curves
- Cross Sections
- Roadside
- Volume

- Urban
- Rural

Segment Length



A All crashes that occur within this region are classified as intersection crashes.

B Crashes in this region may be segment or intersection related, depending on on the characteristics of the crash.

Compile Results

Calculate Expected Crashes
For the Project

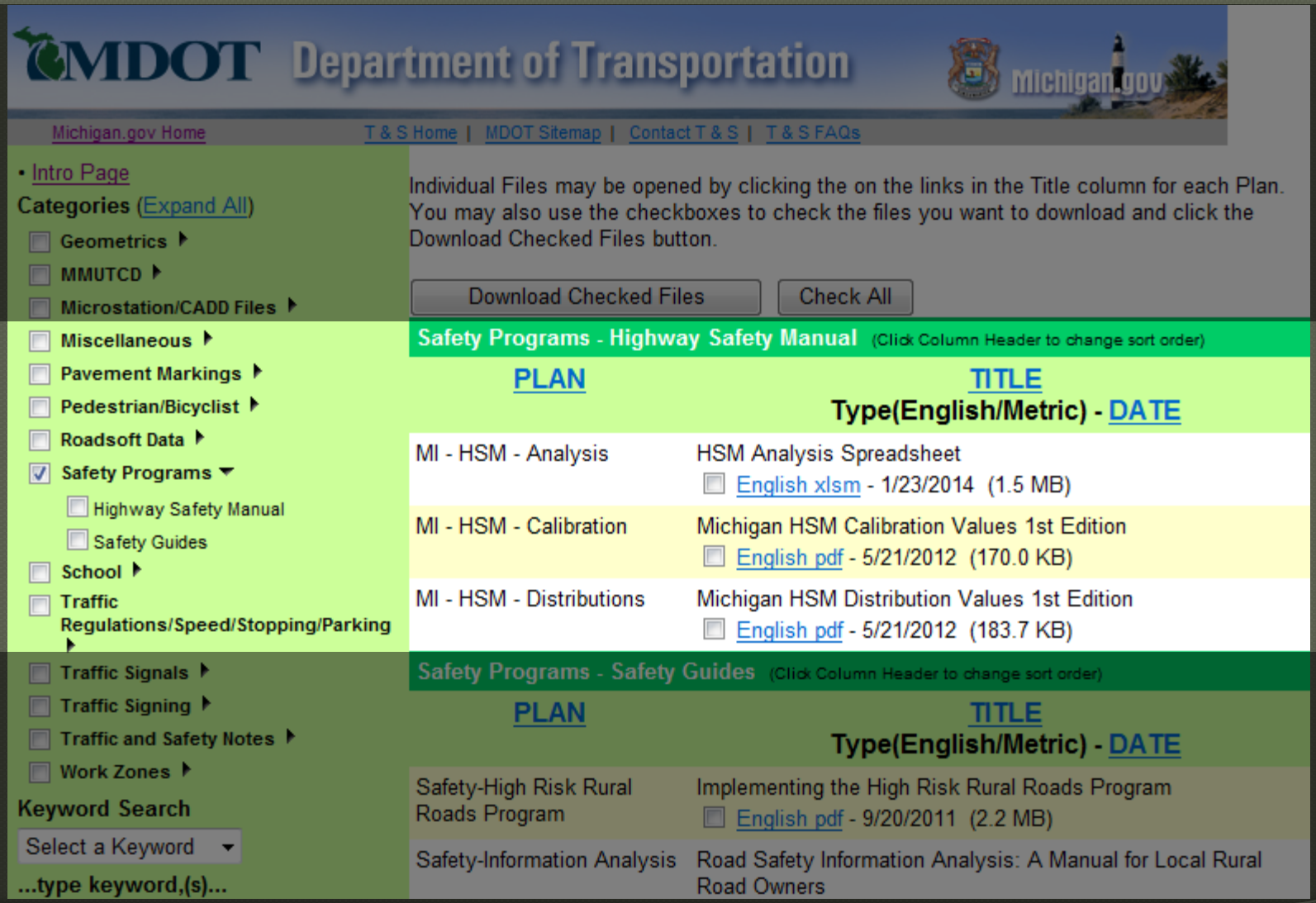
ADD them together!

$$Exp_a + Exp_b + Exp_c = Exp_{project}$$

Crash Distribution in MI

Varies widely from other states!

Michigan Distribution Tables



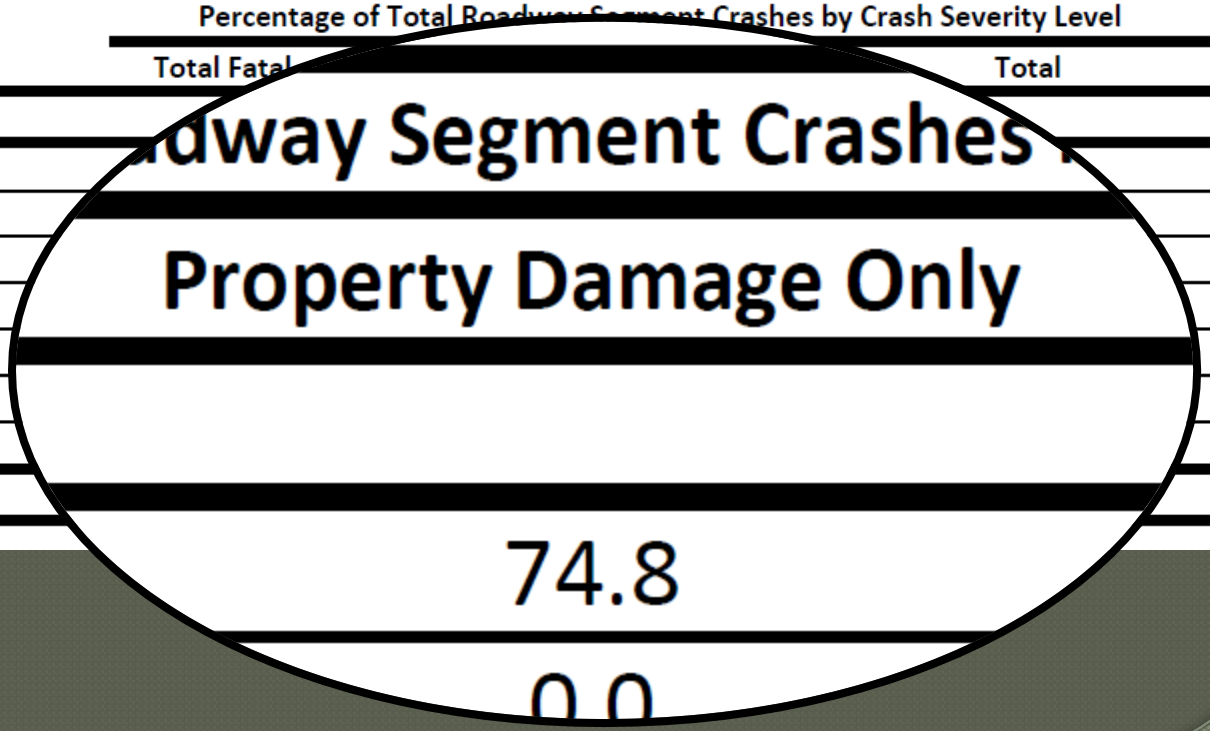
Distribution Tables

- Chapters 10 & 11 ONLY

TABLE 10.4 Michigan Distribution by Collision Type for Specific Crash Severity Levels on Rural Two-Lane Two-Way Road Segments

data 2005-2009

Collision Type	Percentage of Total Roadway Segment Crashes by Crash Severity Level: Total Fatal	Total
SINGLE-VEHICLE CRASHES		
Collision with Animal		
Collision with Bicycle		
Collision with Pedestrian		
Overturned		
Ran off Road		
Other Single Vehicle Crash		
Total Single Vehicle Crashes		
MULTIPLE-VEHICLE CRASHES		
Angle Collision		



Applying Distribution Tables

- Stratify predicted crashes
  - Crash type
  - Injury type
- Already built into the spreadsheets
  - Hide calculations = N

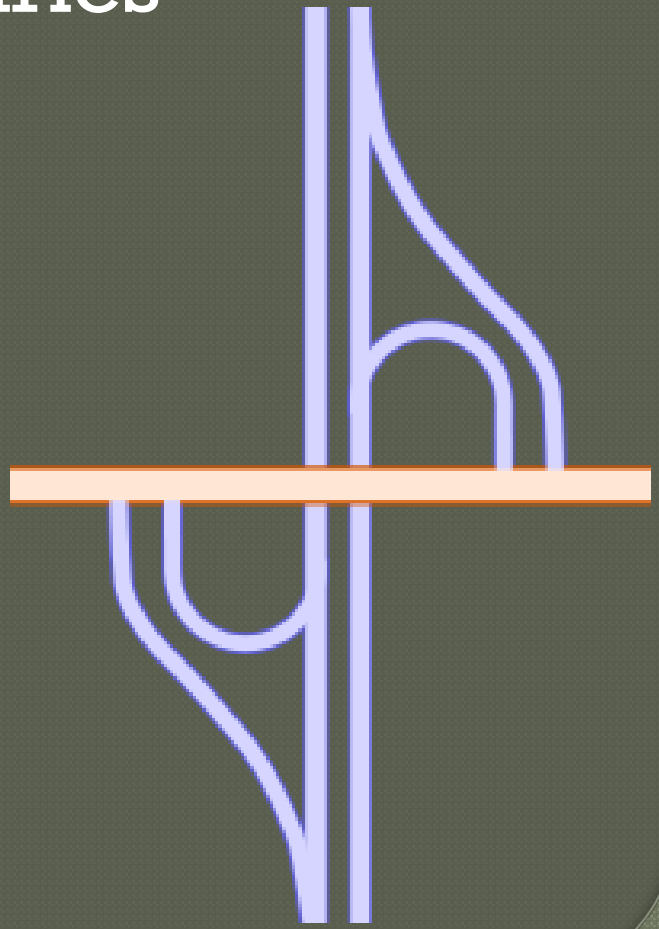
Systemic Safety

A deviation from HSM stuff

Systemic Safety

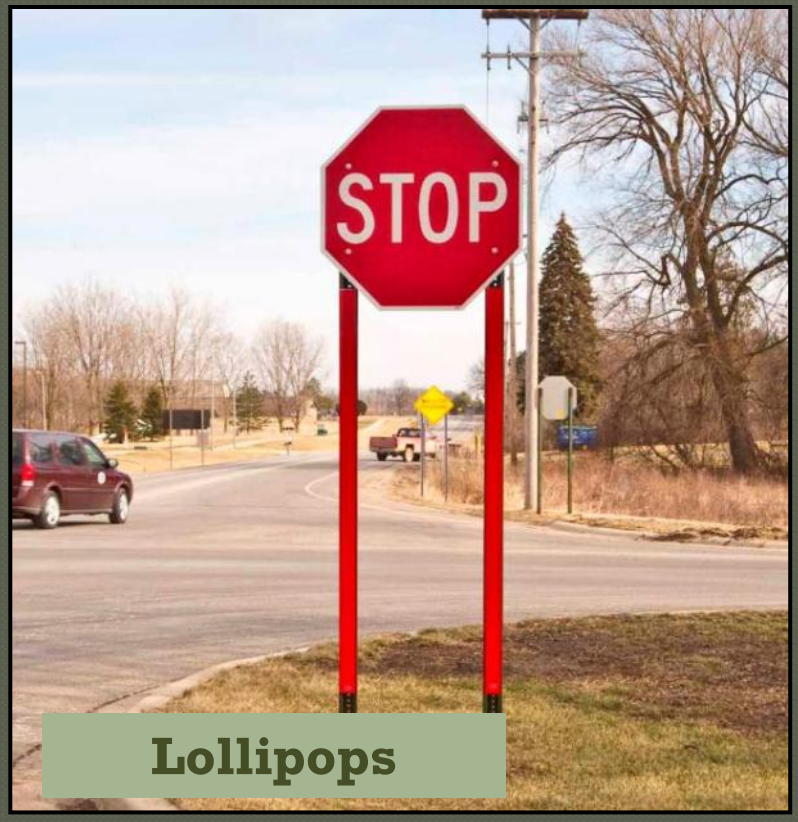
The Problem

- 110 Crashes → 66 K/A Injuries
  - 35 Known Points of Entry
- 791 Interchanges
  - 161 are "Parclo"
  - 70% W-W crashes at "Parclo"



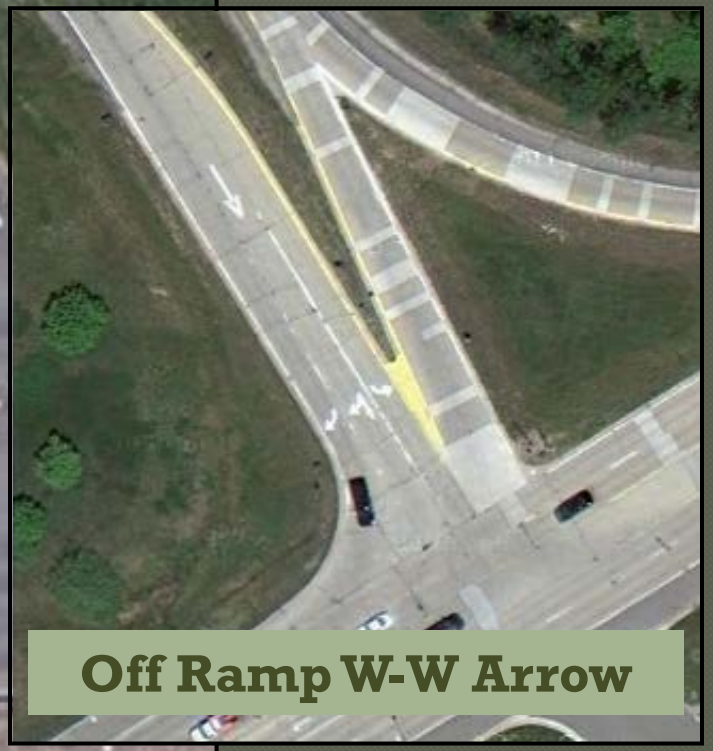
Solutions

Lower Bottom Height



Lollipops

Solutions



Solutions

Pavement Marking Extensions
Painted Gore Island
W-W Delineation

Implementation

- When feasible
- Signing changes at all ramps

- Estimated Cost = $1.16 M (materials)
- TOR = 3.51

Systemic Safety for Local Agencies

Single Vehicle – 65%

- Curves – 25%

Angle – 60%

What We Learned

- What the HSM is
- Types of Safety
- Crash Data
- Language of the HSM
- Crash Prediction
- Systemic Safety

Questions?

"If you don't like the government, why don't you just leave?"

"No way. Why should I leave? They're the ones who suck."

Thank you

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