



# Identification of Crash Types, Risk Factors, and Countermeasures to Implement Systemic Safety

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# Project Team

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# Systemic Safety Management

- Widely implements lower unit-cost safety improvements at sites with characteristics that indicate high-risk of a focus crash type.
  - Focus crash types may not have high frequencies at specific locations
  - But high frequencies scattered across the road system at low densities
- Identifies sites to treat based on estimated crash potential or risk, not necessarily because of crash history.



**Systemic Safety Project Selection Tool**

**A Systemic Approach to Safety**  
Using Risk to Drive Action

The systemic approach to safety involves improvements that are widely implemented based on high-risk roadway features combined with particular severe crash types. As the figure on the right illustrates, 87 percent of total crashes occur on rural roads, which are often part of the local system. Because these crashes are not evenly distributed across the many miles of rural roadways, it is often difficult to locate high-crash locations for safety improvements. The systemic approach answers the question:

**Do all systems and crash types present equal opportunities for crash reduction, or do specific parts of the system and certain crash types offer a greater opportunity to save lives?**

**The Benefits of a Systemic Approach**  
Several agencies implementing systemic improvements have reported staggering results in crash reductions. The systemic approach:

- Solves an Unmet Need in Transportation Safety.**  
A significant number of severe crashes are scattered over a wide area, particularly on rural and local roadways, and for specific crash types such as those involving vulnerable road users. These crashes are rarely identified through the traditional site analysis approach because it is difficult to locate high-crash locations. The systemic approach provides state, regional, and local agencies an alternative method to address these crash types and fulfill a previously unmet need.
- Uses a Risk-Based Approach to Prevent Crashes.**  
The systemic approach starts with a different premise for identifying safety problems, leading to a different set of projects. The systemic approach looks at crash history on an aggregate basis to identify high-risk roadway characteristics. While the traditional site analysis approach results in safety investments of high-crash locations, the systemic approach leads to widespread implementation of projects to reduce the potential for severe crashes.
- Results in a Comprehensive Road Safety Program.**  
The systemic approach does not replace the site analysis approach. It is a complementary technique intended to supplement site analysis and provide a more comprehensive and proactive approach to safety management efforts. Reducing crashes at individual locations clearly requires continued attention. At the same time, the systemic approach aims to reduce the risk of and the potential for the occurrence of future crashes.
- Advances a Cost-Effective Means to Address Safety Concerns.**  
The systemic approach considers multiple locations with similar risk characteristics. When examining the system as a whole, a particular roadway element may have a high-crash experience, and it is more cost-effective to correct the problem on a systemwide basis rather than by individual high-crash locations.

U.S. Department of Transportation  
Federal Highway Administration

Source: Corbridge Semantics, Inc.

U.S. Department of Transportation  
Federal Highway Administration

**Safe Roads for a Safer Future**  
Investment in Safety Starts with Data  
http://safety.fhwa.dot.gov

# Objective and Needs

Identify focus crash types, focus facility types, and their associated risk factors for systemic safety improvements applications

Agency experiences with systemic approaches to safety management continue to increase

There is considerable interest in quantitative approaches to systemic safety analysis

# Task Order Activities

Select data resources and statistical methodologies.

Identify focus crash and facility types with their associated risk factors.

Identify potential low-cost safety strategies to be used as systemic safety improvements.

Develop a technical report and a Quick Reference Guide

Develop a criteria to identify volunteer agencies to implement systemic safety improvements.

# Recommended Data Resources

Fatality Analysis  
Reporting  
System (FARS)

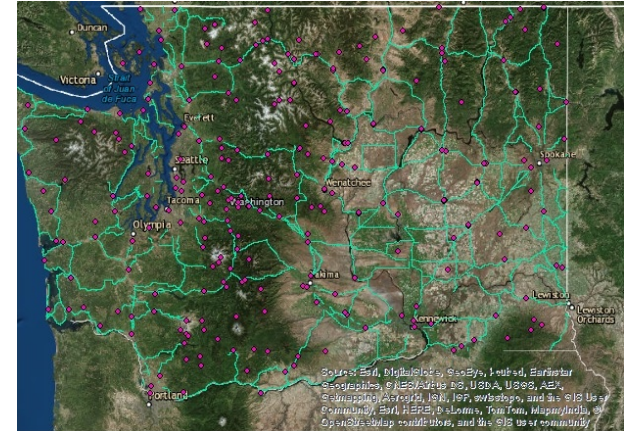
Highway Safety  
Information  
System (HSIS)

Databases from  
the NCEI-NOAA

Databases from  
the U.S. Census  
Bureau

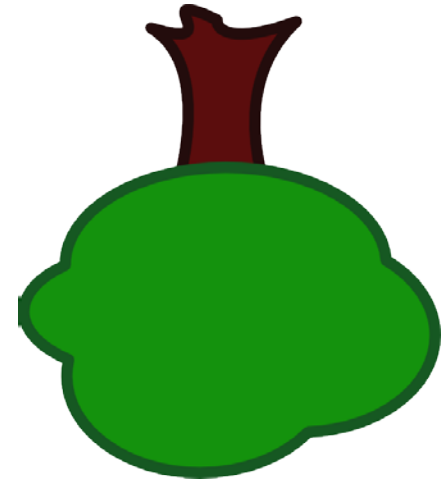
# “New” Safety Data Sources

- National Oceanic and Atmospheric Administration
  - Data reporting generally occurs hourly, daily, monthly, and annually
  - These data are being used to allow weather to be considered for crash frequency-based analyses
- U.S. Census Bureau
  - Provides detailed socio-economic and demographic data.
  - Intent is to provide insights into population-based risk factors



# Identification of Risk Factors (methods)

- Negative binomial regression models
- Classification and Regression Trees (CARTs)
  - Non-parametric methods
  - Compared to regression models, CART is able to more efficiently identify complex interactions between variables
- Random Forests
  - Instead of having one tree, multiple trees are produced using a resampling method, and the aggregate results are then combined
  - Provides a plot to identify the most important independent variables





# Identification of Focus Crash and Facility Types

## ■ Definition

- “First Harmful Event,” “Manner of Collision,” facility type, site type, geometrics, possibly additional levels of detail

## ■ FARS Analysis (2009-2014)

- Total number of fatal crashes
- Total number of fatalities

## ■ CA, MN, OH, WA (2009-2014)

- Total number of fatal crashes
- Total number of fatal plus incapacitating injury crashes
- Total number of fatalities and incapacitating injuries



# Focus Crash Types

- Pedestrian crashes not included (covered in NCHRP Project 17-73)
- Non-intersection (16 combinations)
  - Roadway type
    - Rural two lane
  - Crash Type
    - Run off road
    - Lane departure
    - Head on
    - Rollover/overturn
  - Time of day
    - Daytime
    - Nighttime
  - Curvature
    - Straight
    - Curved

# Focus Crash Types, *contd.*

- Intersection (only angle crashes)
  - Rural two-lane roads at 4-leg minor road stop controlled intersections (daylight and nighttime).
  - Urban two-lane roads at 4-leg minor road stop controlled intersections (daylight).
  - Urban multi-lane divided roads at 4-leg signalized intersections (daylight).
  - Urban multi-lane undivided roads at 4-leg signalized intersections (daylight).
  - Rural two-lane roads at 3-leg minor road stop controlled intersections (daylight).
  - Rural multilane divided roads at 4-leg minor road stop controlled intersection (daylight).

# Identification of Risk Factors (for each selected crash type-facility type )

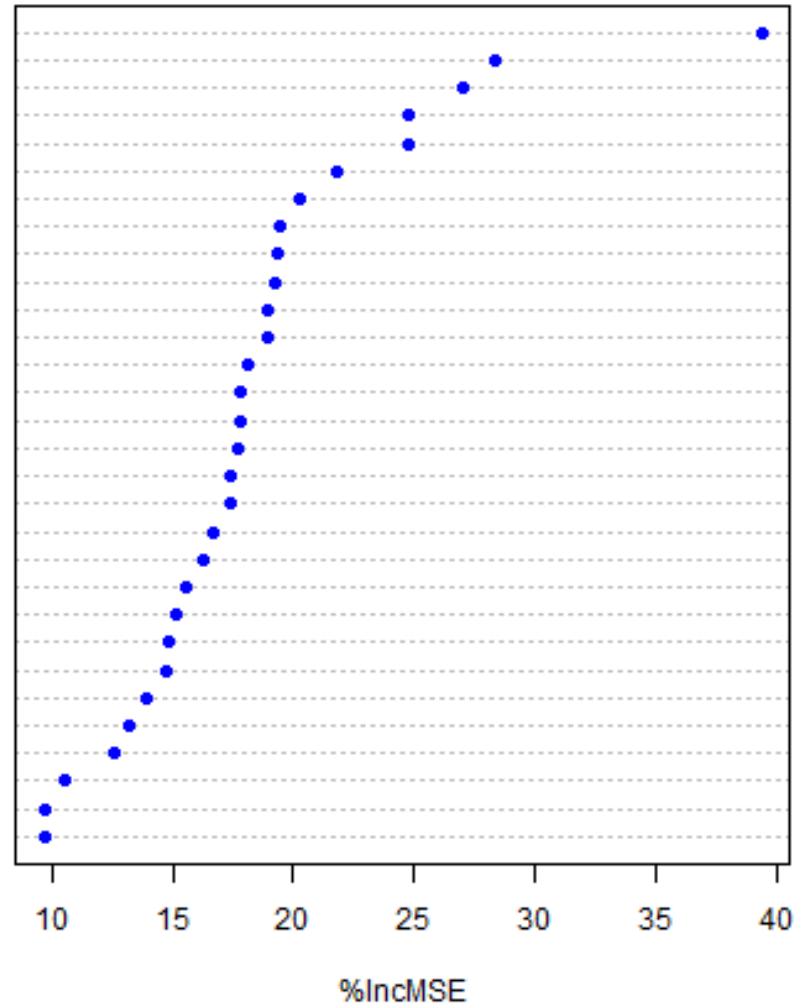
- Factors that increase crash frequency (for KABC and KAB crashes) at the site level
- Identify variables based on results from random forest
- Use predictions from random forest to determine the direction of the safety effect (i.e., increase or decrease in crashes)



# Example plot from random forest (WA rural two-lane roads on horizontal curves during daytime)

RORrate Random Forest

CURV\_RAD  
avg\_aadt  
trkpcts  
pct\_grad  
shldwid  
age45to64  
tempminavg  
temp32fdays  
noedctn25plus  
rainavgyear  
income50to100k  
tempmaxavg  
tempwintermin  
snowavgyear  
workptage16to24  
income100kplus  
income50k  
univ25plus  
noworkage16to24  
unempl16plus  
X1veh  
age20to44  
age15to19  
diploma25plus  
workftage16to24  
age75plus  
X2vehplus  
terrain  
age65to74  
noveh



## Example Risk and Protective Factor Table (ROR-KAB daytime on rural two-lane tangent sections)

Variable	Factor Type
Percent Grade	Risk
Average AADT	Risk
Truck Percentage	Protective
Average Shoulder Width	Protective
Average Annual Rainfall Total	Risk
Percentage of Population (Ages 20 - 44)	Risk
Percentage of People (Ages 16 - 24) Unemployed	Risk
Annual Average Maximum Temperature	Protective
Percentage of Population (Ages 25 plus) with High School Diploma (but no University degree)	Protective
Percentage of Population (Ages 25 plus) without High School Diploma	Protective

# Identification of Risk and Protective Factors

- 57 such Tables were generated based on data from Washington, California, and Ohio
- Top 10 variables from each Table selected to determine whether it is risk or protective
- Some results are counterintuitive based on existing literature
- Census and weather variables were in the top 10 variable in many cases
  - Possibility of multicollinearity
  - Exploring the use of factor analysis

# Countermeasure Selection Process (Steps)

- Step 1: Identify focus crash type
- Step 2: Identify risk factors for focus crash type
- Step 3: Assemble list of potential countermeasures that address the crash type
- Step 4: Identify countermeasures that address the risk/protective factors associated with the focus crash type
- Step 5: Identify countermeasures with crash modification factors (CMFs)
- Step 6: Select countermeasures



# Countermeasure selection (description of steps)

- Identify focus crash type
  - Priorities of an agency
  - Analysis of crash data
- Identify risk factors for focus crash type
  - Using the results of this study, identify risk factors
  - Agency may choose to do their own statistical analysis
- Assemble list of potential countermeasures that address crash type
  - CMF Clearinghouse
  - Highway safety manual
  - Pedsafe and bikesafe
  - Jurisdiction-specific CMF list

# Countermeasure selection (description of steps), *contd.*

- Identify countermeasures that address the risk factors
  - Not all countermeasures may address the risk factor
- Identify countermeasures with CMFs
  - Identify countermeasures with CMFs that are considered reliable by the agency
- Select countermeasure
  - Select appropriate countermeasure based on cost and CMF value

# Technical Report and Quick Reference Guide

- Draft 1 of Technical Report has been reviewed by FHWA and Expert Statistician Support Team
- A Quick Reference Guide is under preparation
  - More concise
  - Identification of focus crash types, risk factors, and targeted systemic countermeasures
  - Description of a repeatable process
- As focus crash types and treatments are identified, we will be interested in the involvement of agencies to implement systemic safety improvements for evaluation.



Thank You

# Questions?

