Exploring Predictive Network Screening Tools: A Deeper Dive

June 30, 2021 3PM EST

Stephen Read, Virginia DOT & AASHTO Highway Safety Manual Steering Committee Chair
Bonnie Polin, Massachusetts DOT & AASHTO Highway Safety Manual Steering Committee Co-Chair
Kerry Wilcoxon & Saroja Devarakonda, Arizona DOT
Exploring Predictive Network Screening Tools

This webinar series features innovative software tools for predictive network screening employed by state transportation agencies around the United States.

Kick-off webinars provided a high-level overview of the tools using a speed-dating format and this webinar provides a more detailed description and demonstration of specific tools.

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Kerry Wilcoxon & Saroja Devarakonda, Arizona DOT
Exploring Predictive Network Screening Tools

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Bonnie Polin, Massachusetts DOT & AASHTO Highway Safety Manual Steering Committee Co-Chair
Kerry Wilcoxon & Saroja Devarakonda, Arizona DOT
Discussion

For additional information go to www.highwaysafetymanual.org or contact Kelly Hardy, P.E. at khardy@aashto.org
Colorado DOT Network Screening with DiExSys: Vision Zero Suite (VZS) June 30th, 2021
Activities Supported:

- Crash Data Requests
- Crash Data Analysis
  - Level of Service of Safety (LOSS)
  - Crash Pattern Recognition and Diagnostics
- Safety Assessment Reports
- Network Screening
- Evaluation of HSIP projects
  - Meets Criteria
  - Benefit Cost Analysis
- Before and After Studies
Data Inputs and Integration:

- Crash Data
- Roadway Data
  - Linear Referencing System
- Safety Performance Functions (SPF)
- Diagnostic Norms
- Crash Reduction Factors
- Crash Costs by Severity
Crash Query Program Features:

- Search by Linear Referencing System (LRS, Highway/Milepoint)
- Search by crash data location fields (Off System Locations)
- Summaries/Listings
- Graphs/Charts
- Economic Analysis (Benefit Cost)
- Crash Mitigation/Reduction Factors

All customized to agencies crash and roadway data
DiExSys: VZS Program

Safety Analysis Features:

- SPF Analysis
- Empirical Bayes Corrected
- Diagnostics Norms
- Crash Pattern Analysis
Safety Performance Functions (SPF)

Colorado Specific SPFs created from Colorado Crash Data (5 to 10 years) by facility type (urban/rural terrain, lanes, highway/freeway)

12 segments types
20 intersection types
5 interchange ramp intersections

Each type has an SPF for total crashes (KABCO) and an SPF for injury and fatal crashes (KABC)

74 total models, more in development
Level of Service of Safety (LOSS)

LOSS 1 - Low potential for crash reduction (Below 20th Percentile)

LOSS 2 - Low to moderate potential for crash reduction (20th Percentile to Mean/Expected)

LOSS 3 - Moderate to high potential for crash reduction (Mean/Expected to 80th Percentile)

LOSS 4 - High potential for crash reduction (Above 80th Percentile)
DiExSys: VZS Program

Safety Analysis Features
Supporting Network Screening:

• SPF/LOSS for Freeway/Highway Corridors

• Crash Pattern Analysis for Freeway/Highway Corridors
DiExSys: VZS Program

Safety Analysis Features
Supporting Network Screening:

• SPF/LOSS for Freeway/Highway Corridors

• Crash Pattern Analysis for Freeway/Highway Corridors

• Create Batch Files
Colorado Network Screening (LOSS)
Colorado Network Screening (Crash Patterns)
DiExSys: VZS Program Costs and Training

Annual License (Colorado DOT):
- $60,000/year
- Unlimited users within agency (100+ users @ CDOT)

Maintenance and Training:
- $25,000/year
- 2 Training Sessions per year

Source: https://roadsafetyanalytics.com
David Swenka, PE PTOE
Safety Programs and Analysis
Traffic Safety and Engineering Services
David.Swenka@state.co.us

https://www.codot.gov/safety/traffic-safety/programs-and-analysis
https://cdot.maps.arcgis.com/home/index.html

Thank you!
CONNECTICUT ROADWAY SAFETY MANAGEMENT SYSTEM (CRSMS)

Presenter
Shanshan Zhao, Ph.D., Research Scientist, Connecticut Transportation Institute, UCONN
Eric Jackson, Ph.D., Director, Connecticut Transportation Institute, UCONN
TOOL OVERVIEW

• Connecticut Roadway Safety Management System (CRSMS)
• Developed by CTSRC and VHB
• Web-based and easy access
• Full-implementation of the Highway Safety Manual with maps and visualizations
• Agency use since 2019
OBJECTIVE

Network Screening

Diagnosis

Countermeasure Selection

Economic Appraisal

Project Prioritization

Safety Effectiveness Evaluation
CHANGES TO DECISION MAKING

BEFORE

• Hot spot list generated annually
• Critical-crash-rate-based measure
• Simple ranking method
• Manual crash query and diagnosis
• Lack documentation of project planning process
• Reactive project planning

AFTER

• Network screening anytime by any geographical area
• Safety-performance-function-based measures
• Sliding window/peak searching method
• Automatic data query and various diagnosis tools
• Report of the entire project planning lifecycle within the tool
• Proactive project planning
SNAPSHOT INFO

Methodology

• State-specific SPF by 44 facility types
• All public roads
  - state, local; segment, intersection, ramp
• Eight performance measures provided based on data availability
  - SPF/EB expected, LOSS, MOM, EPDO, CCR
• Three recommended screening methods
• Analysis, visualization and reporting

Training

• On-demand, manual, self-paced video tutorial, forum
SNAPSHOT INFO (CONT.)

Cost & Setup Duration

- $10 million, 5-year project in CT with other deliverables
- Free of cost to COGS and local agencies in CT
- Setup with full analysis modules through this pooled fund for interested states [https://www.pooledfund.org/Details/Solicitation/1550](https://www.pooledfund.org/Details/Solicitation/1550)
- Commitment needed for each partner state
  - Phase I - $90,000 per state for year 1
  - Phase II - $110,000 per state for year 2 and 3; $70,000 per state for year 4 and 5

Maintenance

- Data update frequency: mostly yearly
- Data update duration: days-weeks
- Documentation (user requirements, system development, Git)
SNAPSHOT INFO (CONT.)

Other Key Features

- Easier data manipulation with Data Management Module
- Screening by emphasis areas, crash type and severity
- Varied diagnosis tools including statistical tests, collision diagram, crash tree
- Integration of the latest CMF Clearinghouse data
- Reporting in MS Word and Excel
- Comparing benefits and costs of proposed projects
- Optimizing project plans within limited budgets
- Conducting EB before-after analysis for evaluating the effectiveness of projects

Features In Progress

- Systemic analysis module
- Complete local intersections
DEMO

NETWORK SCREENING
DEMO

DIAGNOSIS
THANK YOU!

Contact

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Florida Network Screening Analysis for Signalized Intersections

Alan El-Urfali, P.E.
Javier Ponce, P.E.
<table>
<thead>
<tr>
<th>Program</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CARS</td>
<td>Crash Analysis Reporting System</td>
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<tr>
<td>DHSMV</td>
<td>Department of Highway Safety and Motor Vehicles</td>
</tr>
<tr>
<td>Signal 4</td>
<td>Signal Four Analytics Crash Database</td>
</tr>
<tr>
<td>RCI</td>
<td>Roadway Characteristics Inventory</td>
</tr>
<tr>
<td>ARBM</td>
<td>All Roadway Base Map</td>
</tr>
<tr>
<td>SIS</td>
<td>Strategic Intermodal System</td>
</tr>
</tbody>
</table>

**Diagram:**
- The diagram illustrates the connections and data flow between various programs and tools.
- Programs and tools include CARS, DHSMV, Signal 4, RCI, ARBM, SIS, and ArcGIS, among others.
- They are connected through a central SQL Server, with additional tools like SharePoint, Power BI, Azure DevOps, and Tableau.
SAFE STRIDES 2 Zero Program

• Address Florida Transportation Plan goals – efficient and reliable mobility of people and freight; safety of residents and visitors

• Leverage department data, roadway characteristics, and crash data to screen roadway sites for improving safety and mobility

• Use predictive analytics for business decisions on roadway and operational improvement projects

• Track and document the return on investment
STRIDES 2 Zero Programs

SAFE

RDE

Transit

Behavior

Ped

Speed

Motorcycle

......

Bike

School

Work Zone

......
SAFE Program

• SAFE: A subprogram under STRIDES 2 Zero
• Provide network screening tool to identify roadway sites for safety improvements
  • Follow strictly the network screening guidelines in HSM
  • Focus on state highway system
  • Phase I: Signalized intersections
  • Phase II: Roadway segments and unsignalized intersections
• Enhance highway network screening practices in Florida
  • Previous prioritization method: Hot-spot analysis
  • SAFE: Quantitative evaluation with Florida-specific crash predictive models and analytical tools
FDOT Network Screening Tool (SAFE)

• FDOT homegrown tools to implement HSM Part B Roadway Safety Management Process
• SAS-based code and SAS tools (JMP Pro)
• ETL process for assembling roadway and crash data from multiple data sets
• SPFs calculated with SAS code automatically
• Network screening utilizing excess expected average crash frequency with EB adjustment (most reliable)

Note: ETL is for Extract, Transform, and Load
SAFE Methodology
FDOT Highway Safety Management Process

Safety Performance Function Development

Crash Predictive Model Application

Candidate and Sister Intersection Identification

Preliminary Diagnosis

Countermeasure Selection

Economic Appraisal

Project Prioritization

Annual Report

Implementation

Safety Effectiveness Evaluation

NETWORK SCREENING
Safety Performance Function Development

• Florida jurisdiction-specific safety performance functions (SPF) for intersection network screening analysis
  • Calculated annually and used for network screening analysis
  • No SPF calibration required

• Procedures for SPF development
  • Determine intersection groups
  • Collect intersection geometric and crash data
  • SPF regression analysis
  • SPF model verification
FDOT Context Classification

- Describe the general characteristics of the land use, development patterns, and roadway connectivity along a roadway
- Provide cues as to the types of uses and user groups that will likely utilize the roadway
- Replace the “urban”, “suburban” and “rural” classification used in previous crash predictive models

C1 – Natural
C2 – Rural
C2T – Rural town
C3R – Suburban residential
C3C – Suburban commercial
C4 – Urban general
C5 – Urban center
C6 – Urban core
Intersection Classification

• Criteria for intersection classification
  • Context classification
    • C1 to C6 based on land use category
  • Intersection traffic control mode
    • Signalized intersections only
  • Number of legs
    • 3-leg and 4-leg intersection

<table>
<thead>
<tr>
<th>Number of Legs</th>
<th>Context Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-leg</td>
<td>C1/C2/C2T/C3R/C3C</td>
</tr>
<tr>
<td></td>
<td>C4/C5/C6</td>
</tr>
<tr>
<td>4-leg</td>
<td>C1/C2/C2T</td>
</tr>
<tr>
<td></td>
<td>C3C</td>
</tr>
<tr>
<td></td>
<td>C3R</td>
</tr>
<tr>
<td></td>
<td>C4</td>
</tr>
<tr>
<td></td>
<td>C5/C6</td>
</tr>
</tbody>
</table>
Intersection and Crash Data Collection

• Intersection geometric and traffic control data
  ▪ FDOT Traffic Signal Maintenance and Compensation Agreement (TSMCA) Exhibit A
  ▪ FDOT intersection database
  ▪ FDOT Roadway Characteristics Inventory (RCI) database

• Intersection crash data
  ▪ 2017-2019 crash data from FDOT Crash Analysis Reporting System (CARS)
  ▪ Only fatal (K) and serious injury (A) crashes
  ▪ Crashes within 250 feet buffer from intersections as intersection crashes
SPF Regression Analysis and Verification

• SPF regression analysis with SAS
  ▪ Negative binomial distribution

• SPF verification
  ▪ Goodness-of-fit evaluation with cumulative residual (CURE) plot

\[ N_{predicted} = \exp(\alpha + \beta_1 \ln(AADT_{major}) + \beta_2 \ln(AADT_{minor})) \]

Where,

- \( N_{predicted} \) = predicted crashes for intersection
- \( AADT_{major} \) = major road AADT
- \( AADT_{minor} \) = minor road AADT
Crash Predictive Model Application

- Estimate predicted crashes with Florida-specific SPFs
- Determine expected crashes with Empirical Bayesian (EB) method
- Calculate excess expected crashes by subtracting predicted crashes from expected crashes
  - Will be used for selecting candidate intersections
- All analysis with SAS code

\[ w = \frac{1}{1 + k \times \sum_{\text{all study years}} N_{\text{predicted}}} \]

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

\[ N_{\text{excess}} = N_{\text{expected}} - N_{\text{predicted}} \]
Candidate Intersections

• Select candidate intersections based on excess expected crash frequency

• Identify low-cost safety countermeasures for candidates
  ▪ Collect intersection safety features to determine the applicable safety countermeasure(s) for candidates

• Apply crash modification factors (CMF) to calculate crash reduction for safety improvements

• Calculate benefit/cost ratio for intersection improvements

\[
\frac{B}{C}_{Raio} = \frac{All \ reduction \ on \ crash \ costs}{Cost \ for \ countermeasure(s)}
\]
## Countermeasures for Intersections

<table>
<thead>
<tr>
<th>Countermeasure</th>
<th>Countermeasure Description</th>
<th>CMF Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Backplates</strong></td>
<td>Add 3-inch yellow retroreflective sheeting to signal backplates</td>
<td>0.850</td>
<td>CMF Clearinghouse (CMF ID 1410)</td>
</tr>
<tr>
<td><strong>Crosswalk</strong></td>
<td>Install high-visibility crosswalk</td>
<td>0.810</td>
<td>CMF Clearinghouse (CMF ID 4124)</td>
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<tr>
<td><strong>Lighting</strong></td>
<td>Provide intersection illumination</td>
<td>0.920</td>
<td>CMF Clearinghouse (CMF ID 5421)</td>
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<tr>
<td><strong>FYA</strong></td>
<td>Install flashing yellow arrow (FYA)</td>
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<tr>
<td></td>
<td>Permissive only to protected/permisive</td>
<td>0.654</td>
<td>CMF Clearinghouse (CMF ID 7683)</td>
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<tr>
<td></td>
<td>Protected/permisive</td>
<td>0.880</td>
<td>CMF Clearinghouse (CMF ID 9667)</td>
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<tr>
<td><strong>LT Offset</strong></td>
<td>Improve left-turn lane (LT) offset to create positive offset</td>
<td>0.662</td>
<td>CMF Clearinghouse (CMF ID 6095)</td>
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<tr>
<td><strong>LT Lane</strong></td>
<td>Provide a left-turn (LT) lane</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Rural 3-leg intersection</td>
<td>0.850</td>
<td>Highway Safety Manual (Chapter 14)</td>
</tr>
<tr>
<td></td>
<td>Urban 3-leg intersection</td>
<td>0.930</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rural 4-leg intersection</td>
<td>0.820</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Urban 4-leg intersection</td>
<td>0.900</td>
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</tr>
<tr>
<td><strong>RT Lane</strong></td>
<td>Provide a right-turn (RT) lane</td>
<td>0.960</td>
<td>Highway Safety Manual (Chapter 14)</td>
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<tr>
<td><strong>LPI</strong></td>
<td>Implement a leading pedestrian interval (LPI)</td>
<td>0.870</td>
<td>CMF Clearinghouse (CMF ID 9916)</td>
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<tr>
<td><strong>DSWF</strong></td>
<td>Install dynamic signal warning flashers (DSWF)</td>
<td>0.820</td>
<td>CMF Clearinghouse (CMF ID 4201)</td>
</tr>
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</table>
Candidate and Sister Intersections

• Candidate intersections
  • Intersection with below average safety performance
  • Prioritized for safety improvements
  • Calculate crash reduction and B/C ratio for proposed safety improvements

• Sister intersections
  • Have similar intersection characteristics with candidate but above average safety performance
    • Top 5 sister intersections selected for each candidate
  • Collect safety features for sister intersections
    • Provide additional clues on possible safety improvements for candidate intersection

• SAS code to identify candidate and sister intersections automatically
### FLORIDA DEPARTMENT OF TRANSPORTATION
Traffic Engineering and Operations Office
System Analysis and Forecast Evaluation (SAFE) Candidates
Fatal and Severe Crashes at Signalized Intersections 2017-2019

<table>
<thead>
<tr>
<th>RDWYID</th>
<th>Mile Post</th>
<th>Days Between Expected KA Crashes</th>
<th>Proposed Countermeasure</th>
<th>Days Between Expected KA Crashes After Treatment</th>
<th>Expected Savings of Treatment(s)</th>
<th>Months to Reduce One KA Crash</th>
<th>BCR</th>
<th>Comments</th>
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<tr>
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<td>39.63</td>
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</table>

**Four-leg Intersections in Suburban Commercial (CSC)**

<table>
<thead>
<tr>
<th>RDWYID</th>
<th>Mile Post</th>
<th>Days Between Expected KA Crashes</th>
<th>Proposed Countermeasure</th>
<th>Days Between Expected KA Crashes After Treatment</th>
<th>Expected Savings of Treatment(s)</th>
<th>Months to Reduce One KA Crash</th>
<th>BCR</th>
<th>Comments</th>
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<tbody>
<tr>
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<td>0.688</td>
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<td>679</td>
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<td>93016000</td>
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<td>$7,783,172</td>
<td>9</td>
<td>43.75</td>
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</tbody>
</table>

**Four-leg Intersections in Suburban Residential (CHR)**

<table>
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<tr>
<th>RDWYID</th>
<th>Mile Post</th>
<th>Days Between Expected KA Crashes</th>
<th>Proposed Countermeasure</th>
<th>Days Between Expected KA Crashes After Treatment</th>
<th>Expected Savings of Treatment(s)</th>
<th>Months to Reduce One KA Crash</th>
<th>BCR</th>
<th>Comments</th>
</tr>
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<tbody>
<tr>
<td>86039000</td>
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**Four-leg Intersections in Urban General (CG)**

<table>
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<th>RDWYID</th>
<th>Mile Post</th>
<th>Days Between Expected KA Crashes</th>
<th>Proposed Countermeasure</th>
<th>Days Between Expected KA Crashes After Treatment</th>
<th>Expected Savings of Treatment(s)</th>
<th>Months to Reduce One KA Crash</th>
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<td>4,000</td>
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</table>

**Note:** Candidates in italics for duplicates with 2020 candidate list.
FDOT SPF Tool

• FDOT acquired service for SAFE program visualization and dynamic reporting
• Customized for SAFE program with additional functions for candidate and sister intersections
• Visualize 3-D graphics and evaluating safety performance interactively
Main Features for FDOT Network Screening

- State-specific safety performance functions
  - Group intersections by context classification and number of legs
  - SPFs calculated annually utilizing three-year rolling average roadway AADTs and crash data
- Select candidates based on potential safety prioritized by excess expected crashes with EB adjustment
- FDOT unique method for candidate and sister intersections comparison
- Visualize analysis results with 2-D/3-D interactive graphics
FDOT Network Screening Cost

• FDOT in-house resources
  • Initial setup, identifying data sources, and developing SAS code
• FDOT acquired services (SPFTool) Cloud-based ($25,000 per year)
• SPFTool Customization $20,000 first year
• Projected maintenance cost (Data QC and Validation) $15,000 per year
FDOT Next Steps

• Roadway segments
  • Groups
  • Segmentation Historical/Sliding window

• Unsignalized intersections
  • Groups
Questions?

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