An Innovative Approach to Proactively Evaluate Safety Performance of Future Transportation Projects

Presented by
Koushik Arunachalam, P.E.
Associate Project Manager – Traffic / ITS

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Presentation Outline

- Crash Facts
- Overview of Conventional Safety Analysis
- Emerging Techniques for Proactive Safety Analysis
- SSAM Case Study – revive 285 top end
- References / Useful Links
Crash Facts

- Motor vehicle crashes – Leading cause of death for 4-34 age group

- Crash Contributors -
  - Human
  - Roadway / Environment
  - Vehicle

Note: Economic Impact of U.S. Motor Vehicle Crashes Reaches $230.6 Billion, NHTSA Study
Conventional Safety Analysis

- Statistical analysis of historic crash data
- Review and analysis of police reported crash reports

Limitations of Conventional Safety Analysis:

- A reactive approach
- Limitations in testing effectiveness of new design alternatives
The Solution...

To develop / adopt sound procedures to evaluate / predict safety performance measures for

- New roadway designs
- Operational strategies
Safety Tool Box

SAFETY ANALYSIS TOOLS

- Highway Safety Manual (HSM)
- Surrogate Safety Assessment Model (SSAM)
- Interactive Highway Safety Design Model (IHSDM)
- Safety Analyst
- Interchange Safety Analysis Tool (ISAT)
Highway Safety Manual (HSM) – Roadway Safety Management Process (RSMP)\textsuperscript{2}
Predictive Safety Evaluation (HSM)

Application Scenarios

- Existing conditions
- Alternative designs
- New roadway designs
- Countermeasure effectiveness

Applicable Roadway Facility

- Two lane rural roadways (two-way)
- Multi-lane rural roadways
- Urban and sub-urban arterials

Safety Performance Measures

- Expected average crash frequency
  - Crash severity
  - Crash type
Predictive Safety Evaluation (HSM)²

1. Define Study Area
2. Define Period of Study
3. Determine Traffic Data, Geometric Data, Crash Data (Period Specific)
4. Select specific roadway segments / intersection
5. Assign Safety Performance Function (SPF)
6. Assign Crash Modification Factor (CMF)
7. Apply Calibration Factor for SPF's (Site-Specific)
8. Apply Empirical Bayes Models (if observed crash data is available)
9. Expected Crash Frequency – Comparative Analysis

- Function of AADT and roadway facility
- Applicable collision types – Multiple vehicle driveway/non-driveway collision, single-vehicle crashes, Vehicle-Pedestrian and Vehicle-Bicycle
- Crash severity – Fatal-Injury and PDO

- Adjusts SPF for geometric design and traffic control features
- CMF’s available for variety of strategies. Examples: Left turn lane (0.66), signal phasing (0.94), Red-light cameras (0.74 Angle, 1.18 rear end)

² Highway Safety Manual
Interchange Safety Analysis Tool (ISAT)

- Evaluates safety impacts of geometric design and traffic control features
- Spreadsheet tool
- Evaluates freeway system and service interchanges, Isolated and series of interchanges
- Safety performance functions (SPF) built-in to the tool
- Historic crash data (up to 10 years) can be input, if available
- Combines crash data and predicted crashes using Empirical Bayes methodology

**Outputs**
- Predicted crashes by interchange element (ramp, intersections, arterial and freeway)
- Predicted crashes by type
- Predicted crashes by year
“Conflict Analysis” based safety evaluation technique

A conflict is defined as an observable situation in which two or more road users approach each other in time and space to such an extent that there is risk of collision if their movements remain unchanged.

Federal Highway Administration (FHWA) tool for comparative safety evaluation

A post processor that combines microscopic simulation and automated conflict analysis
Surrogate Safety Assessment Model – Work Flow

1. Define Thresholds for the following Surrogate Safety Measures:
   - Minimum Time-To-Collision (TTC)
   - Minimum Post-Encroachment (PET)
   - Initial Deceleration Rate (DR)
   - Maximum Deceleration Rate (MaxD)
   - Maximum Speed (MaxS)
   - Maximum Speed Differential (Delta S)
   - Vehicle Velocity Change (Delta V)

2. Generate Vehicle Trajectory Data (.trj file) from VISSIM for each Design Alternative

3. Input Vehicle Trajectory Data (.trj file) to SSAM Post Processor

4. Integrate design and operational improvements to VISSIM model

5. Estimate possible conflict causes

6. Estimate and analyze the type and incidence of conflicts

7. Perform comparative analysis using T-test and F-test

8. Estimate reduction in conflicts between design alternatives

9. Integrate with other performance measures related to mobility and traffic congestion

10. Identify preferred design alternative

Critical conflict areas:

YES

NO
Rated in top 35 most travelled roadways in the US

Project length – 17 Miles

Key project need – “Provide safer travel conditions along I-285”

http://www.fhwa.dot.gov/policyinformation/tables/02.cfm
Why SSAM for safety evaluation?

- Complex nature of traffic operations
- Shockwave effect due to operational impacts from adjacent interchanges
- An approach to capture safety impacts of dynamic nature of traffic operations
- Ability to capture temporal variation of traffic on safety
- Ability to indirectly capture impacts of heavy vehicles on safety
### SSAM Case Study

#### Define crash to conflict relationship

- Crash Data Sieving
- Estimate conflict rate for existing conditions
- Preliminary statistical analysis

<table>
<thead>
<tr>
<th>Segment</th>
<th>Number Of Crashes</th>
<th>Percent Vehicle Only Crashes</th>
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</thead>
<tbody>
<tr>
<td>I-285 Eastbound from Cobb Pkwy to I-75</td>
<td>62</td>
<td>79%</td>
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<tr>
<td>I-285 Eastbound from I-75 to Northside Pkwy</td>
<td>127</td>
<td>80%</td>
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<tr>
<td>I-285 Eastbound from Northside Pkwy to Riverside Dr</td>
<td>77</td>
<td>83%</td>
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<tr>
<td>I-285 Eastbound from Riverside Dr to Roswell Rd</td>
<td>141</td>
<td>87%</td>
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<tr>
<td>I-285 Eastbound from Roswell Rd to SR 400</td>
<td>144</td>
<td>91%</td>
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<tr>
<td>I-285 Eastbound from SR 400 to Ashford Dunwoody Rd</td>
<td>129</td>
<td>88%</td>
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<tr>
<td>I-285 Eastbound from Ashford Dunwoody Rd to Chamblee Dunwoody Rd</td>
<td>109</td>
<td>92%</td>
</tr>
<tr>
<td>I-285 Eastbound from Chamblee Dunwoody Rd to Peachtree Industrial Blvd</td>
<td>267</td>
<td>94%</td>
</tr>
<tr>
<td>I-285 Eastbound from Peachtree Industrial Blvd to Buford Hwy</td>
<td>169</td>
<td>96%</td>
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<tr>
<td>I-285 Eastbound from Buford Hwy to I-85</td>
<td>188</td>
<td>91%</td>
</tr>
<tr>
<td>I-285 Eastbound from I-85 to Chamblee Tucker Rd</td>
<td>96</td>
<td>81%</td>
</tr>
<tr>
<td>I-285 Westbound from Cobb Pkwy to I-75</td>
<td>39</td>
<td>85%</td>
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<tr>
<td>I-285 Westbound from I-75 to Northside Pkwy</td>
<td>170</td>
<td>91%</td>
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<td>I-285 Westbound from Northside Pkwy to Riverside Dr</td>
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<td>92%</td>
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<tr>
<td>I-285 Westbound from Peachtree Industrial Blvd to Buford Hwy</td>
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<td>97%</td>
</tr>
<tr>
<td>I-285 Westbound from Buford Hwy to I-85</td>
<td>122</td>
<td>80%</td>
</tr>
<tr>
<td>I-285 Westbound from I-85 to Chamblee Tucker Rd</td>
<td>81</td>
<td>75%</td>
</tr>
</tbody>
</table>

**Average**: 124, **Minimum**: 39, **Maximum**: 267, **Standard Deviation**: 47, **Correlation**: 0.70
Define crash to conflict relationship

- Regression Analysis
- Fitted curve analysis

<table>
<thead>
<tr>
<th>ID</th>
<th>Regression Equation</th>
<th>R Square</th>
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</thead>
<tbody>
<tr>
<td>A</td>
<td>Crash rate = 41.21(Conflict rate)^{0.1116}</td>
<td>0.55</td>
</tr>
<tr>
<td>B</td>
<td>Crash rate = 180.67 e^{(2E-8 \times \text{Conflict rate})}</td>
<td>0.75</td>
</tr>
<tr>
<td>C</td>
<td>Crash rate = 1.36E - 5 \times \text{Conflict rate}</td>
<td>0.63</td>
</tr>
<tr>
<td>D</td>
<td>Crash rate = 5E - 6 \times \text{Conflict rate} + 178.52</td>
<td>0.758</td>
</tr>
<tr>
<td>E</td>
<td>Crash rate = (Conflict rate)^{0.3586}</td>
<td>0.99</td>
</tr>
<tr>
<td>F</td>
<td>Crash rate = 15.222 \times \ln(\text{Conflict rate})</td>
<td>0.96</td>
</tr>
</tbody>
</table>
Expected Crash Rates By Alternatives

- Identify conflict hot spots
- Roadway design refinements
- Estimate conflict rates for future alternatives
- Predict crash rates based on regression equation “B” or “D”

### Before
- C-D Lanes

### After
- Braided Ramps (Eliminates weaving)

Based on regression equation “B” or “D”
Comparative Analysis

- Segment level crash rate comparison
SSAM Case Study -

Operations Vs. Safety – Side by Side Comparison

AM Peak LOS

PM Peak LOS

Predicted Crash Rate

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SSAM Case Study - Operations Vs. Safety – Side by Side Comparison
Conclusions...

- Be Proactive and not reactive - Include safety evaluation as part of project development process

- Tool selection from Safety Tool Box should align with your project needs and complexity

- Tools are just tools, use your engineering judgment to obtain meaningful, reasonable and defendable outputs
References / Useful Links

- US Department of Transportation (2008), Surrogate Safety Assessment Model (SSAM): Tech Brief, Publication No. FHWA-HRT-08-049
- US Department of Transportation (2008), Surrogate Safety Assessment Model and Validation: Final Report, Publication No. FHWA-HRT-08-051
- US Department of Transportation (2007), Safety Assessment of Interchange Spacing on Urban Freeways, Publication No. FHWA-HRT-07-031
- http://safety.fhwa.dot.gov/
- Highway Safety Manual
Imagine the result

Contact Information:

Koushik Arunachalam, PE

Koushik.arunachalam@arcadis-us.com

713-953-4723