HSM Freeway and Ramps Calibration For Pennsylvania

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Reasons for Crash Prediction Models

Why PennDOT is using the HSM for safety analysis

- Data Driven Safety Analysis
- Accurately locates true safety needs
- Develop projects that have the best safety impact
- Can predict the safety impact a proposed project will have
- Allows for a impartial network screening of Highways
- Accounts for regression to the mean

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Where is PennDOT Currently at

Accomplishments to Date

- Regionalized SPFs for:
  - Two-Lane, Two-way Rural Roads
  - Multi-lane Divided & undivided Rural Roads
  - Urban/Suburban Arterial Roadways
  - Urban/Suburban Collector Roadways (March 2019)

- 1st network screening based on HSM methodology
  - Screened all 67 counties (about 20,000 locations)
- Created Publication 638A, The Pennsylvania Safety Predictive Analysis Methods Manual (PA-SPAMM)
- Publication 638 May 2019 Update
  - Requires HSM analysis for HSIP project applications

Predictive Analysis Uses

- HSIP program
  - Enhanced network screening based excess crash frequency values
  - All location specific project applications must now use HSM analysis to justify the safety need and show the project safety impacts
  - Now require BCAs for project applications
- Using HSM in Project Development
  - Purpose and Needs studies
  - Design exceptions
  - Design optimization
  - Routine traffic engineering and safety studies
- HOP evaluations
  - We now have Traffic Impact Studies that use HSM methodologies to quantify safety impacts of development

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Where PennDOT Plans to Go

What Needs Done

- Incorporate other facility types into analysis by calibration or SPF development
  - Freeways & Ramps
  - Roundabouts
  - One-way streets
  - Others
- Need to expand network screening
  - More locations
  - More facility types
- Need to include analysis for Freeways and Ramps
  - Calibrate 2014 SPFs for Freeways, Ramps, and Ramp Terminals
  - Add to network screening
- Calibration was the best option for Freeways and Ramps

HSM Predictive Method (Part C)

Ch	Title	National Publication	Pennsylvania Status
10	Rural Two-Lane Two-Way Roads	HSM 1st Edition, 2010	PA SPFs* created
11	Rural Multilane Highways	HSM 1st Edition, 2010	PA SPFs* created
12	Urban and Suburban Arterials	HSM 1st Edition, 2010	PA SPFs* created
18	Freeways	HSM Supplement, 2014	PA calibration ongoing
19	Ramps	HSM Supplement, 2014	PA calibration ongoing

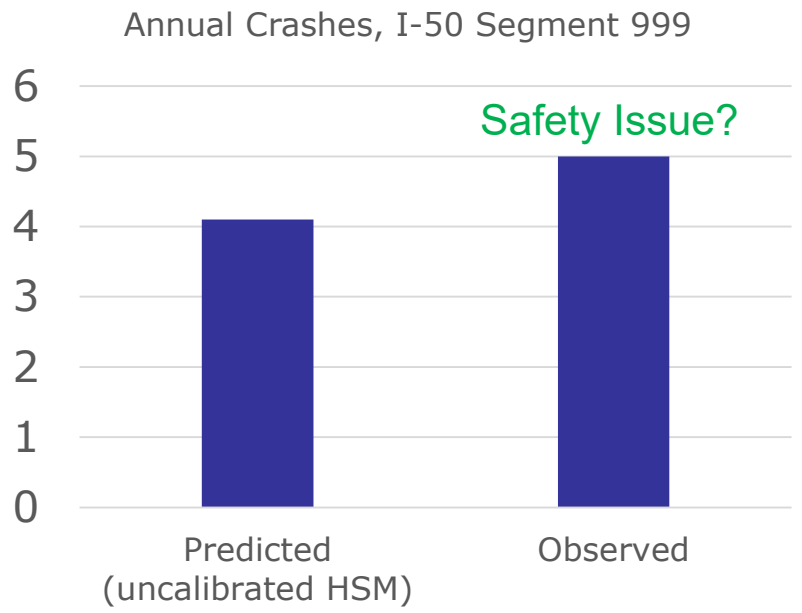
* Safety Performance Functions

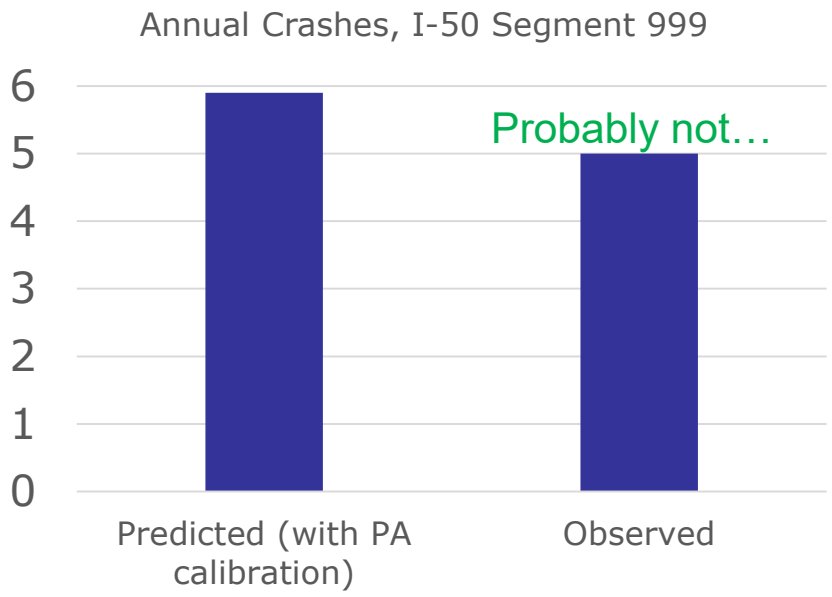
What is Calibration

- Differences in safety performance (crash frequency) are known to occur from state-to-state
  - Weather
  - Police crash reporting thresholds
  - Driver population (behavior, demographics, etc.)
  - Current and historical design practices
  - Vehicle mix
  - Terrain
  - Other factors not accounted for in models
- Calibration uses a large sample of data to compute a state-specific "adjustment" (calibration factor) to make HSM procedures more reliable in a given state

Why Calibration

- More reliable results for alternatives analysis, design exceptions
- Different results for network screening





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HSM CH 18 and 19 Site Types

- Basic Freeway Segments
- Speed Change Lanes
- Ramp Terminal Intersections
- Ramps
- Collector-Distributor Roads (not enough in Pennsylvania for calibration)

Behind the Scenes

- Dozens of Safety Performance Functions (SPFs)
  - Rural vs. Urban
  - Different numbers of lanes
  - Different forms of control
  - Multiple SPFs for a given site, summed to get total crashes
    - PDO and fatal+injury
    - Single vehicle and multi-vehicle
- Calibration process groups some SPFs together to reduce data needs

Calibration Data Needs

- Crash Data
  - Minimum of 30 sites and 100 crashes for each group of calibration factors
  - In practice, having 100 crashes of the rarest type (such as single vehicle fatal+injury) determined sample size
  - Years 2013-2017 used for this project
- AADT
- Geometric and traffic control variables required by HSM models

Site Selection

- Equal number of sites selected from following geographic areas
  - Districts 1 and 2
  - Districts 3 and 4
  - Districts 5 and 8
  - District 6
  - Districts 9 and 10
  - Districts 11 and 12
- Within each district pair, sites randomly selected from RMS list

Computing the Results

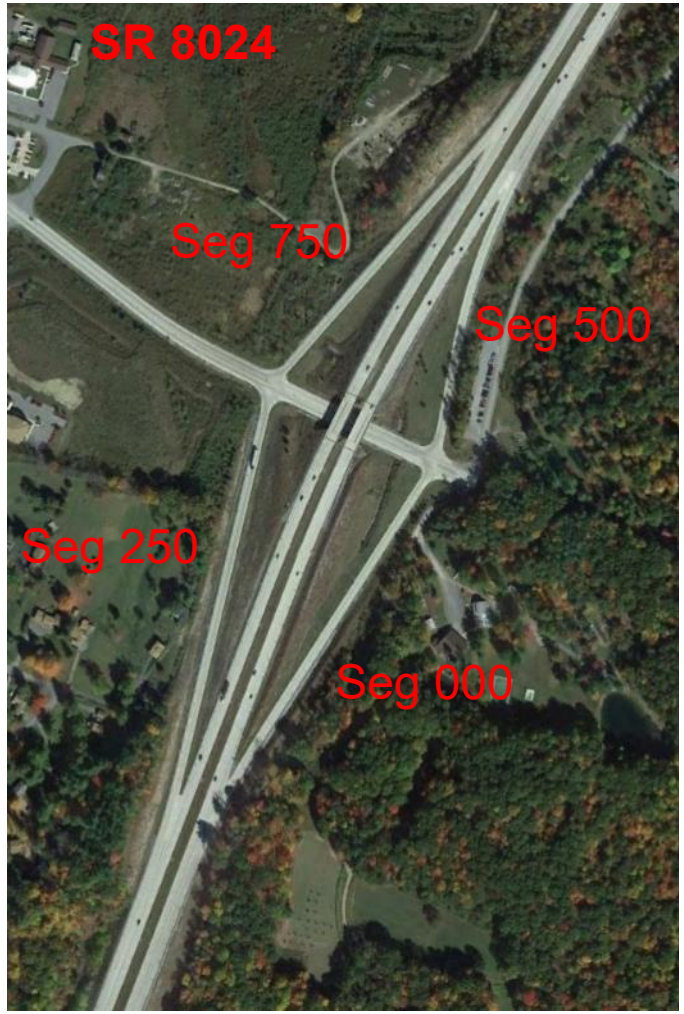
	Observed Crashes (i.e. crash data)	Predicted Crashes (i.e. HSM Results)
Site 1	5	4.3
Site 2	12	16.8
…	…	…
Total	120	100

Calibration Factor = C = 120/100 = 1.2

Highway Safety Manual Second Edition will increase emphasis and information on calibration

Data Challenges – crash coding

- Review of ramp crash narratives revealed assignment of crashes to wrong ramps within an interchange
- Every narrative from the crashes on 660 ramps reviewed, crashes reassigned as appropriate/possible
- PennDOT addressing the issue for crash data in future years



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Assessing the Results

- The Calibrator (FHWA Tool)
  - Outlier identification with scaled residuals
    - Sites where observed and predicted crashes are substantially different relative to other sites
    - Could indicate data issues or highly unique sites
  - Statistical analysis of the quality of the data
    - Coefficient of Variation – are site-to-site differences greater than what would naturally be expected?
    - Indicates if results will be reliable

More Data Challenges

- Ramps
  - PennDOT curve database found to be inaccurate
  - Manual curve measurements being done
- Speed Change Lanes
  - Coefficient of Variation high
  - Calibration effort stopped

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Pennsylvania Calibration Factors

Site Type	Fatal+Injury Multi-Vehicle	Fatal+Injury Single-Vehicle	PDO Multi-Vehicle	PDO Single-Vehicle
Basic Freeway Segment	1.64	1.13	0.87	1.15
Signalized Ramp Terminal	1.03		0.93	
Stop-Controlled Ramp Terminal	1.71		1.35	
Entrance Ramp	Exp. Feb. 2020	Exp. Feb. 2020	Exp. Feb. 2020	Exp. Feb. 2020
Exit Ramp	Exp. Feb. 2020	Exp. Feb. 2020	Exp. Feb. 2020	Exp. Feb. 2020

Speed Change Lanes and Collector-Distributor Roads – No PA calibration factors (use 1.00)

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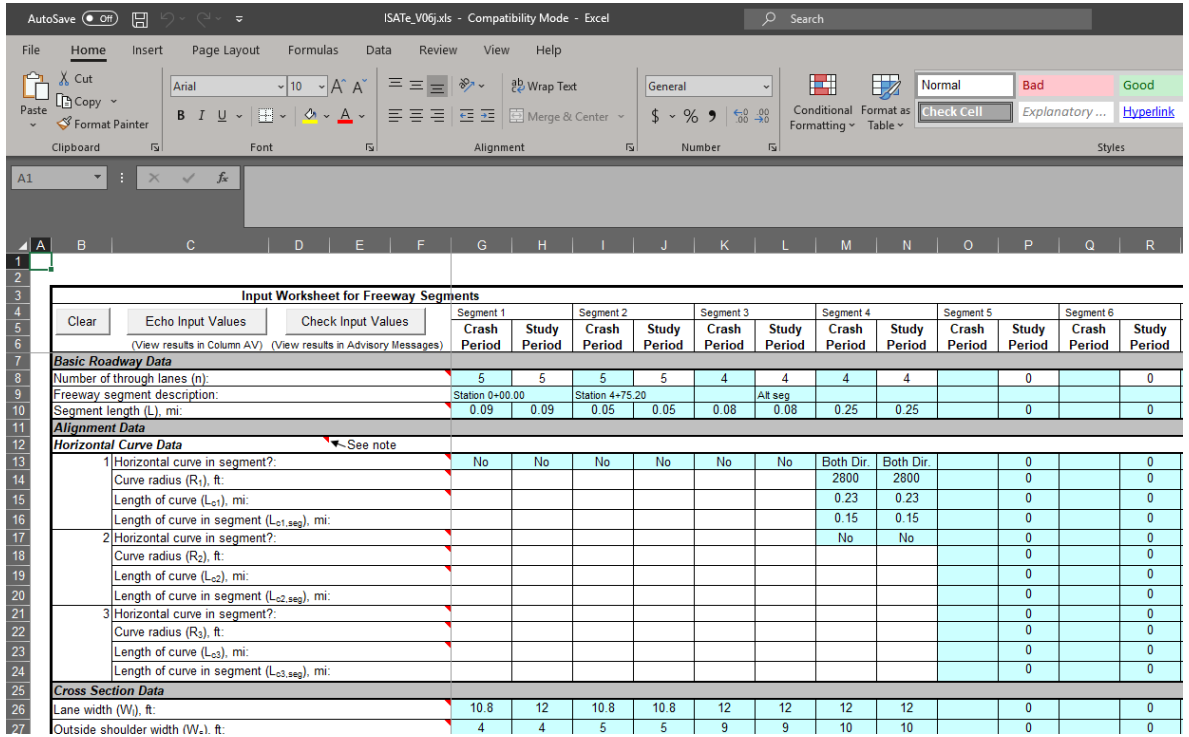
How to use the results

- Interactive Highway Safety Design Module
- Enhanced Interchange Safety Analysis Tool (ISATe)
  - http://www.highwaysafetymanual.org/Pages/Tools.aspx
  - Version with PA calibration factors pre-loaded will be available on PennDOT website



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I-81 Improvement Strategy for South Central Pennsylvania

Application of Pennsylvania Statewide Calibration Factors To the HSM Predictive Method

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Project Overview, Goal, and Purpose

- Overview: Key transportation planning partners in the region are working together on a no-borders evaluation of 100 miles of Interstate 81 (I-81) / Interstate 78 (I-78) in South Central Pennsylvania.
- Goal: Establish a strategy to address needs within the corridor related to safety, congestion, infrastructure condition, access, and relevant connecting roads.
- Purpose: Allow the strategy to serve as a playbook for prioritization for funding future projects via the Statewide Transportation Improvement Program and regional long-range transportation plans.

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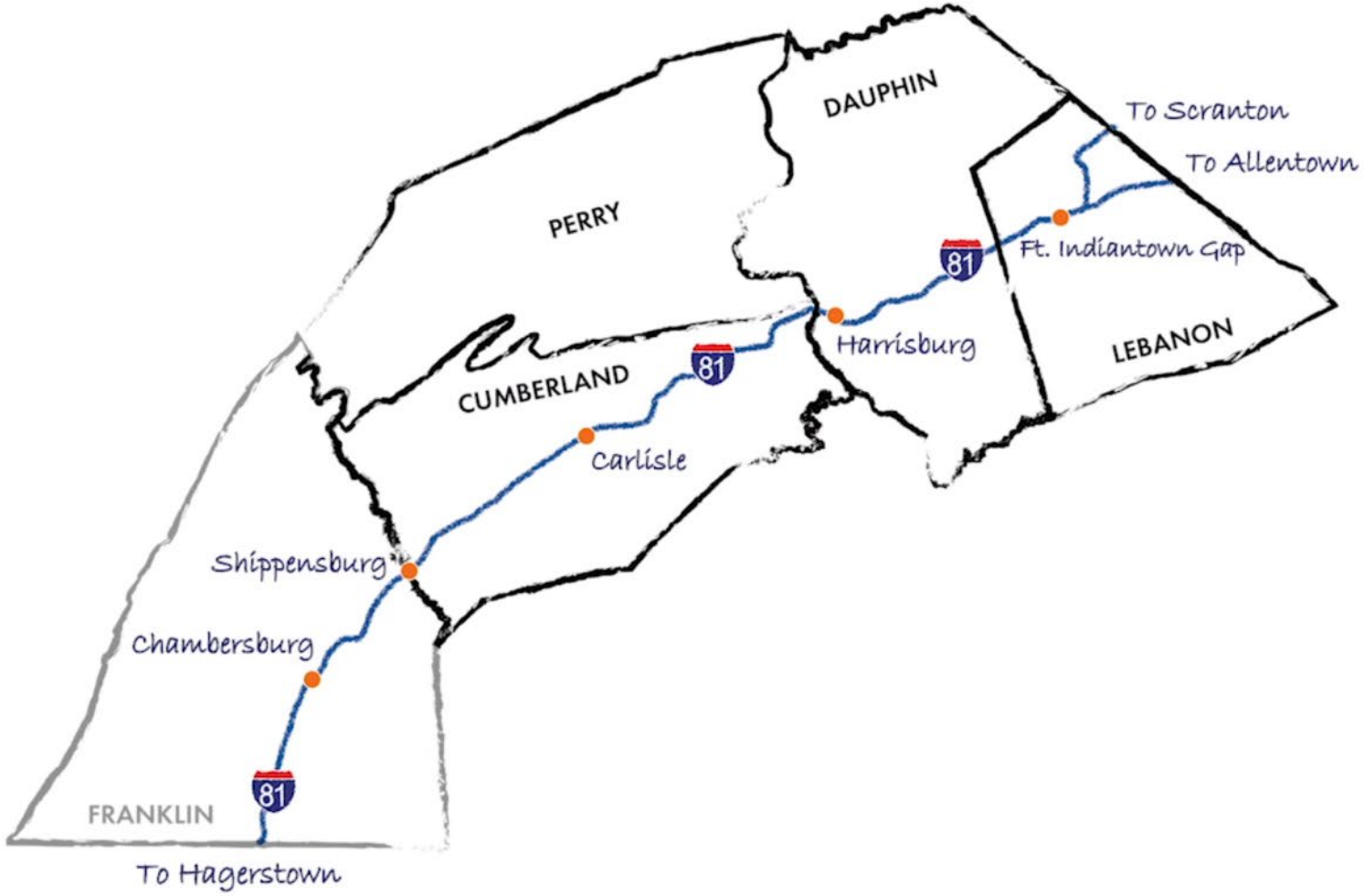
Study Area



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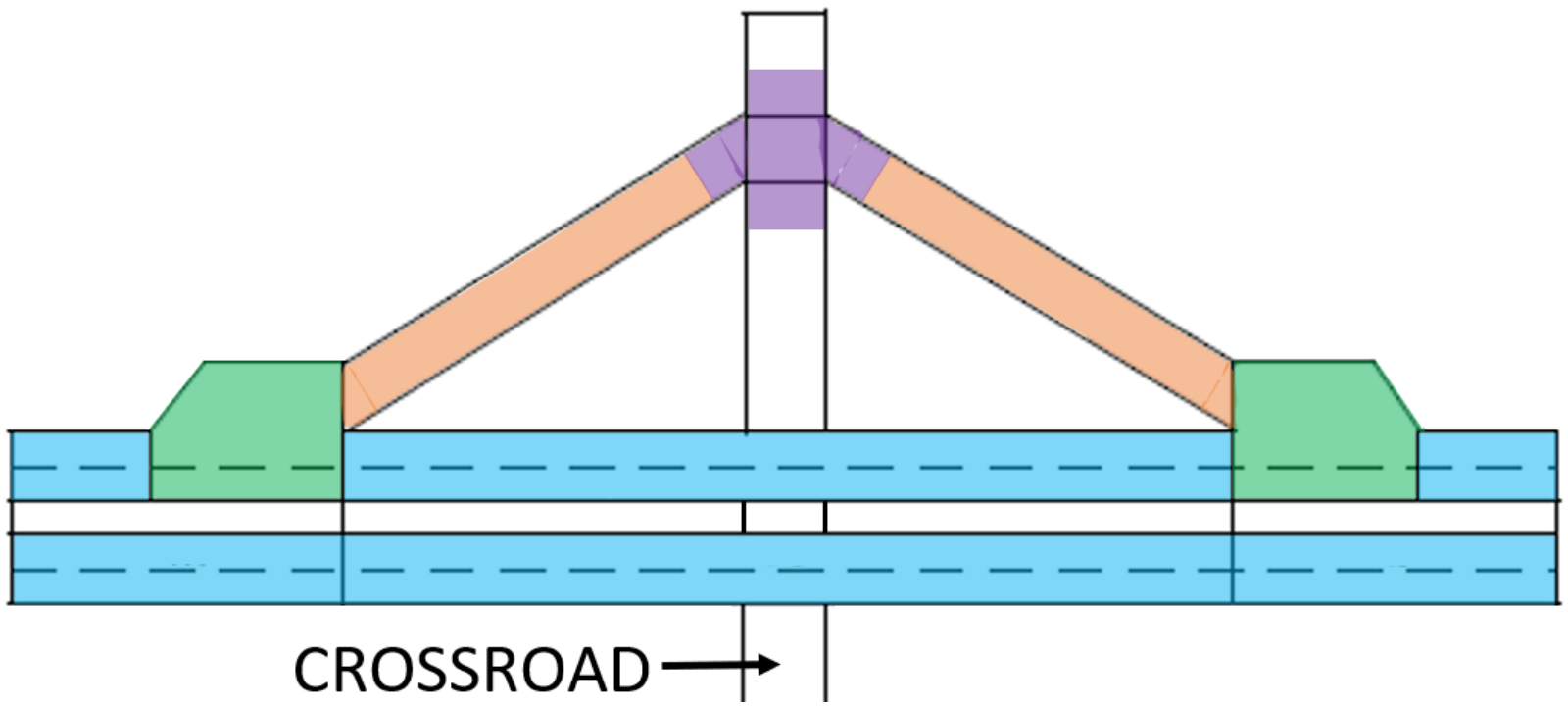
Project Team

- Metropolitan Planning Organizations
  - Tri-County Regional Planning Commission
  - Franklin County Planning Department
  - Lebanon County Planning Department
- Pennsylvania Department of Transportation
- Federal Highway Administration
- Michael Baker International, Inc.

Safety Approach

- Performed a network screening for the I-81 / I-78 corridor.
- Utilized Highway Safety Manual predictive methods for:
  - Freeway Segments
  - Speed Change Lanes
  - Ramps
  - Ramp Terminals
- Applied Statewide Calibration Factors
- Created a custom application to complete the analysis



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Freeway Network Screening Analysis

- Evaluated freeway segments, speed change lanes, ramps, and ramp terminals.
- Calculated predicted crashes and adjustment factors (Part C CMFs)
- Utilized PennDOT RMS data, PennDOT's curve database, and PennDOT crash data.
- Manually collected data that was not readily available.
- Established an excess cost for ease of comparison.

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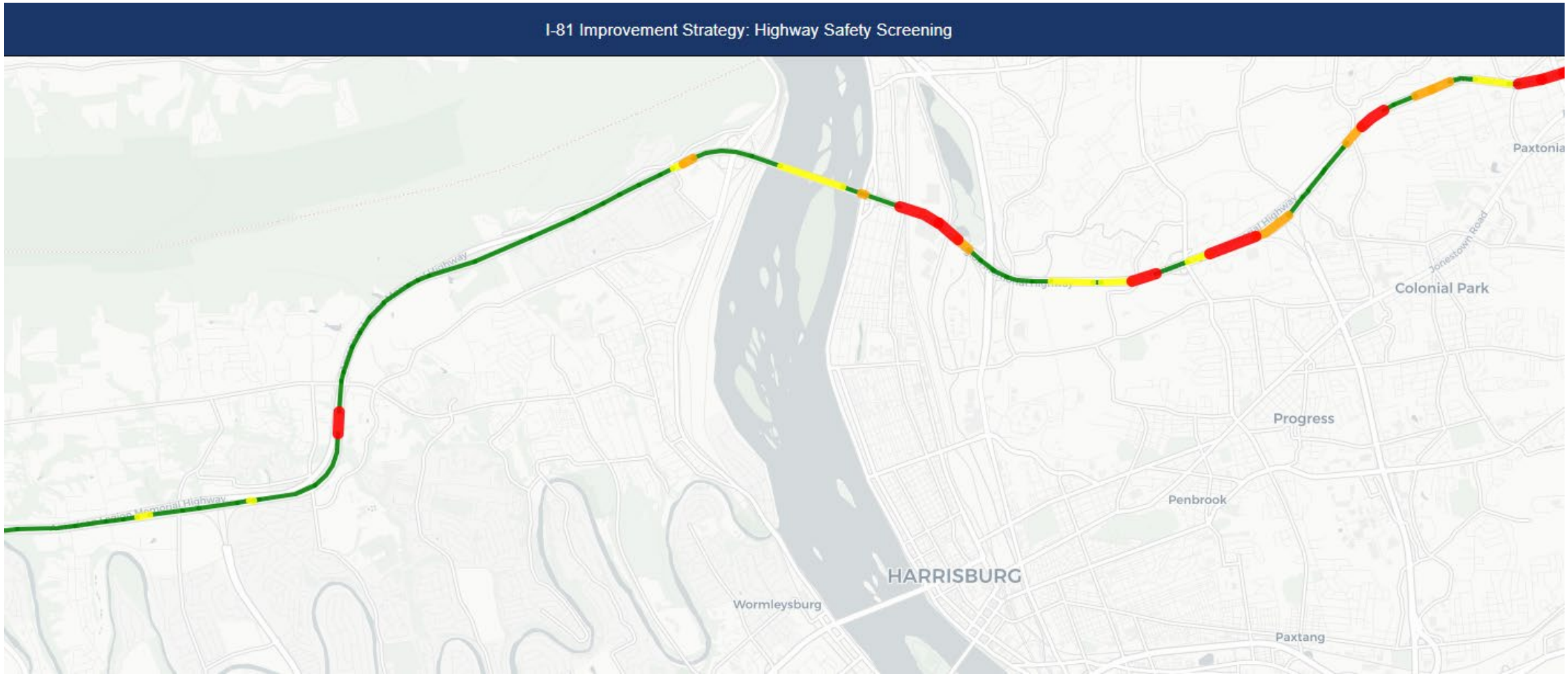
Geographical Depiction of Safety Performance



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Preliminary Results

A cursory review has revealed seemingly obvious safety issues.

EXAMPLE 1:

- Highest potential safety benefit of all speed change lanes
- Deficient acceleration length with shoulder reduction from 8 feet to 2 feet

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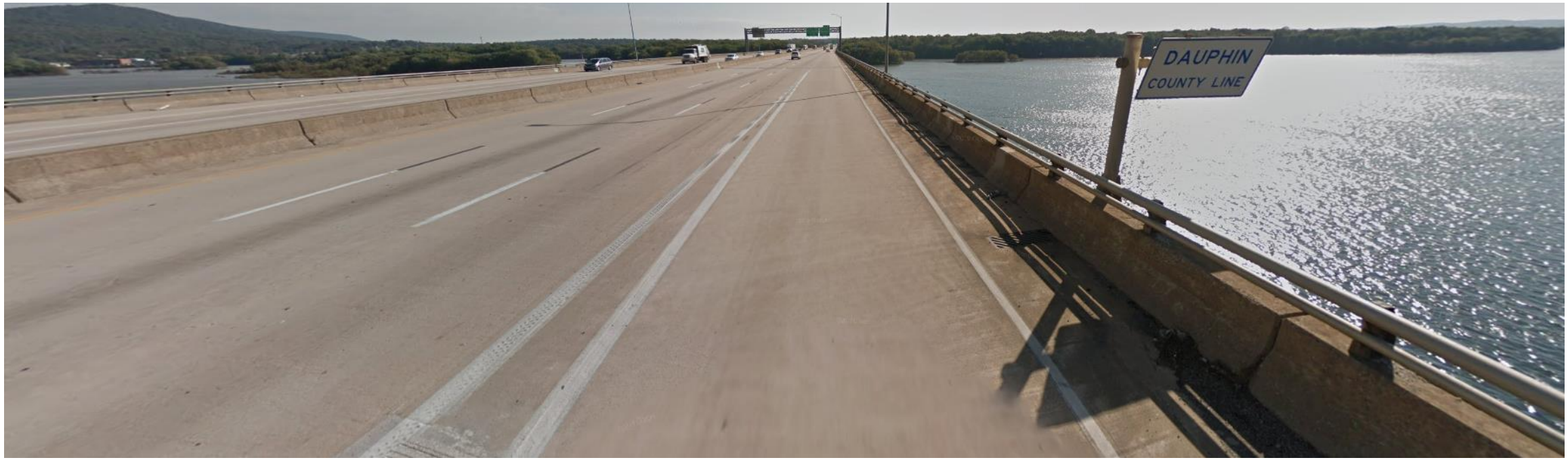
Preliminary Results

EXAMPLE 2:

- Relatively high potential for safety improvement
- Deficient acceleration length
- Missing yield sign



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Next Steps

- Investigate locations with high excess values.
- Modify the existing network in order to quantify safety benefit of potential projects.
- Utilize safety results (and other categories) to prioritize funding for future projects.

Contact Information

Jason Hershock
PA Dept of Transportation
(717) 705-1437

Pete Jenior, PE, PTOE
Kittelson & Associates, Inc.
(443) 524-9432

Ben Brubaker, PE, PTOE
Michael Baker International, Inc.
(717) 221-2084

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