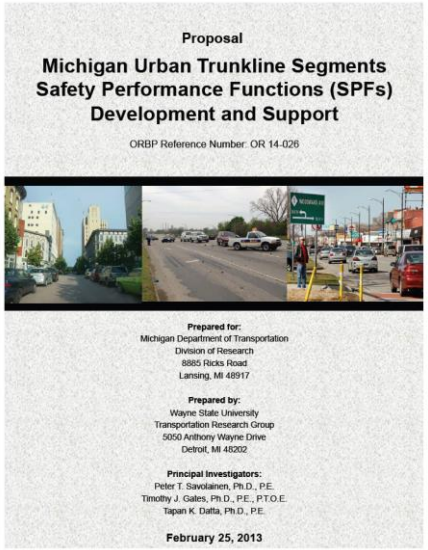
Michigan Urban Trunkline Intersections & Segments Safety Performance Functions (SPFs) Development and Support (OR14-015 & OR14-026)


Proposal

Michigan Urban Trunkline Segments Safety Performance Functions (SPFs) Development and Support

ORBP Reference Number: OR 14-026

Prepared for:
Michigan Department of Transportation
Division of Research
8885 Ricks Road
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February 25, 2013

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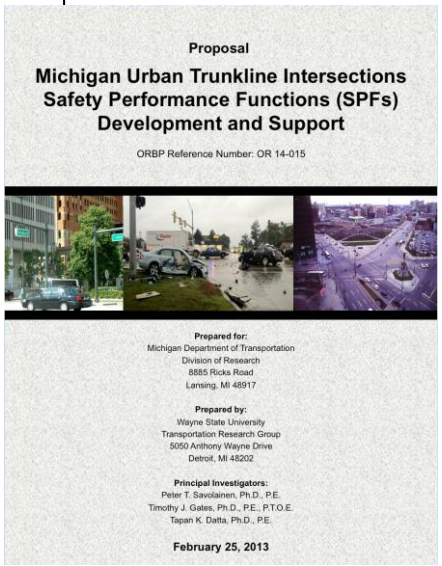
Proposal

Michigan Urban Trunkline Intersections Safety Performance Functions (SPFs) Development and Support

ORBP Reference Number: OR 14-015

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Overview

- Background on SPFs
- Study Objectives
- Methodology
- Recent and Ongoing Work

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What is an SPF?

- Predict crashes
- Relate crash data to site characteristics
  - AADT
  - Number of lanes
  - Etc.
- Screen transportation networks
- Estimate impacts of roadway improvements
- Evaluate effectiveness of safety improvements

Safety Performance Function Decision Guide: SPF Calibration versus SPF Development Final Report. The University of North Carolina Highway Safety Research Center, September 2013.

Study Objectives

- Review and summarize previous and existing efforts to generate Safety Performance Function(s) for agencies.
- Develop SPFs for each of the selected intersections and road segment types.
- Define a maintenance cycle and process for updating SPFs.

Areas of Input from MDOT

- How will these SPFs ultimately be utilized by MDOT?
  - Network screening
  - Safety evaluation

- SPFs → How complex?
  - AADT-only
  - Region-specific AADT-only
  - AADT-only w/regional indicators
  - Full model w/site characteristics

Intersection Types

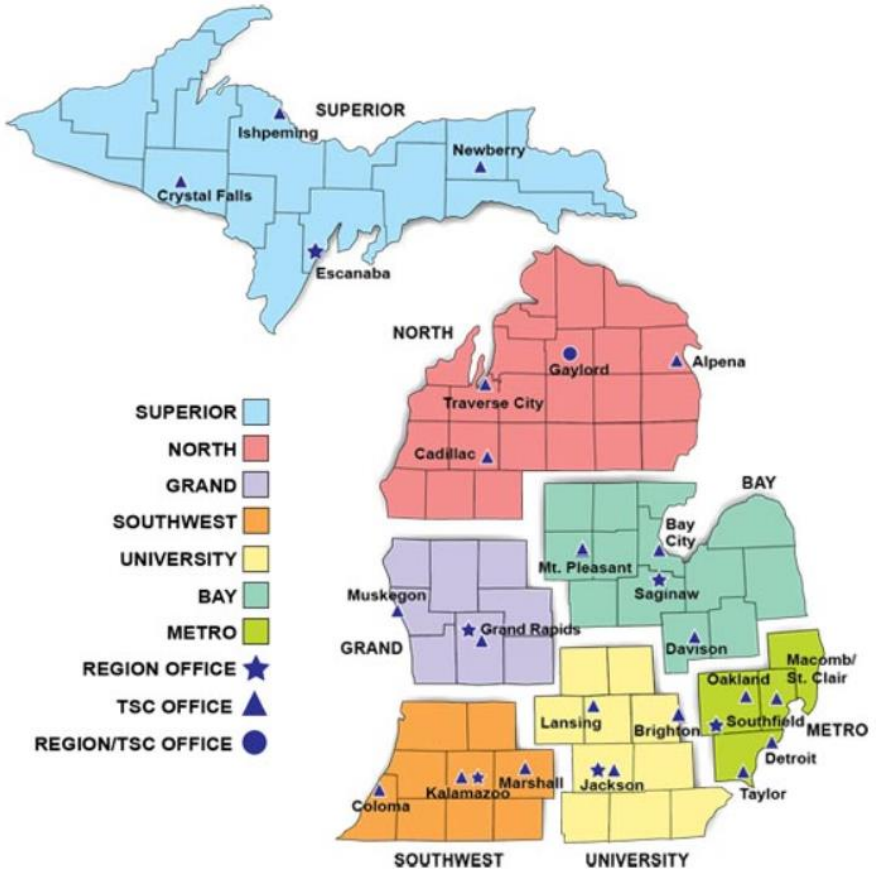
3-Leg, Minor Approach STOP Controlled
(N = 5,731 Sites)

3-Leg Signalized
(N = 485 Sites)

4-Leg, Minor Approaches STOP Controlled
(N = 2,695 Sites)

4-Leg Signalized
(N = 1,710 Sites)

MDOT Regions



Detailed Site Data Collection

- Use of Google Earth for Collection of:
  - Geometric data (number of lanes, skew angle, road width, etc.)
  - Spatial data (schools, bus stops, bike lanes)
- Goal of 50 sites per region for each intersection type

Count of Sites by Intersection Type and MDOT Region								
Intersection Type	**Superior**	**North**	**Grand**	**Bay**	**Southwest**	**University**	**Metro**	**Total**
3SG	9	24	26	21	38	38	55	211
3ST	50	51	51	50	51	50	50	353
4SG	48	50	51	50	52	50	50	351
4ST	50	50	50	50	50	50	50	350

Areas of Input from MDOT

- Crash Type → How specific?
  - HSM crash types
  - MSP crash type
  - MDOT crash type

- Crash Severity → How specific?
  - K, A, B, C, O
  - K/A/B/C, O
  - K/A, B/C/O

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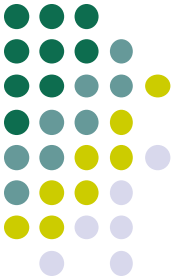
Regional and Statewide Severity Distributions by Intersection Type



Region-specific and Statewide Total Crashes by Severity and Intersection Type									
Intersection Type	Crash Severity	Superior %	North %	Grand %	Bay %	Southwest %	University %	Metro %	Statewide %
3ST	PDO	75.2	84.1	68.0	82.2	78.6	80.7	80.7	78.6
	Fatal/Injury	24.8	15.9	32.0	17.8	21.4	19.3	19.3	21.4
	Total	100.0	100.0	100.00	100.0	100.0	100.0	100.0	100.0
4ST	PDO	76.2	77.4	74.1	71.5	72.3	73.5	71.3	73.8
	Fatal/Injury	23.8	22.6	25.9	28.5	27.7	26.5	28.7	26.2
	Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3SG	PDO	78.2	80.8	78.7	75.4	76.8	76.7	74.8	77.3
	Fatal/Injury	21.8	19.2	21.3	24.6	23.2	23.3	25.2	22.7
	Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
4SG	PDO	72.9	79.1	76.1	76.2	81.4	76.0	75.6	77.1
	Fatal/Injury	27.1	20.9	23.9	23.8	18.6	24.0	24.4	22.9
	Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

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Crash Type Distributions by Region
Signalized Intersections

3 Leg Signalized Intersections: Proportions of Multi-Vehicle and Single Vehicle Collisions by Region								
Collision Type	**Superior**	**North**	**Grand**	**Bay**	**Southwest**	**University**	**Metro**	**Total**
Rear-end collision	57.3	50.3	56.1	48.7	49.1	49.1	53.4	52.1
Head-on collision	6.6	9.6	4.1	6.6	6.6	5.9	4.4	5.6
Angle collision	16.4	20.8	15.4	22.5	25.2	22.7	19.6	20.5
Sideswipe	8.4	8.3	12.1	11.0	9.2	8.4	12.1	10.7
Other multiple-vehicle collisions	0.0	0.0	0.2	0.0	0.4	0.0	0.1	0.1
Single Vehicle Collisions	11.3	11.0	12.1	11.3	9.5	13.9	10.4	11.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

4 Leg Signalized Intersections: Proportions of Multi-Vehicle and Single Vehicle Collisions by Region								
Collision Type	**Superior**	**North**	**Grand**	**Bay**	**Southwest**	**University**	**Metro**	**Total**
Rear-end collision	42.4	48.4	51.2	39.5	46.7	42.8	48.5	46.6
Head-on collision	8.0	7.9	6.5	8.0	6.1	6.5	6.1	6.5
Angle collision	32.6	28.3	25.8	34.8	28.6	31.3	26.1	28.4
Sideswipe	9.1	8.9	9.7	11.5	10.3	12.4	12.5	11.6
Other multiple-vehicle collisions	0.2	0.0	0.4	0.0	0.2	0.1	1.0	0.5
Single Vehicle Collisions	7.8	6.6	6.4	6.1	8.1	6.9	5.9	6.4
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

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Using the SPFs

- Generic Form of Equation
  - $N_{total} = exp(a + b * ln(AADT_{maj}) + c * ln(AADT_{min}))$
- Michigan Statewide Values for 4SG
  - $N_{statewide} = exp(-7.834 + 0.792 * ln(15,000) + 0.235 * ln(9,000)) = 6.830$ crashes/year
- Region Specific Values for 4SG
  - $N_{regionspecific} = exp(-9.196 + 0.924 * ln(15,000) + 0.234 * ln(9,000)) = 6.169$ crashes/year

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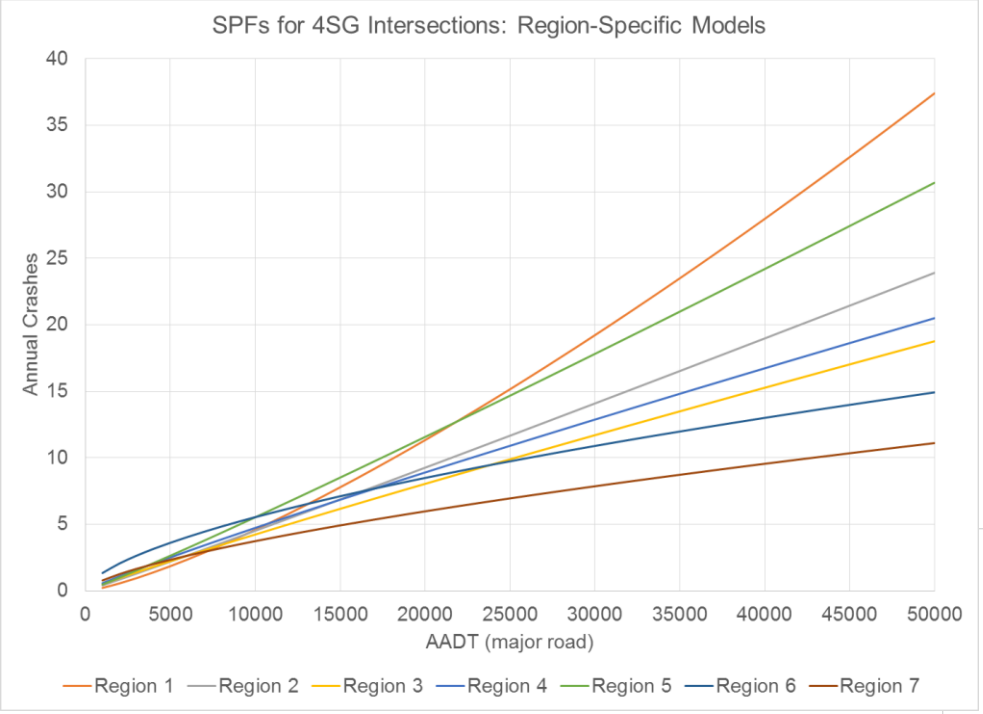

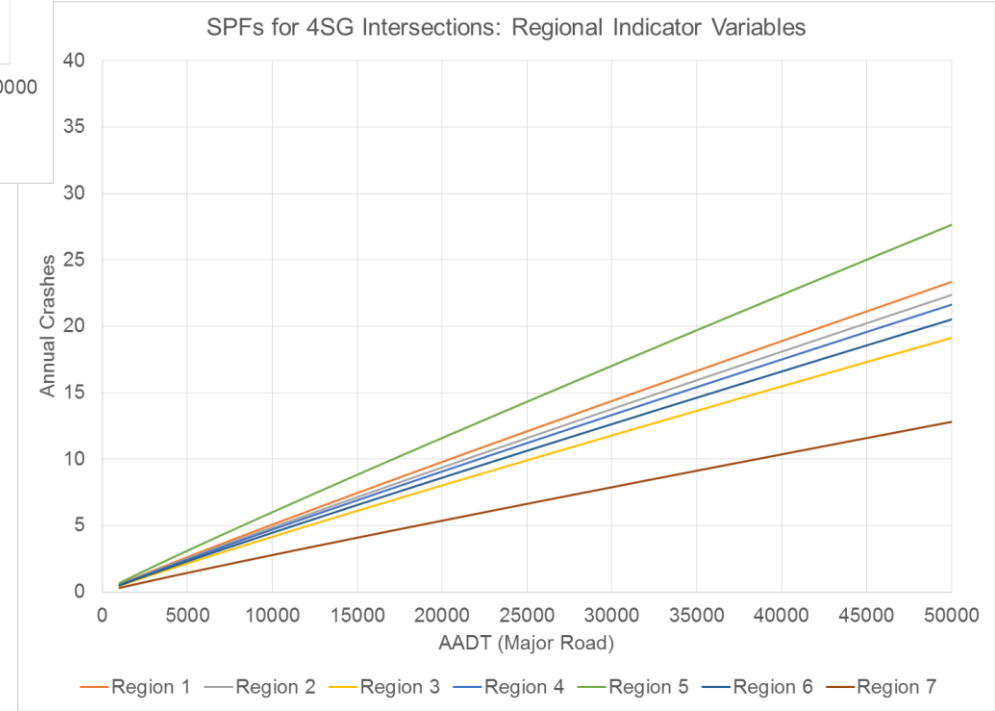

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4-Leg Signalized (4SG)

Safety Performance Function		
Model Parameters	**B**	**P-value**
Intercept	-8.066	0.000
Natural Log of Major Rd AADT	0.644	0.000
Natural Log of Minor Rd AADT	0.159	0.000
Major Rd Number of Incoming Lanes	0.128	0.000
Minor Rd Number of Incoming Lanes	0.162	0.000
Presence of Sidewalk on Minor Rd	0.174	0.000
Presence of Right Turn on Red (on either road)	0.386	0.000
Major Rd Number of Driveways	0.028	0.000
Minor Rd Number of Driveways	-0.021	0.004
Presence of Bicycle Lane Minor Rd	0.319	0.001
Presence of Parking on Major Rd Roadside	-0.246	0.000
Presence of Median on Minor Rd	-0.423	0.000
Presence of Storage Lane on Major Rd	-0.104	0.006
Presence of Left Turn Lane on Minor Rd	-0.225	0.000
MDOT Superior Region	0.602	0.000
MDOT North Region	0.685	0.000
MDOT Grand Region	0.411	0.000
MDOT Bay Region	0.680	0.000
MDOT Southwest Region	0.910	0.000
MDOT University Region	0.626	0.000
Over-dispersion Parameter	**0.19607**	

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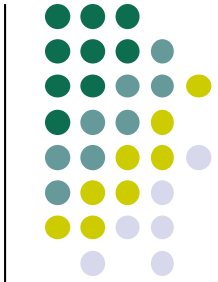
Intersection SPFs (Pedestrian and Bicyclists)

Intersection Types	MDOT (Pedestrian All Crashes)			
	Intercept (a)	AADTmaj (b)	AADTmin (c)	Overdispersion factor (k)
Unsignalized three-leg intersections (stop control on minor-road approaches) (3ST)	-15.512	0.765	0.385	2.143
Signalized three-leg intersections (3SG)	-9.044	0.402	0.187	1.057
Unsignalized four-leg intersections (stop control on minor-road approaches) (4ST)	-11.613	0.547	0.269	2.254
Signalized four-leg intersections (4SG)	-7.578	0.364	0.173	0.959

Intersection Types	MDOT (Bicyclist All Crashes)			
	Intercept (a)	AADTmaj (b)	AADTmin (c)	Overdispersion factor (k)
Unsignalized three-leg intersections (stop control on minor-road approaches) (3ST)	-14.744	0.778	0.394	1.214
Signalized three-leg intersections (3SG)	-11.092	0.575	0.232	1.000
Unsignalized four-leg intersections (stop control on minor-road approaches) (4ST)	-11.173	0.618	0.188	1.184
Signalized four-leg intersections (4SG)	-6.958	0.256	0.227	0.884

Using the SPFs: Sample Problems



- Applying SPFs to predict intersection crashes
- Scoping and planning-level analyses
- Evaluations
  - Empirical Bayes (site-specific)
  - Empirical Bayes (project-level)

Calibration

- The SPFs can be calibrated over time to account for general changes over time
- Predicted number of crashes should be equal to actual (observed) number of crashes:

$$N_{predicted} = exp(a + b * ln\ (AADT_{maj}) + c * ln(AADT_{min}))$$

$$c = \Sigma N_{observed} / \Sigma N_{predicted}$$

- Availability of 2013 and/or 2014 SafetyAnalyst data (e.g., volumes)

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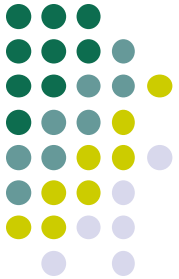
Short-Term Action Items

- Revise SPFs and crash type/severity distributions based on MDOT feedback
- Develop Excel spreadsheet tool (or others)
- QA/QC Review (e.g., construction sites, data outliers)
- Draft Final Report → Target Date = 04/30/15
- Manuscripts for review (e.g., TRB) → post-project



Questions?