



Safety Evaluation of Intersection Conflict Warning Systems (ICWS)

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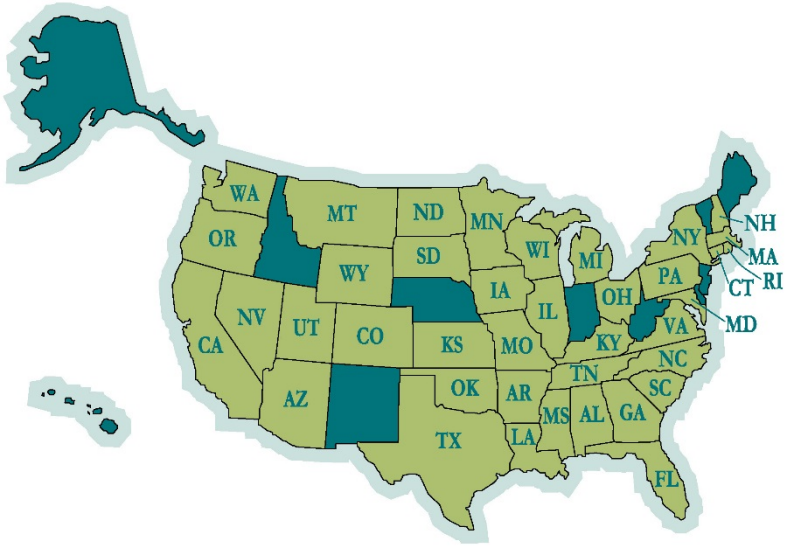
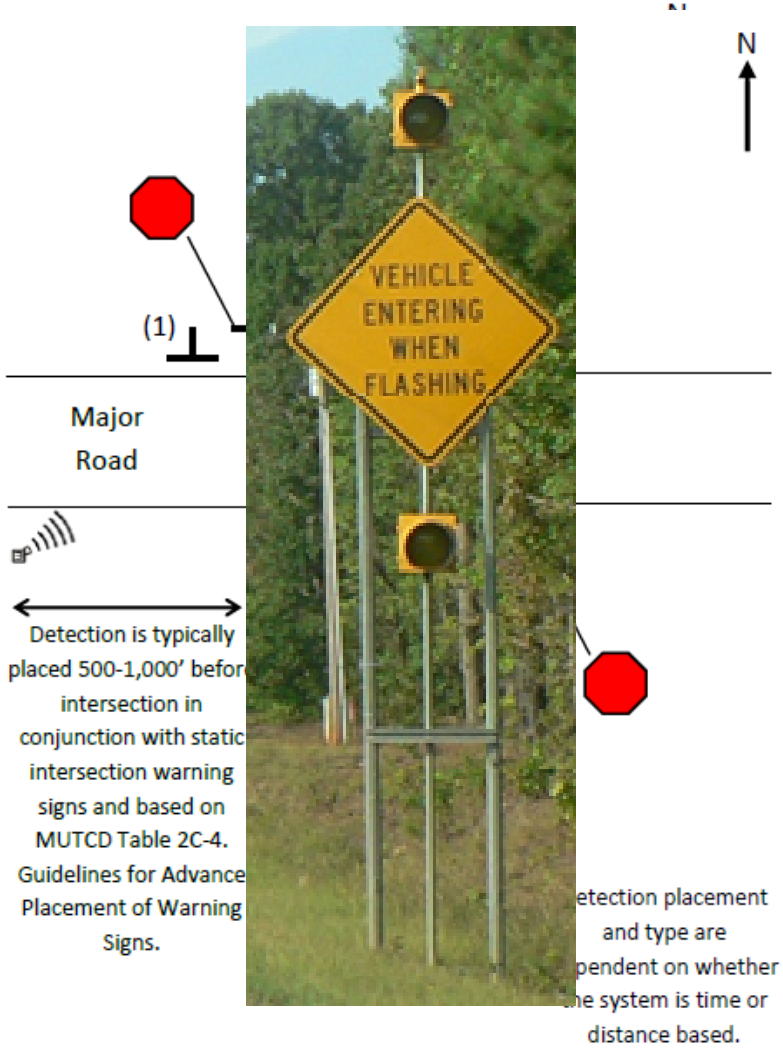


Overview

- ICWS Overview
- Study Design
- Aggregate Results
- Disaggregate Results
- Economic Analysis
- Conclusions

Overview of ICWS

- ICWS – Warning signs with flashing beacons **activated by vehicles** on adjacent intersection approach
  - **Alerts drivers on major road** to vehicles entering
  - **Assists minor road drivers** selecting gaps
  - Combination may be used



Crowson and Jackels – December 2010

Overview of ICWS

- Typical Uses
  - Limited ISD
  - Gap-acceptance crash history
- Installation Locations
  - Post-mounted
  - Overhead

Study Objectives

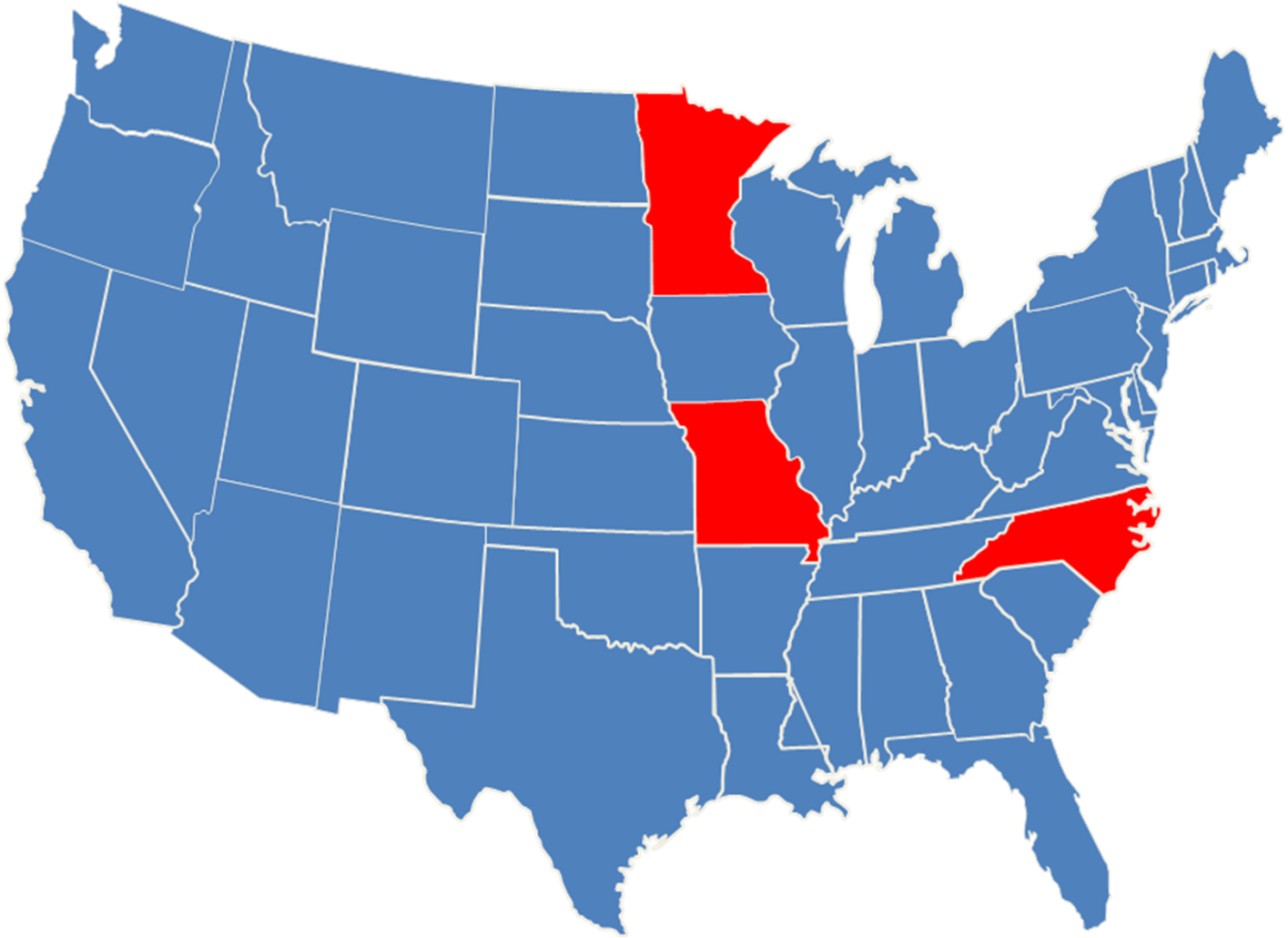
- Evaluate safety effectiveness through development of crash modification factor (CMF)
- Perform disaggregate analysis to determine conditions where treatment is most effective
- Conduct economic analysis to determine cost effectiveness

Crash Modification Factors

- CMF = multiplicative factor for calculating expected crashes after implementing treatment
  - CMF > 1 indicates an increase in crashes
  - CMF < 1 indicates a reduction in crashes
- Percent crash reduction is 100 × (1.00 – CMF)
  - A CMF of 0.77 results in a 23 percent reduction in crashes
- Example – Provide highway lighting for site with 6 nighttime crashes/year: CMF = 0.80

  Expected nighttime crashes after treatment = 6.00 × 0.80 = 4.80 crashes/year

ICWS Evaluation Volunteer States



Applicable Scenarios

- Four-leg intersections with stop control on minor road approaches
- Two-lane major road
- Four-lane major road

Study Design - Overview

- Analysis method
  - Empirical Bayes before-after
  - Project-specific safety performance functions (SPFs)
- Crash categories
  - Total
  - Fatal and injury
  - Right angle
- Study periods
  - MN 2006 – 2012
  - MO 2000 – 2012
  - NC 1992 – 2012
- Two-lane sites
  - MN – 10
  - MO – 6
  - NC – 53
- Four-lane sites
  - MN – 3
  - MO – 8
  - NC – 13

Study Design – Methodology

- Empirical Bayes (EB) before-after
  - Maximum 5 years before/after
  - Establish reference groups for SPF development
  - Predict safety for after period using SPF
  - Use EB procedure to estimate expected crashes with no treatment
  - Observe actual safety for after period with treatment
  - Compare the two

Aggregate Results – Two-Lane

Crash Type	After-Period Crashes		EB	
	Expected	Observed	CMF	S.E.
Total	912.8	670	**0.73**	0.04
Fatal + Injury	515.6	362	**0.70**	0.05
Right Angle	522.2	420	**0.80**	0.05

Aggregate Results – Four-Lane

Crash Type	After-Period Crashes		EB	
	Expected	Observed	CMF	S.E.
Total	464.5	385	**0.83**	0.06
Fatal + Injury	263.6	212	**0.80**	0.07
Right Angle	295.5	252	**0.85**	0.08

Treatment Category – NCDOT

- Category 1 – Overhead signs and flashers on major; loop on minor
- Category 2 – Overhead signs and flashers on minor; loop on major
- Category 3a – Post-mounted signs and flashers on major; loop on minor
- Category 3b – Post-mounted signs and flashers on minor; loop on major
- Category 4 – Other

Results by Category – Two-Lane at Two-Lane

Category		1 OH-Maj	2 OH-Min	3a PM-Maj	3b PM-Min	4 Combo
Sites		16	15	14	8	16
Total	CMF (SE)	**0.74 (0.07)**	0.89 (0.08)	**0.52 (0.06)**	0.89 (0.16)	**0.70 (0.09)**
	N	173	241	120	42	94

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	N	173	241	120	42	94
Fatal and Injury	CMF (SE)	**0.60 (0.08)**	0.94 (0.10)	**0.45 (0.07)**	1.06 (0.29)	**0.74 (0.12)**
	N	91	144	58	18	51
Right Angle	CMF (SE)	**0.81 (0.10)**	1.08 (0.11)	**0.45 (0.07)**	1.25 (0.30)	**0.70 (0.11)**
	N	111	169	61	25	54

Results by Category – Four-Lane at Two-Lane

Category		1	2	3a PM-Maj	3b PM-Min	4
Sites				12	7	
Total	CMF (SE)			**0.75 (0.07)**	**0.69 (0.13)**	
	N			243	35	
Fatal and Injury	CMF (SE)			**0.73 (0.08)**	0.90 (0.21)	
	N			138	22	
Right Angle	CMF (SE)			**0.77 (0.08)**	0.76 (0.17)	
	N			174	23	

Economic Analysis

- Approximated costs for installation, annual maintenance, and annual operations
- Benefits included savings in prevented crashes
- Assumed 10-year lifespan with 7 percent discount rate
- Two-lane B/C ratio: 27:1
- Four-lane B/C ratio: 10:1

Conclusions

- Aggregate results for combined states recommended
- Results indicate statistically significant reductions
- B/C ratios suggest strategy can be cost-effective
- This is an evolving strategy
  - Study reflects installation practices to date
  - As practices change, results may change
  - Overhead applications limited to NC and at-intersection only
  - Post-mounted applications in-advance only
  - Future research should consider placement of warning signs

Final Report

- Available on Evaluation of Low Cost Safety Improvement-Pooled Fund Study website
  - (Search "FHWA ELCSI-PFS" in internet browser)
  - FHWA Report Number: FHWA-HRT-16-035

Thank you!

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