Intersection Safety Case Study

Improving Safety by Providing All-Red Clearance Intervals and Larger Signal Lenses

This case study is one in a series documenting successful intersection safety treatments and the crash reductions that were experienced. Traffic engineers and other transportation professionals can use the information contained in this case study to answer the following questions:

- What are some low-cost treatment options that can reduce angle and total crashes at signalized intersections in urban areas?
- How many crashes did the treatments reduce?
- Are there any implementation issues associated with these treatments, and if so, how can they be overcome?

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U.S. Department of Transportation
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Safe Roads for a Safer Future
Investment in roadway safety saves lives

Introduction

Red-light running is one of the most serious traffic safety problems facing Americans today. It is estimated that vehicles running red lights cause more than 200,000 crashes, 170,000 injuries and approximately 900 deaths per year[1]. Some of these crashes occur because drivers are speeding or are distracted, other drivers may be unaware they are approaching an intersection, or they are unable to see the traffic control device in time to comply.

Clearance intervals—both lengthening yellow-change intervals as well as providing an all-red clearance interval—together with increasing the size of signal lenses, have been shown to improve intersection safety. Increasing the length of the yellow-change interval in accordance with the recommended Institute for Transportation Engineers (ITE) formula has been shown to significantly decrease the chance of red-signal violations. Providing red clearance intervals and increasing the yellow-change interval have been shown to decrease late exits from intersections[7].

Objective

The following case study showcases two successful low-cost strategies that measurably improved safety at 33 signalized intersections in Detroit and Highland Park, MI. The treatments included providing an all-red clearance interval and increasing the size of the signal lens for the red, yellow and green indications.

Treatment Summary

All of the intersection examples used in this report are from a corridor that extends between Detroit and Highland Park, MI. This case study examines the application of two treatment enhancements that reduced angle and injury crashes at signalized intersections:

- **Implementation of all-red clearance intervals ranging from 1.0 to 2.0 seconds[2].**
- **Larger (12-inch) signal lenses (red, yellow and green) to replace 8-inch signal lenses[3].**

Adding or extending an all-red clearance interval (a brief period when lights in all directions are red) provides additional time before conflicting traffic is released following the yellow-change interval. This short all-red clearance interval provides a greater time separation between opposing vehicular movements, clearing the intersection of vehicles between signal phases, thereby reducing the potential for a crash.

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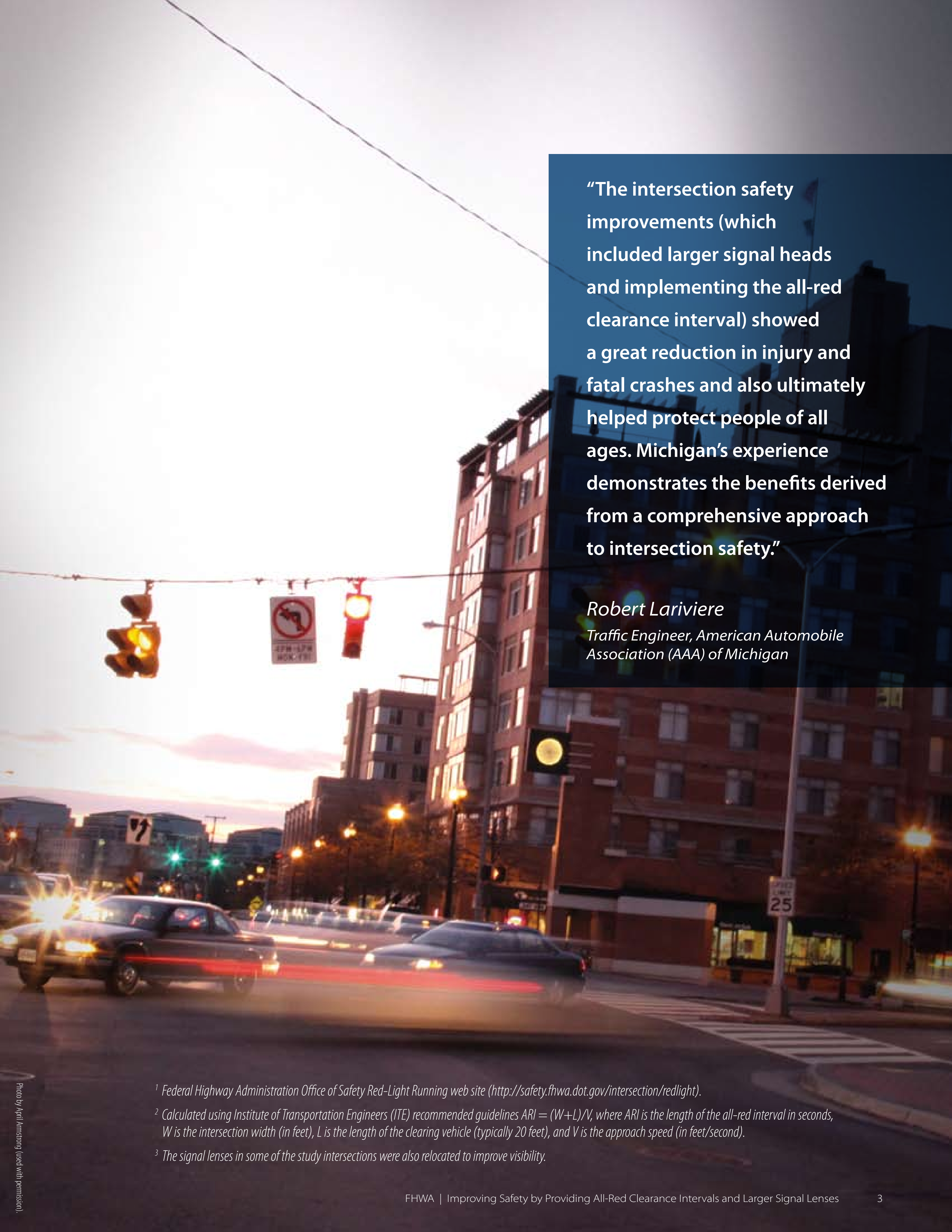
Figure 1: Relative size difference between 12-inch (top lens) and 8-inch signal lens (bottom lenses)

Larger signal lenses make traffic signals more visible and provide motorists with more time to determine and respond to the color indication. Figure 1 provides a visual comparison of the 8-inch and larger 12-inch traffic signals. Agencies can use different sizes of signal lenses in the same signal face or signal head, as specified in the MUTCD Section 4D.15. In this case, the cities increased the lens size of all three lenses in the traffic signals for maximum conspicuity.



> **"The intersection safety improvements (which included larger signal heads and implementing the all-red clearance interval) showed a great reduction in injury and fatal crashes and also ultimately helped protect people of all ages. Michigan's experience demonstrates the benefits derived from a comprehensive approach to intersection safety."**
>
> *Robert Lariviere*
> *Traffic Engineer, American Automobile Association (AAA) of Michigan*

Photo by April Armstrong (used with permission).

[1] *Federal Highway Administration Office of Safety Red-Light Running web site (http://safety.fhwa.dot.gov/intersection/redlight).*

[2] *Calculated using Institute of Transportation Engineers (ITE) recommended guidelines ARI = (W+L)/V, where ARI is the length of the all-red interval in seconds, W is the intersection width (in feet), L is the length of the clearing vehicle (typically 20 feet), and V is the approach speed (in feet/second).*

[3] *The signal lenses in some of the study intersections were also relocated to improve visibility.*

Evaluation Methodology

This case study examines 33 intersections in Detroit and Highland Park, MI with a high incidence of angle crashes (many with injuries). Crash reductions were based on a review of "before and after" data from these intersections during a minimum of 13 months, between 1997—2002[4]. (The "before" and "after" observation periods ranged between 13-34 months depending on the intersection). The safety improvements were implemented in 1997.

Results

Problem: The signalized intersections along the Woodward Avenue corridor (Route 1) which runs between Detroit and Highland Park, MI, were experiencing a high number of angle crashes, as well as a high number of total crashes.

Solution: In 1996, the American Automobile Association (AAA) of Michigan, in partnership with the cities of Detroit and Highland Park, initiated the Road Improvement Demonstration Program (RIDP) to improve intersection safety along this arterial corridor. The program's main purpose was to identify high-crash locations in these cities and develop and implement safety measures.

The cities decided to add an all-red clearance interval and increase the size of the signal lens for the red, yellow and green signals at the intersections along the Woodward Avenue corridor. The corridor is approximately 7.5 miles long (see Figure 2) with a posted speed limit that varies between 35 to 40 miles per hour (mph). The corridor consists of three to four lanes in the north- and south-bound directions and a center lane for left turns.

The safety treatments implemented along the Woodward Avenue corridor reduced the targeted angle crashes as well as total crashes. After implementation of these countermeasures, 90.9 percent of the treated intersections experienced a reduction in angle crashes, 81.8 percent experienced a reduction in injury crashes, and 75.8 percent experienced reductions in total crashes. **At the corridor level, the safety treatments had a positive effect in reducing the targeted angle crashes by 75.7 percent, injury crashes by 45.5 percent, and total crashes by 33.3 percent per year.** See Table 1 for a more detailed tabular summary of these treatments.

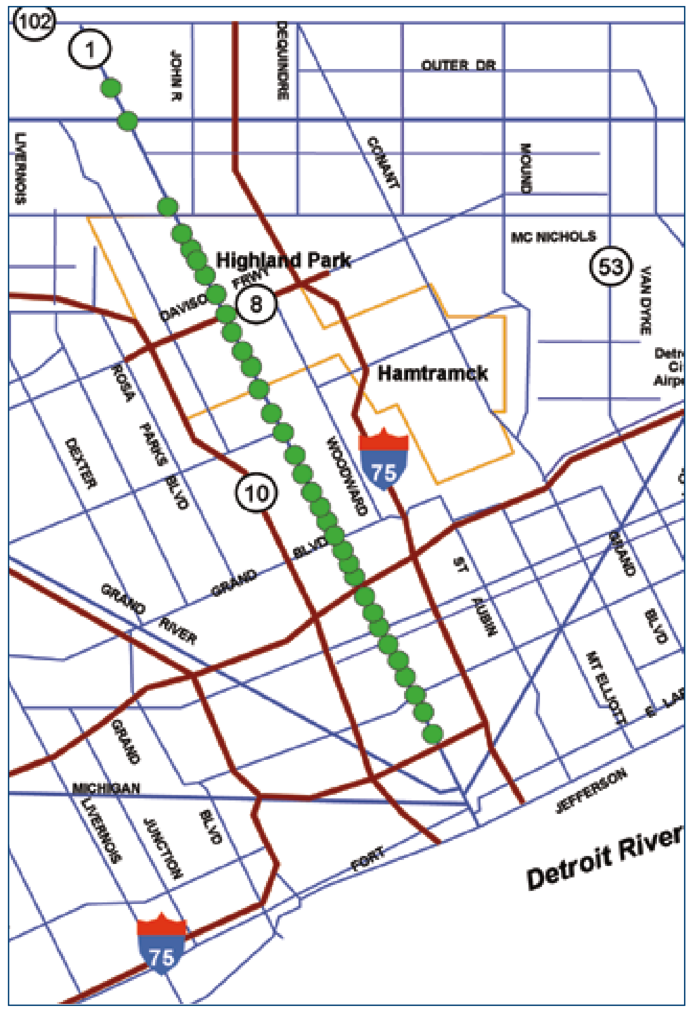


Figure 2: Site Map of the Woodward Avenue Corridor

[4] Note that crash reduction averages in this report reflect the percent reduction per year based on the difference between the total number of "before" and "after" crashes.

Locations along Woodward Avenue corridor	Before				After				Percent Reduction In Crashes/Year (Injuries/Year)		
	Months	Annual Average Total Crashes	Annual Average Injury Crashes	Annual Average Angle Crashes	Months	Annual Average Total Crashes	Annual Average Injury Crashes	Annual Average Angle Crashes	Total Crashes	Injury Crashes	Angle Crashes
Sibley/Adelaide Street	24	1.0	0.0	0.0	34	2.5	1.1	0.4	-150.0	-110.0	-40.0
Charlotte Street	24	5.5	1.5	0.0	34	2.1	0.7	0.0	61.8	53.3	0.0
Eliot/Stimson Street	24	2.0	0.0	0.0	34	1.4	0.4	0.4	30.0	-40.0	-40.0
Mack Avenue	24	19.0	4.0	5.5	34	25.8	5.6	2.8	-35.8	-40.0	49.1
Parsons Street	24	4.0	0.5	0.0	34	5.6	1.4	0.4	-40.0	-180.0	-40.0
Alexandrine Street	24	14.5	2.5	1.5	34	11.6	1.4	0.7	20.0	44.0	53.3
Canfield Street	24	14.0	3.5	3.5	34	7.8	1.4	0.7	44.3	60.0	80.0
Forest Avenue	24	29.0	5.5	14	34	18.0	3.9	1.4	37.9	29.1	90.0
Warren Avenue	24	51.0	11.0	11.5	34	38.5	7.8	6.0	24.5	29.1	47.8
Putnam Street	24	16.0	3.0	0.0	34	9.5	0.4	0.0	40.6	86.7	0.0
Kirby Street	24	13.0	4.5	0.5	34	5.6	0.7	0.0	56.9	84.4	100.0
Palmer Street	24	13.5	2.5	4.0	34	8.8	1.8	1.4	34.8	28.0	65.0
Antionette/Medbury Street	24	3.5	1.5	1.5	34	1.1	1.1	0.4	68.6	26.7	73.3
Baltimore Street	24	12.5	4.0	0.5	34	7.8	1.8	0.0	37.6	55.0	100.0
Milwaukee Street	24	24.0	7.0	12.0	34	10.2	2.1	0.7	57.5	70.0	94.2
Bethune Street	24	6.5	2.0	2.0	34	6.0	2.1	0.0	7.7	-5.0	100.0
Seward/Marston Street	24	8.5	3.0	1.0	34	6.0	1.4	0.4	29.4	53.3	60.0
Euclid Street	24	14.0	4.5	2.0	34	6.7	1.1	0.7	52.1	75.6	65.0
Hazelwood/Holbrook St	24	10.5	2.5	2.5	34	7.4	2.5	1.8	29.5	0.0	28.0
Clairmount/ Owen Street	24	16.0	6.0	6.5	34	7.4	1.8	0.4	53.8	70.0	93.8
Chicago/Aden Park Blvd	24	12.0	4.5	2.0	34	3.9	0.0	0.4	67.5	100.0	80.0
Calvert/Trowbridge Street	24	8.5	1.0	1.5	34	4.2	0.7	0.0	50.6	30.0	100.0
Tuxedo/ Tennyson Street	24	1.0	0.0	0.0	24	2.5	0.0	0.0	-150.0	0.0	0.0
Courtland Street	24	1.0	0.0	1.0	24	1.5	0.0	0.5	-50.0	0.0	50.0
Glendale/McLean Street	24	15.0	4.0	1.0	24	21.0	7.0	1.0	-40.0	-75.0	0.0
Buena Vista Street	24	4.0	1.0	1.0	24	7.0	3.0	0.5	-75.0	-200.0	50.0
Gerald Street	24	2.0	1.0	0.0	24	6.0	0.5	0.0	-200.0	50.0	0.0
Manchester Street	24	38.0	17.0	18.0	24	17.5	6.0	2.0	53.9	64.7	88.9
Sears/Ford Street	24	20.0	10.0	4.0	24	11.0	5.0	1.0	45.0	50.0	75.0
Ferris/Pilgrim Street	24	9.0	2.0	3.0	24	8.0	2.0	0.5	11.1	0.0	83.3
Merrill Plaisance Street	24	6.5	3.5	3.5	13	0.9	0.0	0.0	86.2	100.0	100.0
Seven Mile Road	24	46.0	15.5	8.5	13	24.0	6.5	3.7	47.8	58.1	56.5
State Fair Avenue	24	28.5	9.0	4.0	13	15.7	3.7	0.0	44.9	58.9	100.0
TOTAL	**792**	**469.5**	**137.5**	**116**	**979**	**313**	**74.9**	**28.2**	**33.3**	**45.5**	**75.7**

Table 1: Summary of crash reductions after addition of all-red clearance intervasls and larger signal lenses

Discussion

Implementation Issues

The city experienced no implementation issues with these countermeasures.

Cost

The cost to implement the safety improvements at all 33 intersections totaled $2.3 million (an average cost of $70,000 per intersection). Costs included replacement of the smaller (8-inch) signal lens with the larger (12-inch) lens, and providing the all-red clearance intervals.

Time Frame

The treatments were installed at all locations within six months. This included development of retiming plans, addition of all-red clearance intervals, and installation of the larger 12-inch signal lenses.

Effectiveness

The combinations of enhanced treatments discussed have been effective in reducing crashes at these signalized intersections. AAA Michigan conducted a benefit-cost evaluation using National Safety Council (NSC) cost data and further determined the benefit-cost ratio of 11:1 for the specified treatments[4]. An Empirical Bayes analysis was also performed at selected intersections in the City of Detroit for which suitable control sites were identified. Finally, the significant results of additional tests (Poisson, Chi-Square, and Paired t-tests) conducted by the study team helped to further conclude that the implemented countermeasures were effective in reducing the targeted crashes at a 95 percent confidence interval. These results are consistent with other similar studies of the effectiveness of these treatments.

Summary of Results

The safety enhancements discussed in this case study were added to reduce angle and total crashes. **The combinations of enhanced countermeasures installed in these Michigan signalized intersections cumulatively reduced angle crashes at the treated intersections by 75.7 percent, injury crashes by 45.5 percent, and total crashes by 33.3 percent.** The average reductions in crashes achieved by the treatments are within the range of crash reductions for these treatments (15 percent for all-red clearance interval and 24 percent for 12-inch signal lenses for total crashes) mentioned in the Desktop Reference for Crash Reduction Factors (September 2007), published by the United States Department of Transportation (USDOT) Federal Highway Administration (FHWA)[2].

References

1) *Federal Highway Administration Office of Safety Red-Light Running web site* (http://safety.fhwa.dot.gov/intersection/redlight).

2) *Desktop Reference for Crash Reduction Factors*, FHWA-SA-07-015, Federal Highway Administration, (Washington, DC: September 2007), p. 8, 15.

3) "Evaluating Impact on Safety of Improved Signal Visibility at Urban Signalized Intersections," *Transportation Research Record*, Transportation Research Board, The National Academies, 0361-1981, volume 2019, pp. 51-56, 2007.

4) Datta T.K. and Schattler K.L., Evaluation Studies for the AAA Road Improvement Demonstration Program, Wayne State University, Michigan, 2003.

5) Polanis, Stanley F., "Improving Intersections Safety through Design and Operations (Examples)," presented at ITE 2002 Spring Conference, Palm Harbor, FL, March 2002.

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7) Making Intersections Safer: A Toolbox of Engineering Countermeasures to Reduce Red-Light Running: An Informational Report. *Countermeasures to Reduce Red-Light Running*, Federal Highway Administration and Institute of Transportation Engineers, 2003. (http://safety.fhwa.dot.gov/intersection/redlight/rlr_report)

8) SEMCOG Traffic Safety Manual, Southeast Michigan Council of Governments, Third edition, 1998.

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