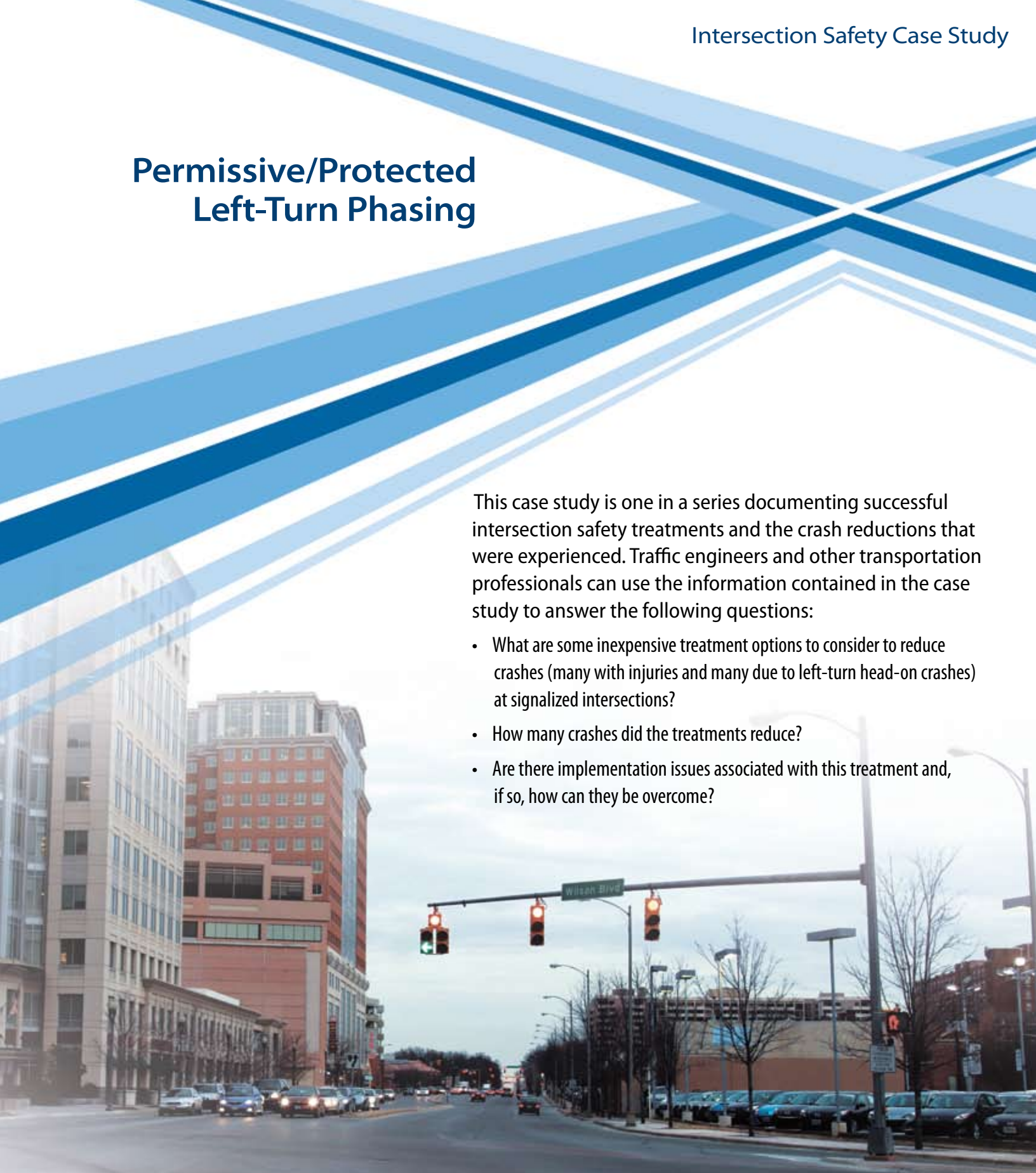
Permissive/Protected Left-Turn Phasing

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 the case study to answer the following questions:

- What are some inexpensive treatment options to consider to reduce crashes (many with injuries and many due to left-turn head-on crashes) at signalized intersections?
- How many crashes did the treatments reduce?
- Are there implementation issues associated with this treatment and, if so, how can they be overcome?



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Safe Roads for a Safer Future
Investment in roadway safety saves lives

Introduction

Left-turning movements are generally acknowledged to be the highest-risk movements at intersections. An estimated 27 percent of all intersection-related crashes in the United States are associated with left turns, with over two-thirds occurring at signalized intersections[1]. Vehicles making this type of movement encounter potential conflicts from several sources including opposing through traffic, through traffic in the same direction, and crossing vehicular and pedestrian traffic.

Several intersection treatments have been developed to reduce these risks, including converting from a permissive left-turn mode to permissive/protected phasing. In a "permissive" mode, a green signal permits vehicles to turn left as traffic allows (see left image in Figure 1). In a "permissive/protected" mode, the permissive left-turn phase is immediately followed by an exclusive, protected left-turn phase, initiated by a green arrow signal indication (see right image in Figure 1). The Manual on Uniform Traffic Control Devices (MUTCD) (Section 4D.06) provides more information on the standards and applications of the permissive/protected mode.

Photo courtesy of Michigan Department of Transportation (used with permission).

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Figure 1: Permissive/Protected mode

In 1996, American Automobile Association (AAA) Michigan, in partnership with the cities of Detroit and Grand Rapids, Michigan, initiated the Road Improvement Demonstration Program (RIDP) to improve intersection safety. The RIDP's main purpose was to identify high-crash locations and to develop and implement safety measures at those locations. While various measures were taken, the AAA Foundation for Traffic Safety reported that the most successful crash reductions were often accomplished with low-cost projects.

"You don't have to spend a million bucks. The biggest savings is really from a societal perspective, from the reduced injuries[2]**."**

AAA Foundation for Traffic Safety, Progress Report. Vol. 6., No 6., December 1999.

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Objective

The following case study showcases a successful and effective low-cost countermeasure that measurably improved safety at three signalized intersections in Michigan. The treatment included converting the permissive left-turn mode to permissive/protected phasing.

Treatment Summary

All intersection examples used in this report are from Detroit/Grand Rapids, MI. Existing intersection treatments met minimum MUTCD standards. This case study examines the effects of the addition of a permissive/protected left-turn mode at three signalized intersections.

Evaluation Methodology

This case study examines three signalized intersections with a high incidence of injury crashes (many due to left-turn head-on crashes). In this study, left-turn head-on crashes were classified as those in which the impacted vehicles were traveling in opposite directions[8].

Crash reduction results were based on a review of "before and after" data from these intersections during a minimum of 2.5 years, between 1998–2002[1].

(The "before" and "after" observation periods ranged from 6 months to 29 months at the treated intersections).

Results

Problem: These intersections were experiencing high incidences of crashes (many with injuries) because of conflicts occurring in the course of the left-turn movement during the permissive left-turn phase.

Solution: The cities upgraded the permissive left-turn mode to a permissive/protected mode to minimize left-turn head-on crashes. They retimed signals as appropriate to accommodate the permissive/protected left-turn phasing.

- **Wyoming Road and Seven Mile Road**
  Wyoming Road is a two-lane urban arterial with a speed limit of 30 miles per hour (mph). Permissive left-turn phasing existed at the intersections of Wyoming and Seven Mile Roads in the "before" condition. The "after" condition involved installing permissive/protected left-turn mode on the Wyoming Road approaches. The "after" data was gathered between March 2002 and August 2002[2] . After the improvements, total crashes decreased from 36 to 26 (an average crash reduction of 27.8 percent). Injury crashes decreased from 8.7 to 4.0 (an average crash reduction of 54 percent). Targeted left-turn head-on crashes were eliminated (from 3.3 in the "before" condition).
- **Eastern Avenue and Alger Street**
  Eastern Avenue is a north-south corridor with a speed limit of 30 mph. In the "before" period, this primarily two-lane roadway had exclusive left-turn lanes with a permissive left-turn mode at its intersection with Alger Street. In the "after" condition, improvements included installing permissive/protected left-turn modes on Eastern Avenue approaches[3]. The "after" data was gathered from January 2001 to August 2002. After the improvements, total crashes per year decreased from 14.2 to 12.7 (an average crash reduction of 10.6 percent). Injury crashes decreased from 1.5 to 0 per year (an average crash reduction of 100 percent). Targeted left-turn head-on crashes were eliminated (from 3.8 crashes in the "before" condition).

[1] 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.

- **Burton Street and Kalamazoo Avenue**
  Burton Street is a major east-west arterial with the posted speed limit varying between 30 mph and 35 mph. Prior to modification, Burton Street had two lanes in either direction with a permissive left-turn mode. The "after" condition involved installing permissive/protected left-turn phasing for all approaches[4]. The "after" data was gathered between April 2000 and August 2002. After the improvements, total crashes per year decreased from 36 to 19.9 (an average crash reduction of 44.7 percent). Injury crashes per year decreased from 9.5 to 4.1 (an average crash reduction of 56.8 percent). Targeted left-turn head-on crashes decreased from 6.0 to 2.1 (an average crash reduction of 65%). Figures 2 and 3 depict the "before" and "after" condition of this intersection.

Westbound Burton Street at Kalamazoo Avenue

Photo courtesy of Michigan Department of Transportation (used with permission).

Figure 2: "Before" condition

Photo courtesy of Michigan Department of Transportation (used with permission).

Figure 3: "After" condition

Table 1 summarizes the percent reductions for total, injury and left-turn head-on crash types for each of the three intersections.

Locations	Implem-entation Date	Before				After				Percent Reduction In Crashes/Year		
		Months	Total Crashes	Injury Crashes	Left-turn head-on Crashes	Months	Total Crashes	Injury Crashes	Left-turn head-on Crashes	Total Crashes	Injury Crashes	Left-turn head-on Crashes
Wyoming Road and Seven Mile Road, Detroit	Mar-02	24	36	8.7	3.3	6	26	4.0	0.0	27.8%	54.0%	100%
Eastern Avenue and Alger Street, Grand Rapids	Jan-01	24	14.2	1.5	3.8	20	12.7	0.0	0.0	10.6%	100%	100%
Burton Street and Kalamazoo Avenue, Grand Rapids	Apr-00	24	36.0	9.5	6.0	29	19.9	4.1	2.1	44.7%	56.8%	65.0%
TOTAL		**72**	**86.2**	**19.7**	**13.1**	**55**	**58.6**	**8.1**	**2.1**	**32.0%**	**58.9%**	**84.0%**

* Total crashes include injury and left-turn head-on crashes, and have been converted to reflect annual averages.
Table 1: Summary of crash reductions after installation of the permissive/protected left-turn modes

[2] The "after" study period closed at the completion of the RIDP.
[3] Signal backplates and secondary post-mounted signal heads to improve visibility were also installed at this intersection.
[4] Other interventions at this intersection included installing backplates and relocating signal heads over the travel lanes to improve visibility. Note that the signal configuration was changed from diagonal span in the "before" condition to box span in the "after" condition.

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Discussion

Implementation Issues

The cities experienced no implementation issues with this countermeasure.

Cost

The costs to implement this countermeasure, including the equipment (i.e., the controller), and technician costs (i.e., signal retiming), were estimated at $25,000 per intersection.

Time Frame

The signal mode improvements at each intersection were implemented within one week.

Effectiveness

This countermeasure was effective in reducing injury crashes, including left-turn head-on crashes, as well as total crashes.

Summary of Results

The "before" conditions at the three treated intersections met minimum MUTCD standards. The safety enhancements discussed in this case study were added to reduce left-turn head-on crashes. **Installation of the permissive/protected left-turn mode cumulatively reduced total targeted left-turn head-on crashes at these intersections by 84 percent, injury crashes by 58.9 percent, and total crashes overall by 32 percent reduction per year.**

The average reductions in crashes achieved by this treatment consistent with the overall crash reduction factor of 16 percent for left-turn crashes when converting from permissive to permissive/protected phasing mentioned in the Desktop Reference for Crash Reduction Factors by the Department of Transportation (USDOT). The Highway Safety Manual reports an Accident Modification Factor (AMF) of 0.99 (equivalent to a CRF of 0.01, or 1 percent reduction) for all crashes for this treatment, which is based on rigorous statistical studies and analyses. The results from the three intersections highlighted in this case study are based on simple "before and after" studies and not necessarily statistically significant. However they demonstrate that implementing permissive/protected phasing does reduce crashes, which is consistent overall with the Highway Safety Manual (HSM).

References

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For More Information

Ed Rice

Intersection Safety Team Leader,
FHWA Office of Safety

202.366.9064

ed.rice@dot.gov

Tapan K. Datta, Ph.D., P.E.

Professor, Civil and Environmental Engineering,
Wayne State University-Transportation Research Group

313.577.9154

tdatta@eng.wayne.edu

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