



Signalized Intersection Safety Strategies

NCHRP Report 500, Volume 12:
A Guide for Reducing Collisions at Signalized Intersections

Speaker Name Goes Here

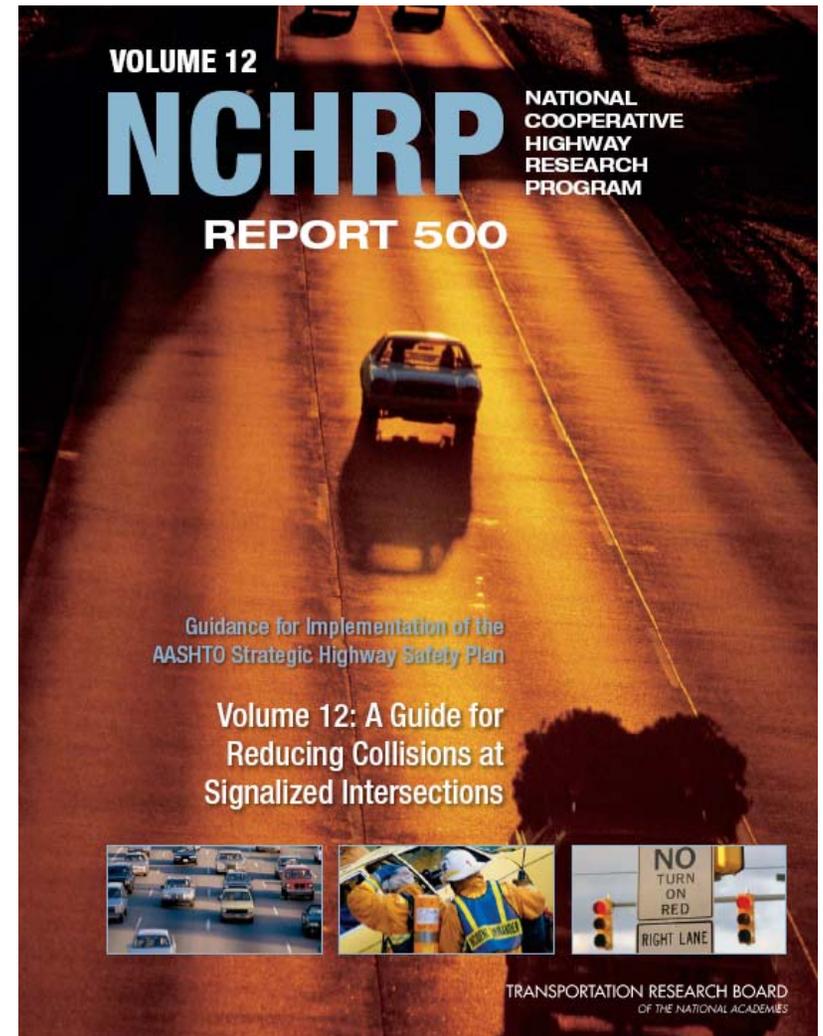


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NCHRP Report 500

- Companion to NCHRP Report 500 Volume 12: A Guide for Reducing Collisions at Signalized Intersections
- Available at:
<http://safety.transportation.org/>



Explanation of Time, Cost, and Effectiveness

- Time Frame
 - Short: a few months up to 1 year
 - Medium: 1 to 2 years
 - Long: More than 2 years
- Cost
 - Low
 - Moderate
 - Moderate-High
 - High
 - Relative cost to other strategies discussed
- Effectiveness
 - **Proven:** Strategies that have been used in one or more locations and properly designed evaluations have been conducted that show it to be effective.
 - **Tried:** Strategies that have been implemented in a number of locations and may even be accepted as standards, but for which valid evaluations have not been conducted.
 - **Experimental:** Strategies that have been suggested and that at least one agency has considered sufficiently promising to try on a small scale in at least one location.



Strategy Categories

- A. Traffic control and operational improvements
- B. Geometric improvements
- C. Improve sight distance
- D. Improve driver awareness
- E. Improve driver compliance
- F. Improve access management
- G. Improve safety through other infrastructure treatments



Employ Multiphase Signal Operation

NCHRP Report 500 • Vol. 12
Strategy: A1



Where to use

Signalized intersections with a high frequency of angle crashes involving left turning and opposing through vehicles. A properly timed protected left-turn phase can also help reduce rear-end and sideswipe crashes between left-turning vehicles and the through vehicles behind them.

Key to success

The overall length of the turn lane is a key element in the design of the lane. A lane that does not provide enough deceleration length and storage space for left-turning traffic could cause the turn queue to back up into the adjacent through lane. This can contribute to rear-end and sideswipe crashes and increase delay for through vehicles.

Cost: ● ○ ○ ○
Time Frame: ● ○ ○
Effectiveness: Proven, Tried

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Optimize Clearance Intervals

NCHRP Report 500 • Vol. 12
Strategy: A2



Where to use

Signalized intersections with a high frequency of crashes related to change interval lengths that are possibly too short. These crashes include angle crashes between vehicles continuing through the intersection after one phase has ended and the vehicles entering the intersection on the following phase. Rear-end crashes may also be a symptom of short change intervals.

Key to success

Yellow intervals should be long enough for motorists traveling at the prevailing speed to enter the intersection before the light turns red, if too close to stop comfortably. All-red intervals should not be so long as to encourage disrespect in drivers for the interval—thereby contributing to red-light running and even more severe crashes—or so short as to violate driver expectancy regarding the length of the interval, resulting in abrupt stops and possible rear-end crashes.

Cost: ● ○ ○ ○
Time Frame: ● ○ ○ ○
Effectiveness: Proven



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Signalized Intersection Safety Strategies

Restrict or Eliminate Turning Maneuvers (Including Right Turns on Red)

NCHRP Report 500 • Vol. 12
Strategy: A3



Where to use

Signalized intersections with a high frequency of crashes related to turning maneuvers. For right turn on red (RTOR), the target of this strategy is right-turning vehicles that are involved in rear-end or angle crashes with cross-street vehicles approaching from the left or vehicles turning left from the opposing approach, and crashes involving pedestrians.

Key to success

One key to success is providing for safe and adequate alternative locations to make the turn in close proximity to the intersection where the prohibition is placed. A careful traffic engineering study should be made to ensure that the safety and operational problems calling for the prohibition are not merely relocated.

Cost: ● ○ ○ ○
Time Frame: ● ○ ○
Effectiveness: Tried



Employ Signal Coordination

NCHRP Report 500 • Vol. 12
Strategy: A4



This photo shows two closely-spaced intersections that are not coordinated. Poor coordination results in unnecessary stops, more delay, and possibly higher crash rates.

Where to use

Signalized intersections with a high frequency of crashes involving major street left-turning and minor street right-turning vehicles where adequate safe gaps in opposing traffic are not available. Major road rear-end crashes associated with speed changes can also be reduced by retiming signals to promote platooning.

Key to success

Signals up to a mile of each other should be coordinated. The grouping of the signals to be coordinated is a very important aspect of design of a progressive system. Factors that should be considered include geographic boundaries, volume/capacity ratios, and characteristics of traffic flow. Coordination across jurisdictional boundaries is strongly encouraged.

Cost: ●●○○
Time Frame: ●●○○
Effectiveness: Proven



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Signalized Intersection Safety Strategies



Employ Emergency Vehicle Preemption

NCHRP Report 500 • Vol. 12
Strategy: A5



Where to use

Signalized intersections where normal traffic operations impede emergency vehicles and where traffic conditions create a potential for conflicts between emergency and non-emergency vehicles.

Key to success

One key to success is ensuring that the preemption system works when needed by providing clear sight lines between emergency vehicles and detectors. Also, it is important to ensure that vehicles from a variety of jurisdictions will be able to participate in the signal preemption program. The focus of the treatment should be on fire and emergency medical services because they often follow standard routes. Another key to success is the coordination of implementation across jurisdictions, including compatibility of equipment and technology, as well as operational policies.

Cost: ●●○○
Time Frame: ●●○○
Effectiveness: Proven



Improve Operation of Pedestrian and Bicycle Facilities at Signalized Intersections

NCHRP Report 500 • Vol. 12
Strategy: A6



Example of a pedestrian countdown signal.



Example of using a no right-turn sign in conjunction with a leading pedestrian phase.



Where to use

Signalized intersections with high frequencies of pedestrian and/or bicycle crashes. Also on routes serving schools or other generators of pedestrian and bicycle traffic.

Key to success

The key to success for this strategy is to get the appropriate agencies to look at pedestrian and bicycle facilities from a more systematic point of view. That is, rather than making improvements where problems occur, anticipate the needs of pedestrians and bicyclists during the design of other intersection improvements. Incorporate appropriate improvements in the design before problems occur. Involve groups representing pedestrians and bicyclists in the early stages of a program's development.

Cost: ● ○ ○ ○
Time Frame: ● ○ ○
Effectiveness: Proven, Tried



Remove Unwarranted Signal

NCHRP Report 500 • Vol. 12
Strategy: A7



Where to use

Signalized intersections where the traffic volumes and safety record do not warrant a traffic signal.

Key to success

Keys to success include determining the appropriate traffic control to be used after the removal of the signal and removing any sight distance restrictions through the intersection.

Pedestrian and bicycle movements through the intersection should be considered when determining traffic control, geometric changes, and signing improvements that will be made when the signal is removed.

Keeping the public informed about the traffic control removal study will also lead to the success of this strategy.

Cost: ● ○ ○ ○

Time Frame: ● ○ ○

Effectiveness: Proven



Provide/Improve Left-Turn Channelization

NCHRP Report 500 • Vol. 12
Strategy: B1



Where to use

Signalized intersections where crashes related to left-turn movements are an issue.

Key to success

Keys to success in implementing left-turn lanes include the appropriate design of all elements (length, width, taper). Another key to success with left-turn lanes is to incorporate other strategies such as protected-only phasing.

Cost: ●●○○
Time Frame: ●●○○
Effectiveness: Tried/Proven



Provide/Improve Right-Turn Channelization

NCHRP Report 500 • Vol. 12
Strategy: B2



Where to use

Signalized intersections with a high frequency of rear-end collisions resulting from conflicts between: (1) vehicles turning right and following vehicles; and (2) vehicles turning right and through vehicles coming from the left on the cross street.

Key to success

Properly designing the right-turn lane is paramount. Visibility of channelizing islands is also very important. Islands can be difficult for drivers to see, especially at night and in inclement weather. Raised islands have proven more effective than flush-painted islands at reducing nighttime collisions.

Cost: ●●○○
Time Frame: ●●○○
Effectiveness: Proven



Improve Geometry of Pedestrian and Bicycle Facilities

NCHRP Report 500 • Vol. 12
Strategy: B3



Where to use

Signalized intersections with high frequencies of pedestrian and/or bicycle crashes and on routes serving schools or other generators of pedestrian and bicycle traffic.

Key to success

A key to successful pedestrian and bicycle facilities is careful planning. The network of facilities should be well connected to meet the needs of the community.

Landscaped medians should not obstruct visibility between pedestrians and bicyclists and approaching motorists or include objects representing a collision hazard to vehicles that may run onto the median.

Cost: ● ○ ○ ○ ○
Time Frame: ● ○ ○ ○ ○
Effectiveness: Proven, Tried

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Revise Geometry of Complex Intersections

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Strategy: B4



In this photo, the photographer's vehicle is in the through lane. Note it is aligned with the opposing left turn lane requiring a shift to the right when going through the intersection.

Where to use

Signalized intersections with high levels of crashes on a leg where other low-cost strategies have not been successful or are not considered appropriate.

Key to success

The key to success for a project of this type is conducting an adequate system traffic study to ensure that the safety and other operational problems are not merely transferred from the intersection being treated to other locations.

Cost: ●●●●
Time Frame: ●●●
Effectiveness: Proven, Tried

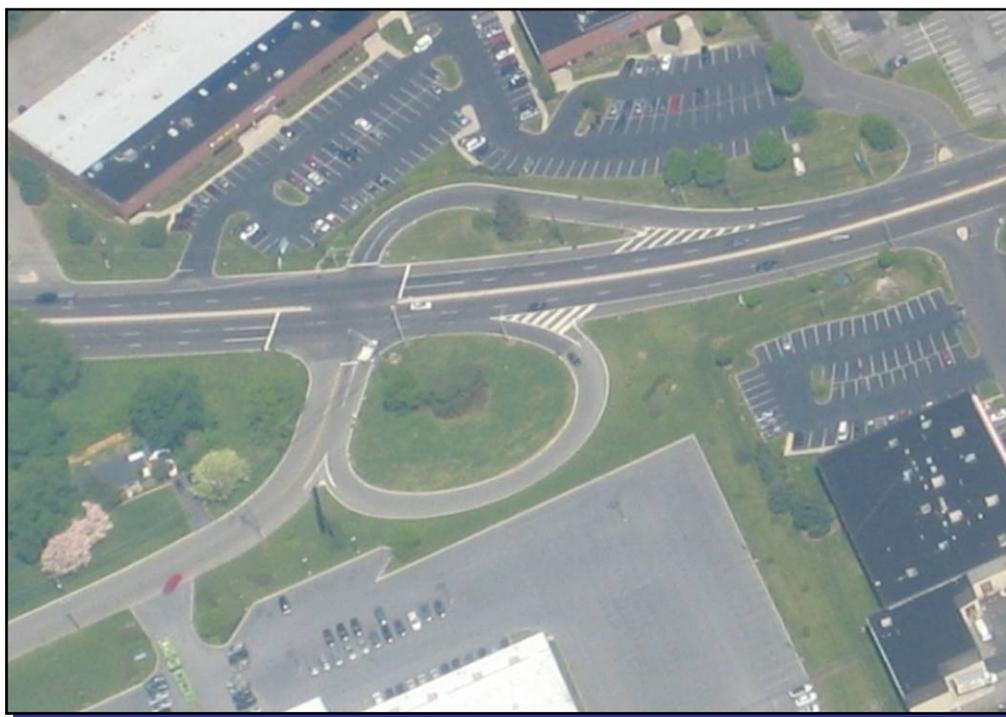


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Signalized Intersection Safety Strategies

Construct Special Solutions

NCHRP Report 500 • Vol. 12
Strategy: B5



Where to use

Signalized intersections with high frequencies of crashes that are not reduced through other lower-cost solutions.

Key to success

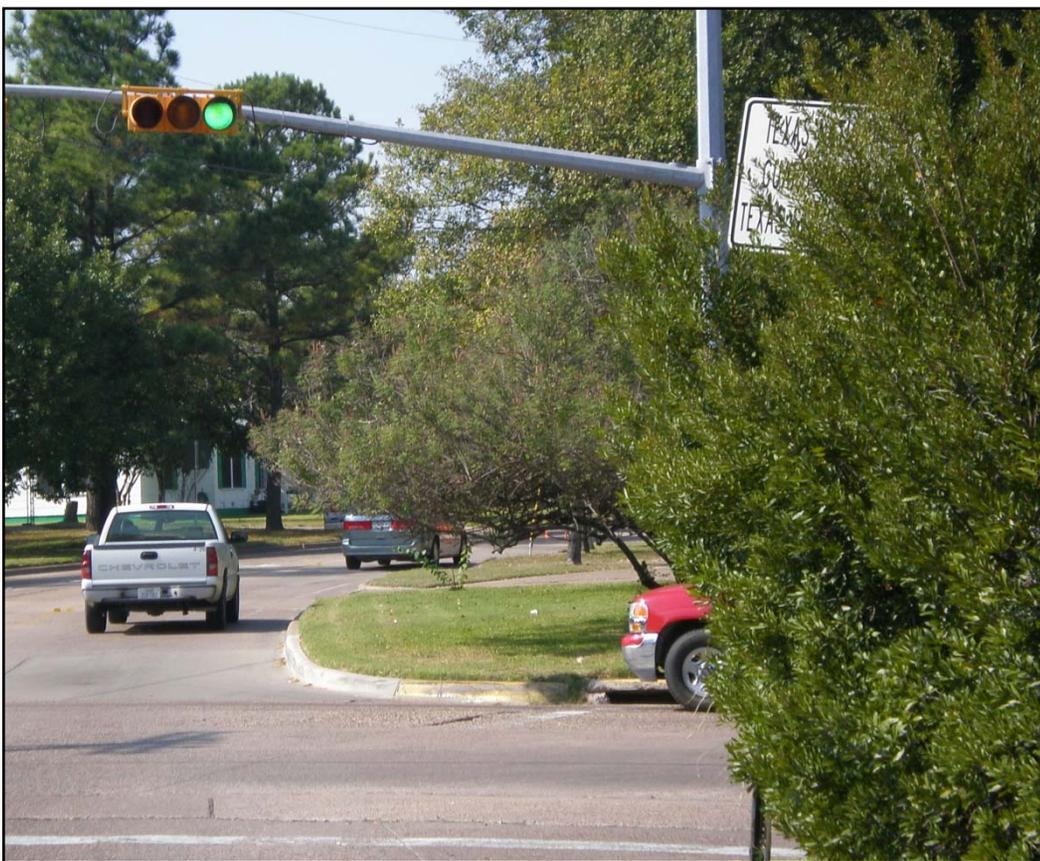
Major construction projects have a greater chance of success when all key stakeholders — including owners of nearby businesses, transit agencies, neighborhood/resident groups, and other primary users of the intersection — get involved.

Cost: ●●●●
Time Frame: ●●●
Effectiveness: Tried



Clear Sight Triangles

NCHRP Report 500 • Vol. 12
Strategy: C1



Where to use

Signalized intersections where there is a high frequency of crashes between vehicles turning right on red from one street and through vehicles on the other street or crashes involving left turning traffic where landscaped medians are present.

Key to success

A key to success for this strategy is effective diagnosis of whether a specific crash pattern observed at an intersection is, in fact, related to restricted sight distance. Currently this is a judgment made by an experienced safety analyst.

Cost: ● ○ ○ ○
Time Frame: ● ○ ○
Effectiveness: Tried



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Signalized Intersection Safety Strategies

Redesign Intersection Approaches

NCHRP Report 500 • Vol. 12
Strategy: C2



Where to use

Signalized intersections with safety problems related to sight distance that cannot be addressed with less expensive methods.

Key to success

There are significant right-of-way and property access issues involved in this strategy, and public information campaigns are vital to the success of the intersection improvements.

Cost: ●●●●
Time Frame: ●●●
Effectiveness: Proven



Improve Visibility of Intersections on Approach(es)

NCHRP Report 500 • Vol. 12
Strategy: D1



Where to use

Signalized intersections with a high frequency of crashes attributed to drivers being unaware of the presence of the intersection.

Key to success

A key to success with this strategy is to select a combination of signing and delineation techniques appropriate to specific conditions. This engineering assessment should, where possible, be accompanied by a human-factors assessment of signing and delineation needs.

Cost: ● ○ ○ ○
Time Frame: ● ○ ○
Effectiveness: Tried

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Improve Visibility of Signals and Signs at Intersections

NCHRP Report 500 • Vol. 12
Strategy: D2



Where to use

Signalized intersections with a high frequency of right-angle and rear-end crashes occurring because drivers are unable to see traffic signals and signs sufficiently in advance to safely negotiate the intersection being approached.

Key to success

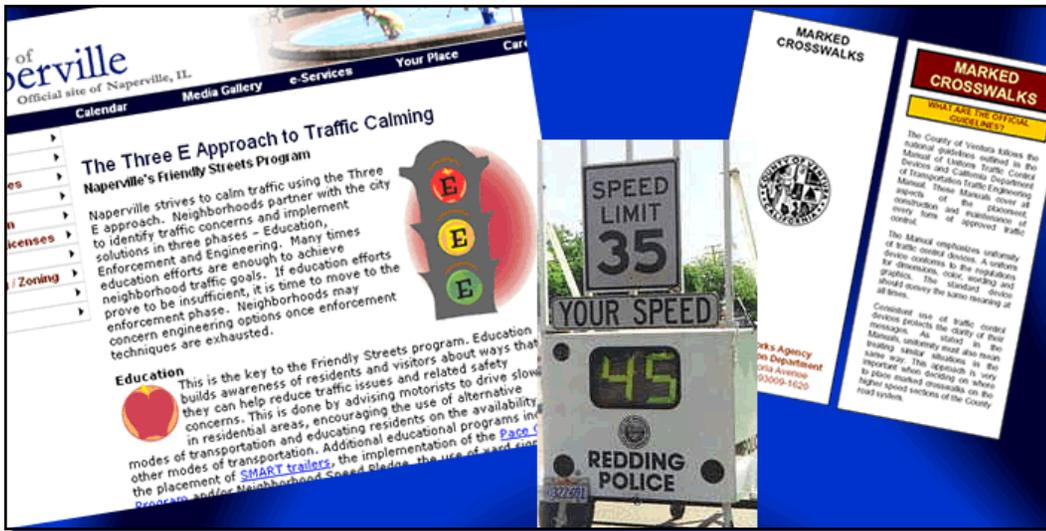
Visibility and clarity of the signal should be improved without creating additional confusion for drivers. Additional signing to warn drivers should not clutter the intersection and should not present confusing or conflicting messages to drivers.

Cost: ● ○ ○ ○ ○
Time Frame: ● ○ ○ ○ ○
Effectiveness: Tried



Provide Public Information and Education

NCHRP Report 500 • Vol. 12
Strategy: E1



Where to use

Signalized intersections with a high frequency of crashes related to drivers either being unaware of (or refusing to obey) traffic laws and regulations that impact traffic safety (especially red-light running, speeding, and not yielding to pedestrians).

Key to success

Keys to success include identifying and reaching as much of the intended audience as possible, providing information in non-technical terms, and providing personnel to answer questions.

It is important to motivate people to drive, bike, or walk safely. People may have a false sense of security and may not see the need to drive more safely or follow traffic regulations in all circumstances.

Using public information specialists and establishing good relationships with the media is important.

Cost: ● ○ ○ ○ ○
Time Frame: ● ○ ○ ○ ○
Effectiveness: Tried



Provide Targeted Conventional Enforcement of Traffic Laws

NCHRP Report 500 • Vol. 12
Strategy: E2



Telltale lights assist police officers by allowing them to sit downstream of the traffic signal and know when the red indication is displayed.

Where to use

Signalized intersections with a high frequency of crashes related to drivers either being unaware of (or refusing to obey) traffic laws and regulations that impact traffic safety.

Key to success

It is important to correctly identify intersections that would benefit from enforcement. Care should be taken to first ensure that the existing signals are operating properly, are visible, and meet Manual on Uniform Traffic Control Devices requirements, as well as that timing plans—including clearance intervals—are appropriate. Analysis of crash statistics can help with this process, as can spot speed or conflict studies. In some cases, public input or observations by law enforcement personnel may suggest that a location should be targeted for enforcement.

Cost: ●●○○
Time Frame: ●○○
Effectiveness: Tried



Implement Automated Enforcement of Red-Light Running (Cameras)

NCHRP Report 500 • Vol. 12
Strategy: E3



These photos show the front and rear of a typical red light camera installation.



Where to use

Signalized intersections with a high frequency of right-angle and rear-end crashes attributed to drivers who intentionally disobey red signal indications.

Key to success

Acceptance by local stakeholders—including officials, the public, and local law enforcement — is key to successful red-light running programs. A public information campaign explaining the program, the need for it, how the cameras work, and the potential benefits are key to successful implementation. Signs informing the public that automated enforcement is being used are frequently used.

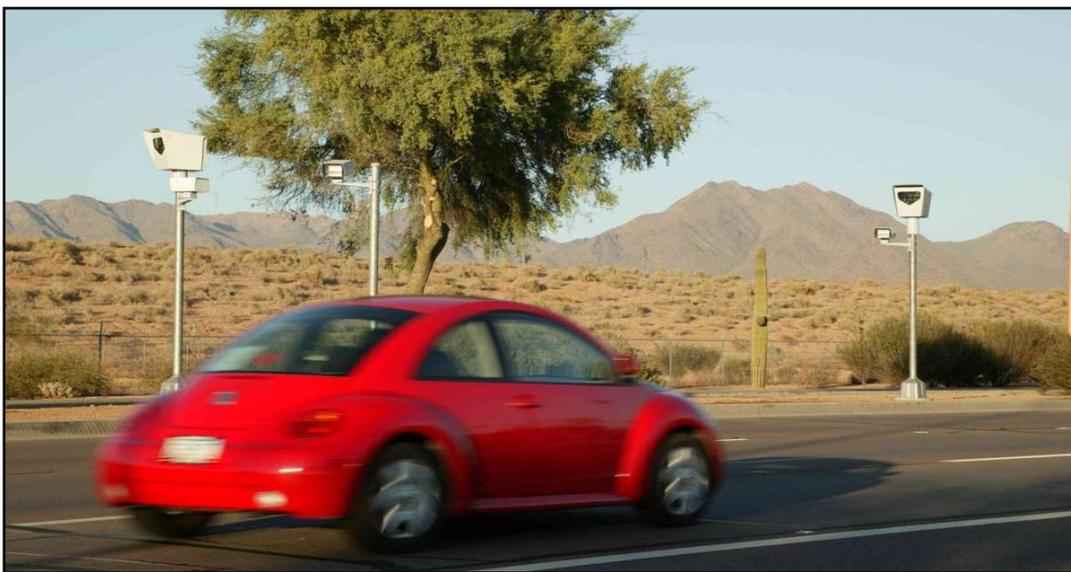
Successful red-light camera programs have generally begun as safety improvement programs. Programs that are perceived as revenue generators are generally not well accepted.

Cost: ●●○○
Time Frame: ●●○○
Effectiveness: Proven



Implement Automated Enforcement of Approach Speeds (Cameras)

NCHRP Report 500 • Vol. 12
Strategy: E4



Where to use

Signalized intersections with a high frequency of crashes attributed to drivers who intentionally disobey posted approach speed limits.

Key to success

A key to the success of this strategy is planning the enforcement and prioritizing the intersections that need it. Such intersections should have a combination of high-speed violation rates and related crash patterns. In some cases, public input or observations by law enforcement personnel may suggest that a location should be targeted with enforcement.

It is important that both the highway agency and the local law enforcement agencies be involved jointly in planning and operating the program. Another critical key to the success of an automated enforcement program is public awareness and acceptance.

Cost: ●●○○
Time Frame: ●●○○
Effectiveness: Tried



Control Speed on Approaches

NCHRP Report 500 • Vol. 12
Strategy: E5



Where to use

Signalized intersections with a high frequency of crashes attributed to drivers who intentionally disobey posted approach speed limits.

Key to success

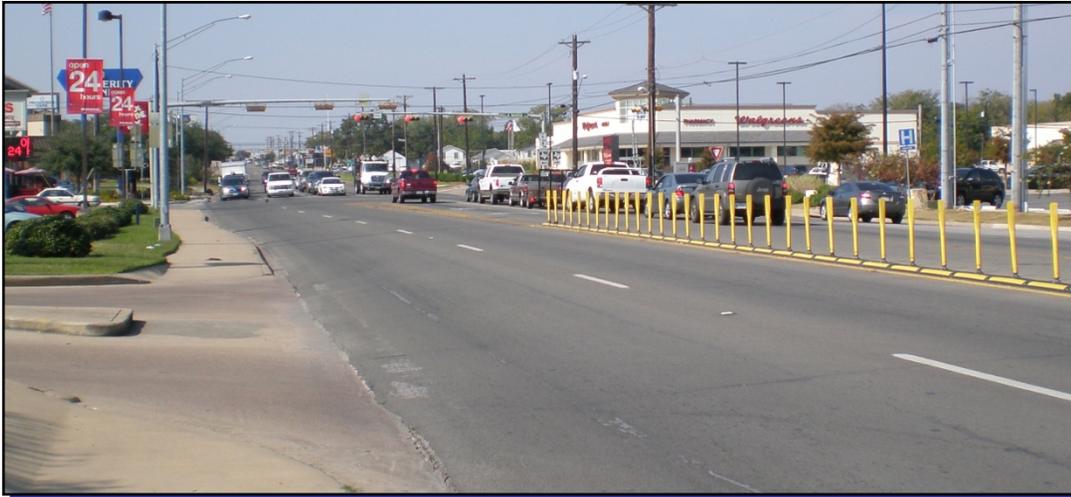
A key to the success of this strategy is careful planning and determination of the type of traffic calming measure viable for the specific intersection approach. Such intersections should have a combination of high speed-violation rates and related crash patterns.

Cost: ●●○○
Time Frame: ●●○○
Effectiveness: Experimental



Restrict Access to Properties Using Driveway Closures or Turn Restrictions

NCHRP Report 500 • Vol. 12
Strategy: F1



Where to use

Signalized intersections with high crash frequencies related to driveways adjacent to the intersection. Generally, driveways within 250 feet of the intersection are the greatest concern.

Key to success

Agencies should work with owners of adjacent properties to assure them that some restriction of access to their properties will improve safety and will not affect their ability (or, in the case of a retail business, their customers' ability) to reach their properties. Where practical, these strategies should be implemented as part of a comprehensive corridor access management plan.

Cost: ● ○ ○ ○
Time Frame: ● ○ ○
Effectiveness: Tried



Restrict Cross-Median Access Near Intersections

NCHRP Report 500 • Vol. 12
Strategy: F2



Where to use

Approaches to signalized intersections with a high frequency of crashes involving drivers making turns across medians.

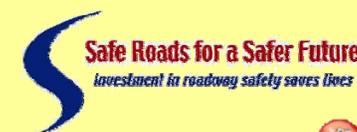
Key to success

Provision of alternative locations for turning maneuvers is key. Care should be taken to prevent the safety problems related to the median opening from being transferred to another location.

Land owners and affected persons should be involved early in the process. Demonstrating a linkage to the safety of their customers and the operational efficiency of the street is important.

Successful access management techniques rely on physical barriers to restrict movements. Reliance on signing and pavement markings only requires strong enforcement to be effective, which in many cases will not be feasible.

Cost: ● ○ ○ ○
Time Frame: ● ○ ○
Effectiveness: Tried



Improve Drainage in Intersection and on Approaches

NCHRP Report 500 • Vol. 12
Strategy: G1



Where to use

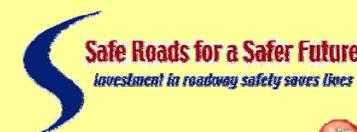
Signalized intersections with a high frequency of crashes that are related to poor drainage. Such crashes involve vehicles that hydroplane and, hence, are not able to stop when required.

Key to success

A key to success for this strategy is involving hydrologic and hydraulic specialists during the initial phases to ensure that proper considerations are given to drainage aspects.

Notification of proposed projects should be communicated to other agencies and the public. Any permits and regulations needed by the project should be identified as soon as possible so there are no delays due to legal processes. The success of this strategy will be significantly aided when provision is made for regular condition surveys of existing structures and hydraulic performance to evaluate the functionality of the improvements.

Cost: ●●○○
Time Frame: ●●○○
Effectiveness: Tried



Provide Skid Resistance in Intersection and on Approaches

NCHRP Report 500 • Vol. 12
Strategy: G2



The surface friction of this intersection is being improved.

Where to use

Signalized intersection approaches where skidding is determined to be a problem, especially in wet conditions.

Key to success

Monitoring the skid resistance of pavement requires incremental checks of pavement conditions. Evaluation must identify ruts and the occurrence of polishing. Recent research has suggested that the surface should be restored between 5 and 10 years in order to retain surface friction, but the life span is affected by site characteristics, such as traffic volume.

Cost: ● ● ○ ○
Time Frame: ● ● ○ ○
Effectiveness: Tried



Coordinate Closely Spaced Signals Near at-Grade Railroad Crossings

NCHRP Report 500 • Vol. 12
Strategy: G3



The use of a pre-signal is depicted in this photograph.

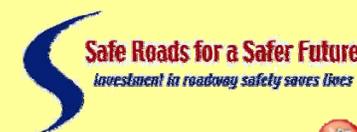
Where to use

Signalized intersections in close proximity to at-grade railroad crossings with a high frequency of crashes. This situation presents a significant potential for vehicle-train crashes, but vehicle-vehicle crashes could also occur if drivers try to speed through an intersection to avoid waiting in a queue near the railroad crossing.

Key to success

A key to success is the compatibility of the traffic signal and railroad active warning devices in order to safely control vehicle, train, bicycle, and pedestrian movements. Vehicles must be provided with adequate green time to clear the railroad tracks when a train is approaching. This means that potential queue lengths during congested periods must be considered and train detection systems provided on the railroad tracks far enough upstream of the crossing for the signal preemption to clear all vehicles. A gate is an integral part of the active warning system.

Cost: ●●○○
Time Frame: ●●○
Effectiveness: Tried



Relocate Signal Hardware out of Clear Zone

NCHRP Report 500 • Vol. 12
Strategy: G4



Where to use

Signalized intersections where signal hardware is located within the clear zone or is a sight obstruction (particularly on high-speed approaches).

Key to success

The new location of the signal hardware should not present a greater safety hazard than the previous location by creating a sight distance obstruction.

Cost: ●●○○
Time Frame: ●○○
Effectiveness: Tried



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Signalized Intersection Safety Strategies

Restrict or Eliminate Parking on Intersection Approaches

NCHRP Report 500 • Vol. 12
Strategy: G5



Where to use

Signalized intersections with permitted parking on the approaches that may present a safety hazard either by blocking sight distance or due to parking maneuvers.

Key to success

Parking regulation signs need to be posted conspicuously. Consistent and rigorous enforcement of these regulations is necessary as well. Working with owners of adjacent properties to communicate the reasons for prohibiting parking is also essential to achieving success.

Cost: ● ○ ○ ○ ○
Time Frame: ● ○ ○ ○ ○
Effectiveness: Proven

