Speed Management Techniques for Collectors and Arterials

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ABSTRACT

Speed management goes a step beyond traffic calming by also looking at higher speed facilities such as collectors and arterials. The most frequently used techniques on collectors and arterials were increased enforcement, flashing beacons, speed limit signing, radar trailers, and rumble strips.

INTRODUCTION

Speeding and speed control are often considered critical issues on residential and collector streets. In addition, speeding complaints are a continuing problem for traffic engineers and police departments. Supporting the idea of controlling speeds is the assumption that reducing speeds also reduces accidents.

Residential and collector streets are intended to provide access and to distribute local traffic between neighborhoods and arterial street systems. Low operating speeds are desired on these facilities to accommodate pedestrians, bicyclists, and local access. On arterial streets, the primary function of the road is to carry traffic, which is frequently associated with high speeds. However, speed management is also needed on arterials due to concerns about pedestrian and cyclist safety, excessive speeds in neighboring areas, pedestrian accessibility, and parking availability in retail areas (*1*). The goal of managing speeds on arterials is safety related: maintaining mobility or capacity but increasing safety by managing speeds.

Traffic calming uses geometric changes to influence travel speed and to perhaps cause drivers to select another route for travel. It is intended to restore local streets to their intended function, thus providing a more livable environment for residents. In most cases, problems on local streets are caused by through traffic, speeding, and/or noise. Speed management goes a step beyond traffic calming by also looking at higher speed facilities, including collectors and arterials. Many of the typical traffic calming techniques used in residential areas to control volume and speed would be difficult to implement on these roadways; however, other techniques need only modifications or a different approach to be effective. Although this area has not had the same amount of attention as traffic calming on residential streets, managing speeds on higher speed

roadways can be an effective part of a neighborhood traffic management plan. Integrating speed management techniques on local, collector, and arterial streets can encourage traffic to use major roadways rather than residential streets and can address needs on an areawide basis rather than for an isolated roadway or intersection.

OBJECTIVES

The goals of a Texas Department of Transportation (TxDOT) project were to identify speed management techniques that are used throughout the country and to develop a handbook documenting these techniques. The project provided one of the first comprehensive approaches to speed management on collector and arterial roadways in addition to providing information regarding the use of traffic calming techniques on local streets. The findings were documented in the *Handbook of Speed Management Techniques* (*2*).

RESEARCH APPROACH

The research approach included reviewing the literature, processing a written mail-out survey, conducting follow-up telephone interviews, performing site visits, summarizing experiences, and developing the *Handbook*. These tasks are summarized in the following sections.

Literature Review

A literature review identified current state-of-the-practice for various speed management techniques used on collector and arterial facilities. Because information for collector and arterial facilities was limited, techniques used on residential streets were also included. The literature review was used to define the speed management techniques available, to determine how they are being used, and to focus the study on areas that warranted additional study. The major findings from the literature review are documented in the *Handbook's* annotated bibliography.

Written Survey

A mail-out survey was used to identify techniques for speed management and to suggest potential locations for on-site visits. Surveys were mailed or faxed to 400 agencies to identify locations where speed management techniques have been considered or implemented. Emphasis was placed on techniques used for collector or arterial facilities or state highways passing through small towns. Other issues addressed by the survey include: public involvement; criteria for approval by residents or businesses; and locations where speed management techniques have been installed. Additional information was requested on local policies and procedures used when considering speed management techniques. Thirty-nine percent (157 of 400) of the surveys distributed to local and state agencies in the United States and Canada were returned. The responses represented 41 states, three Canadian provinces, 78 state agencies, 50 cities, 4 counties, one transportation research center, and one consulting firm. Approximately 40 percent of

the respondents indicated that they had installed or considered speed management techniques on suburban arterials. The most frequently used techniques on collectors and arterials were:

- Increased enforcement,
- Flashing beacons,
- Speed limit signing,
- Radar trailers, and
- Rumble strips.

Survey respondents also stated that they believed that signal coordination with speed limit signing, photo radar, and narrow lanes and/or chokers would be effective in managing speed on collector and arterial streets.

Twenty-eight agencies indicated that they have a process to handle requests for speed management techniques; 49 agencies indicated that they do not have such a program. Additionally, 56 agencies do not require approval of residents or businesses affected by the installation of speed management techniques, while 14 agencies do require such approval.

Phone Interviews

Telephone interviews were conducted to obtain more information about specific techniques, programs, or policies identified in the written surveys and to further identify locations for site visits. Phone interviews were informal, focusing on the particular experience of the agency being contacted. Some of the issues addressed in the phone interviews included: public involvement and response; approval process for installation of techniques; the input of emergency response agencies; cost sharing; removal of implemented techniques; landscaping and maintenance responsibilities; and any before and after study that had been conducted.

Site Visits

Locations for site visits were selected based upon information from the literature review, written survey, telephone interviews, and related site visits for other puposes. The site visits were used to clarify and expand areas with limited information, to identify useful information about specific techniques and sites, and to take photographs for inclusion in the *Handbook* (*2*). Because the use of speed management techniques on arterials and collectors was limited, information on techniques for local and residential streets was also collected for inclusion in the *Handbook*. Both in-state and out-of-state visits were made in order to record a broad spectrum of the types of techniques currently in use. Texas sites visited included Austin, San Antonio, College Station, Bryan, Carrollton, Plano, Garland, Arlington, and several towns in the Atlanta District in northeast Texas. Out-of-state visits included various sites within the states of California, Oregon, Washington, Georgia, Maryland, Virginia, and Wisconsin in addition to the Canadian cities of Toronto, Ontario, and Vancouver.

Handbook Development

The information obtained through the written surveys, telephone interviews, and on-site visits was summarized according to technique. Experiences for each technique include descriptions of the technique, characteristics of the technique, notes on its effectiveness or ineffectiveness, maintenance requirements, and advantages and disadvantages. Both successes and problems with various techniques are included in the discussions.

The *Handbook of Speed Management Techniques* (*2*) was developed as a user-friendly document to provide practitioners with a general overview of speed management techniques. The *Handbook* focuses on collector and arterial streets and also includes techniques used on local streets. The techniques are organized into four chapters: Roadway Design Techniques, Road Surface Techniques, Traffic Control Techniques, and Enforcement Techniques. All the techniques included in the *Handbook* are illustrated in Figure 1.

The Roadway Design Techniques chapter includes physical techniques designed to alter the driver's path. The Road Surface Techniques chapter discusses changing the roadway surface by adding vertical elements such as speed humps, by narrowing the roadway, or by drawing the driver's attention through the use of pavement markings. The Traffic Control Techniques chapter describes the use of traffic control devices such as signs and flashing beacons to reduce speeds or speed variation. The Enforcement Techniques chapter discusses enforcement techniques such as photo radar and speed trailers to remind drivers of the speed limit and of the speed at which they are traveling. Each chapter includes descriptions of the techniques, photographs of the techniques, experiences of agencies that have used the technique, and lessons that have been learned.

SPEED MANAGEMENT TECHNIQUES FOR ARTERIALS AND COLLECTORS

Survey respondents identified five techniques as those most frequently used on arterials and collectors: increased enforcement, flashing beacons, speed limit signing, radar trailers, and rumble strips. The use of these techniques is summarized on the following pages.

Increased Enforcement

Increased enforcement targets specific areas to effectively use public safety and/or police personnel to encourage reduce speeds. Enforcement usually involves the use of radar to identify speeders and the subsequent ticketing of the violators (see Figure 2). Increased enforcement may be handled on a citizen request basis, by a program of alternating locations for added enforcement, or by specific programs funded particularly for this purpose.

Studies have shown that appreciable speed reductions result from enforcement operations. However, speeds are usually reduced only as long as the enforcement is maintained. While speeds are reduced, the number of accidents is generally reduced and overall safety is improved.(*3*)

The city of Madison, Wisconsin, uses annual 402 Highway Safety Funds to provide increased enforcement through overtime hours for law enforcement officers. One officer uses a radar gun to monitor speeds and then calls ahead with license plate numbers

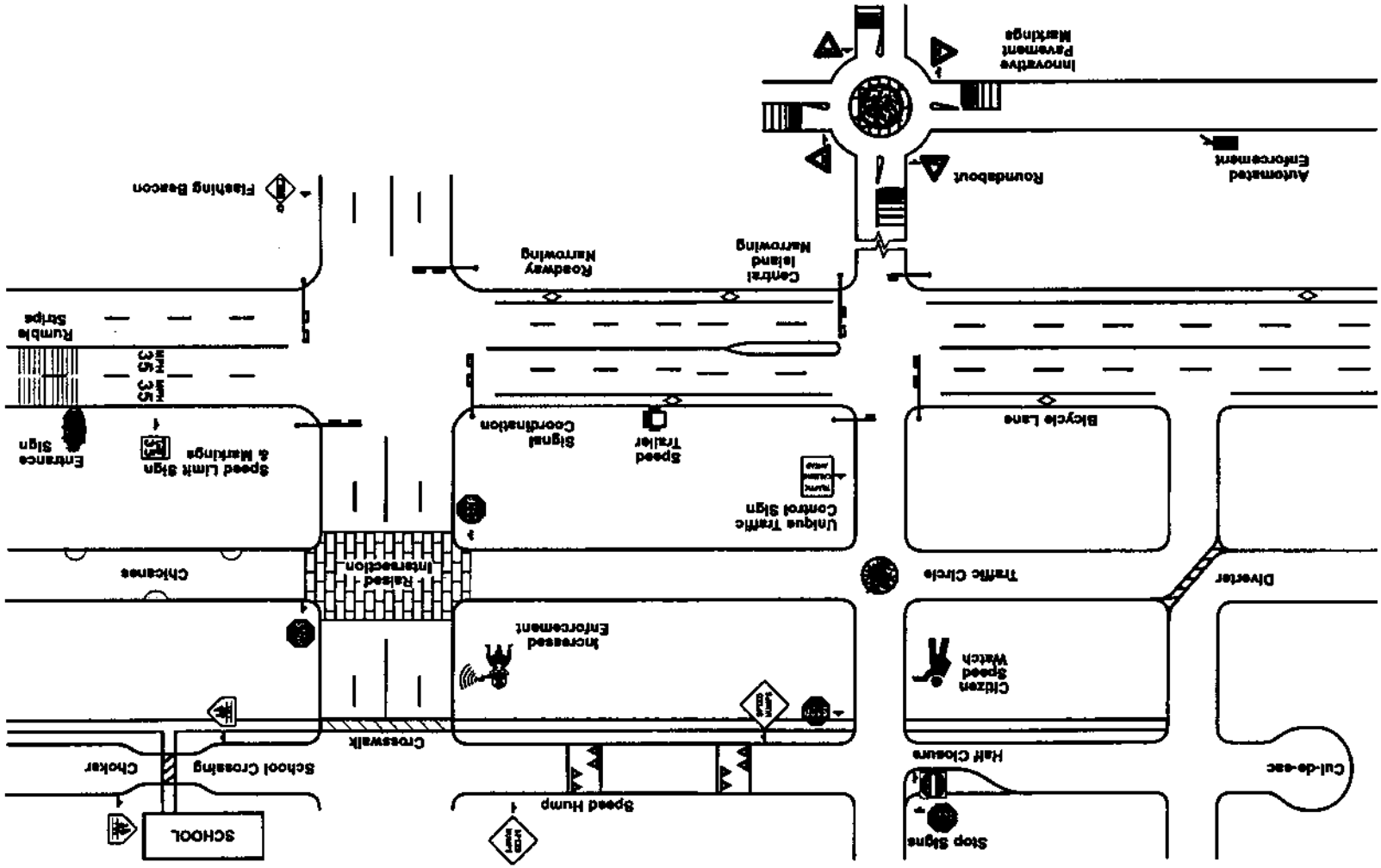


FIGURE 1 Illustration of speed management techniques (*1*).

FIGURE 2 Law enforcement in Texas.

to approximately five other officers who are stationed downstream. Warning signs are installed in targeted areas to notify the public of the "Speed Wave." The program started with the traffic engineering department and is now with the police department. The Speed Wave was originally used at higher-speed accident locations, with locations now also being determined by citizen requests during the year.

In Texas, the Speed Selective Traffic Enforcement Program (Speed STEP) is used to provide additional enforcement using funds from the Texas Highway Traffic Safety Program (Federal 402 funds). The project description is: "Selective traffic enforcement and information projects designed to bring motorists into compliance with all posted speed limits in order to reduce risk-taking behavior by motorists." For fiscal year 1997, the city of College Station, Texas, received a $15,000 grant which was used to target speeders on six roadways in College Station. Citizens were notified of the increased enforcement through articles in the local newspapers.

Flashing Beacons

Flashing beacons are typically used with warning signs and are intended to reduce vehicle speeds prior to an intersection, potential hazard, or unique condition (see example in Figure 3). They are generally used in advance of a downstream traffic control device or hazardous or unique condition. They are also used with school crossing signs to alert drivers that they are entering a school zone. Issues considered for beacon installation include: volume- and crash-based conditions, percentage of repeat users on the roadway, beacon type, placement on post (hardware mounting) and lateral placement, power requirements (for solar options), flash rate, and maintenance requirements.

FIGURE 3 Flashing beacon in Arlington, Texas.

The city of Arlington, Texas, installed flashing sign beacons to reduce vehicle speeds on a 72.5-km/h (45-mph) section of four-lane, divided arterial roadway in advance of an intersection on the crest of a curve. The city was concerned about sight distance for motorists on the minor approach of the intersection and motorists' ability to safely make left and right turns from a stopped position. The major street volume (uncontrolled) is approximately 20,000 vehicles per day, and the minor street volume is significantly less than required to warrant a traffic signal. The city's decision to install the flashing beacon was based on numerous complaints from residents traveling through the intersection on a daily basis. Once the beacons were installed, the agency experienced a significant decline in complaints and received positive feedback from residents.

Speed Limit Signs and Markings

Speed limit signs display the speed limit established by law or by regulation. Drivers generally travel at speeds which they consider reasonable, comfortable, convenient, and safe under the existing conditions, which may or may not be in compliance with the speed limit sign. Therefore, speed limits are most effective when established by an engineering study of the roadway section using the 85th percentile speed approach. Some procedures allow for consideration of horizontal and vertical alignment, sight distance, development, parking and pedestrian activity, and accident history. Speed limits may also be marked on the pavement to reinforce the posted speed limit (see Figure 4). Other horizontal pavement markings, such as arrows or specific words such as "Stop Ahead," may also be used to encourage speed reduction when cars are approaching another traffic control device or unique situation.

A change in a speed limit or the use of a larger sign may result in reduced traffic speeds when used in conjunction with regular enforcement. Officials at the Minnesota Department of Transportation report that larger speed limit signs [91.4 m by 121.9 m (36 in by 48 in)] are more effective when used along with increased enforcement and in locations where normal speed limit signs are being missed.

Researchers with the Insurance for Highway Safety conducted studies to determine if specially designed pavement markings were effective at reducing excessive

FIGURE 4 Speed limit sign and markings in Santa Barbara, California.

speeds on rural and suburban two-lane roadways with sharp horizontal curvatures. These pavement markings consisted of the word "Slow" and a left-curve arrow painted on the roadway. A marginal speed reduction of about 7 percent was attributable to the pavement markings (*5*).

Speed or Radar Trailers

Speed or radar trailers (also known as speed display boards or mobile radar trailers) are mobile roadside devices that use radar to measure the speed of approaching vehicles by recording and displaying the speed to passing drivers in an effort to decrease speed (see Figure 5). The portable units post the legal speed of the roadway and display the current speed of the approaching vehicle. Speed trailers have been used as an enforcement tool in some areas when police officers enforce the speeds; however, they are mainly used as a public relations measure to inform motorists of their speeds in the hope that the speeding motorists will voluntarily reduce their speed (*6*). Speed trailers are also used for automated enforcement in a few states, where speeds and license plate numbers are recorded by hidden cameras and citations are issued by the local law enforcement agency. Equipment to collect traffic volumes may also be used within the speed trailer.

A research study in Bryan, Texas, confirmed that speed trailers *are* effective in reducing speeds and the proportion of speeders on low-speed urban roadways for speeders downstream of the trailer. However, the same research study showed that speed trailers *do not* appear effective in reducing speeds and the proportion of speeders *after* the trailer is removed (*6*). A study in Riverside, California, demonstrated that speed trailers used with enforcement have a carryover effect both alongside and downstream of the device one week after its removal.

Speeds alongside the trailer were reduced by 10.6 km/h (6.6 mph) and speeds downstream of the trailer were reduced by 7 km/h (4.4 mph) one week afer the trailer was removed. Other studies in Orange County and Santa Barbara, California, and in North Carolina have also demonstrated positive effects on vehicle speeds. The Santa Barbara study found that speeds were reduced by 10 percent alongside the device and by 7 percent downstream for a distance of up to 0.8 km/h (0.5 mi) (*7*).

FIGURE 5 Speed trailer in Bryan, Texas.

Rumble Strips

Rumble strips are pavement undulations placed across the driving lane, causing the vehicle to "rumble" or vibrate when crossing them (*8*). Rumble strips can be an effective attention-getting device where a particular situation exists that warrants alerting the approaching driver. They are generally used in advance of a downstream traffic control device or hazardous or unique condition. Rumble strips can be treatments on top of the pavement surface, including asphalt strips, patterned sections of rough pavement, traffic buttons or dots glued to the pavement, brick paving blocks, or layers of thermoplastic striping material. Rumble strips may also be installed by cutting grooves in the pavement. They have had some applications for speed control in residential areas, but the noise generated by vehicles crossing the strips tends to create more protests from residents than the speeding problems they were intended to solve. Advance warning signs are often installed upstream of rumble strips, and a sign indicating the purpose of the strip may be placed adjacent to it.

Rumble strips have been placed north of Houston, Texas, at a high-speed approach to an isolated signalized intersection. They have also been used in Atlanta, Lubbock, and Austin, Texas, at approaches to rural signalized intersections to alert motorists of the signal. Rumble strips are used on the approach to a roundabout in Taneytown, Maryland. They are also installed at a school crossing near Greenbelt, Maryland. The roadway is a six-lane facility, and the school is located across this roadway from a residential area. The rumble strips are placed at 2.7 m (9 ft) intervals in the first grouping and then at 1.5 m (5 ft) intervals approaching the pedestrian crosswalk. The strips are constructed of layers of yellow thermostatic striping material, and the word "School" is also painted on the pavement. In Catonsville, Maryland, rumble strips have been installed on both approaches to a high-accident horizontal curve in addition to warning signs and a hazardous indication beacon. The strips are constructed of thermoplastic material (see Figure 6).

Other Techniques

Other techniques that are appropriate for use on collectors and arterials are illustrated and described in Table 1.

FIGURE 6 Rumble strips in Maryland.

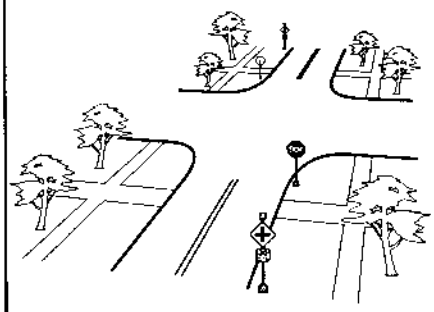
TABLE 1 Summary of Techniques for Collectors and Arterials (*2*)

INCREASED ENFORCEMENT (CONVENTIONAL) increases the use of conventional enforcement to reduce speeds in target areas.

Key Advantages
- Reduces speed during enforcement period
- Increases driver awareness of speeding
- Makes response quick and effective

Key Disadvantages
- Requires regular long-term enforcement to gain long-term benefits
- Is costly for law enforcement agencies

FLASHING BEACONS are used to attract drivers' attention and to inform them of right-of-way conditions or potential roadway hazards.

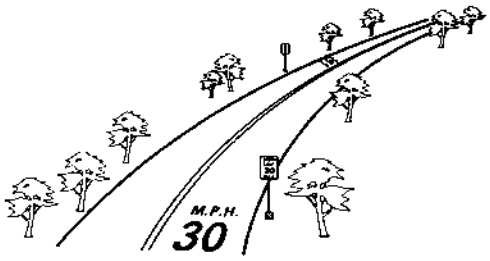


Key Advantages
- Are effective in drawing attention to hazards
- May be a low-cost solution
- Require low maintenance

Key Disadvantages
- Effect may diminish over time if there is a high number of repeat users
- May become over used

SPEED LIMIT SIGNS display the speed limit established by law or by regulation.

PAVEMENT MARKINGS may be used to reinforce the message.

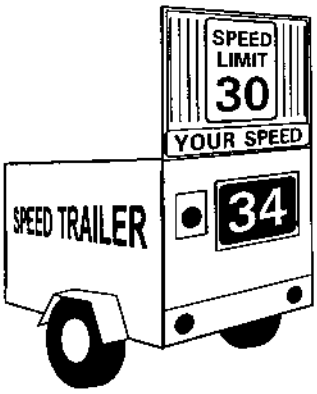


Key Advantages
- (Signs) are well recognized and understood
- (Pavement markings) reinforce speed limits
- (Both) are inexpensive to install
- (Signs) can reduce speeds with regular enforcement

Key Disadvantages
- (Signs) have significant non-compliance rates
- (Pavement markings) are not proven to be effective
- (Pavement markings) may cause concern regarding conspicuity and legibility

TABLE 1 (*continued*) **Summary of Techniques for Collectors and Arterials (*2*)**

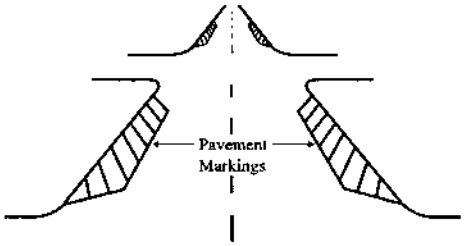
SPEED TRAILERS are mobile roadside devices that use a radar device to detect the speed of approaching vehicles. The devices display the speed limit and the speed of approaching vehicles.



Key Advantages
- Educate the public on posted and excessive speeds
- Are a good educational and public relations tool
- Are easily moved from one location to another

Key Disadvantages
- Do not appear effective in reducing speeds after the trailer is removed
- Have limited use unless combined with enforcement
- Have limited use on multi-lane roadways

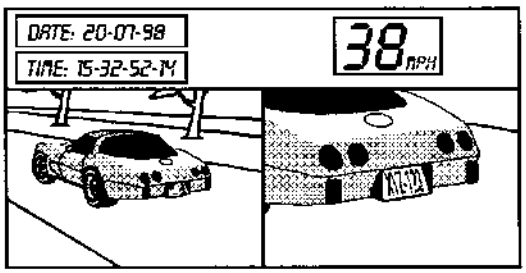
ROADWAY NARROWING TECHNIQUES narrow the roadway for a continuous length using geometric features, pavement markings, or landscaping.



Key Advantages
- Provide continuous, visual channelization
- Can be inexpensive to install
- Can be quickly implemented

Key Disadvantages
- Require regular maintenance
- Increase cost of roadway resurfacing
- May be expensive to install, depending upon technique

AUTOMATED ENFORCEMENT uses a radar device, processing unit, and camera to record vehicle speeds and photograph those vehicles exceeding the speed limit.



Key Advantages
- Can detect and record information about a large number of speeders
- Can provide enforcement in areas where roadway geometry makes it difficult for police officers
- Targets speeders objectively

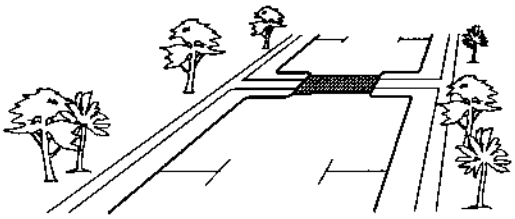
Key Disadvantages
- Allows impaired or unsafe drivers to remain on the road because no traffic stop is made
- May be a less effective learning tool than if the violator were stopped and given a citation immediately
- Doesn't allow an officer to give discretion for an emergency situation

TABLE 1 (*continued*) Summary of Techniques for Collectors and Arterials (*2*)

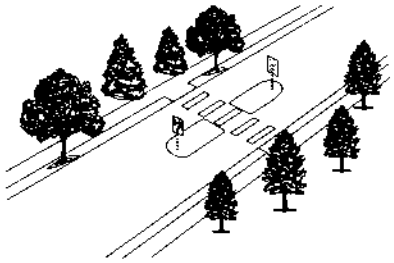
NECKDOWNS/CHOKERS are constrictions of the roadway that reduce the width of the traveled path.

Key Advantages
- Can shorten the crossing time for pedestrians
- Can make pedestrian crossings more visible to drivers
- Do not slow emergency vehicles
- Can be used as a bus stop

Key Disadvantages
- May require some parking removal
- May create potential crash obstacles
- Make it difficult to accommodate full bicycle lanes
- May impede trucks



CENTRAL ISLAND NARROWING ISLANDS are used in the center of the roadway to provide refuge to pedestrians during the crossing maneuver.



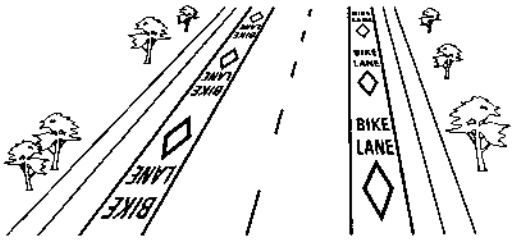
Key Advantages
- Create a refuge so pedestrians can cross half the street at a time
- Make pedestrian crossings more visible to drivers

Key Disadvantages
- May give pedestrians a false sense of security
- May create potential crash obstacles for drivers
- May create problems for street-sweeping or snow-plowing efforts

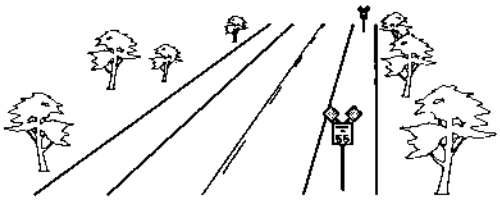
BICYCLE MOBILITY TECHNIQUES are used to accommodate bicyclists. They include shared lanes, bike lanes, bike paths, or bicycle routes.

Key Advantages
- Encourage non-motorist travel
- Better define where bicyclists are expected

Key Disadvantages
- Could create additional conflicts between vehicles and bicycles



UNIQUE TRAFFIC CONTROL SIGNS include regulatory, informational, warning, and guide signs. Such signs are typically designed for a unique situation believed to warrant special attention.

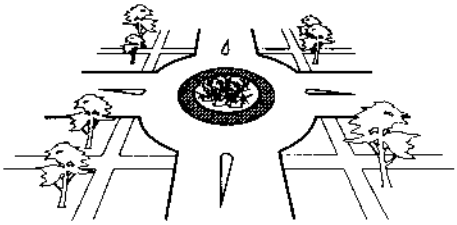


Key Advantages
- May be successful in informing drivers of a unique situation

Key Disadvantages
- May not conform to standards in the *MUTCD*
- Are not easily recognized

TABLE 1 (*continued*) Summary of Techniques for Collectors and Arterials (*2*)

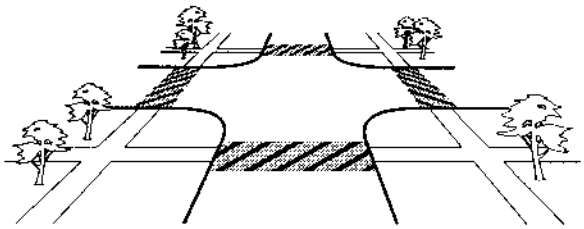
ROUNDABOUTS are raised islands that create a circular one-way flow of traffic.



Key Advantages
- Can noticeably reduce speeds
- Reduces the number of conflict points at the intersection
- Can increase capacity
- Provides an orderly and continuous flow of traffic
- Are effective at multi-leg intersections

Key Disadvantages
- May be restrictive for some larger emergency and service vehicles
- Require pedestrians and bicyclists to adjust to less traditional crossing patterns
- May have reduced aesthetic value due to safety signage

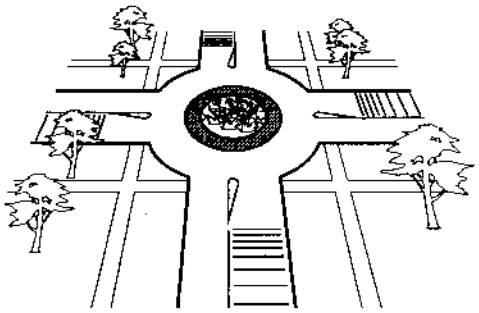
CROSSWALKS are portions of roadways designated for pedestrians to use in crossing the street. **HIGHER VISIBILITY CROSSWALKS** attract additional attention to pedestrian areas. **WIDER SIDEWALK AREAS** provide additional pedestrian space and streetscaping space off the roadway.



Key Advantages
- (Crosswalks) indicate the preferred crossing locations to pedestrians
- (Higher visibility crosswalks) provide more visibility to drivers than standard crosswalks
- (Wider sidewalks) provide additional space for pedestrians and street furniture
- (Wider sidewalks) can improve the aesthetics of the area

Key Disadvantages
- (Higher visibility crosswalks) may provide a false sense of security to pedestrians
- (Higher visibility crosswalks) require consideration of the effect of the materials on the vehicle tires
- Both may require increased construction and maintenance costs

INNOVATIVE PAVEMENT MARKINGS are used to give drivers the illusion that they are traveling faster than they really are.



Key Advantages
- May serve to reduce traffic speeds and crashes by warning or alerting drivers to an upcoming situation and by causing drivers to perceive that they are traveling too fast
- May give drivers a heightened sense of awareness in which they are better prepared to avoid a crash even if vehicle speeds are not reduced

Key Disadvantages
- Need more research to verify the use of these patterns
- Can be expensive to maintain the complex marking patterns

TABLE 1 (*continued*) Summary of Techniques for Collectors and Arterials (*2*)

CITIZEN SPEED WATCH PROGRAMS are public awareness programs involving residents, agency staff, and motorists.

Key Advantages
- Are an effective public relations and educational tool
- Make neighbors feel that they are part of the solution for speed problems
- Long-term effects are possible due to resident interaction

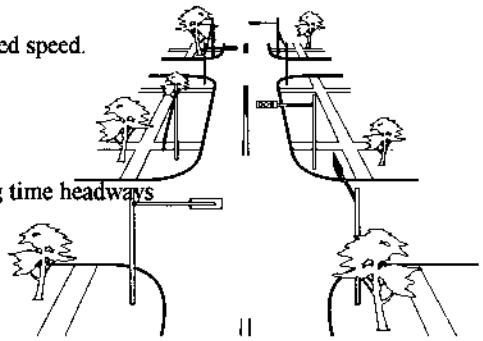
Key Disadvantages
- Are very labor intensive
- Are not an enforcement tool

SCHOOL SPEED ZONES use warning signs, crosswalks, pavement markings, and/or traffic signals to alert drivers of the school zone and to inform them of the beginning and ending of the reduced speed area.

Key Advantages
- Alert drivers of possible pedestrian presence
- Use uniform colors and symbols for easy recognition
- Reduce speed limits for specified hours only

Key Disadvantages
- Can be costly to implement flashing signs
- Can be costly to enforce
- May cause confusion if non-uniform devices or enforcement procedures are used

TRAFFIC SIGNAL COORDINATION allows a platoon of vehicles to progress through a series of intersections at a specified speed.



Key Advantages
- Can reduce the number of stops and reduce delay
- Can encourage a preferred speed
- Can send vehicles through intersections in platoons, reducing time headways
- Can conserve fuel and minimize air pollution

Key Disadvantages
- May be difficult to include all intersections within a corridor
- May be difficult to optimize both directions

WARNING SIGNS are used to warn drivers of existing or potentially hazardous conditions on or adjacent to a highway or street.

Key Advantages
- Are easily recognizable
- Alert drivers of approaching hazards or unique conditions
- Can be supplemented with advisory speed plates or flashing beacons to provide drivers with additional guidance

Key Disadvantages
- Can cause disrespect for signs if used unnecessarily
- Can increase roadside clutter

SUMMARY

A Texas Department of Transportation project identified speed management techniques that are used throughout the country, providing one of the first comprehensive documentations of speed management on arterials and collectors. These techniques are documented in the *Handbook of Speed Management Techniques*, which also provides additional information about techniques on residential streets. The *Handbook* includes descriptions of the techniques, photographs of the techniques in use, experiences of agencies that have used the techniques, and lessons that have been learned. The most frequently used techniques for collectors and arterials include increased enforcement, flashing beacons, speed limit signs and markings, speed or radar trailers, and rumble strips.

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